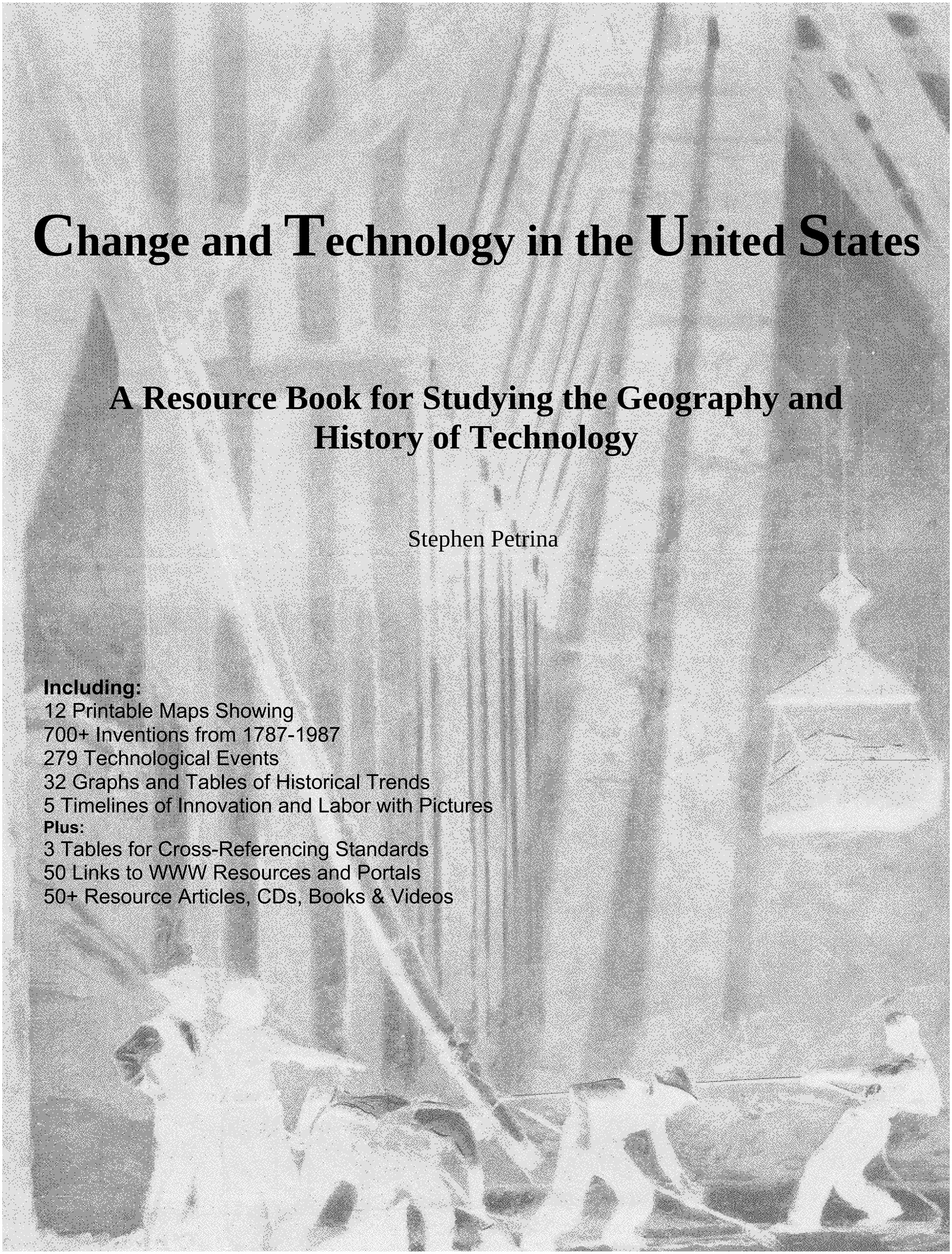

Change and Technology in the United States

A Resource Book for Studying the Geography and History of Technology

Stephen Petrina

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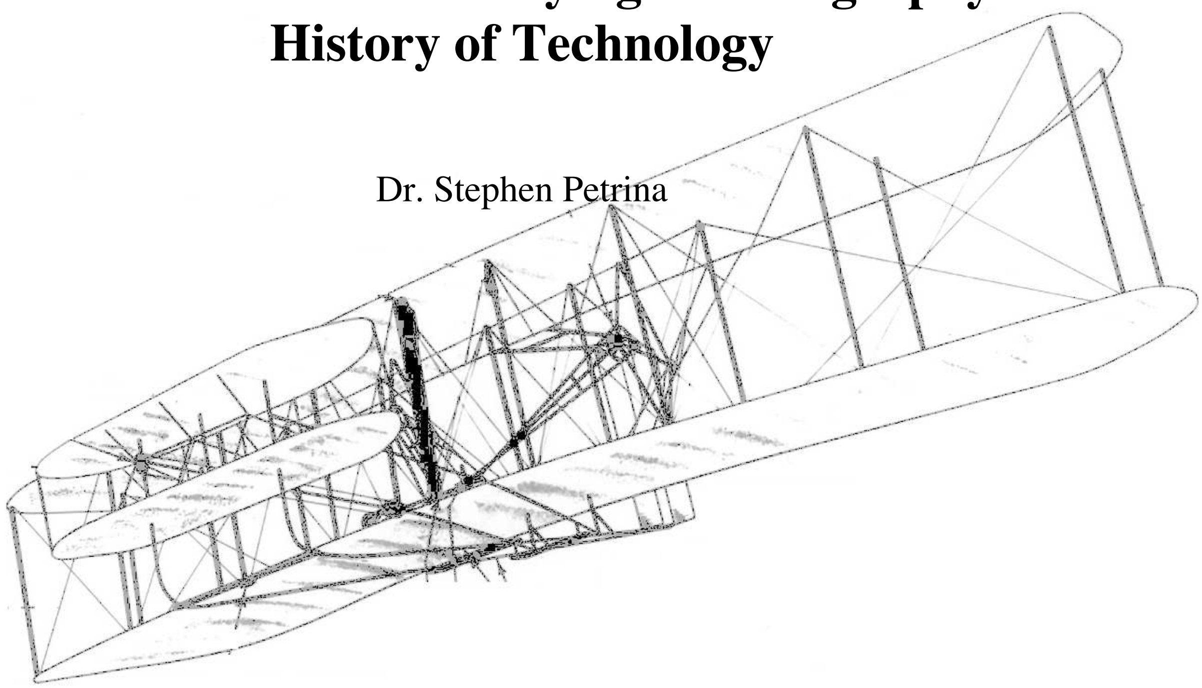

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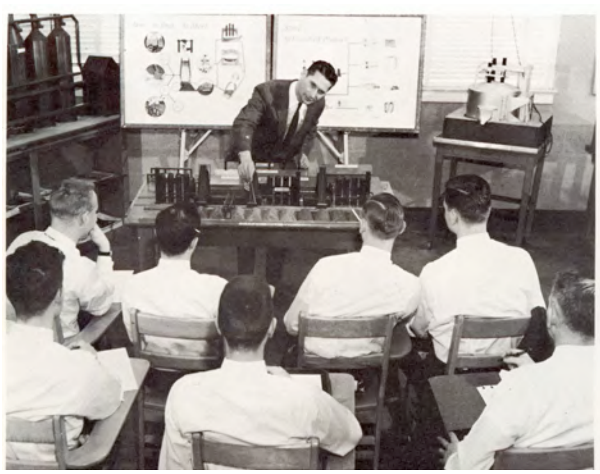
Preface

This project is the result of a project undertaken in my graduate program at the University of Maryland during the late 1980s. When I began, I did not fully realize the scale of the challenge. The research itself was extremely intimidating and time-consuming. It took me a few years to figure out what resources were most helpful in integrating the geography and history of technology. I completed eights maps in 1987 and did a fair amount of writing at the same time. This was the Bicentennial year of the United States Constitution and 1787-1987 provided a neat timeframe for the project. At that point, I had put about 500 hours into research and constructing the maps. However, I eventually found myself burning out from the endeavor, and more pressing obligations took over. I became dissatisfied that I was overly nationalistic. By the time I moved to Canada in 1996, the entire project was generally unappealing to me. I revisited the project at the end of 2003 and decided it was much more worthwhile than I allowed myself to believe. The volume of research that went into it was too immense to simply abandon. I grew inspired again and edited the work, updating each of the sections and formatting the events, inventions, images, graphs and maps.

A notable aspect is that I do not write like this anymore— I probably could not if I tried. That is what makes the monograph unique. It effectively captures the spirit of the research project. The monograph and maps can be criticized for emphasizing a number of issues that historians of technology work to counter. The idea that invention is nationalistic rather than cosmopolitan or international is one issue. Another is the heroic inventor complex, which ignores the fact that even the most stereotypical of lone inventors, such as Thomas Edison, were surrounded by a rich social network. Yet another issue that historians work to avoid is the illusion that invention is a masculine project. Tales of invention and innovation, as we know, too often exclude the measures that girls and women take to alter the technologies they use. Or, these tales exclude by ethnicity and race, by generally ignoring the contributions made by African, Arab, Asian, Hispanic or Indian Americans to the geography and history of innovation. We overlook the innovations that Native Americans made and continue to make. When I was working on this project in the late 1980s, I did not appreciate these caveats. Now I do. With all of this said, the monograph and the accompanying maps offer an extremely important addition to the resources of technology teachers and teachers of other subjects who address the geography and history of technology. The geography and history of technology, as explained in another section, are now part and parcel of the *Standards for Technological Literacy*.

Acknowledgements

My debt to Dr. Donald Maley is impossible to express but easy to acknowledge. At the University of Maryland during the late 1980s, Dr. Maley advised me through the first parts of this project and encouraged me to be as comprehensive as possible. I wish he was here today to see the results that finally made their way into the public domain. Dr. Charles Beatty was the other pillar of inspiration at Maryland throughout this project. Dr. Beatty's enthusiasm was electric and is impossible to match. Drs. Francine Hultgren and Dennis Herschbach were also influential in this project. Dr. Robert Friedel introduced me to the history of technology and all of the insights mentioned in the preface. My graduate student friends at Maryland were, and continue to be, entirely supportive and inspiring. The Council on Technology Teacher Education (CTTE) and the International Technology Education Association (ITEA), by expressing interest in publishing this monograph and the accompanying maps, gave me the incentive to finally finish what I began fifteen years ago. Dr. Mark Sanders paved the way for the CTTE's role and it was his interest in the project that inspired me to bring it to its logical conclusion. Dr. Kendall Starkweather and the ITEA staff were very supportive in recognizing the value of this monograph. Without the CTTE's and ITEA's genuine interests in the technological literacy of students, teachers and the general public this monograph would *not* be accessible. And finally, I am especially indebted to C.M.M. Peters for her inspiration, and expertise in the layout and design of this book.



Dr. Maley and the Maryland Plan, 1959

Dedication

To Dr. Donald Maley (1918-1993) and Dr. Chuck Beatty, University of Maryland.

Table of Contents

Introduction: Change and Technology in the United States

> We the People of the United States, in order to form a more perfect Union, establish Justice, insure domestic Tranquility, provide for the common Defence, promote the general Welfare, and secure the Blessings of Liberty to ourselves and our Posterity, do ordain and establish this Constitution for the United States of America. (Preamble to the Constitution of the United States, 1787)

> Congress shall have the power… to promote the progress of science and useful arts by securing for limited times to authors and inventors the exclusive right to their respective writings and inventions. (Article 1, Section 8, Constitution of the United States, 1787)

After nearly five months of wearisome dialogue, 55 delegates representing thirteen American States proposed and, on 17 September 1787, adopted what was to become the basic political and legal framework of the United States (US). Over 215 years later, the US Constitution continues to serve as a guide for individual freedoms and rights. "It is history: roots for a country with little sense of the past. For a restless people, it is the prime source of stability, of certainty" (Lewis, 1987).

The experimental nature of American life has subjected every facet of the US to the tests of progress, regress and change. As President Franklin D. Roosevelt proclaimed, the US "demands bold, persistent experimentation." As it stands, the Constitution, with its Bill of Rights as well as copyright and patent clause, has proven to a certain extent that resiliency is indeed its paramount quality. While the Constitution is a record of stability, the American culture, landscape, people and society have been subject to incessant alteration. American history books document ages of discovery, expansion and struggle; ages of agriculture, invention and steam; ages of industry, science and steel; ages of wealth, crisis and depression; ages of conflict, power and space; and finally, the age of information or what some have called the post-industrial age. One age mixes with the next, and we learn that the transitions were sometimes celebrated and sometimes merely tolerated. This sustained rhythm, this methodical process called change, has produced results far beyond our imaginations.

The rhythm of change was unscripted, some suggest, and at every accent both the people and the very foundations of the US were tested. Despite the hope of freedom and justice for all, prejudice, hatred and greed hang in the air like a specter. "And this nation, for all its hopes and all its boasts, will not be fully free until all its citizens are free," wrote President Kennedy in 1963. The following year he signed the Civil Rights Act, barring discrimination on the basis of race, color, religion, sex or national origin. In 2003, as in 1964, unfulfilled promises continue to haunt us. "America, like every country, has interests real and fictitious; concerns generous and selfish; motives honorable and squalid. Providence has not set Americans apart from... history's seamless web" (Schlessinger, 1977). This sobering realization is perhaps our most pressing canvass for change.

Change, often welcome, and as often unbearable, in its underlying essence creates a reaction. In the natural environment, reactions are not always immediately visible or observable and we have found out that even a slow, unobservable reaction can be a devastating reaction. Change within a given society may force one sub-group to feel threatened and irritated, while another feels invigorated and enthusiastic towards the change. For many individuals, changes seem swift and unpredictable, leaving a wake of isolation, morbidity or solitude. To others, changes seem gradual and inviting, opening a passage to adventure, exhilaration or relief. And then there are those who, in having created their own little insensitive world, continue through life's course unaware and unconcerned. Nevertheless, change and its cantankerous effects are forces that have in one way or another given us the world in which we live. There is a constant give and take between natural habitat and material artifact, between the causes, sources or triggering elements for change and the resulting variations or transformations within our environment. Futurists, by examining these relationships provide us with an idea of the probable changes that will take place between the present and a certain period in the future. The historian, by contrast, studies events in time and reconstructs the changes in the interval between. Alvin Toffler offered this: "Change is the process by which the future invades our lives" (1970, p. 1). Both futuristic and historical studies enable us to assess the present and prepare for tomorrow.

Most of us have at one time or another attempted to reconstruct our own past to put the process of change into perspective. When describing the value of retracing her childhood, Eleanor Roosevelt reflected in *Tomorrow is Now* that "only by doing so can one form a sharp picture of our changing world, and of the changes one has had to make, no matter how painfully or reluctantly, to adjust to that world" (1940, p. 17). As Mrs. Roosevelt alluded, it is the past from which we learn our mistakes. In retracing the US past, we sense the urgency for distinguishing the country from Europe, the urgency to develop autonomy, which meant the means to power and independence. In everyday life, this meant that a vast majority of men, women and children worked, slaved and sweated to serve mixed causes, some noble, some selfish, some ignoble. Despite claims that "the business of the USA is business," we could say that the fortunes of the US rest on the back of labor and technology.

By coincidence and by design, the signing of the Constitution in 1787 marked the beginnings of what historians call the industrial revolution of the US (1790-1860) (Hindle and Lubar, 1986). Not coincidentally, 1790 marked the signing of the first Patent Bill or the beginning of the US patent system, setting the stage for private ownership of intellectual property rights. These property rights granted the inventor "the right to exclude others from making, using, offering for sale or selling" the invention in the US or importing the invention to the US. The patent law granted an inventor a monopoly for a period of years (today's patents are for 20 years), but it also required the inventor to disclose the details of her or his invention to the public. Fuelled by inventions such as the steam engine and a new economics of capitalism, England's industrial revolution (1760-1820) was already in its third decade when the US began to transform their means of power and livelihoods with the power of new technologies and patents. Changes in the rural landscape and urban environments were swift. One could feel increases in the general pace of life. Many bemoaned the invasion of the pastoral landscape by machines. Many imagined a reduction in toil. Many felt empowered, many felt disenfranchised. The first patent was issued in 1790 and in 2000 the total number of patents issued exceeded six million. Currently, the US grants about 180 thousand patents per year and any one of these inventions and innovations can challenge the very foundations on which the US Constitution was founded.

Over the past two centuries, technology has empowered and threatened the Constitution and its principles of governance, liberty and intellectual property. Most recently, the convergence of information technologies and telecommunications has threatened our concepts of free speech, privacy, national sovereignty, limited government, democratic representation and separation of powers within the three branches of the national government. For example, the great symbol of this convergence, the world wide web, is not so much national as entirely international.

Our study of the economics, geography and history of technology will help us to understand our current political climate as well as changes in the past. For our future, for our survival, it is important that we understand the interrelations among environmental and social changes and the successes and failures of economics, geography, history and technology.

Coping with Change

> Change is avalanching upon our heads and most people are grotesquely unprepared to cope with it. (Alvin Toffler, 1970)

Change has been described as the great disturber. The belief that since the beginning of the world the only constant has been change is the base of philosophies rooted in pragmatism and Darwinian theories of evolution. In *The Third Wave*, the futurist Toffler noted that "humanity faces a quantum leap forward. It faces the deepest social upheaval and social restructuring of all time. Without clearly recognizing it, we are engaged in building a remarkable new civilization from the ground up…. We, who happen to share the planet at this explosive moment, will therefore feel the full impact of the Third Wave in our own lifetimes" (1983, p. 26). Change, for Toffler, occurs in waves. "Unprecedented social, political, and technological changes have occurred during this century. More profound changes lie ahead. To make the decisions that will be required, we must understand the nature of change itself— its causes and effects— its dangers and possibilities." This was the conclusion of Lisa Taylor, Editor of *The Phenomenon of Change* (1984, cover). What is change? What can we do to understand change? Why should we try to understand change? What does change have to do with our lives?

No definition captures the abstract concept of change. Some changes are based on cause-effect conditions. Other changes cannot be attributed to a single governing source. There is a dynamic interaction between the catalysts, sources or stimuli for change; resultant effects, variations or consequences; reactions or responses following the change; and more changes. The most we can say at times is that change is the transition from one state of mind, condition or matter to another. Change is emotional, environmental, physiological, or perceptual and psychological. It is variance over time. Change, whether for better or worse, serves as a continuum for the past, present and future. "Change is all pervasive," wrote Taylor (1984, p. 4), "touching every aspect of life. It is different situations. Because of the many factors affecting it, change follows diverse patterns and has unexpected repercussions." Change is inherent in every aspect of our society and environment. Our world is characterized by change. Changes we face and see are an endless source of angst and wonder.

The study of change is common to all sciences. Nuclear physicists are concerned with changes within sub-atomic particles. Physical scientists and chemists study molecular and chemical changes. Psychologists make sense out of changes in human behavior. Meteorologists are primarily interested in atmospheric changes. Geologists and anthropologists spend lifetimes piecing together changes in our distant past. Ecologists spend most of their time grappling with long-term changes. Anthropologists deal with changes in cultures and the activity and beliefs of the members of a culture. We analyze change through history, observation, experience or any combination.

The historian, by isolating two "events" in the past is, to some degree, able to reconstruct the changes and chain of events in the interval between. Richard Guy Wilson (1984), in the *Phenomenon of Change* concluded that "the principal focus of the historian is the study of change, for without change, history does not exist…. in the study of the past, change— how and why events occurred, how and why people acted as they did is the core." History puts concepts such as time, space, form, complexity and novelty into perspective, thus making it possible to comprehend some of the dimensions or characteristics of change. Interpretations of history direct our attention to the characteristics of change and also promote a comparison between time periods. It is through these comparisons that principles of continuity and analogy are derived. Accurate interpretations of change depend on detailed historical documentation and techniques based on observation.

Observing and analyzing the matter of the moment may require the exploitation of intuition, insight, survey, description (qualitative or quantitative), evaluation, measurement, experimentation and verification. The interaction of observable fact and abstract idea can alter or reinforce our comprehension of change. Through observation, we can assess the cause and effect dimension of change. Observation helps us measure and view change as a natural phenomenon. Perhaps the most educative method of analyzing change is through direct participation: through experience.

Reconstructing our personal experiences of the past helps put the process of change into perspective. This is narrative— this is how we tell our story. As Mrs. Roosevelt suggested, the nature of change is felt through experience. Narratives of the past reveal not only triumphs and failures, but also characteristics of change such as rate and sequence. Through experience we realize the interactions of certain changes and interrelationships among events. A narrative of personal experience can bring to light information regarding patterns and manifestations of change. Experience enhances our ability to evaluate and categorize change and to discriminate relevant from irrelevant, or lasting from transient. As in observation, recollection of experience enables us to assess the catalyst-consequence quality of change. Our perceptions of the past are extremely beneficial when choosing alternatives. The past is a source for learning and yet, historical and experiential accounts of change may alone prove to be an inadequate guide to the future. It is both the accurate *assessment* and *anticipation* of change that are critical to our survival. The future exists only as a concept.

"Time and change together join to make possible the concept of the future," William Conboy (1979) proposed. "Past, present, and future are meaningless except in the concept of change…. The future is important because it is where we will spend the rest of our lives. It is the only part of life we can still change. It is the area of alternatives and choices." For Conboy, a "desirable state" for any individual is a balanced, yet developed, sense of the past, present, and future. If it is reasonable to accept that the ability to conjecture and imagine a future is a human characteristic, then it is also reasonable to accept change as part of that image. Assessments of the past imply a continuation of change through time. Toffler's *Future Shock* was an evaluation of how woefully inadequate we are for dealing with change. Accurate assessments of the past provide us with ideas of the relationship between change and time. Change is dependent on current and past conditions, events and decisions. It is common to reflect on the past and it is natural to form a perspective on the present with an outlook on the future. Critical analysts note that we are much too preoccupied with the present— we obsess with our current, often trivial, predicaments to the neglect of patterns formed in the past and sustainable designs on the future.

Current global problems are creating our future. The realization that our problems will *not* be solved today intensifies our sense of moral obligation to the future. In 1971, Walter C. Wagner reasoned that humans must be moral toward the future as well as the present. Published in the *Futurist*, Wagner's essay, titled "Future Morality" was a reasoned argument for a futuristic sense of empathy. "Forecasting, by bringing a sense of life into the present, affects us in many ways. We have an enhanced or closer role intimacy with the inhabitants. We take their roles. We experience intensified awareness and identification; social role distance is narrowed. Forecasting heightens our perceptions of their problems. Problems are made explicit. Problems are posed that challenge our problem-solving intellects…. For self-love reasons we should act toward the future so as to most fully actualize ourselves in the present."

Wagner argued that futurism, or a study of the future, is psychologically healthy and helps us develop self-esteem, goal-orientation and organizational skills. Individual visions of the future may be shaped by ways we perceive the past, our involvement in the present, the way we interpret fact or fiction, and futuristic forecasts. Futurism deals with descriptions of probable alternative futures and the probabilities of their coming into existence. Futurism is based on the premise that although anything is possible, there are aspects of the future that are highly probable and others that are next to impossible. By exploiting methods involving trend extrapolation, impact analyses, scenarios, simulations or analogy futurists are able to provide us with an idea of the probable changes that will take place within a certain period in the future (Petrina, 1990). Just as history is beneficial in assessing the characteristics of change, futurism can help us to anticipate certain changes. Historical, experiential, and futuristic studies enable us to live today and prepare for tomorrow. Today, we are experiencing change that feels unprecedented.

Individually and collectively, we seem to be facing more changes than any other society in history. In *The Study of the Future*, Edward Cornish (1977) observed that "a hurricane of change is sweeping through all human institutions, upsetting, destroying, and creating more in a generation than was accomplished during centuries or even millennia in times past." An "acceleration of change" is threatening our ability to cope with increasing levels of transience, novelty and diversity, Toffler noted in *Future Shock*. Changes on a scale and scope never before realized by humans have been well documented over the past thirty years. Our institutions, organizations, beliefs and attitudes have been subjects of this accelerated change. "We have less time for preparation and adaptation," Conboy concluded. "The mainstream of life has become a swift current; we feel swept along, and we raise powerful questions about our destinations." Our reactions depend on how well, or if at all, we prepare ourselves.

Humans , like all life forms, are extremely sensitive to change. Change, often welcome and as often unbearable, in its underlying essence always gets a response. Social change may force one sub-group to feel threatened and irritated while another may respond enthusiastically. Depending on individuals and circumstances, social change may seem swift, unpredictable, gradual, liberating, innovative or destructive. There are also those who close their minds to change and refuse to accept the fact that change exists. Reactions differ across boundaries of ability, age, class, gender, race, and sexuality. The psychological effects of change and why individuals react inconsistently are issues confronting the social and physical sciences. To manage or cope with change, we have to recognize the relationship between change, stress and time as a first step. Managing change may involve counseling, narrative, short and long-term planning and stress reduction techniques. In managing or coping with change, comprehending the dimensions of time are beneficial.

Toffler coined the term "future shock" in 1965 to "describe the shattering stress and disorientation that we induce in individuals by subjecting them to too much change in too short a time." Although we are not "doomed to a mass adaptational breakdown" such as Toffler warned, future shock, like culture shock, is real. In "The Hazards of Change," published in *Time*, Thomas Holmes (1971) wrote that change— even pleasant change— is stressful. He found that too many changes in a short time produce illness, panic, or depression; but, he explained that physical and emotional illness can be prevented by managing life changes. We are often dysfunctional when we experience serious changes. "I may wonder whether human beings can go on psychologically coping with an ever more complicated environment, for complication produces tension, distraction, and confusion," Charlton Ogburn acknowledged in 1966 (p. 308). "But if technology has created an environment in which strains and frustrations multiply," he continued, "it has also given us the leisure and access to sundry vacationlands in which perhaps to escape them." Today, he would probably acknowledge the intense stress of information and the virtual worlds we create to escape.

We began by calling attention to how important it is for us to comprehend change. We looked at the futility of defining change and then addressed three methods for investigating the dimensions of change. We then dealt with the relationship between change and time. Futurism, we suggested, is a valuable tool for studying the future and resolving anxieties about the future. In summary, to aid in our understanding of the nature of change, we can: 1) view contemporary life from a historical perspective, 2) assess the characteristics of change through methods involving observation, 3) reserve time to recall and analyze our personal experience with change, 4) reorganize and reformulate perceptions of past experience with change with regards to new experiences by creating narratives, 5) enhance our awareness of our role in the present through the speculation of future possibilities and an empathy with future citizens, and 6) consider that we make our own history but not necessarily as we want.

Can We Be More Sensible and Sustainable?

> If facts are the seeds that later produce knowledge and wisdom, then the emotions and the impressions of the senses are the fertile soil in which the seeds must grow... Senses other than sight can prove avenues of delight and discovery, storing up for us memories and impressions. (Rachel Carson, 1956)

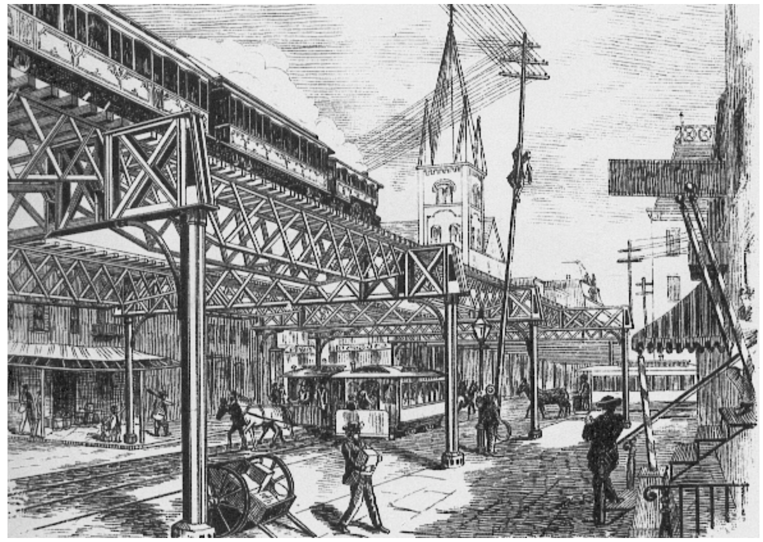
We actively participate in the process of change. Humans, along with insects, plants and other animals, are able to detect changes within their physical environment. We sense an addition, deletion or alteration. The environment is full of targets for our senses to fix upon. We can see, hear, smell, taste or touch our surroundings. The stimulation of our senses arouses emotions. Something or someone we see may make us sad. What we smell or taste may make us happy. We may hear something that brings back fond memories. We hate touching that which frightens us. We enjoy walking through some places more than others. We use our senses to understand our environment. We develop relationships with the natural and synthetic worlds alike.

The relationships we develop with certain aspects of our environment are different than those developed by our ancestors. The quantity, time, and frequency of our relationships with people, places and things have changed. In *Future Shock,* Toffler argued that "we no longer feel life as people did in the past. And this is the ultimate difference, the distinction that separates the truly contemporary human from all others. For this acceleration lies behind the impermanence— the transience— that penetrates and tinctures our consciousness, radically affecting the way we relate to other people, to things, to the entire universe of ideas, art and values." There is literally a world of difference between the environment we experience and that which was experienced just a few lifetimes ago. We can only wonder how 19th century citizens would react in our present environment. Throughout our daily activities, we approximate culture shock or even future shock, if throughout the day, we ask ourselves questions such as: What if I never saw this before?… heard this… smelled, tasted, or touched this before ? In contrast, by asking ourselves: What if I knew I will never see, hear... touch it again?, we sense what it is that we individually and as a society truly value.

> There is a new America every morning when we wake up. It is upon us whether we will it or not. The new America is the sum of many small changes— a new subdivision here, a new school there, a new industry where there had been swampland— changes that add up to a broad transformation of our lives. Our task is

> to guide these changes. For, though change is inevitable, change for the better is a full time job. (Adlai Stevenson, 1956)

It is quite obvious that the US is much different today than it was in 1787. A comparison reveals a number observable differences: economic and political shifts, cultural changes, demographic changes in the population. Even the Constitution has been changed through amendments. Perhaps the most visible difference is in our physical environment.

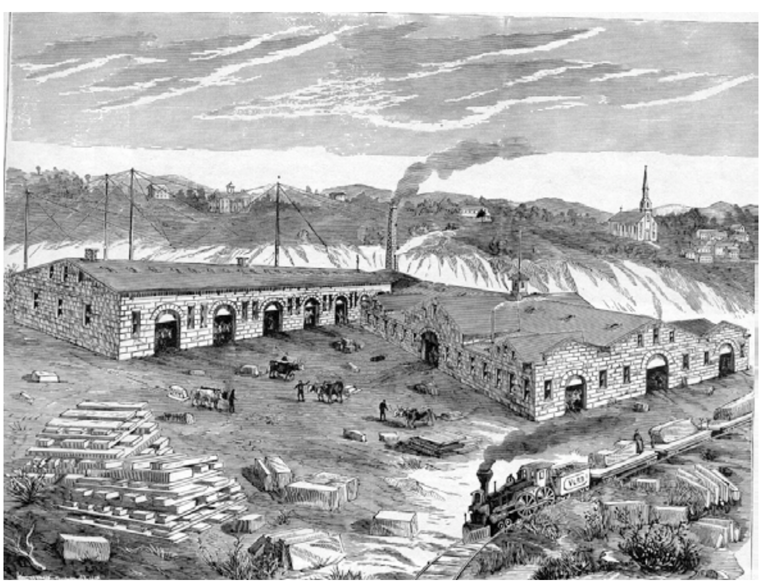


The natural beauty of the US has forever been a subject of inspiration. Thomas Jefferson, in an emotional letter written in 1786 to a friend, expressed his view of the American landscape: "The Falling spring, the Cascade of Niagara the Passage of the Potomac thro the Blue Mountains, the Natural Bridge. It is worth a voyage across the Atlantic to see these objects; much more to paint, and to make them, and thereby ourselves, known to all ages." Jefferson was not alone. History's page portrays generations of people, both native and immigrant alike, deeply in love with the American land. Artists from all walks of life desperately attempted to capture the feeling and preserve the beauty so that it may be "known to all ages." The *natural* beauty of our land has faded. The pastoral ideals of our descendents still ring true, but now with each ring comes the reminder that progress has its price. The wake from over two centuries of national expansion has spelled disaster for nature. In the 48 contiguous states only 6% of the land is considered to be "wild." Irrepressible development continues. For some time we have been facing questions such as those put to judgment in 1976 by *National Geographic* writer Dorothy Nicholson: "Where do you draw the line between using the land and using it up?" and "In this land of plenty, is there such a thing as too much?"

Much of the pristine wilderness known to the Native and early Americans was dramatically transformed and buried beneath a concrete jungle. Farmland and the harvest of corn and wheat have been replaced by the blacktop pasture and a more modern harvest of litter. "They paved paradise," Joni Mitchell sings in Big Yellow Taxi, "and put in a parking lot…. They took all the trees and put them in a tree museum…" Our trees, once the giants of the world, are shadowed by sky-scrapers, billboards and distended bridges. Restless smokestacks and tailpipes turned once blue skies into an agitated color of dusk. Many of our streams, rivers, and lakes are discolored from injections and lethal blends of oil and chemicals. We literally hollowed, disintegrated, and removed mountains. We have irreversibly transformed the landscape.

A bit of culture from the past along with bits of our natural heritage have been preserved. Through conservation efforts we managed to save a fair abundance of plant and animal life. We promised natural treasures, such as the National Wilderness and the National and State Park systems, to tomorrow's children. Yesterday's world is found in nature as well as ritual, poetry, story and picture. And, by learning the hard way, we basically realize that so-called progress leaves no room for negligence or mistakes. The American landscape has changed, and as Archibald Macleish wrote in "The Unimagined America,"

> The ideal landscape which Jefferson painted hangs unaltered in the American imagination— a clean, small landscape, with its isolated figures, its pleasant barns, its self-reliant roof trees, its horizons clear of the smoke and the fumes of cities, its air still, its frontiers protected by month-wide oceans, year-wide wildernesses. No later hand has touched it, except Lincoln's maybe, deepening the shadow, widening the sky, broadening the acreage in the name of freedom, giving the parts a wholeness that in brighter, sharper light they lacked.... No one had dreamed a new American dream of the new America— the industrial nation of the huge machines, the limitless earth, the vast and skillful populations, the mountains of copper and iron, the mile-long plants, the delicate laboratories, the tremendous dams.



In as much as it was the beauty of the landscape which provided a source of inspiration in the past, it was the bounty of our natural resources, oftentimes hidden beneath the surface, which provided a source of pride. The fertility of the soil, the rushing waters, the trees and the minerals played a major role in American pageantry. We can appreciate the following passage taken from Captain Frederick Marryat's (1839) *A Diary in America:*

> America is a wonderful country... with natural advantages which no other can boast of; and the mind can hardly calculate upon the degree of perfection and power to which, whether the states are eventually separated or not, it may in the course of two centuries arrive.... It is the country, and not the government which has been productive of such rapid strides as have been made in America. Indeed it is a query whether the form of government would have existed down to this day, had it not been for the advantages derived from the vast extent and boundless resources of the territory in which it was established.

The United States has long been considered a land of boundless opportunity and resources; in the same breath, this nation is a land of endless production and consumption. We need only glance at the statistical analyses provided by the Bureau of Mines or the Environmental Protection Agency to understand the scale of resource consumption involved. Likewise, one need only glance at the data provided by the Geologic Survey to understand the finite characteristics of our once plentiful resources. Barring any territorial expansion, what you see is what is left.

We are all somewhat knowledgeable about the limits of our natural resources. Common sense will tell us that the only hope for future reserves will come through the conservation efforts that include alternative sources, increased efficiency, reduced consumption and recycling. Concentrated action on any one of these may require a change, individually and collectively, in the North American way of life. Soon we may not have a choice— either we all pitch-in now, or we resort to a program of austere, centralized resource management later. The law of the land will require us to comply.

Can We Grasp the Scale and Scope of Our Technology?

> My toaster has never once worked properly in four years. I follow the instructions and push two slices of bread down in the slots and seconds later they rifle upward. Once they broke the nose of a woman I loved very dearly. (Woody Allen, 1975)

Scale and scope are two characteristics that come to mind when we study technology. Scale refers to size, and contemporary technology extends scale in two directions. Larger and larger complexes of technology mark our landscapes. Smaller and smaller scales of technology, biotechnologies, miniature electronics and nanotechnology define mark our bodies and minds. Scope refers to the pervasive and invasive characteristics of technology. Nearly all facets of or life are affected by technological changes, and as we noted, coping is growing more difficult for many people.

Technology cannot be understood without referring to other characteristics, such as persistence, precision and imperfection. Technology is persistent, relentless in its increasing effects on our education, health, play, imagination, wars and work. Technology is increasingly precise, but it is also increasingly imperfect.

Looking around, it is easy to see that while we have been busy altering the landscape and consuming resources, we have also been busy producing a overwhelming volume of physical objects. This is the stuff that basements, garages, dumps and landfills are made of. From functional objects, such as automobiles, to semi-functional objects like funhouse mirrors; from life saving objects to life taking objects; from objects that look great to objects that are offensive; from objects that make objects to objects that destroy objects: North Americans have a love affair with "things." It has been an adventure-packed roller coaster ride on the "pursuit of happiness." If we don't produce the objects ourselves, we import them— functional, aesthetic, political, religious, or next to useless. This materiality of our environment is not just floating, it has its place, it has a geography.

We have added thousands of sounds to our environment. We have created an audio wonderland— a soundscape— a habitat where the sounds of nature are virtually inaudible and silence is only a moment of time bound by buzzers, bells, beeps, bands, booms, bangs and blasts. We have also learned that the human ear has its limits. Noise is a form of pollution, and in some cases, actually degrades the quality of life. Noise is a health hazard. "Prolonged exposure to high-level noises causes irreversible hearing damage." And, according to the US Government's *Report on the Panel of Noise Abatement,* "there is a growing body of evidence that noise has other physiological and psychological effects on the human organism. Even low levels of noise impair a satisfactory relationship between humans and the environment— for example, speech communication is rendered difficult, sounds of warning are not heard, and the normal pattern of rest and sleep may be interrupted." The numerous economic, legal, medical, social and technical implications make the controlling and abating of noise a serious problem.

New sights and sounds mean new smells. The latest in designer scents control moods— for shopping, relaxing thinking and loving. Directions on a can of chemicals read: "repels all insects— lasts 30 days." Yesterday's headline states: "congestion in tunnel— driver overcome by fumes." Daily urban news briefs pronounce that "ozone/pollution levels are dangerously high— so bad you can smell it!" Step outside and you know when someone is spray painting. Fertilizers, herbicides, pesticides, fuels, lubricants, inks, waxes, deodorants, detergents, softeners— each product unleashes a unique smell. Familiar smells include the subway, the garbage dump, the steel mill, the pulp mill, the railroad yard, the integrated circuit plant, the plastics mill, the tire plant. Entire cities and surrounding suburbs take on unique scents— Pittsburgh, Gary, Las Vegas, Houston, Los Angeles, Boston— there are some smells you never forget. Air pollution—you never really get used to it.

