Interview with Paul Israel, Managing Editor of Thomas A. Edison Papers at Rutgers University and co-author of *Edison's Electric Light,* for Program Two: "Electric Nation"

Note: This transcript is from a videotaped interview for the "Electric Nation" segment of "Great Projects." It has been edited lightly for readability.

Paul Israel (PI): Edison formed Menlo Park, the laboratory in 1876, he had come from Newark where he had had a machine shop devoted to his inventive activity and now he wanted to separate himself out of from the city, go to a place where he could build his own facility.

He combined the machine shop with this rather significant electrical and chemical laboratory, one of the best in existence at the time. A lot of university professors would have been jealous. And, primarily, he used his own money, royalties that he had gotten for his work on the stock ticker and other inventions for Western Union and Golden Stock Telegraph Company.

But he also found support after he'd opened the laboratory, from Western Union, which was willing to pay $100 a month to support the machine shop, which was a really important element of the laboratory, where the devices were turned into things that he could experiment with. And over time, of course, Western Union continued to support the laboratory, especially the work on the telephone, but by the time Edison got to the period when he began to work on the electric light, he needed considerably more resources, and so a number of Western Union investors, J. P. Morgan who had some ties to the Western Union, [and other] people agreed to fund a rather significant research and development project. And over the course of the two and a half years that Edison worked at Menlo Park on the research and development, they funded him to the tune of about $130,000, which was a pretty significant figure in 1878, '79, and '80.

PI: When Edison began working at the Menlo Park laboratory, primarily what he brought with him were the few close assistants he had at his New York Telegraph shop. Charles Batchelor had been his principle assistant since 1873. John Kruesi who sort of headed the machine shop, and a couple of other experimenters and machinists. By the time he began working on the electric light, there were about a dozen people all together working in the lab. And he tried to begin to add new people. A couple of chemists, a fellow named Francis Upton who was the first, actually, person trained in physics, both at Princeton, then in Berlin, studying a post-graduate degree. And then over the course of the research on the light, the staff eventually grew to 50 or 60 people, as they moved into the development phase in 1880 and Edison really began to develop a research and development facility where he divided up the work amongst a number of different research groups.

PI: I think the electric light really sets the stage in two ways. First, that it received such a significant amount of money from a group of people willing to invest in invention. I

mean, before there had been companies like Western Union who had supported, to a limited extent, inventors like Edison, providing minimal resources but some resources for their work. But here you had a group of people who were willing to invest over $100,000 in the hopes that this guy could do what he said he would do. And he accomplished it obviously.

And what that enabled him to do was, in fact, develop the first research and development laboratory and the electric light is really the first technology that's developed in a modern fashion, that is, that you have a research and development laboratory and you have this long phase of research and development that takes place where they move the product from the ideas in Edison's head and those of his assistants into the marketplace. And that's a really crucial distinction between the electric light and what had come before.

PI: When Edison began working on the incandescent electric light, there were other people who had worked on it. What they'd been doing primarily was taking either sticks of carbon, like Joseph Swann in England, or various types of metals as a number of people had in the US, primarily platinum wires, and heating them up, sometimes in a vacuum, sometimes in rare gases, sometimes just in the air, but nobody had developed a lamp that lasted very long. And Edison thought he had a solution to the problem, he would use a bunch of relays, like he used in telegraphy, to turn the circuit on and off, to keep the metal filaments that he was using from burning out. But in fact, Edison's key insight was not so much how he was going to solve the problem of keeping the lamp lit as that he recognized he needed high resistance, that is, that the more resistance to the circuit that the lamp offered, the better for his system, because in that way he could use much smaller copper conductors because of the nature of electrical laws. And so this was a key insight that allowed him to, I think, move beyond what everybody else had done because it moved him into the realm of working on an entire system, and so he developed not just the lamp but the generator and the various other components, meters, and fixtures, and so on and so forth, in order to really be able to develop a system that he could put into commercial use.

PI: At the time that Edison began working on the incandescent light, there were commercial arc lights. These are very powerful lights where a gap between two carbon poles allowed a spark to pass and this created a huge light, that was great for outdoors, but … not very good for interior lighting. And so what Edison wanted was a much softer light and the way you did this was to heat something up so that it incandesced, that is, it glowed, kind of a white or yellowish-white light, as the lamps that we have today. And that's what he was looking for, something that would be a much softer light that could be sort of divided amongst the rooms, instead of having one large powerful light.

