Course: Science, Technology and Society

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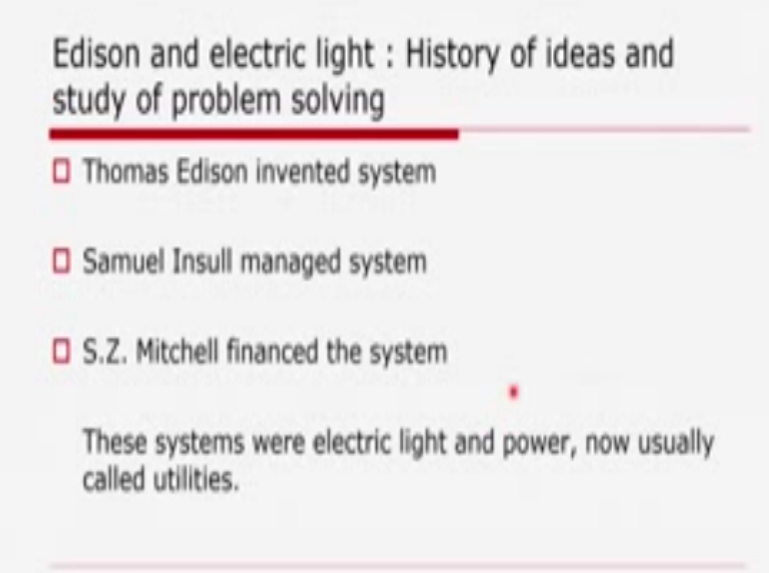
Week: 09 (Social Shaping of Technology II)

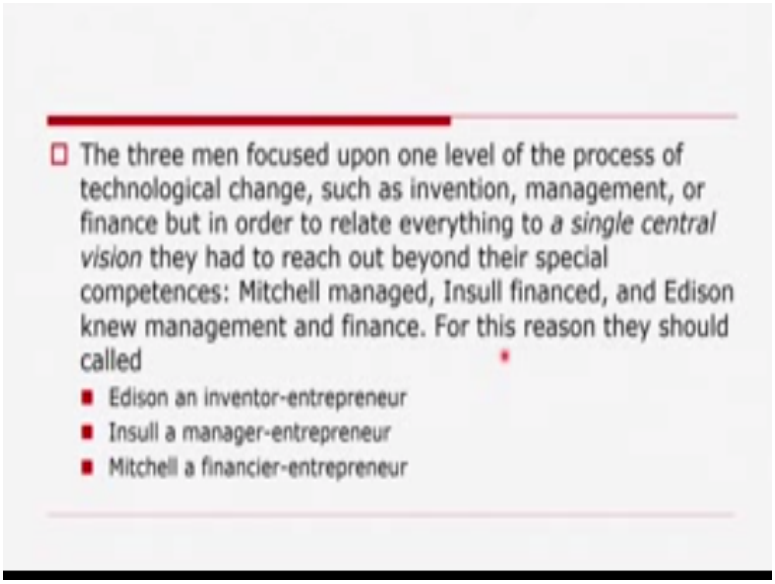
Lecture: 27 (Thomas Edison)

Staying on with the social shaping of technology in contradistinction with the technological shaping of society or the technological shaping of technology itself, because S T S scholars we always try to look at the dialectical relationship between three forces of production namely, science one, technology two, and society three, because we always believe in the fact that science and technology are not independent systems of thought, rather they are a byproducts of society. And we have discussed in the context of New York bridge by Robert Moses, we have discussed in the context of the political construal of technological systems, we have discussed technology as knowledge. Now, we are going to discuss Thomas Hughes's paper on or reflection on Thomas Alva Edison and the invention of electric bulb, electric in the context of history of ideas and the study of problem solving. We all know that Thomas Edison invented electric bulb, , but how he did it in the context of history of ideas and the study of problem solving, let us see.