Eliminating odors has also become popular. Mechanical and electrostatic filters remove odors, fragrances mask odors— we have learned how to accommodate our noses. Have we created smells that are beyond the human sniff? What makes a dog so happy? However ridiculous it may sound, everything has flavor. The oil embargo of the mid-1970's gave many people the taste of gasoline when they siphoned tanks. Whether by accident or choice, we taste nylon, rayon, linoleum, paint, cement, asphalt, several glues, bakelite, Teflon, celluloid, masonite, cellophane, glass, steel, aluminum, chrome, miscellaneous electronic components, freon, polyester, wood, stainless steel, and photographic film— an array of natural and industrial materials.

Perhaps most significantly, the changes in our environment appeal to our sense of touch. Nature has been harnessed and someone ingeniously devised new methods to feel it. Remember these?

Electrical energy: "Here's how you test a 9-volt transistor battery." OUCH!

Mechanical energy: "See, the mouse pulls the cheese out like this." OUCH!

Heat energy: "Sure, you can unscrew a light bulb while it's on." OUCH!

The home is now one of nature's classrooms. Baby won't touch the TV until she sees daddy turn it on. Now baby touches the screen and "zap," baby's first bout with static electricity. We gain our best insights when we are in contact with everyday objects. China boutiques, antique stores and museums testify, we like to touch. Metal is cold. Wood is warm. Glass is smooth and hard, yet fragile. Plastic is light but sturdy. Chains are strong but flexible. Oil is slippery. Electric motors vibrate. Electric drills torque in our hands. We have access to millions of objects that we can touch or feel in some way. Millions more are off limits. Of course we feel most comfortable with those that have been tailored towards interactive contact.

We believe in comfort and convenience. When we work, travel, or relax at home, we enjoy a "controlled" environment. Air conditioners keep us cool. Heaters and furnaces allow us to relax indoors while wearing only a T-shirt. Humidifiers add moisture, de-humidifiers remove moisture from the air. We can choose between up-drafts, down-drafts, or cross-drafts. We can feel forced air or vacuum. Wonders of nature have been duplicated. Artifact has become habitat.

Our wonderful sense of touch has long been the target of Madison Avenue marketing strategists. Uncomfortable? We'll make it roomy, compact, soft, firm, smooth, textured, sharp, blunt, heavy or light. Comfort means luxurious cars, artificial furs, foam cushions, water beds, shock absorbers, lumbago adjustments, touch-tone dialing and touch sensitive screens. The slick marketeers insist, "there's no need to buy, just try." The slightest of our discomforts can be alleviated, or so we think. Sooner or later we realize that there is a contradiction between fashion, comfort, convenience and sustainability. The drastic yet somewhat orderly transformation of the environment has been matched by several generations of changes. The US has undergone tremendous transitions in total population, population composition, and population distribution. The country is constantly undergoing demographic changes. The first census in 1790 reported a total population of just over 3.9 million people. The first three doublings of the population occurred at 25 year intervals through 1865. The fourth doubling occurred in 1900 and the fifth in 1950. The increased time between doublings indicated a decline in the rate of population growth. Today in 2003, the US population stands at about 276 million. Changes in total population involve several components: fertility, mortality, and migration.

> In 1914, the Ford Company passed its first 1000-cars-a-day production. So Americans woke up and said: "We got to have somewhere to put these things"; and somebody thought of the idea of roads to store them on. And as fast as they would make roads, these things would clutter them up. I don't care where you try to hide a road, one of those road fillers will find it. (Will Rodgers)

The continuous blending of mobility, access, production, and consumption has for years been the mainspring of the modern way of life. Mobility? Access? Transport? We can drive 177 million different motor vehicles over 570 thousand bridges through 1,500 tunnels on 3.9 million miles of road covering 35 million acres to inch our way across 60 million acres of urban sprawl. We can navigate 4 million boats on 25.5 thousand miles of inland waterways (exclusive of the Great Lakes). We can fly 276 thousand planes over 332 thousand miles of federal airways and land on 14.7 thousand airfields. In one year, we haul 1.6 billion metric tons of freight on 168 thousand miles of railroad track across 192,000 bridges. In one year, 740 merchant trade vessels carry 1.2 billion tons of goods in and out of 44 coastal ports. In a one year period, we transport 18 trillion cubic feet of natural gas and 136 million gallons of petroleum through 1.3 billion miles of pipeline.

Communication? In one day, we send 800 million telephone messages that travel over 170 million subscriber lines and dishes using 280 million telephones. Over 170 million people have cell phones. We can listen to over 10,304 radio broadcasting stations by tuning in with 575 million radios. We can tune into 1,150 TV broadcasting stations on our 270.5 million TV sets. Over 220 million have access to over 30 cable television channels. In one year we receive 611 pieces of snail mail per person and deliver 62.8 million newspapers. Over 148 million of us who use the web send billions of messages over 200 million personal computers via 8,000 internet hosts. Some receive over 100 messages of "spam" mail each day from bulk remailers that make it next to impossible to trace the message back to an original sender.

Production? In one year we utilize 3.4 thousand generating plants to produce 3.678 trillion kilowatt-hours of electricity that power 4 million commercial buildings, 19.2 million retail trade establishments, 95 million housing units, and 358 thousand manufacturing establishments. About 70% of our electricity is produced by burning fossil fuels, 20% is produced with nuclear power, 8% is produced by hydropower and 2% is produced with alternative technologies. Rolling off our assembly lines are 7.8 million cars, 3.4 million trucks and busses, and 631 thousand motor cycles. We produce 7.6 billion pounds of synthetic fibers, 12.1 million men's suits, and 152 million women's dresses, 81.6 million tons of raw steel, 4.58 billion pounds of copper-based products, and 11.4 billion pounds of aluminum mill products. We produce 756 million pounds of herbicides, 370 million pounds of insecticides, and 109 million pounds of fungicides. Our mines produce 2.5 billion tons of minerals including 896 million tons of coal. We produced more than our share of CFC's and ship 2.7 million residential air conditioners, 5.8 million refrigerators, and 1.1 million freezers in one year. We ship 31.3 million calculators, 3 million personal computers, 2 million electric typewriters, and 12.6 million microwave ovens, and 6.1 thousand robots.

Consumption? Our 3.45 trillion kilowatt-hour demand for electricity nearly outpaces our production. Daily, we use 33.8 trillion gallons of water for manufacturing, 3.3 trillion gallons for mining, and 100 million gallons of municipal water drains into 1 billion miles of sewer systems. In one year... we dispose of 95 million tons of industrial waste (10 million tons are hazardous), and 160 million tons of municipal waste. We put 8.5 million metric tons of particulates into the air. Each year we discard 10 million vehicles, 35 million tires and 75.2 million batteries. We consume 3.2 billion pounds of cotton, 7.7 billion pounds of synthetic fibers, 1.2 billion pairs of shoes, 13 million suits, 153 million dresses, 12 million microwave ovens, 79.8 million sheet tons of paper and 21 billion square feet of plywood. Along with consuming 120 pounds per day in resources, each American throws four pounds of garbage away each day. The 1995 Index of Environmental Trends concluded that "the United States is arguably the most wasteful— that is, waste-generating— society in human history."

We managed to fill our air with particulates, our water with toxins and our fields with herbicides and pesticides. We pump into our air tons of sulfur oxides, nitrogen oxides, volatile organic compounds, carbon monoxide, particulate matter (e.g., soot) and carbon dioxide. We place about 48,000 industrial chemicals into our air, and only a quarter of these are documented and monitored. Indoor air pollution is on the rise and basically unmonitored. Reductions in NOx (nitrogen oxides) and CO2 (carbon dioxide), seem to require far more changes— fewer conveniences— than we are willing to make. The sulfur oxides we spew out cause acid rain, which chokes our lakes and wetlands. Indicators of our water pollution include dissolved oxygen, nitrates, phosphorus, ammonium and metals in ground water, lakes and rivers. But our information is poor on water quality, as only 29% of the nation's river miles are monitored. In addition to contaminates, develop our wetlands, which have been reduced by 53% since 1787. Of the 70,000 chemicals in commercial use, only 2% have been fully tested for human health effects, and 70% have not been tested for health effects of any kind. At least 1,000 new chemicals are introduced into commercial use each year and go largely untested. The chemical industry continues to grow at a rate of 3.5% a year, and doubles in size every twenty years. When Rachel Carson published *Silent Spring* in 1962, she documented the effect of DDT on nature and signaled an alarm for a generation. While DDT has been shipped south to developing countries, in North America we continue to pollute our air and flood our water with hazards that we know little about.

Standard of living? Over 177 thousand schools support our education system which contributes to, our mental and physical maturity. Over 61 thousand health care facilities are dedicated to our physical and mental soundness, the immunization and elimination of countless diseases, and the extension of our life expectancy to 74 years. We can visit countless resorts interested in leisure, relaxation and rest. We can do almost anything on 116 million acres set aside for recreation. We all have a stake in basic research facilities devoted to our nutritional and medical needs. We have 553 million acres of farm and pasture land supporting tons of food grains, feed crops, cattle, and dairy products. We employ, although not nearly enough, pollution control measures to monitor our air and water quality; natural resource and wildlife management strategies; and natural disaster warning systems. Our cities and towns are sources of the performing arts, spectator sports, amusement parks, and scores of recreational activities.

Statistics in isolation are at times meaningless, yet in this case the message is clear: We live in a wasteful, technological society. A technological society? Think about it. What if we are asked: "What does it mean?" This is an easy question to ask, but a complex one to answer. Living in a technological society may mean: Accelerated change, comfort, leisure time, access, mobility, and a high standard of living. It may mean the production of dangerous levels of pollution and waster. It may also mean that we rely on technology, or that the economic base of our society is technology. Now suppose we are asked: "What is it like *living* in a technological society?" Without reciting the statistics, or saying something existential like "you have to experience it," can we really answer that question? Of course we can. Realizing that we can gain quite a bit of insight on our way of life by examining any single aspect of our culture, let us direct the rhetorician who is asking these questions through a typical cultural analysis.

Look back at the beginning of the list and examine the statistics on roads: "we can drive... on over 3.9 million miles of road." We can give the statistic more meaning by asking, "what is the significance of all these roads in our society?" Like the network of veins and arteries in our bodies, our system of roads plays a fundamental role in keeping people and products flowing smoothly and efficiently. We have been referred to as a "nation on wheels." Road travel is our society's major form of transportation. Roads are a catalyst in the dissemination of culture. Our roads are economically, culturally and, for each of us, personally significant. Economically, our roads enable us to move goods and services from coast to coast or city to town; are often the first step in building up depressed areas; provide a source of various occupations; often determine the location of cities and factories; attract new industry; enable occupational and domicile mobility; provide sources of state and federal revenues and, roads can improve or degrade property values. Politically, our roads encourage participation in national affairs (campaigning, voting, protesting, surveys, parades); enable mass distribution of information (newspapers, mail); provide access to all judicial and legal centers (borough, township, city, national); strengthen our national defense, and aid in territorial expansion. Our roads provide access to our centers of learning (schools, museums, historic landmarks, zoos), places of worship (cathedrals, churches, mosques, shrines, synagogues), and performing arts centers (theaters, bandstands, galleries). Roads also enable an exchange of educational, religious, and artistic materials.

Roads are also of personal significance for each of us. We have roads that lead to work, vacation spots, families and to friends. Psychologically, roads liberate us from the stresses of our daily lives—We can "get away" or "escape from it all." Some of us choose and others are forced to "live" on the road; some are homeless on the streets with a shopping cart of all their possessions. We are annoyed when roads are closed, congested or unnavigable. We value the individuality that roads reinforce. Roads have "inspired" countless songs and poems, while books and movies have attempted to recreate life "on the road." Some of us lament the continuous construction of roads—the continuous incursion of roads into nature. Some despise the ease of access to pristine wilderness that logging roads provide for all terrain vehicles. The statistic of "3.9 million miles of road" is now somewhat more meaningful, but one can gain more insight by asking another question.

Why, how, and when do we utilize these roads? Simply speaking, we use roads because we built them. Most of us use vehicles that operate more efficiently on roads than off. We determined that roads best support the methods that we use to meet our needs. Never mind that these methods are generally unsustainable and come at a huge cost to nature. Roads are the basis of convenience. How we use our roads is determined by both a body of laws and common sense. Who uses roads? Anyone can use any public road and a great majority of them are free. We can use our roads at any time, day or night, and we do. We walk, jump rope, roller skate, bounce, run, play ball, park and drive on our roads. And despite laws, potential danger, and outright ugliness, we deposit a large volume of garbage on our roads. For many, roads provide the means to illegally and secretly dump our waste.

There is one more question that we ought to ask, a question of historical importance: What have we lost when we created this or that road? Roads induce tremendous strains on physical and social environments. Migration and roaming routes for entire species of animals have been carved up and interrupted by our endless desire for roads and highways. Some animals, such as wolves, are extremely wary and avoid crossing roads at almost any cost. In our cities, entire communities have been destroyed, literally leveled, by the construction of massive clover leafs and ramps. Time after time, these communities were the poorest and most vulnerable in our cities. The citizens of these communities saw their houses and stores bulldozed in the name of progress. In most cases, these people had no chance of input to defend their communities. They were simply told that their time was limited. Dislocation in 90 days whether you want it or not.

We take many of our affordances and conveniences for granted. We have difficulty looking beyond the products that we routinely come in contact with. We seldom think about the myriad of materials and processes that are used in controlling and producing our means of communication and transportation. We avoid thinking about where our products come from and go after we have used them up. We want to ignore deal the dirty details of resource streams and ecological footprints. We fail to see the relationship between the versatile machines that dig our tunnels and the delicate instruments that show us DNA, the ocean floor and distant stars. Automobiles, cameras, computers, generators, jet airplanes, radios, synthetic foods, fabrics and supplements, telephones, televisions and video games play inconspicuous roles in our technological society. If we knew more about them would we change our habits? Today, genetic engineering, robots, space shuttles, the web, digital video, virtual reality, artificial organs, lasers, and super conductors are rapidly becoming commonplace. Our society now has the capability to annihilate itself, to control life-threatening diseases, clone vital organs and alter the natural order of life. Yet, considering our potential, most of us rarely stop to wonder how we created it or where it all came from. Can we re-educate ourselves?

If we stop to think about it, we soon realize that we are both the fortunate and unfortunate beneficiaries of contributions and labors of millions of individuals in our recent past. Perhaps they didn't anticipate the potential dangers and setbacks that their labors would wrought. We inherited a world of opportunity, possibility and endless danger and disturbances. What we leave to future generations depends on how we entertain the most redeemable qualities that each of us possess—resourcefulness and creativity. What we leave depends on our abilities to assess what we inherit and the effects of what we want.

We are now back to the point where we began: change, the US Constitution and technology. After our overview of technological change it is clear how invasive and pervasive technology has become. The next section addresses the new information and communication technologies and the challenges they pose to the US Constitution and our civil liberties. The new technologies demonstrate how durable and how vulnerable the Constitution is at this point in time.

Digital Convergence and the US Constitution

The operative word in the communications industry is convergence (Petrina, Volk and Kim, in press). Currently, we are witnessing the convergence of communication, media and information technologies (computer, copier, fax, messaging, phone, printer, audio & video player etc.), modes (image, print, sound, etc.), practices (art, communication, design, fashion, film, marketing, medicine, programming, technology, etc.) and corporate formations (cable & internet providers, music, newspaper, radio & television networks). This is having a profound effect on the way we interact with and think about technology. These convergences are also challenging fundamental principles of democracy (constitutional issues, free speech, participation, privacy, etc.) and the social structure of the US (OTA, 1987, 1988a, 1988b).

Until the establishment of the internet and world wide web, communication networks were generally utilized to transmit data, image, video and voice in analogue forms. Digital and optical technologies have changed the definition and speed of the transmission resulting in massive increases of accessible information for any conceivable purpose. The equivalent of an entire 30-volume encyclopedia can be transmitted in a few seconds between the world's most powerful computers. Point-to-point and broadcasting communication are instantaneous. Time and distance, which in the past were conceptual barriers to channels of communication, have basically been overcome.

Demands to improve the capacity and quality of communication systems, along with changes in the laws and regulations governing the communication industry, have historically contributed to the improvement of existing communication technologies. In the past, new communication technologies were introduced as additions and complements to, not replacements for, existing communication media (i.e. broadcasted information complemented newspaper information). This condition does not hold true in this era of convergences. For example, trends indicate that direct marketing through television and database systems are replacing some catalogue publications. Eventually, even the widest of distributed catalogues, such as the Sears Catalogue, will be drastically downsized or completely phased out in favor of the world wide web and telemarketing. Technologies such as computer-generated broadcast telephone calls and targeted broadcasting, or narrowcasting, confuse the situation by creating a number of intermediate steps between "broadcasting" a message to a broad audience, and communicating a specially tailored message "point-to-point" or person-to-person (OTA, 1987, 1988b).

Our new capabilities to collect, compare and combine information about individuals pose serious threats to our legal and political systems. Since September 11, these threats have been articulated nearly everyday by legal and constitutional scholars. The new capabilities for information mining and retrieval, and remote and intimate sensing, affect the balance of governmental powers and their limitations. With a variety of means, information about an individual can be generated without his or her consent or knowledge. For instance, electronic surveillance violates common notions of privacy and one does not know anymore whether one is under observation. Both private and public actions are being arbitrarily monitored. Airlines may soon be required to turnover the credit card information of all passengers, where indications of personal preferences for what we buy and where we go are revealed. A new world of opportunities have opened up for law enforcement including early detection of criminality through intimate sensing.

To be sure, the new convergences are affecting the fundamental principles on which the Articles of the US Constitution rest. Intellectual property, national sovereignty, limited government, democratic representation, federalism with reserved State powers and separation of powers within the three branches of the national government are all affected by the communications practices. National sovereignty is directly challenged by transborder data transmission. Global communications networks have diminished the powers of any government to act as an autonomous sovereign. For instance, free speech on the internet challenges the very notion of state sovereignty as the ability to prosecute for libel and slander across borders is next to impossible. World-wide financial networks increase competition *and* the necessity for economic and political cooperation.

In the first Article of the Constitution, the principle of intellectual property rights is spelled out. The "exclusive right" to intellectual property of an individual or corporation is secured under the Constitution. Intellectual property rights were eventually spelled out in subsequent copyright, patent and trademark laws. However, the very notion of intellectual property has been challenged by the nature of cyberspace. Copyright law has attempted to accommodate cyberspace by merely calling it a conveyance— another shell or (form)at— for the content of expression. For example, copyright law extends ownership, distribution and reproduction rights for music copied from record to tape to CD to MP3. Extension of copyright is one thing; protection is something entirely different. As John Perry Barlow has asked, if digital property can be "infinitely reproduced and instantaneously distributed all over the planet without cost, without our knowledge, without its even leaving our possession, how can we protect it?" Never mind that it's 13 year-old kids who can do the reproducing and distributing. It is questionable whether copyright law can hold in cyberspace— the game has changed too much for mere accommodation and extension.

Democratic representation, a key concept of democratic rule, has been altered by the new convergences. There has been a marked increase in the numbers of non-elected branches of government (i.e., various commissions), the use of electronic mail to facilitate geographic and demographic targeting of political messages and the use of mass media to present political images or frame political issues. There is now a tremendous potential for instructed representation instead of real public interest in political issues. Throughout the elections of the past decade, we saw rapid increases in electronic town meetings and direct electronic voting. Public access to governmental databases has increased along with interactive video for governmental meetings and forums. These new complexities can weaken the principle of representation and, at the same time, enhance representative ability. The role and authority of federal powers are also changing.

Federal power, since the late nineteenth century, has been gradually increasing. Reasons for this include expanding markets and centers of production, increases in the capacities of telecommunications networks, a mobile citizenry, and the homogenization of culture across boundaries. Increasing Federal power can be countered as the convergences of communications and information technologies provide the states with capabilities to act independently or cooperatively. Cooperation between states can alleviate the need for Federal solutions to state problems, such as health care. Telecommunication technologies impinge on the principle of Federalism and provide reason to reconstruct the system of checks and balances. The system of checks and balances protects the separation of powers in government. A distinguishing feature of American democracy is the interpretation of law to protect the separation of powers. Military conflict and technological change are the two most influential factors that change the locus of power between the President and Congress. The war on terrorism demonstrates quite clearly the dangers of centralizing, under one branch of government, military power and the power to collect information on individuals.

Technology has complicated the relationship between the government and people of the US as spelled out in the Constitution. The Constitution defines the inalienable rights of each US citizen. John H. Gibbons (OTA, 1988a), Director of the now defunct US Office of Technology Assessment, commented that "as science and technology become ever more important... the delicate balance between individual rights and the national interest becomes both more important and more difficult to maintain" (p. iii). The new security powers exercised by the US are conflated with the powers of the new technologies for surveillance, both remote and intimate, and never before has the Constitution and government been subject to the volume of litigation over individual rights to freedom and privacy that we are currently witnessing.

Spelled out in the Bill of Rights, or the provisions of the first ten amendments to the Constitution are the most fundamental elements of democracy. The First Amendment secures our freedom for the expression of thought and opinion. It protects our most sensitive areas of personal expression: religion, ethics and political philosophy. The First Amendment occupies a preferred position in the constitutional order. Nonetheless, the Supreme Court has never interpreted freedoms of religion, speech, press or assembly to be without limitations. Constitutional rights are not absolute; hence, the courts of law try to balance the rights of individuals against the interests of government. Constitutional interpretation is complicated as decisions are made within the context conflicting values and institutions, including economic, scientific and technological institutions. Technologies that amplify individual expression or intensify the capabilities of individual and mass communication challenge the First Amendment. The convergence of computers with satellites, wireless and digital transmission lines have changed the ways in which we "communicate ideas, theories, opinions, and incitements to action- they affect who can say what, to whom, to how many, and at what cost" (OTA, 1988a, p. 7).

The very principle of freedom of the press is ambiguous when the press is redefined from a central authority that disseminates information to many individuals to, via the internet, many individuals that share information with each other. Constitutional interpretation requires that Congress identify what is the press, non-media and media. Moreover, the definitions of public and private are changing. Other problems are related to ownership of the media, access to the media, breach of privacy, editorial control, liability, foreign press publishing, convergence of the media, national security, and the underground press. The underground presses no longer operate underground and their presences on the web are catalysts for public action.

Freedom of speech, most often threatened in times of crises, is in direct odds with the practices and new technologies of censorship. Citizens who once enjoyed constitutional rights are finding themselves censored or at the risk of censorship via surveillance practices of their governments. Surveillance practices threaten both the First and Fourth (privacy) Amendments. Internet sites blur the lines between local and remote, making judicial decisions on First Amendment rights extremely difficult to make. If a US citizen creates a biochemical militia site to "publish" the recipes for bombs but houses this site on a server in another country, can s/he be censored or prosecuted? The web provides unprecedented opportunities to establish "zines" and publish controversial or "unpatriotic" views. The boundless opportunities provided by the web are accompanied by new powers of surveillance (OTA, 1988b, 1988c, 1989).

The Fourth Amendment protects our rights to individual privacy and against the practice of arbitrary power and surveillance. New technologies of surveillance threaten individual rights protected under this amendment. Satellite systems empower commercial owners and governments with the abilities to monitor and manipulate public and private activities. Data mining systems provide the means to track and trail the financial and cultural activities of citizens. A complement to remote sensing systems are the technologies for intimate sensing. Intimate sensing provides the government— the police, FBI or CIA— or private companies with the means to detect identity and monitor the use of drugs or sexual activities. Fingerprint, retinal and voice recognition, semen, urine and DNA analysis are just some of the new technologies that threaten the Fourth Amendment. The power to intrude into the very core of personal privacy and autonomy is accessible to nearly anyone or any institution (Marker, 1987; OTA, 1987).

The invasive technologies also threaten rights protected under the Fifth, Sixth and Eight Amendments. These amendments protect citizens accused, convicted or suspected of crimes. The new forensic technologies offer governments incredible powers to try and predict who is and who is not a threat to national security or policing. Racial profiling, biochemical technologies and genetics provide the incentive to identify determinants of criminal behavior and the temptation to intervene prior to the commitment of a crime. Suspected criminals can now be tested to determine their disposition toward criminal behavior. In other words, they are proven guilty before they have done anything.

Of course, with the omnipresence of new communications and information technologies, we have seen dramatic changes in the structure and performance of local, national and global economies. Examples are found in all economic sectors: business, clothing and personal care education, defense, food, housing, transportation, food, health, housing and recreation. Some analysts suggest that the new technologies have reshaped every product, every service and every job in the US. Economic changes have led to increased an expansion of consumer choice and opportunities for self expression as well as sweeping change in occupational demographics. The expansion of the economic reach of global corporations, with their infrastructure of the new communications and information technologies, make the principle of national sovereignty difficult to sustain. Sovereignty of a republic is impossible to sustain in this scenario. Wide-scale global expansionism, as we are witnessing, requires the military force and operations of empire (Petrina, Volk and Kim, in press).

Why Study the Geography and History of Technology?

> There are important changes arising out of human interaction that have enduring consequences, and these changes merit careful attention. An example from the past is the Industrial revolution. An example from the present is the continuing scientific-technological revolution. Our recent experience in coping with energy and environmental problems illustrates a need for individuals and for society as a whole to develop better ways of adapting to changes resulting from the scientific-technological revolution. To most people science is a from of magic capable of producing miracles both good and bad. Unable to make judgments about it, they alternate between excessive faith and feeling helpless and uncomfortable. In the future, applications of science and technology inevitably will have an increasing role in affecting people's lives. One can choose to live in ignorance and hence be subject to blind fear, or one can enjoy through knowledge a more relaxed attitude. One can live in a state of helplessness about the changing world or one can perceive more clearly than most the outlook for the future, the better to adjust to it and shape it. (Abelson, 1976, p. 1)

As we realize, there are some very important reasons to study change— geographic, historical and technological change. Geography answers basic questions related to human life on the land and water of the earth. It answers questions about where we are, where we come from, where we are going, where danger is located, and where we find safety. It helps us determine where we want to live, work and get our recreation. "Geography is the study of the patterns and processes of human (built) and environmental (natural) landscapes, where landscapes comprise real (objective) and perceived (subjective) space" (Wassmansdorf, 2002).

Geography prepares us to deal with basic environmental and social issues. We can determine where to locate dumps, develop new suburbias, and locate commercial developments and industrial plants. Living locally in communities or cities, we actually function at the continental and global scales. Food is shipped over long distances, clothes and shoes are produced overseas and imported, and communication and transportation systems reduce time and space. Geography, like ecology, is concerned with the fragile state of resources and the footprint that humans make on the earth. Economic and political competition mark the world at a variety of levels. Wars are primarily conducted over geographic features and resources. Geographic knowledge provides us with empathy and insight into the sources of our material comforts. Despite the accessibility of maps and television news, most of us would be challenged to locate the sources of our energy, food or clothes. Most of us would be hard-pressed to describe the location of the landfill where our waste is deposited. We could not trace the source of our electricity or fresh water supply. But it is in fact the source and geography of our technology that influence our environmental conditions most.

Geography and technology are interrelated in a number of ways: demographics, economics, environment, exploration, industry, trade or war. However, according to Wilbanks (2004, p. 5), there are three fundamental dimensions to the geography of technology:

1. Technology affects the meaning of proximity, and thus the significance of location and operational definitions of efficient spatial organization, by helping to determine the effort required to overcome distance.
2. Technology affects the meaning of places by shaping what happens there, what it is to live like there, and how its residents think about their sense of place.
3. Technology shapes nature-society relationships by changing social demands for nature's services and by changing tools for environmental management.

These dimensions of the geography of technology, says Wilbanks, are interrelated with conditions and forces such as "poverty, democratization, globalization, technological change, environmental sustainability and homeland security." When we think of the geography of technology we tend to think of the technology of geography: the digital earth. But the geography of technology, as Wilbanks notes, involves the meaning of location and the character of people and places as well as the gathering and modeling of geographic information. The production of knowledge through Geographic Information Systems (GIS), digital modeling, virtual geography, and remote sensing are significant practices for studying as well as changing the earth. We humans began to understand basic geographic facts of existence (i.e., desire to explore and return home) when we began to control the changes we could make to environmental conditions. As described earlier, the scale and scope of our activities have thrown control into question. Change involves knowing where and how we live and where we came from.

History is our collective memory and a source of personal identity. As a memory, history keeps alive the experiences, deeds and ideas of people of the past. It connects our past with the future. History is collective immortality. By rooting human beings on a continuum of the human enterprise history provides each woman and man, each girl and boy, with a sense of immortality. History is also cultural tradition, or a shared body of ideas, values and experiences with coherent shape. It is an explanation of change. Through an ordering of the past into some larger connectedness and pattern, historical events become "illustrations" of approaches to life and of possible options. Within each individual is a "psychic need for explanations of the past. A study of history can provide an awareness of both individual identity and social belonging. According to Gerda Lerner (1982), history education helps us satisfy fundamental human desires and needs.

1. A memory and as a source of personal identity.... As a memory, it keeps alive the experiences, deeds, and ideas of people of the past... history connects past and future.
2. Collective immortality.... By rooting human beings on a continuum of the human enterprise history provides each man and woman with a sense of immortality
3. Cultural tradition.... A shared body of ideas, values, and experiences, which have coherent shape, becomes cultural tradition.
4. Explanation...Through an ordering of the past into some larger connectedness and pattern, historical events become "illustrations" of philosophies and of broader interpretive frameworks (p. 10).

Lerner noted that each individual has a "psychic need" for explanations of the past (p.11). History can inspire and offer lessons to learn. Our conceptions of the past affect decisions on the future.

Despite an information overload, many of us suffer a case of "historical amnesia," or an inability to remember the past. Are television and video games the culprits? "Many of today's students do not see the relevance of history to the present or to their future," noted the renowned historian Melvin Kranzberg (1986, p. 554). "I suggest that this is because most history, as it is currently taught, ignores the technological element. Our students know that they live in a technological age, but any history that ignores the technological factor in social development does little to enable them to comprehend how their world came into being." "All history is relevant," he argued, "but the history of technology is most relevant."

These sentiments have always been part and parcel of the technological literacy movement. For example, in 1989, the Technology Education Advisory Council (TEAC) defined a technologically literate person as one who understands, among other things, "the history, evolution, nature, and development of technical means, including knowledge of people, places, and cultures where the means were invented and developed" (p. 10). Donald Maley (1984) advocated, for forty years, the design of educational activities that address the history of technology. In 1987, he noted that technological literacy involves "the development of understandings related to the role of technology" in history. Donald Lauda, another key architect of technological literacy, presented a scope and sequence model for technology education and recommended that student activities be designed for "historical perspective as well as the current state of the art" (1983, p. 13). He proposed that high schools offer courses in the history of technology.

In the same way, twenty years ago, a number of commissions on education concluded that the history of technology should be included in the education of all students (Boyer, 1983; Diem, 1983; National Assessment of Educational Progress (NAEP), 1986; National Science Foundation (NSF), 1983). These were the early days of defining technological literacy and its sources. These were the first major institutional acknowledgements that the history of technology was essential to technological literacy. For instance, in 1983 the NSF stated that studies of "the historical role of technology in human development" were central to technological literacy. The NAEP suggested that *all* secondary students study the history of technology during their school years. Countless recommendations were made for social studies teachers to finally include "instruction in the history of technology" (Diem, 1983, p. 3).

But these types of recommendations go back much further, to John Dewey (1900), who maintained that studies of the geography and history of technology provide insight into a record of how we learn "to think, to think to some effect, to transform the conditions of life... It is an ethical record as well; the account of the conditions which [humans] have patiently wrought out to serve their ends" (pp. 152-153). Dewey observed that students have a natural tendency to relate aspects of the geography and history of technology to other disciplines. His contemporaries, Katherine Dopp (1902), Gordon Bonser and Lois Mossman (1923) produced a range of materials for elementary students and teachers to understand the geography and history of technology. Their books, *The Place of Industries in Elementary Education* and *Industrial Arts for Elementary Schools* are characterized by lessons in the invention of food, shelter, clothing and transportation. In the early 1900s, there were also numerous studies that recommended the inclusion of the history of technology in engineering education (Seely, 1995).

Report after report documents the deficiencies of students' knowledge of history. For instance, in 1986 the NAEP reported on a "growing concern that students may lack the elementary knowledge of US history necessary to formulate concepts, establish relationships, and discern patterns" (p. 9). And for years, historians of technology have been arguing that the history of technology can make a difference in student understandings of history. Even in 2003, most school lessons in history, textbook writers, and historians do *not* deal with technological innovation. Perhaps we can say that technology should be taught in the context of history while history should be taught in the context of technology.

It was not until the 1990s that historians of technology took K12 education as a serious site for curriculum development. At that time a group of historians of technology met with groups of teachers and undertook the "Whole Cloth: Discovering Science and Technology Through American History" project. The premise for the undertaking was stated in terms of technological literacy:

> The Society for the History of Technology has become increasingly concerned about the dwindling interest among students in studying science and engineering in college, and about the lack of what has come to be called "technological literacy" among the general population. The Society believes that these trends have potentially troubling social, economic, and political implications…. One way to address the problem is to reach students in middle and high school and to persuade them that studying science and technology is not only intellectually possible for them, but also fun and exciting. SHOT is convinced that introducing students to these subjects through their historical contexts is an extremely promising way of demystifying science and engineering and of helping students to realize that machines can be understood and managed…. SHOT believes that using the historical approach can be especially empowering to students previously intimidated by science and engineering studies. (Smulyan, 1994, pp. 855-856)

That is the background for studying the geography and history of technology. The latest, and most important, premise for including the history of technology in the schools comes from *Technically Speaking: Why all Americans Need to Know More About Technology* and the *Standards for Technological Literacy*.

Standards for the Geography and History of Technology

The ITEA's *Standards for Technological Literacy* extend over five broad themes: the Nature of Technology, Technology and Society, Design, Abilities for a Technological World, and the Designed World. These standards are providing an effective blueprint for the creation of a scope and sequence of content for technology subject at the K-12 levels. The breadth of the twenty standards is quite comprehensive and inclusive, encompassing nearly all facets of technology. This is one aspect of technological pluralism— the acknowledgement that we need to study all of our technologies and all facets of these technologies. The standards name the scope of what is to be studied and place parameters around the disciplinary content of technology. *Standards for Technological Literacy* reinforce the importance of geography and history in the technology education of students. For example, the first seven standards deal with concepts directly tied to the issues described in this monograph:

Standards for Technological Literacy

The Nature of Technology

1. Students will develop an understanding of the characteristics and scope of technology.
2. Students will develop an understanding of the core concepts of technology.
3. Students will develop an understanding of the relationships among technologies and the connections between technology and other fields of study.

Technology and Society

4. Students will develop an understanding of the cultural, social, economic, and political effects of technology.
5. Students will develop an understanding of the effects of technology on the environment.
6. Students will develop an understanding of the role of society in the development and use of technology.
7. Students will develop an understanding of the influence of technology on history (Table 1).

Table 1. The Benchmark Topics for ITEA Standard #7.

Standards	Benchmark Topics Grades K-2	Benchmark Topics Grades 3-5	Benchmark Topics Grades 6-8	Benchmark Topics Grades 9-12
The Influence of Technology on History	Ways people have lived and worked	Tools for food, clothing, and protection	Processes of inventions and innovations Specialization of labor Evolution of techniques, measurement, and resources Technological and scientific knowledge	Evolution of technology Dramatic changes in society History of technology Early technological history and Iron Age Middle Ages and Renaissance Industrial Revolution Information Age

There are also a range of national geography and history standards that relate directly to the *Standards for Technological Literacy*. The entire range of subject standards can de found at the Mid-continent Research for Education and Learning (McREL) website (http://www.mcrel.org/compendium/browse.asp). Standard 16 of both the geography and history standards relates directly to technological literacy. These standards are extremely helpful because they provide depth to the broad expanse of the *Standards for Technological Literacy* .

Geography Standards

Environment and Society

Standard 16: Understands the changes that occur in the meaning, use, distribution and importance of resources

Level III (Grade 6-8)

1. Understands the reasons for conflicting viewpoints regarding how resources should be used (e.g., attitudes toward electric cars, water-rationing, urban public transportation, use of fossil fuels, excessive timber cutting in old growth forests, buffalo in the western United States, soil conservation in semiarid areas)
2. Knows strategies for wise management and use of renewable, flow, and nonrenewable resources (e.g., wise management of agricultural soils, fossil fuels, and alternative energy sources; community programs for recycling or reusing materials)
3. Knows world patterns of resource distribution and utilization (e.g., petroleum, coal, iron ore, diamonds, silver, gold, molybdenum)
4. Understands the consequences of the use of resources in the contemporary world (e.g., the relationship between a country's standard of living and its accessibility to resources, the competition for resources demonstrated by events such as the Japanese occupation of Manchuria in the 1930s or the Iraqi invasion of Kuwait in 1991)
5. Understands the role of technology in resource acquisition and use, and its impact on the environment (e.g., the use of giant earth-moving machinery in strip-mining, the use of satellite imagery technology in the search for petroleum, rates of resource consumption among countries of high or low levels of technological development)
6. Understands how energy resources contribute to the development and functioning of human societies (e.g., by providing power for transportation, manufacturing, the heating and cooling of buildings)
7. Understands how the development and widespread use of alternative energy sources (e.g., solar, wind, thermal) might have an impact on societies (in terms of, e.g., air and water quality, existing energy industries, and current manufacturing practices)

Level IV (Grade 9-12)

1. Understands the relationships between resources and exploration, colonization, and settlement of different regions of the world (e.g., the development of mercantilism and imperialism and the consequent settlement of Latin America and other regions of the world by the Spanish and Portuguese; the abundance of fur, fish, timber, and gold in Siberia, Alaska, and California and the settlement of these areas by the Russians)
2. Understands programs and positions related to the use of resources on a local to global scale (e.g., community regulations for water usage during drought periods; local recycling programs for glass, metal, plastic, and paper products; different points of view regarding uses of the Malaysian rain forests)
3. Understands the impact of policy decisions regarding the use of resources in different regions of the world (e.g., the long-term impact on the economy of Nauru when its phosphate reserves are exhausted, the economic and social problems related to the overcutting of pine forests in Nova Scotia, the impact of petroleum consumption in the United States and Japan)

4. Knows issues related to the reuse and recycling of resources (e.g., changing relocation strategies of industries seeking access to recyclable material, such as paper factories, container and can companies, glass, plastic, and bottle manufacturers; issues involved with the movement, handling, processing, and storing of toxic and hazardous waste materials; fully enforced vs. consistently neglected approaches to resource management).