PI: Well, what he was looking for was what would be an appropriate burner. For the first few months, what he chose was platinum. You take a platinum wire, very thin, coil it up. As it heats, it goes from a red to a kind of yellowish, to finally a bright white glow. In fact, about the same candle power as a gas light, but a purer light than you would get with gas, where you have various kinds of things in the chemicals of the gas that made it not quite as good a light. And, in fact, one of the first facilities that used his lamp was a

printing press, and they found it just gave a better light for looking at the colors of their operations and so forth. And so that's what he was looking for, was something that he could heat up to incandescence and eventually he would turn to carbon, after about a year of research.

PI: After working for a while on his lamp, Edison decided that he needed to investigate better the materials he was using. He was heating up these platinum filaments in the air and they would last for a very short period of time and he was trying to get them to last much longer. So he began to look at them under the microscope, studying them under different conditions of heating and he began to discover cracks and air bubbles in them, and so he thought to himself, well, I need to protect this from the atmosphere. And so he began to heat them, or I should say, place them in a vacuum bulb, he [had] already got a guy from New York to create his first vacuum bulbs, and then later in the summer hired a full time glass blower who was crucial to the development of the vacuum technology they used at Menlo Park. But what he eventually discovered was that it wasn't the gas, or the oxygen in the air that was affecting the bulbs so much, as it was that the gas in the metal itself was creating a problem.

So he developed this process of driving off the gases as he heated it in the vacuum and this, in fact, improved the platinum significantly where he didn't need the kind of regulators that he had to try and keep the current from getting too high, because it raised the melting point.

But platinum lamps didn't give him very high resistance, they were still not lasting as long as he wanted, and eventually he decided to try carbon again. And one of the reasons for this may be that he had been working on the telephone during the summer and the lampblack that he was using could be rolled into a very thin, wire-like substance and he began to think about trying to make wire spirals out of soft carbon. Well, the laboratory couldn't do this, but eventually what they decided to do was take a thin wire form of carbon, that is, a thread, and put that in a lamp and see what happened.

PI: Well, they took this thread, they put it in a lamp and they heated it up and they discovered that it was lasting much longer than any of the lamps they'd had up to that point. After about 13 and a half hours, where they were getting a nice glow with a fairly high resistance lamp, they decided to see what would happen if they really kicked up the current. And after a couple of hours, it finally burned out. But they realized now, they were on to something. And sometime after they began to work with carbon, you see Francis Upton draw a little cartoon figure in the notebooks, where he basically, you know, shows a lamp that's sort of got a human face on it, and underneath he writes, there's millions in it, because they realized they were really on to the future of electric lighting.

PI: By the time he'd finally developed this carbon bulb that worked, that is, that it was high resistance, it lasted for a relatively long time, he realized what he needed to do next was to find the best substance, so he began a literature search to find out what kinds of carbons would be best suited. He just determined that tall grasses with long uniform

fibers would be good, eventually turning to bamboo from Japan as the best substance, and this became the commercial lamp, but it took him, you know, several months of continuing work to develop better and better lamps, so he that was getting long life lamps. And at the same time, he'd already begun to develop the system in the spring and summer of '79, before he developed the carbon lamp, he'd already improved his generator, for the system. He'd begun to work on other components, and once they had this lamp, once they demonstrated it to the public at the end '79, then 1880 become the development year. And they spent a year developing underground conductors, better meters, fixtures, improving the bulb, improving the generator, developing motors.

PI: Well after a couple months of real intensive work to develop a better and better carbon bulb, Edison had told a reporter friend for the New York Herald about the work that he had done and this guy had published a story somewhat prematurely so Edison realized he needed to demonstrate this bulb to the public and to his investors much more quickly than he had originally planned.

So they quickly hurried to install poles at Menlo Park. They got permission from Western Union to use some old poles to string the wires, although he eventually wanted them underground. They put up street lights they wired all the buildings, the laboratory, Edison's house, Francis Upton's house, and Sarah Jordan's boardinghouse where the workmen lived.

And they brought in the investors and they began to show the light off. So these fellows from Western Union came out on special trains and they were taken in to view the lamps and they were astounded by what Edison had accomplished. And it wasn't just the people from Western Union. Jay Gould showed up on one occasion, and then eventually the public began to come out to see what was going on in Menlo Park, and so they decided that they needed a full scale demonstration to the public, and so they decided that on New Year's Eve, they would have a full scale demonstration, and special trains came out from New York, and crowds of people came to Menlo Park to see this wondrous display of these soft white lights all over the landscape and in the buildings.

