A HISTORY

OF

EDISON'S WEST ORANGE LABORATORY

1887-1931

BY

A.J. Millard

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with

W.B. Carlson

PREFACE.

This final report on the history of Edison's laboratory began as National Park Service Contract number CX 1600-4-0047. W.B. Carlson and I won the contract in June 1984 and we formed Electro History to execute it. We carried out the research at the Edison National Historic Site in 1984 and 1985, and jointly wrote a first draft in June 1986. At this point it was decided that more research was required. I produced a new version of the history and delivered it in the first months of 1987. This draft was approved by the Park Service and all corrections and suggested changes have been incorporated into the final report. Dr. Carlson has contributed material on the storage battery and Portland Cement and has written the sidebars for chapters seven and eight. As primary author, however, I am responsible for all errors in the text.

A.J. Millard
Electro History
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(All illustrations are from document and photograph collections of Edison National Historic Site. Color photographs were taken of machines at the Site.)

INTRODUCTION

The Edison National Historic Site attracts thousands of people to West Orange who would normally avoid the harsh, de-industrialized landscape of north New Jersey. Situated about 45 minutes from New York City, the Edison laboratory and museum is one of the most popular of all the National Parks on the East Coast. The Park Service anticipates that over 50,000 people will visit the site in 1987--its centenary year. These visitors come from all parts of the nation and a large section come from abroad. It is hardly surprising that Edison's laboratory is most popular with Japanese tourists, who share his work ethic and commitment to innovation.

It is perhaps significant that the architects of today's micro-electronics "revolution" find relevance in the history of the Second Industrial Revolution, which began in the 1870s and lasted until the Great War of 1914-1918. This period of rapid economic growth came after the first wave of industrialization had begun to transform the economy and society of the United States. Edison's invention of the incandescent light bulb marked the beginning of another burst of innovation that created several major new industries. The Second Industrial

Revolution does not have the same powerful images as the First; the steam engine and textile mill are universally recognized as the symbols for that great movement which began in Great Britain and spread to the United States in the second decade of the nineteenth century. The new industries of the 1870s and 1880s do not have the same familiar symbols. Edison's Pearl Street station--the architectural relic of the electrical industry--is no longer standing in downtown Manhattan. The Bessemer steel and synthetic chemical industries have left no structure that the general public immediately associates with a period of rapid economic growth in which the United States led the world. Edison's laboratory in West Orange, on the other hand, is both an accessible and appropriate symbol of the Second Industrial Revolution.

The complex of buildings in West Orange was erected in the late 1880s, when the Second Industrial Revolution was just beginning. As the greatest industrial research facility in the United States, the laboratory was the breeding ground for a new generation of technology and the starting point of some important new industries of the twentieth century. Here Edison worked at spreading his electrical lighting systems all over the industrialized West and lowering the price of electricity until it was available to everyone. The motion picture camera was invented at the laboratory, along with a host of other important products such as the Edison storage battery and dictating machine. Edison perfected the phonograph at this facility and manufactured thousands of them in his nearby factories. Two of the twentieth century's most influential service industries--motion pictures and musical entertainment--had their humble beginnings in this cluster of brick buildings.

The experimental rooms and machine shops in the lab are a reminder of the highly complex technologies introduced by Edison. The impressive, multi-tiered library is evidence of the growing importance of science in the technologies of the Second Industrial Revolution--a revolution that was based on the so-called scientific industries of electricity, steel, chemicals, and communications. The rows of technical journals (many of them from outside the United States), scholarly books, and bound patents show that the information age had begun well before the twentieth century, and that Edison saw the importance of keeping up with scientific and technical progress wherever it occurred. The "old man" often began his day by reading the newspapers and technical journals at his desk in the library. Now only tourists walk around the library and cross the courtyard to the experimental buildings which serve as museums of Edison's achievements. The lathes and drills in the grimy machine shops are quiet now, the lights no longer burn all night in the experimental rooms and the "old man's" bunk in the library is never used. The surviving buildings of this once vast industrial complex serve not only as a museum but also as a reflection of the life and work of one of

America's greatest businessmen. The West Orange laboratory bore witness to a critical period in the economic history of the industrialized West and it provides an invaluable resource to understand our immediate past.

CHAPTER ONE

THE BEST LAB EVER.

When Edison reached the age of 40 in February 1887, he had achieved more than many men do in their whole lifetimes. (Illus 1-1, Edison in Metallurgy Lab.) As a successful manufacturer of stock tickers, Edison had gained profits and some influential friends on Wall Street. The invention of the phonograph had brought him world-wide fame. The apex of his career was his development of electricity as a commercial product at his Menlo Park laboratory. After his most famous invention in 1879, Edison spent many years designing and installing the first electric lighting system. New York's Pearl Street central station was completed in 1882. It distributed electricity for light and power to a few blocks of the commercial district in lower Manhattan. Although the Pearl Street Station did not look like an impressive engineering feat, it proved that electricity supply was technologically feasible. It was a triumph for Edison and the beginning of a great new industry.

Once Edison had demonstrated the commercial potential of his invention, he formed several companies to promote his system of lighting and manufacture the lamps and machines to

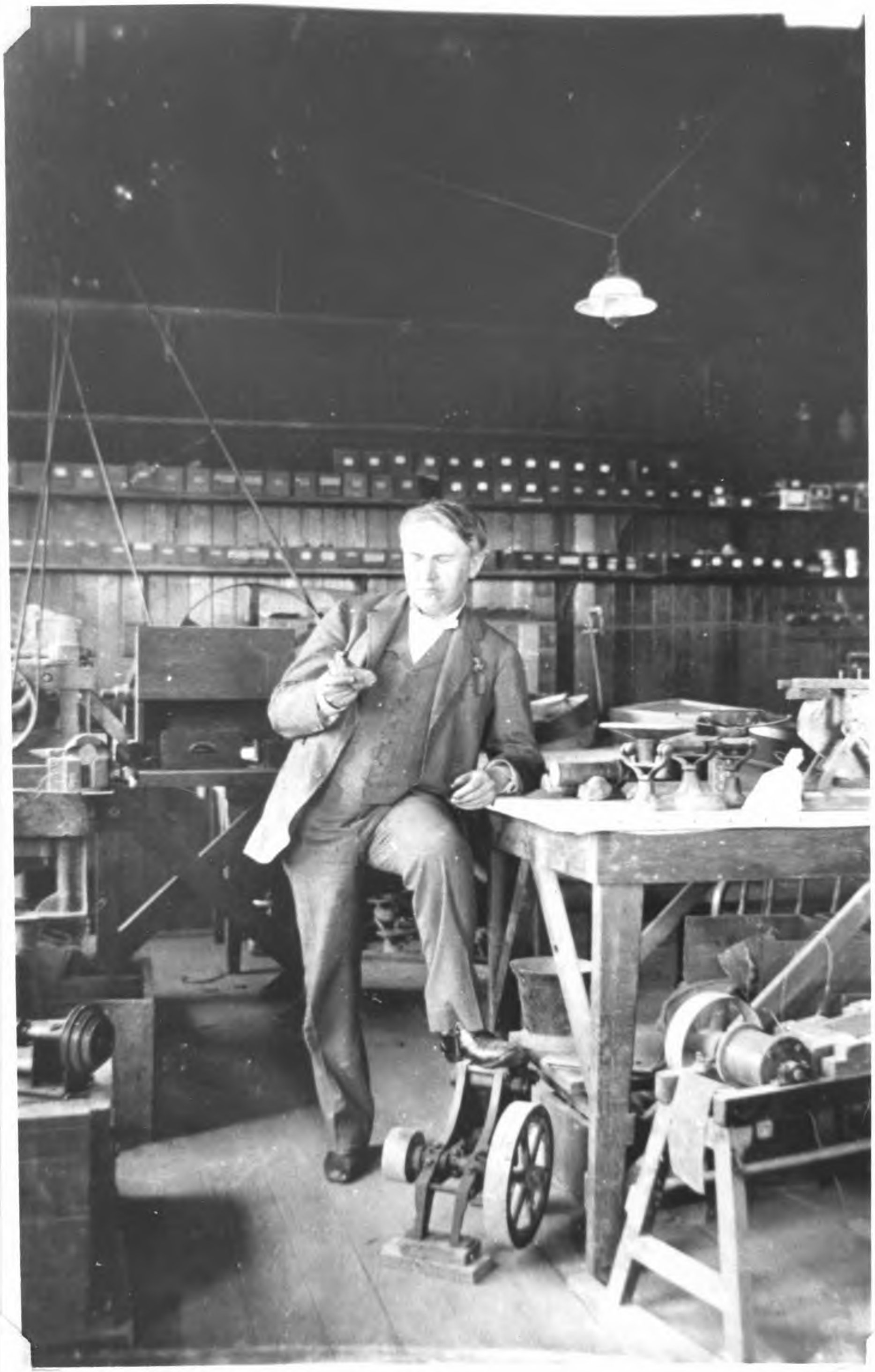


Illustration 1-1

Edison in Building 4

bring electric light to the world. The Edison Machine Works was established in New York to make heavy dynamos for power stations. The Electric Tube Company made underground conductors and the Edison Lamp Works made incandescent bulbs. Bergmann and Company provided the switches, fixtures, and other small parts of the lighting system. Small lighting installations were installed by the Edison Company for Isolated Lighting, but the large power stations were erected by local lighting companies who had to pay for the Pearl Street technology. Edison's important electrical patents were in the hands of the Edison Electric Lighting Company which sold the franchises to local lighting companies and provided overall direction to the Edison electrical empire.

Edison soon moved out of his laboratory in Menlo Park and set up house in Granmercy Park in lower Manhattan, a short walk away from the headquarters of the Edison Electric Light Company at 65 Fifth Avenue. He made sure that his friends and allies were given important positions in the new companies. The Electric Lighting Company was presided over by Edward H. Johnson, a friend and colleague from their days as telegraphers. Samuel Insull, Edison's secretary at Menlo Park and New York, was made manager of the Machine Works. As private secretary, Insull had administered Edison's business and personal finances and now he had the job of running the financial affairs of the Edison lighting empire. The superintendent of the Edison Machine Works was John Kruesi--a faithful mechanic who had worked with the inventor for years. Another member of the laboratory staff, Sigmund Bergmann, was set up in his own manufacturing company.

Edison himself was absorbed with management problems after the great engineering work at Pearl Street was complete. He said in 1883 that "I'm going to be a business man, I'm a regular contractor for electric lighting plants and I'm going to take a long vacation in the matter of invention."[1] He formed the Edison Construction Company to build central stations and travelled the country erecting lighting systems. By 1886 the work of "pushing the system" was well underway. Over fifty Edison power stations had been built in American cities and many were in use in European countries, where installations were made in nearly every major city on the continent. In the United States, his factories were full of orders and running constantly. The Edison electric lighting companies were capitalized at around $10 million. [2] By 1886, Edison was the hero of his generation, a rich and powerful industrialist, and an inventor of world wide fame. He was also in love.

Edison married Mina Miller in February 1886. She came from a well-to-do family from Akron, Ohio, attended finishing school in Boston, and was a more than acceptable partner for the famous inventor. Marriage inevitably brought changes to Edison's life. He must have been tempted to remain in New York, the center of his business interests and the home of close associates (such as Charles Batchelor) and important financial connections (such as Henry Villard). But instead of joining the other millionaires building mansions on the blocks to the south of Central Park, he chose a rural setting for his new life as married man and industrialist. The newly-weds moved to West Orange in the scenic Orange valley, a resort area for the urban masses of Newark that was only 12 miles west from New York City. Here they purchased a house in Llewellyn Park, an enclave of magnificent houses that was the first planned residential community in the United States.[3]

The idea for this development, "country houses for city people," came from Llewellyn Haskell, a successful importer of pharmaceuticals and a supporter of projects like Central Park in New York City. Haskell helped pioneer the idea of finding rural alternatives to living in the city in the 1850s and 1860s. He purchased 350 acres of land in the Orange valley and set about creating a romantic, rustic setting for a residential community. Llewellyn Park contained all the elements of a well-landscaped arcadia, including a 50 acre park called the Ramble, and was dotted with impressive mansions built in high American gothic style.[4] Edison purchased Glenmont, a sprawling castle that cost him nearly a quarter of a million dollars in 1887 and was appraised at a much higher figure. Glenmont is an impressive Victorian house which reflects a multitude of architectural styles and enthusiastic decorative motives. Designed by Henry Hudson Holly, one of the most influential and popular residential architects of his time, it is an exuberant example of the American romanticism that was popular during the Gilded Age.[5] Glenmont came fully furnished and gave Edison instant social substance; his biographers note that he was now settling down to a lifestyle far removed from his Bohemian existence as an itinerant telegrapher.

An ordinary mortal might have taken time off to savour the pleasures of married life and business success, but Edison was no ordinary man. He was still at the peak of his inventive powers and the flow of ideas had not ceased during the years of perfecting his lighting system. In addition, his honeymoon in Fort Myers, Florida in 1886 and a convalescence from sickness in early 1887 gave him two long breaks to contemplate future inventions. In 1886 his mind turned to building a new laboratory to replace the one he had left at Menlo Park. His idea of making this laboratory an "inventions factory" had been great success and now he was going to go one better: "the best equipped and largest laboratory extant, and the facilities superior to any other for rapid and cheap development of an invention."[6] The Menlo Park complex was the largest private laboratory in the United States in the 1870s; now Edison planned build an even bigger facility that would enable him to carry out industrial research on an unprecedented scale and reflect his new status as the preeminent American inventor.

The first ideas committed to paper about the new lab indicate the grandeur of his plans and something of his method of inventing. The plan reproduced from a notebook as Illus 1.2

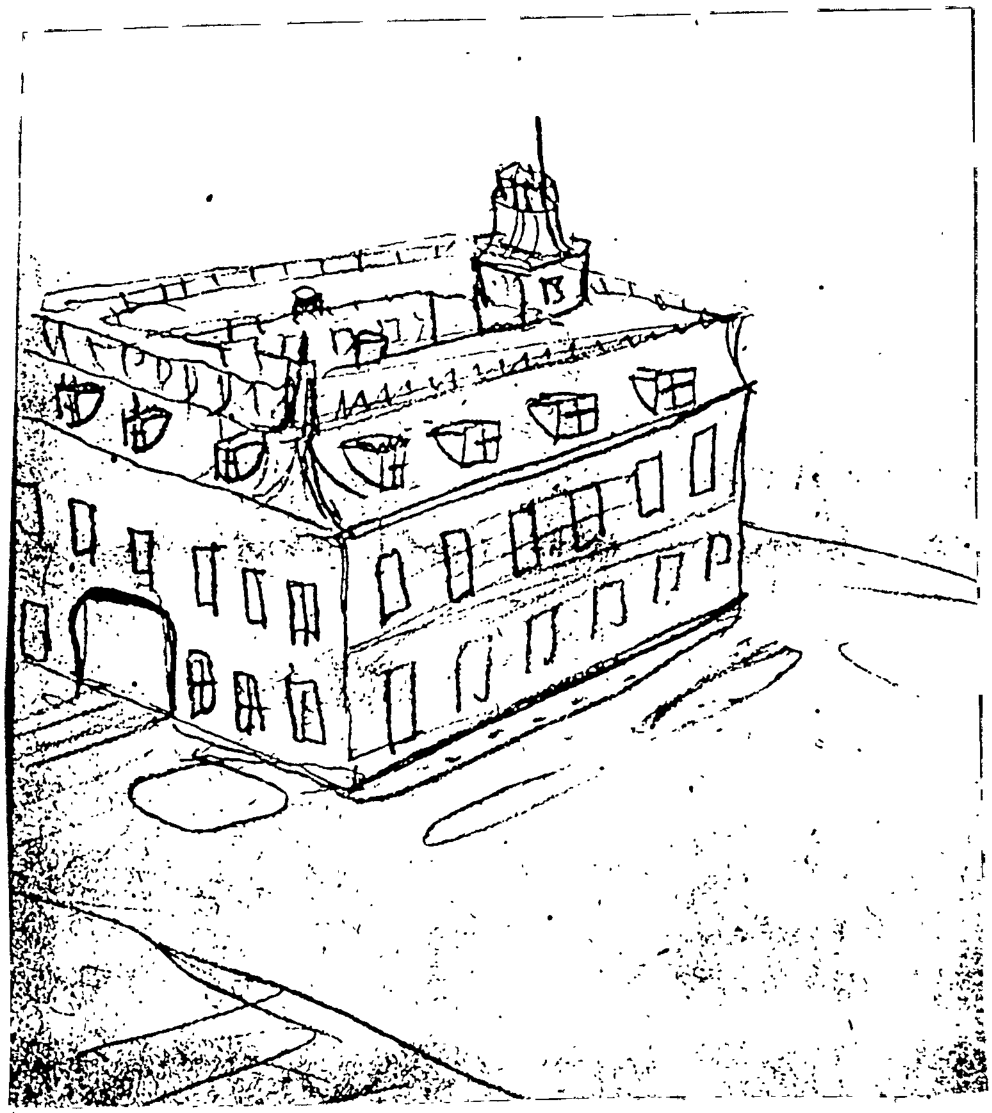


Illustration 1-2

Drawing of Planned Lab

shows that he was thinking about a structure that would reflect his new prestige as a great inventor and man of substance. This laboratory is an impressive three-story building with a Mansard roof. The tower and courtyard are its two distinctive features (which are often found in the large textile mills of Newark), and these give it the dignity of a public building. These and later sketches always depict a laboratory based on a manufacturing facility called a "shop". The machine shop was central to Edison's method of inventing for it was here that his ideas were made up into experimental models. During his years in the telegraph industry Edison had grown accustomed to inventing in this machine shop environment, where the tools and skilled machinists were always at hand to turn ideas into working devices. His first labs were in machine shops. Edison's style of inventing and management was influenced by the machine shop culture he had absorbed in Newark. Wherever he moved, he made sure that his experiments were done close to a machine shop. In the years between the Menlo Park and West Orange laboratories Edison's base was never far from a machine shop, firstly in Bergmann's factory in Manhattan, and then in the Lamp Works at Harrison, New Jersey.

Another fixture of Edison's method was a chemical laboratory. The development of industrial research was closely associated with the advancement of the science of chemistry. The first industrial research labs were established by German chemical companies to carry out testing and basic research, and similarly the first American corporate laboratories were set up for industrial chemistry. The Pennsylvania Railroad, for example, created a chemistry laboratory as early as 1875 to analyze and test materials. Even Andrew Carnegie, who maintained that "pioneering don't pay," saw the advantages of hiring a chemist to analyze the operation of his blast furnaces. His conclusion that "9/10ths of the uncertainties of pig iron making were dispelled under the burning sun of chemical knowledge" was repeated by other industrialists who saw the value of chemistry in their businesses.[7] Edison planned several chemical projects for his new laboratory: tanning, electro-chemistry, ozone for bleaching, and the production of aluminium. Some of these experiments would have immediate commercial application in the large tanning and textile industries of New Jersey. Edison had also discussed several other projects with Batchelor, including a new method to make fine wire and a process of electroplating. The latter noted in his diary that "immediately the new lab is finished these will be commenced in earnest."[8]

By 1887 Edison's ideas for the new lab were taking shape. Another plan for the new laboratory contained a machine shop, chemical laboratory, and library all placed on the ground floor. The latter was a very important part of Edison's method. He always began an experimental project with a thorough search of the scientific literature. The first two steps were described thus: "1st. Study present construction. 2nd. Ask for all past experience ... study and read everything you can on the subject." The development of the electric light had shown the importance of information gathering. Electrical technology was international in nature and its rapid development was the result of the transatlantic movement of men, machines, and ideas. The experience of the electrical industry had shown that a key piece of information, the key to a breakthrough, could easily be hidden in an obscure scientific journal--such as Pacinotti's discovery of the ring armature--and Edison planned to locate and take advantage of any new piece of scientific knowledge that came his way. He now had the money to gather all the technical journals and scientific literature which would be the starting point of his innovations. These were ordered for the library which would be a resource for all Edison's workers and a testament to the importance of information flow in his laboratory.[9]

The second floor of the building in this plan contains the supply and apparatus room, which were positioned close to the experimental rooms to be called upon when needed. Edison knew that experimenters needed all kinds of supplies and therefore placed the supply room close to them. The supply rooms served both experimenters and machine shops, containing a complete store of metal parts, screws, wire, joints, gears, tubes, and sheets. It would also contain the batteries, magnets, and electrical sub assemblies that were needed to make up experimental apparatus. It was Edison's goal to have everything needed for invention at hand. This included the facilities to make large metal parts, such as castings for dynamos, which had usually been made outside the laboratory because of their size. Edison decided that this inconvenience would not hinder him at the new lab and subsequently planned to erect a forge and furnace on the ground floor.

A galvanometer room for electrical testing also figures in the plan, evidence that Edison intended his new laboratory to be fully equipped to carry out electrical work, especially on his incandescent lamp. A glass blower's room is included in this plan and subsequent sketches show a vacuum pump room; Edison planned a complete facility devoted to research and testing of electric lights.

The upstairs of this planned laboratory contain the experimental rooms where the work of invention was to be carried out. The experimental room as conceived by Edison was a long (75 feet) room filled with tables. On each table would be experimental apparatus and the models in stages of construction. Also placed on these tables would be the experimental notebooks in which each experimenter would record the progress of his work. Edison had begun using notebooks in the formative days in Newark, envisaging them as "a daily record containing ideas previously formed, some of which have been tried,..., and some that have never been sketched, tried, or described." [10] The notebooks would be left on the tables to be picked up whenever a idea needed recording or the results of a test noted. Sometimes they were used by Edison to quickly jot down an idea and lay the plan for an innovation; at other times they were used to record the progress and outcome of an experiment after it had been completed. The information in these books was indispensable to both historians and patent lawyers. The laboratory notebooks do more than document the work of the lab: they were the raw material of invention at the Edison laboratory.

BUILDING THE LABORATORY

Edison bought the land on which his laboratory was to stand in January 1887. The 14 acres were situated on the main road through the Oranges, at the bottom of the hill that led up to Glenmont. Like the mansions of the factory masters of the Industrial Revolution Edison's magnificent house was to overlook the workshops and chimneys that provided his income. In the spring he gave his assistant Charles Batchelor the task of preparing drawings for the laboratory and overseeing its construction. Henry Holly, the architect of Glenmont, was retained to design the laboratory. He produced plans for a handsome three-story building 250 foot long and 50 foot wide, and Batchelor spent the summer turning these plans into bricks and mortar. Edison was always around, either coming down from Glenmont or stopping on his way to the Lamp Works in Harrison. The inventor exerted his powerful influence, firing Holly, denouncing bad workmanship, and constantly changing the plans. Yet Batchelor worked steadily on, accustomed as he was to the ways of the "old man."

Charles Batchelor had been at Edison's side since he joined the inventor's staff in the early 1870s. Born in England, he was one of the many workmen who left the factories of the "Black Country" for the textile mills of Massachusetts and New Jersey. Batchelor was sent to install machines in the Clark thread mills in Newark, met Edison, and never returned home. The dark-bearded Englishman had the craft skills that made Manchester the workshop of the world. A master of metal working, he was also a competent foreman and manager. His neat, well-organized notebooks are an indication of his orderly mind and precise hand. He was an ideal counterbalance to Edison who often got so involved in an experimental project that he forgot everything else. According to one of Edison's experimenters, Batchelor was the "sometimes needed, conservative element of the combination." [11] Throughout 1887 Batchelor got on with the job of building and equipping what was to be the largest private laboratory in the world.

The first building to be erected was the original laboratory designed by Holly. (Illus 1-3,#6110) The west end of the long building faced the road that cut through the Oranges. Here the graceful, arched windows of the library rose two stories to break the line of a plain industrial structure. Edison's laboratory presented a dignified face to the world passing on main street. The library--always situated by the entrance in all Edison's plans for the laboratory--gave an impression of intellectual effort within and leant support to the notion that learning was essential to inventing. But at the other end of the laboratory stood the power house which contained the steam engine and dynamos to provide power, heat and light. This was the work end of the laboratory where

Illustration 1-3

Building 5

machines roared and men sweated in the grimy heat.

Once the main laboratory was completed work began on four smaller laboratory buildings, identical in size 100ft by 25ft) and positioned at right angles to the main building.(Illus. 1-4, Lab and satellite buildings, # 7206) They were numbered 1 through 4 starting with the one closest to Main Street. Building 1 was devoted to electrical work and the study of magnetism. The "galvanometer room" in the early plans for the lab was now made into a separate building, completely dedicated to electricity. It was constructed on a deep foundation of brick and cement that would dampen any shocks to the delicate electrical measuring equipment inside. Great pains were taken to avoid all metal fittings that might influence the electromagnetic devices used in experiments. This building contained all sorts of electrical measuring devices, including several kinds of galvanometers, wheatstone bridges, and a large selection of meters in use in the Edison lighting system. There were also numerous condensers, induction coils, relays, and electro-mechanical assemblies at hand.