History Standards

Era six: The Development of the Industrial United States
Standard 16: Understands how the rise of corporations, heavy industry, and mechanized farming transformed American society
Level III (Grade 7-8)

1. Understands influences on business and industry in the 19th century (e.g., how business leaders attempted to limit competition and maximize profits, the role of the government in promoting business, the concept of the "American Dream")
2. Understands responses to the challenges of rapid urbanization in the late 19th century (e.g., how urban political machines gained power; the response of urban leaders, such as architects and philanthropists)
3. Understands influences on the development of the American West (e.g., cross-cultural encounters and conflicts among different racial and ethnic groups; the daily life of women on the western frontier; disputes among farmers, ranchers, and miners over water rights or ranges)
4. Understands differences in commercial farming in various regions of the United States (e.g., crop production, farm labor, financing, and transportation in the Northeast, South, Great Plains, West; the significance of farm organizations)
5. Understands various influences on the scenic and urban environment (e.g., how rapid industrialization, extractive mining techniques, and the "gridiron pattern" of urban growth influenced the city and countryside; environmentalism and the conservation movement in the late 19th century)

Level IV (Grade 9-12)

1. Understands the development of business in the late 19th century (e.g., types of business organizations that affected the economy; the impact of industrialization on availability of consumer goods, living standards, and redistribution of wealth; how new industries gained dominance in their field; the changing nature of business enterprise)
2. Understands issues associated with urban growth in the late 19th century (e.g., how city residents dealt with urban problems; demographic, economic, and spatial expansion of cities; how urban bosses won the support of immigrants)
3. Understands influences on economic conditions in various regions of the country (e.g., effects of the federal government's land, water and Indian policy; the extension of railroad lines, increased agricultural productivity and improved transportation facilities on commodity prices; grievances and solutions of farm organizations; the crop lien system in the South, transportation and storage costs for farmers, and the price of staples)
4. Understands the factors leading to the conservation movement of the late 19th century (e.g., how emphasis on staple crop production, strip mining, lumbering, ranching, and destruction of western buffalo herds led to massive environmental damage)
5. Understands how rapid increase in population and industrial growth in urban areas influenced the environment (e.g., inefficient urban garbage collection and sewage disposal, how city leaders and residents coped with environmental problems in the city)

6. Understands the role of class, race, gender, and religion in western communities in the late 19th century (e.g., hardships faced by settlers, how gender and racial roles were defined, the role of religion in stabilizing communities)

Table 2 indicates relations between technological concepts and geographic or historical concepts that are essential to technological literacy. Both tables 2 and 3 expand of the concepts and themes provided in the standards. The standards for technological literacy and the geography and history standards are integrated into the two tables.

Table 2. Geographic, Historical and Technological Concepts

	Technological Concepts				
Geographic and Historical Concepts:	Technological Content—Facts, Terms, Concepts	Technological Invention—Research & Development	Technological Innovation & Dissemination—Technology Transfer	Relationships Between Technology Nature & Culture	Technological Enterprise & Business (Institutional, Individual)
Historical Time—Chronology & Serialization (Dates, Events)					
Historical Time and Geographic Place					
Historical Anecdote "What Happened?"					
Historical Eventuality, Continuity & Change					
Historical Context					
Cultural, Economic, Natural, Political & Social Patterns and Trends					
Human & Institutional Deeds, Actions & Motives					
Causation & Agency					
Explanation and Generalization					

To understand the geography and history of technology, students begin with an understanding of fundamental concepts. Their literacy is dependent on, but not limited to, developing a sense of nine fundamental concepts. They should have a sense of historical time and geographic place. Technologies are developed at specific times and in specific locations. They should grasp the concept of anecdote, or the fact that there is a story behind a technology or event. Eventuality refers to the concepts of continuity and change. All events and technologies have a context— cultural, economic, environmental, political or social trends may be a part of the context. Human and institutional actions, desires, deeds and motives are behind these events or technologies. Perhaps most difficult for students are the concepts of causation and agency, which relate to generalization and explanation. Table 3 indicates relations between technological concepts and geographic or historical themes. The five themes listed are generalizations from the geography and history of American technology. Other themes are also important and teachers will have to work with their students to thematically design activities related to the geography and history of technology.

Table 3. Geographic, Historical and Technological Themes

	Technological Concepts				
Geographic and Historical Themes:	Technological Content—Facts, Terms, Concepts	Technological Invention—Research & Development	Technological Innovation & Dissemination—Technology Transfer	Relationships Between Technology Nature & Culture	Technological Enterprise & Business (Institutional, Individual)
Expansion of Capital, Economic Development and Imports or Exports					
Increasing Interdependence & Organization of Life and the Environment					
Expanding Social Welfare Role of the Federal Government					
Maintenance of Constitutional or Human Rights					
Mobilization for War or Peacetime Maintenance for National Security					

Working from the concepts and themes in Tables 1 and 2, we acknowledge that any given invention has a geography and a history, or a context. Contexts can be cultural, economic, environmental, political or social. Geographers and historians place inventions in their contexts to tell a story about the inventions. These stories involve people, often engineers and inventors, and institutions. The people in the stories, those who invent and develop technologies, are driven by motives. These motives, such as profit or power, are often directed by deeper causes, such as economic trends. Geographers and historians try to explain why technologies were developed, succeeded or failed by describing motives and causes. Choose a technology and work through the following questions when analyzing your particular technology (Marker, 1987):

Analyzing Technology (Marker, 1987)

1. List all the effects you can think of for *one* invention or innovation made since 1787.
2. Categorize the effects on your list according to whether they were planned and/or foreseen by those who introduced or eagerly adopted the innovation or were unplanned or unforeseen.
3. Indicate which effects were felt only in a local area, which were felt regionally, nationally or globally.
4. Classify the effects as beneficial or harmful, or both.
5. List four factors you consider to be essential to a good quality environment for humans, and which influenced your choice in item #4.
6. Which subgroups in society benefited most from the invention you are assessing? Which subgroups of society bear (or did bear) the majority of the harmful effects? List two reasons for the inequitable distribution of benefits and burdens.
7. What was the time lapse between: (a) the scientific or technological advancement that made the invention possible and its widespread innovation (adoption and diffusion)? (b) between the planned benefits and the appearance and/or the awareness of the burdens?
8. What actions were or are being taken to alleviate the burdens? Who (e.g., consumers, industry or government) is taking these actions? Who is paying the cost of alleviating these burdens in money? Who is paying the cost of alleviating these burdens in Quality of Life?
9. What areas of CHOICE did the invention open up for individuals?
10. What choices or rights did the invention open up for society in general (seen most likely in legislative and judicial decisions? What choices or rights were compromised?

Telling a story of a technology is very important challenge. When we undertake this challenge, we also must analyze the effects of this technology. If you had to tell the story of an invention, how would you do it? How would you find out about an invention that was made in 1790 or 1929? What would you want to know about this invention? What should we know about this? There are technical concepts to learn about each invention. There are also economic and geographic concepts to understand. Once you choose an invention to study, locate the invention in geographic space and historical time. Where was the invention made? When was it made? What was it made of? Why? What events was the technology associated with? What is or was its context? Follow this through to effects and implications— to rights and the US Constitution.

As historian of technology Carol Pursell wrote: "About a machine, one can ask a number of questions: who designed it?, how does it work?, who owns or controls it?, what does it do?, what does it mean?" Perhaps the last question is the most important, and the least asked.. We should ask that question of every tool, every machine, every technology with which we interact" (1996, p. 4). Tell a story, but do not just tell any story. Tell as story that is different than one we would have told in 1987 or 1787. The history of technology is not what it used to be!

What History of Technology Should we Study?

Within the Society for the History of Technology (SHOT), there is a commitment to rescue the history of technology from mythic “heroic inventor," “success story," and “boundless progress” traditions. The heroic inventor myths turn out to be celebrations of American invention and ingenuity. Stories of bottleneck, failure and backfire are typically ignored. Mostly through the influences of SHOT, historians have worked to critically interpret technology in its messy historical, cultural and social contexts (Cutcliffe & Post, 1989). Success and progress stories along with "technological impacts," and "advancing technology-lagging society" metaphors reflect the early histories of William Ogburn (1923) and Roger Burlingame (1938). The advancing technology and technological impacts metaphors reinforce a mechanistic and deterministic view of technology— a view suggesting that technology determines social and cultural direction. Society and individuals merely roll with, and adapt to technological change. It is important that we become conscious of the assumptions that are hidden within our language, and of the constraints that they place on our imagination and discourse, questions we ask, or problems that command our efforts (Pannabecker, 1991, 1995; Petrina, 1992).

These days, most historians of technology conclude that it is counter productive, if not impossible, to try and trace social changes to technological roots. Not surprisingly, the popular conceptions of an earlier era of technology are still adopted by general American historians. Historians of technology cite a lack of any historical evidence to support notions of either autonomous technology or the related theory of technological determinism. The historical record simply does *not* suggest that technology "feeds on itself", advances autonomously. Autonomous technology suggests that technology is self-determining and has a life of its own. This notion was prevalent in Jacques Ellul's (1962) critique of Western technology. Ellul argued that technology has become autonomous in that it is governed by itself rather than by any redeemable cultural values. He proposed a philosophical theory to explain his notions of technological autonomy and determinism. In this theory, the relationship of technology to culture is understood in terms of a one-way causal impact. Technology, self-governing, is advancing forward. If autonomous, then the question of shaping the form, substance, and direction of technology through democratic participation is irrelevant. If advancing, one can merely hope to get out of its way or catch up with it. These notions tend to augment political passivity, as there is no point in attempting to direct an entity with a forward autonomous momentum. Technology is therefore considered to be beyond human control. As Ellul and others see a deterministic force in history having its expression in technology, historians of technology tend to see the human agent acting within a complexity of social and cultural dramas to design and select technologies.

Notions that technology autonomously advances and, in effect, impacts either positively or negatively on society are reflections of an ideology in which new technology is assumed to be socially progressive. Within frames of reference constituted through the ideology of technological progress, technology is "modern, Western, and science-based, [and] related to culture as an independent driving force demanding adaptive change from all other cultural institutions" (Staudenmaier, 1985, p. 144). Science and technology autonomously progress in a forward motion and, given these forces, people and cultures are expected to conform. Those who choose to question this progress are questioned themselves and labeled modern Luddites. Endorsement of this ideology is an endorsement of social inaction toward technological issues, as expertise is viewed as a requisite for action. Norms that are technical, such as efficiency and speed, are generally the only measures of technological progress. Hence, cross-cultural comparisons are at-base, generalizations related to superiority or inferiority. From a cultural perspective, one can see how an ideology of technological progress inspires something less than an affirmation of unique cultural values. Language that reflects the ideology of technological progress, with its suggestion of inevitability, obscures underlying human motives and an assessment of who is served and who is left out. According to Staudenmaier (1985, 1989, 1990), only by adopting a critical stance toward technology and its concomitant talk of progress can we begin to act responsibly and democratize the technological design and decision making process.

On anecdote to a language of progress is found within the history of technology. In describing changes in the history of technology, John Staudenmaier (1989) maintained that

> historians of technology labor to situate each artifact within the limited, historically specific, value domains from which they emerged and in which they operate. They speak of "technologies," and not Technology," of cultural options rather than inevitable progress. This approach attempts what history traditionally holds dear, the liberation of human beings by demythologizing false absolutes and by paying attention to the human context of change. . . . Responsible technology talk fosters a language of engagement where "Technology" is understood to be a variety of particular technologies, each carrying its own embedded values, each related to its own unique cultural circumstance. It is a language that reweaves the human fabric, reintegrating method and context, and inviting us all, technical practitioners and ordinary citizens alike, to engage in the turbulent and marvelous human endeavor of our times. (pp. 285, 287)

The language that we use with our students as we teach about the geography and history of technology is extremely important (Pannabecker, 1991, 1995; Petrina, 1992). With our enthusiasm in celebrating the progress of American technology we risk alienating and disenfranchising our students. We risk having the exact opposite effect that we desire.

American Genesis

Thomas Hughes has managed to integrate the changes in the history of technology with general issues of American history. He begins with the following thesis: "the century of technological enthusiasm was the most characteristic and impressively achieving century in the nation's history, an era comparable to the Renaissance… this was the American genesis" (1989, p. 3). While most historians locate the American industrial revolution in the years between 1790 and 1830, Hughes notes that American technology inspired a cultural renaissance between 1870 and 1970. In *American Genesis*, Hughes spins his tale of the development of modern America with a thread of technology and values. The values of control, order and system are dominant influences on modern technology, and in effect, on modern America.

Modern America began to take shape during the era of independent inventors (i.e., 1870s-1930s). This was the era of Edison, Bell, Maxim, Sperry, The Wrights, Tesla, de Forest and others who gained heroic inventor status. The independent inventors primarily used trial and error methods of inventing and solving problems, struck out on their own in finding funds and loathed bureaucracy. Their drive for control, order and system was designed into their machines, and their machines helped to reinforce those societal values. The twilight of the era of independent inventors marked the dawn of industrial research. Hughes indicates that under the leadership of Jewett, Stine, and Whitney at Bell, DuPont, and GE respectively, empirical methods of the independents gave way to more disciplined and scientific methods of the corporate researchers and scientists. In research labs, inventions were more likely to be incremental and sparked by science rather than radical and sparked by intuition; nonetheless, the technological enthusiasm gained momentum. Like the inventions of the independents, the results of the industrial researchers reinforced and were shaped by control, order and system.

As the enthusiasm evolved in method, it also evolved in scale. The power plant visions of Edison were succeeded by the power grid visions of electric utility manager and "system builder" Samuel Insull. While inventors and entrepreneurs like Edison solved technical problems, managers and system builders like Insull solved the organizational problems that facilitated the growth of interlocking networks and systems. Ford's concepts and methods of manufacturing applied at Highland Park were succeeded by his massive manufacturing system at River Rouge. During the 1930s and 1940s, the scale of technological systems continued to increase. In the 1930s, the Tennessee Valley Authority (TVA) combined large-scale technology, governmental planning, and regional development. The Manhatten Project, initiated in 1942, shadowed all previous technological projects in comparison. Under the influence of government and corporate planners, scientists, technologists and strategists, the modern military-industrial complex was created. During the genesis of modern America, machines were developed into systems, and systems evolved into megasystems. The system builders and their systems defined modern America. Inventors and engineers such as Taylor, Ford, and Insull were successful because they were able to think in terms of systems. They recognized the apparent market for systems design. They projected the values of control, order and system into their technologies.

What were some of the responses to the dominance of values and forces that transformed a basically agrarian nation into a complex technological society? Paradoxically, it was the Europeans who first artistically responded to machine and material America. The control, order and system of modern technology can be found in the modern style of architecture and design of Walter Gropius and his associates from the Bauhaus in Germany. Le Corbusier, in France, articulated modern technology in his art, architecture, and interior design style. While modern technology had its genesis in America, modern art had its beginnings in Europe.

Many of our most persistent problems arise from the automation and systematization of life. But we cannot merely blame our machines and systems. Our problems are rooted in the dominance of 19th and 20th century values such as control, order and system. The complexity and momentum of existing megasystems are nearly impossible to direct, and many analysts suggest that only a counterforce, such as a catastrophe, can change their direction.

Geographic, Historical and Technological Events

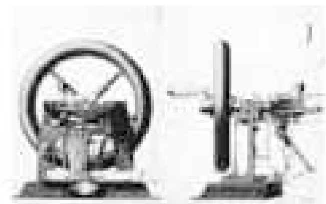
The following events were influential in the American Genesis— in the geographic, historical and technological changes that occurred in the US over the past two hundred years. Many of these events stand as milestones in US history. The first group of events deals with the copyright, patent and trademark laws that provide a system of intellectual property rights for entrepreneurs, business, government and industry. The second group of events involves innovations in communication, manufacturing, power and energy and transportation. The third group involves events in labor. While the US has been extremely creative in innovating with new technologies in industry, it also has a rich labor history. The relations between labor and innovation in industry have not always been complementary, and many labor historians caution that the US has the bloodiest history of labor in the world.

Intellectual Property Laws in the United States, 1790s-1990s

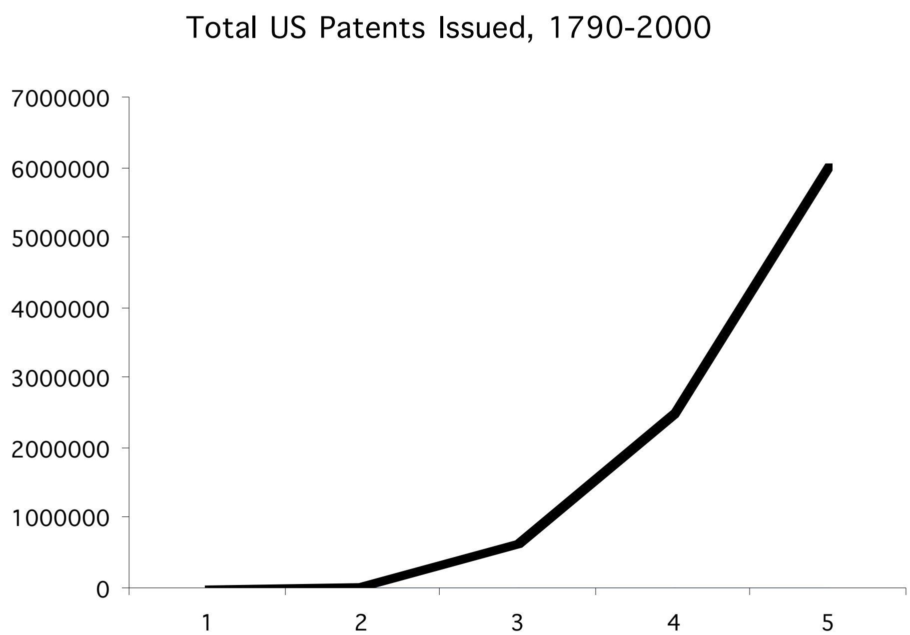
1. Earliest documentation of a patent in North America. Granted by special act of the Massachusetts colonial government for the development of a salt works- 1641
2. Article I, Section 8, Clause 8 includes property rights as part of the US Constitution: "The Congress shall have power… to promote the progress of science and useful arts, by securing for limited times to authors and inventors the exclusive right to their respective writings and discoveries"- 1787
3. US government enacts the first patent law in a bill that passed on April 10, 1790. The new law places complete power over the granting of patents in the hands of the Secretary of State, the Secretary of War, and the Attorney General. Secretary of State Thomas Jefferson personally examines each patent application filed-1790
4. The First Congress also implements the copyright provision of the US Constitution. The Copyright Act of 1790, An Act for the Encouragement of Learning, by Securing the Copies of Maps, Charts, and Books to the Authors and Proprietors of Such Copies, is modeled on the Statute of Anne (1710). It grants American authors the right to print, re-print, or publish their work for a period of fourteen years and to renew for another fourteen. The law provides an incentive for artists, scientists and writers to create original works by providing creators with a monopoly- 1790
5. On February 11, 1793 the congress passes a new patent law, after just less than three years of operation for the first US law governing patents. The new patent law defines a patentable invention as "any new and useful art, machine, manufacture, or composition of matter, or any new or useful improvement thereof." The first law failed because the Cabinet offices charged with examining patents lacked the time necessary to do the work. Under the new law, which would remain in effect until 1836, an inventor simply submits a description of the invention, drawings and a model, and paid a fee. This system— no examination— put the burden of determining validity on the courts.
6. Without a system for examination, inventors were taking out patents at the rate of more than 600 per year. Many were not new, and the fact that the only way to establish the validity of patents was through litigation created enormous dissatisfaction. The new law, which passed on

July 4, 1836 establishes the system of examiners that has been used, with many modifications, ever since. The Patent Office becomes a separate bureau under the Secretary of State.

7. Control over the Patent Office is transferred from the Department of State to the newly created Department of the Interior- 1849
8. The patent law is amended to provide a grant of monopoly for 17 years. This provision replaces the early period of 14 years with possibility of a 7 year extension-1861
9. The Federal Trade-Mark Act of 1870 provides for the first federal registration of trademarks.
10. A major overhaul of the patent system. One of the more important new provisions eliminates the requirement for filing a model with the application- 1870



11. Pasteur is issued a patent on yeast, and becomes the first to patent a life form in the US- 1871
12. The Federal Trade-Mark Law of 1870 is held unconstitutional because it applied its reach to intrastate commerce. The 1870 law was based on the patent and copyright clause of the Constitution. The law was held unconstitutional because it did not distinguish between intrastate and interstate commerce— the constitution allows regulation of interstate commerce, not intrastate commerce- 1879
13. Congress passes a new trademark law that applies only to goods traded in foreign commerce- 1881
14. The first comprehensive US Trademark statute is adopted on the principle of prior ownership and use, that is, the law allows those who had established marks within the previous 10 years to consolidate their ownership through the registration procedure- 1905
15. Major revision of the US Copyright Act. The bill broadens the scope of categories protected to include all works of authorship, and extends the term of protection to twenty-eight years with a possible renewal of another twenty-eight years- 1909
16. Amendments to the 1905 Trademark Law allow those who had established trademarks prior to the 10 year limit set in the original legislation to establish ownership. The amendments serves primarily to assist companies with foreign registrations that required registration in the company of origin- 1920
17. By Executive Order, the US Patent Office is moved from the control of the Department of the Interior to the Department of Commerce- 1925



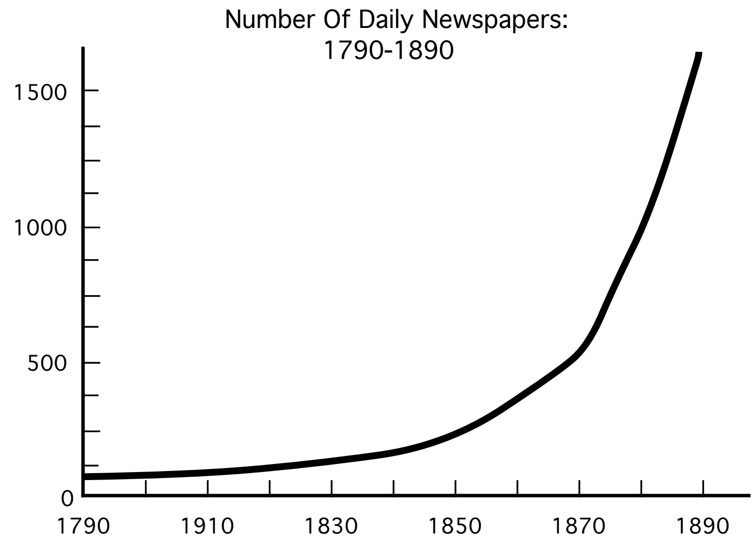
18. Plant life forms, the biological sources of many medicines, are made patentable. These patents extended only to asexual non-reproducing plants, but in 1954 provisions are expanded to include cultivated hybrids, mutants and newly discovered seedlings- 1930
19. The Lanham Act establishes the modern US Trademark system. The primary requirements for registration and maintenance of ownership: 1) Certification of date of first use; 2) Certification of continued use; 3) Provision for striking abandoned marks; 4) Requirements for periodic renewal; 4) Allowance for special registrations (e.g., defensive); 5) Requirement for enforcement to avoid abandonment- 1946
20. Major overhaul of US patent law. The system had been amended at least 60 times by Congress since 1870. The major addition at this point was the requirement that the patented matter must be "not obvious." The word "art" in the 1793 definition of patentability is replaced with the word "process"- 1952
21. The first human body part patent is issued for a spleen cell removed from John Moore at the UCLA hospital- 1976
22. The 1976 copyright act preempts all previous copyright law and extends the term of protection to life of the author plus 50 years (works for hire are protected for 75 years). With this revision, for the first time the fair use and first sale doctrines were codified, and copyright was extended to unpublished works. In addition, a new section was added, section 108, that allows

library photocopying without permission for purposes of scholarship, preservation, and interlibrary loan under certain circumstances- 1976

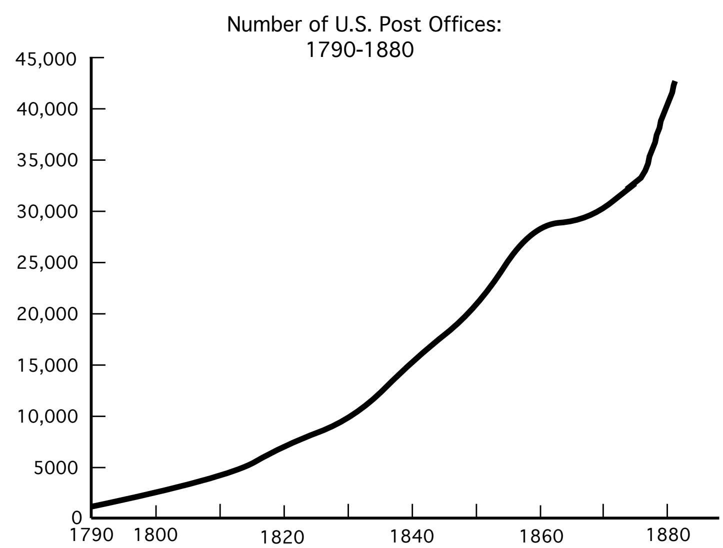
23. The first human gene patent (No. 4,322,499)- 1982
24. The first patented animal in the world— the Harvard Oncomouse- 1988
25. Most recent revision of the patent law establishes such provisions as maintenance fees. Passes as a compromise between the interests of corporations and independent inventors, the law still recognizes the "first true inventor" but also stiffens the difficulty of maintaining a patent that is not being practiced- 1995
26. The Digital Millennium Copyright Act (DMCA) and the Sonny Bono Copyright Term Extension Act (CTEA), both of which are overly sympathetic to corporate intellectual property (IP) rights, are signed into law. The DMCA attempted shores up ownership of digital property for large lobby groups, such as the music recording industry. The CTEA was signed into law in 1998, effectively adding twenty years of copyright protection for works produced prior to 1976. Critics dubbed it the Mickey Mouse bailout bill because it coincided with the year that Disney's Mickey Mouse copyright would have expired- 1998
27. Advanced Cell Technologies and the University of Massachusetts, which cloned two cows (George and Charlie), are issued the primary US patent (No. 5,945,577) for cloning animals in- 1999

Communication in the United States, 1790s-1990s

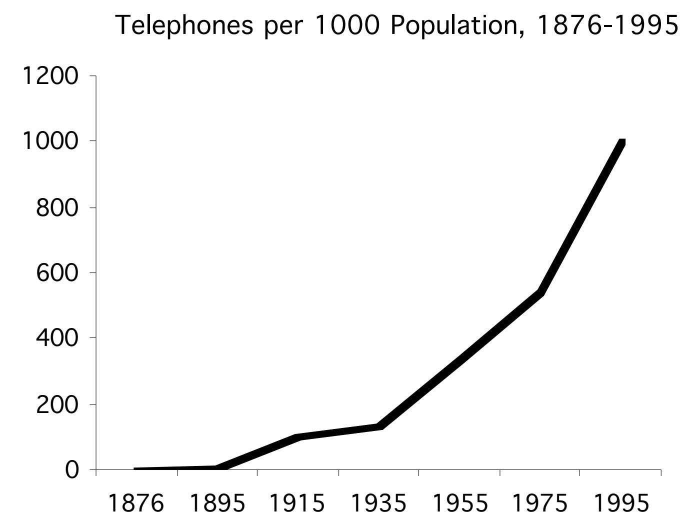
1. The *Saturday Evening Post* Begins Circulation- 1821
2. First U.S. Mail Train- 1831
3. The *New York Sun* Begins Circulation as an Affordable (Penny Press) Daily Paper- 1833
4. First American Portrait Photograph Is Taken By John W. Draper In New York City, NY- 1839



5. Samuel B. Morse Sends the Words "What Hath God Wrought" Over a Telegraph Line From Washington, DC to Baltimore, MD on May 24, 1844
6. Electronic News is Initiated When the *Baltimore Patriot* Publishes a Telegraphic Dispatch on May 25, 1844
7. Western Union Telegraph Company is Formed- 1849
8. First Trans-Atlantic Cable is Laid- 1858
9. U.S. Postal Service Establishes the Pony Express- 1859
10. Western Union Telegraph Service (New York to San Francisco)- 1861
11. Mathew Brady Begins Photographing the Civil War- 1861
12. Second Trans-Atlantic Telegraph Cable is Laid- 1866

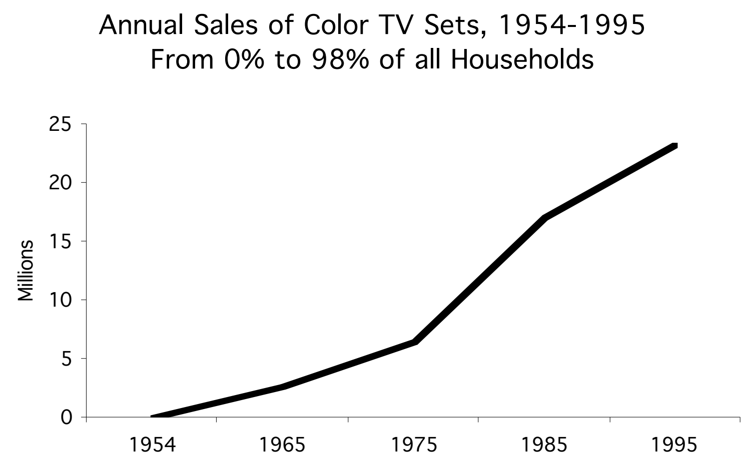


13. First Public Motion-Picture Show Is Exhibited By Henry Heyl, In Philadelphia, PA- February 5, 1870
14. First Telephone Call, From Alexander Graham Bell to Thomas A. Watson, In Boston, MA, March 10, 1876
15. Thomas A. Edison Records and Plays Reproduces "Mary A Little Lamb" On a Phonograph in Menlo Park, NJ- 1877
16. First Commercial Telephone Exchange (New Haven, CT)- 1878
17. The Federal Government Decreases Postal Rates For Magazines and Other Publications to Boost Circulation- 1879
18. Long Distance Telephone Service (New York to Boston)- 1884

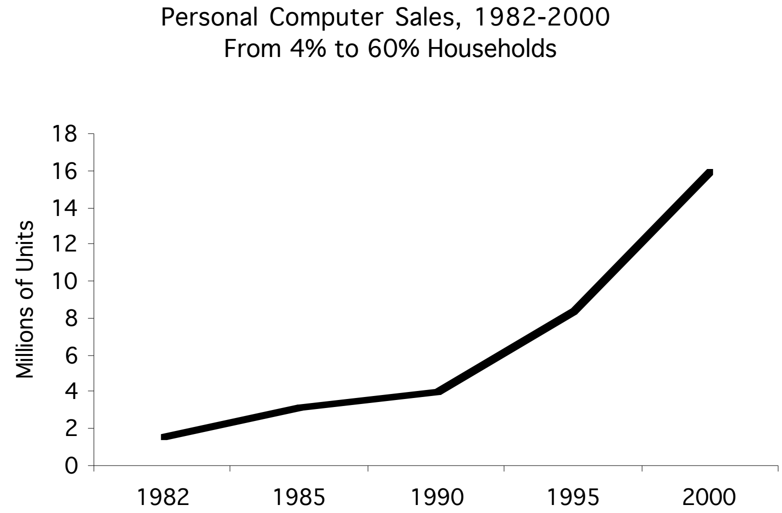


19. First Public Broadcast by Radio (Bryant Rock, MA)- 1906
20. Cross Country Telephone Line Completed (NY to CA)- 1914
21. U. S. Post Office Begins Regular Airmail Service- 1918
22. Radio Corporation of America (RCA) is Formed- 1919
23. First Commercial Station (KDKA-Pittsburgh, PA)- 1920
24. The Harding-Cox Election Returns are Broadcast by KDKA and the Age of Instant News Begins on November 2, 1920
25. WEAF, in New York, Begins Selling Air Time to Advertisers- 1922
26. The *Canons of Journalism* are Adopted by the American Society of Newspaper Editors and Objective Journalism is Stressed- 1923

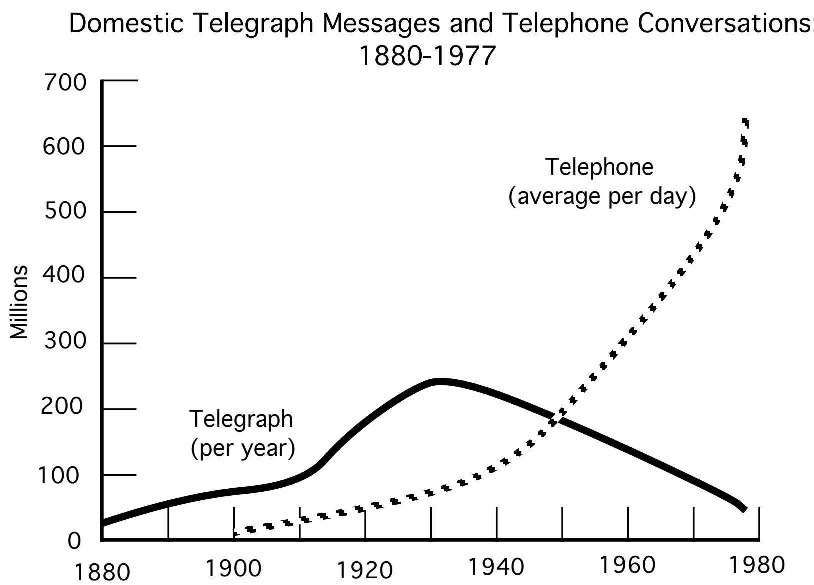
27. Feature Length Films ("Don Juan" & "The Jazz Singer"), by Warner Brother's, Are Introduced as the first "Talkies" to the Public-1926
28. Regularly Scheduled TV Programs are Broadcasted by W2XAB, a 500-watt Experimental Station, in New York City on July 21, 1931
29. War of the Worlds is Broadcast and Creates Panic Among Radio Listeners- 1938
30. First Experimental FM Station Goes on the Air (New Jersey)- 1939
31. The Federal Communications Commission Approves Regularly Scheduled Commercial TV Broadcasting on July 1, 1941
32. Demonstrations of Color Television are Given by CBS and NBC- 1946



33. Noncommercial TV Programming Begins in Houston, TX- 1953
34. First Telephone Cable Is Laid Across the Atlantic- 1955
35. The United Press International (UPI) is Formed- 1958
36. "Echo 1", the First U.S. Communication Satellite (Aluminized Mylar Balloon) is Launched- August 12, 1960
37. World's First Weather Satellite, "TIROS 1", Is Launched by NASA- 1960
38. NASA Launches "INTELSTAT 1", a Global Communication Satellite- 1964
39. More Than 4000 Close-Up Photos of the Moons Surface Are Sent Back to Earth by U.S. Spacecraft, "Ranger 7"- 1964
40. The FCC Assumes Control Over Cable Television Broadcasting- 1966
41. ARPAnet (Advanced Research Projects Agency) is the name given to the world’s first computer network set up for resource sharing between UCLA and Stanford. Software developed by Bolt, Barenak and Neuman (BBN)- 1969

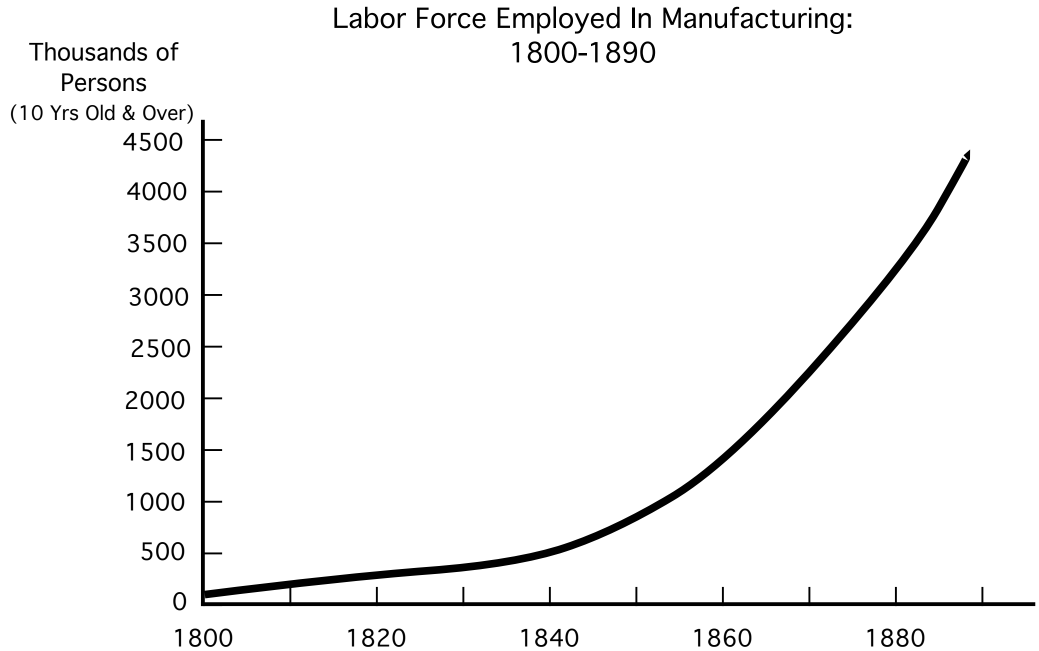


42. Intel designs the world's first general-purpose microprocessor, the Intel 4004, consisting of 2,300 transistors in a 4-bit architecture (4 MHz) (Intel's 1995 Pentium Pro has 5.5 million transistors). This chip is the root of pervasive changes in the computer world- 1971
43. Bob Kahn and Vint Cern redesign the basic ARPANET system into an Internet- 1973
44. Electronic "Mailgrams" Are Made Possible Through the Launching of "WESTAR 1" and "WESTAR 2" Satellites- 1974
45. A Tracking and Data Relay Satellite "TDRS1" is Placed into Orbit From the Space Shuttle "Challenger- April 4, 1983
46. Deregulation of Radio- 1981
47. Deregulation of Television- 1984
48. University of California, Berkeley releases its version of Unix and TCP/IP to the public as open source code, and the combination quickly becomes the backbone of "the Internet."