PI: Well from the beginning, Edison had this conception of a system. In part, he was modeling it on the gas light systems that already existed in places like New York. And one of the key elements of that, of those systems, was that the conductors were underground. And so Edison decided that that's what he was going to do with his system. But it wasn't only because he was modeling after gas. He recognized, because he'd been involved in the telegraph and telephone industries that there was a lot of pressure on the part of state legislatures and city councils to get the jumble of wires that had begun to appear in the city streets underground.

They were worried about public safety, about aesthetics, and so there was a lot of pressure to pass laws to do that. And Edison, being ahead of the curve, decided that he would develop his system with that in mind, so in 1880, when they really began to focus on developing this system, a lot of time was spent on trying to figure out the best way to insulate the wires so they could put it underground. And in fact, the first couple of

methods that they used didn't work very well and it took them quite a while of research to develop an underground conductor that would work well, but eventually they did.

They also worked on various ways of manufacturing the lamp. Something that Edison was aware of from the beginning was the connection between a new invention and ways of making it so he could bring it into commercial use. And so they began to develop the tools and the special machinery that they needed to develop the lamp. They improved the vacuum process to speed up the lamp making and, in fact, took an old laboratory where Edison had for awhile manufactured another invention, and turned that laboratory -- turned that building I should say -- into the first commercial lamp factory at Menlo Park, and hired a bunch of people to work in it. They worked on fixtures, sockets, all these things that you don't think about until you begin to say, well, how are we going to put this in people's homes and offices.

And so after spending, you know, nearly a year trying to develop this system and all the components for it, Edison and his backers decided that they needed to get permission to lay those conductors in New York, and the best way to do that was to get the City Council on their side. So they hired a special train, they brought the Alderman out from New York, and they brought them into the laboratory. And it was in the evening, so it was dark, and they brought the Alderman upstairs into the darkened laboratory second floor.

And there was a little bit of grumbling, “what's going on here, I thought we were supposed to see this wonderful lamp that Edison had invented.” And so everybody finally makes their way up the darkened stairs and lo, and behold, Edison gives a signal and the place is lit up, it's beautiful, there's a table in the horseshoe shape like his filament, and on it is this beautiful catered dinner from Delmonicos, champagne, wonderful meal, and so the Aldermen, mollified and quite happy to partake, sat down, and enjoyed the meal, and afterwards there were toasts to Edison, to the wonderful invention. And they went back to New York and passed the law so that Edison could, in fact, light his conductors underground, without objection. But that, in fact, was a process that took about a year and a half. Edison thought it would not take as long as it did, but it was a very difficult process to tear up the city streets, lay those underground conductors and wire everything up.

PI: In asking the Alderman for permission to put his lines underground, Edison was in fact doing them a favor, because they were quite concerned about this jumble of wires, the telegraph and telephone wires and now there were arc light wires as well, as they began to light up things like Brooklyn Bridge and some streets, and so more and more wires were being added to city streets and the Alderman were growing more concerned about this, and here was Edison saying, “I've got a solution, what we'll do is we'll put them underground” and I'm sure that was also in his favor, besides the wonderful meal from Delmonicos.

PI: Once they decided that they were going to go into New York and set up a demonstration central station in order to show the system to the public, they decided that

they needed to figure out where to place the station. Their first idea was that they would go to an older manufacturing district below Wall Street, where they thought they could get a building cheap. Well, in fact, it turned out that the building wasn't very cheap, but it had the advantage of being close to Wall Street and all those other financiers who might fund other central stations, and secondly, that's where all the newspapers were, in the same general area, and so Edison had both, finance and publicity available to him, and by wiring those buildings he could garner himself very favorable publicity.

PI: There were all sorts of problems that they faced in kind of retro-fitting the building [for the central power station] and they had to reinforce it in order to put the dynamos in there, and they had to figure out how they were going to get the coal to the boilers from the steam engines, and all sorts of difficulty that they had in trying to define how the building itself should be used for a central station since they were retro-fitting them.

PI: In early 1880, in the Spring, as Edison began to figure out the different aspects of his system for development, he began to redesign his dynamo. And one of the things that he thought was that he could save on energy costs by directly coupling the generator to a steam engine. And, these direct driven dynamos would be more compact.