Building 2 was established as the chemical laboratory. It was fitted with a balance room and lined with shelves containing bottles of chemicals. Building 3 was used as a storeroom for the overflow of chemicals for Building 2, an indication of the growing importance of chemistry in the Edison laboratory. The rear part of Building 3 was turned into a wood-working shop to make the jigs and patterns needed in the

manufacture of Edison products. The last of the satellite buildings, number 4, was established as a metallurgical laboratory. It contained rock crushers and graders, assay furnaces, and containers for the many samples of ore that Edison had collected.

These four satellite buildings indicate the experimental directions that Edison intended to follow: electricity, chemistry, and metallurgy. They are physical proof of Edison's habit to break down experimental problems into electrical, chemical, and material parts. They complimented the work of the main laboratory building, and their spatial relations with it defined the physical shape of Edison's West Orange laboratory. Building 1 formed an entrance gateway with the west end of the main building, and the space between it and Buildings 1 and 2 formed a courtyard. His new laboratory had an open architecture which enabled him to convert workspace and add buildings as the need arose. The West Orange laboratory was an organic structure which constantly changed to meet the needs of Edison's research, new buildings added and old ones refurbished.

The five main buildings were completed by September, and Batchelor then turned his attention to fitting out the laboratory. He followed the current industrial practice in establishing a power house at one end of the main laboratory building and running shafts along the two first floors. Leather belts took the power from the drive shafts to the machines below. The laboratory was wired for electricity throughout and some of the experimental rooms were fitted with outlets of different voltages, yet the days of electrically driven machine tools were still well in the future.

The work of equipping the machine shops provided some diversion for Edison and Batchelor who scoured the manufacturer's catalogues and purchased a wide selection of machine tools: lathes, drills, grinders, and presses. The great number of machine tools ordered were too many for one shop, consequently Batchelor divided them between two floors of the main laboratory building: heavy lathes, drill presses, and milling machines on the first floor; smaller lathes, grinders, and polishers on the second. The heavy machine shop, under the supervision of Batchelor, was intended to produce large equipment like dynamos for central stations. It came equipped with a travelling crane to move about the heavy dynamos of the electrical industry and massive ore milling machines. The second floor machine shop was called the "precision room," for the men who worked here were highly skilled mechanics and watchmakers who built experimental models.

At the end of September 1887 Batchelor began moving experimental equipment and supplies from the laboratory in the Lamp Works, where Edison and a skeleton crew of around 10 experimenters had maintained the effort on a number of experimental projects in electricity, ore milling and the phonograph. In October and November loads of "experimental stuff" were shipped by horse cart from Harrison. These loads contained the vital parts of experimental projects, and their arrival at West Orange during the first weeks of December must be taken as the true start of work in the new lab.[12]

In addition to the loads of tools and equipment arriving at West Orange, Edison had also ordered masses of supplies for the store rooms of the lab. During 1887 and 1888 a stream of consignments arrived in West Orange from all parts of America, not only lengths of steel and pipe but rare and exotic materials such as seahorse teeth and cow hair. The main store room was set up on the first floor of the main laboratory building, in between the library and the machine shops. Experimenting meant that one could never anticipate what could be needed, not only tools and metal parts but also all kinds of materials. At the big lab, Edison wouldn't have to search out rare books and new technical journals because they lined the shelves of the library, and he wouldn't have to search the world for some crucial raw material that might be needed. Having everything at hand was the great advantage of building the biggest research laboratory in the world.

Edison believed that the process of invention could only be successful if carried out next to a store house of materials--"the most important part of an experimental laboratory is a big scrap heap." [13] The larger the heap the better, for somewhere in the pile of different materials and discarded experimental apparatus might be the key part to invention. The greatest lab in the world was to be equipped with every possible material in case it was ever needed at the height of a research project. Edison's interest in metallurgy was reflected in the great collection of different ores and minerals that was housed in the library. The analysis of materials was one of his great strengths as an inventor; some of his greatest breakthroughs had been the identification of a material that would perform an important task in an invention, such as the bamboo for the filament of his incandescent bulb or the chalk button for his telephone microphone. The lab carried out basic research into the nature of materials because this knowledge could easily be applied to many different projects. For example, Edison began experiments at the laboratory in 1888 to examine the properties of hard materials that could be used for the filament of his incandescent lamp and the stylus of the phonograph.[14] Another important function of the laboratory was to find cheaper and better materials to replace those already in use.

The great store of supplies gave the West Orange laboratory its comparative advantage over the laboratories of Edison's rivals. The inventor truly believed that when it came to research, bigger was indeed better. He had built a facility that had the machine tools to turn out "anything from a lady's watch to a locomotive," and the extensive hoard of supplies offered significant economies of scale in the pursuit of many different experimental goals. The real savings of a large lab were in reducing the expensive delays caused by waiting for critical materials or a machining job. A large staff fully supported with everything it might need meant that "Inventions that formally took months and cost a large sum can now be done in 2 or 3 days with very small expense. [15]

Another advantage of a large laboratory was that it allowed efficient routing of experimental projects. Edison's method of inventing was based on close cooperation between experimenters and machinists. He liked to jot down some ideas for an experimental device and then have it made up, modifying it while it was being built.[16] The second floor plan of the laboratory was organized to facilitate this cooperation, and did it on a larger scale than ever before. The siting of the precision machine shop next to the experimental rooms of the second floor established a floor plan built around the idea of speed--as ideas occurred to experimenters on the second floor they could quickly draw on the skilled mechanics of the precision room to build the models and devices they needed. The arrangement of facilities at the West Orange lab point to a concept of throughput of innovation; the various elements flowing together from one end of Building 5 to the other, from Edison's room to the heavy machine shop and then to the manufacturing stage. His idea to group all the experimenters together reflected his emphasis on flexibility and good communications within the lab.

The experimental rooms on the second floor were the heart of the laboratory where some of the great inventions were made.

They were divided by wooden partitions and could be arranged to suit any project. Edison wanted a flexible floor plan to change experimental directions as he saw fit. The rooms were lined up on each side of the main corridor that led to the precision shop and numbered beginning at the head of the stairs. At the end of the row of experimental rooms on the south side of the corridor was Room 5, the photographic studio. This room was kept locked, and had opening in the door to pass through supplies. Here W.K.L. Dickson experimented on the motion picture camera and kinetoscope. Edison's room was number 12, to the left of the stairs and facing the laboratory's courtyard.[17] Close to his room was the room of Fred Ott, whose precision lathe often gave life to Edison's ideas. It was just a short walk down the hall to take advantage of the skilled men and specialized machines of the precision shop. At any time, several experimenters would probably be in this shop, watching the construction of models and apparatus and swapping ideas with the machinists.

EDISON'S LABORATORY AND THE CONTEXT OF INDUSTRIAL RESEARCH

Although Edison claimed that "there is no similar institution in existence," his new laboratory was by no means the only research facility in the United States. By the 1880s there was already a tradition of works laboratories and material testing in American companies that dated back to the First Industrial Revolution. The larger, and more scientific, industries of the Second Industrial Revolution put a higher premium on industrial research. Several of the new corporations--Standard Oil and the Pennsylvania railroad among them--saw the advantages of chemical laboratories. The rapid technological change of the "Second Industrial Revolution" made it imperative to keep pace with technological development as well as monitor ever more complex operations. Successful inventors like Alexander Graham Bell needed no encouragement to set up their own laboratories to further their work. He established the Volta Laboratory Associates in 1881 which included his cousin Chichester Bell and Charles Tainter. [18] The Bell Company faced the problems of operating a complicated technological system and quickly formed corporate laboratories charged with testing, product improvement, and examining new telephone technology. One of the laboratory managers was Ezra Gilliland, a self-taught electrician and an old friend of

Edison's from their days as telegraphers. Gilliland soon left the organization to join up with Edison, and his place was taken by Hammond V. Hayes, one of the first Phds in physics granted by Harvard.

The triumph of the incandescent light proved that there was money to be made in invention, and in the years after 1879 several electrical laboratories were established by private and corporate concerns. The inventor Edward Weston constructed a two storey laboratory next attached to his home in Newark. It contained a machine shop, a room for electrical research, and a chemistry laboratory. This duplicated (on a much smaller scale) the facilities Edison had erected at West Orange.[19] Many of the early research laboratories were closely connected to machine shops and factories. Weston's factory in Newark was the host institution for his laboratory. The electrical inventor Charles Brush worked in machine shops in Cleveland's telegraph industry. The eminent electrician Elihu Thomson carried out experiments and devised new equipment in a "model room" in the Thomson-Houston factory in Lynn, Massachusetts. Thomson's laboratory was called the "model room" because its function was to produce experimental devices and patent models. Precision machine tools occupied the bulk of the room, which also contained electrical instruments. With "a few tools and perhaps one or two workmen," Thomson labored to produce "devices and new appliances...to be refined and immediately put into manufacture."[20].

The laboratories of the electrical and communications industries were outside main stream of American industrial research in their orientation towards new technology; the major function of the laboratories of the railroads, steel works, and petroleum companies was testing. Much of Edison's West Orange laboratory was also devoted to testing, namely building 4 (ore samples) and building 1 (electricity). Testing electrical equipment was a major function of the Edison laboratory for only the lab possessed the accurate measuring equipment to do the job. The lab tested dynamos, conductors, and incandescent bulbs for all the other organizations in the Edison electric lighting enterprise. Building 1 housed a Lamp Testing Room where a team of about four experimenters tested lamps under the direction Charles Deshler. This laboratory was specially fitted up to test many bulbs under different operating conditions. A continual program of improvement in its equipment was carried out during the first years of operation as Edison's engineers constantly sought more precise measurement and a more realistic operating environment.

The most impressive testing installation at the laboratory was the dynamo room in the main laboratory building. This was equipped with several different types of electrical generators and was used to simulate all aspects of central station operation. The laboratory supplied current to houses in Llewellyn Park and this small distribution system was used for testing by Edison's engineers. [21] The whole West Orange complex, including the Llewellyn Park lighting installation, served as a test bed for the distribution network of cables and feeders and for the meters in central stations which recorded output. At the time it was built, the West Orange laboratory was the most complete and advanced electrical testing laboratory in the world.

It was also the largest electrical laboratory yet built. None of its contemporaries employed more men than Edison's West Orange complex; the laboratory of the Bell Company employed 29 men around 1885, the staff of Charles Dudley's chemical laboratory at the Pennsylvania railroad did not exceed 30, Thomson's model room at its peak employed less than 20 people, and so did Weston's laboratory. In comparison, Edison's new laboratory was built to employ over 100 men and the physical facilities at West Orange dwarfs those of Weston and Thomson. There were no other facilities in the U.S. in the nineteenth century that could compare with the West Orange laboratory in terms of its great size and ambitious scope. Testing was only one of the tasks of the laboratory, and only one small part of a large operation which was centered on innovation

The term "research and development" implies a two part process: research that leads to an invention, and then the development of a commercial product from this original idea. Although historians and economists are not agreed on a common definition of industrial research, it must include the research and development of new products in addition to testing and analysis. The West Orange laboratory was built to support the technological development of the Edison system. Its mission was to provide the electrical technology for the second decade of electricity (the 1890s). The primary goal of the lab was to produce new electrical products: This placed it firmly in the vanguard of electrical science.

Edison and his West Orange laboratory have not been credited with original scientific research, and it is perhaps for this reason that other laboratories are thought of as the true progenitors of modern industrial research. This honor is normally given to the corporate laboratories of GE and AT&T who had a more formally trained staff and were advertised as carrying out basic scientific research. The GE laboratory, for example, was described to the stockholders as "a laboratory to be devoted exclusively to original research." Many historians have used this definition to conclude that industrial research laboratories did not exist until the twentieth century.[22]

The idea that R&D somehow requires a scientific component has clouded the issue; it fails to grasp the objectives of industrial research and the primitive nature of electrical knowledge in the nineteenth century. There is no doubt that the new industrial research organizations of the twentieth century had highly-skilled staff, many with advanced degrees and impressive academic credentials. Yet at the time Edison established the West Orange laboratory in the 1880s, the cutting edge of scientific understanding of electricity was in the operation of electrical equipment rather than in basic research in the universities. There were no formally trained electrical engineers. The gift of Edison electrical equipment formed the core of MIT's newly formed department of electrical engineering. The expertise of Edison's laboratory, and its advanced equipment, made it a center for the scientific and academic community and many meetings were held there. In 1888 the electrical section of the American Institute met at the lab and 250 people attended a lecture given on electrical measurement.[23]

The stated objective of the West Orange facility was to conduct experiments and "scientific investigations...with a view of making inventions useful in various arts." [24] Despite his many pronouncements to the contrary, Edison was not opposed to basic scientific research in his laboratories, provided that it might have broader applications or commercial potential in the future. The fact that he had his eye on a commercial pay-off for research does not detract from the quality of R&D at the Edison laboratory. In practice, scientific endeavor in research laboratories has always been conditioned by, and normally channelled into, corporate goals. If pure science was basic research just to discover new knowledge without the motivation of future profit there was never any pure science in industrial research. As the one chief engineer of AT&T put it " the distinction between pure science and industrial research is (merely) one of motive."[25] The means might have changed in a hundred years of industrial research, but the end remains the same--profit.

Some historians have characterized Edison's relationship with science as more "borrowing" from it than actually creating it. Yet when there was nothing to borrow from, Edison was obliged to create, carrying out basic research to gain a deeper understanding of what was going on. This was especially true of research into electromagnetism. Although many observers believed in the 1880s that the knowledge of electrical science was almost perfect, in fact, it was in a state of ignorance. Electrical equipment at the time of the pioneer Pearl Street station was heavy, inefficient, and prone to breakdown. Scientists and engineers on both sides of the Atlantic worked frantically to improve the efficiency of the equipment before the fragile electrical industry went under in a sea of debts. Yet until more was known about electromagnetism and how it worked in generators, there was little room to improve the low output and poor efficiency of dynamos. The great electrical engineer Silvanus Thomson noted in 1886 that "until we know the true law of the electromagnet, there can be no true or complete theory of the dynamo." [26]

Edison had gathered men around him who were well qualified to chart new ground in electrical technology; among them were Reginald Fessenden and Arthur Kennelly. Although not graduate trained in advanced physics, these were college trained men with vital practical experience. Fessenden and

Kennelly went on to make great contributions to electricity, the former as an inventor and the latter as one of the eminent nineteenth century electrical engineers. These men used scientific methods in their laboratory work and and wrote scholarly articles. Fessenden wrote several articles about his work at West Orange in the 1880s and 1890s, but Edison would not give him permission to publish them.[27] Edison would not let academic freedom give his competitors any business secrets, and in this he was no different from the men who ran the corporate laboratories of the twentieth century. Fessenden and Kennelly were free to conduct expensive research for scientific goals with the minimum of interference. The experiments in electromagnetism carried out during the first decade of the laboratory were scientific investigations without a short term pay-off. This work were to provide the foundation for innovation in the future.

The Edison laboratory was insulated from the demands of corporate policy, unlike the many industrial research laboratories of its era who had to prove their worth to a cost conscious management. The corporate laboratories were under the control of the management of the corporations who financed the operations. They used it as a defensive weapon rather than directing it towards producing revolutionary new technology. As one historian commented, "To a manager concerned with meeting the competition in matters of service, price...and technical capabilities, research meant working towards straight forward technological goals."[28] R&D became the tool of corporate policy in the United States and was directed more by management strategies than by scientific considerations.

The expense of research had to be justified, and this could only be done by showing results. In many cases the management turned out to have a conservative attitude to R&D. Before the great scientific endeavors of the twentieth century the new corporate laboratory had to earn its keep and justify its existence in a cost-conscious world. Willis Whitney, the manager of GE's laboratory, moved in this direction very quickly and by 1901 the laboratory was solving engineering problems brought to them by other parts of the company. Much the same can be said for the Bell Company's pioneer industrial research laboratory. Hammond V Haynes, the director, had begun projects to examine the fundamental science of telephone transmission in his laboratory. But he soon gave this up, abandoning theoretical work for "the practical development of instruments and apparatus."[29] The basic scientific work, he decided, was best carried out by institutions like MIT.

Where the Edison lab diverges from the convention of an American research laboratory, was its relationship with the manufacturing facility. Edison's plan was not for a laboratory to support manufacturing, to provide defensive technology to ward off the competition, as was the case with the Mechanical room and Dudley's lab; but as the center for a vast industrial complex. The lab was not an adjunct to a manufacturing facility but the brains of a larger organization. Although the laboratory was the last part of Edison's electrical empire to be constructed, it was the most important. Building 5, the main laboratory building, was the technological nerve center of the Edison lighting industry; it housed the impressive library of technical literature and journals, the blueprints of many central stations built by the Edison Central Station Construction Department, and the technical experts on the Edison system. The laboratory served as a repository of operating experience and new knowledge that was of great value to the individual lighting companies. It was an information center where operating problems could be brought to the lab's experienced staff for solutions. The West Orange laboratory was also the symbolic center of the Edison lighting industry, where board meetings were held and important decisions made. All technological issues were automatically referred to the laboratory and one of the earliest meetings called at the laboratory, in November 1887, was to discuss a technical report on the Westinghouse lighting system.

The difference between the status of an independent laboratory and the faceless corporate R&D department is evident to the naked eye; the West Orange lab is an imposing, free standing structure which expressed the status and importance of Edison's work. (Illus 1-5, #7209) On the other hand, the industrial research laboratories of the twentieth century are unimposing structures: a wooden shack that housed the GE laboratory in Schenectady, anonymous offices in corporate headquarters, and machine shops in corners of large factories. The lab complex makes a statement about the preeminent role of R&D in industry that no other laboratory duplicated. As the driving force of a great industrial concern, and the center of an international industry that was creating the second industrial revolution, the Edison laboratory stood alone in the nineteenth century. There was no doubt in the minds of the men making their way to West Orange in the fall of 1887. Stocked with every conceivable supply and led by the nation's most famous inventor, it was simply "the best laboratory ever."[30]

NOTES FOR CHAPTER ONE

Unless otherwise stated, all primary source material is from the Edison National Historic Site.

1) Leonard Reich, The Making of American Industrial Research (New York: Cambridge, 1985), p. 45.

2) George Prescott, Dynamo Electricity (New York: Appleton, 1888), p. 228 estimates that there were 164 Edison installations in the United States in 1886 and 142 in Europe. The European installations were in W. Europe, Italy, and Russia; Mathew Josephson, Edison: A Biography (New York: McGraw Hill, 1959) pp. 300:301.

3) Robert Stern, Pride of Place: Building the American Dream (New York: Houghton Mifflin, 1986), p.129.

4) Ibid and Stern, Gilmartin and Massengale, New York City 1900, p. 421.

5) Carole Rifkind, A Field Guide to American Architecture (New York: New American Library, 1980), p.80.

6) Thomas A. Edison (TAE) to Hood Wright, Nov 1887, Laboratory Notebook N 871115.

7) Louis M Hacker, The World of Andrew Carnegie (New York: J.P. Lippincott, 1968). p. 349.

8) Batchelor diary, 1336, p. 279, Sept 1887, Laboratory Notebook, N 870000.3.

9) J.P. Constable to product engineers, 11 Sept 1917, Lab blue book. The first important innovation in armature design was the work of the Italian scientist, Antonio Pacinotti. His slotted ring armature of 1869 was a breakthrough, but the scientific paper describing it languished in the pages of an obscure scientific journal for ten years, unnoticed by the engineers who were trying to make a better armature, Malcolm Maclaren, Rise of the Electrical Industry during the Nineteenth Century (Princeton: Princeton University Press, 1943), p. 114. The lab had this journal and loaned it out, Seely to TAE, 30 Dec 1892, Document file for 1892, Electricity. All citations to document files will follow this format of sender to recipient, date, year and name of file.

10) Josephson, p. 90.

11) Reginald Fessenden, "The Inventions of R.A. Fessenden,"

Radio News, 1925.

12) Vouchers, #1-601, voucher series, 1886-1887.

13) Maurice Holland, "Edison: Organizer or Genius," April 1927, p. 7 in Ford Archives, Dearborn, Box 12 Folio 7.

14) Lab notebooks for 1887, Reel 279.

15) TAE to Hood Wright, Nov 1887, N871115.

16) " Sometimes I get an idea and jot it down in the book, sometimes I would get it while the machine was being made and change it and then note it in the book." Edison's testimony in the Complainants record, Edison vs American Mutascope, p. 119, Legal Box 173.

17) Frank L. Dyer and Thomas C. Martin, Edison: His Life and Inventions (New York: Harper, 1910), pp. 648-650.

18) John Rae, "The Application of Science to Industry," in A. Oleson & J. Voss, eds. The Organization of Research in Modern America (Baltimore: Johns Hopkins, 1979), pp. 249-263; Robert V. Bruce, Alexander Graham Bell and the Conquest of Solitude (Boston : Little Brown, 1973), pp. 340-345; (Robert Conot, A Streak of Luck (New York: Seaview, 1979), p. 246.

19) Scientific American 57, Nov 1887, 287-290.

20) Darwin H. Stapleton, "Early Industrial Research in Cleveland," April 1897; W. Bernard Carlson, "Invention, Science, and Business: The Professional Career of Elihu Thomson," (University of Pennsylvania, 1984); David Noble, America by Design (New York: Knopf, 1977), p. 113.

21) Electrical Review, XXI (Oct, 1887), 391.

22) George Wise, Willis Whitney, GE and the Origins of Industrial Research (New York: Columbia, 1985), p. 97; Reich, Making of Industrial Research, p.2.

23) Electrical World, X (Nov, 1888), 238

24) Draft laboratory agreement with Henry Villard, 1888 W.O. Lab.

25) Noble, America by Design, p. 112.

26) Silvanus Thompson, Dynamo-Electric Machinery (New York: F.N. Spoon, 1886), p. 20.

27) Fessenden to TAE, 14 April 1893, Biographical Files. Of

Fessenden's scientific achievements, Hans Fantel wrote in the New York Times of 28 Dec 1986: "In December 1906, for the first time, Fessenden injected earthly music into the heavens, and the world hasn't been the same since."

28) L. Reich, "Industrial Research and the Pursuit of Corporate Security," Business History Review, LIV (1980), 504-505.

29) Wise, Willis Whitney, p. 79, see also Reich, Making of Industrial Research.

30) Quoted in C. Withington, Interview with A. Kennelly, 1920s Edison Pioneers File.

CHAPTER TWO

FINANCING A GRAND STRATEGY

It was not Edison the inventor who built the West Orange laboratory, but Edison the capitalist. He knew from experience that there was little money in selling patent rights; the profits went to the financier and manufacturer. In Edison's worldview the inventor was often the victim of the innovative process. He claimed that the money he made was from manufacturing the invention and not selling the patent. [1] Edison therefore formulated a grand strategy for his lab, envisaging a large industrial undertaking that would manufacture the many new products devised in the laboratory:

> My ambition is to build up a great industrial works in the Orange Valley starting in a small way and gradually working up--The Laboratory supplying the perfected invention models pattern and fitting up necessary special machinery in the factory for each invention. [2]

His conception of the process of innovation, or "pioneering" as he called it, did not end in the laboratory. It was not enough to develop new products. Edison wanted to control the manufacturing stage and use the resources of his laboratory to continually reduce the cost of manufacture. The idea was to innovate at all stages of production until the goal of low cost mass production was reached. This plan of innovation led Edison into the role of entrepreneur and factory manager. He wrote later that it was never his intention to act as a capitalist, except to "pioneer" his inventions which required both finance and control of the manufacturing process.[3] It might not have been his original intention to become a capitalist, but Edison certainly played the role at West Orange, where he constructed many factories, formed numerous companies, and carried out business strategies similar to his industrial peers--Andrew Carnegie, John D. Rockefeller, and Henry Ford. All these captains of industry promoted vertical integration of their operations, sought self-sufficiency in raw materials, and had a paternalistic, and often hostile, attitude toward organized labor. All used innovation to create or dominate markets. All formed new types of business organizations, operated by professional managers and financially interrelated.

Edison planned to establish a massive industrial complex in North New Jersey and was determined to "dot the Orange Valley with factories." At the center of this empire was the laboratory. Charles Batchelor was told of this grand design while the laboratory was being built. He wrote in his diary: "Edison's idea now for the future is to get up processes for manufacture and start factories...as soon as the new laboratory is finished this will be commenced in earnest."[4] Edison's plan for his West Orange complex was the logical extension of the vision for Menlo Park that foresaw a stream of inventions flowing from a research laboratory. He had also begun to use his laboratory to support manufacturing at Menlo Park.[5] The move to West Orange permitted Edison to continue this design on a grand scale: the laboratory was intended to be the nerve center of a massive industrial enterprise.