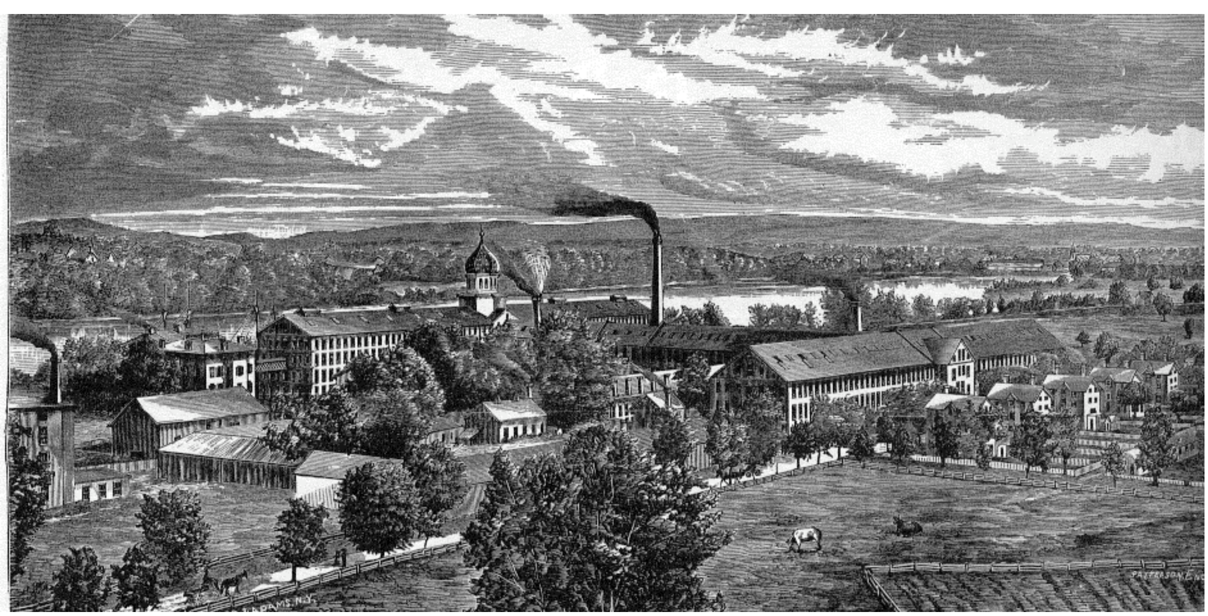


Source: U.S. Dept. of Commerce, Bureau of the Census, *Historical Statistics of the United States, Colonial Times to 1970.*

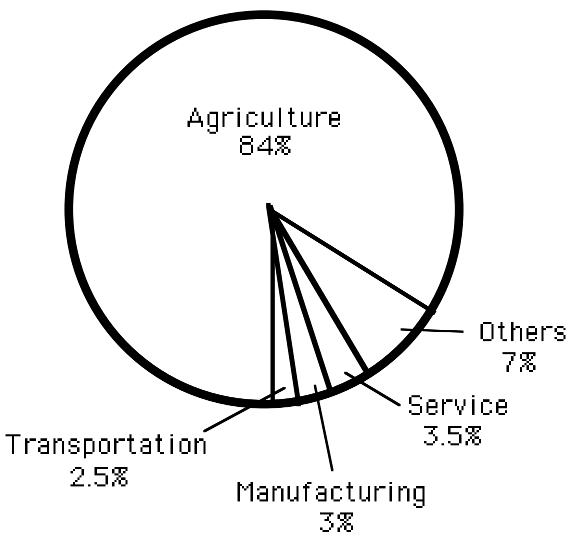
Manufacturing in the United States, 1790s-1990s



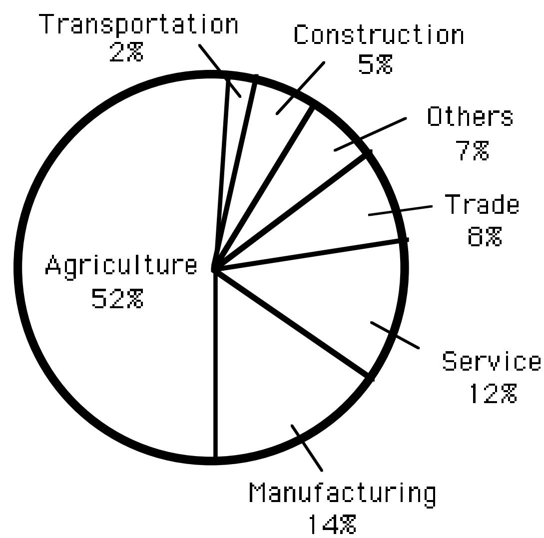
1. Samuel Slater Opens a Water Powered Textile Mill In Pawtucket, RI- 1793
2. Construction Begins on the Great Falls Raceway and Power System for the Paterson, NJ Planned Industrial Complex- 1793



Labor Force Distribution, By Industry: 1810

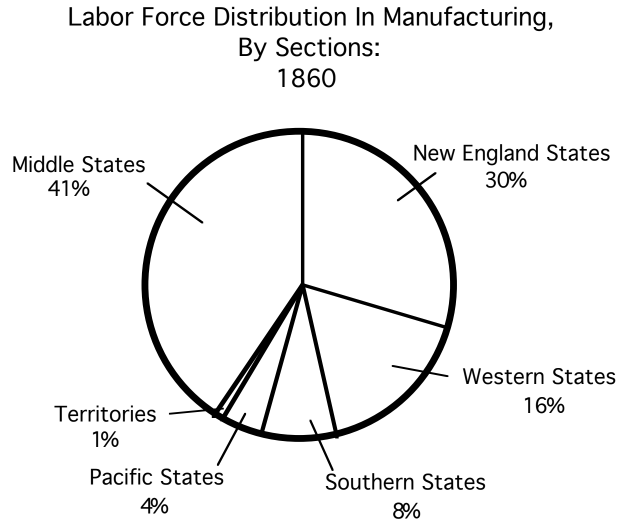


Labor Force Distribution, By Industry: 1860

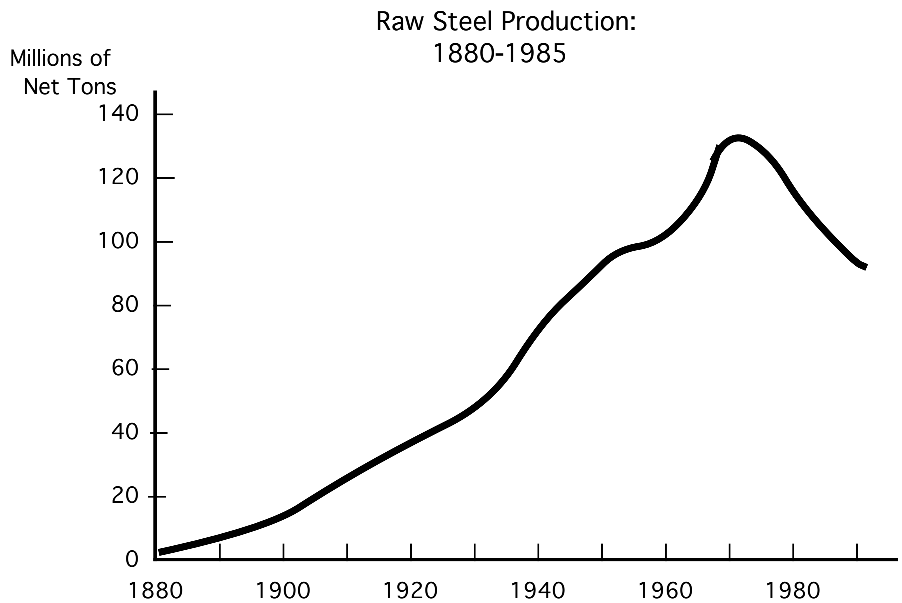


3. Oliver Evans Opens the Mars Iron Works in Philadelphia, PA- 1803
4. David Wilkinson Begins Production of Textile Machinery- 1812
5. The Boston Manufacturing Co. Is Established At Waltham, MA and Opens a "Cotton To Cloth" Textile Factory- 1813
6. Gold is Discovered in Sutter's Mill, CA by James Marshall- 1848
7. John Hall and his Skilled Machinists Achieve Interchangeable Parts Manufacturing at Harper's ferry Armory, WV- 1826
8. The Amount of Horsepower Used by All Manufacturing Industries Combined, is Still Somewhat Less Than the HP Used by the Railroads- 1859
9. First Bessemer Converter built in the US (Troy, NY)- 1864
10. Open hearth process in brought to the US (Pittsburgh)- 1868
11. The Amount of Steam Power utilized for Manufacturing Surpasses the Amount of Water Power Utilized- 1868

Clairton Coke Works, Pittsburgh



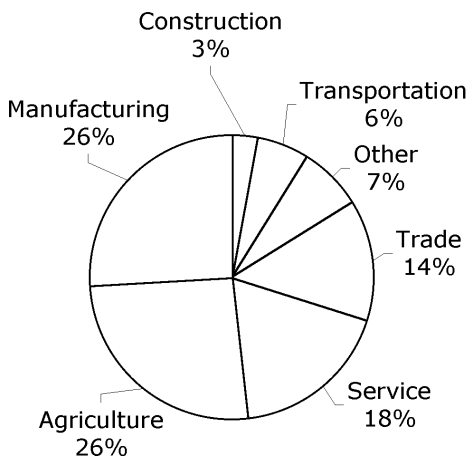
12. Thomas A. Edison Opens the First Industrial Research Laboratory In Menlo Park, NJ- 1876
13. Sydney W. Winslow Forms the United Shoe-Machinery Company, and Opens the "World's Largest" Shoe-Machinery Factory in Beverly, MA- 1890
14. Henry Ford and Walter E. Flanders Apply "Mass Production" and "Progressive Assembly" Techniques to the Manufacturing of Automobiles- 1903
15. U.S. Steel Production Exceeds 23,000,000 Tons- 1911
16. Ford Opens Mass Production At the Highland Park Car Manufacturing Plant- 1913



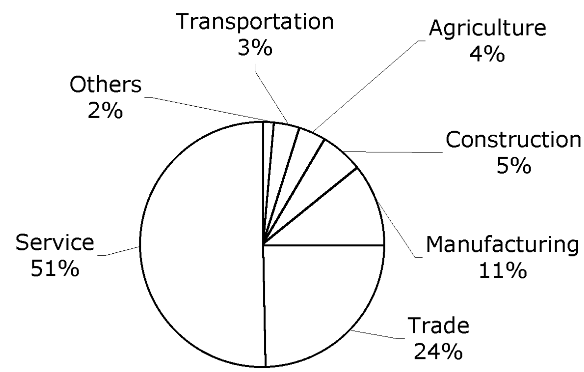
17. The Number Of Motor Vehicles Built In the U.S. In One Year Reaches production 350,000,000— 81% Of World Output- 1927
18. The World's Largest Piece Of Glass, Produced by Corning Glass Co., Is Installed In the Reflecting Telescope At Mount Palomar Observatory in CA- 1934

19. Western Electric Opens a Computer Controlled Production Line In Hickory, NC- 1960
20. Skylab Orbiting Space Laboratory is Launched From Cape Canaveral, FL- May 14, 1973
21. The John Deere Co. Opens "The Factory Of the Future" Complex In Waterloo, IA- 1983
22. Total Volume Of Plastics Produced Equals the Total Volume Of Metals Produced- 1983

Labor Force Distribution by Industry, 1920

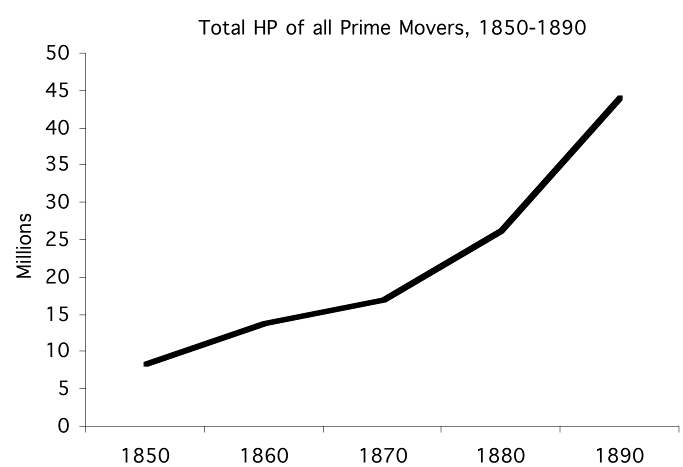


Labor Force Distrubution by Industry, 1984

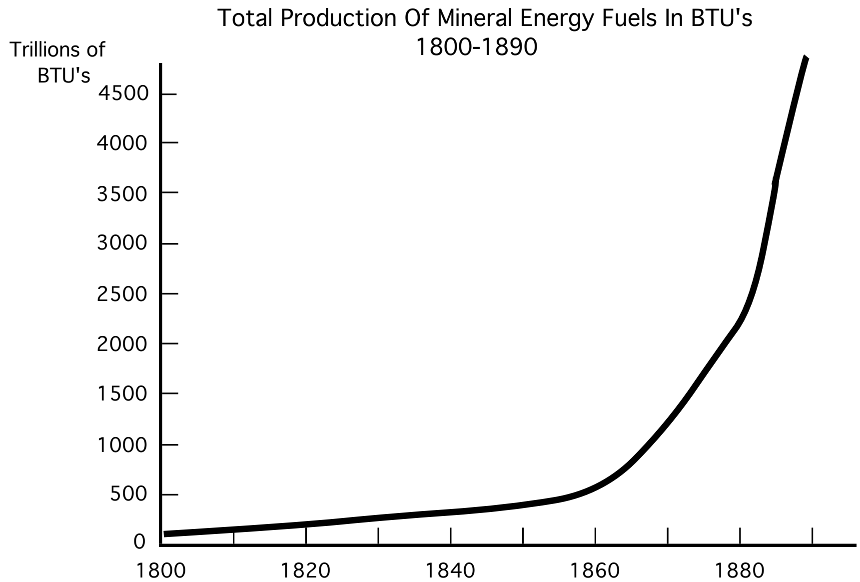


Power and Energy in the United States, 1790s- 1990s

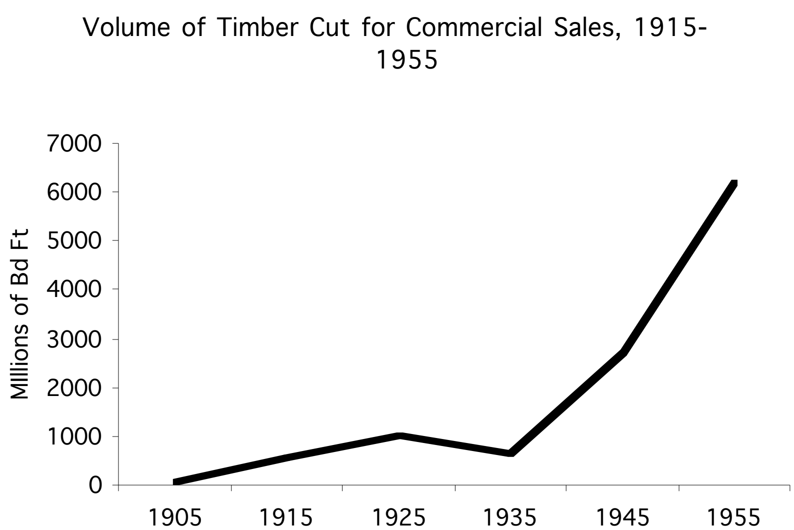
1. Anthracite Coal Found In PA- 1791
2. Isolated Use of Gas Lighting- 1812
3. Camphene (First Synthetic Liquid Illuminant)- 1813
4. Distillation of Burnable Gas from Refuse- 1815



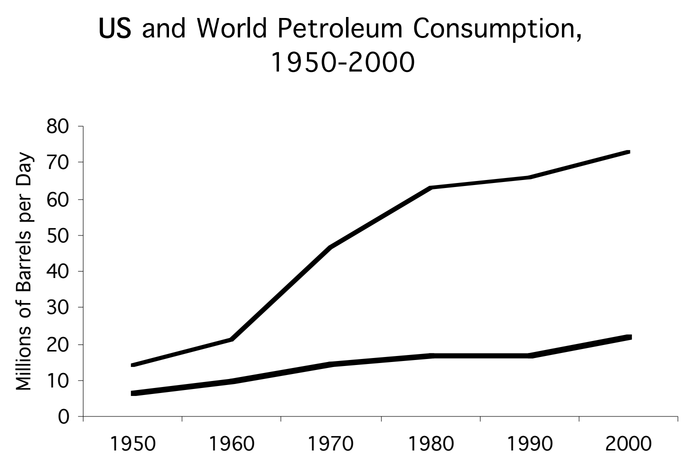
5. A Natural Gas Well is Discovered in Fredonia, NY-1821
6. Oil is Discovered in Titusville, PA by Edwin L. Drake – 1859



7. Petroleum Based Additives for Gas Lighting- 1870
8. U.S. Geologic Survey is Established to Examine Mineral Resources in the U.S. Domain- 1879
9. Pennsylvania Petroleum Shipped to California- 1881
10. The Vulcan Street Hydroelectric Central Station, in Appleton, WI Begins Operation on September 30, 1882
11. The Pearl Street Power Station Goes into Service, in New York City, on September 4, 1882
12. First "Large Scale" Oil Pipeline is laid across the Appalachian Mountains- 1878
13. Coal Surpasses Wood as Major Energy Source- 1885

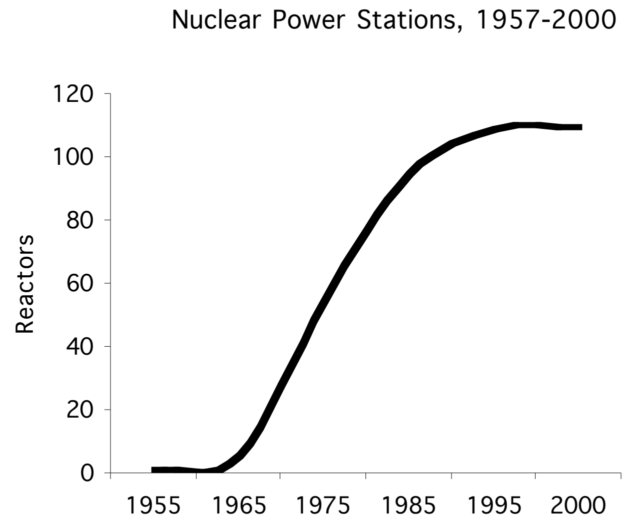


14. An 11,000 Volt Three-Phase Alternating Current is Transmitted from the Folsom Hydroelectric System to Sacramento, CA (22 miles)- 1895
15. Niagara Falls Power Station Opens- 1895
16. Strip Mining of Coal Begins-1886
17. Westinghouse Electric Co. Installs the First "Large Scale" Alternating Current Station in Buffalo, NY- 1886
18. Annual U.S. Electrical Use Reaches One Billion Kilowatt-Hours-1899
19. Bureau of Mines is Established- 1910
20. U.S. Oil Wells Produce Nearly Two-Thirds of the World's Oil Supply- 1920

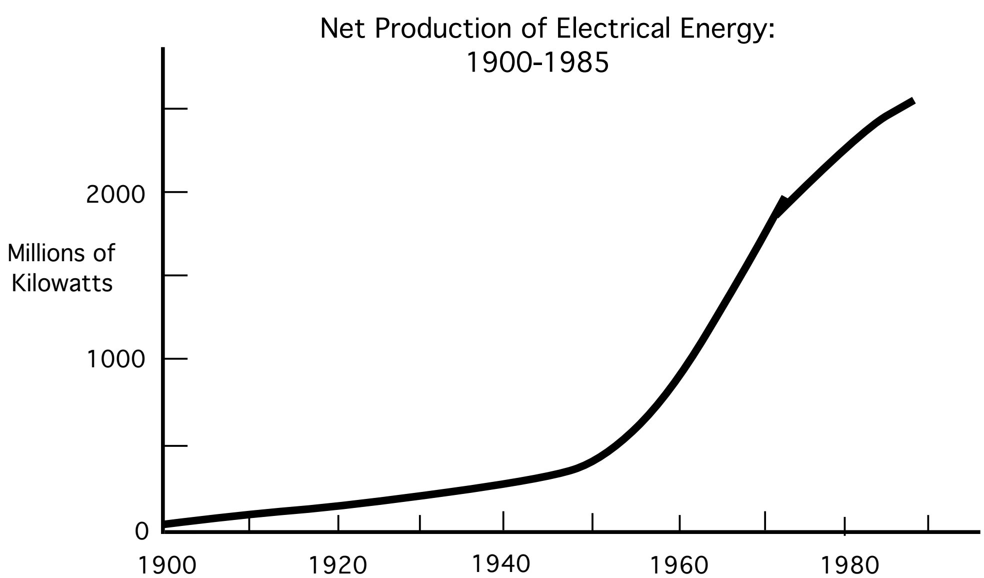


21. First Pumped Storage Hydroelectric Power Station (New Milford, CT)- 1929
22. Tennessee Valley Authority (TVA) established- 1933
23. Hoover Dam Is Completed- 1936
24. A Large Scale Wind Turbine Is Erected At Grandpa's Knob, VT- 1941
25. First Plutonium Production Nuclear Reactor is Placed in Operation in Hanford, WA- 1944
26. Oil Matches Coal As An Energy Supply In the US- 1951

27. First Commercial Nuclear Power Plant Goes Into Operation In Shippingport, PA- 1957

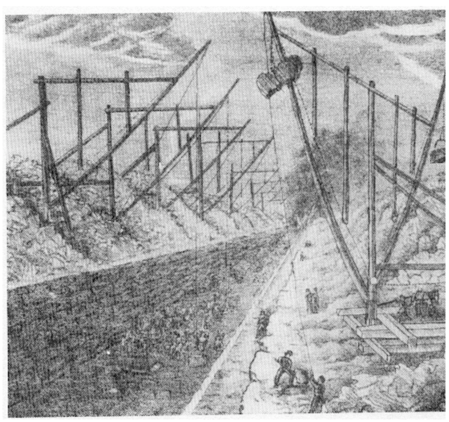


28. Geothermal Electric Power Begins Production At The Geyser's, CA- 1960
29. U.S. Electrical Use Reaches One Trillion Kilowatt-Hours- 1963
30. The Trans-Alaska Pipeline Is Completed- 1977
31. "Solar One," A Solar Power Plant, Is Put Into Operation In Albuquerque, NM- 1978

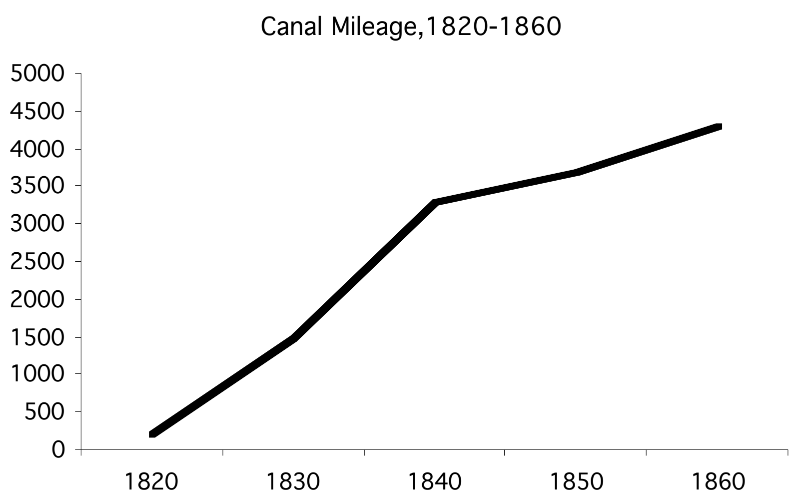


Transportation in the United States, 1790s-1990s

1. The Cape Henry Lighthouse, Erected at the Entrance to the Chesapeake Bay, is the First Public Work Built by the U.S.- 1792
2. Work Begins on First True U.S. Canal in Charleston, SC- 1793
3. First Balloon Flight in the U.S. is Piloted by Jean-Pierre Blanchard in Philadelphia, PA- 1793
4. First Hand-Surfaced Road In the US, Philadelphia and Lancaster Turnpike, is Opened- 1795
5. Construction of the National Road Begins- 1811
6. World's First Wire Suspension Bridge for Foot Traffic is Constructed in Philadelphia- 1816
7. Erie Canal Digging Begins- 1817



Digging the Erie Canal



8. First Tunnel in the U.S., a Canal Tunnel, is Constructed near Auburn, PA- 1821
9. The "Savannah" is the First Steamship to Cross the Atlantic (Savannah, GA to Liverpool, England in 29 days)- 1819

Steam Craft and American River Boating

1. "Perseverance"- 1790
2. "Little Juliana"- 1804
3. "Phoenix"- 1807
4. "North River Steamboat"/"Clermont"- 1807
5. "Paragon"- 1809
6. "Car Of Neptune"- 1810
7. "New Orleans"- 1811
8. "Vesuvius"- 1814
9. "Chancellor Livingston"- 1814
10. "Savannah"- 1819
11. "Washington"-1820
12. "New Philadelphia"- 1821
13. "Hercules"- 1837
14. "Buckeye State"- 1841

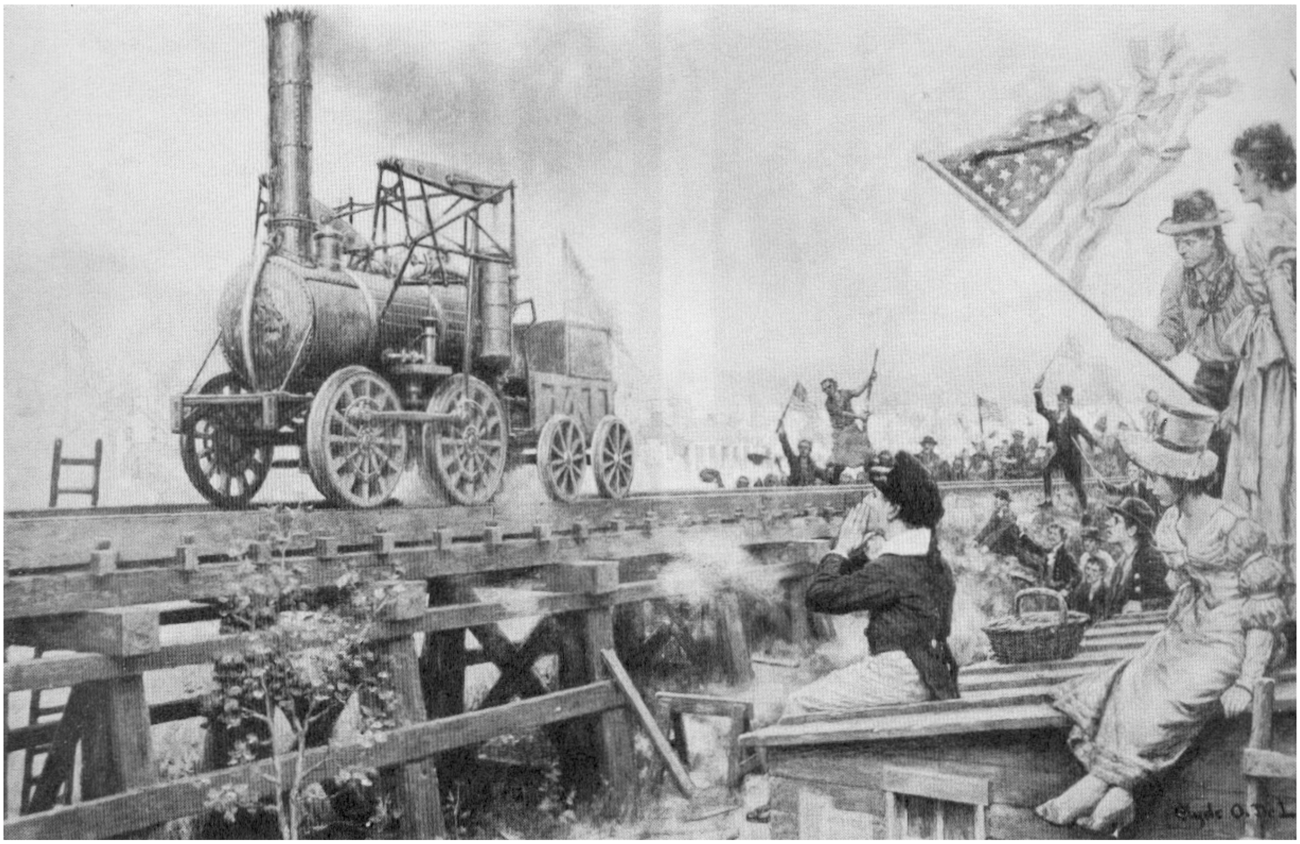
10. The Steamship "Walk-in-the-Water" is Launched at Buffalo onto Lake Erie- 1819
11. Four Steam Locomotives Imported from England by the Delaware and Hudson Canal Co.- 1829
12. The Erie Canal is Completed (363 Miles, from Albany to Buffalo)- 1825
13. First American Railway (Horse-Drawn Railcars to Transport Stone) is Opened From Quincy to Boston MA- 1826
14. West Point Foundry Begins Production of First "Practical" American Locomotives (NY) – 1830
15. The "Tom Thumb" Steam Locomotive is Given a Run (Baltimore to Ellicott's Mills) on the Baltimore and Ohio Railroad- 1830

Steam Locomotives and American Railroading

1. "Stourbridge Lion"- 1829
2. "Tom Thumb"- 1830
3. "Best Friend of Charleston"- 1830
4. "West Point"- 1831
5. "DeWitt Clinton"- 1831
6. "John Bull"- 1831
7. "Experiment" & "Brother Jonathan"- 1832
8. "Old Ironsides"- 1832

16. "Best Friend" Makes a Run on the South Carolina Railroad from Charleston to Hamburg- 1830
17. First Timber Railroad Bridge in the U.S. is Designed by Lewis Wernwag and is Constructed to Span the Monocacy River in Maryland- 1830
18. The Camden and Amboy Railroad (Passengers and Freight) is Opened Between New York and Philadelphia- 1833

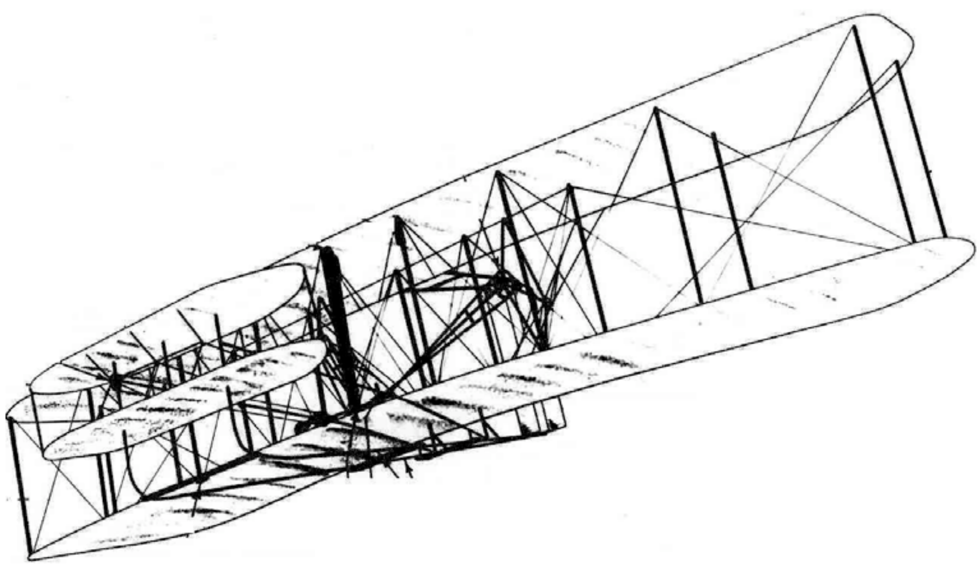
19. First Railway Tunnel Constructed Near Johnstown, PA by the Allegheny Portage Railroad- 1833
20. First All-Metal Bridge in the U.S. is Constructed in Brownsville, PA- 1838
21. Railroad Construction in the West Begins (Line from Detroit to Ann Arbor)- 1838



Stourbridge Lion, 1830

22. W. F. Harnsden Inaugurates the Business of Transporting Valuable Freight Under Guard- 1839
23. The National Pike is Opened from Maryland to Illinois- 1839
24. A Caravan of 200 Wagons Leave Westport, MO for Walla Walla, WA (Beginning of Westward Migration)- June, 1843
25. Wells and Fargo Start the Western Express- 1845
26. The World's First Suspension Aqueduct is Completed in Pittsburgh, PA- 1845
27. The Delaware Aqueduct is Completed (Lackawaxen, PA to Minisink Ford, NY)- 1849
28. Railroads Use More Horsepower Than All Manufacturing Industries Combined- 1859
29. Transcontinental Railroad Completed at Promontory, UT on May 10,1869
30. An Experimental Pneumatic Tube Subway is Opened in New York City, NY- 1870
31. First Paved Road (Asphalt) in the U.S. (Newark, NJ)- 1871

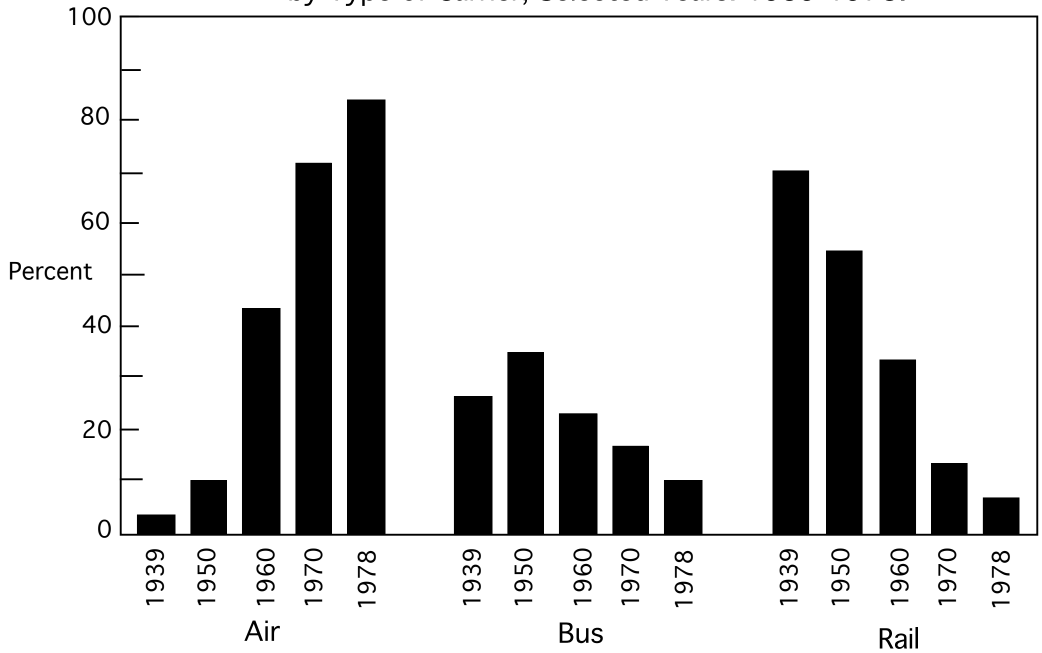
32. The Brooklyn Bridge, Designed by John A. Roebling, is Completed- 1883
33. First Electric Mine Locomotive is Put Into Service in Lykens, PA- 1887
34. First Subway System in the U.S. is Opened in Boston, MA on September 1, 1897
35. First Automotive Taxicab Fleet (13 electric automobiles) in the U.S. Begins to Roll on the Streets of New York City- 1897
36. The Wright Brothers Complete the First Successful Manned Flight (12 seconds. 120 feet) Near Kitty Hawk, NC on December 17, 1903



37. First Automobile Crossing of the U.S. (6.5 Weeks)- 1903
38. An Underground Railway, "Tubes", Goes Into Operation in New York City, NY on October 27, 1904
39. The Long Island Railroad is the First to Abandon Steam in Favor of Electrification- 1905
40. First U.S. Concrete Paved Road (Woodward Ave.) Opens-Up for Traffic in Detroit, MI- 1908
41. Phil Parmalee Pilots a Biplane Loaded with Silk from Dayton to Columbus, OH and the Flight Marks the Beginning of Aerial Freight Transportation- 1910
42. First Transcontinental Plane Flight (Cailbraith Rodgers) (Flying Time: 82 hrs., 4 min.)- 1911
43. Panama Canal Opens and Cuts Sailing Distance From NY to California by 8,415 Miles- 1914
44. First American Use of Aircraft in Actual Military Operations- 1914
45. Rand-McNally Publishes their Auto Trails Map and Introduces the Concept and System of Numbered Routes- 1917

46. The First U.S. Airport to Provide an Integrated System of Runways, Floodlighting and a Terminal Complex is Completed at Cleveland, OH- 1925
47. The Air Commerce Act is Passed- 1926
48. Robert Goddard Launches the First Liquid-Propellant Rocket from Auburn, MA, on March 16, 1926
49. Lindburgh Makes the First Non-Stop Trans-Atlantic Solo Flight (33 Hrs, 39 Min.)- 1927

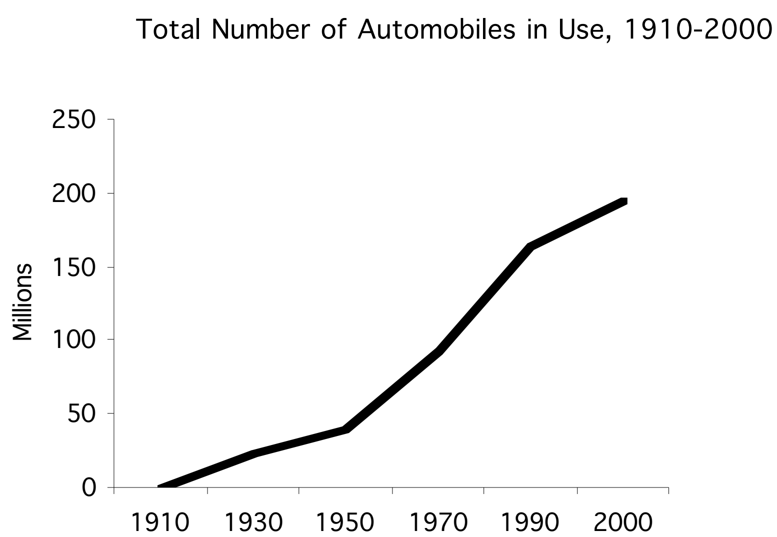
Distribution of Intercity Travel by Public Carrier, by Type of Carrier, Selected Years: 1939-1978.



Source: Transportation Association of America, *Transportation Facts and Trends* (16th Ed.), July 1980.