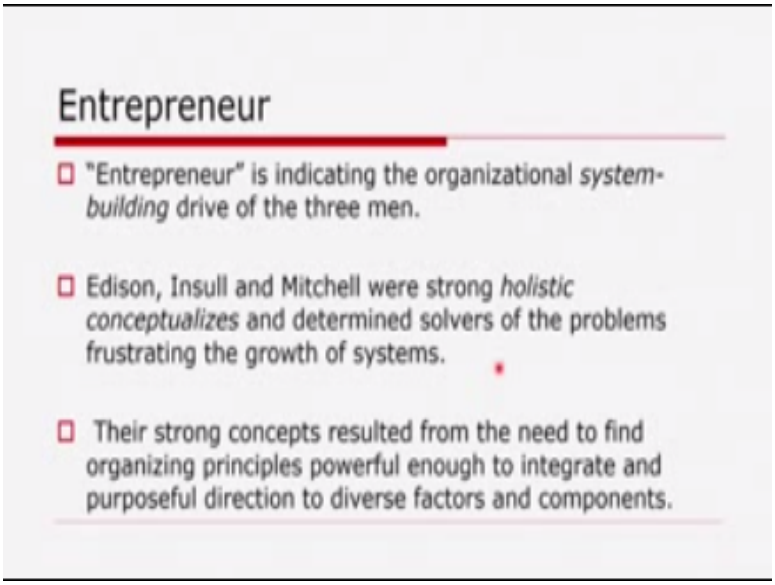
In fact, Thomas Edison invented systems, Insull ,Samuel Insull managed systems and Mitchell financed their expense. And these t three systems one is one is related to invention, second is related to management, third is related to finance, because whenever we produce something it must have some kind of implications may be social, may be economic, may be political, may be cultural and so on.

And these systems were electric light and power and now usually called utilities, what is utility? In economics in basic economics utility means want satisfying power of a commodity, then what is a commodity? A commodity is that which has got exchange value, in this sense we are using. Suppose, if I say water in a river may have more use value, but diamond has more exchange value, in this sense we are using utility want satisfying power of a commodity. And Edison invented the system the system of electric light that took form as the Paul Street generating station of the New York Edison illuminating company, now it is known as consolidated Edison company.



Insull on the other hand managed electric light and power companies that consolidated into Chicago's commonwealth Edison company. And S. Z. Mitchell, he provided for the growth of large regional power systems. Then in this context, one may say Edison as an inventor-entrepreneur, Insull as a manager- entrepreneur and Mitchell as a financier- entrepreneur. But, so far as these lectures are concerned we will restrict our purview to Edison as an inventor entrepreneur.

But, the background against which we are going to discuss Edison as an inventor entrepreneur must involve both Samuel Insull and Mitchell as a manager- entrepreneur and a financier- entrepreneur respectively. Let us see how they did and these three individuals, these three individuals namely Edison, Insull and Mitchell focused upon one level of the process of technological change such as invention, management or finance. But, in order to relate everything to a single central vision they had to reach out beyond their special competences.



Mitchell managed, Insull financed and Edison knew management and finance. For this reason they should be called Edison as an inventor- entrepreneur, Insull as a manager- entrepreneur and Mitchell as a financier- entrepreneur. This is very important Edison, Insull and Mitchell were strong holistic conceptualizers and determined solvers of the problems frustrating the growth of systems. That is why if you look at the initial point which we started with history of ideas in the study of problem solving, their strong concepts resulted from the need to find organizing principles powerful enough to integrate and give purposeful direction to diverse factors and components.

The problems emerged as the system builders strove to fulfill their ultimate visions, not one of them was satisfied to solve a part of the problem simply to invent or manage or finance. For each believed that the invention would not become an innovation, the managerial structure would not evolve and the financial means would not bring growth unless electric light and power were viewed as a coherent system. Then what is the difference between invention and innovation? People may say that both speak of the new things.

The difference between invention and innovation lies in the fact that in the context of innovation the aspect of marketability, the aspect of industrial utility must be there. In the context of invention it may not have marketability immediately, but in the context of innovation it must be new, at the same time it must be non-obvious and it must have industrial utility. It must go to the market, it must attract more and more consumers.

That is how these three, Edison, Insulll and Mitchell, they were strong conceptualizers and they were determined solvers of the problems frustrating the growth of systems. Their strong concepts resulted from the need to find organizing principles powerful enough to integrate and purposeful direction to diverse factors and components.