This conception of industrial research was totally different from the corporate R&D of companies like GE and A.T.&T. Their laboratories were subordinate to the manufacturing process and acted as tools of corporate policy. On the other hand, Edison's laboratory was the brain of the organization that controlled production and provided leadership. The manufacturing facilities were central to Edison's plans for the West Orange complex and subsequently construction of the factories began as soon as the laboratory complex was finished in the spring of 1888.

The ground was broken for the Edison Phonograph Works in May 1888 and the buildings were completed by the end of the year. Located to the east of the laboratory, the Works centered on two large buildings: one was about 75 feet wide and 200 feet long, and the other was the same width but 400 feet long. [Illus. 2-1, #60466] The shorter building was located next to the laboratory and contained the many tools used to make up the component parts of the phonograph. A photograph shows that its interior was left open, allowing belts and pulleys to take power from the overhead main shaft to each machine.[Illus. 2-2, #0-7980] The larger building was divided into rooms separated by a central corridor. Here were offices, the assembly and

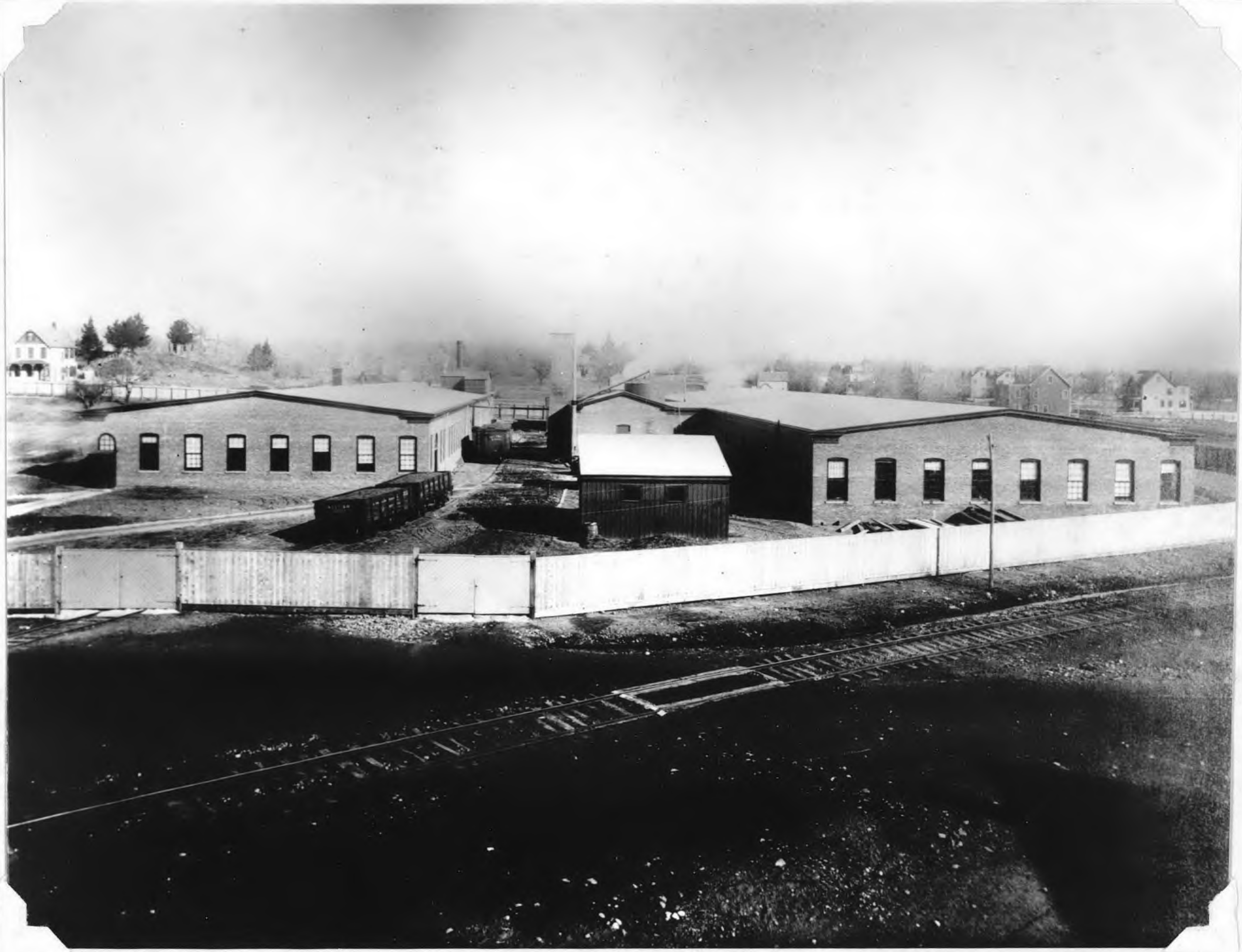


Illustration 2-2

Interior of Edison Phonograph Works

testing rooms, and the japanning ovens for the phonograph's varnished finish. The wax cylinders and phonograph batteries were made in this building, which also contained the finishing and packing rooms. In between these two long structures were three smaller buildings, one of which contained the powerhouse for the Works. Fully equipped with a large foundry, and illuminated throughout by electric light, the Works could carry out all aspects of phonograph manufacture from toolmaking to testing. [6] It also had every facility to manufacture a wide range of precision products, especially those requiring electrical parts.

The completion of the Edison Phonograph Works in 1888 rounded out the original plan for Edison's West Orange operation--a large manufacturing facility adjoining a laboratory complex, and all under the control of one man. Edison intended the West Orange complex to be his own personal endeavour. The electric light had made him a rich man and enabled him to turn his dream of a great research laboratory into reality. Edison invested a considerable part of his fortune in the laboratory. It cost him around $180,000 to build and this represents over two million 1987 dollars. The laboratory was his and his alone. It was owned and operated by Edison until his death in 1931 and he never thought of it as anything but his personal business. But the sheer scale of Edison's grand strategy meant that he could not support it with his own resources alone. The history of his laboratory is tempered by the continual demands of financial need: its growth and evolution influenced by Edison's search for operating funds.

Edison quickly spent the fortune he made in electricty. The profits from electric lighting were held in Edison's bank account with Drexel Morgan. Throughout 1888 and 1889 this was continually depleted to pay for the establishment of the West Orange complex. [7] Buying a fine house and building a great laboratory, equipping it with supplies and hiring the labor probably cost Edison close to half a million dollars by the end of 1888. Edison also assumed the costs of building and equipping the Edison Phonograph Works. Edison's strategy for his laboratory was a grand one and so was the financial burden he had to carry: "The Lord only knows where I am to get the shekels--Laboratory is going to be an awful pull on me."[8]

After making the initial investment in the laboratory Edison still needed a steady flow of cash to maintain a large work force and cover the day-to-day expenses of R&D. The operating costs of the laboratory alone were around $80,000 per annum--a considerable sum in the 1880s when the deflation of the Great Depression gripped the American economy.[9] Edison hoped to avoid using his own money to operate the laboratory, declaring that "it is no part of the inventor to furnish money."[10] It was Edison's intent to cover all the costs of the laboratory by selling its experimental services.

The first source of finance for the lab were the companies set up by Edison to manufacture his inventions. Supporting research from the profits of manufacturing had been a basic strategy for financing his work. The ideal financial basis for research, as envisaged by Edison, was a profitable manufacturing operation. His normal practice was to form a manufacturing organization as soon as an experimental project had proved its commercial viability, and then bill development work to the new company. In this way continuous research could be included in the costs of production. The company provided the money to support research and pay for the construction of manufacturing facilities.

Edison usually formed a separate company to absorb the costs of developing each one of his innovations, such as the Edison-Sims Torpedo Company or the Edison Ore Milling Company. Edison was sometimes the sole owner of the company and therefore the financing of R&D was simply a matter of transfering his funds or assets. In other cases the company was partially owned by Edison or he was the major shareholder. The means of financing the Edison Phonograph Works, for example, was the sale of shares to investors. Edison was the majority stockholder, ran the Works, and decided its R&D needs.

Research and development in electricity naturally promised to be a major occupation of the West Orange laboratory. The physical layout of the laboratory--with Buildings 1 and 5 heavily involved in electricity--reflects an emphasis on electrical work. The rapid growth of the electrical industry founded by Edison had created a perfect market for the services of a research laboratory--new products and processes were needed and engineering support was in demand. The highly competitive market for electrical goods placed a premium on technological innovation, and Edison's West Orange laboratory was built with this in mind. Edison had appreciated the need to continue R&D work on electricity when he first began to organize his lighting companies. The Edison Electric Light Company, the holder of Edison's patents and the licenser of local illuminating companies, was conceived by Edison to support the great costs of the experimental effort. Samuel Insull noted that this company was "formed for the purpose of supplying Edison with funds for carrying out experiments in connection with the development of the electric lighting system." [11]

Several manufacturing concerns had been founded by Edison to provide the equipment with which the Edison illuminating companies were electrifying America, including the Edison Machine Works and Bergmann and Co. These manufacturing shops, as they were called, became important customers for the laboratory, which was kept busy continually improving the design of all parts of the Edison system. Edison held majority control of the shops and after 1886 they provided him with a steady income and plenty of business for his laboratory.

While the manufacturing concerns could be relied upon to purchase specific engineering services like production engineering--making products cheaper and easier to manufacture-- or new product design from the lab, the Edison Electric Light Company was often the customer for basic scientific research related to the Edison lighting system. It contracted for a wide range of experiments from the Edison laboratory, ranging from measuring the resistance in power lines to devising ways to kill bugs with electricity. The Edison Electric Light Company also supported research that would help its commercial position and thwart the competition, such as the physiological experiments on the effect of electricity on the human body, used in the campaign against alternating current.[12]

Beyond electric lighting, Edison had identified two other major industries to be promoted once he had finished the West Orange laboratory. The phonograph and ore milling businesses were based (respectively) on new products and processes, and both were still in the development phase: their successful conclusion depended on further innovation at West Orange. Edison's invention of the phonograph in 1877 had brought him great fame but few profits. He organized the Edison Speaking Phonograph Company in 1878 to support the development of his fragile tinfoil instrument and market its novelty value. The Company put up $10,000 to support Edison's experiments to improve the invention but little was done because his time was taken up with electricity. Once the electric light system had been completed, Edison returned to the phonograph and expected that his new laboratory would be able to perfect it as a commercial machine.

The Edison Ore Milling Company was formed in 1880 to exploit his new patents on ore separation. Edison had devised a magnetic ore separator because he saw a profitable business in the extraction and processing of the rare metals used in lamp filaments. His first separator was designed to extract iron ore, employing powerful magnets to divert iron particles from a falling stream of crushed ore. The Edison Ore Milling Company was reorganized in August 1887, its capital increased, and a new agreement made with Edison. The Company provided $25,000 to cover the costs of experiments and Edison promised to "construct a special laboratory for the conduct and prosecution of said experiments." [13] Edison saw the new laboratory as the tool to bring the ore milling and phonograph ventures to a successful conclusion. It was the critical element of an industrial empire rapidly assuming form in the inventor's mind.

The phonograph, electrical, and ore milling businesses provided the financial foundation for the laboratory. Edison's expectations can be seen in his estimate of the yearly business of the lab with the following companies:

Edison Lamp Co	$10,000
Edison Electric Light Co	$5,000
Edison Machine Works	$6,000
Phonograph Co	$6,000
Ore Milling Co	$3,000

This brings the total yearly business with the Edison companies to $27,000--a sum less than half of his estimated operating costs. [14] The balance was to be found in marketing the services of the laboratory and carrying out research for venture capitalists.

Edison's financial planning for his laboratory was intended to make him independent of bankers. Edison had used the services of private bankers in the past--Drexel, Morgan and Co. played the important role of financing the Edison electric lighting system--and his experience with them had not been pleasant. He disliked paying high interest rates and resented the banks' practice of calling in their loans at short notice. Edison believed that the private bankers were out to deprive inventors of the returns on their inventions, and he knew that he could get better terms in joint projects with venture capitalists. Rather than deal with a private bank, Edison preferred to develop a one-on-one relationship with a venture capitalist. Here the Wizard of Menlo Park could work his special magic on impressionable financiers. His loathing of the New York banking community, which he called "the usual crooked gang of Wall Street promoters," runs through his correspondence. Edison avoided borrowing money from Wall Street if possible, instead he looked to venture capital to support his work. [15]

The importance of venture capitalists in financing Edison's work cannot be underestimated; financiers and entrepreneurs had played a crucial role in bringing his inventions to the marketplace. Venture capitalists not only supported Edison's R&D with their own money but had also mobilized additional funds by using their financial connections. In some cases they acted as entrepreneurs as well as financiers, taking an active interest in developing a new technology and managing its introduction. Men like George Harrington and Jay Gould had given him the capital to move from machine shop operator to professional inventor in the 1870s, and in the 1880s Edison looked to this quarter to finance his grand strategy. He sought partners to finance the work of the lab, and create joint-projects in which Edison and financiers shared the costs of research. This strategy had some important advantages; by involving other capitalists in experimental projects Edison could maintain several lines of experiment at the same time. He also spread the risk and limited his loss if an experimental program failed to produce results. Edison never underestimated the importance of finance in innovation; he knew that "the most difficult thing for an inventor is to get hold of people who will back him up." [16] He therefore began the search for financial support before the laboratory was completed, contacting several venture capitalists.

The formation of the Edison electric lighting organization had brought Edison into contact with several groups of investors. These were the first people he approached. J Hood Wright, one of the most active partners in Drexel &

Morgan, was invited by Edison in 1887 to join in some ambitious experimental projects but he declined, preserving his fortune. Similarly, the German entrepreneur, Henry Villard, initially became associated with Edison in the electric lighting business. Edison wasted no time in contacting him while the buildings were still being erected at West Orange and invited the financier to come and view the new laboratory.[17]

Henry Villard was a very early believer in the potential of electricity and played an important role by encouraging Edison in his experiments. According to Edison's secretary, William H. Meadowcroft, Villard was one of Edison's strongest financial backers. [18] Like many of the venture capitalists around Edison, Villard had begun his business career in the railroad industry. In 1881 Villard became president of the Great Northern Railroad and was, at that time, heavily involved in Edison's experiments to develop electric traction. Unfortunately for Villard and Edison, Villard's railroad empire crashed in 1884, forcing him to leave the country for his native Germany. When Villard returned to the United States, he was further impressed with the rapid advance of electricity and keen to support Edison's new laboratory. Villard not only had considerable entrepreneurial experience but also valuable connections in international finance. He was to become the most important venture capitalist in the early days of the West Orange laboratory, providing funds for a major part of the lab's work on electricity.

Edison was able to build a financial relationship with one venture capitalist to support a massive R&D effort on the phonograph. Jesse Lippincott had made his money in the manufacture of glassware, and had become interested in establishing a monopoly in the new talking machine business. He bought Edison's interest in the phonograph and provided funds throughout the years of work to produce a commercial machine. Money was all he could give to this project for he had little industrial experience and was not a good businessman. His funds ran out well before the phonograph venture began to return a profit and he died in 1891. Alfred Tate concluded that the attempt to dominate this industry cost him both his fortune and his life.[19]

The financiers of the motion picture venture were also entrepreneurs on the lookout for profitable new businesses. Norman C Raff and Frank Gammon were gamblers who saw a new industry in the flickering images of the kinetoscope. They were much different from the Wall Street investors who supported the electric light; Edison's biographer Matthew Josephson describes them as "speculators, backers of race track entries or theatrical shows" [20] These attributes were useful in the promotion of the kinetoscope. Although Edison certainly had the knack of seeing a commercial product in a laboratory phenomenon, he was out of his depth in sales and usually looked to his backers to organize marketing.

The financial relationships that Edison created, or tried to create, show that he originally wanted to concentrate on the innovating and leave marketing and sales to his financial backers. He told J. Hood Wright, "I am perfectly aware of the fact that my place is in the laboratory."[21] His creation of the many electric lighting companies was partly motivated by his desire to shift the responsibilities of running the lighting industry to a cadre of managers. He disliked the corporate infighting in the electrical industry and feared that Wall Street would gain control of the enterprise. In 1884 Edison was involved in a struggle to control the Edison Electric Lighting Company. Although his allies resisted a takeover from the Morgan interests, Edison felt that he had been "cut-off" by the company and later claimed that he "took no further interest" in running it.[22] The construction of a dream laboratory marked Edison's return to inventing after his time as a businessman in the electrical industry. He was looking forward to spending more time at West Orange, where he could do want he most wanted to do--innovate.

The central theme of the financial agreements devised by Edison in the 1880s was that he would develop new products while his financial backers were to support the cost of manufacture and organize the marketing. In a draft agreement with Henry Villard for example, Villard was to assess the market impact of the innovation and make the decision to manufacture and market. Villard was also given the freedom to choose the marketing arrangement as he wished, whether in the form of a license, joint-operation, or outright sale of marketing rights.[23]

Edison's boldest stroke for the finance of his laboratory was the promotion of one single organization to manufacture and market the stream of innovations he planned to produce. The Edison Industrial Company was conceived as "one organized avenue for the manufacture and introduction of all his inventions." [24] This company was to funnel money into the lab from many different investors. The financial arrangement involved entrepreneurs putting up the money for manufacturing and marketing, and Edison receiving a half share in the operation in return for the rights to his inventions. Edison had some experience in setting up financial relationships with several different parties at the same time. This had been his strategy while running several workshops in Newark during the 1870s and it offered important advantages to him, not least of which was the ability to move funds from one project to another without informing the investors.

He sold potential investors on the commercial potential of the research he planned as well as the facilities of his laboratory. Edison was careful to exclude his core businesses from the agreements with venture capitalists. The phonograph, electrical, ore milling, and telegraph operations were established as Edison's own. Instead Edison offered speculators a share in completely new inventions that would emerge from the many experiments undertaken in the new laboratory. Here was the advantage of a flexible organization: it could move quickly into "those industries as offer the most promising field for invention and experiment.[25]

It is significant that the future of innovation, as seen by Edison from his vantage point of 1887, was not in the great systems of electrical technology, but in consumer durables for a mass market. He planned to develop small products with a high profit potential and low capital requirements; the enormous costs of introducing the electric light were still fresh in his mind and he wanted to avoid "cumbersome inventions like the electric light." The industries he conceived of were to supply small items of commerce--"useful things that every man, woman and child wants"--that would be sold through a network of jobbers.[26]

Edison's attempts to interest investors in new technology reveal his ideas about the role of R&D in the Second Industrial Revolution. The lists of projects he planned to undertake at West Orange throws light on the research directions of his new laboratory and shows the enormous scope of his inventive imagination. At one end of the spectrum, he offered investors shares in truly revolutionary new technology, such as the process to make electricity directly from coal with his pyro-magnetic generator. This invention consisted of several metal armatures within field magnets all positioned over a furnace. Edison hoped that rapidly heating and cooling these armatures would produce rotation.[27]

While some of the experimental projects he suggested would, if successful, "change the entire motive power and lighting of the world," other inventions were oriented to more immediate commercial goals: he offered valuable improvements in the production of butter from milk, for example. [28] Surprisingly, the bulk of the innovations suggested by Edison were directed at product improvement. He saw that R&D could be used to reduce the cost of manufacturing many existing products, ranging from metal wire to plate glass. The research of his laboratory was to be directed into finding more efficient--and therefore cheaper--ways of doing things, especially reducing the cost of manufacture.

Edison was fascinated with materials and confident that he could find, or make, cheaper alternatives. The great investment in the chemical facilities of the laboratory was expected to generate returns in the search for artificial substitutes for valuable materials, such as silk, ivory, and rubber. The role of R&D in the Second Industrial Revolution, as conceived by Edison, was not completely oriented towards brave new technologies and great new industries: The West Orange laboratory was a place where "old devices and articles" could be quickly and easily improved.[29]

He often found opportunities in the familiar areas of electrochemistry, electromagnetism and electromechanical machines. Edison had built up an expertise in these areas and was quick to apply them to a wide range of problems. His innovation for snow sweeping, for example, was a device which used electricity to melt snow. In many cases Edison saw new products that could be easily spun off from existing technology. In the field of electricity, he thought he could produce an electrically driven tricycle and a wide range of electrically powered tools. His confidence in his abilities as a machine builder was unbounded. He tried to interest capitalists in the development of a mechanical cotton picker to do for cotton what the combined harvester was doing to cereal production.

The lists of planned projects indicate that the beginning point of many of Edison's experimental campaigns was a close study of the market. He looked for products that had great market appeal and the potential to become items of mass cosumption. For example, Edison saw enormous potential in an improved storage battery to take the place of the lead acid cells then in use. Edison knew the electrochemical technology well and he also knew the market. He estimated that the annual sales of storage batteries in the U.S. amounted to one million dollars and expected that sales would triple "if a good battery could be obtained."[30]

RESEARCH FOR HIRE.

The attempt to draw many investors into supporting the West Orange complex met with little success, and Edison was unable to embark on the construction of the Edison Industrial Works. The plan to focus all financial support into one organization failed because venture capitalists tended to make product specific investments. Many financiers who were drawn to Edison were looking for the "Big Score": a revolutionary new technology which offered to create a new industry and generate incredible profits as the electric light had. They therefore wanted to make their own judgements on the commercial future of an invention rather than rely on Edison to make the choice for them.

This was not an easy time to raise money. The Great Depression had begun in 1872, and whatever is said about the extent of this depression, Edison found it difficult to raise capital in the middle of a long period of deflation punctuated by financial panics.[31] In addition, his basic core of investors--nurtured through the telegaph and electrical days--were fully committed to the electrical industry which was insatiable in its demands for capital. The failure to attract funds from individual investors led to the demise of the Edison Industrial Works and severly damaged Edison's financial strategy. He was forced to explore many different sources of funding and develop a new strategy to finance the lab: research for hire.

The overriding goal of the research laboratory, in Edison's mind, was to make money. His West Orange complex was a commercial undertaking and subsequently Edison used his laboratory to generate income in any way he could, energetically courting many kinds of customers for services offered by his new laboratory. This business strategy evolved from Edison's need to find outside sources of finance for the laboratory. He had to put the laboratory to work to pay its keep, finding many ways of making money in addition to the work of research and development. The lab in these early years carried out a wide range of tasks and was truly a multipurpose facility.

This practice had begun in his Newark days, when Edison's workshops carried out a diverse mix of research, design, manufacturing, and repair services. Much of the work of the West Orange facility was also a carry-over from his activities in Newark and Menlo Park. For example, the lab still carried out research work for A.B. Dick on the mimeograph and the American Bell Telephone Company supported experiments in telephony.[32] The lab performed a variety of services under contract to outside companies. These ranged from continued work on an existing technology such as telegraphy, financed in part by Western Union, to surveys into completely new areas. For example, the Parrot Copper company paid Edison to examine the possibilities of copper smelting with electricity.[33]

The policy of contract research meant that the lab had to be all things to all people. The income of the laboratory was not restricted to research and development; it also earned money from manufacture and repair. The lab serviced and rebuilt office machinery, including the Sholes typewriter and telegraph apparatus. Sholes had brought his typewriter to Edison and the latter claimed to have improved it and made it into a commercial product.[34] The West Orange laboratory continued the development work on the typewriter while Edison contemplated building a large factory to manufacture an improved model. This plan was probably forgotten during the great experimental campaigns on the phonograph and nothing came of it.

The telegraph industry was Edison's first business involvement. His knowledge of the market, and the store of technical expertise in the laboratory, made telegraphy an appropriate area to launch into. It was a major focus of research when the laboratory opened; in December 1887 Edison made out a list of experiments to be started which included the phonoplex, and "grasshopper" telegraph.[35] The latter was a wireless telegraph system that utilized induction coils to communicate between moving trains and a fixed telegraph station. Edison clearly saw a vast market in wireless communication over land and sea. He devoted several experiments to this problem and claimed that he had transmitted messages over an air space of 580 feet. This idea never achieved any commercial success, but Edison had several highly lucrative telegraph products on hand to generate funds.

The availability of two large machine shops in the laboratory complex provided the opportunity to make money from manufacturing telegraph instruments. The phonoplex was a successful invention that enabled telegraph and telephone messages to be sent over the same wire. There was a great demand for phonoplex sets from the railroad industry and Edison made handsome profits manufacturing the device. After manufacturing the telegraph equipment in the machine shops, Edison sold it directly to industry. Among the products actually manufactured at the lab were telegraph signalling sets, phonographs, electric meters, and chemicals and plates used in storage batteries. Edison found a more economical way to make India ink and set up manufacture at West Orange. As soon as the phonograph was perfected, the lab was put to work manufacturing the cylinders, both blank and recorded, for the new machine.