50. Garret Morgan Invents the First Automatic Traffic Signal, Cincinnati, OH- 1927
51. Robert Goddard Establishes the First Rocket-Testing Center in the U.S., in Roswell, NM- 1930
52. The "Zephyr" Completes a Record-Breaking Run from Denver to Chicago (1,015 miles @ 77.6 mph) in 13 hrs, 5 min- May 29, 1934
53. The Golden Gate Bridge is Opened to Traffic- 1937
54. The Federal Aid Highway Act is Passed- 1944
55. USS Nautilus, the First Nuclear Powered Submarine is Launched- 1954
56. "Explorer 1", the First U.S. Satellite is Launched-1958
57. Project Mercury is Initiated- 1958
58. The National Aeronautics and Space Administration (NASA) is Formed- October 1, 1958

59. The USS Savannah, the World's First Experimental Atomic-Powered Merchant Ship is Launched at Camden, NJ- 1959
60. U.S. Navy Utilizes Satellites to Aid in Navigation- 1964
61. Edward H. White, Becomes the first American to "Space Walk" (22 minutes)- June 5, 1965
62. The "Eagle" Lunar Module Touches Down On the Moon's Surface, and Neil Armstrong Becomes the First Human to Walk On the Moon- 1969
63. The "Double Eagle II" Completes the First Trans-Atlantic Balloon Flight- 1978
64. The STS-1 "Columbia" Space Shuttle Completes Its Maiden Voyage on April 14, 1981



Labor in the United States, 1787-1980s

1. First strike in the US by workers in a single trade. Printers in Philadelphia achieved a minimum wage of $6.00 per week- 1786

2. First strike for workers in the building trades. Unsuccessful strike for a minimum 10 hour day- May, 1791

3. The United Tailoresses of New York, the first trade union for women only, is formed in 1825

4. The Mechanics Union of Trade Associations, made of unions of skilled artisans in different trades, is formed in Philadelphia. This is the first union to organize a wide variety of trades- 1827

5. Children employed in silk mills in Paterson, NJ strike for a 11 hour day and 6 day work week- July 3, 1835

6. Unions are declared legal in a Massachusetts court. They are defined against a conspiracy, which is "a combination of two or more persons, by some concerted action, to accomplish some criminal or unlawful purpose"- 1842

Child Labor Photo by Lewis Hine

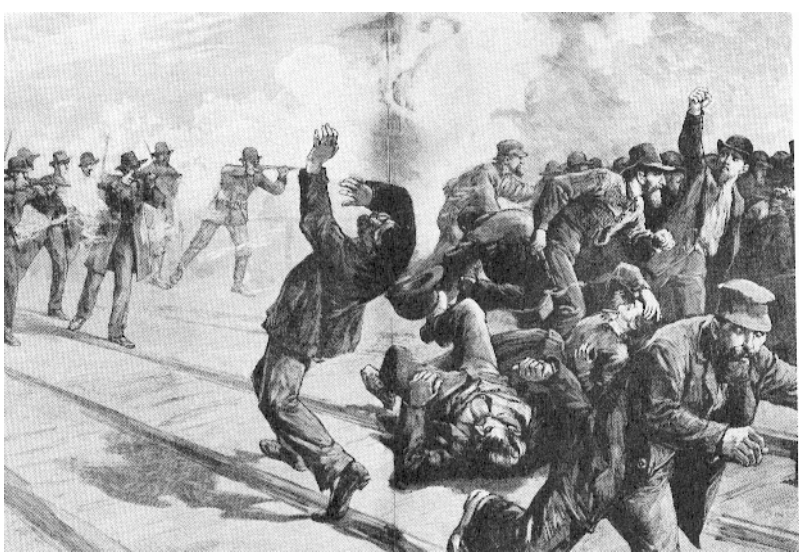
7. Women working in mills in Lowell, Massachusetts, form the Lowell Female Labor Reform Association, which leads to the first investigation of worker health and safety- 1844

8. New Hampshire passes first law fixing the legal workday at 10 hours- 1847

9. Pennsylvania passes the first law fixing the minimum age for child labor at 12 years- 1848

10. The American League of Colored Laborers, the first organization of black workers, is established in New York City- 1850

11. Two railroad strikers are shot dead and others injured by the state militia in Portgage, New York- July, 1851



12. The last slave ship arrives to the United States, the Clothilde, in Mobile Bay, AL- 1859

13. Over 800 women operatives and 4,000 workmen march during a shoemaker's strike in Lynn, MA- 1860

14. Slavery is abolished in the District of Columbia— an important step on the road for freedom and the end of slave labor for all African-Americans- 1862

15. Congress approves the Thirteenth Amendment. Slavery is outlawed in the US by the Thirteenth Amendment, which Congress approves and sends to the states for ratification on January 31, 1865. The amendment is ratified on December 18, 1865

16. Newly freed African-American women, working as laundresses in Jackson, Mississippi, form a union and strike for higher wages- 1866

17. Karl Marx's *Das Kapital* is published, placing a theoretical tool in the hands of the worker's movement. Marx links capitalism to the exploitation of labor and describes the birth of an entire class of people— the urban factory proletariat- 1867

18. The first federal 8 hour work day is passed by Congress, but applies only to government workers- 1868

19. The first national black labor organization, the Colored National Labor Union, is formed- 1869

20. Tompkins Square Riot. As unemployed workers demonstrated in New York's Tompkins Square Park, a detachment of mounted police charge into the crowd, beating men, women and children indiscriminately with billy clubs and leave hundreds of casualties in their wake. Abram Duryee, the Commissioner of Police commented that "It was the most glorious sight I ever saw..."- January 13, 1874

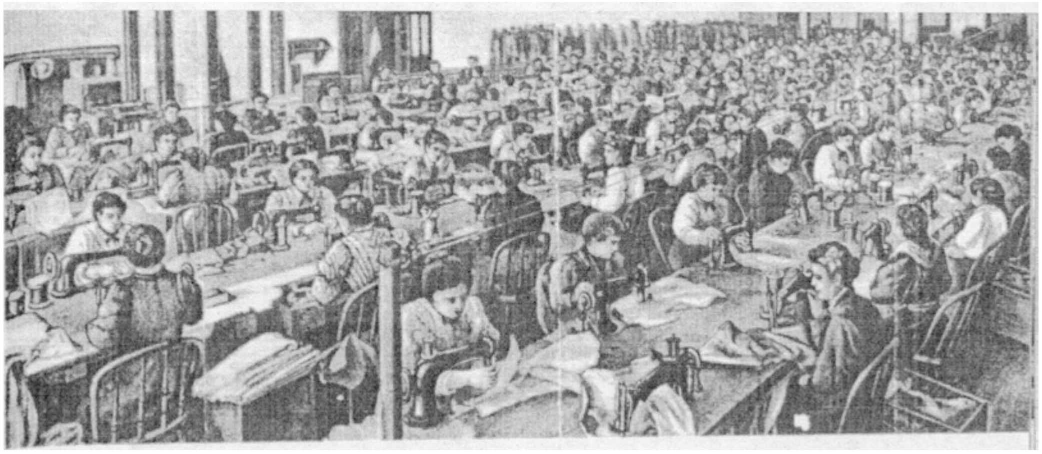
21. Ten coal mining activists ("Molly Maguires") are hanged and 14 are imprisoned in Pennsylvania. The Molly Maguires were a group of Irish coal miners who agitated for better working conditions in the anthracite fields- June 21, 1876

22. US railroad workers begin a series of strikes to protest wage cuts- February 12, 1877

23. A general strike halts the movement of US railroads. In the following days, strike riots spread across the United States. The next week, federal troops are called out to force an end to the nationwide strike. At the "Battle of the Viaduct" in Chicago, federal troops (recently returned from an Indian massacre) kill 30 workers and wound over 100- July 14, 1877

24. The Federation of Organized Trades and Labor Unions ((FOTLU) is organized in Pittsburgh- November, 1881

25. Thirty thousand workers march in the first Labor Day celebration in New York City- September 5, 1882



Women sewing jeans in San Francisco's Levi Strauss & Co. Factory, ca. 1890s

26. The FOTLU passes a resolution stating that "8 hours shall constitute a legal day's work from and after May 1, 1886." Though the FOTLU did not intend to stimulate a mass insurgency, its resolution has precisely that effect- 1885

27. American Federation of Labor is formed from the FOTLU. African Americans continue to be excluded from labor organizations- 1886

28. About 340,000 workers, increasingly determined to improve working conditions and resist subjugation to capitalist power, pour into the Knights of Labor. Beginning on May 1, 1886, they take to the streets to demand the universal adoption of the eight hour day- 1886

29. Chicago is the center of the labor movement. Workers agitate for an eight hour day for months, and on the eve of May 1, 1886 50,000 workers are already on strike. Another 30,000 join their ranks the next day, bringing most of Chicago manufacturing to a standstill. Fears of violent class conflict grip the city. No violence occurs on May 1— a Saturday— or May 2. But on Monday, May 3, a fight involving hundreds breaks out at the McCormick Reaper factory between locked-out unionists and the non-union workers McCormick hires to replace them. The Chicago police, swollen in number and heavily armed, quickly move in with clubs and guns to restore order. They leave four unionists dead and many others wounded- May 1886

30. This is the Chicago Haymaker riot. Angered by the deadly force of the police, a group of anarchists, led by August Spies and Albert Parsons, call on workers to arm themselves and participate in a massive protest demonstration in Haymarket Square on Tuesday evening, May 4. The demonstration appears to be a complete bust, with only 3,000 assembling. But near the end of the evening, an individual, whose identity is still in dispute, throws a bomb that killed seven policemen and injured 67 others. Hysterical city and state government officials round up eight anarchists, try them for murder, and sentence them to death- May, 1886

31. For radicals and trade unionists everywhere, Haymarket becomes a symbol of the stark inequality and injustice of capitalist society. The May 1886 Chicago events figured prominently in the decision of the founding congress of the Second International (Paris, 1889)

to make May 1, 1890 a demonstration of the solidarity and power of the international working class movement- May, 1886

32. The Louisiana Militia, aided by bands of "prominent citizens," shoots 35 unarmed black sugar workers striking to gain a dollar-per-day wage. The reactive mob also lynches two strike leaders- October 4, 1887

33. New York garment workers win the right to unionize after a seven-month strike. They secure agreements for a closed shop, and the firing of all scabs- July 25, 1890

34. The Homestead Strike. Pinkerton Guards, trying to pave the way for the introduction of scabs, open fire on striking Carnegie steel mill in Homestead (section of Pittsburgh). In the ensuing battle, three Pinkertons surrender, then, unarmed, they were set upon and beaten by a mob of townspeople, most of them women. Seven guards and eleven strikers and spectators were shot to death- July 6, 1892

Carnegie Steel Mill, 1912

35. The first of several bloody mining strikes at Cripple Creek, Colorado- 1893

36. During a strike against the Pullman Palace Car Company, which drastically reduced wages, the 1892 World's Columbian Exposition in Chicago is set ablaze, and seven buildings are reduced to ashes. The mobs rage on, burning and looting railroad cars and fighting police in the streets, until July 10, when 14,000 federal and state troops finally succeed in putting down the strike- July 5, 1893

37. Federal troops kill 34 American Railway Union members in the Chicago area attempting to break a strike, led by Eugene Debs, against the Pullman Company. Debs and several others are imprisoned for violating injunctions, resulting in the end of the union- 1894

38. Nineteen unarmed striking coal miners and mine workers are killed and 36 wounded by a posse organized by the Luzerne County sheriff for refusing to disperse near Lattimer, Pennsylvania. The strikers, most of whom are shot in the back, were originally brought in as strike-breakers, but later organized themselves- September 10, 1897

39. Fourteen are killed and 25 wounded in violence resulting when Virden, Illinois mine owners attempt to break a strike by importing 200 non-union black workers- October 12, 1898

40. When their demand that only union men be employed was refused, members of the Western Federation of Miners dynamite the $250,000 mill of the Bunker Hill Company at Wardner, Idaho, destroying it completely. President McKinley responds by sending in black soldiers

from Brownsville, Texas with orders to round up thousands of miners and confine them in specially built "bullpens"- April 29, 1899

41. The International Federation of Trade Unions is formed on August 21, 1901

42. Fourteen miners are killed and 22 wounded by scab herders at Pana, Illinois- October 12, 1902

43. Labor organizer Mary Harris ("Mother") Jones leads child workers on a 125 mile march to demand a 55 hour work week- July, 1903

44. The US Department of Commerce and Labor is created- 1903

45. William Randolph Hearst's San Francisco Chronicle begins publishing articles on the menace of Japanese laborers, leading to a resolution of the California Legislature that action be taken against their immigration- February 23, 1904

46. Industrial Workers of the World (IWW) is formed in Chicago- 1905

47. A battle between the Colorado Militia and striking miners at Dunnville ends with six union members dead and 15 taken prisoner. Seventy-nine of the strikers are deported to Kansas two days later- June 8, 1904

48. The Supreme Court holds that a maximum hours law for New York bakery workers was unconstitutional under the due process clause of the 14th amendment- April 17, 1905

49. The "Uprising of the 20,000." Female garment workers go on strike in New York and many are arrested. A judge tells those arrested: "You are on strike against God"- November 22, 1909

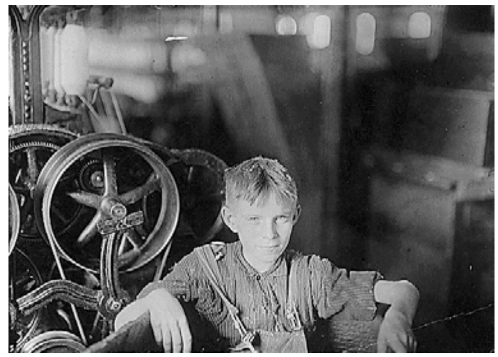
Viscose Worker, 1929

50. The Supreme Court orders the American federation of Labor (AFL) to cease its promotion of a boycott against the Bucks Stove and Range Company. A contempt charge against union leaders (including AFL President Samuel Gompers) is dismissed on technical grounds- 1911

51. The Triangle Shirtwaist Company, occupying the top three floors of a ten-story building in New York City, is consumed by fire— 147 workers, mostly women and young girls laboring in sweatshop conditions, lose their lives. Approximately 50 die as they leap from windows to the street; the others were burned or trampled to death as they desperately attempt to escape through stairway exits locked as a precaution against "the interruption of work." On April 11 the company's owners are indicted for manslaughter- March 25, 1911

52. Women and children were beaten by police during a textile strike in Lawrence, Massachusetts- February 24, 1912

53. Massachusetts adopts the first minimum wage law for women and minors- 1912



Child Labor Photo by Lewis Hine

54. The National Guard is called out against striking West Virginia coal miners- April 18, 1912

55. The Ford Motor Company raises its basic wage from $2.40 for a nine hour day to $5 for an eight hour day- January 5, 1914

56. The "Ludlow Massacre." In an attempt to persuade strikers at Colorado's Ludlow Mine Field to return to work, company "guards," employed by John D. Rockefeller, Jr. and other mine operators and sworn into the State Militia just for the occasion, attack a union tent camp with machine guns, then set it afire. Five men, two women and 12 children die as a result- April 20, 1914

Workers on the magneto line in the Ford factory, ca. 1912

57. World famous labor leader Joe Hill is arrested in Salt Lake City. He is convicted on trumped up murder charges and executed 21 months later despite worldwide protests and two attempts

to intervene by President Woodrow Wilson. In a letter to Bill Haywood shortly before his death he penned the famous words, "Don't mourn - organize!"- January 19, 1915

58. On this same day, twenty rioting strikers were shot by factory guards at Roosevelt, New Jersey- January 19, 1915

59. 1916 marks the beginning of a series of child labor laws that are enacted and declared unconstitutional. A federal child labor law is finally passed in 1924, but is not ratified by the necessary 36 states.

Child Labor Photo by Lewis Hine

60. Strikebreakers hired by the Everett Mills owner Neil Jamison attack and beat picketing strikers in Everett, Washington. Local police watch and refuse to intervene, claiming that the waterfront where the incident took place was Federal land and therefore outside their jurisdiction. When the picketers retaliate against the strike-breakers that evening, the local police intervene, claiming that they had crossed the line of jurisdiction.- August 19, 1916

61. Federal employees win the right to receive Worker's Compensation insurance- September 7, 1916

62. The Supreme Court approves the Eight-Hour Act under the threat of a national railway strike- March 15, 1917

63. The Supreme Court upholds "yellow dog" contracts, which forbid membership in labor unions- January 25, 1917

64. IWW organizer Frank Little is lynched in Butte, Montana on August 1, 1917. Federal agents then raid IWW headquarters in 48 cities- September, 1917

65. United Mine Worker organizer Fannie Sellins is gunned down by company guards in Brackenridge, PA- August 26, 1919

66. Looting, rioting and sporadic violence breaks out in downtown Boston and South Boston for days after 1,117 Boston policemen declare a work stoppage due to thwarted attempts to affiliate with the AFL. Massachusetts Governor Calvin Coolidge puts down the strike by calling out the entire state militia- September 19, 1919

67. The "Great Steel Strike" begins. Ultimately, 350,000 steel workers walk off their jobs to demand union recognition. The AFL Iron and Steel Organizing Committee call off the strike on January 8, 1920 with their goals unmet- September 22, 1919

68. IWW organizer Wesley Everest is lynched after a Centralia, Washington IWW hall is attacked by Legionnaires- November 11, 1919

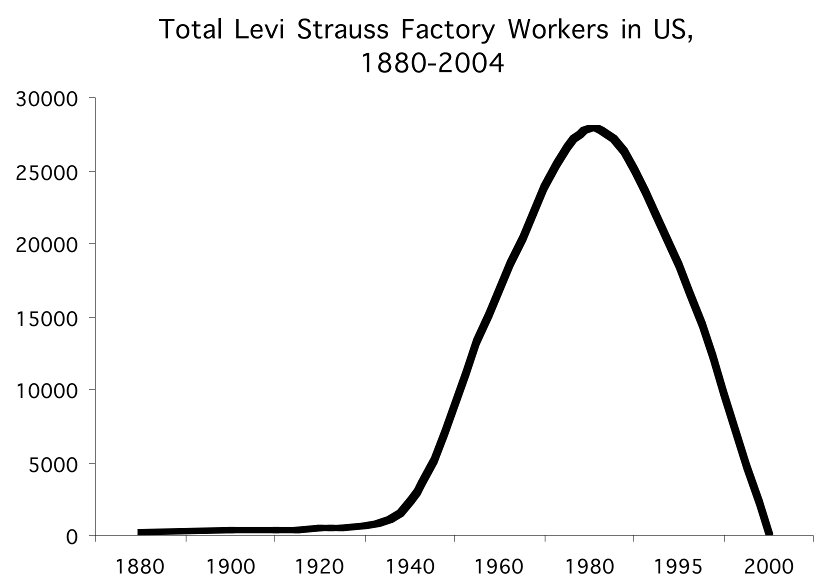
69. The US Bureau of Investigation begins carrying out nationwide Palmer Raids. Federal agents seize labor leaders and literature in the hopes of discouraging labor activity. A number of citizens are turned over to state officials for prosecution under various anti-anarchy statutes- January 20, 1919

70. The Battle of Matewan. Despite efforts by police chief (and former miner) Sid Hatfield and Mayor C. Testerman to protect miners from interference in their union drive in Matewan, West Virginia, Baldwin-Felts detectives hired by the local mining company and thirteen of the company's managers arrive to evict miners and their families from the Stone Mountain Mine camp. A gun battle ensues, resulting in the deaths of 7 detectives, Mayor Testerman, and 2 miners. Baldwin-Felts detectives assassinate Sid Hatfield 15 months later, sparking off an armed rebellion of 10,000 West Virginia coal miners at "The Battle of Blair Mountain," dubbed "the largest insurrection this country has had since the Civil War- May 19, 1920

71. Over 100 farm workers are arrested for their unionizing activities in Imperial Valley, California. Eight are subsequently convicted of "criminal syndicalism"- April 14, 1930

72. Police kill striking workers at Ford's Dearborn, Michigan plant- March 7, 1932

73. Levi Strauss & Co., the last holdout in San Francisco's garment district, recognizes the United Garment Workers union to avoid an immanent strike- July, 1934



74. The Battle of the Overpass. Walter Reuther and a group of United Auto Workers (UAW) supporters, fresh from having organized GM and Chrysler, attempt to distribute leaflets at Gate 4 of the Ford Motor Company's River Rouge plant, but are beaten up (along with bystanders) by Ford Service Department guards- May 26, 1937

Firestone Factory, 1922

75. Police kill 10 and wound 80 during the "Memorial Day Massacre" at the Republic Steel plant in South Chicago- May 30, 1937

76. The Fair Labor Standards Act is passed, banning child labor, establishing a 25-cent minimum wage and a 40-hour work week. The Act went into effect in October 1940, and was upheld in the Supreme Court on 3 February 1941- June 25, 1938

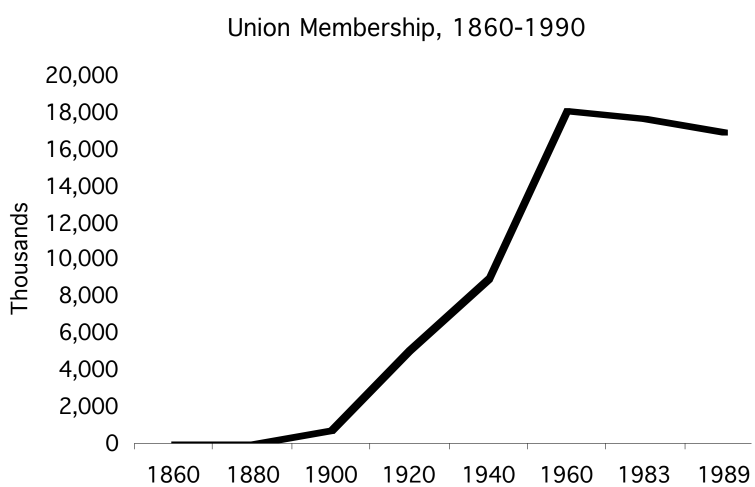
77. The Supreme Court rules, under the Sherman Anti-Trust Act, that sit-down strikes are illegal- February 27, 1939

78. Henry Ford finally recognizes the UAW- June 20, 1941

79. A massive government and industry media campaign persuades women to take jobs during the war. Seven million women respond, becoming industrial "Rosie the Riveters," and over 400,000 join the military- 1941

80. A strike by 400,000 mine workers in the US begin. Military troops seize railroads and coal mines the following month- April 1, 1946

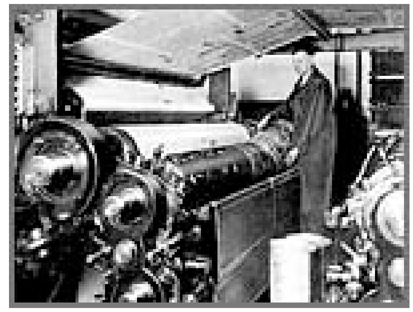
81. The two largest labor organizations in the US merge to form the AFL-CIO, with a membership of 15 million- December 5, 1945



82. The Ives-Quinn Act, the first state legislation prohibiting discrimination in employment on the basis of race, creed, or color, is passed- 1945

83. The Fair Labor Standards Act is amended to raise the minimum wage from 75-cents to $1 per hour- 1955

84. The longest newspaper strike in US history ended. Nine major newspapers in New York City ceased publication over 100 days before- April 1, 1963



Chicago Tribune, 1922

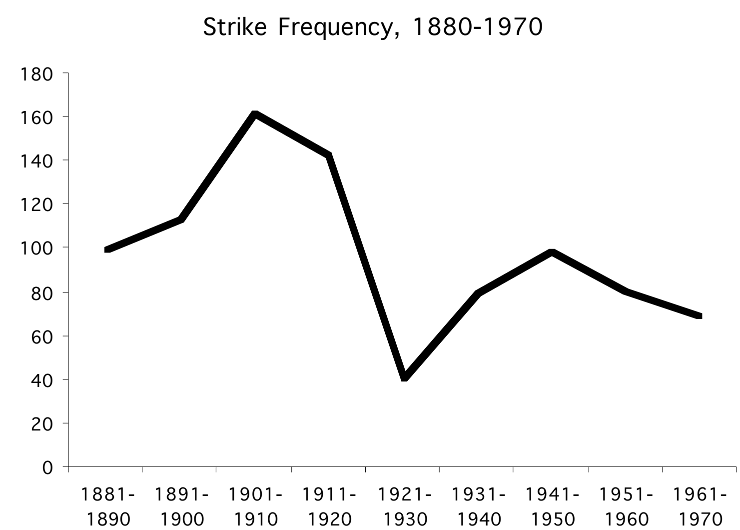
85. President Kennedy signs the Equal Pay bill to prohibit differentiated pay scales based on sex- June 10, 1964

86. President Kennedy signs the Civil Rights Act. Tile VII— Equal Employment Opportunity— bars discrimination on the basis of race, color, religion, sex, or national origin in hiring, promotion, training and union membership- July 2, 1964

87. The first mass work stoppage in the 195-year history of the Post Office Department begins with a walkout of letter carriers in Brooklyn and Manhattan, and soon involves 210,000 of the nation's 750,000 postal employees- March 18, 1970

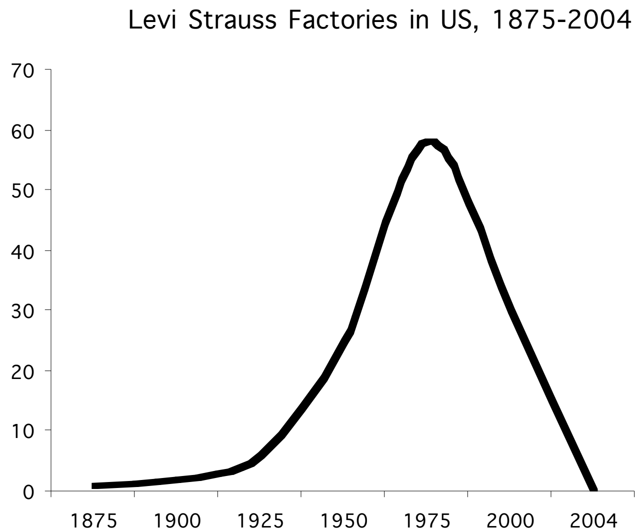
88. The Coalition for Labor Union Women is founded- 1974

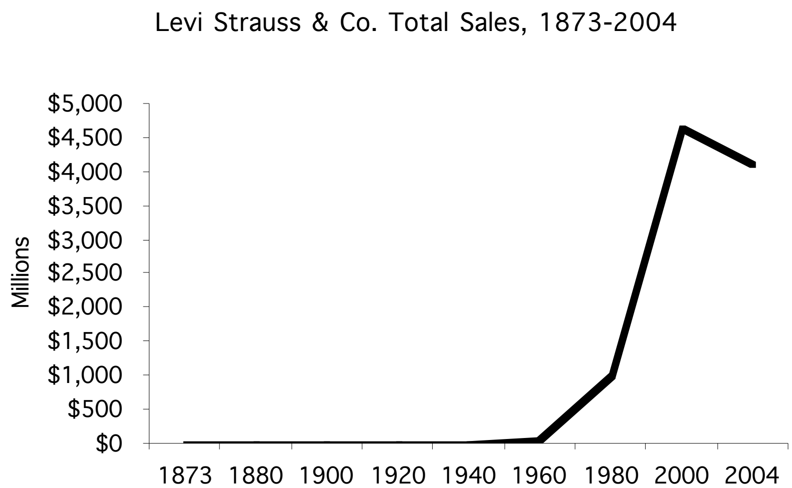
89. Federal air traffic controllers begin a nationwide strike after their union rejects the government's final offer for a new contract. Most of the 13,000 striking controllers defy the back-to-work order, and are dismissed by President Reagan on 5 August- August 3, 1981



90. 1,700 female flight attendants win an 18-year lawsuit (which includes $37 million in damages) against United Airlines, which fired them for getting married- October 6, 1986

91. After celebrating its 150 year anniversary on 5 May 2003, Levi Strauss & Co. closed its last US factory in San Antonio, Texas. This closing is indicative of the trend of textile manufacturing and other industries, which shifted operations into Asian and Central American sweatshops to take advantage of (i.e., exploit) foreign labor (mostly women) who work for $1 per hour. Levi Strauss was paying US workers $11.00- $14.00 per hour- 9 January 2004

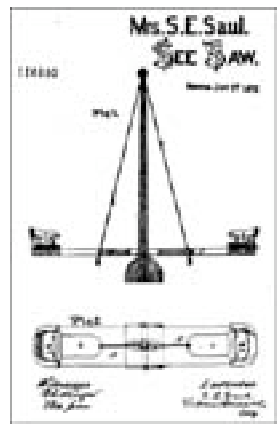




Inventions and Innovations

The next section provides an extensive list of technological inventions and innovations in the US. The list corresponds to the accompanying maps in this monograph. More than 700 of the following inventions and innovations are located on the maps that follow. Students should be able to find individual technologies on the maps and begin to explain why an invention or innovation was located in a certain geographic area at a specific historical time. The should necessarily be expanded, and students can continually update with inventions and innovations that they think are contributing to the development, for good or ill, of ecology, economics and culture.

The first US patent was issued in 1790. In 1794 Eli Whitney patented his cotton gin and in 1809, Mary Kies became the first woman to receive a patent. Through the 19th century, the increase in the number of applications submitted, and patents issued, steadily increased. However, by the turn of the 19th to the 20th century, the number of patents issued increased in unprecedented ways. Patent No. 1,000,000 was issued in 1912, in 1935 Patent No. 2,000,000 was issued and in 1961 the number of patents issued reached 3,000,000. Currently (December 2003), the number of patents issued is over six million. Copyrights and patents were, in theory, a legal protection of individual property rights and the public good. However, the commercialization of intellectual property throughout the nineteenth century changed the original intent (Noble, 1977, pp. 84-109). Copyrights and patents, for example, became a means to monopolistic control.



Mary Kies was issued awarded the first patent for women in 1809 for her invention of Straw Weaving with Silk or Thread. By 1895, 5,535 patents had been issued to women, or 1 of every 100 patents granted. The most patents granted to women during that period were in the areas of "Culinary Utensils" and "Wearing Apparel" (Table 4). The categories "Furniture And Furnishings" and "Washing And Cleaning" were also substantial for women inventors. Between 1905 and 1921, the most common patents issued to women included Household and Personal Wear And Use (Table 5). It is estimated that about 60,000 patents were granted to granted to women between 1790 and the late 1980s. Today, women receive about 11% of all patents issued each year (US Patent and Trademark Office, 1998). A good resource from women's inventions is *Mothers of Invention.*

Table 4. Patents Issued to Women, 1892-1895.

Class	Number	Class	Number
Agricultural Implements	15	Motors	3
Art Appliances	9	Musical Apparatus	6
Baby Carriers	6	Plumbing	3
Barrel Attachments	4	Preserving and Disinfecting	2
Bicycle Attachments	2	Printing and Binding	5
Building Appointments	22	Railway Appliances	8
Bottling Apparatus	2	Screens and Awnings	6
Boxes and Baskets	6	Sewing and Spinning	30
Clocks	3	Stationary	9
Culinary Utensils	102	Theatrical Apparatus	4
Educational Appliances	15	Toilet Articles	11
Flowers and Plants	5	Toys and Games	27
Furniture and Furnishings	55	Trunks and Bags	18
Heating Apparatus	31	Typewriters and Appliances	6
Horseshoes	3	Washing and Cleaning	52
Medical Appliances	23	Wearing Apparel	132
		Miscellaneous	27

Source: (1895). *Women Inventors to Whom Patents have been Granted by the US Government, October 1, 1892-March 1, 1895*. Washington, DC: Government Printing Office.

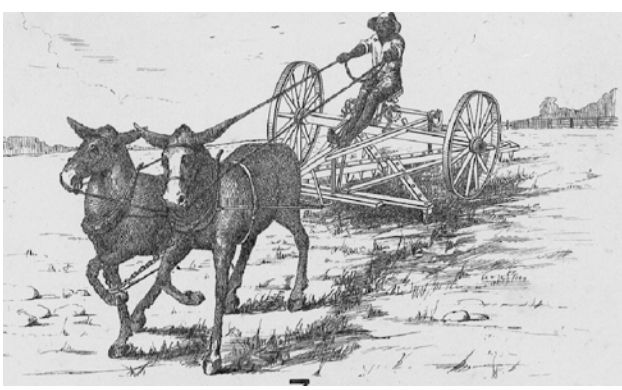
Table 5. Patents Issued to Women, 1905-1921

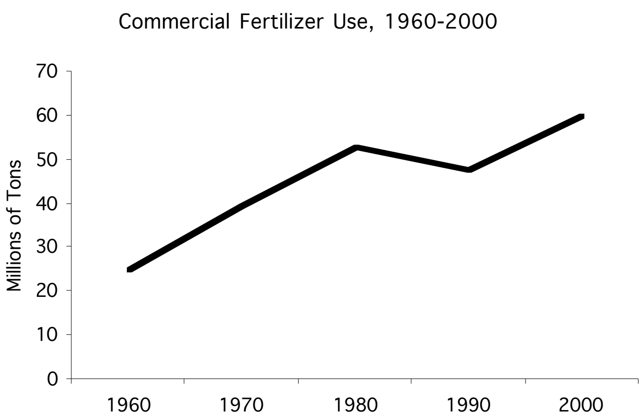
Purpose Served	Number	Percent
Agriculture, Forestry and Animal Husbandry	221	4.4
Mining, Quarrying and Smelting	14	0.3
Manufacturing	223	4.4
Structural Equipment and Materials	208	4.2
Transportation	345	6.9
Trade	71	1.4
Hotel and Restaurant Equipment	10	0.2
Steam Laundry, Dying and Cleaning Equipment	6	0.1
Dressmaker and Milliner Supplies	118	2.4
Office Supplies and Equipment	71	1.4
Fishing	9	0.2
Household	1385	27.6
Supplies for use in Industry, Commerce, Agriculture	378	7.5
Scientific Instruments and Lab Equipment	76	1.5
Ordnance, Firearms and Ammunition	22	0,4
Personal Wear and Use	1000	21.7
Beauty Parlor and Barber Supplies	46	0.9
Medical Surgical and Dental Equipment	227	4.5
Safety and Sanitation	129	2.6
Education	75	1.5
Arts and Crafts	67	1.3
Amusement	211	4.2
Miscellaneous	14	0.3

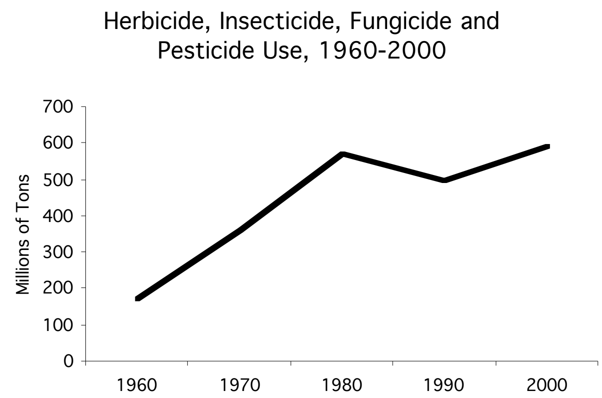
Source: (1923). Bulletin of the Women's Bureau, No. 28: Women's Contributions in the Field of Invention. Washington, DC: Government Printing Office.

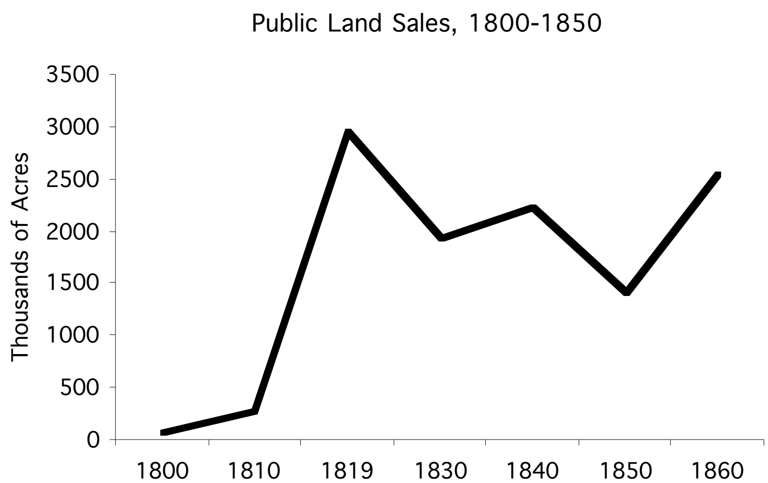
Technological Developments in the United States
Agriculture, 1787-1887

1.	Cotton Gin- 1792	Eli Whitney
2.	Plow Mouldboard Design-1793	Thomas Jefferson
3.	Cast Iron Plow- 1797	Charles Newbold
4.	Seeding Machine- 1799	Eliakim Spooner
5.	Reaper- 1830	Obed Hussey
6.	Reaper- 1831	Cyrus McCormick
7.	Steel Blade Plowshare- 1835	John Lane
8.	Horseshoe Machine- 1835	Henry Brandon
9.	Steam Thresher- 1839	George Westinghouse & Jacob Wemple
10.	Binder- 1850	John Heath
11.	Thresher Fanning Mill- 1833	Hiram A. Pitts
12.	Revolving Disk Harrow- 1847	G. Page
13.	Chilled Plow- 1855	James Oliver
14.	Twine Knotter- 1858	John F. Appleby
15.	Rower Corn Planter- 1864	John Thompson & John Ramsey
16.	Twine Binder- 1867	John Appleby
17.	Barbed Wire- 1874	Joseph F. Gliddon









Technological Developments in the United States
Communication, 1787-1887

1. Metal Ink Pens- 1810 — Peregrine Williamson
2. Hand Printing Press "The Columbian"- 1816 — George Climer
3. Paper-Making Machine- 1817 — Thomas Gilpin
4. Steam Powered Platen Press- 1822 — Daniel Treadwell
5. "High-Speed" Printing Press- 1822 — Henry A.W. Wood
6. Electric Telegraph & Chemical Recording- 1827 — Harrison D. Dwyer
7. Electro-Magnetic Telegraph- 1828 — Joseph Henry
8. "Typographer" Writing Machine- 1829 — William A. Burt

9. Paper-Making Process- 1829	G.A. Shrycock
10. Toggle-Joint Printing Press "Washington"- 1829	Samuel Rust
11. Lead Pencil- 1830	Joseph Dixon
12. Electric Bell- 1831	Joseph Henry
13. Typecasting Machine- 1836	David Bruce
14. Communications Code- 1836	Samuel B. Morse
15. Electric Printing Press- 1839	Thomas Davenport
16. Submarine Cable- 1842	Samuel B. Morse
17. Typewriter- 1843	Charles Thurbur
18. Alligator Printing Press "Franklin"- 1851	George P. Gordon
19. Rotary Printing Press- 1846	Robert Hoe
20. Telegraph System- 1844	Samuel B. Morse
21. Photographic Slides- 1850	F. Langenheim
22. Duplex Telegraph- 1858	J.B. Stearns
23. Kinematoscope- 1860	Coleman Sellers
24. Electronic Wave Transmission- 1864	Mahlon Loomis
25. Web Printing Press- 1865	William Bullock
26. Paper from Sulfite Pulp Process- 1866	Benjamin Tilghmann
27. Wood Pulp (Sulfite Process)- 1866	B.C. & R. Tilghmann
28. Improved Typewriter- 1867	Christopher L. Sholes
29. Collecting Cylinder for Printing Press- 1871	Richard M. Hoe & S. Tucker
30. Paige Compositor- 1873	James W. Paige
31. Pneumatic Dispatch Tube- 1875	Alfred Beach
32. Mimeograph- 1876	Thomas A. Edison
33. Telephone- 1876	Alexander Graham Bell
34. Telephone Switchboard "Central"- 1877	E.T. Holmes
35. Magneto-Electric Call-Bell- 1877	Thomas A. Watson
36. Microphone- 1877	Emile Berliner
37. Phonograph- 1877	Thomas A. Edison
38. Telephone Booth- 1878	Thomas A. Watson
39. Telephone Switchboard- 1878	Charles A. Scribner

40. Megaphone- 1878	Thomas A. Edison
41. Cash Register- 1879	James J. Ritty
42. Half-Tone Process- 1880	Stephen Horgan
43. "Bridging Bell"- 1882	John J. Carty
44. Telephone Transmitter- 1884	Granville Woods
45. Linotype- 1884	Ottmar Merganthaler
46. Monotype- 1884	Tolbert Lanston
47. Electric Tabulator "Census Machine"- 1886	Herman Hollerith
48. Photographic (Nitrocellulose) Film- 1887	Hannibal Goodwin
49. Lateral Cut Recording Phonograph Disks- 1887	Emile Berliner
50. Gramophone- 1887	Emile Berliner
51. Calculating Machine- 1887	William S. Burroughs

Technological Developments in the United States
Communication, 1887-1987

1. Serial Photography- 1887	E. Muybridge & John D. Isaacs
2. Gramophone Record- 1887	Emile Berliner
3. Roll Film Camera- 1888	George Eastman
4. Practical Motion Picture Camera- 1888	Thomas A. Edison & William Dickson
5. Automatic Telephone Exchange- 1889	Almon B. Strowger
6. Punched Card Automation- 1889	Herman Hollerith
7. Kinetoscope- 1889	Thomas A. Edison
8. Data Processing Computer- 1889	Herman Hollerith
9. Telephone Call Box (Coin Operated)- 1889	William Gray
10. Movie Projector "Phantascope"- 1891	C. Francis Jenkins
11. Magazine Press- 1892	C.B. Cottrell
12. Film Studio- 1893	W. K. Dickson
13. "Underwood" Visible Typewriter- 1896	Herman L. Wagner
14. Radio Broadcasting- 1900	Reginald Fessenden
15. Electric Loading Coil- 1900	Michael Pupin
16. Electric Typewriter- 1901	Thaddeus Cahill

17.	Mass Production Mail Order- 1903	Sears-Roebuck Co.
18.	"Practical" Offset Lithography- 1904	Ira W. Rubel
19.	Triode Amplification Tube "Audion"- 1906	Lee de Forest
20.	Teleprinter- 1906	Jay Morton & Charles Crum
21.	Crystal Radio Detectors- 1906	H.H.C. Dunwoody & G.W. Pickard
22.	Cinema Projection System- 1907	D.J. Bell & A.S. Howell
23.	Automatic Typewriter- 1908	T.A. McCall
24.	Improved Radio Transmitter- 1909	E.F. Alexanderson
25.	35mm Format- 1909	Thomas A. Edison
26.	High Frequency Alternator- 1910	E.F. Alexanderson
27.	Heterodyne Radio System- 1912	Reginald Fessenden
28.	Regenerative Circuit- 1912	E.A. Armstrong &
29.	Polaroid- 1929	Lee de Forest
30.	"Vest-Pocket" Kodak Camera- 1912	Edwin H. Land (Kodak Co.)
31.	Regenerative Oscillating Triode- 1912	E.A. Armstrong & Lee De Forest
32.	"Talking Pictures"- 1913	Thomas A. Edison
33.	Autopress- 1914	R. Hoag
34.	Amplitude Modulation- 1915	R.A. Heising & H.J. van der Bijl
35.	Public Address System-1916	Bell Telephone Co.
36.	Radio Direction Finding Loop Aerial- 1916	F.A. Kolster
37.	Radio Telephone- 1916	Western Electric
38.	Telephone Tuning Device-1916	E.F. Alexanderson
39.	SONAR-1917	U.S. Navy
40.	Superheterodyne Circuit- 1917	E.H. Armstrong
41.	Neutrodyne Receiver- 1919	Alan Hazeltine
42.	Micro-Film Reading Machine- 1919	B.A. Fiske
43.	3-D Film- 1922	Perfect Pictures
44.	Phase Shift Distortion- 1922	H. Taylor, L.C. Young &
45.	Sound Film on Motion Pictures- 1923	U.S. Navy
46.	16 mm Film- 1923	Joseph T. Tycocyner
47.	Phonofilm- 1924	Kodak Co.