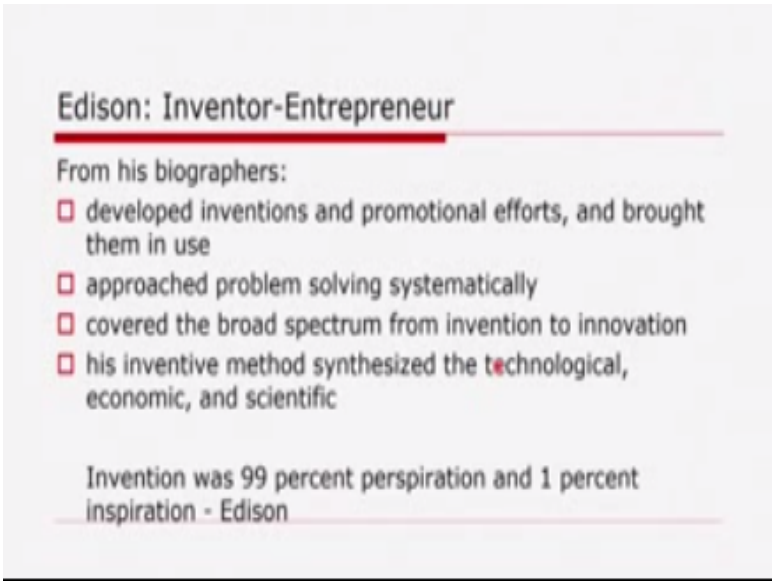
The problems emerged as the system builders strove to fulfill their ultimate visions. Not one of them, not either Edison, Insulll or Mitchell, not any one of them was satisfied to solve a part of the problem. simply to part of the problem, I mean simply to invent or simply to manage or simply to finance.

For each believed that the invention would not become an innovation, the managerial structure would not evolve and the financial means would not bring growth unless electric light and power were viewed as a coherent system. They must constitute a coherent system, invention, management as well as finance. Besides focusing upon systems directing attention to these individuals who presided over their growth, it is imperative to identify stages in the history of electric light and power.
That is why whenever we talk about technology, we must be able to reflect on the social history of technology. This is very important. Otherwise, there is no point in studying technology because technology whenever we talk about technology is always a socio-technical system.

Around 1880, when Edison flourished, electric light and power were clearly in the inventive stage and he is representative of many other leading inventors like Thomson, Stanley, Tesla, Insulll rose to prominence about one quarter century later, in the first decade of the 20th century, after the technology had been shaped and managing large utilities was an even greater challenge. As a result, the names of utility heads like John Leib, Joe and Insulll dominate the industry. In the 1920s, invention and management remained important, but

regional systems financed, organized and managed by holding companies dominated the scene and the individuals like Mitchell, Stone, Webster and again Insulll were preeminent.

But for our purpose, we are going to discuss Edison as an inventor- entrepreneur. We are going to know, inventor entrepreneur, Edison as an inventor entrepreneur by keeping the other two, Insulll as a manager- entrepreneur and Mitchell as a financier- entrepreneur. This is very important.



Edison, what we get to know from his biographies, what we come to know from his biographer's, reflection on Edison's life. Edison was not a simple tinkerer hunting and then trying his way to new inventions. He said that he was no genius of heroic proportions.

Invention, he explained interestingly was 99 percent perspiration and 1 percent inspiration. His more scrupulous and better informed biographers portray him as more than an inventor. They describe his engineering activities as he developed his inventions and his promotional efforts as he brought them into use.

His notebooks, give evidence that his concepts were bold and encompassing. They go beyond the territory of invention. They go beyond the territory of invention when I say, I mean they go to the realms of both management as well as finance. Edison's activities covered the broad spectrum from invention to innovation, market, finance, management. He approached problem solving systematically and his incentive method synthesized three things.

One is technological, second economy and third scientific. In his early days, Edison was content to invent a quadruplex telegraph, a telephone transmitter. that is the receiver was a necessary after thought for reasons of competition or some other component of a technological system.

Someone else, of course not Edison, , integrated those components into a commercial system, which was ready for the ultimate consumer, target customer based. After Edison moved to Menlo Park to establish his research laboratory in 1876 and when he decided to introduce a system of electric lighting in 1878, his reach was far more extended and sweeping. He was ready to preside over the introduction on to the market of a complete system of technology, synthesizing components of his own invention.

As an inventor entrepreneur, Edison coordinated a team of electricians, mechanics and scientists and cooperated with associates concerned about the financial, political and business problems affecting the technological system as a whole. After conceiving in general and sweeping terms of a system of incandescent lighting in the fall of 1878, Edison announced his brain child with a fanfare in the New York sun on the 20th of October 1878. Always good newspaper copy, he told reporters of plans for underground distribution in mains from centrally located generators in the great cities, predicted that his electric light would be brought into private houses and simply substituted for the gas burners at a lower cost.

And confidently asserted that his central station would furnish light to all houses within a circle of half a mile. He spoke not only for his incandescent lamp, but of other envisaged components of his system such as meters, dynamos and distribution mains. A month earlier, he had written privately of his concept, have struck a bonanza in electric light in definite subdivision of light.