Despite the flow of money from paid research, Edison was still plagued with shortages of operating funds. His finances had been stretched by the costs of building the laboratory and his great optimism had led him to undervalue the expense of experimentation and overvalue the commercial worth of its product. In August of 1887 Tate wrote to Insull that the task of building the lab "was going to require a good deal more money than was at first anticipated." [36] Consequently, Edison had to draw on his financial reserves to support his ambitious plans to perfect the phonograph. Edison had to rely more and more on his own money to finance the West Orange laboratory.

The lack of outside funds placed Edison more firmly in control of the laboratory and inexorably led to more adventurous experimental campaigns. Although Edison the businessman was eager to sell shares in his R&D projects, his laboratory was his operation and he expected to have the last word. He directed the research effort and he controlled the work of the laboratory irrespective of who was paying for the research. Even when the laboratory was busy selling itself as a commercial undertaking that offered R&D services for hire, it did not lose its independence. Offering its staff and resources to anybody who could pay for them still left the initiative with Edison and his staff. The services of the lab did not come cheaply and Edison's customers found it very difficult to control the work of the lab, as subsequent chapters will show.

Edison made the important decisions about what projects the laboratory should follow. Many of the projects undertaken by the laboratory were done for Edison's personal financial interest, such as the experiments on electrically driven rock drills or the development of a torpedo motor for the Edison-Sims torpedo in the 1880s. It was his laboratory and he was determined to make the most of any new technology developed there. Edison always kept some ideas for new products (and carried out small scale research) in reserve--waiting for a technological breakthrough or the influx of funds to push their development. He boasted that "I have always got something new underway" and one such project in the early years of the lab was the kinetoscope. [38] During the late 1880s the lab was working on 70-100 experiments at a time, some were large and costly like the work on phonographs; others small such as the experiments on preserving meat and fruit. The lab provided basic engineering services for the electric light companies in testing and redesigning electrical equipment, and, at the other end of the spectrum, carried out Edison's flights of fancy into flying machines and pyro-magnetic dynamos. In the balmy days of "research for hire" the laboratory could be hired to erect an ore milling plant, with a capacity of 1000 tons a day, to be completed in ninety days. [39]

Here was a laboratory that could go in several different experimental directions at one time, and usually did! It had to be all things to all people. It was forced to serve many different types of customers, from reckless venture capitalists to the core of corporate America. To meet these needs, Edison designed a laboratory that could innovate with speed and flexibility, creating a structure that facilitated communication and cooperation. Yet so much of the effectiveness of the laboratory depended on the performance of its staff, who needed to be as resourceful and flexible as their leader.

SIDEBAR 2-1

FINANCIAL PRACTICES AT THE LAB.

The lab's services were requisitioned by shop orders, each one giving a name and a number for a series of experiments. Each worker filled in a time card indicating the number of hours spent on a project, or in an experimental room, and these were used to compute the labor cost. In the early days of the lab only supplies were added to this basic computation but over time methods were devised to count in overhead. The shop orders were used for billing purposes. The shop orders for each customer were identified, compiled, and finally a bill was sent out to the relevant company.

Several different types of financial arrangements were established between the laboratory and the Edison companies: in some cases a fixed limit of experimental costs was determined for each year of operations, in others a lump sum was appropriated for experiments, and finally an experimental account was sometimes established to cover continuous research with no limit--the company receiving bills at regular intervals. This latter arrangement was normally between the lab and one of Edison's companies.

In times of financial hardship, Edison could call in the many loans he had made to other Edison companies. Many of the Edison electrical manufacturing companies had been founded with his money. The Edison Machine Works, for example, owed Edison $94,457 in 1888.[1] Another source of funds were his personal notes, discounted by financiers like J. W. Chapman and the banks of Newark, which often provided emergency cash for the laboratory. The major source of funds for the lab was Edison's personal fortune and it is difficult, if not impossible, to distinguish between his own finances and those of the laboratory.

Edison funnelled money into the lab's accounts by transferring funds from his "private" account, where he held his income, to his "personal" account with the laboratory which provided advances to cover experimental costs. The "personal" account paid for experiments carried out specifically for Edison's personal interest and it was often used to cover the expense of experiments that had not been billed to another party. When business was slack, he often put the laboratory staff to tasks in his own household; they carried out construction and repair work for him and also for some of his leading assistants. Several shop orders were used to account for the work on Edison's house by the lab and one even covered the making of a lunch box for Edison's daughter Marion.

NOTES

1) S. Insull to TAE, 26 Jan 1888, Electricity.

ENDNOTES FOR CHAPTER TWO

1) Article in Munsey's Magazine, 20 July 1901, Letter Book (LB) 100521, p. 435. Henceforth letterbooks will be cited as LB number then page number.

2) TAE to J. Hood Wright, Nov 1887, N871115.

3) TAE to Ore Milling Syndicate, 19 Feb 1901, LB 000608.

4) Batchelor Diary, 1336, Sept 1887, pp. 277-278.

5) Edison's Menlo Park laboratory is described by Robert Friedel and Paul Israel, Edison's Electric Light (New Brunswick: Rutgers University Press, 1986)pp. 30-38

6) Orange Herald, 24 Nov 1888, 1888 Phono Gen.

7) Bank records of Drexel, Morgan, E2530, A 182.

8) TAE note to Edison Electric Light Co, 6 July 1887, in Conot, p. 246.

9) One of his first estimates of the yearly cost of running the West Orange laboratory was:
 1) Interest on Investment (opportunity costs of an investment of 184,000 @ 5%) = $9,200
 2) Insurance $1,100
 3) Depreciation 9,200
 4) Supplies 7,000
 5) Labor costs 62,000

This makes total yearly operating costs $88,900. TAE Memo, 1888 W.O. Lab. The data available for 1890 shows that the year's experimental work was billed at about $80,000, showing that Edison's estimate of operating costs was fairly accurate.

10) TAE to E.H. Johnson, undated, 1888 Phono General.

11) Insull's notes in Meadowcroft Box, #68.

12) Bill Book #3, pp. 394, 397.

13) Eaton & Lewis to Tate, 27 June 1889, H F Miller file 121.

14) Draft Agreement with Villard, 1888 W.O. Lab General.

15) TAE to Review of Reviews, Oct 19 1910, LB 100829, p. 277.

16) Article in Munsey's Magazine, 20 July 1901, LB 100521, p. 435.

17) TAE to J. Hood Wright, (Nov 1887) N871115; TAE to Villard, Jan 19 1888, WO Lab general.

18) Meadowcroft Box MB 68, p. 53.

19) A.O. Tate, Edison's Open Door (New York: E.P. Dutton, 1938), p. 152.

20) Josephson, p. 394.

21) TAE to J. Hood Wright, (Nov 1887) N871115.

22) Undated letter TAE to E.H. Johnson, 1888 Phono General and Tate, Open door.

23) Draft agreement with Villard, W.O. Lab 1888 General.

24) "Prospectus and Plan of Organization" for Edison Industrial Co, 1887 Edison Industrial Co.

25) Ibid.

26) TAE to J Hood Wright, (Nov 1887) N87115.

27) The Electrical World, XIV (Sept, 1889), 166.

28) Appendix A, 1888 W.O. Lab General.

29) Agreement 1887 Edison Industrial Company.

30) Exhibit A 1888, W.O. Lab General.

31) Edison wrote in 1891 that "this raising of several hundred dollars in a panic has been tough on me," LB 900412, p. 190, ENHS. The various interpretations and scholarly debates about the character and extent of the Great Depression can be found in S.B. Saul, The Myth of the Great Depression 1873-1896 (London: Macmillan, 1969).

32) Accounts, Bill Book #2.

33) Exhibit A 1888, W.O. Lab General.

34) TAE to Pittsburgh Chronicle Telegraph found in Biographical file under S: "promoters came to me and asked me to redesign machine and construct it of steel so it could be made on a commercial basis."

35) Experiment list, 30 December 1887, 1887 Phono General.

36) Tate to Insull, 30 Aug 1887, LB 87-06-21, p. 73.

37) S Insull to TAE, 26 Jan 1888, Electricity, Ed Machine Wks.

38) <u>Brooklyn Eagle</u>, 2 Aug 1891.

39) Annotation on letter from S Ritchie, 21 Nov 1889, 1899 Ore Milling (OM).

CHAPTER THREE

LIFE AND WORK AT EDISON'S LABORATORY.

The West Orange lab quickly became famous. Edison's already considerable reputation, and his carefully orchestrated publicity campaign, attracted international attention to the new laboratory. It was the new home of the "Wizard of Menlo Park," and this gave it an aura of mystery and power. The impressive buildings and the "Wizard's" extravagant claims did the rest. Edison was a celebrity and his laboratory a public place. The many visitors to West Orange were given free access to the lab in its early years. They included newspapermen, hangers-on, the curious bystanders who had heard about the great events of the lab, and gentlemen conducting their own experiments with Edison's approval. Edison was careful to cultivate good relations with the press; it was very important to generate favorable publicity at this time because he needed to attract venture capitalists to the laboratory to finance his experiments. Although many of the visitors were merely spectators, the famous people who visited the lab, whether royalty or popular entertainers, continued to generate free publicity for Edison and his work, keeping him in the public eye. These groups were carefully and lavishly entertained and were often given the great honor of a guided tour of the lab by the inventor himself.

The worldwide fame of the "Wizard" also attracted a wide spectrum of workers and as soon as the lab opened in 1887, it was inundated with applications for employment. Custom built and well stocked with every conceivable supply, it was widely publicized as the best lab in the world. Working for a man as famous as Edison was considered a great honor, and even the unskilled sons of the rich clamored to work at the laboratory at any wage. He was therefore able to pick and choose from many applicants to create an impressive work force. "The best lab ever" was not merely the product of Edison's genius and the facilities he built at West Orange. The real strength of the laboratory were the men who worked for him.

The West Orange work force was an eclectic mix of many different skills and cultures, ranging from university trained chemists to laborers of no fixed abode. Edison's reputation was international and it attracted many foreigners who came to West Orange from all corners of the globe and from all strata of society. Future captains of industry and sons of the wealthy worked shoulder to shoulder with machinists who journeyed back to New York City to seek shelter after work. In addition to experimenters, Edison habitually employed many machinists and tool-makers in his laboratory, along with specialists like glassblowers, watchmakers, and draftsmen. There were also laborers, untrained experimenters, and ambitious young men who hoped to begin their inventive careers with an apprenticeship at this famous laboratory.

Edison brought the core of his workforce with him to West Orange. These were called the "Boys." Batchelor, John Ott, and Fred Ott were members of Edison's old guard from Menlo Park who played a major role in setting up the new facility. All had been with the "old man" (as Edison was affectionately called) since his early days in Newark and all were on close personal terms with him. Batchelor duplicated the multi-talented Edison, an accomplished experimenter and inventor with little formal education but a wealth of management experience in workshops and factories. The Ott brothers represented the kind of workmen with whom Edison had surrounded himself from his early days as an inventor and factory manager. They were highly skilled machinists who could interpret the "old man's" rough sketches and produce working models of inventions in a very short time. A hurried sketch on a piece of scrap paper with the legend "John Ott--make this" was the starting point of many of Edison's great inventions. The Otts were more than craftsmen; they experimented freely and frequently participated in the formative stages of an invention. Their forte was to make mechanical things work, and then make them work a bit better.

Fred Ott's craftsmanship and his rapport with Edison made him a close associate of the latter. Nicknamed "Santcho Pantcho," Ott was Edison's chief sidekick and confidant. On the second floor of the laboratory, Fred Ott and his precision lathe were only a few steps away from Edison's own room. Fred Ott worked with W.K.L. Dickson on the development of the motion picture camera and has gained immortality as the first face on film. His status in the laboratory organization can be judged from the famous picture of the group of workers around the improved phonograph taken in the summer of 1888. (See Illustration 3-1, #6164) Ott sits at Edison's right hand, and immediately behind the inventor are Batchelor and John Ott.

Many of the new employees were college graduates. Edison was very proud of his college trained experimenters who had strong math and science skills. He had first employed these men during the electric lighting era, and many more were hired to work in the new laboratory at West Orange as Edison gradually raised the skill level of his laboratory work force. Much has been made of Edison's anti-intellectualism and his disdain for theorectical science, yet this did not prevent him from employing the products of universities and technical schools. A self taught chemist, Edison probably thought that a college education was overrated. His comments on the career plans of Mr. G.C. Yee, a chemical experimenter in the lab in 1920, reveal this viewpoint: "I cannot understand why he wants to attend college as I find he is really a fine chemist."[1] Edison's basic objection to employing academics was that they were not practical men and that he was in the business of making practical innovations.

Many of the formally trained employees at West Orange had

Illustration 3-1

Group Around 1888 Phonograph

received their education overseas. Edison had made a practice of hiring foreigners while operating machine shops in Newark because these men were highly skilled and did not expect high wages. The majority of the international labor force at West Orange came from Germany and England. The large German communities in Newark and New York contained skilled workmen and college trained professionals, and the number of German names on the payroll testifies to their employment at the new lab. The best traditions of German engineering and culture were maintained at the lab by men like Theodore Wangemann, a skilled pianist who took charge of the experiments on phonograph recording. The lab was usually in need of trained chemists and would invariably hire a "good chemist" if one could be found. Several learned German chemists (called "professor" by the rest of the experimental staff) were much in evidence at the lab in its early days, among them were Erwin Von Wilmowski, Dr. Braun, Dr. Franz Schulzeberge and Dr. Wuntz. When Edison became frustrated with his chemists's lack of results, he sometimes swore that he would never again employ foreign chemists; but the lack of American-born chemists prevented him from carrying out this threat.

The English educational system also produced skilled men who worked as experimenters, and chief among them was Arthur Kennelly. Kennelly had also received practical experience working for the English Society of Telegraphers and his scientific talents soon made him chief electrician at West

Orange. He was considered to be the most gifted mathematician at the lab and went on to enjoy a distinguished career as a professional engineer and academic.[2] The factories of Britain supplied many skilled machinists to the Edison enterprise, but of more importance were the managers and accountants who ran "the workshop of the world." Edison used several managers of English descent, including Samuel Insull, Alfred Tate, Hamilton Miller, and Charles Batchelor.

A large proportion of the formally trained employees at the lab were foreign-born and educated, yet there were a growing number of American college graduates working there. Rutgers College in New Brunswick provided many lab workers: four in the early days according to David Trumbull Marshall, a chemist who worked in the laboratory at that time.[3] Reginald Fessenden and Marshall were typical of the American experimenters--they were well educated, with some experience working in industry or higher education. They were young (mostly in mid-twenties when they came to the lab), upwardly-mobile professionals.

Many of the experimenters at the lab served their apprenticeship in the Edison electrical companies. The Edison electric light empire naturally provided an ideal pool of talent to be drawn upon, not only for experimenters but also for the experienced administrators Edison needed at West Orange. The Machine and Lamp Works provided the training grounds in the basic engineering skills which were then perfected at the Edison laboratory.[4] The Edison Machine Works kept some of their men at the lab to work on projects in which they were interested, and they paid the men's wages. The other Edison electrical companies carried on the same practice, drawing on the laboratory's position as a source of higher education in the Edison enterprise.

Edison's labor force also included administrators and clerks, notwithstanding his well publicized disdain for office work. In fact, he was a stickler for accurate record keeping, and determined to find the costs of experimentation. These were no mere academic pursuits. The requirements of patent law made a daily record of experiments a neccessity and financial backers required breakdowns of experimental costs. In the old days at Newark and Menlo Park, the administration of the laboratory had been carried out by Edison's personal secretary who doubled as bookkeeper, chief clerk, and general assistant. Samuel Insull had defined the position of private secretary to Edison and made him a very important person in the hierarchy of the laboratory. At West Orange, Edison employed secretaries who not only carried out bookkeeping duties, but also had power of attorney to deal with financial affairs. Insull was succeeded as secretary by a protege, Alfred O.Tate, who became indispensable to Edison as a business manager and personal secretary. As well as dealing with all company business, Tate also handled Edison's voluminous correspondence and his family affairs. The sheer volume of the work done at West Orange and the growing complexity of Edison's personal finances led to an increase in Tate's staff to include a stenographer (Thomas Maguire), and a number of boys.

Like every other businessman of his times, Edison used child labor in his laboratories. Much of the chaotic atmosphere of the lab was provided by the many youths who worked there. They performed a variety of very important functions: they did the fetch-and-carry work, the dirty menial tasks--such as washing out experimental apparatus--and they operated as the eyes and ears of the lab, carrying messages and materials around. They were dispatched to obtain everything from newspapers to supplies. They guarded the main gate and helped administer the store rooms. Boys even carried out semi-skilled clerical work, such as copying letters, typing, and assisting with the bookkeeping.[5] Working conditions were certainly better than in tanning, mining and metallurgy. Whatever the fairness of their employ, the children were a vital part of the lab's operations and communications. They were were often called lazy, difficult, and boisterous by other workers, but the lab could not have functioned without them.

MANAGING THE WEST ORANGE WORK FORCE.

Edison was not a newcomer to managing a large labor force for he had operated large factories in Newark in the 1870s. The telegraph industry gave him indispensable experience in running a manufacturing operation, and as he reminded one of his financial backers "You are aware from your long acquaintance with me...that the works which I control are well managed...I know how a shop should be run & also how to select men to manage them." He found "honest, young, ambitious" men, blended their skills in his team approach to innovation, and then delegated administrative power to them in the new industries he created.[6] By the time he moved to West Orange, Edison had proved that he could pick good men to work with him. Samuel Insull, Charles Batchelor, and Alfred Tate fully justified the "old man's" faith in them. All were more than capable managers who would have been an asset to any industrial enterprise. The London Electrician respected his choices, commenting "We have always been sure that his business agents were equal if not superior to him in ingenuity." [7]

Edison developed a team approach to innovation which exploited the diverse skills of his work force. The success of his method was based on an ability to frame the problem and then pick the right man for the job. Edison broke each experimental project down into its component parts and allotted teams of men to each part. He often divided an experimental project into chemical, electrical, and mechanical problems and alloted a specialist to each. He gave each experimenter a brief overview of the problem and some broad instructions. All the workers at West Orange knew that the "old man" could assign three weeks of work in three minutes! In many cases his personal instructions would be supplemented with a written document (sometimes a scrap of paper and sometimes in a notebook) which listed experiments to be carried out. This system was designed to work with all Edison's muckers, who had different skills and experiences: the written list provided the basic work plan, but it was constantly being changed and supplemented through Edison's personal contact with his workers.

Edison usually gave a task to an experimenter and provided him with an assistant, while the laboratory supplied the logistical support and information to do the job. The machinists, who could be called in from the machine shops, would divide their time between experimental groups, moving from team to team as required. The chief experimenter ran the group with the minimum of interference from Edison. He told Bergmann: "the way to do it is to organize a gang of one good experimenter and two or three assistants, appropriate a definite sum yearly to keep it going...have every patent sent to them and let them experiment continuously."[8] This is a succinct summation of the Edison method. It shows his reliance on information gathering and his concern with covering experimental costs.

Edison would regularly tour the lab, stopping in each room to check on his experimenter's progress. He used this technique in Menlo Park: each afternoon he would tour the laboratory going to each man at the workbench, questioning him about what he had done and deciding what to do next.[9] Although he was easily distracted and often spent too much time on some projects, Edison's informal approach was generally effective; it kept him in close touch with his workers and their projects, and it produced a large number of experiments. Edison knew what was going on in the laboratory. An extremely observant man with an excellent memory, he never lost track of an experimental project and could be counted on to remember previous experiments that might provide useful information.[10]

Edison gave his muckers a great deal of freedom of action in pursuing their experimental projects; in many cases he guided their research rather than told them exactly what to do. When Marshall once asked him what to try next, Edison replied: "Don't ask me. If I knew I would try it myself."[11] Yet if a researcher was genuinely stymied by a problem, Edison could be relied upon to suggest an experiment or new approach. When things were not going right, and the results were not forthcoming, Edison often chose a completely different approach. The experimenters agreed that their boss could always think of many different ways of doing things, and one of

Edison's great strengths in the laboratory was his ability to see a problem from many different sides. In his efforts to improve the power source of the phonograph, for example, he detailed one man to redesign the motor, another to get a stronger charge from the battery, and another to work on the bearings to reduce friction. Edison's inventive mind could often see new approaches to old problems. His associates noted that he had a knack of getting to the important issue of an experimental project by merely asking questions and from his questions would emerge a new direction. In some cases, Edison would frame an experimenter's work plan by merely giving him a list of questions.

Normal operating procedure at West Orange was for Edison to switch his employees from job to job, expecting them to not only to pick up the line of experiments, but also to brief their replacements. The high morale of the labor force was an important part of their flexibility, for as Marshall noted "we were all interested in what we were doing and what the others were doing."[12] One major advantage of the lab's physical structure was that it enabled excellent communication between workers, especially on the second floor of the main building where the experimental rooms were grouped together. Edison encouraged comunication between teams; when a particular experiment went well, he instructed the experimenter "this answer is so good that I wish you would expand it a little, as I want to pass it along to the other boys."[13] The physical plant had been designed to be flexible. Rooms could be quickly reorganized and fitted up, yet much of the flexibility of the operation depended on how quickly his men changed from job to job.

When Edison recognized a promising line of investigation, or if he had to mount a rush job, he would quickly marshall his troops, shifting men from other projects, forming larger teams (but always keeping one leader), and drawing on the large labor pool in the machine shops. A payroll for the machine shop in 1889 bears Edison's notation "give me one (man) for...." [14] The wide range of skills of his labor force, combined with the loose organization, allowed Edison maximum flexibility to utilize labor as the need arose. This was the key to his strategy of flexibility and speed. He could quickly mass his men into task forces when a problem needed solution or a promising line of research was identified. When faced with "bugs" in the storage battery, Edison rapidly fitted up two rooms in the lab and put 12 testers to work there "night and day."[15]

Edison drove his men hard and believed in making them work as hard, and as long, as he did. He led by example. He loved his work and was happiest at the experimental table. He was enthusiastically involved in every major experimental project in the laboratory and carried out numerous experiments himself. Edison's long hours and buoyant personality could not have failed to motivate his staff. His high level of enthusiasm was transferred to his workers, who would also decline sleep when a project got to a critical point "and enthusiasm ran high."[16] Working all night at the lab was not unusual; Edison certainly expected it of his experimental staff. His success as an inventor was partly the result of his ability to get the maximum effort from his work force, for as he commented: "The real measure of success is the number of experiments that can be crowded into twenty-four hours."[17]

Edison was a very demanding employer who did not shrink from telling his men that they were lazy, insisting they work throughout the night. The hours of storytelling provided some distraction from the hours of tedious work, yet it was the attractive side of a personality that could also be hostile and unyielding. He liked to keep his experimenters under constant stress, submerging them with work and criticizing their results. When he wanted work done, it had to be done immediately--"on the jump"--or there would be trouble. Some of his employees could not stand his dictatorial nature and biting tongue, and at least one of them quit on the spot after enduring his relentless verbal hazing. Working for Edison was not an easy task and he once noted that an employee's departure was "due perhaps to the conditions here, which are rather exacting."[18] The muckers were often set impossible goals and were always working to a demanding timetable. Some of them suffered nervous breakdowns, others left in disgust.

Edison could be a charming man, and he knew how to use his great personal charisma, especially on newsmen and venture capitalists. On the other hand, he was feared when he lost his temper, and his men knew that he "could wither one with his biting sarcasm or ridicule one into extinction."[19] Edison let his men know when he was pleased or displeased with their work, and at any time in the lab some teams were in Edison's displeasure while some enjoyed his favor. One member of the lab wrote that some teams were "on the ragged edge" and some were "the favorites."[20] The men all knew the score and strived to be in the enviable position of Edison's favorite experimenter, especially when displeasure might lead to dismissal. Edison wanted his experimental teams to be in competition with one another, believing that this would motivate them to greater efforts. At one point he reviewed the work on a project and noted that "there is great rivalry, which seems to be a good thing all around."[21] The great competition between experimenters at the lab, and their powerful ambitions, often led to feuds between them.

The lab presented a disorganized exterior to the casual visitor, who usually came away impresssed with the democratic work style and the lack of formality. Yet there was a hierachy at the laboratory, and it did motivate and mould the work force. At the top of the hierachy stood Edison and the pantheon of "the boys"--a position here could lead to fame and fortune. The lab was full of ambitious young men who saw their future in

Edison. Edison commented on the "men around me" that "its not the money they want, but a chance for their ambition to work."[22] Success meant more responsibilities and bigger challenges. As an experimenter moved up the ladder he could expect larger rewards and bigger projects. For those experimenters who could stand the rigorous work schedule and survive Edison's cajoling, teasing, and practical jokes, work at West Orange was exciting and rewarding. Those who pleased the "old man" were quickly promoted and given more responsibility. The West Orange laboratory had a complex wage structure, increases coming with increased skill and responsibility. In a memo written to Batchelor in 1888, Edison listed some workers and instructed that their wages be increased because "these are good men."[23] Included in this list of fast-rising Edison employees were Fred Ott and Jonas Aylsworth--two increasingly important figures in the operations of the lab.