48. Language Lab (Gramophone Based)- 1924	Lee de Forest
49. Telephoto- 1924	Ralph Waltz
50. Short-Wave Radio	R. Ranger & RCA
51. Transmitter- 1924	F. Conrad & Westinghouse Corp.
52. Data-Handling Punched Cards- 1924	IBM
53. Kinescope (Cathode Ray Tube)- 1924	Vladmir Zworykin
54. Electric Gramophone- 1925	Brunswick Co.
55. HI-Fi Loudspeaker- 1925	C.W. Rice & E.W. Kellogg
56. Vococoder (Voice Recognition)- 1926	Bell Labs
57. Electronic T.V. System- 1927	Philo Farnsworth
58. Magnetic Recording Tape- 1927	J.A. O'Neill
59. Negative Feedback- 1927	Henry S. Black
60. Teletype- 1928	Edward E. Kleinschmidt
61. Iconoscope Electronic T.V. Camera- 1928	Vladmir Zworykin
62. Differential Analyser- 1930	Vannever Bush & MIT
63. Radiographic Enlarger- 1930	Irving Langmuir
64. Televisual Telephone- 1930	AT & T Co.
65. Radio Wave Research- 1930	Karl Jansky & Bell Labs
66. Exposure Meter- 1931	J.T. Rhamstine
67. Crystal Microphone- 1931	C.B. Sawyer
68. Zoom Lens- 1932	Bell & Howell Co.
69. Electric Typewriter- 1933	R.G. Thompson
70. Frequency Modulation- 1933	E.H. Armstrong
71. Color Film- 1935	Leo Godowsky Jr. & L. Mannes
72. "Sound Mirror" Recording- 1935	Mervin Camras & Armor Research
73. "Vocoder" (Voice Coder)- 1936	Bell Labs
74. Pulsed Code Modulation- 1937	A.H. Reeves
75. Photocopier (Xerography)- 1937	Chester Carlson
76. Radio Telescope- 1937	Grote Reber
77. Microfilm Camera- 1938	Elging Fassel
78. Wein Bridge Oscillator- 1938	W. Hewlett & D. Packard

79. Speech-Simulating Machine- 1939	Bell Laboratories
80. Photo-Composing Machine- 1939	William C. Heubner
81. High Definition Color TV- 1940	Peter Goldmark & CBS
82. Computer Program- 1940	J.P. Eckert, J. Mauchly & H. Goldstine
83. RADAR (Applications)- 1940	Robert M. Page & U.S. Navy
84. Portable Two-Way FM Radio- 1941	Motorola Co.
85. LORAN Receiver- 1942	M.I.T
86. Photographic Enlarger- 1943	A. Wolcott & J. Johnson
87. ENIAC (Digital Computer)- 1946	J.W. Mauchly & J. P. Eckert
88. Vinyl Disc Records- 1946	RCA- Victor Co.
89. Mobile Phone Service- 1946	Bell Telephone
90. Polaroid Land Camera- 1947	Edwin H. Land
91. Scan-A-Graver- 1947	Fairchild Industries
92. Computer-Aided Design (CAD)- 1947	California Institute of Technology
93. Transistor - 1948	W. Shockley, J. Bardeen, W. Brattain & Bell Labs
94. Commercial Copying Machine- 1950	Haloid Co.
95. Vidicon (TV Camera Tube)- 1950	RCA
96. Magnetic Core Memory- 1951	Jay Forester
97. Cinerama- 1951	Fred Waller
98. Digital Display- 1952	Andrew Kay
99. Zone Refining- 1952	William G. Pfann
100. "High Purity" Crystals- 1952	William G. Pfann
101. UNIVAC (Computer)- 1952	Eckert & Mauchly
102. Computer Videotape- 1952	John Mullen & Wayne Johnson
103. Cinema-Scope- 1953	20th Century Fox
104. Rapid Computer Print-Out- 1953	Remington Rand Co.
105. Computer Memory Magnetic Cores- 1954	IBM
106. Transistor Radio- 1954	Regency Electronics
107. Light Pen- 1956	Everett and MIT
108. Video Tape Recording- 1956	Ginsberg, Anderson, Pfost, Maxey & Dolby

109. E-101" Personal Computer- 1956	Burroughs Corp.
110. Ampex Video Tape Recorder- 1956	Ampex Co.
111. Transistorized Computer- 1956	Bell Labs
112. Automatically Programmed Tooling- 1957	Douglas Ross
113. Thyristor- 1957	General Electric
114. Silicon Transistor- 1957	Texas Instruments
115. Optical Wavelength Maser- 1958	C. Townes, A. Schawlow & Bell Labs
116. Silicon Grown Junction Transistor- 1958	Texas Instruments
117. Planar Process- 1959	J. Hoerni & Fairchild Industries
118. PDP-1- 1959	Digital Corp.
119. Integrated Circuit- 1959	Jack S. Kilby
120. Artificial Intelligence Computer Program- 1959	Claude A. Shannon & Bell Labs
121. Transistorized Computer- 1959	IBM
122. Pulsed Ruby Laser- 1960	T.H. Maiman & Hughes Research Lab
123. Argon Laser- 1960	D.R. Herriott, A. Javan & W.R. Bennett
124. Magnetic Ink Character Recognition- 1961	Honeywell Corp.
125. Minicomputer- 1961	Digital Corporation
126. Computer Time Sharing- 1961	F.J. Corbato & MIT
127. Stereophonic Radio Broadcast- 1961	Zenith & General Electric
128. Gallium-Arsenide Semiconductor Laser- 1962	R.N. Hall & General Electric
129. Silicon Integrated Circuit- 1962	Texas Instruments
130. Synchronous Orbit Satellite- 1962	Hughes Aircraft & NASA
131. (L.E.D.) Light Emitting Diode- 1962	Nick Holonyak, Jr. & General Electric
132. Computer Aided Graphic Design System- 1963	IBM
133. Tablet Input Device- 1963	Tom Ellis, Mel Davis and RAND
134. Sketchpad-1963	Ivan Sutherland and MIT
135. Microfilm- 1963	Eastman-Kodak Co.
136. "Mayday" Radio Transmitter- 1964	U.S. Navy
137. Voltage Control Synthesizer- 1964	Robert Moog
138. 3-D Laser Holography- 1964	E. Leith & Juris Upatnieks
139. Word Processor- 1964	IBM

140. Linotron- 1965	Merganthaler-Linotype Co.
141. Noise Reduction System- 1966	Ray M. Dolby
142. Bubble Memory- 1967	A.H. Bobeck & Bell Labs
143. Electronic Video Recording- 1967	CBS
144. ARPAnet (Networked Computers)- 1969	Bob Taylor, Charlie Herzfeld & University of California (UCLA & Stanford)
145. Human Speech Machine- 1970	IBM
146. Bar Code (Computer Signal Code)- 1970	Monarch Marking
147. Floppy Disk- 1970	IBM
148. Micro-Processor- 1971	R. N. Noyce, G. Moore, T. Hoff, S. Mazor, F. Faggin & Intel Corp.
149. Shirt-Pocket Radio Pager- 1971	Motorola Co.
150. Portable Hologram Camera- 1971	Hughes Aircraft
151. Compact Disk (Non-Laser)- 1972	RCA
152. Programmable Hand-Held Calculator- 1972	Hewlett-Packard
153. Video Game- 1972	Noland Bushnell
154. Optical Glass Fibres- 1974	MacChesney, O'Conner & Bell Labs
155. Laser Engraving of Printing Plates- 1974	Optronics, Inc.
156. Magnetic Tape Computer Cartridge- 1975	IBM
157. High Speed Non-Impact Printing- 1976	Honeywell, Inc.
158. "Super" Computer- 1976	Cray Research, Inc.
159. Telephonic Optical-Fiber Cables-1977	General Telephone Co.
160. Instruction Machine "Speak and Spell"- 1978	Texas Instruments
161. Human Speech Machine- 1979	IBM
162. Infra-Red Laser- 1979	Columbia Univ. & Naval Research Lab
163. Micropad- 1979	Quest Automation
164. Silane Process- 1979	Union Carbide Corp.
165. "Augment" Automated Office- 1980	Stanford Research Institute
166. Laser Enhanced Etching & Plating- 1980	IBM
167. Laser Repair System- 1980	Western Electric Co.
168. Pencept System- 1981	Pencept Inc.

169. Simulated Listening Typewriter- 1981	Gould, Conti & Hovanyecz
170. 32-Bit Single Chip CPU- 1981	Hewlett-Packard
171. Electronic Mail Service- 1982	RCA
172. Magnetic Bubble Binary Memory- 1982	Texas Instruments
173. Tracking and Data Satellite System- 1983	NASA, John Whitney & Gary Demos
174. Digital Scene Stimulation- 1983	Sadeg M. Faris & IBM
175. Superconducting Transistor- 1983	J. Halbout, D. Grischkowsky, A.C. Balant,
176. Laser Light Compressor- 1984	H. Nakatsuka & IBM
177. Kodavision (Video Film)- 1984	Kodak
178. Transportable Laser-Radar "LIDAR"- 1984	MIT
179. Holo-Camera- 1984	Newport Corporation
180. Computerized Proof-Reader- 1984	Bert de Pamephilis
181. Laser Optical Storage System- 1985	Jerome Drexler
182. "DECtalk"- 1985	D.H. Klatt, Ed Bruckert & W. Tetchner
183. 64K-Bit Memory Chip- 1984	Stanley Schuster & IBM
184. Gallium-Arsenide Microchip- 1985	Honeywell Science Center
185. Computerized Text-To-Speech System- 1985	Dennis H. Klatt & M.I.T.
186. Integrated Circuit (Half Micron)- 1985	IBM
187. Connection Machine- 1986	Thinking Machines Corp.
188. World Wide Web- 1992	Tim Berners-Lee and CERN Laboratory in Switzerland

Technological Developments in the United States Manufacturing, 1787-1887

1.	Carding Machine- 1790	Samuel Slater
2.	Spinning Frame- 1790	Samuel Slater
3.	Textile Mill Design- 1790	Samuel Slater
4.	Pot-Ash & Pearl Ash Process- 1790	Samuel Hopkins
5.	Cotton Gin- 1792	Eli Whitney
6.	Wool Carding Machine- 1793	Arthur & John Scholfield

7.	Conveyer Belt- 1795	Oliver Evans
8.	Nail-Making Machine- 1796	Jacob Perkins
9.	Screw-Cutting Lathe- 1796	David Wilkinson
10.	Production Jig- 1798	Eli Whitney
11.	Cold Rolled Copper- 1801	Paul Revere
12.	Spray Gun (Paint)- 1803	Alan de Vilbiss
13.	Tack Cutting and Heading Machine- 1807	Jesse Reed
14.	Loom Temple- 1808	Ira Draper
15.	Standardization of Clock Parts- 1808	Eli Terry
16.	Screw Cutting Machine-1809	Abel Stowel
17.	Industrial Lathe- 1810	David Wilkinson
18.	Nail Manufactory- 1811	J. Leander Bishop
19.	Power Loom- 1814	Francis Lowell
20.	Anthracite Coal for Iron Production- 1812	Joseph Smith
21.	Steel Plate Engraving- 1814	Jacob Perkins
22.	Oxyhydrogen Torch- 1816	Robert Hare
23.	Profile Lathe- 1818	Thomas Blanchard
24.	Milling Machine- 1816	Simeon North
25.	Milling Machine- 1818	Eli Whitney
26.	Production Of Textile Machinery- 1820	Merrimac Co.
27.	Fixture- 1822	John Hall
28.	Compound Gear- 1823	Asa Arnold
29.	Babbitt Metal- 1825	Isaac Babbitt
30.	Interchangeable Parts- 1826	John Hall
31.	Drop Forging Machine- 1828	Samuel Collins & David Collins
32.	Multi-Process Woodworking Machine- 1828	William Woodworth
33.	Insulation of Wire- 1828	Joseph Henry
34.	Power Knitting Machine- 1831	Egbert Egberts
35.	Forging & Tempering Techniques- 1831	E.K. Root
36.	Hydraulic-Powered "Factory"- 1832	E. Egberts & Timothy Bail
37.	Electric Motor- 1834	Thomas Davenport

38.	Mass Production Techniques- 1835	Samuel Colt
39.	Harness Loom- 1837	William Crompton
40.	Vulcanization of Rubber- 1839	Charles Goodyear
41.	Iron Furnace with Anthracite Hot Blast- 1840	David Thomas
42.	Coke Oven- 1841	P. McCormick, J. Campbell & J. Taylor
43.	Pin-Making Machine- 1842	John Howe
44.	Water-Turbine Powered Textile Mill- 1843	Uriah A. Boyden
45.	Sewing Machine- 1846	Elias Howe
46.	Quantity Production- 1847	Cyrus McCormick
47.	Wooden Peg Machine- 1848	Henry P. Wescott
48.	Improved Shoe-Pegger- 1851	A.C. Gallahue, E. Townshend & B.F. Sturtevant
49.	Improved Sewing Machine- 1851	Isaac M. Singer
50.	Hard Rubber- 1851	Nelson Goodyear
51.	Chuck Lathe- 1852	Elisha K. Root
52.	Kelley Steel Process- 1852	William Kelley
53.	Improved Turret Lathe- 1854	Richard Lawrence & S.E. Robbins
54.	Pneumatic Process of Steel Production- 1856	Henry Bessemer
55.	Four-Harness Loom- 1856	L.J. Knowles
56.	Wrought Iron I-Beams- 1856	Peter Cooper
57.	"Large Scale" Steelmaking- 1860	Alexander Holley
58.	Knitting Machine- 1863	Christopher Spencer
59.	Micrometer Caliper- 1867	Joseph R. Browne &
60.	Universal Milling Machine- 1867	Lucian Sharpe
61.	Open Hearth Process- 1868	J.R. Brown
62.	Celluloid- 1869	Abram S. Hewitt
63.	Welt Machine- 1871	Isaac Hyatt & J.W. Hyatt
64.	Riveting Process for Jeans- 1873	Jacob Davis and Levi Strauss
65.	Shoe-Lasting Machine- 1880	C. Goodyear Jr., D. Mills & A. Destovy
66.	Time and Motion Study- 1881	J.E. Matzeliger
67.	Industrial Management Techniques	

	"Efficiency Engineering"- 1881	Frederick W. Taylor
68.	Electric Fan- 1882	Schuyler S. Wheeler
69.	Electrolytic Reduction of Aluminum- 1886	Charles Martin Hall
70.	Electric Welding- 1886	Elihu Thompson
71.	Electric Steel Furnace- 1887	Robert Hare

Technological Developments in the United States Manufacturing, 1887-1987

1.	Northrup Loom- 1889	James Northrup
2.	Silicon Carbide- 1891	E.G. Acheson
3.	Motorized Rotary Crane- 1892	Seward Babbitt
4.	High Speed Tool Steel- 1899	F. W. Taylor & Maunsel White
5.	Grinding Machine- 1900	Charles Norton & Co.
6.	Glass Blowing Machine- 1903	Michael J. Owens
7.	Nickel Refining Process- 1905	Ambrose Monell
8.	Humidity Control & Dust Filter- 1906	Stuart W. Cramer
9.	Nichrome- 1906	Albert Marsh
10.	Ductile Tungsten- 1908	William Coolidge
11.	Phenolic Resin "Bakelite"- 1909	L.H. Baekeland
12.	Cellulose Fiber "Rayon"- 1910	American Viscose Co.
13.	Hydraulic Hoist- 1911	Garfield A. Wood
14.	Stainless Steel- 1912	Elwood Haynes
15.	Hydraulic Hoist- 1912	Elwood Haynes
16.	Synthetic Wood Glue- 1912	L.H. Baekeland
17.	Iron-Nickel Alloy Wire- 1913	Colin G. Fink
18.	Moving Assembly Line System- 1913	Henry Ford
19.	Gear-Hobbing Machine- 1915	Brown & Sharpe Co.
20.	Borosilicate Glass- 1915	Corning Glass Co.
21.	Process for Beryllium Production- 1918	A. Stock & H. Goldschmidt
22.	Quality Control Program- 1916	Western Electric/Bell Labs
23.	Light Bulb and Vacuum Tube Machine- 1920	Corning Glass Co.

24.	Isopropyl Alcohol- 1920	Standard Oil Co.
25.	Mass Production Of Light bulbs- 1920	Corning Glass Co.
26.	Continuous Hot Strip Steel Rolling- 1922	John B. Tytus
27.	High Frequency Induction Furnace- 1922	Edwin F. Northrup
28.	Acetate- 1924	Celanese Corporation
29.	Statistical Control Charts- 1924	Walter Shewhart
30.	Cellophane- 1924	DuPont Co.
31.	Hydraulic Pump- 1925	Harry Vickers
32.	"Modern" Refractory- 1925	Corning Glass Co.
33.	Beryllium-Copper Alloy- 1926	M.G. Corson
34.	Continuous Casting Of Metals- 1927	Irving Rossi
35.	Continuous Mill- 1928	Columbia Steel Co.
36.	PVC- 1928	DuPont Co.
37.	Automatic Factory- 1930	A.O. Smith Co.
38.	PVC- 1930	W.L. Seamen & B.F. Goodrich Co.
39.	Fiber-Glass- 1931	Owens Glass Co.
40.	Neoprene- 1932	A.M. Collins, W.H. Carothers, & DuPont
41.	Electroslag Welding- 1935	R.K. Hopkins
42.	Vinyl Polymers- 1935	B.F. Goodrich Co.
43.	"Butyl" Synthetic Rubber- 1937	R. Thomas, W. Sparks & Standard Oil
44.	"Micarta" Plastic Laminate- 1937	Westinghouse Electric
45.	Photo-Sensitive Glass- 1938	R.H. Dalton
46.	Nylon- 1938	W.H. Carothers & DuPont Co.
47.	X-Ray Tube- 1942	Westinghouse Labs
48.	Teflon- 1943	DuPont Co.
49.	Machine Control (Primitive Robot)- 1946	George Devol
50.	Acrylic- 1950	DuPont Co.
51.	"Partial" Automated Manufacturing- 1952	Ford Motor Co.
52.	Polyester Fiber- 1953	DuPont Co.
53.	Programmed Milling Machine- 1954	M.I.T.
54.	Artificial Diamond- 1955	G.E.C.

55.	Nitinol (Memory Metal)- 1960	William Buehler
56.	"SP" Super Polymer- 1961	DuPont Co.
57.	Industrial Robot- 1962	Unimation,Inc.
58.	CAD-CAM System- 1968	M.I.T. & U.S. Air Force
59.	Commercial Water Cutting Techniques- 1971	McCartney Manufacturing Co.
60.	3-D Microscope- 1973	University of Texas
61.	Scientific Sampling- 1973	Abraham Wald
62.	Flexible Manufacturing System- 1974	Cincinnati Milacron
63.	Electronic Sewing Machine- 1975	Singer Co.
64.	Laser-Based Manufacturing System- 1977	Bell Labs
65.	"PUMA" Industrial Robot- 1978	Unimation
66.	Laser Annealing- 1978	Stanford University
67.	Laser Cutting- 1980	Hughes Aircraft Co.
68.	Laser-Based Cutting System- 1980	Hughes Aircraft Co.
69.	Laser Repair System- 1980	Western Electric
70.	"RSI" Computer Robotic System- 1982	IBM
71.	Hobot (Integrated Robot)-1984	Hubotics Corp.
72.	Synthetic Ultra-Strong Fiber- 1985	Allied Corporation
73.	Ryton (Advanced Composite)- 1985	Phillips Petroleum Co.
74.	Arylon (Advanced Polymer)- 1985	DuPont Co.

Technological Developments in the United States
Power and Energy, 1787-1987

1.	High Pressure Steam Engine- 1787	Oliver Evans
2.	Water-Tube Boiler- 1788	James Rumsey
3.	Multi-Tubular Boiler- 1803	John Stevens
4.	"Time Bomb" Marine Torpedo- 1805	Robert Fulton
5.	Wood Stove for Heating- 1808	Daniel Pettibone
6.	Street Lighting- 1816	Rembrandt Peale
7.	Cooking Stove- 1819	John Conant

8.	Illuminating Gas Apparatus- 1820	David Mellville
9.	Mine Drill- 1822	A.C. Rand
10.	Steam Pressure Research- 1823	Jacob Perkins
11.	Improved Stationary Steam Engine- 1827	Jacob Perkins
12.	Insulation of Wire- 1828	Joseph Henry
13.	"Intensity" Electromagnet- 1828	Joseph Henry
14.	Electromagnetic Motor- 1829	Joseph Henry
15.	Electric Relay- 1829	Joseph Henry
16.	Centrifugal Pump- 1831	Blake
17.	Wire Drawing Machinery- 1832	Ichabod Washburn
18.	Electric Motor (DC)- 1834	Thomas Davenport
19.	Friction Match- 1836	Alonzo Phillips
20.	Steam "Wheels"- 1837	T. Avery
21.	Telexplosion Technique- 1837	Samuel Colt
22.	Hot Water Heating System- 1840	Robert Briggs
23.	Improved Hydraulic Turbine- 1845	Uriah A. Boyden
24.	Improved Reaction Turbine- 1846	James B. Francis
25.	Scoop Engine Pump- 1848	Bartols & Merrick and Sons Engineers
26.	Power Rock Drill- 1849	J.J. Couch
27.	Corliss Steam Engine- 1849	G.H. Corliss
28.	Lamp Chimneys- 1852	Christopher Dorflinger
29.	Hydraulic Mining- 1852	Chabott
30.	Sluicing Process- 1853	E.E. Matterson
31.	Kerosene "Coal Oil" Developed- 1854	Abraham Gessner
32.	Parafin Lamp- 1854	John H. & George Austen
33.	Annular-Sail Wind Pump- 1854	Daniel Halliday
34.	Hydraulic Testing Techniques- 1855	James B. Francis
35.	Inclined Water-Tube Boiler- 1856	Stephen Wilcox & George Babcock
36.	Improved Waterwheel- 1856	J.P. Upham
37.	Coal Tar Distillation- 1857	Samuel Warren
38.	Oil Refining Process- 1858	A.C. Ferris

39.	Oil Well- 1859	Edwin L. Drake
40.	Torpedo for Oil Drilling- 1862	E.A. Roberts
41.	Oil Pipeline- 1865	Samuel van Syckel
42.	Deep Sea Sounding Apparatus- 1865	J.M. Brooke
43.	Rotary Steam Engine- 1865	George Westinghouse
44.	Compressed Air Rock Drill- 1866	Charles Burleigh
45.	Improved Windmill Water Pump- 1867	Leonard H. Wheeler
46.	Offshore Drilling Platform- 1869	Thomas F. Rowland
47.	Bucket Wheel Water Turbine- 1870	Lester A. Pelton
48.	Testing Flume- 1870	J.B. Emerson
49.	Pneumatic Drill- 1871	Simon Ingersoll
50.	"Water Gas"- 1872	Thaddeus S.C. Lowe
51.	Improved Generator- 1873	Z.T. Gramme
52.	Dynamo (Lighting)- 1875	William B. Anthony
53.	"Sun Motor" Solar Energy Boiler- 1875	John Ericsson
54.	Interferometer- 1876	A.A. Michelson
55.	High-Grade Kerosene- 1876	J.A. Scott & California Star Oil Works
56.	Dynamo- 1876	Charles F. Brush
57.	Coal Cutting Machine- 1877	F.M. Lecher
58.	Practical Light Bulb- 1879	Thomas A. Edison
59.	Glass Bulb Fabricating Process- 1879	Corning Glass Company
60.	Electric Power System Design- 1879	Thomas A. Edison
61.	Incandescent Light Bulb- 1879	Thomas A. Edison
62.	Arc Lighting System- 1879	Charles F. Brush
63.	Suction Fan- 1880	B.F. Sturtevant
64.	Ore Crusher- 1881	P.W. Gates
65.	Dynamo "Jumbo"- 1882	Thomas A. Edison
66.	Hydroelectric Central Station- 1882	Thomas A. Edison & Elmer Berlin
67.	Traction Engine (Steam)- 1882	L. Copeland
68.	Carbon Filament for Light Bulbs- 1882	Lewis Latimer
69.	Electric Fan- 1882	Schuyler S. Wheeler

70.	Polyphase System- 1882	Nikola Tesla
71.	Electrical Indicator- 1883	Thomas A. Edison
72.	Selenium Photo-Cell- 1883	Charles E. Fritts
73.	Power Log Splitter- 1883	Horace Butters
74.	Oil Floatation Ore Refining Process- 1886	Carrie J. Everson
75.	Transformer- 1886	William Stanley
76.	Electric Heater- 1887	W. Leigh Burton
77.	Air-Cooled Transformer- 1887	George Westinghouse

Technological Developments in the United States
Power and Energy, 1887-1987

1.	Electric Motor (AC)- 1888	Nicola Tesla
2.	Oil Refining Process- 1888	Hermann Frasch
3.	Electric Induction Motor- 1888	Nikola Tesla
4.	High Frequency Generator- 1890	Elihu Thompson
5.	Spectroheliograph- 1891	George E. Hale
6.	Water Pumping Engine- 1894	E.D. Leavitt
7.	Hydro-Electric Plant- 1895	Horatio Livermore
8.	Coal Tipple- 1896	George S. Rice
9.	Steam Turbine- 1896	Charles E. Curtis
10.	Jack-Hammer- 1897	J.G. Leyner
11.	Thermal Cracking Distillation- 1900	Charles Palmer
12.	Alkaline Storage Battery- 1900	Thomas A. Edison
13.	Solar Powered Water Pump- 1901	G. Eneas
14.	Solar Engine- 1902	H. E. Willsie
15.	Air Conditioning- 1902	Willis Carrier
16.	Blowout Preventer- 1903	Harry Decker
17.	Mercury Vapor Arc Light- 1903	Peter Cooper
18.	Electric Mine Drill- 1903	W.A. Box
19.	Casing-Head Gasoline- 1904	A. Fasenmeyer
20.	High Voltage Rectifier- 1905	Charles Steinmetz

21.	Suspension Insulator- 1907	E. Hewlett & H.W. Puck
22.	Rock-Drilling Bit- 1908	Hughes Tool Co.
23.	Tungsten Filament (Ductile)- 1908	William D. Coolidge
24.	Bakelite- 1909	L.H. Baekeland
25.	Underwater Drilling Techniques- 1911	Gulf Refining Co.
26.	Turbo-Alternator- 1911	Charles Parsons
27.	"Recharged" Oil Well- 1911	H.E. Smith & T.L. Dunn
28.	Cracking Process- 1913	William M. Burton
29.	Mercury Steam Turbine- 1913	William L. Emmett
30.	High Volume Screw Pump- 1913	Alfred B. Wood
31.	Pyrex Glass- 1915	Corning Glass
32.	Gas-Filled Incandescent Lamp- 1916	Irving Langmuir
33.	Reaming Cone Bit- 1917	Hughes Tool Co.
34.	Glass-Tubing Machine- 1917	E. Danner & Libbey Glass Co.
35.	Three-Core Power Cable- 1920	Martin Hochstadtler
36.	Magnetron- 1921	Albert Hall
37.	High-Pressure Steam Electric	I.E. Moultrop & Stone and Webster
38.	Power Station- 1925	Engineers
39.	Electrostatic Generator- 1929	Robert Van de Graff
40.	Cyclotron- 1930	E.O. Lawrence & N.E. Edelfson
41.	Gasohol- 1932	D. Egloff
42.	Sodium Vapour Lamp- 1933	General Lamp
43.	Electrostatic Particle Accelerator- 1933	Merle A. Tuve
44.	Fluorescent Lighting- 1935	General Electric Co.
45.	Hydrogen Cooled Generator- 1937	Dayton Power & Light
46.	Off-Shore Oil Well- 1937	Superior Oil & Pure Oil Co.
47.	Fluorescent Lighting- 1938	A.H. Compton & G. Inman
48.	Continuous Coal Cutting Machine- 1940	Consolidation Coal Co.
49.	Isolation Of U-235- 1940	K. Kingdon & H.C. Pollock
50.	Isolation Of Plutonium- 1941	E. Seaborg & E. McMillan
51.	Atomic Reactor "Manhatten Project" -1942	Enrico Fermi & Univ. of Chicago

52.	Gas Turbine (Commercial)- 1949	General Electric
53.	Breeder Reactor- 1951	Walter H. Zinn
54.	Solar Battery- 1954	G.M. Chapin, C.S. Fuller, G.L. Pearson & Bell Labs
55.	Mercury Dry Cell- 1957	Texas Oil Co.
56.	Pressurized Water-Cooled Reactor- 1957	Westinghouse Corporation
57.	A. G. Electron Synchotron- 1962	M.I.T. & Harvard Universities
58.	Strain Seismograph- 1964	Hugo Benoiff
59.	"Practical" Fuel Cell- 1962	NASA
60.	Armless Windmill- 1974	U. S. Dept. Of Energy
61.	"Liquid" Explosives- 1970	Explosives Corp.
62.	Two Megawatt Wind Turbine- 1979	Boeing & Dept Of Energy
63.	Wind Turbine Farm- 1982	Dept. of Energy
64.	Electricity Conducting Polymer- 1985	Brookhaven National Lab.

Technological Developments in the United States
Transportation, 1787-1887

1.	First American Steamboat- 1787	John Fitch
2.	Steam Powered Amphibious Vehicle- 1789	Oliver Evans
3.	Teamboat- 1791	John Fitch
4.	Screw Propeller- 1792	John Stevens
5.	Covered Bridge- 1792	Timothy Palmer
6.	Lift Model for Ship Design- 1794	Orlando Merrill
7.	Submarine-1800	Robert Fulton
8.	Suspension Bridge- 1800	John Finley
9.	Steamboat- 1807	Robert Stevens
10.	Practical Navigation System- 1802	Nathanial Bowditch
11.	Ironclad- 1813	John Stevens
12.	Horse-Drawn Carriage "Volontas"- 1822	Miln Parker
13.	Steam Automobile- 1825	Thomas Blanchard

14.	Multi-Tubular Steam Locomotive- 1826	John Stevens
15.	Lattice Trussed Railroad Bridge- 1829	Stephen Long
16.	"T"-Rail- 1830	Robert L. Stevens
17.	Swivel Truck for Locomotives- 1831	John B. Jervis
18.	Equalizing Lever- 1831	John B. Jervis
19.	Cow Catcher- 1831	Isaac Dripps
20.	Link Motion- 1832	William T. James
21.	Coal Burning Steam Locomotive- 1832	John P. Jervis
22.	Railroad Spike Machine- 1832	Henry Burdon
23.	Dry-Docking Facilities- 1827	L. Baldwin, Jr.
24.	Horseshoe Machine- 1835	Henry Brandon
25.	Clipper Ship Design- 1841	J.W. Griffiths
26.	Screw Propelled Warship- 1843	John Stevens
27.	Electromagnetic Locomotive- 1846	Ira Farmer
28.	Clipper Ship- 1850	Donald McKay
29.	Elevator- 1852	E.G. Otis
30.	Sleeping Car- 1858	George M. Pullman
31.	Steam Carriage- 1849	S.H. Roper
32.	Gas Engine (Point Ignition)- 1855	A. Drake
33.	Signal Flare- 1856	Martha Coston
34.	Lag-Bed (Steam-Driven)- 1859	W.P. Miller
35.	Railroad Velocipede- 1860	G.F. Sheffield
36.	Block System for Railroads- 1863	Ashbel Welsh
37.	Streetcar (Horsedrawn)- 1865	John Stephenson
38.	Cog Railway- 1866	Sylvester Marsh
39.	Supercharger- 1866	J.D. Roots
40.	Dining Car- 1868	George M. Pullman
41.	Refrigerator Car- 1868	J.B. Sutherland
42.	Tunnel Shield- 1869	Alfred E. Beach
43.	Air Brake- 1869	George Westinghouse
44.	Steam Powered Bicycle-1870	Lucious D. Copeland

45.	Passengers-Only Incline- 1870	John Endress & Samuel Diescher
46.	Cable Street Car- 1873	Andrew S. Hallidie
47.	Generator- 1873	Z.T. Gramme
48.	Electric Railway- 1874	Stephen D. Field
49.	Steel Arch Bridge- 1874	James B. Eads
50.	Refrigeration Car- 1875	G.W. Swift
51.	Streetcar (Overhead Wire)- 1875	George Green
52.	Cantilevered Viaduct- 1876	Charles S. Smith
53.	Dynamo- 1876	Charles Brush
54.	Gasoline Carriage (Motor Car)- 1877	George B. Seldon
55.	Sailing Railway Car- 1878	C.J. Bascom
56.	Human Powered Flying Machine- 1878	C.E. Ritchell
57.	Submarine "Fenian Ram"- 1881	John Holland
58.	Bolometer- 1881	Samuel P. Langley
59.	"Farthing Penny" Bicycle- 1881	Smith Machine Co.
60.	Trolley Car- 1882	Frank J. Sprague
61.	Trackless Trolley- 1882	D. Finney
62.	Overhead Lumber Skidder- 1883	Horace Butters
63.	Trolley Car- 1883	Charles Van Depoele
64.	Suspension Bridge- 1883	John & Washington Roebling
65.	Commercial Street Railway- 1884	E.M. Bentley & W.H. Knight
66.	Human-Carrying Glider- 1884	John J. Montgomery
67.	Lumber Raft- 1884	J.D. Leary
68.	"Conduit" Street Railway- 1885	Sydney Short
69.	Safety Bicycle- 1886	Albert A. Pope
70.	Electric Passenger Elevator- 1885	William Baxter
71.	Petrol Pump- 1885	Sylvanus F. Bowser
72.	Forest Tractor- 1887	George T. Glover
73.	Pneumatic Tire- 1887	J.B. Dunlop

Technological Developments in the United States
Transportation, 1887-1987

1.	Electric Tramway- 1888	Frank Sprague
2.	Electric Induction Motor- 1888	Nikola Tesla
3.	Tractor (Petrol-Engined)- 1889	Charter Engine Co.
4.	Elevated Railway- 1890	T.C. Clarke
5.	Electric Bicycle- 1890	G.P. Hachenberger
6.	Electric Automobile- 1891	William Morrison
7.	Two-Stroke Cycle Engine- 1891	John Day
8.	Gas-Powered Tractor- 1892	John Froelich
9.	"Modernized" Gas Carriage- 1894	Charles & Frank Duryea
10.	Escalator- 1896	Jesse W. Reno
11.	Aerodrome- 1896	Samuel P. Langley
12.	Biplane-Glider- 1896	Octave Chanute & A.M. Herring
13.	Ore Unloader- 1896	George H. Hulett
14.	"Hopper" (Rail Car)- 1897	George H. Hulett
15.	Remote Controlled Boat- 1898	Nikola Tesla
16.	Submarine Petrol-Electric)- 1898	John P. Holland & U.S. Navy
17.	Locomobile- 1899	Anzi L. Barber
18.	Auto-Tractor- 1901	Alvin A. Lombard
19.	Motorboat- 1902	New York Kerosene Co.
20.	Clincher Pneumatic Tire- 1903	William E. Bartlett
21.	Improved Four-Stroke Engine- 1903	R.E. Olds
22.	Aeroplane "Flyer"- 1903	Orville & Wilbur Wright
23.	Tandem Monoplane- 1903	Samuel P. Langley
24.	Caterpillar/Crawler Tractor- 1904	Benjamen Holt
25.	Ailorons (Airplane Wings)- 1906	Orville & Wilbur Wright
26.	High-Speed Steam Car- 1906	F.O & F.L. Stanley
27.	Marine Outboard Engine- 1906	C. Waterman, G., Thrall & O. Barthel
28.	Closed Car Body- 1907	Fred & Charles Fisher

29.	Petrol-Powered Dirigible- 1907	Thomas Baldwin & Glenn Glass
30.	Super-Charged Motor Car- 1907	Lee S. Chadwick
31.	Biplane "Junebug"- 1908	Glenn Curtiss
32.	Hydroplane- 1908	William H. Fauber
33.	Four-Wheeled Drive- 1908	O. Zachow & W. Bessedich
34.	Tractor-Trailer W/"Fifth-Wheel"- 1909	Charles F. Martin
35.	Gyro-Compass- 1910	Elmer A. Sperry
36.	Self-Starter (Auto)- 1910	Charles F. Kettering
37.	Aircraft Carrier- 1911	U.S. Navy
38.	Autopilot- 1913	Lawrence Sperry
39.	Electric Traffic Light- 1914	Alfred A. Benesch
40.	Commuter Airplane- 1914	Benoist Flying Boat Co.
41.	Tractor Trailer- 1915	August Fruehauf
42.	Motor Scooter- 1915	Auto-Ped Co.
43.	All Steel-Body Motor Car- 1916	Dodge Motor Co
44.	Hydrofoil- 1919	Alexander G. Bell & Casey Baldwin
45.	Pilotless Aircraft- 1924	U.S. Navy
46.	SONAR-1917	U.S. Navy
47.	Rigid "Six-Wheeler"- 1920	Goodyear Tire Co
48.	Safety Coach- 1921	Frank & William Fageol
49.	Tetraethyl Lead- 1921	C F. Kettreing & T. Midgley
50.	Hydraulic Braking System- 1921	Duesenberg Motor Co.
51.	Rigid Dirigible- 1924	Goodyear Tire Co.
52.	Rigid Airship (Helium)- 1925	U.S. Navy
53.	Bulldozer- 1926	R.G. LeTourneau
54.	Power Steering- 1926	F.W. Davis & G.W. Jessup
55.	Liquid Fueled Rocket- 1926	Robert H. Goddard
56.	Traffic Signal- 1927	Garrett Morgan
57.	Twin Coach Motor Bus- 1928	Frank & William Fageol
58.	Creighton Process (Laminated Glass)- 1928	PPG
59.	Safety Plate-Glass Windshield- 1929	Corning Glass Co.