As Edison began to consider the elements of the central station design, in the spring of 1880, one of the things he thought about were the energy requirements. He could install a bunch of steam engines and drive belts and a bunch of different generators, or, he had a different idea: He could take a much larger dynamo, so you would need fewer of them, and directly link each dynamo with its own steam engine. And so instead of 25, 50 or more dynamos in each central station, you could have five or six. And, he thought that as well the direct coupling would reduce the amount of energy that was lost because of the belting. And so he spent a considerable amount of time with his chief engineer, Charles Clark, who because the chief engineer at the Edison Electric Light Company, in designing this new dynamo, and this is what went into the Pearl Street station, it's what he sent to Paris for the 1881 exhibition, on the same ship that Jumbo the elephant had just returned from the Barnum and Bailey circus, and so the dynamos because known as Jumbos, as a result.

PI: As Edison was thinking about how to design this new direct, coupled dynamo, one of the problems was he needed a very specific kind of steam engine, very high speed steam engine. So he had to go the engineers involved in steam engine design and ask them to work with him, in developing a specialized steam engine for that purpose.

Edison had begun laying the mains and getting a central station set up in, in the spring of 1881. And they were still at it in the summer of 1882; they'd been working at it for quite a while. The mains were getting closer to being finished but there were still a lot of work to be done. The station itself was in much better shape. But Edison still had to spend a considerable amount of time. Samuel Insull, who was his secretary, recalls that they would go late at night to the central station. Edison would confirm with the people who were there and he'd often, in fact, take a nap on the cot there, he'd spend the night at the station.

And so, over the course of the summer, things neared completion and by the end of the summer they were ready to begin testing the system itself and the first time they turned on a couple of dynamos, they linked them together because this was the way they were planning on running the station, having the several dynamos linked together.

The first time they do this, lo and behold what happens is the whole thing begins to shake. And they realize that the coupling was a real problem and that they were going to have a difficulty in running the system if they couldn't figure out a better linkage between dynamos and Edison had to go back to work tying to figure out how you're going to solve that problem.

PI: As Edison tried to figure out how to solve this problem with linking up different dynamos in the central station, one of the things he recognized, that part of the problem was the steam engines themselves. And so he had to go to Armington Sims, a different steam engine manufacturer and have them redesign steam engines. They built another special set of engines for these dynamos. And then as they began to test the system, testing the conductors to make sure they were working properly, they also discovered another problem, which is that one occasion there was apparently some leakage from one of the junction boxes, and as these horses would come down the street, they'd be shocked. And, this made the papers, and Edison had to mollify the public that this was in fact a safe thing and that he'd solved the problem. It was a little bit of a setback but not much of one.

Well, finally, on September 4, 1882, Edison was ready to demonstrate his system. And I'm sure he was somewhat nervous that everything would work properly, since they'd had all sorts of problems getting it set up in the first place. He left his chief engineer of the station at the station, synchronized his watch, went over to the J.P. Morgan offices, looked at his watch, threw the switch at the office at the same time the fellow at the central station started up the steam engines, threw the switch to put electricity in the system, and lo and behold, everything worked perfectly. And, later on, a reporter talked to Edison and asked him what he thought, and he said, well, I've done everything that I set out to do.

PI: Edison had gone to the J.P. Morgan office as the place where he was going to show his system to the investors, because Morgan was one of the principal investors in the system. He was one of the principal financial figures in New York and [became] even more important in the years afterwards. But at that point he was the man that Edison wanted most to impress with the system.

PI: When Edison had been doing the research and development of the light, reporters had beat a path to the laboratory. He was often front-page news with his different pronouncements on where he was at. But by the time they finally got Pearl Street lit after the long time it took to lay the system, the public had actually begun to lose interest.

And there were only small stories in the newspaper; it wasn't that big a deal in the long run, because in fact it was the earlier demonstrations at Menlo Park that had showed the system worked and this was just a commercial installation. And in fact this proved difficult for Edison because people weren't beating a path to his door, and the door of the Edison Electric Light Company.

And in fact after about six months he decided that he needed to go out and promote the use of central stations. He gave up working in the laboratory for a while, and became what he called a businessman for a year in order to be able to promote and install central stations in a lot of the manufacturing town up and down the east coast and Midwest.