Edison's own life reflected the American belief that hard work and initiative could take a man from rags to riches and the democratic organization of his laboratory permitted workers to rise from being common laborers to chief engineer. Fred Devonald, newly arrived in the U.S. from Wales, took his first job as a laborer at the West Orange lab in 1888. By 1900 he was in charge of engineering there. Some of the unruly youths who haunted the lab went on to have distinguished careers in the Edison enterprise. Fred Ott was 14 when he joined Edison.

Walter Miller entered the lab as a youth when it opened and he became the expert on phonograph recording techniques, rising to the enviable position of being one of the "boys."

Edison judged, and paid, his men according to their results and one mistake was enough for instant dismissal. Edison was particularly vindictive toward those men who had failed him, sometimes calling them dumbheads and idiots. His comment about one manager shows a sarcastic tone: "a man who can do this could not manage a water closet." One employee concluded: "Some of the men liked him. Many of them feared him. A few even disliked him."[24] On the other hand, Edison's informal style, his egalitarian nature, and his comradeship endeared him to many of his workers.

The West Orange lab was a commercial organization that was dedicated to the goal of continual, profitable innovation. When a line of research did not meet with success or the profitability of the final product came into doubt, Edison did not hesitate to close it and discharge the workers. In 1889 Edison terminated a project because he thought its work on finding new insulating materials was not showing results. Some of the team were transferred to ore milling work, and some left the lab permanently, including Dr. Wuntz and Fessenden. Fessenden received a good recommendation as a chemical experimenter and Edison explained his leaving because "his line of work has come to an end." On the other hand, Edison concluded that Wuntz was unsuitable for the lab because "I can't make his work pay me."[25]

Edison was notorious for paying his men the lowest possible wages. There can be no doubt that he capitalized on his fame and exploited the prestige of the West Orange laboratory. He knew that working for him was considered an opportunity and an honor and so he paid accordingly. His practice of using foreign workers has been interpreted as part of his policy to pay low wages. Edison was concerned with keeping labor costs as low as possible and getting the most out of his laboratory employees. He wrote in 1917: "the men I use receive only ordinary workmen's salaries," although he expected them to work harder than the ordinary worker.[26]

The wage sheets for 1890 show a wide range of different wage rates within specializations, for example weekly wages for experimenters range from $7 to $30. The muckers were paid by the week and Edison was determined to get the most out of them even if it meant working all night. Although the leading experimenters earned, on average, more than the skilled machinists, there were still plenty of the latter who earned more than experimenters by putting in long hours. The wage of the machinists was set from 20 to 45 cents an hour depending on their skill. Edison also continued the old machine shop practice of piecework and subcontracting with machinists. It was possible for skilled machinists to earn more than $20 a week--this was more than Aylsworth or Walter Miller received for their experimental work on wax compounds and recording. The blacksmith and draftsman each earned more than Fessenden, who was a trained experimenter with a broad range of experience. Craft skills were still in demand at West Orange in 1890 and were well rewarded.[27]

Edison was well aware that the payroll constituted the bulk of the cost of running the lab. The staff of the machine shops was constantly being trimmed and the number of workers changed each week as Edison and his managers strove to keep the work force lean. The Edison industries acquired a reputation of firing workmen when economic conditions turned bad, and at the lower skilled levels of the work force there is a great deal of turnover indicated in the wage records. Yet at the other end of the skill ladder, some experimenters and skilled machinists remained with Edison for long periods of time. Long and close friends like Fred Ott were given many benefits, including his house payments, and were supported by the company when they were old and infirm. [28]

The one thing that motivated the muckers to work and scheme their way up to the enviable status of becoming one of the "boys" was the chance to profit from an invention. Edison often shared the profits with those employees who were especially useful and who had demonstrated their loyalty to him. During the electric light period, Edison said that he intended to pay back the "boys" who helped him. This might be in the form of royalties or a percentage on an extremely profitable invention, or a share in one of Edison's manufacturing or marketing enterprises. Men like Batchelor were amply rewarded with stock, royalties, and a share of the profits from manufacturing. Samuel Insull used his connection with Edison to rise to power and wealth in the electrical utility industry. Some of the "boys" were appointed to the boards of Edison companies and enjoyed several salaries, others were given lucrative concessions to market new inventions.

Working at the West Orange lab was the basic training that many captains of industry, engineers, and academics enjoyed in the formative days of their careers. Some of Edison's workers went on to become industrialists and inventors in their own right. Sigmund Bergmann, for example, used the fortune he amassed in manufacturing Edison equipment to create an industrial empire in Germany. Many remembered their life and work at the West Orange laboratory fondly, claiming that Edison taught them how to experiment and innovate. As Kennelly noted years after leaving the lab "The privilege which I had of being with this great man for six years was the greatest inspiration of my life."[29]

ENDNOTES FOR CHAPTER THREE.

1) TAE annotation on letter from U. of Illinois, 12 Feb 1920, D box

2) C. Withington, Interview with A.E. Kennelly, 19 May 19??--Edison Pioneers, Kennelly folder.

3) David Trumbull Marshall, Recollections of Edison (Boston: Christopher, N.D.), p. 94.

4) Bergmann to TAE, 3 April 1888, 1888 Phono Gen J-A; Kruesi to Batchelor, Oct 30 1890, 1889 Electric Light (El lt), Ed Machine Wks.

5) Macguire to Tate, 19 Nov 1888, 1888 W.O. Lab; Tate memo July 1 1889, 1889 WO Lab general.

6) TAE to J Hood Wright, Nov 1887, N871115; Edison's comment (about A.O. Tate) is in TAE to Batchelor, 6 April 1887, WO Lab.

7) The Electrician, XXI, 20 July 1888, 330.

8) TAE to Bergmann, Dec 14 1910, LB 101208.

9) F.R. Welles to Dr Jewett, 17 Feb 1932, D10 Telephone.

10) Phonogram, Vol III #2, June 1893

11) Marshall, p 61

12) Ibid., p. 59.

13) Charles Edgar, "An Appreciation of Mr Edison, Science, Jan 15 1932 vl 75, p. 61.

14) 1889 W.O. Lab, employees, machine shop.

15) TAE to Bergmann, 29 Nov 1904, LB 040727, p. 169.

16) Marshall p. 89.

17) "Edison-Organizer or Genius" by Maurice Holland, National Research Council.

18) TAE to Tate, 1888, Electricity, Gen 1 of 2; N 281101; TAE to F. Applegate, 26 Dec 1916, LB 160913, p. 606.

19) Marshall. p. 57.

20) Frank to Meadowcroft, 10 Aug 1922, D box bio M.

21) TAE to Bergmann, 11 Jan 1905, 1905 Storage Battery.

22) TAE to Villard, "Mr Edison's Reply to T-H" 23 March 1889, Villard Ms 78 Box 63.

23) TAE to Batchelor, May 1888, 1888 W.O. Lab General.

24) Recollections of Richard G Berger, Beacon Herald, 30 Aug 1937.

25) Edison to Tate, 21 March 1889, 1889 W.O. Lab, employees.

26) TAE to N D Baker, 30 Aug 1917, Naval Consulting Board records (NCB) box 21, Experiments.

27) Some of the few surviving wage records for the laboratory (not the machine shop) are in 1890 Doc file, laboratory payroll.

28) Randolph to TAE, 13 Aug 1895, 1895 W.O. Lab Employees; TAE annotation on letter of 4 Dec 1917: "John Ott is to be paid under any circumstances, he is in for life," D box bio O

29) Interview with A.Kennelly. by C. Withington, Edison pioneers file.

CHAPTER FOUR

THE PHONOGRAPH

A CASE STUDY OF RESEARCH AND DEVELOPMENT

The phonograph played an important part in Edison's financial plans for the laboratory; it was to be the first product to come out of the new lab and an immediate source of operating funds. Edison was depending on the rapid introduction of his improved phonograph to replenish his treasury. The first great test of Edison's business strategy for his West Orange laboratory was therefore the phonograph. Edison had to mount a massive research and development program to bring a "perfected" phonograph to market. The phonograph might have been Edison's "baby"--his favorite invention--but it proved to be a temperamental and unresponsive machine that stoutly resisted perfection! The phonograph project required all the speed, flexibility, and control Edison could muster and it strained even the large-scale facilities of West Orange. Edison spent years of his time and a considerable part of his fortune in his attempts to introduce a commercial phonograph.

The 1877 tinfoil phonograph was no more than a demonstration model of the idea, a scientific curiosity or an amusing toy as Scientific American had noted.[1] It was not a commercial product. Edison recalled that only a small number of tinfoil machines were actually manufactured (many in the shops of his associate Sigmund Bergmann), and that "no commercial instrument was made." [2] The "curiosity" market for the phonograph was quickly satisfied and the tinfoil, and the company formed to exploit it, languished while Edison worked on his incandescent lighting system. He believed that the phonograph idea could be turned into a successful product and returned to this problem after his electrical work was complete, giving it his close attention during 1886 when he toyed with several different designs for a new machine. The initial experiments were carried out in the temporary laboratory in the Lamp Works. The major problem was the power source; the tinfoil phonograph was hand-cranked and required a steady, even turning motion to produce a recognizable sound. Another source of power had to be found before the phonograph was a commercial product.

Edison's work on improving the phonograph picked up momentum when he realized that he faced competition in this field. Chichester Bell and Charles Tainter were working on the Edison tinfoil machine in the Volta Associates laboratory in Washington. They improved it by substituting wax for the tinfoil on the cylinder. This made the machine more practical because the wax covering of the paper cylinder was more durable than tinfoil and lasted longer. In 1885 Edison's English patents on the phonograph lapsed, leaving the field wide open on both sides of the Atlantic. They filed for several patents in 1885 and formed the Volta Graphophone Company the following year. They had the financial support of Sigmund Bergmann and he manufactured several of their graphophones. Bell and Tainter exhibited their machine in 1886 and this brought them to the attention of the press and a showdown with Edison.

Representatives of Bell and Tainter visited Edison at his temporary laboratory and suggested that both parties come together to develop and manufacture an improved phonograph. Edison was offered a very generous financial arrangement: all experimental costs paid for by the new company, and all capital requirements to manufacture the machines to be met, in return for a half share in the new enterprise. Normally, Edison would have jumped at such a proposition, yet he would have none of it; his competitive instincts were aroused and he feared that his rivals were going "to deprive me of the honor of the invention." [3] Edison could not be persuaded to come to some accommodation with Bell and Tainter, whom he referred to as "pirates", because he was planning the construction of the ultimate competitive weapon--the West Orange laboratory. Although Bell and Tainter had a considerable lead in developing a commercial phonograph, Edison refused to work with them, claiming in November 1887: "I have assumed all along that the business was open (to competition), and that with my experience and facilities I should have an advantage in competition." [4]

Edison had originally imagined several uses for the phonograph: it could be used in schools, courtrooms, and business offices to record and reproduce the human voice. The Graphophone Company directed their machine at the business user and Edison followed suit. His strategy was to introduce the improved phonograph as a business machine to be used for correspondence. He had considerable experience in designing business machines: the telephone, typewriter, stock ticker, and electric pen (mimeograph) had all been put to good use in American offices, and he expected that the phonograph would replace the stenographer and make the businessman more productive. His business connections, including A.B. Dick, had shown interest in the phonograph in 1887 and were eager to see the new machine as soon as it was completed. Edison was confident that it would become commonplace in the office.[5]

Edison expected that the improved phonograph would be as easy to use as the telephone and typewriter. Leaving aside the problems of manufacture and marketing, the conversion from toy to commercial machine involved fundamental changes in the means of power, material of cylinder, and method of reproduction. The latter had to be loud and distinct if the phonograph was to have a commercial market. The tinfoil itself was not a practical material for an office machine, being fragile and difficult to handle, and Edison eventually replaced it with a wax cylinder. The wax of the cylinder had to be hard enough to bear the groove yet soft enough to take the cut. These were the problems that faced Edison and his staff in 1887.

Edison set out not only to perfect the phonograph, but also to design it for mass production. This was consistent with his strategy of controlling both the invention and manufacture of new products at West Orange. It was in the production engineering of the new machine that Edison felt he had the advantage over his rivals. He telegrammed his English representative, Colonel George Gouraud, "Tainter not practical man; don't know how to make cheap." [6] The phonograph was to be the first high-tech product manufactured by Edison at his West Orange facility, and he was confident that the large new laboratory could solve all the problems encountered in bringing the improved phonograph to market.

In the summer of 1887 he promised substantial improvements on the original design and expected to put it on the market "in a few months."[7] Assisted by Ezra Gilliland, who had left his job at Bell Telephone's Mechanical Department, Edison energetically experimented on the phonograph in the fall of 1887. He explained to Henry Villard that they should have had the phonograph on the market before the end of the year, "but we saw so many things that could be changed to make it more convenient to the customer" that its introduction was delayed."[8]

Edison applied for a patent on his improved phonograph shortly before he made the move to his new laboratory, and the phonograph work was quickly transferred from Harrison to West Orange. The new phonograph unveiled at the laboratory in

December 1887 drew heavily on several features patented for the tinfoil machine. The cylinder was fitted onto one end of the main shaft, and at the other end a lead screw moved the traveler arm which pushed the reproducer along the cylinder. The reproducer and recorder diaphragms were mounted together in the form of a pair of spectacles. A needle in the recorder cut a groove into the soft wax cylinder and, after recording, the spectacle frame was then turned to bring the reproducer stylus onto the surface of the cylinder. The fragile reproducer consisted of a diaphragm made of gold beater's skin (or animal membrane) which was connected to a curved steel wire serving as the stylus. Central to the new design was an electric motor which turned the main shaft by means of bevelled friction wheels.[9]

Intensive research and development on the phonograph began in the new laboratory in 1888 as Edison switched the resources of his lab into the phonograph. Much of the third floor of the main building was taken up with the continuing development of the phonograph: a newly hired chemist, Jonas W. Aylsworth, worked on developing chemical substances for the cylinders; in an adjoining room an English experimenter called Gladestone tried to improve the output of the battery; Wangemann experimented on recording music at one end of the floor, surrounded by a piano, several different phonographs, and sometimes by a four piece orchestra; and Edison, assisted by the chemist Franz Schulzeberge, applied himself to the problems of duplicating cylinders. Edison also grappled with the problems of sound reproduction. Many different substances were tried for the wax cylinder, and new arrangements for the recorder/reproducer were ordered. Edison began his research on the latter by testing many organic and inorganic materials for the diaphragm, including ivory, horn, porcelain, rubber, shellac, sheet steel, and carbonized paper. He then looked closely at the construction of the spectacle frame and attempted to improve the linkages between the needle and the diaphragm in order to increase the loudness of the reproduction. [10] The R&D on the phonograph covered many different disciplines--chemistry, physics, electricity, and acoustics--and was a true test of Edison's team approach. There were many different problems to be solved and many of them involved close cooperation between the experimental teams. By the summer, Alfred O. Tate (Edison's secretary) reported that Edison was employing about 120 men and had 60 different experiments going [11]; the lab was working full out as Edison concentrated on perfecting the phonograph while other experimenters maintained the effort in electricity and ore milling.

Edison did not direct all his inventive effort into perfecting the basic phonograph in 1888, but instead diversified the research work to cover many commercial uses of the phonograph. He wrote to his lawyer, Richard N. Dyer, that he had many other ideas worth patenting in addition to the perfected phonograph: a toy phonograph for use in talking dolls, coin-in-the-slot amusement phonographs, and improvements in phonograms, clockwork and hand-turning phonographs. He also experimented freely on the basic configuration of the phonograph, designing several disc phonographs including one with an articulated recorder/reproducer assembly. [12] One of the most important experimental projects connected with the phonograph was begun in 1888 when Edison filed a caveat (a preliminary outline of an intended patent application) to cover the duplication of cylinders. This involved covering a master record with a conductive coating (gold leaf) and electroplating it to form a matrix, which was then used to make copies.

The laboratory was not only used as the base for the R&D effort; its growing fame generated publicity for the phonograph, and attracted venture capital to support the ruinous cost of R&D. Potential investors and customers were invited to the lab, where the third floor had been turned into an exhibition hall to demonstrate the phonograph. In the spring of 1888 a group of prominent bankers and investors were invited to the laboratory to see the "perfected" phonograph. The group was led by Jesse Seligman, senior partner in the banking house of J & W Seligman. Unfortunately, the phonograph refused to work for the distinguished guests and Edison lost a golden opportunity to finance the development and manufacture of the machine. [13] Some time later a special model was constructed and then demonstrated at the Seligman house, with better results.

Financial salvation was finally found in the form of Jesse Lippincott, a venture capitalist with his eye on a phonograph monopoly. After purchasing the American Graphophone Company (the successor of Bell and Tainter's Volta Company), Lippincott set out to acquire the Edison Company, paying $500,000 for Edison's interest in September 1888. [14] The latter urgently needed the capital supplied by Lippincott; the costs of developing the phonograph were growing rapidly, and by September 1888 he estimated that he had $67,000 of his own money in phonograph experiments. [15] Lippincott's new organization was named the North American Phonograph Company and its goal was to produce a commercial dictating machine to be leased to businesses. It franchised local companies to market, lease, and service machines and alloted each company an exclusive sales area. Each customer could chose between Edison's phonograph and the graphophone which Tainter manufactured in a factory in Bridgeport, Conn. Edison must have been confident that he could remedy all the faults of his existing machine because he began to prepare for mass production in the summer of 1888. He had established a small shop in Bloomfield in 1887, and although it was working at full capacity during that summer, its production of component parts could not support the ambitious plans of the North American Company. Consequently, a larger facility was planned at West Orange with a target output of 200 machines a day, made by 500 employees. [16]

The Edison Phonograph Works was deliberately sited next to the laboratory so that Edison could manage production. Here was his strategy of control at work--Edison had only to step outside Building 5 and walk a few yards to be in the Works. He intended to oversee all elements of its work and monitor every aspect of manufacture. This was considered extremely important to its success: Alfred Tate noted that all the manufacturing operations had to be located as close to the lab as possible in order to benefit from Edison's personal supervision. [17] While the factories were being built, phonograph manufacture was done in the laboratory's machine shops which turned out small batches of phonographs under contract to the North American Phonograph Company. The manufacture and assembly of the delicate diaphragms was also done in the precision machine shop of the lab, and this probably continued after the Phonograph Works took over full-scale production.

Edison planned a large output using interchangeable parts, and claimed that much of the estimated $1,000,000 expended on the Works went into special task machinery. The account records of January 1889 show an outlay of around $250,000 to establish the Phonograph Works, including $65,000 on machinery and tools, and $20,000 on "special" phonograph tools. Edison had always intended to manufacture phonographs using interchangeable parts, stating in 1878 that "this machine can only be built on the American principle of interchangeability of parts like a gun or sewing machine." The newspapers were told in 1888 that the proprietors "rely upon their special methods of production rather than their patents; they can manufacture much cheaper than any competitor." [18] Charles Batchelor had begun the enormous task of designing the tools at the temporary lab in Harrison, and throughout 1888 he joined Edison in laying out the factory and training the men. The design of tools and the perfection of commercial processes was done in the laboratory; much of the machinery used to make phonographs and cylinders was set up and first operated in the laboratory, and then transferred to the Phonograph Works. [19] The factory started to produce phonograph parts in the fall of 1888, but by late November the superintendent estimated that, at best, daily output would reach only 10 per day. [20]

The plan to standardize the parts of the phonograph not only facilitated mass production but also permitted constant development of the design. Edison hoped that each interchangeable part could be taken out, improved, and put back. He wanted a design based on discrete, replaceable sub-assemblies "so that I can keep on improving." [21] This was a wise move because most of 1888 was spent on constantly changing the design of the phonograph. Edison kept hold of the prototype and delayed delivering sub-assemblies to the Works while the laboratory staff worked on eliminating "bugs"--the defects and minor design problems that caused malfunctions.

Illustration 4-1

1888 Phonograph in Use

PERFECTING THE PHONOGRAPH

In the summer of 1888 a now famous photograph of Edison appeared in the press showing the exhausted inventor (in a somewhat Napoleonic pose) with the new phonograph.(Illus. 3-1, #6164, Chapter Three) This device was the result of the first experimental campaign of the West Orange laboratory. Although introduced as the "perfected phonograph," the machine was far from perfect. Its design shows that Edison had considered the commercial aspects of the phonograph for it now came in a compact form and was fully enclosed in a wooden box. The design owed a lot to the telegraph equipment Edison had once manufactured--its precise electro-mechanical works were mounted on a metal casting that served as a base plate, easy to access and adjust. The mechanism was more sturdy, and the motor and governor had been redesigned to provide constant speed. (Illus 4-1) Yet the right composition of the wax cylinder, as well as the best arrangement of reproducer and recorder, still eluded the experimenters at West Orange.

This first prototype of the "perfected" phonograph went to England with Gouraud immediately after the photograph was taken. This event should have marked the end of the phonograph campaign and the beginning of the ore milling venture, but Edison made the ore milling syndicate wait while he continued work on the phonograph. Tate assured them in September 1888 that the machine was at last perfected and out of the inventor's hands, but in reality the phonograph still absorbed his attention.[22] (Edison promised Lippincott that he would devote more of his time to the phonograph in 1889.) The reproduction of sound was his major concern--he aimed at clearer articulation, louder reproduction, and easier manipulation of the spectacle frame. The expenditure on development rose rapidly in the last half of 1888 as several experimenters in the laboratory worked to eliminate the "bugs" in the phonograph. The wax composition of the cylinders was hardened to improve recording and permit a finer cut. The motor was redesigned to increase power while requiring less current. Finally, the main shaft and the bearings were improved to eliminate the "wobble" that ruined reproduction. By October Edison was sure that he had finally perfected the instrument and wired Gouraud that he would "drop dead" when he saw the improvements that had been made. [23] Nevertheless, the frantic activity continued into December and Edison was so overburdened with work that he had to suspend the exhibitions and interviews in the laboratory which were vital for the marketing of the machine. In fact, the marketing went better than the "perfecting"; the lab was flooded with inquiries about the phonograph and the newspapers were full of articles about the wonderful new machine.