60.	Flight Simulator- 1929	Edwin Link
61.	Automatic Diesel Engine- 1930	Cummins Diesel Co.
62.	Bathysphere- 1930	C.W. Beebe & Otis Barton
63.	Autogiro- 1931	H.F. Pitcairn
64.	Caterpillar Tractor (Diesel)- 1931	Caterpillar Tractor Co.
65.	Tractor (Rubber Tire)- 1931	B.F. Goodrich
66.	Streamlined Diesel Train- 1932	Ralph Budd
67.	Wind Tunnel- 1932	Ford Motor Co.
68.	Diesel-Electric Railway- 1933	C. Kettering, G. Codrington & H. Hamilton
69.	DC-1- 1933	Douglas Aircraft
70.	Streamlined Production Automobile- 1934	Chrysler Corp.
71.	Piper J-3 "Cub"- 1935	G.C. Taylor & W.T. Piper
72.	Hydromatic Transmission- 1937	General Motors
73.	Chairlift- 1937	Union Pacific R.R.
74.	Flying Boat- 1938	Boeing
75.	Practical Helicopter- 1939	Igor Sikorsky
76.	Automatic Gearbox- 1940	General Motors Co.
77.	RADAR- 1940	Robert M. Page & U.S. Navy
78.	Jeep- 1940	Karl K. Pabst
79.	Jet "P-80"- 1944	Lockheed
80.	Tubeless Tires- 1947	B.F. Goodrich
81.	Bell X-1 (Rocket-Powered Plane)- 1947	Bell Aircraft
82.	Polyester-Resin Boat building- 1948	Irving E. Muskrat & Marco Resins Co.
83.	Key-Start Ignition- 1950	Chrysler Corp.
84.	Fiberglass Automobile- 1953	Chevrolet
85.	Nuclear Submarine- 1955	U.S. Navy
86.	Amphibious Hydrofoil- 1959	Lycoming Co.
87.	Digital Flight Simulator- 1960	Univ. of Pennsylvania
88.	Turbo-Jet Engined Car- 1960	Nathan Ostich
89.	Back-Pack Aero Engine- 1961	Wendell F. Moore
90.	Space Center "Mission Control" - 1961	NASA

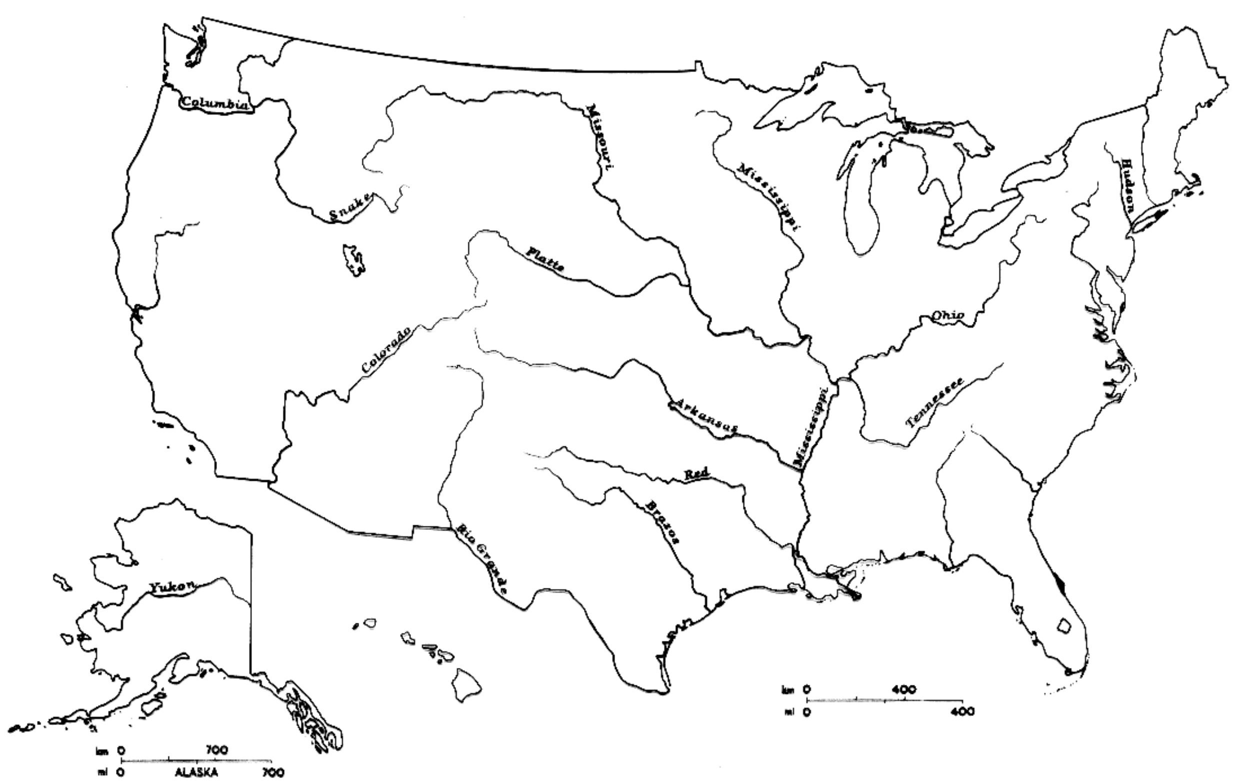
91.	Crawler Transporter- 1962	Marion Power Shovel Co. & NASA
92.	DC-9- 1964	McDonnell-Douglas
93.	Rocket Car- 1967	Reaction Dynamics
94.	Digital Flight Computer- 1969	Honeywell Inc
95.	Jumbo Jet "747"- 1969	Boeing
96.	SR-71 (Supersonic Jet)- 1973	Lockheed Corp.
97.	Rapid Transit System "BART"- 1973	Aero-Engines
98.	Jetfoil- 1975	Boeing
99.	Hybrid Helicopter- 1976	Bell Helicopter Textron & NASA
100.	Human-Powered Aircraft- 1977	Paul Macready
101.	Arneson Drive- 1978	Howard Arneson & Dan Arena
102.	Ceramic Diesel Engine- 1979	Cummins Technical Center
103.	Solar Powered Aircraft- 1980	Paul Macready
104.	Streamlined Cabin Tricycle- 1980	Versatron Research Inc.
105.	Laser Gyro Navigation System- 1982	Honeywell Avionics
106.	90% Plastic Car Engine- 1984	Polimotor Research
107.	Human-Powered Hydrofoil- 1984	Alec Brookes & Allan Abbott
108.	Manned Maneuvering Unit (MMU)- 1984	NASA
109.	Supersonic Swept-Wing Aircraft- 1984	U.S. Air Force
110.	Driverless Automobile- 1985	Carnegie-Mellon Univ.
111.	Unducted Fan Aero-Engine- 1985	General Electric

Maps of the Geography and History of Technology

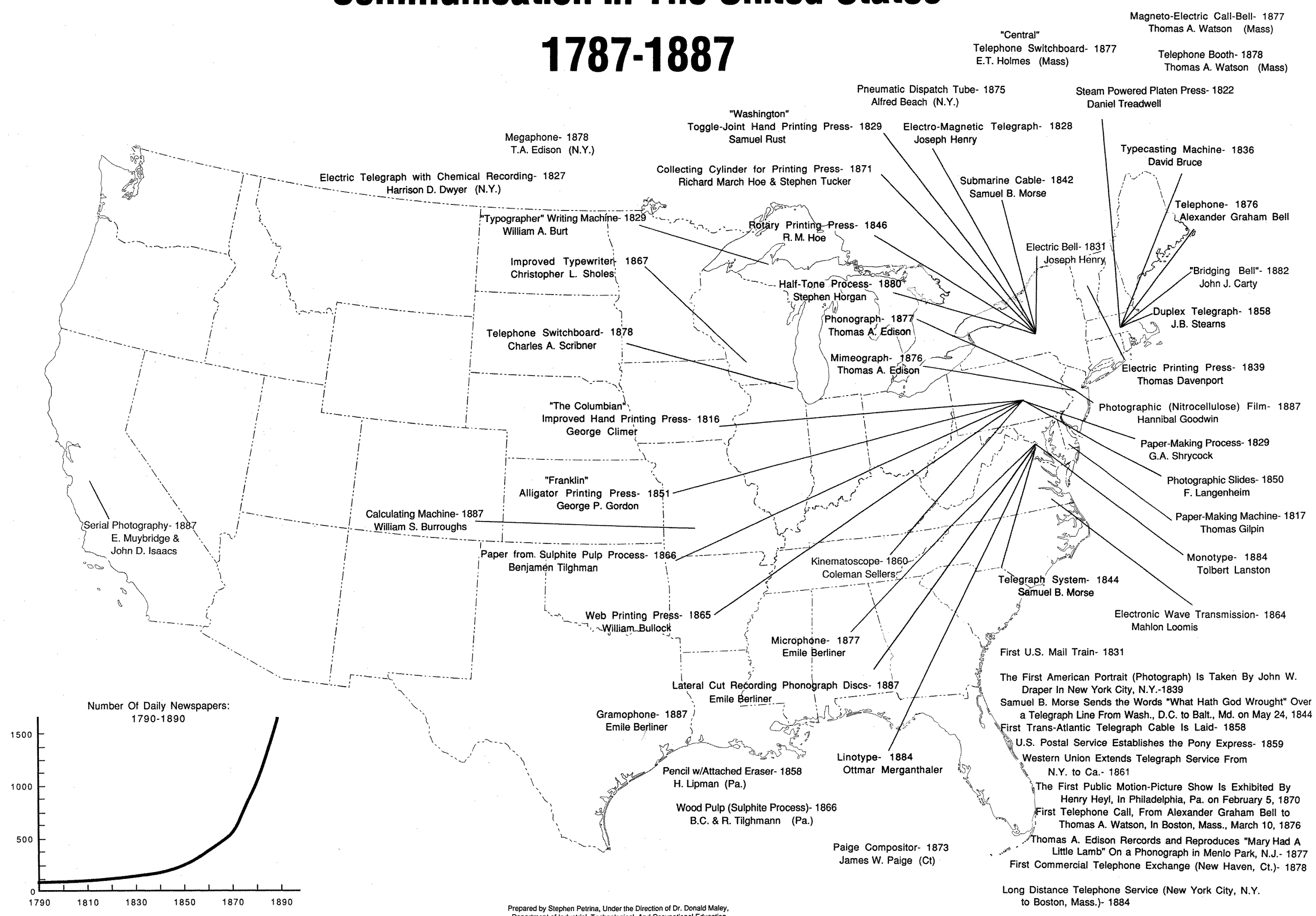
Nearly all of the 700+ inventions and innovations listed above are located on one of the following eight maps of the US. Why are certain types of inventions located in specific geographic areas at certain times? For example, Chicago was the heart of scientific instrument makers in the US since the late 1800s. The Silicon Valley in California was the heart of the computer industry in the US beginning in the 1970s. What are or were the reasons for this? What were the specific resources that made these locations attractive to businesses, so much so that entire industries were established? Were these primarily natural resources or were there other resources that were attractive? Is it an advantage to locate a business in close proximity to other similar businesses? What are the advantages? Or is it more advantageous to open a business in a unique location? Are the new technology industries as tied to geographic locations as older ones, such as the steel industry? These are the types of questions that are raised when we investigate the geography and history of technology.

Technology is always located in geographic space and historical time. Each invention is embedded in a unique cultural and social context— place and time are primary forces in these contexts. The maps project an image of the industrialization of the US, generally from east to west and north to south. In this process, land that was once wild was lost. This process is a significant aspect of the context of our technologies. The expansive urban areas of the northeast, the Baltimore-Washington metropolitan corridor, and the Chicago-Great Lakes region claim broad swaths of land. How do we come to terms with this? What roles do our technologies play?

The eight maps can be printed on an 8.5x11 sheet of paper. The original size of each of the maps is 22 x 30 inches. These originals were scanned at 400 dpi resolution. Each map can be increased to poster (22 x 30) size with minimal reduction in quality. There is also a series of four resource maps, such as the map of major river systems below.



Technological Developments Contributing To The Growth Of Communication In The United States 1787-1887



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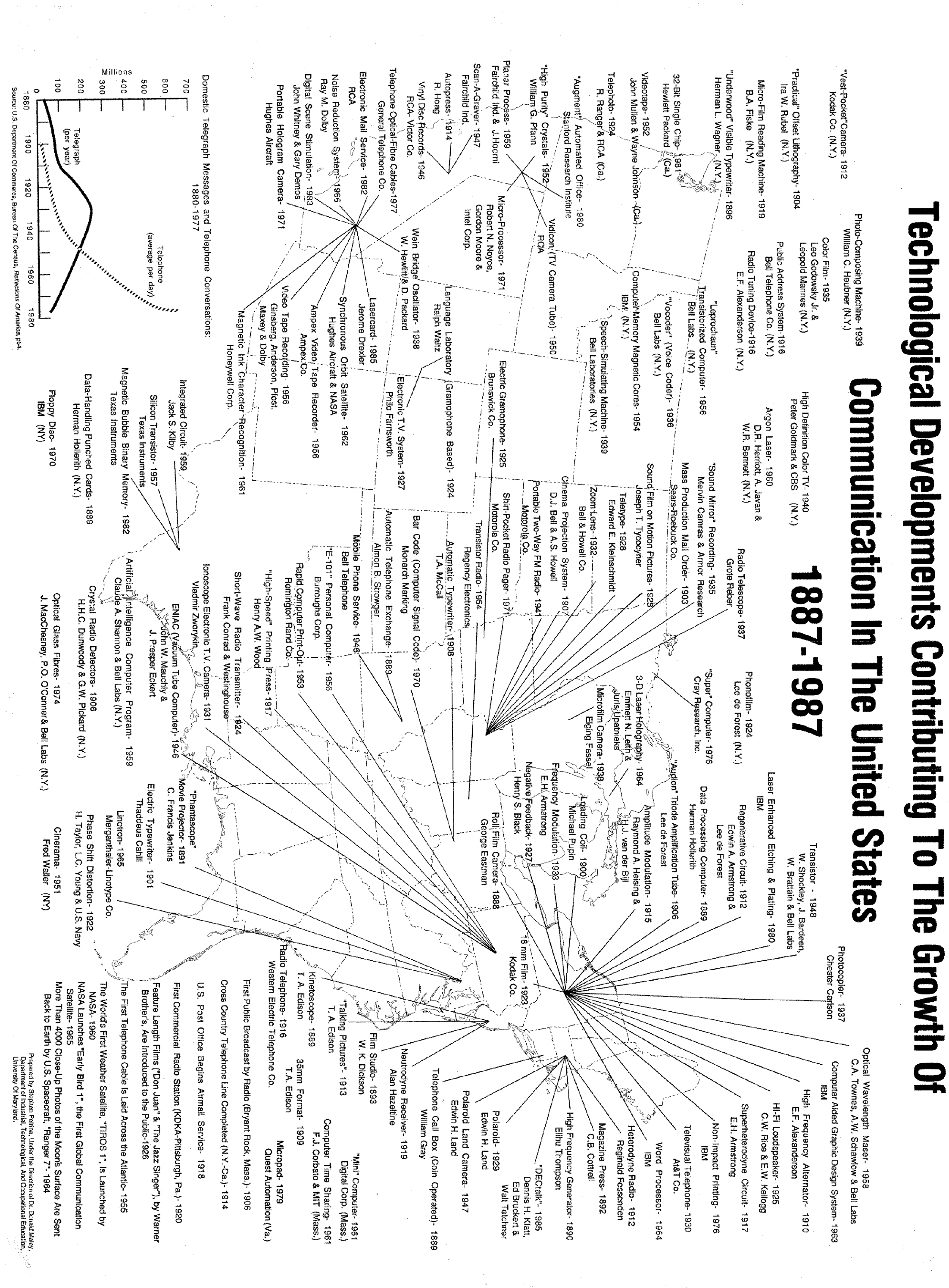
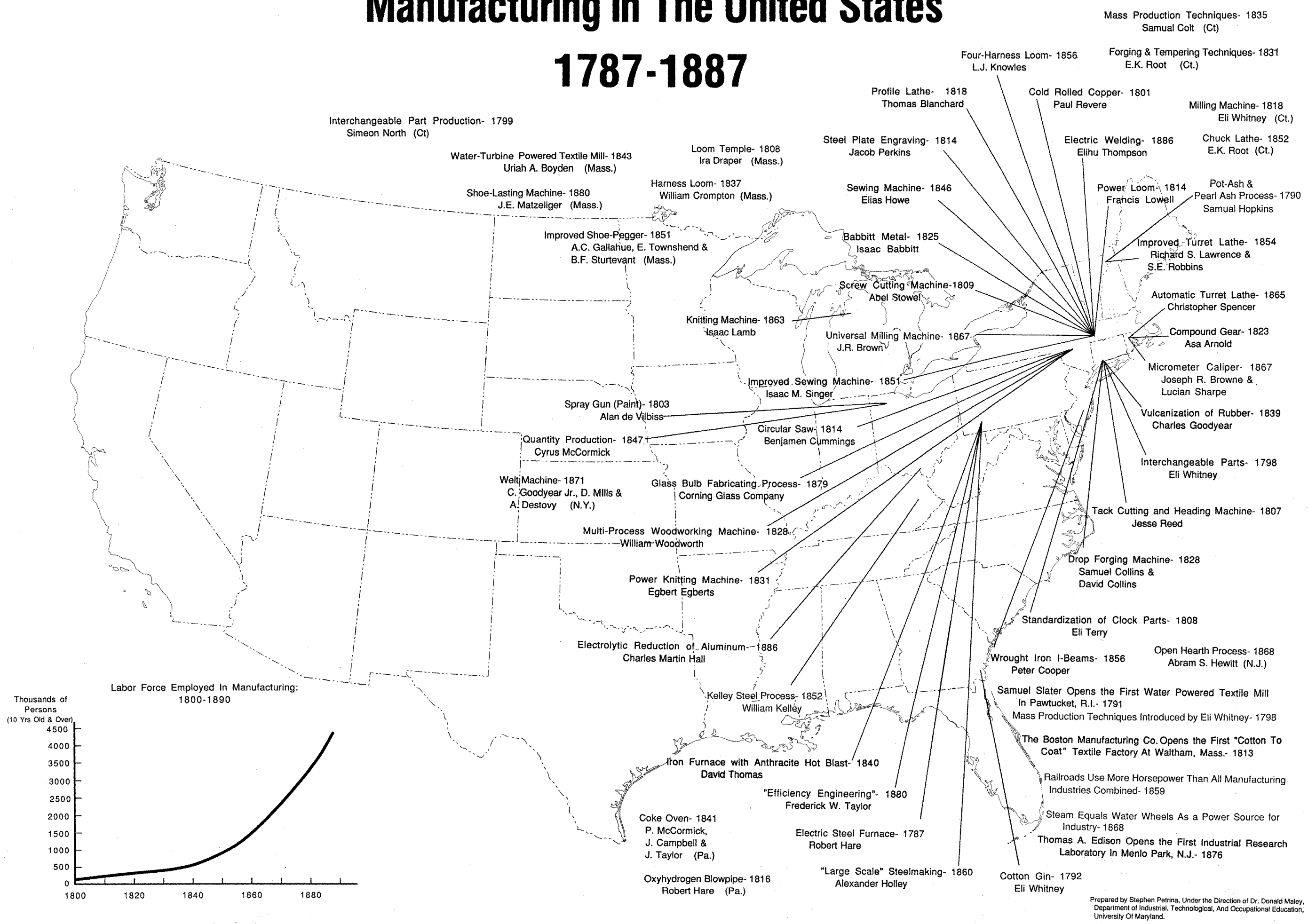
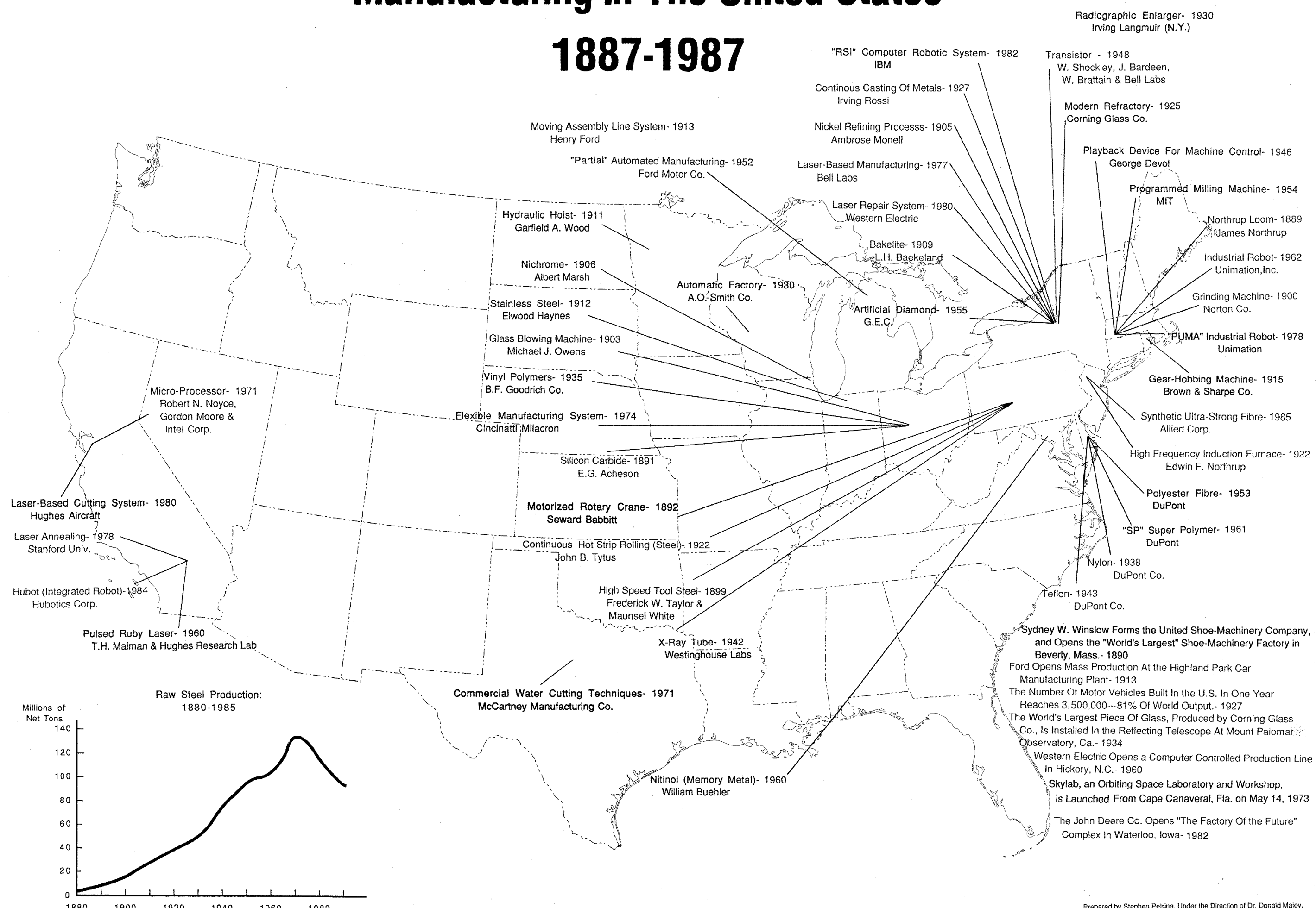

Technological Developments Contributing To The Growth Of Communication In The United States
1887-1987
"Vest-Pocket" Camera- 1912 Kodak Co. (N.Y.)
"Practical" Offset Lithography- 1904 Ira W. Rubel (N.Y.)
Micro-Film Reading Machine- 1919 B.A. Fiske (N.Y.)
"Underwood" Visible Typewriter- 1896 Herman L. Wagner (N.Y.)
32-Bit Single Chip- 1981 Hewlett Packard (Ca.)
Videotape- 1952 John Mullen & Wayne Johnson (Ca.)
Telephoto- 1924 R. Ranger & RCA (Ca.)
"Augment" Automated Office- 1980 Stanford Research Institute
"High Purity" Crystals- 1952 William G. Pfann
Planar Process- 1959 Fairchild Ind. & J.Hoerni
Scan-A-Graver- 1947 Fairchild Ind.
Autopress- 1914 R. Hoag
Vinyl Disc Records- 1946 RCA- Victor Co.
Telephone Optical-Fibre Cables-1977 General Telephone Co.
Electronic Mail Service- 1982 RCA
Noise Reduction System- 1966 Ray M. Dolby
Digital Scene Stimulation- 1983 John Whitney & Gary Demos
Portable Hologram Camera- 1971 Hughes Aircraft
Photo-Composing Machine- 1939 William C. Heubner (N.Y.)
Color Film- 1935 Leo Godowsky Jr. & Leopold Mannes (N.Y.)
Public Address System-1916 Bell Telephone Co. (N.Y.)
Radio Tuning Device-1916 E.F. Alexanderson (N.Y.)
"Leprochaun" Transistorized Computer- 1956 Bell Labs (N.Y.)
"Vocoder" (Voice Coder)- 1936 Bell Labs (N.Y.)
Computer Memory Magnetic Cores- 1954 IBM (N.Y.)
Speech-Simulating Machine- 1939 Bell Laboratories (N.Y.)
Vidicon (TV Camera Tube)- 1950 RCA
Micro-Processor- 1971 Robert N. Noyce, Gordon Moore & Intel Corp.
Electric Gramophone- 1925 Brunswick Co.
Language Laboratory (Gramophone Based)- 1924 Ralph Waltz
Wein Bridge Oscillator- 1938 W. Hewitt & D. Packard
Electronic T.V. System- 1927 Philo Farnsworth
Lasercard- 1985 Jerome Droxler
Synchronous Orbit Satellite- 1962 Hughes Aircraft & NASA
Ampex Video Tape Recorder- 1956 Ampex Co.
Video Tape Recording- 1956 Ginsberg, Anderson, Plost, Maxey & Dolby
Magnetic Ink Character Recognition- 1961 Honeywell Corp.
High Definition Color TV- 1940 Peter Goldmark & CBS (N.Y.)
Argon Laser- 1960 D.R. Herriott, A. Javan & W.R. Bennett (N.Y.)
Radio Telescope- 1937 Grote Reber
"Sound Mirror" Recording- 1935 Mervin Camras & Armor Research
Mass Production Mail Order- 1903 Sears-Roebuck Co.
Sound Film on Motion Pictures- 1923 Joseph T. Tycocyner
Teletype- 1928 Edward E. Kleinschmidt
Zoom Lens- 1932 Bell & Howell Co.
Cinema Projection System- 1907 D.J. Bell & A.S. Howell
Portable Two-Way FM Radio- 1941 Motorola Co.
Shirt-Pocket Radio Pager- 1971 Motorola Co.
Transistor Radio- 1954 Regency Electronics
Automatic Typewriter- 1908 T.A. McCall
Bar Code (Computer Signal Code)- 1970 Monarch Marking
Automatic Telephone Exchange- 1889 Almon B. Strowger
Mobile Phone Service- 1946 Bell Telephone
"E-101" Personal Computer- 1956 Burroughs Corp.
Rapid Computer Print-Out- 1953 Remington Rand Co.
"High-Speed" Printing Press- 1917 Henry A.W. Wood
Short-Wave Radio Transmitter- 1924 Frank Conrad & Westinghouse
Ionoscope Electronic T.V. Camera- 1931 Vladmir Zworykin
ENIAC (Vacuum Tube Computer)- 1946 John W. Mauchly & J. Presper Eckert
Artificial Intelligence Computer Program- 1959 Claude A. Shannon & Bell Labs (N.Y.)
Crystal Radio Detectors- 1906 H.H.C. Dunwoody & G.W. Pickard (N.Y.)
Optical Glass Fibres- 1974 J. MacChesney, P.O. O'Conner & Bell Labs (N.Y.)
Integrated Circuit- 1959 Jack S. Kilby
Silicon Transistor- 1957 Texas Instruments
Magnetic Bubble Binary Memory- 1982 Texas Instruments
Data-Handling Punched Cards- 1889 Herman Hollerith (N.Y.)
Floppy Disc- 1970 IBM (NY)
Phonofilm- 1924 Lee de Forest (N.Y.)
"Super" Computer- 1976 Cray Research, Inc.
3-D Laser Holography- 1964 Emmett N. Leith & Juris Upatnieks
Microfilm Camera- 1938 Elging Fassel
Transistor - 1948 W. Shockley, J. Bardeen, W. Brattain & Bell Labs
Laser Enhanced Etching & Plating- 1980 IBM
Regenerative Circuit- 1912 Edwin A. Armstrong & Lee de Forest
Data Processing Computer- 1889 Herman Hollerith
"Audion" Triode Amplification Tube- 1906 Lee de Forest
Amplitude Modulation- 1915 Raymond A. Heising & H.J. van der Bijl
Loading Coil- 1900 Michael Pupin
Frequency Modulation- 1933 E.H. Armstrong
Negative Feedback- 1927 Henry S. Black
Roll Film Camera- 1888 George Eastman
16 mm Film- 1923 Kodak Co.
"Phantascope" Movie Projector- 1891 C. Francis Jenkins
Electric Typewriter- 1901 Thaddeus Cahill
Linotron- 1965 Merganthaler-Linotype Co.
Phase Shift Distortion- 1922 H. Taylor, L.C. Young & U.S. Navy
Cinerama- 1951 Fred Waller (NY)
Photocopier- 1937 Chester Carlson
Optical Wavelength Maser- 1958 C.A. Townes, A.W. Schawlow & Bell Labs
Computer Aided Graphic Design System- 1963 IBM
High Frequency Alternator- 1910 E.F. Alexanderson
Hi-Fi Loudspeaker- 1925 C.W. Rice & E.W. Kellogg
Superheterodyne Circuit- 1917 E.H. Armstrong
Non-Impact Printing- 1976 IBM
Televisual Telephone- 1930 At&T Co.
Word Processor- 1964 IBM
Heterodyne Radio- 1912 Reginald Fessenden
Magazine Press- 1892 C.B. Cottrell
High Frequency Generator- 1890 Elihu Thompson
"DECtalk"- 1985 Dennis H. Klatt, Ed Bruckert & Walt Tetchner
Polaroid- 1929 Edwin H. Land
Polaroid Land Camera- 1947 Edwin H. Land
Telephone Call Box (Coin Operated)- 1889 William Gray
Neutrodyne Receiver- 1919 Alan Hazeltine
Film Studio- 1893 W. K. Dickson
"Talking Pictures"- 1913 T. A. Edison
Kinetoscope- 1889 T. A. Edison
35mm Format- 1909 T.A. Edison
Radio Telephone- 1916 Western Electric Telephone Co.
"Mini" Computer- 1961 Digital Corp. (Mass.)
Computer Time Sharing- 1961 F.J. Corbato & MIT (Mass.)
Micropad- 1979 Quest Automation (Va.)
First Public Broadcast by Radio (Bryant Rock, Mass.)- 1906
Cross Country Telephone Line Completed (N.Y.-Ca.)- 1914
U.S. Post Office Begins Airmail Service- 1918
First Commercial Radio Station (KDKA-Pittsburgh, Pa.)- 1920
Feature Length Films ("Don Juan" & "The Jazz Singer"), by Warner Brother's, Are Introduced to the Public-1926
The First Telephone Cable Is Laid Across the Atlantic- 1955
The World's First Weather Satellite, "TIROS 1", Is Launched by NASA- 1960
NASA Launches "Early Bird 1", the First Global Communication Satellite- 1965
More Than 4000 Close-Up Photos of the Moon's Surface Are Sent Back to Earth by U.S. Spacecraft, "Ranger 7"- 1964
Domestic Telegraph Messages and Telephone Conversations: 1880-1977
Millions
700
600
500
400
300
200
100
0
1880
1900
1920
1940
1960
1980
Telephone (average per day)
Telegraph (per year)
Source: U.S. Department Of Commerce, Bureau Of The Census, Reflections Of America, p54.
Prepared by Stephen Petrina, Under the Direction of Dr. Donald Maley, Department of Industrial, Technological, And Occupational Education, University Of Maryland.