He was in essence sharing his movement of inspiration with associates and readers of the Sun, “New York Sun” newspaper. He had no generator, no promising incandescent lamp, much lesser system of distribution. There were at least, a year away.

Edison however, had the concept. Let me quote what he said. He said, “I have the right principle and I am on the right track, but time, hard work and some good luck are necessary too. It has been just so all, so in all of my inventions. The first step is an intuition and comes

with a burst and then difficulties arise. This, this thing gives out and then that. Bugs as such little faults and difficulties are curled. So, themselves and months of intense watching study and labor are requisite before commercial success or failure is certainly reached, but he had the right principle. He was on the right track."

From his biographers, what we, learn that , Edison as an inventor- entrepreneur, he developed inventions and promotional efforts and brought them in use. He approached problem solving systematically. the first step is intuition. Second, with a burst and then difficulties arise. This thing gives out and then that.

, whenever you look at a particular invention by an inventor- entrepreneur namely Edison, it covers the broad spectrum from invention to innovation. his inventive method synthesized all three components as we have already discussed technological, economic and scientific. His biographers also report that Edison had a general concept of his system in the fall of 1878.

For example, Francis Jehl who joined Edison as a laboratory assistant in November and who later published reminiscences of the Menlo Park days recalled that in October 1878, 12 months before the construction of a practical incandescent lamp and the announcement of his basic generator design. Let me quote here that Edison had his plans figured out as a great general figures , out his battle strategy before the construction his first canon is fired, first rule, first norm is fired. The secret according to Jehl of his accomplishments lay in his early vision far in advance of realization.

Obviously, , as a determined conceptualizer, Edison conceptualized so audaciously and enmarked upon the invention of an entire system because he had a laboratory and staff to draw. He integrated the individuals, he integrated the experts and facilities with his concept just had as he did the technical components. By synthesizing all these three technological , If you look at this technological, economic and scientific components. At Menlo Park there was a hierarchy of systems. His note books show that he assigned to his Menlo Park electricians, mechanics and scientists problems associated with the various components of the system. When I say various components, I mean various parts of the general problem. The broad concepts were generally, developed by Edison himself as an inventor- entrepreneur.

The individuals experimented, the experts experimented and calculated within the rubric of his guidelines. Among those to whom he turned often in the first two years of work on the electric light system were Upton, Jehl, Batchelor and Cress. An analysis of the first 200 of the laboratory note books which began in November 1878 and cover the years of 1879 as well as 1880 indicates that Francis Upton figured most often in the experimentations as well as calculations.

Francis Upton did a literature search for Edison in the fall of 1878 in New York city before he joined him at Menlo Park. Just before taking up residence there in December, Upton asked if Edison wanted him to continue the search in Boston in the United States of America because the Berlin summary of Progress in Physics since 1857 and an index to "Poggendorff's Annalen" were there. Edison knew his aspirations to invent a system in a field of technology cultivated by scientists as well as electricians could only be fulfilled , if he drew upon science.

Upton reinforced and supplemented Edison in this regard. Edison's systematic approach ignored disciplinary boundaries. That is why whenever we talk about science, technology and society, we do not restrict ourselves to a particular discipline.

That is why when we initiated our discussion in the initial lectures that it is STS, science, technology and society is a conglomeration of many disciplines. We borrow ideas from philosophy of science, history of science, sociology of science and so on. Edison's systematic approach thus ignored or went beyond disciplinary boundaries.

Today, we would say that he was problem not discipline oriented. His approach was problem oriented not discipline oriented. Upton had come a long way to Menlo Park. Characterized as a scholar and gentleman by his planner Menlo Park companions, he had studied at Phillips Academy, Andover, Bordeaux in college, Princeton University and under Herman Von Helmholtz at Berlin University in Germany. Ross Van Orr, Lowrey, Edison's counsel, business and financial advisor recommended him to Edison knowing of his need for a physicist and mathematician. Jehl said that whatever Upton did and worked on was executed in a purely mathematical manner.

Any wrangler at Oxford would have been delighted to see him juggle with integral and differential calculations, differential equations. Upton often concentrated upon the development of a dynamo for the system. Jehl appears frequently in the notebooks in connection with lamp filament investigations. , Jehl also came to Edison in November or December of 1878 on the recommendation of Lowrey. As a junior scientist, as a boy, he had read every scientific paper one could find and as a young man, he became a great admirer of Edison's inventions, Edison's writings, Edison's research. Lowrey, who was general counsel for western union, employed Jehl as an office boy and arranged for him to take an apprentice course in the western union repair shops.