The extensive R&D work on the phonograph failed to produce a commercial product in 1888; the other phonograph project of the Edison laboratory, the Talking Doll, was plagued with design and production difficulties which delayed its introduction. The toy doll was the first attempt to market the phonograph invention; experiments were begun at Menlo Park and continued at the West Orange laboratory as soon as it opened in December 1887. [24] (Illus 4-2, Doll Advert.) Charles Batchelor, the father of two girls, took a special interest in the doll experiments, developing a small phonograph mechanism and fitting it into a doll that was less than two feet high. One important design criterion for the doll was cost--as usual Edison was eyeing a mass market--and an experimental project was soon begun on a "smaller cheap doll phono". A group of businessmen from Boston established the Edison Toy Doll Company in 1889 to market the doll and support the cost of its development. Edison and Batchelor received stock in the company in return for their inventive efforts and the costs of their experiments were billed to the company in Boston. Edison patented his first doll phonograph in the summer of 1889, but it was not until the end of the year that the laboratory began to design tools and prepare for manufacture. [25]

While cautious minds might have had reservations about the reliability of a small doll mechanism, Edison was confident that he could produce a working doll phonograph and even made ambitious plans to manufacture 500 a day in the Phonograph Works. There was nothing wrong in the marketing strategy; the

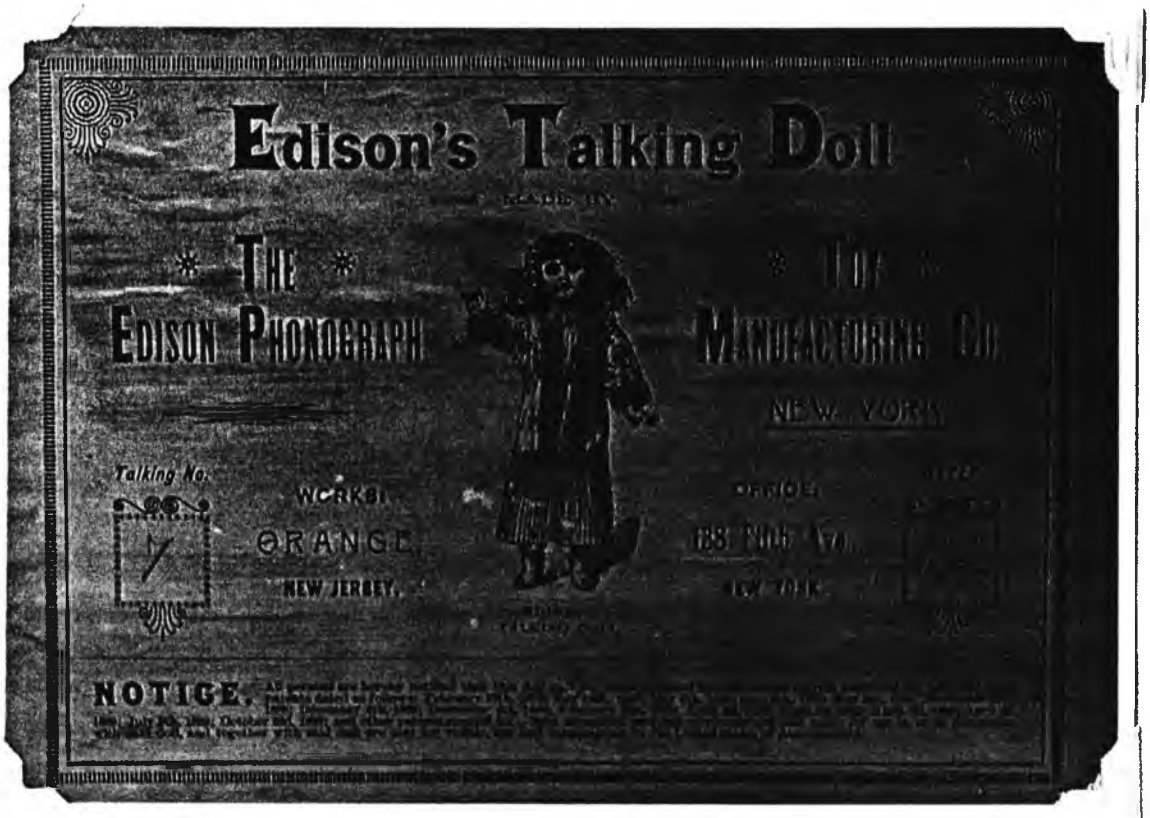


Illustration 4-2

The Talking Doll

talking doll proved to be a popular toy and orders soon outstripped supply. The problem lay in the design of the small phonograph movement inside the dolls. The fragile needle assembly would not stay in the fine groove of the wax record and consequently most of the dolls failed to work properly, steadfastly refusing to talk for their new owners. One dealer reported that 188 dolls were returned out of 200 sold. [26] Despite the strenuous efforts of the laboratory, the talking doll could not be made to work. This was an important project for Edison's manufacturing strategy for half the capacity of the Phonograph Works was devoted to dolls by 1890. Yet continual failure in the engineering effort led to the abandonment of the venture by the end of the year, manufacture ceased, and Edison dissassociated himself from the Talking Doll Company.

The toy doll was too complex a device to ensure the level of reliability required in a commercial product. Reliability was also the chief problem with the business phonograph. The feedback coming back to the laboratory indicated that the phonograph was still too delicate for office use; its operation required a level of precision and manual dexterity that came easily to the hands of a trained telegrapher, but was usually lacking in the average business. The recorder/reproducer assembly had to be handled carefully and lowering it onto the cylinder needed a deft touch to avoid damaging both assembly and cylinder. Frequently, a phonograph that worked perfectly in the factory would grind to a halt after a few days of operation for the machine demanded continual adjustment or it would break down. The phonograph mechanism turned out to be highly sensitive to dirt, and it was quickly discovered that shavings from the wax cylinder fell onto the machine and gummed up the works. The machine could not absorb the shocks of transportation and often broke down after being shipped. Similar problems occurred with the toy doll mechanisms--the dolls would "talk" perfectly when tested in the laboratory but would be out of order and useless by the time they got to the customer.

The laboratory staff worked feverishly through 1888 and 1889 to remedy the growing list of operating problems with the phonograph. A member of an experimental team remembered that they worked "night and day" during this time. One document shows that during one experimental campaign in 1888, over 40 changes and improvements were carried out, ranging from changing the number of threads on the cylinder to moving the location of small screws; many of the small design changes made the machine easier and cheaper to manufacture.[27] The laboratory staff were finding out that mass production of a complex product needed attention to detail. They were locked into a cycle of innovation: product development, manufacture, marketing, feedback, and then more development--the phonograph had to be continually redesigned to eliminate its "bugs."

Edison acknowledged in May 1889 that there were still defects in his phonograph but they were being remedied "as fast as human flesh can stand it." [28] Many of the mechanical defects of the machine had been eliminated, but there still remained two more important problems to be solved: the power source and the wax of the cylinder. The former produced a constant flow of complaints; the battery and electric motor combination were totally unsuitable for office use since the battery was unreliable and expensive. One alternative to this format was an electric motor powered by current from electric lighting circuits. The major design consideration of this type of motor was constant speed because the slightest variation in speed distorted sound reproduction. This problem defied solution in the 1880s. The laboratory staff developed several alternate methods of running the machine, including spring motors, and among the different designs actually manufactured in the 1890s was a treadle-driven model and a water-powered phonograph. [29]

As each power source alternative was tried and found wanting, Edison intensified his efforts on the battery and electric motor format. The primary battery then in use was an electro-chemical cell which required replacement of the chemicals once the electricity was discharged. He had to get more power from the primary batteries in use because their charge ran down very quickly and presented the user with an expensive and messy replacement process. This problem started Edison on a series of researches which eventually led to the creation of a new primary battery.

The wax cylinder was a critical part of the phonograph and it caused many of the operating problems. One of the first business users of the perfected phonograph was Edison's secretary Tate. He found that some of the chemicals in the wax cylinder tarnished the metal stylus of the recorder and rendered the machine useless. [30] The composition of the wax was the speciality of Dr. Jonas Aylsworth, an industrial chemist. During 1888 Aylsworth labored on mixing, heating, and testing hundreds of wax compounds. He tried every conceivable combination of oils and fats to find a hard substance that would take and hold the impression from the phopnograph stylus. The smallest imperfection or bubble in the compound--invisible to the eye--caused a crackle that could be distinctly heard as the record played.

As more phonographs were put to use, more "bugs" emerged and even the brushes of the electric motor version had to be redesigned to avoid damage by "ignorant people" who turned the cylinder backwards. The number of adjustments of the recorder/reproducer assembly was reduced, yet the complaints about the difficulties of operation continued. [31] No amount of R&D in the West Orange laboratory could defuse the major criticism of poor reproduction. One user described the reproduction of the phonograph as "but a parody of the human voice" that required "careful adjustment by a practised hand" to be understood.[32] Each subsequent model of the phonograph had better reproduction and was more rugged. It was slowly gaining acceptance in business offices, yet not enough to warrant the large-scale production that Edison planned in 1887. Full scale production of machines did not begin until the spring of 1889 and by June only 1200 had been completed. In August 1889 the Phonograph Works produced 708 machines, and received orders for only 217 phonographs. During the sales period of December, 991 phonographs were ordered and 753 were made. [33] The Works average daily output was probably less than 50--much less than the original production target of 200 a day!

Edison had been highly optimistic in his plans to set up mass production of phonographs at West Orange. The "American system" of manufacture with interchangeable parts was easier said than done. Edison admitted later that "so called interchangeable parts have to be adjusted in place." [34] It was naive to even consider mass production when the prototype was being continually redesigned. Mass production at West Orange turned into a continual process of adjustment in manufacture. The laboratory served as the conduit for information about production (and the product) and it made the required changes in the design of the product and the process of manufacturing it. The laboratory staff were charged with production engineering. In 1889, Batchelor and J.E. English, the Works manager, labored to improve production methods: changing operations, laying out the machines in a more logical sequence, and redesigning tools. An essential part of organizing production was hiring and training the right personnel for the job, from tool-maker to factory manager. The phonograph was a complicated product and it took a long time to train the work force; many of the delays were caused by "breaking in" new men.[35]

The laboratory provided the testing that was essential to maintain quality. The sub-assemblies and completed units were checked on the third floor of the laboratory by skilled staff who knew the standard that Edison wanted for reproduction. Even when inspectors were employed in the Works, it was the lab staff who had the last word on the sound of the machines. The increased attention given to quality control was considered to be well worth the time and expense; as Tate wrote to Edison in 1892: "I am satisfied that had you been less rigid in your methods of inspecting phonograph parts, the North American Company would have big claims on us today." These efforts nevertheless failed to prevent some costly recalls of phonographs back to West Orange.[36]

Although sales of business machines were very disappointing, a growing demand for amusement phonographs kept Edison's hopes, and the finances of the North American Phonograph Company, alive. The entertainment value of the phonograph had been first demonstrated by the showmen who attracted crowds to listen to the machine and pay for the privilege. Penny arcades were set up by small businessmen to sell this form of entertainment on a larger scale. Edison responded to this market by developing a coin-operated machine which was soon manufactured at West Orange. (Illus. 4-3, #9218) The coin-in-the slot phonograph was highly successful: it attracted attention, increased user familiarity with the machine, and maintained a steady level of sales which provided much needed work for the laboratory.

Edison's commitment to the single-user business market in his 1887-1889 patents is shown in his emphasis on speaking and listening tubes rather than horns which provided a means of acoustic amplification.[37] Yet as soon as the feedback from the local companies indicated that there was a market for an amusement phonograph, Edison began to consider the design of a phonograph for entertainment use in the home. This included designing a wooden cabinet for the machine and developing a recorder/reproducer assembly suitable for music. The work on the latter was a vital part of the evolution of an amusement phonograph. Edison applied for a patent in November 1889 which incorporated many of the improvements made during that busy year. The spectacle with two diaphragms was replaced by a single dual purpose recorder/reproducer. It also featured an improved start/stop control and shaver mechanism which removed the groove from the cylinder, enabling more than one recording to be made. The late 1889 model phonograph had one holder to be used for either the reproducer or recorder instead of the spectacle arrangement. Now the laboratory staff could design reproducers and recorders of different weight which gave them the flexibility to improve the reproducer. The reproduction of

Illustration 4-3

Phonograph Manufacture

music (rather than the voice alone) demanded more sensitivity and more volume from the diaphragm. These were conflicting goals while the spectacle format was used with the soft soap wax cylinders--the heavier the weight of the reproducer the greater the volume, but heavier tracking pressure marred fidelty and damaged the wax surface. Moving to a separate device for recording and reproducing functions opened the way for better sound recreation. [38]

The musical phonograph was not only a different machine from the business phonograph, it also needed a supply of prerecorded cylinders to augment the musical recordings made in the home. To provide these recordings, part of the top floor of the laboratory was converted into a recording studio. The functions of this "Music Room" ranged from experiments on recording techniques to providing musical cylinders to the North American Phonograph Company. (Illus 4-4, Music Room, 29.430, #7058.) These would then be sold to businessmen who were using the phonographs in arcades. A cheap method of duplicating these recordings had to be found before the amusement phonograph had a commercial future. The only way to duplicate recordings on cylinders was either to make the artist repeat the performance several times or copy the cut on the cylinder by a pantograph process. These two options were expensive, time consuming, and produced poor quality recordings. Edison recognized the great profit opportunity in mass producing recorded cylinders and set about finding a cheap

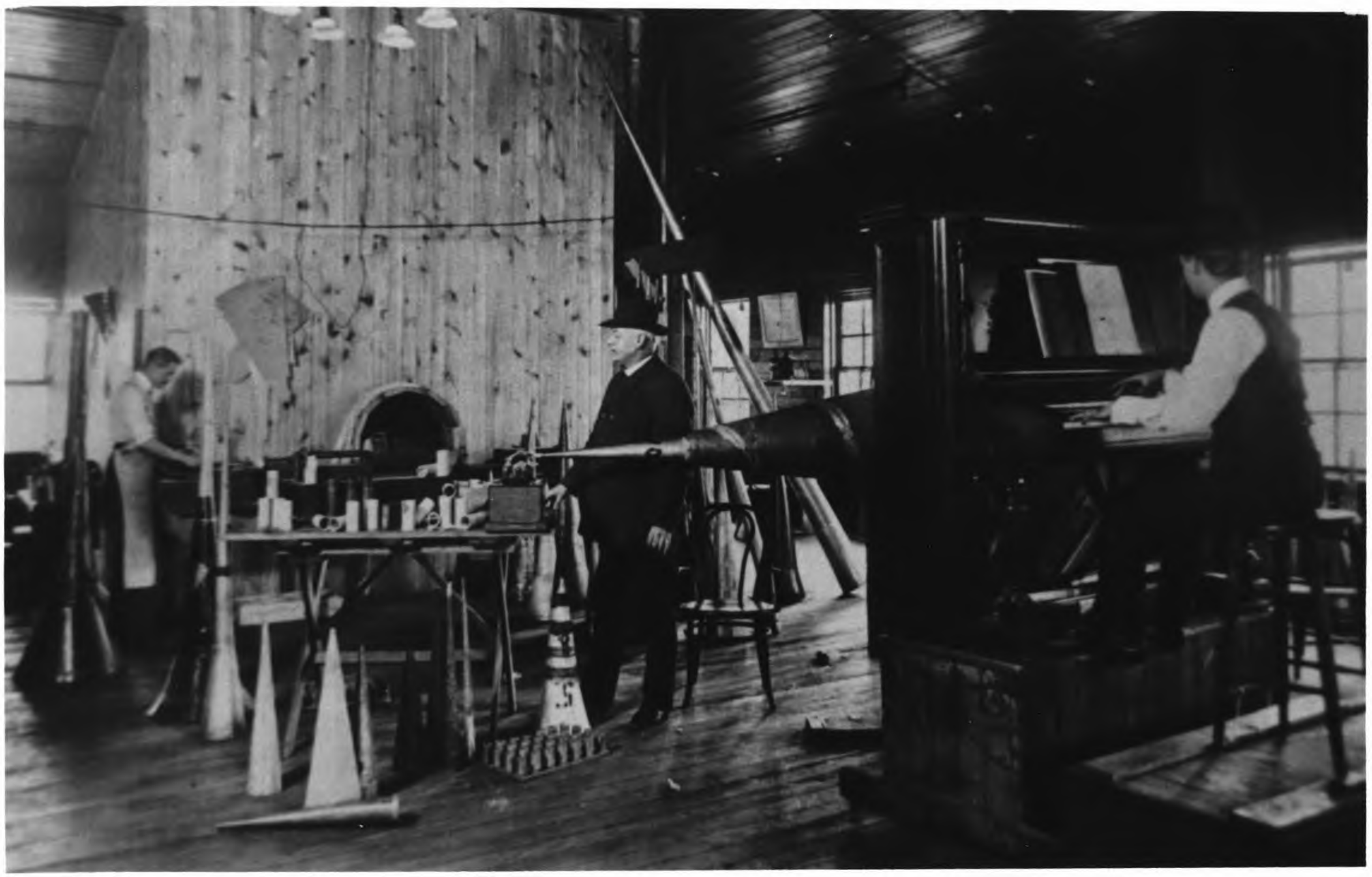


Illustration 4-4

The Music Room

method of making duplicates.

The development of a commercial phonograph technology had been an expensive and time consuming task and it had not achieved the success that Edison had forecast in 1887. His plan to perfect the instrument and then move into mass production in the space of a year was wildly unrealistic. Even today, 12 months to equip a new factory and start up production would be considered incredibly fast. Edison wanted his laboratory to innovate with speed and flexibilty and it had done so, but the sheer number of problems in developing the phonograph had swamped its resources. "The amount of work to get phono out has been stupendous" Edison wrote in May 1889 [39], and it was reflected in the enormous number of phonograph patents he obtained: 31 in 1888, 22 in 1889, and 22 in 1890. The enormous cost of R&D had not produced a commercial product and had ruined Edison's plans to industrialize the Orange Valley. The business phonograph had failed to become a staple in every American office, as Edison had hoped in 1886. The failure of perfecting the phonograph forced the West Orange laboratory into more profitable fields.

ENDNOTES FOR CHAPTER FOUR

1) "The New Edison Phonograph," Scientific American LVII (Dec 31 1887), p. 415.

2) TAE to (EHJ) handwritten memo undated, 1888 Phono General.

3) Ibid. & Tate, Edison's Open Door, p. 135-7.

4) TAE to (Gouraud?), 22 Nov 1887, 1887 Phono General.

5) A.B. Dick to TAE, 23 July 1887, Phono Gen; Scientific American LVII (29 Oct 1887), 273.

6) TAE to Gouraud, 1 October 1888, 1888 Phono General.

7) TAE to G.H. Gould, LB 870621, p. 24, 21 July 1887.

8) TAE to Villard, 19 Jan 1888, Villard Papers, Harvard Business School, MS 78, box 63.

9) Scientific American LVII (31 Dec 1887), 422; patent analysis by Mark E. Ham, "Edison and the Phonograph," 19 May 1986.

10) Lab notebook N 880601.1.

11) Tate to Mack, 1888 Electric Light General, July 1888 .

12) List of experiments, 1888 Phono General May-June; Drawing of "plate phono," 1 Oct 1888, N88001.

13) Tate, Open Door, pp 152-156.

14) Agreements in 1888 Phono agreements, 1888 Phono general; Edison had attempted to revive the old phonograph company by offering to exchange one third of the stock of a new company for the interest of the old shareholders. They refused and Edison formed the new Edison Phonograph Company without them in December 1887. The right to manufacture phonographs was given to the Edison Phonograph Works.

15) Gilliland extracted a large commission out of Lippincott on the understanding that Gilliland would sell Edison's interest to Lippincott for half its worth. Once he got the money from Lippincott, Gilliland then fled the country. This story is told in Tate, Conot, and Josephson. Edison's faith in the "boys" was shaken, see TAE to (E.H.Johnson) handwritten memo undated, 1888 Phono General.

16) TAE to A. Lawson, 22 May 1888, 1888 Phono Gen May to June.

17) Tate to A Wright, Feb 16 1888, Phono Gen Jan to Apr.

18) Account sheet, 1 Jan 1889, 1889 Phono General; TAE to G.S. Notage on 23 Mar 1878: ."Cited in D. Hounshell, "From the American System to Mass Production (Baltimore: Johns Hopkins, 1984), p. 333; London Daily Telegraph, 9 Nov 1888, 1888 Phono Gen.

19) Tate to Lippincott, 2 Nov 1888, LB 870621, p. 394.

20) F.W. Toppan to Lippincott, 24 Oct 1888, 1888 Phono General.

21) TAE to G. Gouraud, 30 May 1889, LB 890521, p. 170.

22) Tate to Dyer, 7 Sept 1888, Phono Gen

23) TAE to Gouraud, 1 Oct 1888, Phono Gen.

24) List of experiments dated 30 Dec 1887, 1887 Phono Gen.

25) TAE to P.S. Dyer, 17 May 1889, LB 890408, pp. 434-5.

26) "A boom that collapsed," Philadelphia Times, 2 Jan 1891, 1891 Phono, Talking doll.

27) Louis Glass to TAE, 6 July 1910, 1910 Personal friends; "New Model" List, 1888 Phono Gen.

28) TAE to Batchelor, 7 May 1889, LB 890408, p. 325.

29) Phonogram, V2 # 12, Dec 1892, p.274.

30) Tate, Open Door, pp. 161-162; N 880823, Aylsworth's notebook. The composition of the wax cylinders was based on a mixture of stearic acid and its salt, sodium stearate, which is used in soaps. The acid in the compound reacted with the metal of the stylus to create the oxidization problem referred to by Tate. A further problem was cracking caused by low temperatures. Byron Vanderbilt, Edison the Chemist (Washington, D.C.: American Chemical Society, 1971), pp. 121-124.

31) Caveat for improvements in phonographs, 21 July 1890, 1890 Phono, caveats; J.A. Beecher to TAE, Nov 1 1889, Phono General; Electrical World, 28 Sept 1889.

32) T.C. Hepworth "The Phonograph," in The Technical Educator, 1890, 154-156

33) Batchelor Diary, 1337 p.582.

34) <u>Scientific American</u>, LXII (26 April 1890), 263; Annot on G Morrison to TAE, 1 July 1895. phono Ed United Co .

35) Scientific American, LXII (26 April 1890), 263; Tate to Lippincott, 17 Nov 1888, LB 870621, p. 394.

36) Tate to TAE, 29 July 1892, 1892 WO Lab Business Conditions; Tate, Open door, pp. 247-248.

37) Mark Ham, "Edison and the Phonograph," p. 17.

38) Edison's handwritten notes on phonograph development found in N 880103 and dated from 1890, 1890 Phonograph.

39) TAE to Batchelor, 7 May 1889 LB 890408, p. 325.

CHAPTER FIVE

"A POWERFUL INCENTIVE"

EDISON'S LABORATORY AND THE ELECTRICAL INDUSTRY

The great experimental campaigns to perfect the phonograph went unnoticed as the public continued to associate Edison's laboratory with electricity. Edison's fortune, and his financial future, were dependent on the success of the phonograph but it was electricity which kept the laboratory in the public eye. A period of intense competition and rapid growth focused attention on the most dynamic new industry of the Second Industrial Revolution. Edison once said that he needed an incentive to invent: in 1887 he had the opportunity to pit his inventive powers, and his great new laboratory, with the best of his contemporaries.(Illus 5-1, Edison laboratory in the 1890s.)

The Edison electrical companies made the most of their special relationship with Edison and the prestige of the largest industrial research center in the United States. The Edison Electric Light Company naturally stressed the technological advantage it possessed in Edison and his laboratory, and used it as a selling point to market its franchises. Deputations from potential customers were given a

Illustration 5-1

The Laboratory in the 1890s

tour of the facilities "for the sole purpose of impressing upon them that whatever improvements are made in the Edison system that their company will receive them at any future time." [1] Its successor, the Edison General Electric Company, also emphasized the importance of the technological resources it possessed. Its prospectus of 1889 stressed the links between Edison's laboratory and the technical staff of the Siemens & Halske Company (the holders of Edison lighting patents in Germany), and claimed that "the regular exchange of laboratory and manufacturing experience" gave the new company "a vast advantage not heretofore possessed." [2] The West Orange laboratory stood at the center of a technology that had spread out on both sides of the Atlantic.

Edison's electrical research at West Orange had two basic goals: improvement of the system through research and development, and engineering aimed at lowering the costs of generating electricity. Edison dreamed of a time when electric lighting would be universally used and knew that the price of the light had to come down before it appealed to mass markets. Edison had no illusions about the competitive nature of the electrical industry and saw increased economy as the means to dominate the market. In a letter to a central station manager, Edison elaborated his mission of cutting the costs of electric lighting:

> Try everything you can towards economy. No one is safe in this cold commercial world that can't produce as low as his greatest competitor. No matter how much money you are making never for an instant let up on

economizing.[3]

Guided by this philosophy, Edison wanted his laboratory to be the driving force in reducing the costs in the electrical industry. This role was reaffirmed by the laboratory contract of 1889 with the Edison General Electric Company: "the gen(era)l company recognizes the importance of further perfecting and cheapening the manufacture, installation, maintenance of the electric light system." [4]

Edison's system thinking was probably always centered on improving the bulb--making it burn brighter and last longer. The results achieved along these lines by the lab illustrate the importance of its work to the Edison Illuminating companies. The bulbs manufactured by the Edison Lamp Works suffered from poor reliability and a short life.[5] One of the major problems was the blackening of the inside of the bulb by a carbon deposit which led to a loss of candle power. Edison had come upon the "Edison Effect" while working on this problem, and his discovery of this phenomenon earned him the title of "Father of the Electronics Industry." Yet he had little time to investigate the potential of the "Edison Effect" because he was continually at work on the incandescent lamp. In 1886 he produced an improved lamp with a high resistance filament that saved on the copper content of the conductors and lowered the output load of the central stations. This small improvement was instrumental in lower production costs, lower prices, greater sales volume, and more profits. When the new bulb was incorporated into the larger lighting systems it was estimated to increase return on capital from 18.6% to 34.6%.[6] Several pages of computations in Edison's hand reveal his strategy of increasing output and continually cutting unit costs of each incandescent lamp.[7] Here was the mind of the factory manager at work.

The market for lamps was extremely crowded and the high price of the Edison lamp was a disadvantage in making sales. Continual decrease in price and improvement in performance was therefore necessary to stay competitive with the many cheaper lamps on the market. Edison made this a priority of his West Orange laboratory. Edison's commitment to lowering the cost of making bulbs covered manufacture as well as design. He gave this problem a great deal of attention at the Harrison Works of the Edison Lamp company before he moved his experimental base to West Orange and continued work there. One of the first jobs he gave to Fred Ott in the new laboratory was to construct a machine to test the carbonizing properties of several hundred substances at once.[8] Edison developed a method of mass producing filaments by squirting cellulose through a die "like macaroni," and applied for a patent in 1888.[9]

He believed that he had a real talent to find ways of cutting costs and no part of the system was too small to merit the great man's attention. In 1889 he asked to be sent reject lamps from the factory because, "I want to experiment to see how money can be saved" by lowering the number of rejected lamps.[10] The Edison lighting companies continually asked the parent organization for a cheaper lamp with better performance. Their complaints and pleas for more innovation were referred to the laboratory. One important line of experiments was basic research on new materials for filaments and new types of lamps. Edison had begun research on fluorescent lamps as early as 1888, experimenting with layers of fluorescent substances in high vacuums. [11] The development of the incandescent bulb was an important part of the laboratory's electrical work and it continued into the twentieth century.