PI: Edison's vision had always been the central station -- you would put a central station in an area in a city, light up several blocks, set up another central station, light up some more blocks. The problem was that central stations were very expensive. And the investors in the Edison Electric Light Company were already beginning to make money from people who were installing smaller systems in their own buildings, like, mills and printing plants and so forth. And so they weren't interested in investing in these much more expensive central stations. And so Edison had to set up his own company. He called it the Thomas A. Edison Construction Company. Samuel Insull, his secretary, did the day-to-day running of the business, while Edison worried about the technical details of each station. Some of his chief assistants became the engineers who established the central stations. And over the course of the next year, Edison installed about a dozen or so central stations, and proved that in fact this was a very effective way of lighting up manufacturing towns, and so more and more competition began to emerge from other companies that also began to install their own systems. And this is where Samuel Insull cut his teeth. Insull would later go on to have a rather magnificent career in Chicago, installing large network of electrical systems in the Chicago area. And it was working for Edison in the construction department that he really cut his teeth on the business.

PI: One of the reasons that the Pearl Street Station didn't cause people to suddenly say, “Oh, I want a central station in my town” was that this was a very expensive station. Now admittedly, it was a demonstration plant so the costs were pretty high. But even still, it was over $300,000 to install this plant. And there weren't many places where you were going to get investors who were willing to invest that kind of money.

So, in fact, when Edison, in fact, goes out to install central stations elsewhere, most of the systems he installs are not underground. It's only in some of the larger towns that he actually installs underground stations. And they're not as expensive as Pearl Street. He finds ways to cut costs. But, in fact, he develops another system for smaller towns where overhead wires are used. And he finds various ways to make it a less and less expensive system, so that, in fact, now it becomes economical.

And now there becomes a period where people are beginning to say, Well, hey, you know, maybe, a central station's a good idea. It'll bring notoriety to our town. We'll be seen as progressive. And so more and more people begin to see electric light as the

future instead of this expensive but not very effective technology that they might invest in.

PI: The year that Edison spent promoting and installing central stations demonstrated something very important, that is that central stations didn't sell themselves. And so, after a year, the Edison Electric Light Company finally began to realize that, you know, they could make money off of this but, in fact, it required some effort. They were willing to take over the central station business and to begin to sell it. And so now by putting on a promotional effort, central stations began to spread and other companies began to jump into the act as well and new central stations began to spring up in town after town.

PI: By the time that Edison had died, in October of 1931, Central Stations, in fact, were not just the future but the present. And the country was so wired that by the time he died, when [President] Herbert Hoover wanted to create a memorial to Edison by having the country turn off its power for a minute, he was told that this would be impossible. And, in fact, what happened as a result was that lights were dimmed in individual buildings.

PI: Well, as they were laying the mains for the Pearl Street station, winter came along and it was a rather cold winter, and all of a sudden they found that digging up the ground became a very difficult thing and it really slowed down work on the conductors. Winter demonstrated something else -- that Edison was going to have trouble with his meter because of the freezing cold. And so he had to redesign the meter, and, in fact, put a little electric light-bulb in the meter to keep it heated up since it was a chemical meter where the deposit -- like a battery -- would deposit metal from one electrode to the other. That's how the meters worked, and because the chemicals would freeze, he needed to find a way to keep it warm.

PI: The process of laying the mains involved digging up the street, putting down these conductors in tubes, setting up junction boxes so they could take the lines off in different directions. They had to pour in the tar coating that they were using for the conductors. Then they had cover everything back up. They had to test it to make sure that it worked before they covered it up. Some of the workmen were concerned about, you know, the "devil in the wires" as they called it; whether, in fact, this new technology was safe, and that was one of the key things that Edison had to do. For example, he goes to the Board of Fire Insurance Underwriters in New York to demonstrate his safety fuse. For example, he had to design a safety fuse to show that inside wiring would be safe. And so the safety concerns became a big part of the story for Edison as he designed a system.

PI: One of the key elements of Edison's work in technology was that, even if he began with just a component of the system, that is -- well, how do you build an incandescent lamp that will work -- he was always concerned about the way it fit into the larger system. And as he thought about these system requirements, he would begin to think about the relationships of the different components to each other. And that, combined with the resources of the laboratory allowed him to leapfrog over everybody. His closest competitor in America, a fellow named William Sawyer, was busy working on the lamp but he wasn't working on generators. He wasn't working on meters. He wasn't working on

sockets -- all the different parts of the system that he needed. And Edison was able to do this, in part, because he had this larger vision, including, in fact, this notion of the high resistance lamp, which Sawyer and others didn't understand, and of the various requirements of the components themselves, and how they interacted with each other.