Jehl also attended cooper union evenings studying chemistry, physics and algebra. Another member of the electric lighting team was Charles Batchelor. Batchelor, Charles Batchelor too filled out the Edison system for he was an ingenious master craftsman, dexterous and sharp eyed whose wide ranging experimental techniques and mechanical aptitude kept him at Edison's right hand.

Batchelor was so intimately involved with Edison in all of his works that his absence from the laboratory was invariably a signal for Mr. Edison to suspend labor. John Tracy, who was in charge of the Menlo Park machine shop also played a major role. Trained in Switzerland as a fine mechanic, he could adeptly construct Edison's various designs with nothing more than rough sketches and cryptic instructions.

He like, Tracy just like Batchelor had been with Edison in New York, New Jersey before the establishment of the Menlo Park laboratory. It is very important to understand Edison as an inventor entrepreneur is a conglomeration of many other experts, many other individuals. I do not want to demean Edison in any sense, but, Edison and his electric light must be examined in the context of this, this kind of social history of technological systems.

Many others at Menlo Park were assigned to work on various components of the evolving electric light system. For example, Claudius, a former officer in the Austrian telegraph corps built simulations of the system with batteries for generators, fine wires for the distribution system and registers for the load. Jehl reported that Claudius had Kirchhoff's laws of conductor networks at his finger tips. The names of some other Edison pioneers who made it possible for him to invent and develop an entire system include Lawson, Ott, Head, Hammer

and so on including Boyle. The availability of these varied talents experts helps explain the encompassing character of Edison's concept of a system.

That is why when we said it is he invented the system or Insull managed the system or Mitchell financed the system. This kind of invention of that particular system is very much encompassing. Furthermore, , they were also supported by a broad array of expensive machine tools, chemical apparatuses, library resources, scientific instruments and electrical equipments in the Menlo Park laboratory complex.

A major reason for the establishment of the Edison Electric Light Company in October 1878 was to acquire funds for additional laboratory equipment and new workers like Upton and Jehl. Obviously, the common characteristics of Edison, his experts, the kind of varied talents that he was associated with and the laboratory were set by a systematic demanding endeavor. At Menlo Park there was more than a system, there was a community as well.

Edison chose Menlo Park because the isolated rural setting insulated the staff from the distractions of an urban environment like New York. Edison and other members of the community bought or rented farm houses in the vicinity. Upton brought his bride to a comfortable house provided with the new Edison light.

Others lived at Mrs. Jordan's cozy nicely appointed boarding house located at a short walk from the laboratory compound. The meals were undoubtedly county and hearty and the environment was well ordered. There were scores of anecdotes about the character of life in the laboratory.

If one wants to read, one can read even “Laboratory Life” by Bruno Latour, but that is another thing. There are scores of anecdotes I repeat about the character of life in the laboratory including accounts of late hour breaks after especially arduous days. On these occasions, the pipe organ at the end of the lab's second floor added to the festive consumption of food and drink.

Since the working day sometimes extended nearly 24 hours, it can be assumed that Edison was willing to charge the expenses to business. The system, the community and the style of

invention were essentially Edisonian. Few witnesses or historians challenged the conclusion that the organizing genius was Edison's.

Yet there was one individual Grosvenor Lowrey who during the early days of the electric light project appears to have closely advised Edison on financial and political matters. Edison laid down the guidelines for bachelor, crèche and option in the laboratory, but Lowrey often guided Edison when the problems involved Wall Street or New York City politicians. Edison, however, did not step back, immersed himself in technological and scientific problems and the element of politics to Lowrey.

The correspondence shows that Edison always had a prominent role in the financial and political scenarios. Because of his knowledge of the world of legal business and financial affairs, Lowrey's strengths complimented Edison's. Born in Massachusetts, Lowrey took up the practice of law in New York City and rose to prominence.

He acted as counsel to the US express company, Wells Fargo and Company and the Baltimore and Ohio Railroad. He was also the legal advisor to the financial entrepreneur Henry Villard. In 1866, he became general counsel of the Western Union Telegraph Company, a position that brought Edison and him together in connection with Telegraph patent litigation.

We will discuss patent when we will be discussing IPR regime, intellectual property rights regime towards the end of these lectures. Lowrey was one of those who persuaded Edison to turn to electric light. Having observed the sensational publicity given to the introduction of the Jablokov arc light in Paris in 1878, Lowrey urged Edison to enter the field and offered to raise the money Edison needed to expand Manilova.