Edison's financial interest in electrical manufacturing was an additional motivation to experiment on lowering the cost of production. The business of the electrical equipment suppliers began to increase rapidly in the late 1880s and therefore each cost reduction was multiplied by the growing output of the manufacturing shops. The Edison Pearl Street system had been in operation for five years when the West Orange laboratory opened. When he began to design the system in 1881, Edison was more concerned with trying to make it work rather than economize on the manufacture of its component parts. The operational experience gained in operating the first pioneer central stations (based on the Pearl Street station), coupled with the rapid advance of electrical knowledge, offered many opportunities to improve the first generation of electrical supply systems. The second wave of electrical engineering, which began at the West Orange laboratory, concentrated on redesigning each component part of this system, from socket to central station generator, for greater efficiency and economy. Edison confided to Henry Villard in 1889 that the price of "all electric lighting machinery is entirely too high now." [12] The West Orange facility was to develop cheaper and more efficient technology to enable the supply systems to move into the next stage of electrical development: mass distribution of very cheap electricity.

The growing competition in electric lighting was reason enough to concentrate on reducing the costs of generation. The new entrants in the electrical industry had made the central station business much more competitive; in the beginning there had only been the Edison system, but by 1888 there were several other systems available. Edison had begun work on an entirely new design of a central station dynamo to reduce its production costs and therefore lower its price. In 1888 much more was known about the properties of electromagnetic circuits and this new knowledge enabled electrical engineers to break away from the basic Edison design of two magnetic poles and develop bigger, and better, electrical generators. The large size of the dynamo meant that R&D and testing had to be carried out on a large scale and this greatly added to the cost of developing it: "This was a very difficult problem but owing to the great competition it was thought necessary to meet the same." [13]

The Edison electric light companies had progressed from learning how to operate the system to increasing the size of their installations to take advantage of the economies of scale. They had used the technology developed at the Pearl Street station to establish utility companies. This system had proved its technological feasibility but not its commercial worth; a return on the large initial investment could only come with increased revenues--the profits lay in extending the system to serve more customers. The Edison Illuminating Company of New York was typical of the Edison companies--in 1886 it was enjoying a steady increase in earnings but saw its future in supplying more customers with power and light. The company was inundated with requests for service from customers uptown (from the Pearl Street station), but was unable to supply current to meet demand. This was a barrier to the growth of both the Illuminating Company and the electrical manufacturers; the demand for lamps, motors, and fittings would not begin until electricity was available uptown. [14]

The West Orange laboratory developed the technology to make this important transition from experimental prototype to a fully developed commercial system. Although the new central station dynamo had initially been designed to reduce manufacturing costs, it soon filled the need to equip the second wave of larger central stations, which aimed at much greater output for many more customers. Larger prime movers were being introduced into power stations and the new multipolar dynamo was found to have twice as much output per pound weight than any other comparable dynamo. [15] This very expensive research project had produced a vital part of the larger supply systems of the 1890s.

Most attention was on the production of electricity and it was not until the end of the 1880s that the importance of electrical measurement was appreciated. Precise electrical measurement was the starting point of the new art of creating a profitable load and controlling costs of generating electricity. This was the priority of Edison central stations in the 1880s. When a committee met to discuss some general engineering problems confronting the Edison companies in 1888, the first three items on the agenda were pressure meters, feeded equalizers (in distribution systems), and ampere meters.[16] The electric lighting industry urgently required better measuring instruments to monitor output and Edison's laboratory quickly produced an improved pressure meter for central station use. The staff of the galvanometer room (Building 1) continually monitored the performance of measuring equipment used in Edison central stations and led the way in technological development of electricity measurement.(Illus 5-2, Galvanometer Room by Dickson.)

At the user's end of the system, the electric meter was subject to numerous complaints about its poor accuracy and frequent breakdowns. Edison had first designed an electrochemical meter to be used in his electric lighting system. This probably worked well enough in the laboratory, but proved to be ineffectual under normal operating conditions--it

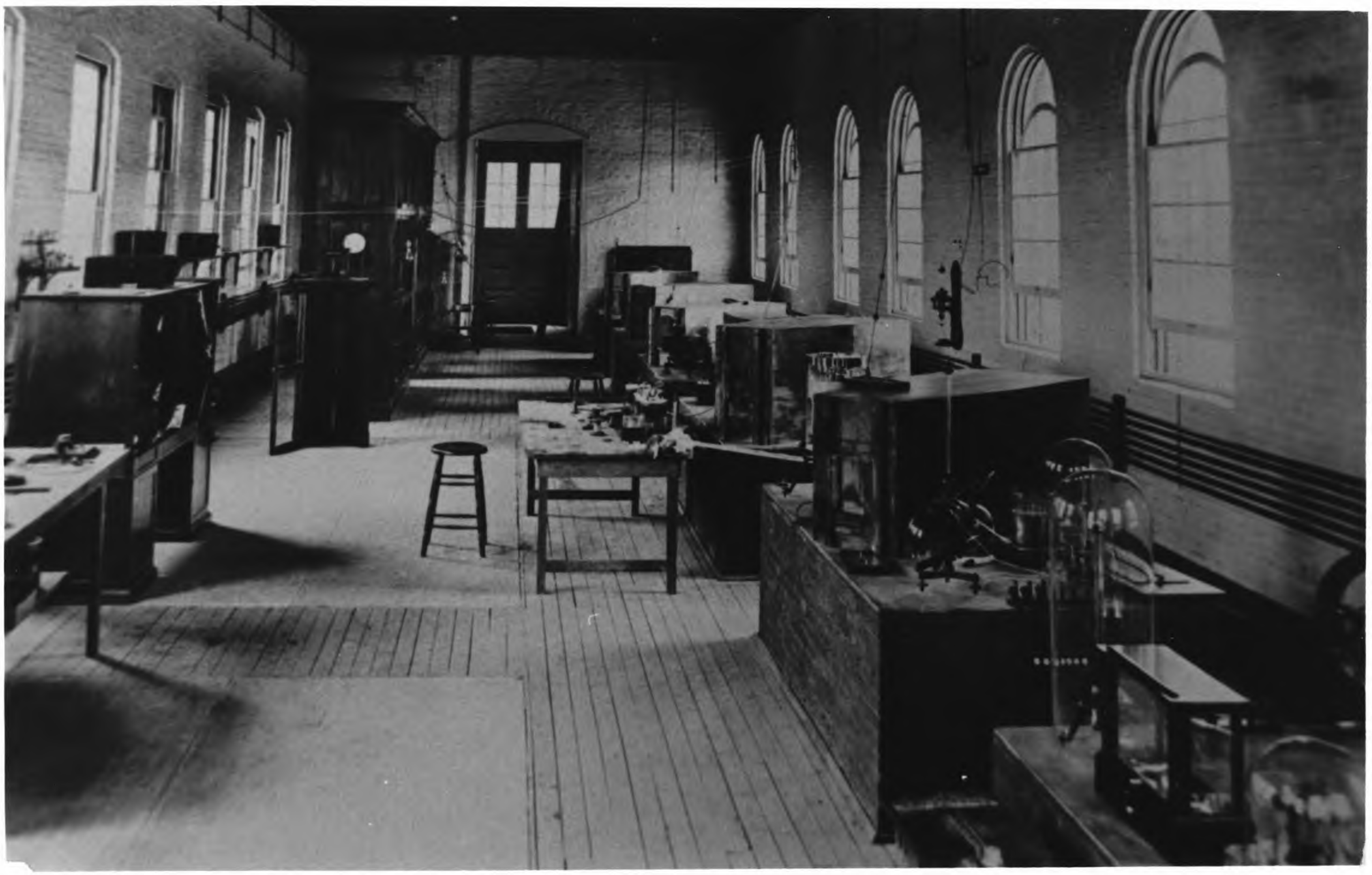


Illustration 5-2

The Galvanometer Room

was cumbersome, expensive to maintain, and often highly inaccurate.[17] The electric meter can hardly have been a major consideration in the overall design of an electrical system, but when the Edison companies set about selling electricity for a profit they found that an easily maintained, accurate meter was vital.

The growth of new electrical knowledge, especially in electromagnetism, offered new solutions to the problems of measuring electrical energy. Advances in the manufacture of small springs and magnetic materials made an electromagnetic meter possible in the late 1880s. A great many experiments on metering electricity were carried out at the West Orange lab by Edison and the chief electrician, Arthur Kennelly. They produced several new designs which were patented and introduced, including weight-and-beam and electromagnetic meters. The Edison laboratory was soon involved in a race to introduce a new electromagnetic meter before its rivals in the electric lighting industry, who had also appreciated the value of an improved meter. The Thomson-Houston Company, a major competitor to the Edison companies, had produced a successful meter in 1889 and the West Orange lab spent 1890 racing to bring out Edison's mechanical meter before the Thomson-Houston meter achieved widespread adoption within the Edison system.[18] The lab continued to work on meters until well into the twentieth century, and Edison and his staff gained many more patents for electric meters. [19]

The main technological problem to be solved before the second generation of electrical technology could begin was the cost of the supply network. Consequently, one of the most important, and pressing, R&D campaigns of the West Orange laboratory was directed at lowering the costs of distributing electricity over larger areas. A note from Edison to Edward H. Johnson (President of the Edison Electric Light Company) in November 1887 shows that the earliest electrical concern of the new laboratory was the development of technology "useful for bringing in power at a distance."[20] The Pearl Street system of 1882 had been based on low voltage direct current which gave it a supply radius of a few square miles around the central station. The short supply area was appropriate for a pilot system where corrections and repairs had to be carried out continually, but as the popularity of electricity grew, the small supply radius became a liability. The problem with low voltage direct current was that the size of the copper conductor had to be increased with the supply distance. The very high price of copper made the Edison system uneconomical over a supply area greater than two square miles, and this prevented the growth of the system.

The very sharp increase in the price of copper had not gone unnoticed by Edison, nor had the commercial potential of expanding the distribution area. His electrical experiments at West Orange were therefore primarily directed at increasing the efficiency of the lighting system and decreasing the costs of distributing electricity over wide areas. He had specifically designed the three-wire system to meet these two criteria in 1883 and went on to design more economical systems using more wires. Another solution to the long-distance problem was his "municipal" lighting system, which used higher voltages to serve large areas. Its important features included a high voltage (200v) lamp, and a cut-out device that would maintain current if one of the lamps blew.[21]

Edison and his staff examined all possible solutions to the long-distance transmission problem, taking an early interest in alternating current (a/c). This was one of the very first experimental projects undertaken when the lab opened for business in 1887. This form of electrical energy had the advantage of being easily transformed from low to high voltages which could be transmitted over long distances much more economically than direct current. After transmission, alternating current could be transformed down at the point of use. Edison developed his own alternating current system and applied for a patent for this "system of electrical distribution" in December 1886. The purpose of the invention was to economically transmit electricity over long distances. It employed high voltage current which was transformed down by motor generators and rotating transformers to produce low voltage electricity for business or home use. [22] The first commercial use of alternating current took place in Europe and Edison was able to use his overseas contacts to get an initial evaluation of the new technology. The Siemens & Halske Company sent a detailed report on alternating current technology to Edison in 1886 which outlined the progress of the new technology in Europe. [23] The Edison Electric Light Company went on to buy an option on the alternating current transformer system of Zipernowski, Blathy, and Deri (ZBD), which had achieved success in Europe. This and other alternating current technology was examined at the West Orange laboratory.

As as practical inventor, Edison was concerned with the loss of efficiency in alternating current transformers. As a businessman, the lack of an a/c motor and meter in the late 1880s made its commercial value slight. The meter was indispensable in estimating costs and constructing a profitable load for central stations. Edison was firmly convinced of its importance in the system and improvement of the meter was a major research project. The lack of an alternating current motor was an even greater disadvantage; Edison considered that the motor load was the essential part of a profitable central station operation. He decided to build the first central station in a commercial district in downtown Manhattan (instead of the more thickly populated uptown), because he expected that electric lighting could not beat the competition of gas "but hoped to meet it by selling power."[24]

Edison criticized the high voltage alternating current technology he saw in the late 1880s on the grounds of its complexity, unreliability, and threat to public safety. He told his friend and financier, Henry Villard, that it was "not worth the attention of practical men"--meaning that it had no commercial potential. [25] Edison believed that the large scale of alternating current systems would cost too much money to construct and that interest charges on the investment would eliminate any operating profit. His evaluation of all electrical systems was based primarily on commercial considerations--the best designed central station system was the one that returned the highest profits to the smallest possible investment. [29] This viewpoint was shared by the capitalists running the electrical utility industry.

THE LEADENED COLLAR

The increasing scale of electrical technology demanded better organized companies to finance and administer it. As Chandler noted in The Visible Hand, large supply and traction schemes led to the evolution of business organizations with the operational and financial resources to run them.[26] The electrical companies that Edison founded in the early 1880s grew into structured organizations run by professional managers. Their relationship with the West Orange laboratory had to change when a more formal management style clashed with Edison's informal leadership.

The Edison lighting companies were growing ever larger, and assuming more financial obligations, as they encouraged a forced growth of the lighting industry. Every city and town in America wanted the electric light and private companies were only too happy to oblige. The manufacturing "shops" were hard pressed to keep pace with the explosive growth of the electrical supply industry. While the Edison companies were controlled by the "old man" and their management was carried out by "the boys," there was little that Edison could not do; but as these companies grew their management had to take a harder line to Edison's activities, especially his billing practices for expensive R&D projects.

In the 1870s, Edison's abuse of bookkeeping formalities enraged his suppliers and frustrated his customers; in the 1880s it alienated his old comrades who were now running the electrical companies. (See Sidebar EDISON'S FINANCES AND THE ELECTRICAL INDUSTRY.) These managers, who had once been colleagues of Edison, were now responsible for large operations and had to exercise the financial restraint that was alien to "the old man." Samuel Insull had once been the man who had devised stratagems to raise cash for Edison, but in 1888 he found himself managing the Edison Machine Works and constantly frustrated at Edison's financial ploys. Insull found out that the lab was charging its supplies to the Machine Works. He complained to Edison that "we are constantly being asked to pay bills of the laboratory." [27] Insull knew that the ruinously expensive phonograph venture was eroding Edison's credit standing and making it harder for all the Edison companies to borrow money. The companies bearing Edison's name were irreversibly identified with him and his financial dealings were giving all of them a bad name.

On the other hand, Edison wanted to be free from business worries in order to concentrate on his experiments. He often pushed an experimental campaign forward regardless of cost when more cautious minds found the expense hard to justify. Edison was riding the crest of the wave in the electrical industry and he was driven forward by his vision of an electrically run world of the future. He was in a brave mood and enthusiastically supported expensive projects such as the search for new filaments. Edison's agents were scouring the globe for exotic materials while managers in New Jersey were counting the cost--over $100,000 for each sample filament. His secretary warned that "It made no difference to him what the cost might be when he had an objective in view." [28]

The companies wanted to integrate Edison's R&D into their business strategies, rather than have Edison's technological choices decide their future. They wanted to be convinced of the potential return on R&D expenditure. Their attitude to research was expressed thus: "Before authorizing any expenditure...the first and most important question they will want determined is ... the nature and extent of the advantages to be derived to this Company? and to whom will the resultant benefits accrue? [29] These were valid questions to ask before beginning an experimental project. The development of insulating materials provides an example of the growing tension between Edison and his customers in the electrical industry. (See Sidebar THE INSULATION PROJECT)

The management of the Edison lighting companies believed that research and development was certainly important, but it had to be placed within the constraints of time and money. Nobody challenged the purpose, or the validity, of the laboratory's work--managers merely wanted prompt and accurate information about its cost and the opportunity to veto a project that was running over budget. The Edison companies were wary of the ambitious experimental projects springing into Edison's mind. The companies remembered the astronomical costs of developing the first electrical systems and they wanted to know exactly how much it was going to cost before they committed themselves to an experimental campaign.

Finance of R&D became an issue because Edison and the electrical companies were both running short of cash. Edison had put all his money into perfecting the phonograph. The individual Edison Illuminating companies did not have the money to buy the lighting system outright, and consequently the Edison Electric Light Company, and the various manufacturing companies, often had to accept stock in payment for equipment and patent rights. Pushing the system depended as much on the credit arrangements as on the technology, and only the financially strong could successfully market a lighting system in the 1880s. The financial burden of introducing the Edison lighting system had left the companies heavily in debt. They were dangerously overextended and increasingly vulnerable to shifts in money markets. When their finances were under pressure they immediately cut back on R&D expenditure. A financial crisis hit them in the winter of 1888/1889 and they recalled many of their employees from the West Orange laboratory, closing down several experimental projects.[30]

Edison had little respect for the management of the Edison companies, claiming that "All these people are amateurs." He resented their caution, which he argued was a "leadened collar" that prevented him from quickly developing new electrical technology. Edison complained to Villard that "with the leadened collar of the Edison Electric Light Company around me, I have never been able to show what can be done." [31] He came to believe that the companies had reneged on his initial plan to make the West Orange laboratory the spearhead of electrical development in the 1880s. He told Villard that "the Genl Co were morally bound to take advantage of the costly facilities erected primarily for the purpose (of R&D into the Edison lighting system)...they did not do so." Edison maintained that he had to fight the battles of the lighting companies with money from his own pocket, telling Villard that half the cost of meeting the technologial challenge of the competition could not be billed to the Edison lighting companies. He criticized the directors of the Edison Electric Light Company for their unwillingness to use the competitive tool he had constructed for them at West Orange, and blamed them for the gains of the competition. [32]

The managers criticized by Edison had no easy task. Competition in the electrical industry was ferocious and getting worse. What Edison saw as lack of vision and courage, they saw as rational decisions about available resources. Managers had to weigh the cost of R&D against the immediate demands of keeping the system running. They were the ones who had to integrate the work of engineering into their broad strategies of overcoming the competing companies. The Edison enterprise was forced to become more efficient to meet competition and one area of improvement was the engineering effort. The rapid expansion of the industry had led to the creation of separate engineering departments in illuminating companies and electrical manufacturers. The duplication of engineering services on each level of the organization was wasteful and the management soon moved to rationalize the engineering effort in the Edison enterprise. In 1888 the Edison Electric Light Company formed a Standardization Bureau to oversee the standardization of each component part of the Edison electric lighting system. This involved close supervision of the many engineering and test departments that were all working individually on electrical problems. Six months of operations brought such bad feeling between the Bureau and the engineering departments that the demarcation lines between them had to be redefined--the Bureau gaining the power to initiate and implement all engineering changes.

The Bureau also carried out many functions that had originated with Edison's laboratory, such as gathering and dissemination of operating experience and technical information, acting as a receptacle for complaints about the system, and making sure all engineering changes were carried out by the manufacturers. The central role of the West Orange laboratory in this reorganization remained unchanged: it was to produce innovations when "entirely new forms are required which the factories are not prepared to originate." [34] Each part of the Edison organization had its part in the struggle: the Edison Illuminating Companies redoubled their efforts in the marketplace, the Edison Electric Light Company used its patents to harass the competition in the courts, and the West Orange laboratory developed new technology needed to compete in a crowded market. Edison assumed the symbolic leadership of these forces and his laboratory stood at the center of the struggle.

The main competitive threat to the Edison enterprise came from alternating current systems which could reach customers that the direct current systems could not. Competitors such as the Westinghouse Company combined alternating current distribution networks with direct current lighting systems to provide larger, and probably more economical, systems. By the end of the 1880s alternating current had assumed the mantle of electrical supply technology of the future, but Edison opposed it for economic and safety reasons and tried to prevent its continued diffusion in the United States. Like many of the great engineer-inventors before him, Edison took a personal responsibility for the safety and efficiency of the technology he introduced. His risk assessment of alternating current was unfavorable. He believed it was too dangerous to be used commercially because the high voltages of the distribution networks would kill anyone coming into contact with it.

The issue of safety had first been brought up in the battle between gas and electric lighting and it remained a priority of Edison. As an electrical pioneer, he realized that public confidence was vital for the successful introduction of a new technology. Edison believed that the supplier of electrical technology should have faith in his equipment and in the future of public lighting. This had been the original reason why the electrical manufacturers accepted stock in the lighting companies; it brought about a union of interest between manufacturer and supplier. Edison, and his laboratory, stood behind the equipment bearing his name. His electrical lighting system was marketed on the basis of its safety and reliability.

Apart from the commercial challenge of alternating current, Edison had his own reputation at stake in the electrification of America. His name had become associated with high technology and practical engineering. His reputation, and the wide appeal of his name, was a asset of great value. It was a boon in marketing new technology, standing for solid, reliable products that the public could trust. Edison's name gave the competitive advantage to the companies marketing his lighting systems; no other person was as closely associated with electricity in the public mind. Edison had ethical and commercial reasons for opposing dangerous technology, fearing that any electrical accident would reflect back on him and the companies that bore his name.

The many fires and deaths caused by arc lights in the 1870s were an indication of the special risks of electrical systems, and it was at this time that Edison began his lifetime opposition to high voltages. He knew that the notoriously poor workmanship of the electrical contractors, compounded with wear and tear on electrical components, created hazards with even the safest system. His early experiences in introducing electricity made him sensitive to the public's apprehensions of the danger of new lighting technology. Mindful that regulation of the electrial supply industry was on the horizon, Edison maintained safety as a priority in the development of lighting apparatus. He saw, correctly, that safety issues would quickly attract the attention of legislators and lead to the stringent regulation that would hamstring the American industry, as the Electric Lighting Act had done to the British.[36]

As Edison considered public support for new technology essential, his lab carried out research and development to reduce the risks of electricity. This involved making electrical installations safer by adding cut-outs and fuses to minimize the damage done by short circuits. Fire was an ever present risk with electricity--consuming the Pearl Street and several other central stations--and the lab worked to develop fireproof materials for central stations and insulation for wires and cables.[37] Safety was a major engineering criterion at West Orange, and it often determined the direction of research. The decision to develop a traction system with a third rail instead of an overhead pickup was motivated by Edison's fear of accidents with the latter system. He expected that regulation would soon prohibit the overhead wires from all electrical installations and therefore the only feasible traction system would pick up low voltage current from a third rail. [38] Much of this kind of work was initiated and financed by Edison personally.

The intensive investigation of all new alternating current equipment carried out by the laboratory staff did little to assuage Edison's fears about the danger of high voltage currents. He maintained an unrelenting opposition to a/c, insisting that the Edison Electric Light Company drop its option on the ZBD patents--the easiest access to alternating current technology.[35] The Westinghouse Company had no such reservations about the danger of high voltage current and began to market a/c equipment vigorously in 1888. This company, along with the Thomson-Houston Company, were the major rivals to Edison in the electric lighting field. Westinghouse used the Sawyer-Mann lighting patents to challenge the Edison monopoly of incandescent lighting and the two companies were locked in a bitter struggle for the new lighting markets opening up in the late 1880s.

Alternating current was the most dangerous electrical technology of its time not only because of the high voltages used but also because it greatly increased the size of electrical systems. As the systems got larger, more people were at risk and magnitude of a potential accident increased. There is little doubt that, at the time of its introduction, the a/c system produced by Westinghouse was complex, experimental, and dangerous. Edison anticipated dire results from its hurried introduction:

> Just as certain as death Westinghouse will kill a customer within six months after he puts in a system of any size. He has got a new thing and it will take a great deal of experimenting to get it working practically. It will never be free of danger.[39]

The great fear of the Edison interests was that a major disaster involving alternating current would harm the whole electrical industry and produce a backlash of legislation and fear that would hinder, or even stop, the spread of electrical technology. The immediate task of the Edison enterprise was to distance itself from the alternating current technology, and the companies marketing it, and educate the public about its dangers. Here the Edison laboratory played its major role. It stood behind the claim that Edison's was the "safest, most convenient, most efficient" lighting system, and "the **only** one that is not absolutely injurious to the health of the people using it." [40]

EDISON'S LABORATORY AND THE BATTLE OF THE SYSTEMS

Edison was dismayed with the many new entrants in the electrical industry and feared a price war between competing electrical manufacturers. The greatest threat came from the Westinghouse and Thomson-Houston companies who both had alternating current systems on the market. It soon became evident at the headquarters of the Edison Electric Light Company that the opposition was prepared to sell electricity at a loss to win lighting contracts; many of the Edison franchisees reported back to the parent company that Westinghouse agents were pricing their current well below cost and these "ridiculously low prices" were winning customers from the Edison companies.[41] Westinghouse claimed that its system had a lower first cost than Edison's, and this brought an outraged response from the latter, who had carried out a detailed costing of the Westinghouse system. The two parent companies fought a war of words, each attempting to promote its own system and discredit the competition. The Edison Electric Light Company under the presidency of Edward H. Johnson made every effort to refute the "extravagant and fictitious" claims made by Westinghouse. Johnson went into battle under the banner of "Patents, Investment, Futility of Guarantees, Danger and Moral"--stressing the strong patent position of Edison and the higher standards of his engineering.[42] (Illus 5-3, advertising

Illustration 5-3

THE EDISON DIRECT SYSTEM OF CENTRAL STATION ELECTRICAL DISTRIBUTION.