Technological Developments Contributing To The Growth Of Manufacturing In The United States 1787-1887



Technological Developments Contributing To The Growth Of Manufacturing In The United States 1887-1987



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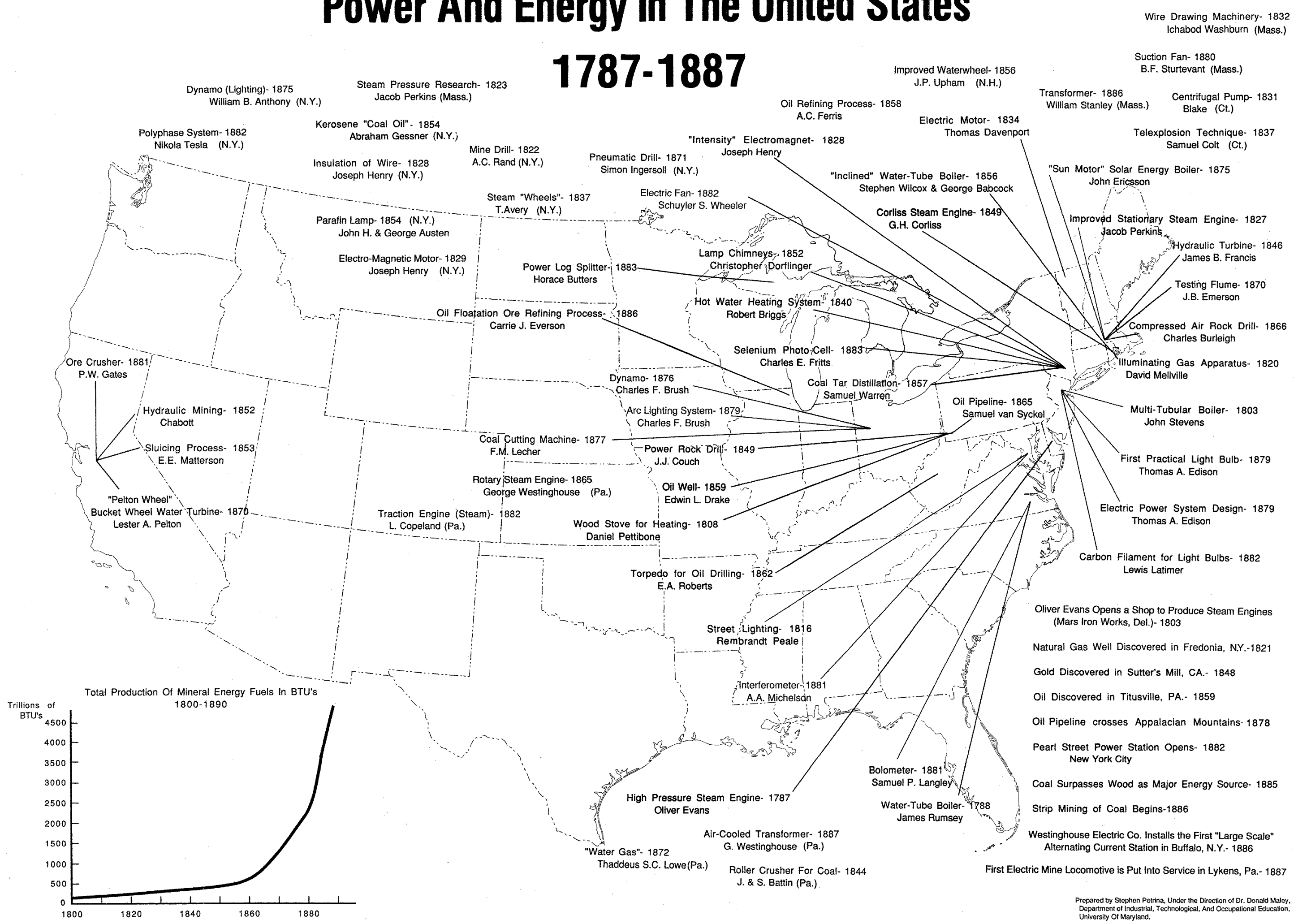
Technological Developments Contributing To The Growth Of Power And Energy In The United States 1787-1887



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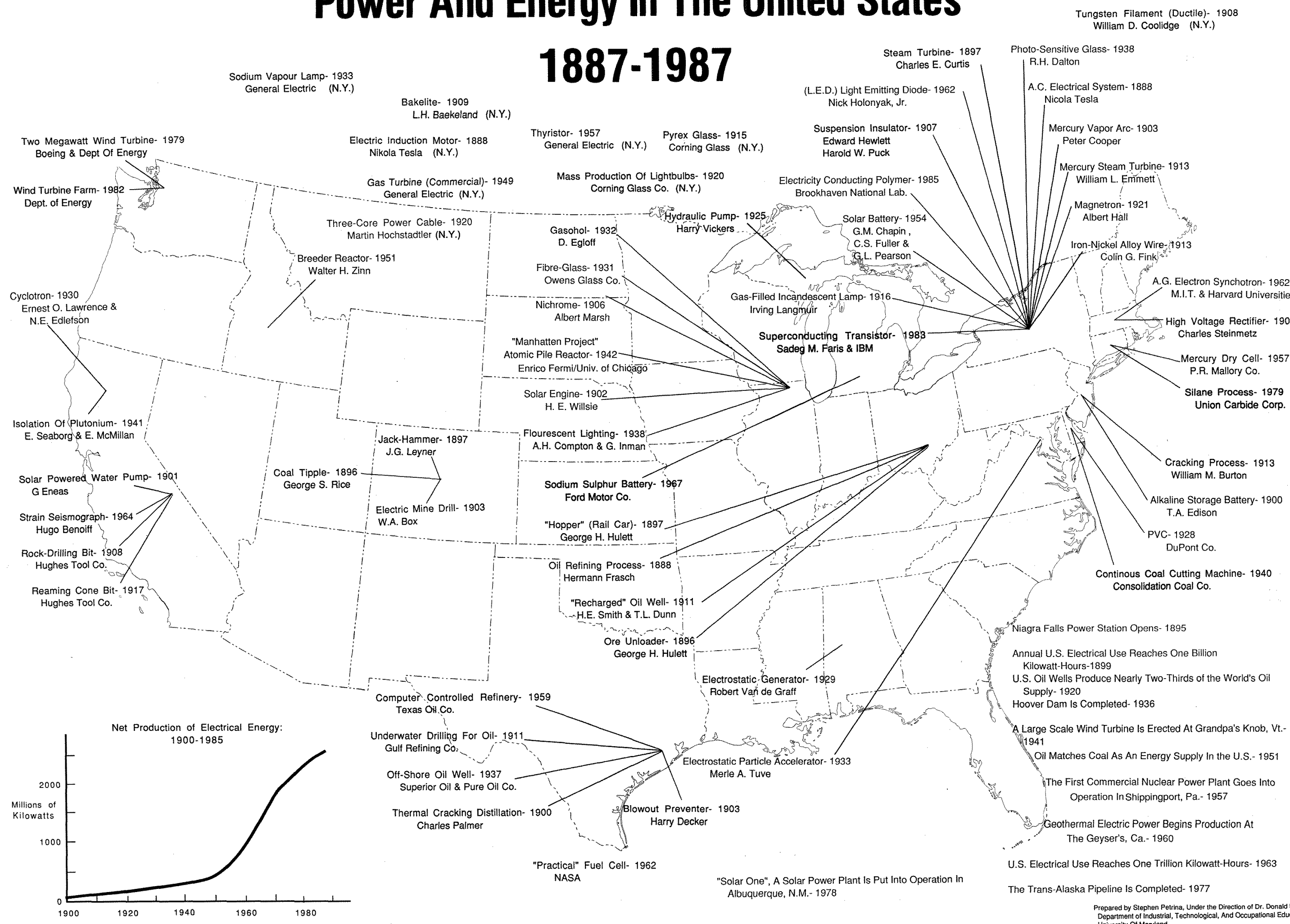
Technological Developments Contributing To The Growth Of Power And Energy In The United States 1887-1987



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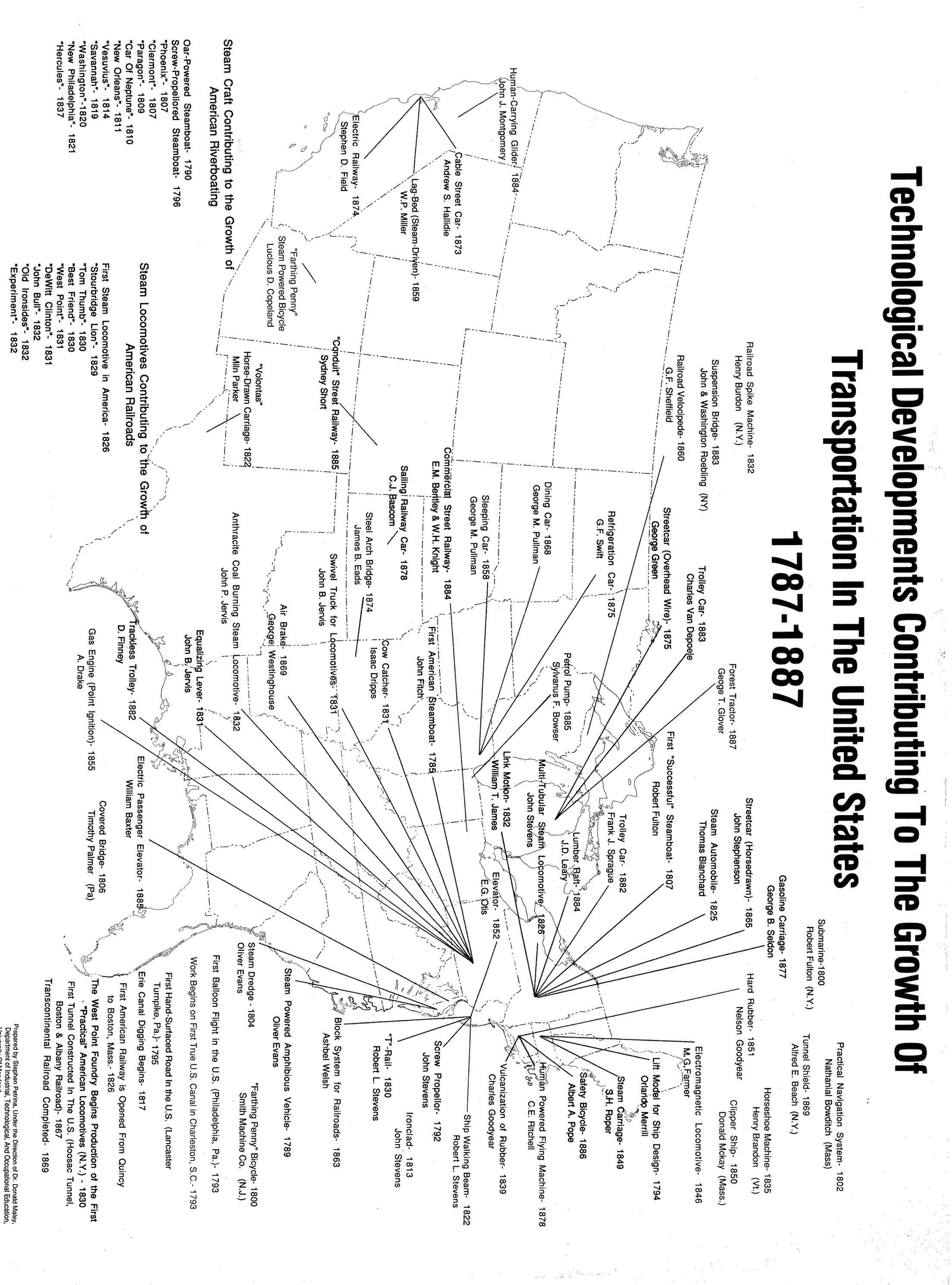
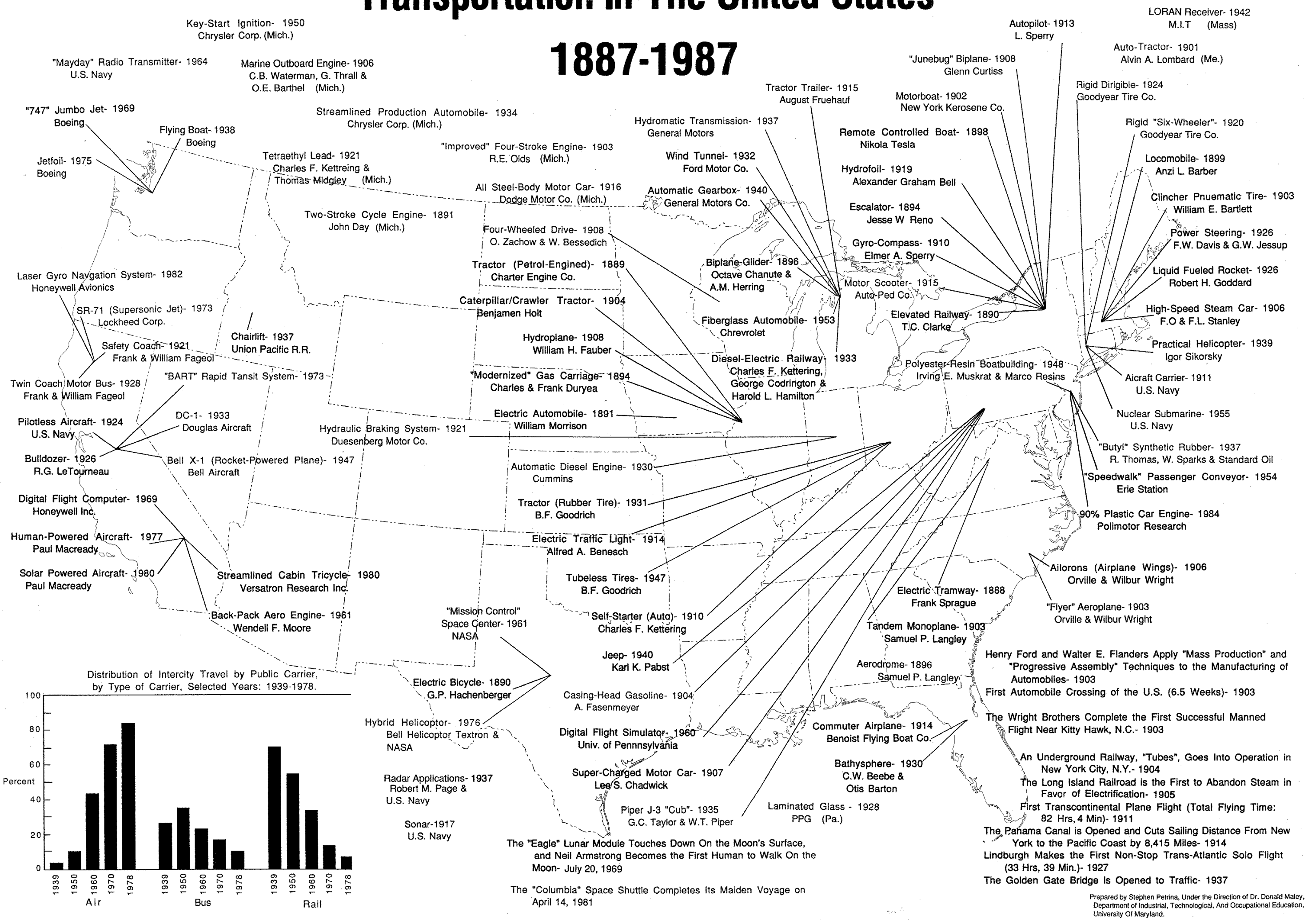
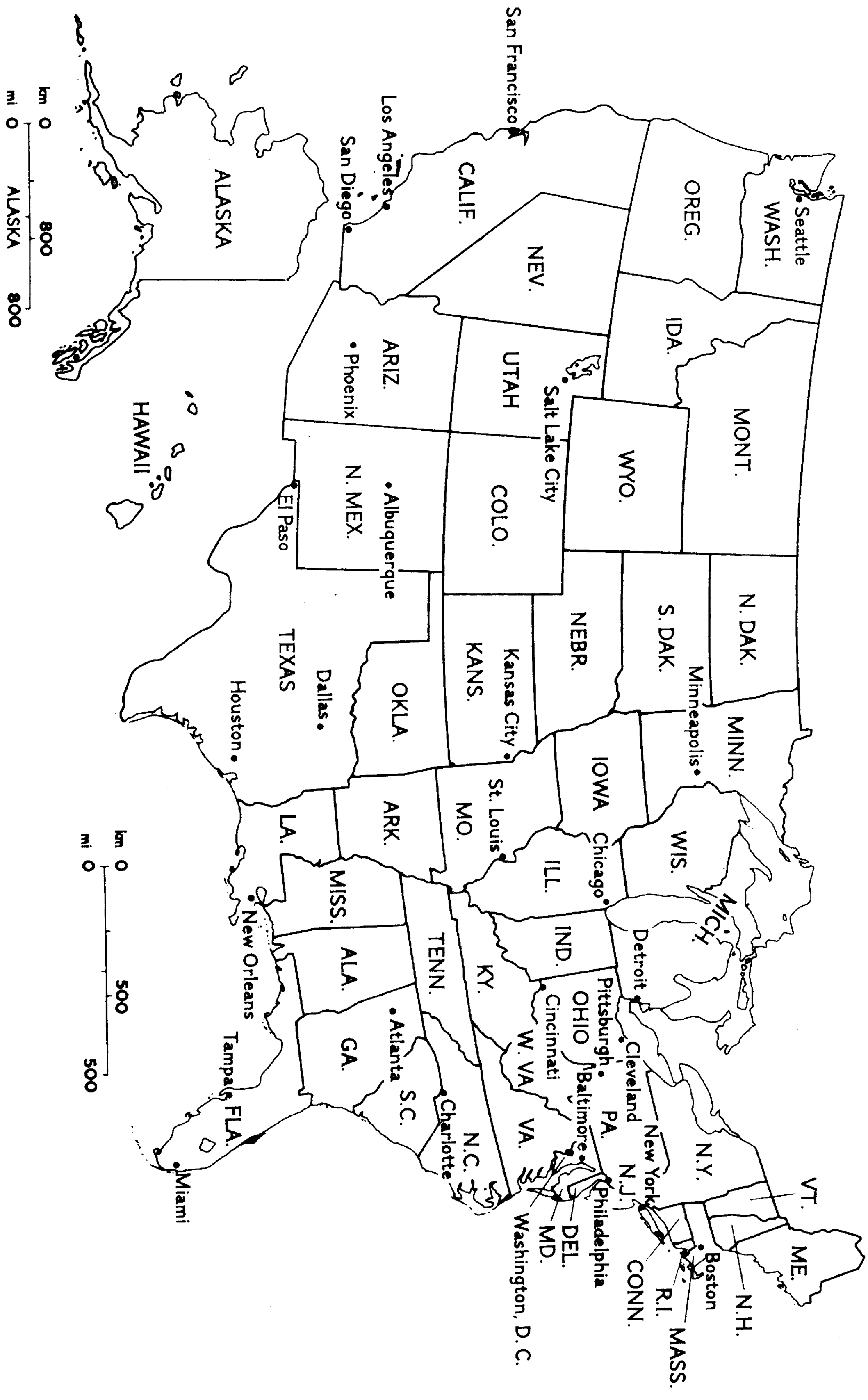

Technological Developments Contributing To The Growth Of Transportation In The United States
1787-1887
Railroad Spike Machine- 1832 Henry Burdon (N.Y.)
Suspension Bridge- 1883 John & Washington Roebling (NY)
Railroad Velocipede- 1860 G.F. Sheffield
Trolley Car- 1883 Charles Van Depoele
Forest Tractor- 1887 Gege T. Glover
Streetcar (Overhead Wire)- 1875 George Green
First "Successful" Steamboat- 1807 Robert Fulton
Streetcar (Horsedrawn)- 1865 John Stephenson
Steam Automobile- 1825 Thomas Blanchard
Gasoline Carriage- 1877 George B. Seldon
Submarine-1800 Robert Fulton (N.Y.)
Practical Navigation System- 1802 Nathanial Bowditch (Mass)
Tunnel Shield- 1869 Alfred E. Beach (N.Y.)
Horseshoe Machine- 1835 Henry Brandon (Vt.)
Hard Rubber- 1851 Nelson Goodyear
Clipper Ship- 1850 Donald Mckay (Mass.)
Electromagnetic Locomotive- 1846 M.G. Farmer
Lift Model for Ship Design- 1794 Orlando Merrill
Steam Carriage- 1849 S.H. Roper
Safety Bicycle- 1886 Albert A. Pope
Human Powered Flying Machine- 1878 C.E. Ritchell
Vulcanization of Rubber- 1839 Charles Goodyear
Ship Walking Beam- 1822 Robert L. Stevens
Screw Propellor- 1792 John Stevens
Ironclad- 1813 John Stevens
"T"-Rail- 1830 Robert L. Stevens
Block System for Railroads- 1863 Ashbel Welsh
Steam Powered Amphibious Vehicle- 1789 Oliver Evans
Steam Dredge - 1804 Oliver Evans
"Farthing Penny" Bicycle- 1800 Smith Machine Co. (N.J.)
First Balloon Flight in the U.S. (Philadelphia, Pa.)- 1793
Work Begins on First True U.S. Canal in Charleston, S.C.- 1793
First Hand-Surfaced Road In the U.S. (Lancaster Turnpike, Pa.)- 1795
Erie Canal Digging Begins- 1817
First American Railway is Opened From Quincy to Boston, Mass.- 1826
The West Point Foundry Begins Production of the First - "Practical" American Locomotives (N.Y.) - 1830
First Tunnel Constructed In The U.S. (Hoosac Tunnel, Boston & Albany Railroad)- 1867
Transcontinental Railroad Completed- 1869
Trolley Car- 1882 Frank J. Sprague
Lumber Raft- 1884 J.D. Leary
Refrigeration Car- 1875 G.F. Swift
Petrol Pump- 1885 Sylvanus F. Bowser
Multi-Tubular Steam Locomotive- 1826 John Stevens
Dining Car- 1868 George M. Pullman
Link Motion- 1832 William T. James
Elevator- 1852 E.G. Otis
Sleeping Car- 1858 George M. Pullman
Commercial Street Railway- 1884 E.M. Bentley & W.H. Knight
First American Steamboat- 1785 John Fitch
Sailing Railway Car- 1878 C.J. Bascom
Cow Catcher- 1831 Isaac Dripps
Steel Arch Bridge- 1874 James B. Eads
Swivel Truck for Locomotives- 1831 John B. Jervis
"Conduit" Street Railway- 1885 Sydney Short
Air Brake- 1869 George Westinghouse
"Volontas" Horse-Drawn Carriage- 1822 Miln Parker
Anthracite Coal Burning Steam Locomotive- 1832 John P. Jervis
Equalizing Lever- 1831 John B. Jervis
Trackless Trolley- 1882 D. Finney
Electric Passenger Elevator- 1885 William Baxter
Covered Bridge- 1806 Timothy Palmer (Pa)
Gas Engine (Point Ignition)- 1855 A. Drake
Human-Carrying Glider- 1884 John J. Montgomery
Cable Street Car- 1873 Andrew S. Hallidie
Lag-Bed (Steam-Driven)- 1859 W.P. Miller
Electric Railway- 1874 Stephen D. Field
"Farthing Penny" Steam Powered Bicycle Lucious D. Copeland
Steam Craft Contributing to the Growth of American Riverboating
Oar-Powered Steamboat- 1790
Screw-Propellored Steamboat- 1796
"Phoenix"- 1807
"Clermont"- 1807
"Paragon"- 1809
"Car Of Neptune"- 1810
"New Orleans"- 1811
"Vesuvius"- 1814
"Savannah"- 1819
"Washington"-1820
"New Philadelphia"- 1821
"Hercules"- 1837
Steam Locomotives Contributing to the Growth of American Railroads
First Steam Locomotive in America- 1826
"Stourbridge Lion"- 1829
"Tom Thumb"- 1830
"Best Friend"- 1830
"West Point"- 1831
"DeWitt Clinton"- 1831
"John Bull"- 1832
"Old Ironsides"- 1832
"Experiment"- 1832
Prepared by Stephen Petrina, Under the Direction of Dr. Donald Maley, Department of Industrial, Technological, And Occupational Education, University Of Maryland.

Technological Developments Contributing To The Growth Of Transportation In The United States 1887-1987

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El Paso
N. DAK.
S. DAK.
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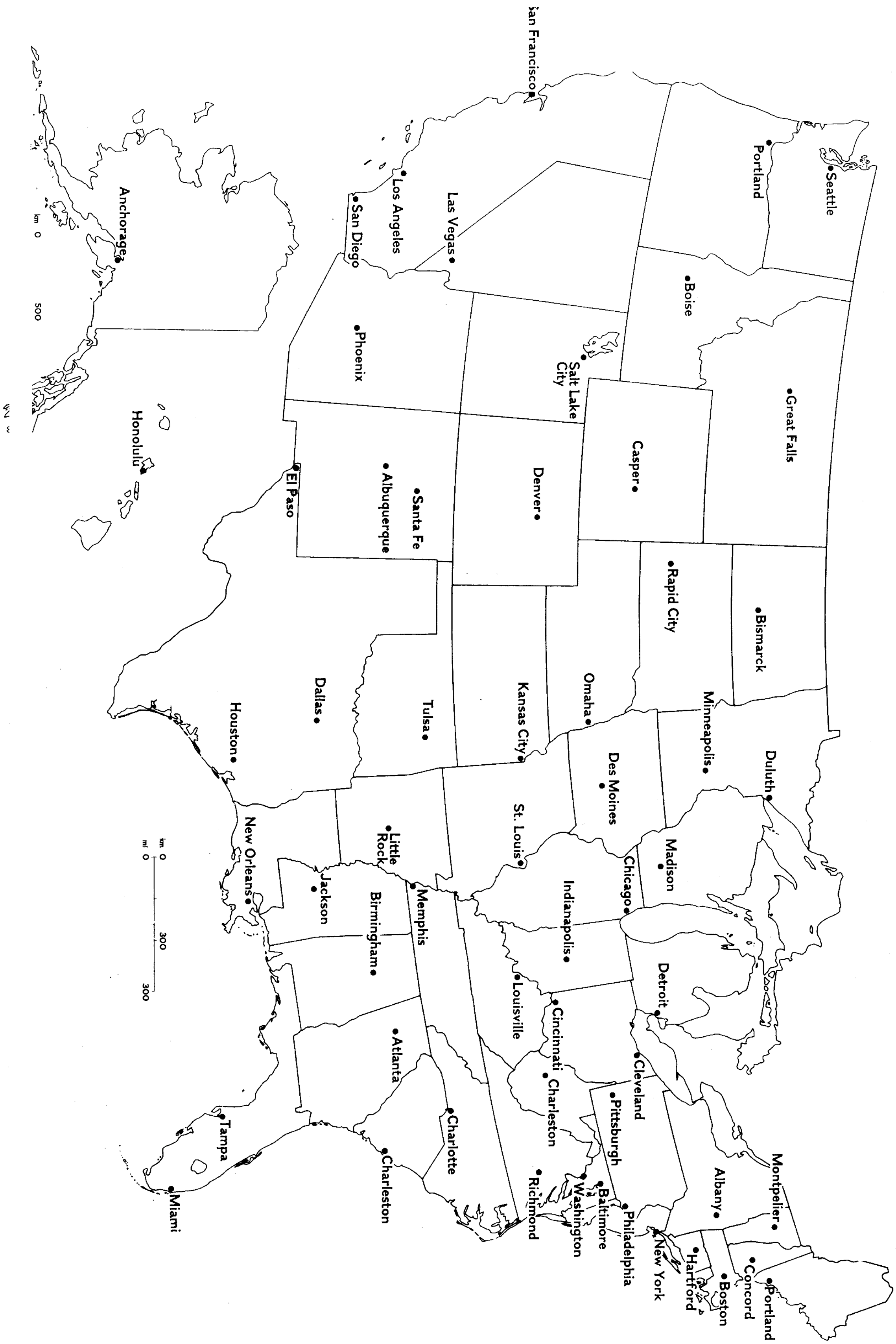
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Santa Fe
Denver
Rapid City
Bismarck
Dallas
Houston
Tulsa
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Minneapolis
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Des Moines
St. Louis
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New Orleans
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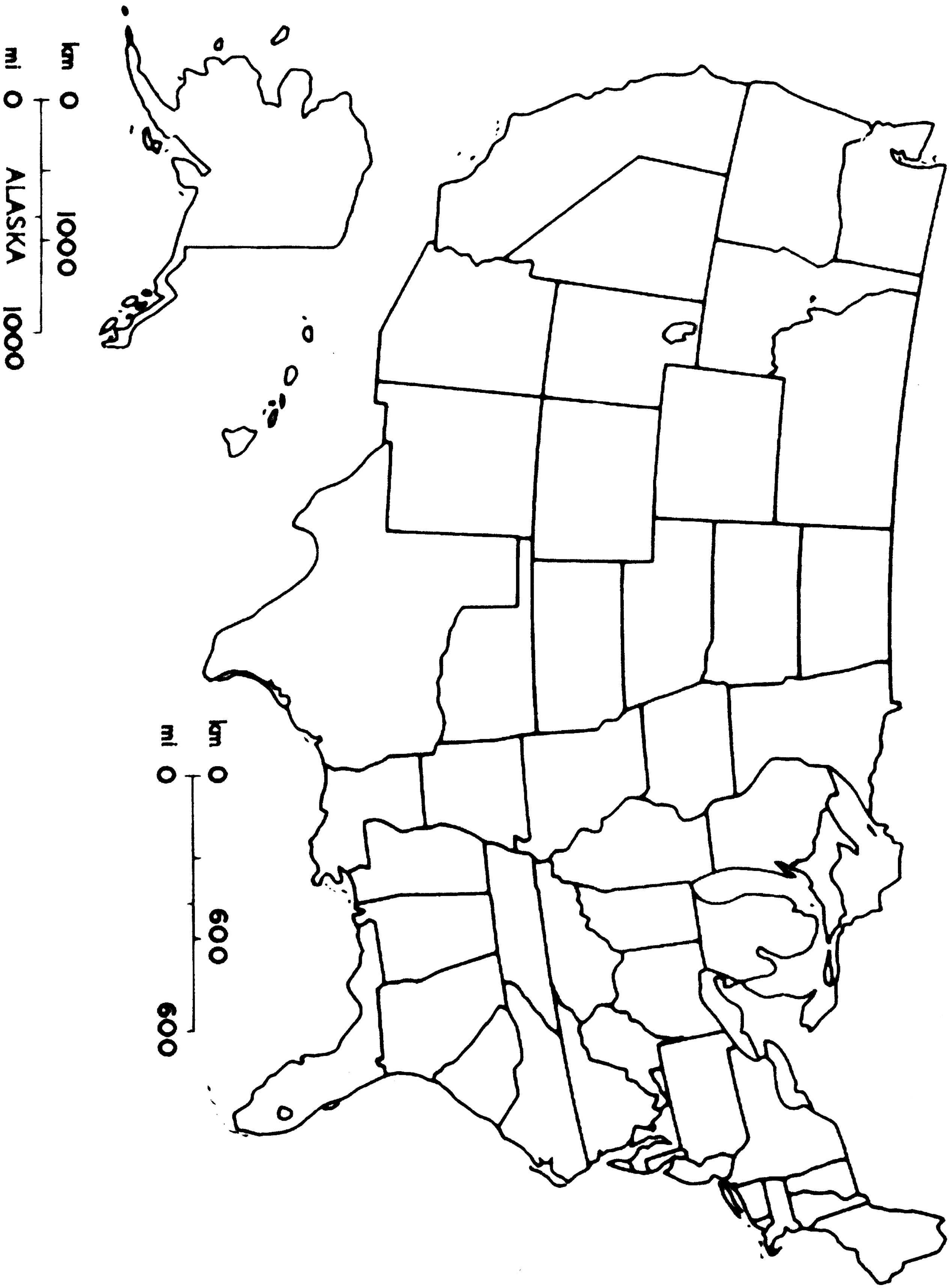
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Selected Resources

Almost daily, rich resources for teaching the geography and history of technology are made available and accessible to students and teachers. The US Library of Congress, for example, has made thousands of historical resources available for downloading. Film clips and photos from the early twentieth century provide an amazingly graphic look at labor and technology in factories, fields and offices. The Prelinger Collection in the Library of Congress contains hundreds of films and film clips produced by advertisers and marketers of technology and documentary film makers (http://www.prelinger.com/prelarch.html).

The Westinghouse films from the early 1900s, are among the earliest and best portrayals of factory work from that time (http://memory.loc.gov/ammem/papr/west/westhome.html). There are thousands of still photos online that portray the realities of war and military technologies, or of child labor and shoe and textile technologies. For example, Lewis Hines' famous photos are readily available for downloading and integration into lessons on child labor (http://www.historyplace.com/unitedstates/childlabor/index.html). The Library of Congress's "Who Really Built America?" Project contains hundreds of files for classroom use (http://memory.loc.gov/learn/lessons/98/built/) and the Lost Labor Archive contains high quality still photos (http://www.lostlabor.com/index.htm). Military images, at the Defense Visual Information Center, are extensively available and helpful for understanding the role of technology in defense and security (http://www.dodmedia.osd.mil/dvic/menu03.htm).

The National Archives Digital Classroom project is a good place to begin to browse the historic images that are in the public domain (http://www.archives.gov/digital_classroom/). The US Patent and Trademark Office has also made a large volume of resources, such as patent and trademark drawings, available for on-line work and downloading (http://www.uspto.gov/ and http://www.uspto.gov/patft/index.html and http://www.myoutbox.net/polist.htm). At the turn of last century (1900) women received about 1% of all patents. Currently, women receive 11% of the total, due to a sharp increase (mainly in biotechnologies) during the 1990s. Great portals are maintained for the history of female inventors (http://www.stemnet.nf.ca/CITE/inventorsfemale.htm) and African American inventors (http://www.enchantedlearning.com/inventors/black.shtml) and databases (http://www.slpl.lib.mo.us/libsrc/inv20.htm) or (http://www.detroit.lib.mi.us/glptc/aaid/index.asp).

The virtual museums on the web are plentiful and extremely helpful for educational resources on minority invention and the history of invention in general (http://americanhistory.si.edu/ve/, http://vmoc.museophile.com/ and http://www.ieee.org/organizations/history_center/related_sites/inventors.html). Some of the best textbooks, such as *Inventing America*, now come with CD ROMs and thousands of images and audio or video clips. The following resources are among the most helpful for teachers and students.

Professional Associations

American Society of Civil Engineers (ASCE): Sponsors the Civil Engineering Landmarks project and offers a wealth of materials for teachers related to the History and Heritage of Civil Engineering (http://www.asce.org/history/hp_main.html).

American Society of Mechanical Engineers (ASME): Sponsors the Mechanical and Civil Engineering Landmarks. The Landmarks are richly described in a series of impressively detailed pamphlets (http://www.asme.org/history/index.html) (http://www.asme.org/history/brochure.html).

Council on Technology Teacher Education (CTTE): Sponsors a wide range of materials and policies for teachers and teacher educators, including the *Journal of Technology Education* (http://teched.vt.edu/ctte/).

Exploring and Collecting History Online (ECHO): A great portal for finding online resources in the history of technology. (http://echo.gmu.edu/).

George Meaney Center for Labor Studies: Publishes a variety of resources for understanding and teaching about the history of Labor in the US (http://www.georgemeany.org/).

History of Science Society (HSS): Publishes *ISIS* and sponsors research on the history of science and technology (http://www.hssonline.org/).

Industrial Designers Society of America (IDSA): Publishes *Innovation* and sponsors a wealth of resources for design, invention and innovation (http://www.idsa.org/).

International Technology Education Association (ITEA): Sponsors a variety of policies and resources for technology teachers, including *The Technology Teacher* and *Technology and Children*. The poster series and monographs (*Technology Resource Packet* and *STS Resource Packet*) prepared by graduate students at the University of Maryland under the direction of Donald Maley are most relevant to the geography and history of technology (http://www.iteawww.org/).

Lemelson Center: The Jerome and Dorothy Lemelson Center at the National Museum of American History is particularly helpful rich resource for the history of invention and innovation. Whole Cloth, a Lemelson project sponsored by SHOT, is an extremely rich resource for manufacturing, mainly textile, history. Primarily for high school teachers and students\ (http://www.si.edu/lemelson/ and http://www.si.edu/lemelson/centerpieces/whole_cloth/).

National Academy of Engineering (NAE): Sponsors a number of projects related to the welfare of engineering and its history. Their Technological Literacy project is of particular interest (http://www.nae.edu/nae/techlithome.nsf/weblinks/CTON-557RLU?OpenDocument).

National Center for Economic and Security Alternatives: Publishes the Index of Environmental Trends, which contains very helpful data for tracking environmental changes in history (http://www.ncesa.org/html/publications.html).

National Geographic Society: Publishes *National Geographic* magazine and a wide variety of resources for teachers. Published the *Making of America* series of maps during the1980s which are an outstanding integration of history, geography and technology. For scholars of geography, teachers and students (http://www.nationalgeographic.com/).

National History Day: Sponsors the design of teaching materials each year. In 1999, the theme was Science, Technology, Invention in History and generated a rich resource of online materials (http://nationalhistoryday.org/03_educators/teach99/index.html

Northern Prairies Wildlife Research Center: Offers a very helpful report of wetlands degradation from the 1790s to the 1990s (http://www.npwrc.usgs.gov/resource/othrdata/wetloss/wetloss.htm#contents).

Smithsonian Institution: A network of museums that deal with the history of American technology. Publishes the *Smithsonian Guide to Historic America* (http://www.si.gov/).

Society for the History of Technology (SHOT): Publishes a range of monographs and the academic journal *Technology and Culture*. For scholars of the history of technology, teachers and post-secondary students (http://shot.press.jhu.edu/).

United States Historical Census Browser: Provides statistics from *Measuring America: The Decennial Census from 1790-2000*. Extremely helpful databases can be found on their website(http://fisher.lib.virginia.edu/collections/stats/histcensus/).

United States Environmental Protection Agency: Provides extremely relevant data on the health of the environment over time. Their Bioindicators site is especially helpful (http://www.epa.gov/bioindicators/).

United States Patent and Trademark Office: Center of intellectual property in the US. Offers a variety of historical resources (http://www.uspto.gov/).

World Resources Institute: Watchdog organization that publishes *World Resources: Environmental Change and Human Health*. Helpful statistics can be found at http://www.wri.org/wri/wr-98-99/.

Publishers for Immediate Classroom Use

American Heritage of Technology and Invention: Popular magazine. For teachers and secondary school students (http://www.inventionandtechnology.com/.

American Social History Project and the Center for History and New Media published two extremely effective books and CD ROMs in their *Who Built America?* Series. These are very rich resources for teachers and secondary school students. The CDs contain hundreds of primary documents, photos and video clips on labor history and the history of technology (http://www.whobuiltamerica.org/).

Labor's Heritage: Popular magazine. For teachers and secondary school students. An excellent resource for labor history (http://www.georgemeany.org/archives/lh.html).

Tech Directions Books: Popular magazine for technology teachers. Publishes *Tech Directions* and a great series of posters and books. Nice collection of resources documenting minority inventors (http://www.techdirections.com/).

Technology, Innovation and Entrepreneurship for Students (TIES): Popular magazine for students and teachers. An excellent source of ideas and information related to design and technology (http://www.tiesmagazine.org/).

The Great Idea Finder (TGIF): Website. A very resource-intensive site for inspiring students to design and innovate (http://www.ideafinder.com/home.htm).

Grade 8-12 Books for Immediate Classroom Use

James, P. (1989). *The real McCoy: African-American invention and innovation, 1619-1930*. Washington, DC: Smithsonian Institution Press.

Karwatka, D. (1999). *Technology's past: America's industrial revolution and the people who delivered the goods*. Ann Arbor, MI: Prakken.

Karwatka, D. (1999). *Technology's past, volume II: More heroes of invention and innovation*. Ann Arbor, MI: Prakken.

Karwatka, D. (2003). *Building civilization: The growth of production*. Ann Arbor, MI: Prakken.

Karwatka, D. (2003). *Connecting civilization: The growth of communication*. Ann Arbor, MI: Prakken.

Karwatka, D. (2003). *Moving civilization: The growth of production*. Ann Arbor, MI: Prakken.

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Webster, R. (1999). *African American firsts in science and technology*. Detroit: Thomson & Gale.

Resource Books on the History of Women Inventors

Corea, G. (1995). *The mother machine: reproductive technologies from artificial insemination to artificial wombs*. New York: Harper & Row.

Cowan, R. S. (1983). *More work for mother*. New York: basic Books.

MacDonald, A. (1992). *Feminine ingenuity: Women and invention in America*. New York: Ballantine.

Oldenziel, R. (1999). *Making technology masculine: Men, women and modern machine in America, 1870-1945*. Amsterdam: Amsterdam University Press.

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Vare, E. A. and Ptacek, G. (1988). *Mothers of invention: From the bra to the bomb- Forgotten women & their unforgettable ideas*. New York: Morrow.

Vare, E. A. and Ptacek, G. (2002). *Patently female: From AZT to TV dinners*. New York: Wiley.

Wosk, J. (2001). *Women and the machine: Representations from the spinning wheel to the electronic age*. Baltimore: Johns Hopkins University Press.

Grade 8-12 CD ROMs and Videos for Immediate Classroom Use

African American Chronicle Educational Software Publishing Company. (1996). *African-American inventors and innovators, CD ROM*. Minneapolis: Author.

American Social History Project. (1993). *Who built America?, CD ROMs 1-2*. New York: Center for history and new media.

American Society of Mechanical Engineers. (1987). *Mothers of invention*. Wayne, NJ: Karol Media.

Compton's Media. (1996). *The genius of Edison, CD ROM*. Cambridge, MA: Author.

Educational Video Services. (2001). *The black inventor and the patent, CD ROM*. New York: Macromedia.

Lemelson Center. (2002). *She's got it! Women inventors and their inspirations*. Washington, DC: Author.

MPI Home Video. (1991). *The entrepreneurs: An American adventure, Volumes 1-3*. Oak Forest, IL: Author.

US Patent and Trademark Office. (1990). *A bicentennial tribute, Women inventors, 1790-1990*. Washington, DC: Author.

US Patent and Trademark Office. (1998). *From dreams to reality: A tribute to minority inventors*. Washington, DC: Author.

US Patent and Trademark Office. (2002). *Minority inventors: America's tapestry of innovation*. Washington, DC: Author.

Articles and Books with Statistical Information

Berlow, L. (1998). *The reference guide to famous engineering landmarks of the world: Bridges, tunnels, dams, roads, and other structures*. Phoenix: Oryx.

Bernstein, P. (1999). *The statistical handbook of technology*. Phoenix: Oryx.

Carter, S. (Ed.). (1997). *Historical Statistics of the United States on CD Rom, Colonial Times to 1970: Bicentennial Edition*. New York: Cambridge University Press,

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Lienhard, J. (1979). The rate of technological improvement before and after the 1930s. *Technology and Culture, 20*(3), 515-530.

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US Department of the Interior. (2003). *Minerals yearbook*. Washington, DC: Government Printing Office.

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Zero Population Growth. (1988). *USA by numbers*. Washington, DC: ZPG.

Academic Journals in Science and Technology Studies

Appropriate Technology
Appropriate Technology Journal

Alternatives: Technology and Ecology
Antipode
Architecture
Architecture Digest
Architecture and Ideas
Architecture and Planning
Architectural History
Business and Economic History
Business History Review
Environmental Science and Technology
Enterprise and Society
Futurist
Design Issues
Design Studies
History and Technology
IEEE Annals of the History of Computing
Journal of Cultural Geography

Journal of Design History
Journal of Historical Geography
Journal of Material Culture
Journal of the Society of Architectural Historians
Journal of Urban Technology
Invention and Technology (American Heritage)
ISIS
Labor History
Labor's Heritage
Labor Studies Journal
Perspectives on Science
Public Understanding of Science
Science and Technology Studies
Science as Culture
Science, Technology and Human Values
Science and Society
Science and Culture

Science in Context
Science Studies
Social Studies of Science
Technology and Society
Technology in Society
Technology Studies

Technology and Culture
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Transactions of the Newcomen Society

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