Not only did he advised, Edison, he often encouraged the inventor. Lowrey promised in 1878 that the income from electric lighting patents would be enough to fulfill an Edison dream.-“ to set you up forever to enable you to build and formally endow a working laboratory such as the world needs and has never seen.” At the time, the only buildings in the Manilov arc group were the laboratory building, the carpenter shop and the carbon shade, there were no machine shop, library or office buildings. Shortly forward, Edison gave Lowrey a free hand for this purpose in negotiating the sale of forthcoming electric lighting patents and establishing

business associations and enterprises at home and abroad. Let me quote here, as he said, “go ahead, I shall agree to nothing, promise nothing and say nothing to any person leaving the whole matter to you. All I want at present is to be provided with funds to push the light rapidly.” Because , as an as an inventor entrepreneur, Edison wanted the entire United States of America to be under light 24* 7 even when the sun sets. Lowrey had close contacts with the New York financial and political world. His law offices were on the third floor of the Drexel building. Drexel, Morgan and company had the first floor. Working closely with his long time friend Fabry, an Italian financial genius and partner Morgan, he obtained the funds for Edison from Drexel, Morgan and company. His skill and effectiveness in dealing with politicians and political problems is conveyed by a Manolo Park episode.

In December 1879, Lowrey arranged a lobbying extravaganza. The objective was to obtain a franchise allowing the Edison Illuminating Company to lay the distribution system for the first commercial Edison lighting system in New York City. Behind the opposition of some New York City elder men lay gas light interests and even lamp lighters who might be thrown out of work by the new incandescent light.

A special train, brought the mayor elder men to Manolo Park. Behind the opposition of some New York City elder men lay gas light interests and even lamp lighters who might be thrown out of work by the new incandescent light. A special train brought the mayor elder men to Manolo Park.

In the dusk, they saw the tiny lamps glowing inside and outside the laboratory buildings. After a two hour end demonstration by Edison and his staff, someone pointedly complained of being thirsty which was a signal for the group to be laid up to a darkened second floor of the laboratory. Lights suddenly went on to disclose a lavish parade from famous Delmonico's. Lowrey presented Edison and the Edison case after dinner. , in due time the franchise was granted. The franchise was as necessary for commercial success as a well working diner.

The organization and early management of the companies formed by Lowrey and Edison in connection with the electric light system have been well told elsewhere also. Here, it is important to emphasize that the pristine character of the companies manifested Edison's determination to create a coherent system and his willingness to preside over the broad spectrum of technological change. The first company formed that is the Edison Electric Light

Company was essentially a means of funding Edison's inventive activity and obtaining a return of investment by sell or licensing patents on the system throughout the world.

This is very important. The Edison Electric Illuminating Company of New York was a license of the parent Edison Electric Light Company. The Edison Electric Illuminating Company built the first commercial Edison system with its central generating station on Wall street in New York city which was started in September 1882 because Edison invented and developed all major components for the integrated system except the boilers and steam engines he had also to establish the Edison machine works to build dynamo chip. The Edison electric tube company to make the underground conductors and the Edison lamp works to turn out incandescent lamps in quantity. He entered into a partnership with Bergman, former Edison employee in a company to produce various accessories.

Not only was Edison the pivotal figure in the companies during the early years, he personally supervised the construction of pearl street station. In these companies, Edison was an engineer and a manager, but the focus and the commitment for him remained invention. That is how he developed inventions and promotional efforts and brought them in use which could solve the real world problems.

Supplemented and complimented by his laboratory staff and by the particular resources of Lurie, Edison solved problems associated with technological change on various levels and in a systematic integrated way. His systematic approach, to problem solving was most clearly demonstrated however, in the invention of incandescent light technology. Edison could not conceive of technology as distinct from economics at least when engaged with the electric light system.

After initiating the project, he read extensively and deeply about gas lighting from central stations especially with the economics of it. Also, he canvassed the potential lighting market in the wall street district in New York where he intended to locate his first central station. His notebooks show that he analyzed the cost of operating the Grammy and the wallace or light generators that he had acquired for rest purpose for test purposes.

From available literature, both Edison as well as Upton also determined the cost of operating Jablokov arc lighting system. Laboratory notes reveal that he was especially concerned about

the cost of copper and hoped it to reduce it in generator and distribution wiring. As early as December 1878, Edison estimated that the physical plant needed for one incandescent lamp in his system would require capitalization of 11 dollars at that time.

At an interest rate of 10 percent of this investment and assuming lamp use of 300 hours a year, the percent per lamp would have to be more than 3.66 mils per hour. Edison was clearly thinking within the context of a capitalistic system. Perusal of Edison's notebooks should lay to rest the myth that he was a simple inventor tinkering with gadgets.

There on page after page are concepts, ingenious experimentation, careful and sustained reasoning and close economic calculation. Notebook number 120, what Hughes suggests one of his biographers, that y (probable date 1880) for example, has 30 pages of calculations. for example, his 30 pages of calculations (probably Upton's under Edison's instructions) about the cost and income of a central station supplying 10000 lights at that time.

These were probably in anticipation of the Pearl street system to be built in New York city. that is why his dream, his ambition was to see New York city always within light even after sunset. These were probably in anticipation of the Pearl street system to be built in New York city.

By the time the calculations were made, Edison and obtained new enough from experimentation and literature searches to assume that 1-h.p steam engine and dynamo could supply 816-c.p incandescent lamps. Therefore, they needed about 1200- h.p for the 10000 lamp system to house this power plant. They estimated an iron structure or building that would cost 8500 US dollars at that time in 1880s.

Using a Babcock and Wilcox estimate, they estimated 30100 US dollars for boilers and auxiliaries. Kreusi predicted that the steam engines and dynamos would cost 50000 US dollars. They were very expensive, after extensive calculation, they estimated 57000 US dollars.

Ultimately, if you look at, it came to almost 100000 US dollars, 90886 approximately. , in fact, estimated minimum income from 10000 installed lamps. They calculated at that time more than almost 1.5 lakh, 1 and a half lakh US dollars at that time.

This is very important. , whenever you talk about invention, whenever you talk about entrepreneurship, you must be able to keep management as well as finance in mind, whenever you talk about innovation. That is why, when you switch from invention to innovation, you must keep these things in mind.

Calculations like these were as much a part of Edison's invention and development of an electric lighting system as his overly publicized and well remembered endeavors to find the lamp filament. As a matter of fact, the search for the lamp filament was conditioned by cost analysis like the way he calculated, Edison calculated. It is known that Edison was determined to discover a high resistance lamp filament in contrast to the low resistance one generally tried before him by inventors of incandescent lamps.

It is not widely realized that his determination was a logical deduction from cost analysis. To explain this, we must consider the cost analysis once more and also introduce science. In doing so, we shall demonstrate that Edison's method of invention and development in the case of the electric light system was a blend of economics, technology, especially experimentation and science.

In his notebooks, pages of economic calculation are mixed with pages reporting of experimental data. Among these, one encounters reasoned explication and hypothesis formulation based on science. The wave is seamless.

His originality and impact lie as much in his synthesis as in his exploitation of the research facilities or utilization of research facilities at Mangrove Park. , there were many calculations. To solve the dilemma , but current was needed to light the incandescent. So, how was one to reduce it? to solve this dilemma, Edison tried to synthesize again the three components- technological, economic and scientific. Wanting to reduce the current in order to lower conductor losses, Edison realized that he could compensate and maintain the level of energy transfer to the lamps by raising the voltage proportionately. Then, he brought Ohm's law into play. Ohm's law, resistance is equal to voltage divided by current. It was the Eureka moment for him. what in Greek philosophy, what we learnt that Archimedes used this term. Eureka, I have found it, I have invented it. Now, I have known it. it was the Eureka moment for he realized that by increasing the resistance of the incandescent lamp filament, he raised

the voltage in relationship to the current. In that case, resistance was the value of the ratio, ratio between voltage and current. Hence, his time consuming search for a high resistance filament, but the notable invention was the logical deduction. The filament was a hunt and try effect.

While the essence of Edison's reasoning seems clear from the available evidence, what Hughes tried to do, , what he had to find in his notebooks or elsewhere. The date when he realized that a high resistance filament would allow him to achieve the energy consumption desired in the lamp and at the same time, keep low the level of energy loss in the conductors and economically small the amount of copper in the conductors. In an essay attributed to Edison and sent to Henry Ford at his request in 1926, Edison stated that in the fall of 1878, he had experimented with carbon filaments, but that the major problem with these was their low resistance.

He observed that in a lighting system, the current required to light them in great numbers would necessitate such large copper conductors for men and so on. That the investment would be prohibitive and absolutely uncommercial. In other words, an apparently remote consideration, the amount of copper used for conductors was really the commercial crux of the problem.

He provided better evidence that about the time of origins of his high resistance concept in stating that about , December 1878, that he was engaged as his mathematician, a young man named Upton, Francis Upton. Their figures proved that an electric lamp must have at least 100 ohms resistance to compete commercially with gas. Edison then said that he turned from carbon to various metals in order to obtain a filament of high resistance continuing along these lines until about April 1879, when he had a platinum of great promise because the occluded gases had been driven out of it, thereby increasing its infusibility.

Edison then established a search for a high resistance filament between, December 1878 and April 1879. Jehl in his reminiscences maintains that Edison wanted a high resistance lamp as early as October 1878 and had reached this conclusion by reasoning about his envisaged system of electric lighting. Jehl also states that Edison reasoned to the essentials of his system by applying joules and ohms law.

Edison's reasoning can be illustrated with a simple example using approximate rounded off values. By 1880, he obtained a carbonized paper filament with resistance ranging from about 130 ohms cold to about 70 to 80 ohms heated. He wanted 100 ohms.

Desiring a lamp with candle power equivalent to gas, he found that this filament required in present day units the equivalent of about 100 watts. This meant that the product of the voltage across the lamp and the current must equal 100 watts. Since the resistance was 100 ohms, the current had to be 1 amp because by joules law, the heat energy was equal to the product of the c square and the resistance. what was resistance we discussed? Resistance was, was equal to voltage divided by current.

if you, look at this to, summarize today's lecture, we started with Edison and electric light in, i terms of the social history of ideas and the social history of technology and the study of solving the real world problems. However, there was a combination of three systems, invention, management as well as finance.

That is why Edison is known as an inventor- entrepreneur, Insulll as a manager- entrepreneur and Mitchell as a financier- entrepreneur. Entrepreneur indicates the organizational system building drive of these three geniuses. Edison, Insulll and Mitchell were strong holistic conceptualizers and determined solvers of the problems frustrating the growth of systems.

Their strong concepts resulted from the need to find organizing principles powerful enough to integrate in purposeful direction to diverse factors and components. What we, learnt from , from Edison's biographers that the invention and development of the incandescent light seem to have been the leading gauge of Edison's systematic approach. After the characteristics of the lamp were established, then the problem of generator design was generally defined.

The generator for instance had to supply 100 volts for the parallel wired incandescent lights and an amperage equal to the number of lamps times approximately 1 amp. The relationship between the generator and lamps was determined by the decision to wire the lamps in parallel , which in turn resulted from the need to keep the system voltage at a safe level and to keep possible operation of the lamps independent of one another. The Edison system was evolving like a drama with a cost of developing interacting ideas.

In October 1879, the same month in which he found the first practical filament, Edison announced the generator for his system. Other components followed. In September 1882, the Pearl street system began to supply light for the wall street district with the opening of the Pearl street station of The Edison Electric Illuminating Company.

The age of central station incandescent lighting had begun. thereby, we witnessed the modern age of public electricity supply. that is how the modern age of public electricity supply had opened.

What we found from his biographers that the way Edison as an inventor- entrepreneur, how he developed inventions and promotional efforts and brought them in huge. He approached problem solving in a systematic manner. He covered the broad spectrum from invention to innovation.

you are not trying to create something new, but also you are trying to create something new for the market, for the consumers, for the individuals. His incentive method synthesized three components that is the technological, the economic and scientific. That is how he said that the kind of according to Edison that invention was 99 percent perspiration and 1 percent inspiration.

Staying on with the social shaping of technology in contradistinction with technological shaping of society and technological shaping of technology itself. In the lectures to follow , we are going to provide more examples on social shaping of technology, but the dialectical relationship between technology, science and society must be kept alive for the debates to continue. Because our real world problems, they involve controversies.

If controversies remain then our debates must remain. Even if we f for a moment we think that our we are done with our controversies, but we must debate those controversies. We must try to evolve a culture of debating the controversies over time and across space.

In the lectures to follow what we are going to do? We are going to provide more and more examples on the principle of the social shaping of technology or the methodological canons of the social shaping of technology. Then before we move on to how science today, how

scientific knowledge in India today has turned into an intellectual property from a public resource. We will also discuss reception of modern science in India in the lectures to follow, but before getting involved in the critical discussion on science and technology in India. We will provide more examples to substantiate our viewpoint, our perspective on the relationship between technology, science and society. Our perspective on social shaping of technology. I hope that was helpful. Thank you.