The Edison Incandescent Lamp Figures for the United States alone now aggregate More than

1,000 INSTALLATIONS, 100,000 HORSE-POWER, 1,000,000 LAMPS, AND $20,000,000 CAPITAL.

EDISON ELECTRIC LIGHT CO.

THIS COMPANY IS THE OWNER OF THE INVENTIONS AND PATENTS OF

THOMAS ALVA EDISON,

Which Patents absolutely control this THE ONLY permanently Established and commercially Successful

METHOD OF GENERAL ELECTRICAL DISTRIBUTION.

As evidence of the growth and present prosperity of the Edison System attention is called to the character and scope of a few of the Stations now in operation and under construction.

NEW YORK CO.: Capital, $2,500,000, 4 Stations; Capacity, 150,000 Lamps.

CHICAGO CO.: Capital, $750,000, 1 Station; Capacity, 40,000 Lamps.

BOSTON CO.: Capital, $650,000, 2 Stations; Capacity, 50,000 Lamps.

PHILADELPHIA CO.: Capital, $1,000,000, 1 Station: Capacity, 50,000 Lamps.

It is significant to note the fact that the Edison Company has during the past year enlisted an amount of capital and put under construction a station capacity far in excess of the aggregate Incandescent work of all other companies combined. Nothing could more forcibly emphasize and attest the accepted value of the Edison Central Station Industry as an investment.

WRITE FOR PAMPHLET ON THE FIVE HEADS

PATENTS, INVESTMENT, FUTILITY OF GUARANTEES, DANGER AND MORAL.

For information relative to Central Station Business apply to the

EDISON ELECTRIC LIGHT COMPANY 18 Broad Street, New York.

And for Information relative to Isolated Plants apply to the

EDISON UNITED MFG. COMPANY, 65 Fifth Avenue, New York.

material.) Edison, who loved a fight and considered the Westinghouse Company to be "the enemy," enthusiastically joined the fray.

The propaganda war was the essential part of the "battle of the systems," a colorful episode in the early years of electricity that had a lasting impact on the development of the technology and the industry. It was fought between the proponents of two competing systems of electrical supply: the Edison low voltage direct current (d/c) and the high voltage alternating current (a/c) marketed by Westinghouse. The long distance transmission capabilities of high voltage current gave Westinghouse the edge in the war of words, because they could claim to be able to reach any customer. Edison and his company believed that Westinghouse was being reckless in pushing a system that was technologically and economically unsound. They feared that the opposition would win the propaganda war and Westinghouse's "army" of sales people would overcome a safer and more efficient system. Their response was to discredit the claims made by Westinghouse. Edison only wanted the public to know the difference between a/c and d/c, and set out to prove that the "shyster" Westinghouse was in fact marketing an unsafe technology.[43] The series of experiments that achieved this goal became one of the best known episodes in the "battle of the systems" and put the West Orange laboratory on center stage in this drama.

The laboratory had begun experiments into the effects of electricity on the human body as early as 1887. This was done with a practical purpose; Edison wanted to know more about this phenomenon to better safeguard the lives of the men working in the electrical industry.[44] Edison did not originate the investigation into the killing powers of alternating current, he was drawn into it by the work of a New York state commission investigating humane methods of capital punishment. In December 1887 the commission polled the leading figures in the electrical world on this issue and Edison was one of the respondents. According the Arthur Kennelly, the chief electrician at the laboratory and the leader of the team investigating the effects of electricity, they had not distinguished between the two types of current in their experiments up to this point. A reporter from the New York Herald asked the questions which set a new direction of experiments in motion and Edison asked Kennelly to find out how much alternating current would kill a dog.[45]

Edison was not the only one interested in the effect of electricity on the human body. The therapeutic use of electricity had begun well before Edison invented the incandescent bulb and its popularity grew steadily as electricity became more available. Among the people carrying out research in this area was Harold P. Brown, a self-styled consulting engineer and a rabid opponent of Westinghouse's alternating current system. Brown had no connection with the Edison enterprise other than his employment by an electric pen company in Chicago. In the spring of 1888 Brown began a publicity campaign to draw attention to the "large number of deaths caused by careless methods...on the part of many electric lighting companies." Harold P. Brown's "movement in favor of greater care for public safety" was aimed directly at alternating current.[46] He was steered towards Edison by F.S. Hastings, the secretary of the Edison Electric Light Company. It was Hastings who mobilized the facilities of Edison's laboratory for Brown and his colleague Dr Petersen, a nerve specialist from Vanderbilt Hospital. Brown and Petersen electrocuted animals at the West Orange laboratory and at a public exhibition at Columbia College in July 1888 to demonstrate the dangers of alternating current.[47] Equipment from the laboratory was used at the Columbia exhibition and at subsequent demonstrations. More electrocution experiments were organized by Hastings in the fall and winter of 1888.

Kennelly reported that the experiments were done in a hurry, with makeshift equipment, and the whole process normally taking up less than an hour. The experiments were carried out at night to prevent the curious public from attending and to spare Kennelly's valuable time, which during the day was taken up with more important work on batteries, motors, lighting, meters, insulation, and dynamos.[48] The climax to this series of experiments came on December 5 1888, when several large animals were dispatched by Brown in the dynamo room in the lab. A Siemens alternator was used to generate the current and electrodes were attached to the feet of the unfortunate animals. The Edison Electric Light Company covered the costs of these gruesome experiments, which were billed by the lab as "made for Mr. Hastings" with "full reports... made to the Company." [49]

Edison's purpose in sponsoring these experiments, in the view of Kennelly, was merely to demonstrate that alternating current could kill. Edison forbade any public comment by the laboratory staff on the grisly events of the fall of 1888. The results of the experiments would speak for themselves. Kennelly insisted that there was no bias in the experiments and his notebooks testify to the scientific method used and the accuracy of the recording of results.[50] Kennelly could not make the claim that the Edison Electric Light Company was a disinterested third party for they organized, administered, and paid for the experiments. Hastings' correspondence shows that the company was very interested in the outcome of the experiments and considered them to be "of very great importance."[51]

As chief electrician of the West Orange laboratory, Kennelly also played a leading part in another campaign in the "battle of the systems." The account records of the laboratory show that from 1888 to 1892 a wide range of experiments was done in the areas of alternating current equipment, high voltage direct current technology, and devices like rotary convertors to join the two types of current in one system.

Edison's laboratory was leading a three-pronged attack on Westinghouse: development of high voltage d/c, development of a competing a/c system, and a campaign to discredit the "death current" of Westinghouse. Edison might not have had the mathematical education to understand the complexities of alternating current and this could have deterred him from working with it, as some of his biographers have argued. Yet he did have an aptitude for mathematics and the alternating current technology of the 1880s was far from scientifically complex. Moreover, his laboratory had all the apparatus and trained staff to develop alternating current equipment. Kennelly, for example, was a highly competent electrical engineer who went on to teach the subject and make several important contributions to high voltage technology.

The tempo of research into alternating current at the West Orange laboratory quickened as the competition with Westinghouse grew more intense. In 1889 the Edison franchisees were calling out for the technology to meet the threat from Westinghouse and Edison was told that "the call for some sort of direct current transformer is getting louder and louder every day."[52] Later that year the annual meeting of the Edison utility companies ended with an appeal for a high voltage system. The development of a high voltage direct current system (the municipal system) was underway at the laboratory at this time and Edison was reported to be "not only willing but anxious that something should be done as to an arc light as well as an alternating current system."[53] (Illus 5-4, the Edison municipal system, 18.100, #6611) The laboratory was carrying out its appointed mission to provide the new technology needed by the Edison electric utility companies.

Both Edison and the parent company promised the franchisees that high voltage a/c and d/c systems would be available to them by the end of 1889. This development program was plagued with delays caused by poor liaison between the different parts of the Edison lighting empire. At the very time when the "battle of the systems" reached a climax, the whole structure of organization was radically changed. The highly competitive environment that had helped create the "battle of the systems" also led to changes in the structure of the electrical industry. The many companies formed by Edison to exploit his inventions were gradually consolidated into larger business organizations that were better equipped to compete. The formation of Edison General Electric (EGE) in 1889 amalgamated the Edison Electric Light Company with the various manufacturing companies. It was done with an eye on Westinghouse. Edward H. Johnson believed that at last the Edison enterprise had the financial strength to meet the competitive challenge and excitedly predicted "goodbye Westinghouse!"[54]

The leadership of the new company was conservative and determined to control rising costs. One advantage of consolidating several Edison companies into one large

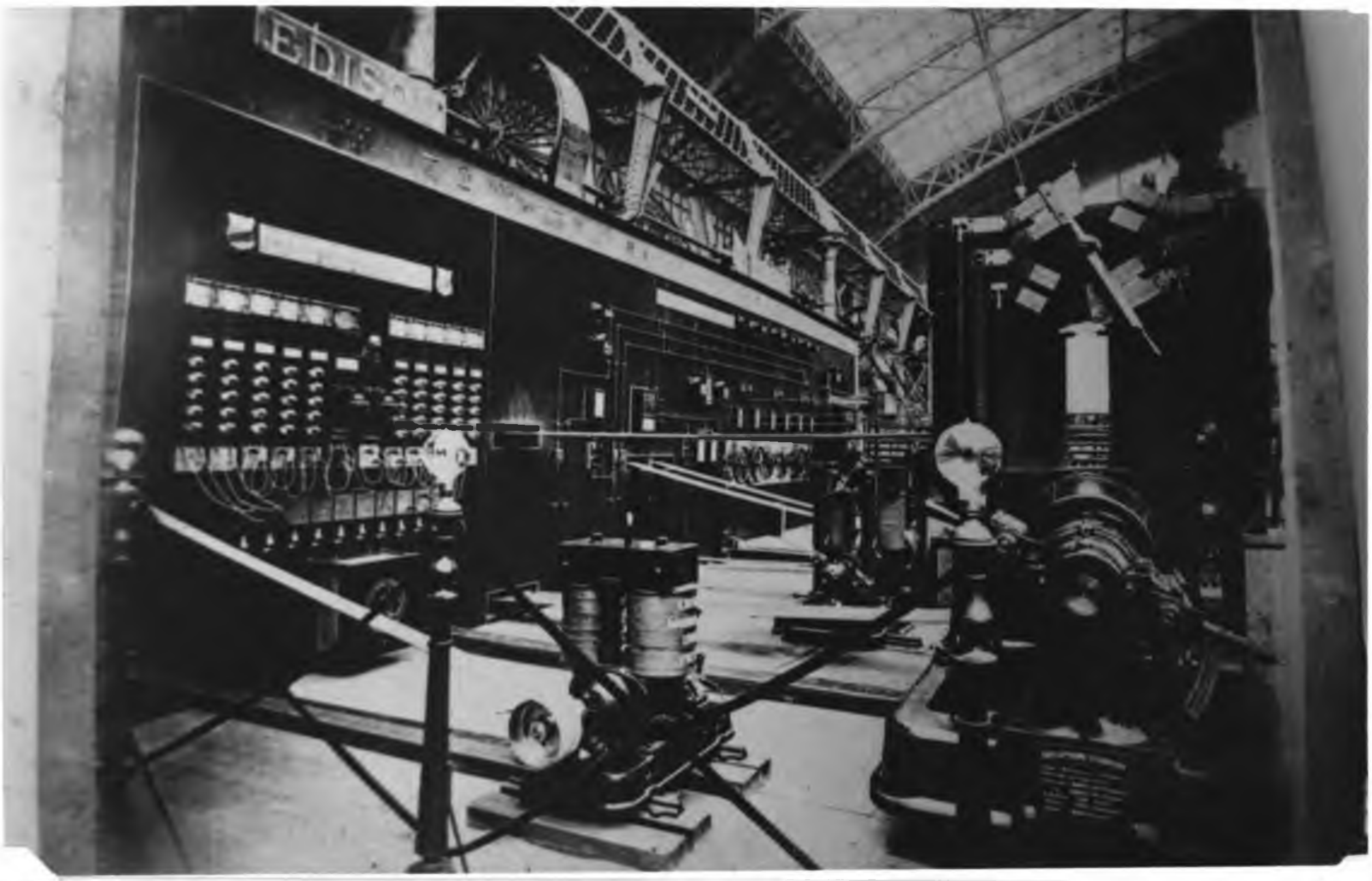


Illustration 5-4

The Edison Municipal System

organization was better control of expenditure. The management of Edison General Electric quickly moved to reduce costs, including the costs of research and development. EGE was now the major contractor for the services of the laboratory. (See Sidebar) Research was to be carried out under contract and bills had to be presented promptly for payment. The company reserved the right to dispute bills and refuse to pay for research they had not commissioned. The "leadened collar" was being pulled tighter and Edison came to the conclusion that the financial and technological conservatism of EGE cramped his inventive style.

Edison's growing dissatisfaction with the management of EGE was centered on their inability, or refusal, to introduce his improved technology of the second generation of electric lighting. He noted caustically in 1890 that the "gen(era)l company" (EGE) asked for a system that could compete with Westinghouse "in our small town business," but they did not employ his 5-wire system because "they were unwilling--although the system was a success--to enter into the competition when using so many wires."[56] Edison criticized the company for not energetically introducing his high voltage direct current system. They were afraid of the hazards of high voltage currents and thought it was too risky to introduce it to the utility companies. When EGE finally offered an a/c high voltage system to its franchisees, it did so with a caveat that the technology was "dangerous and inefficient at best, but procurable on demand."[57] The management of EGE shared some of Edison's fears about the dangers of high voltage technology, but as businessmen they had to have it available if their customers wanted it.

The delays in the production of this equipment have reinforced the view that Edison and his laboratory did not have the inclination or ability to work with high voltage technology. Harold Passer, the great historian of the electrical industry, concluded: "In 1879, Edison was a brave and courageous inventor, in 1889 he was a cautious and conservative defender of the status quo."[58] Edison's emphasis on practicality and profit obviously swayed him towards the high voltage direct current solution, but this did not stop him from exploring all avenues of long distance distribution. The goal of the West Orange laboratory's work in electricity was to perfect and cheapen the system, and this involved solving the long distance transmission problem, but by 1889 Edison no longer had the freedom of action to be the courageous and pioneering inventor he had been in 1879. The manufacture, installation, and maintenance of the system was in other hands: Edison and his laboratory now carried out research commissioned, and controlled, by the managers of the Edison companies.

In 1887 the West Orange laboratory had been the focal point of Edison's electrical empire. He had the power to decide on experimental projects and to suppress technologies that he did not like, such as the ZBD a/c system. Two years later the laboratory was just one part of a large organization and much of its electrical work was done as commissioned experiments: Edison no longer had the power to set the direction of R&D for the companies that bore his name. They did not want to bear the costs of a major assault on the long distance transmission problem and Edison knew this. He thrived on competition and probably would have given his all in the fight against Westinghouse if he had the full resources EGE behind him. But this he did not have. The "leadened collar" of EGE prevented Edison from fully committing his laboratory to the "battle of the systems."

The new business organizations in the electrical industry wanted to control the pace and direction of R&D. The engineers and scientists they hired were tools of corporate policy who had to follow orders. [59] The Edison companies were a little wary of the great independent laboratory in their midst. Edison had enormous prestige in the organization, but his goals--especially his technological preferences--were not necessarily those of the organization. The formation of Edison General Electric was the first step in a gradual consolidation of the electrical industry that reflected a general trend in American business. This was the era of "big business" and the "trust." The intense competition in the electrical industry was not good for profits. The policies of managers and financiers in the industry were aimed at replacing competition with agreements and pre-monopoly practices such as price fixing and patent pools. Edison was opposed to this movement because he believed that technological leadership was the way to dominate markets and make money. He had to be motivated by technological competition arguing that "I can only invent under a powerful incentive. No competition means no invention."[59] Once the industry and its technology had matured, Edison and the electrical companies had to go their different ways.

SIDEBAR 5-1

THE INSULATION PROJECT

The development of better insulating material illustrates the problems emerging between laboratory and electrical companies. Insulation of the copper wires conducting the electricity was an unglamorous, but vital part of the system--its performance under difficult operating conditions helped determine the reliability and economy of the system. Edison had chosen to place the distribution system underground, and although this greatly reduced the risk of accident, it increased costs and made a vital part of the system vulnerable to the action of corrosion and decay.

The first electrical wires went uninsulated; they were simply attached to wooden carriers or even to gas fittings! The underground mains of the Pearl Street system employed an asphalt-linseed oil-paraffin wax-beeswax compound. This was pumped into a metal pipe containing the rope-covered copper conductors. Conductors inside houses and offices were covered with either paper, cotton, shellac, rosin, or parafin wax.[1] The electrical lighting companies experienced many problems with insulation of wires, both above and below ground, and needed a better insulating material. John Kruesi of the Edison Machine Works commissioned the development work, asking Edison in August 1887 to find an insulation that was waterproof, fire retardant, and flexible. This was no easy task. Edison responded by assuring Kruesi that the problem would be solved in the new West Orange laboratory, which had facilities "to settle anything in a short time." [2]

This search proved to be long and difficult. Numerous materials were tried but few could successfully fit all three criteria. The longer the search for a better insulation went on, the more it stressed the working relationship between laboratory and Machine Works. Edison owned 90% of the stock of the Edison Machine Works, but his friend and associate, Samuel Insull, had to insist on prompt and accurate billing for experiments carried out by the laboratory. Insull knew all the "old man's" financial ploys, having devised many of them while he was Edison's secretary. He knew that the accounting techniques used at West Orange favored Edison, and that the longer the delay in billing, the more likelihood of Edison adding other (non-related) experiments to the bill. Insull complained about the high prices used in billing, which were about twice the normal cost for materials, and commented that "some of the charges are simply outrageous." [3] In order to reduce the costs to the Machine Works, Insull asked the lab to return all scrap to the Works. He also insisted on bills being presented promptly and at regular periods, and argued that no other concern in the United States would "dare" to do business in this manner. [4]

The development of new insulation involved close cooperation between the lab and the Machine Works. Once a new material was developed in the lab, it was coated onto wires at the Works and then tested under operational conditions. The results then had to be sent to the lab for another round of experimentation. The Works wanted this project finished in the shortest possible time, but the laboratory did not share this concern for haste and there were many delays.

The frustration of the Works is evident in Insull's complaint to Edison: "we have spent a great deal of money on experimental work on insulation and we ought to be getting some result out of it."[5] The essence of the problem was that there was no union of interest between the lab and the Works. The former acted like an independent laboratory despite efforts to produce a more "businesslike" approach to contract research. As Edison's laboratory it was not going to be dictated to by a group of Works engineers and ignorant businessmen.

NOTES

1) Vanderbilt, Edison the Chemist, pp. 78-81.

2) J Kruesi to TAE, 24 Aug 1887, Kruesi Collection, E 6192

3) Insull to Tate, 5 July 1888, 1888 Electricity.

4) Insull to Tate, 28 June 1888, ibid.

5) Insull to TAE, 2 May 1888, ibid.

SIDEBAR 5-2

EDISON'S FINANCES AND THE ELECTRICAL INDUSTRY

Although the experimental facilities at West Orange were second to none, the accounting system left much to be desired. Edison's low opinion of the profession of accounting has become part of his myth, but he was very interested in calculating and recording the exact costs of R&D. He was less concerned with the formalities of bookkeeping--statements and billing.[1] Edison developed his method of costing and billing for experiments while he was at Newark. The procedure was to enter into a contract for experimental services, carry out experiments, cost them, and finally bill them to the appropriate company. The costing and billing normally took place well after Edison had carried out the experiments. The practice of Edison's bookkeepers was to make up a list of all experiments carried out over a fixed time period, and then Edison, or an assistant, would indicate to whom the experiment should be billed. This practice suited Edison's freewheeling style of invention and reflected the bookkeeping heritage brought with him from Newark and Menlo Park.

Edison preferrred experimenting to accounting and often left the task of covering all the experimental costs of the lab until money was badly needed. Then he would sit down with his secretary and go through shop orders, deciding who should be billed for experimental work. The lab still billed well after the experiments had been done, and sometimes supplementary bills would be made up at the end of the accounting year. In this case, the unfortunate customer would suddenly be presented with a very large bill for experiments done many months, or years, before!

The key to financing the laboratory was to overcharge regular customers and use the surplus to pay for general experimenting. Edison's customers often complained about the high price of R&D carried out by the West Orange laboratory. The companies who hired the lab's services were often charged the full price of supplies and equipment that had a long potential life at the laboratory. Edison often used the companies' money for research in his own interests. Edison's chronic lack of cash in the early years of the lab made him exploit every opportunity to bill now and pay later. He certainly was not a poor man, but he resisted liquidating his investments in electrical companies and railroad bonds to pay the daily expenses of the lab, preferring to extract all the cash he could from contract research.

In the "old days" at Newark and Menlo Park, the costs of R&D were determined by experimenters and analysed by venture capitalists. But by the time the West Orange laboratory was in operation, the astounding growth of the electrical industry had created better organized business units; the costs and benefits of research were now being studied by accountants and business managers. Mindful of the escalating costs of research, these men wanted more information about costs, and prompt billing.

The means to bring order to Edison's billing practices was evident in the headquarters of the Electric Light Company; they would place the laboratory within the bureaucratic structure and control it with paper. In 1888 Edison proposed that the Edison Electric Light Company pay him a weekly stipend to cover the costs of experiments done on their behalf before a formal bill could be prepared. This was, no doubt, precipitated by Edison's serious cash flow problems at the lab, but the Electric Light Company had no intention of giving Edison carte blanche to carry out research. They put so many conditions on weekly payments that Edison gave up in disgust and swore that he would never ask the company for any more money to support the laboratory.[2] He didn't mean this. He needed the company and they needed him.

A strong bond existed between the electrical companies and the West Orange laboratory, which had a symbiotic relationship with the rest of the organization. The various Edison companies had installed their own men at the lab to carry out testing or research into their products. The Edison Lamp Company, for example, paid the salaries of the team who tested incandescent lamps in Building 1, and the Edison Machine Works paid the wages of some of the experimenters working on insulation. As a repository of technical information and experience, the lab served all parts of the electrical empire. Free advice and consulting was dispensed to both Edison

Electric Light Company and humble local lighting company. Company and laboratory were bonded togther by Edison's patents and the potential of his laboratory to produce revolutionary new technology.

In 1888 an attempt was made to rationalize all engineering work in the creation of a Standardization Bureau. The Bureau was soon given more control over the West Orange Laboratory's work. In the beginning of 1889 an agreement was reached between the lab and the Electric Light Company which gave the Bureau the right to approve all bills rendered by the lab for experimental work. The lab had to present a bill during the first ten days of the month following the month when the research was contracted or approval was not to be given. In reminding the Edison laboratory of their obligations, W.J. Jencks, the director of the Bureau, noted that "we are also doing this work under the limitation of expense; and in order to know how much further we can go in this matter, it is necessary to get your bills to date."[3]

The development of a more formal relationship between laboratory and companies deprived the latter of many services that had once come free. The lab still carried out consulting and advising to these companies, yet it was extremely expensive to send a valuable experimenter to work in the field and Edison soon tried to avoid this. He noted later that he was unable to recover these costs from the individual lighting companies. The practice of placing company men at the laboratory appears to have died out by 1890.

The formation of EGE in 1889 drastically changed Edison's finances. The rush to establish electric utility companies had produced a buoyant market for electrical goods and his manufacturing shops enjoyed rapid growth and impressive profits, returning 18% on the initial investment in 1888. Edison had invested these profits, and much of his personal fortune, in the laboratory and did not have the capital to support the expansion of manufacturing facilities. When Henry Villard approached Edison with his idea to incorporate manufacturing shops into a larger organization (EGE), Edison agreed, thinking that "it was better to be safe than sorry."[4] The sale of these interests to Villard brought Edison badly needed funds and relieved him of the burden of financing the growth of the electrical manufacturing industry, yet it cost him a considerable part of his income because these profitable operations were now part of EGE. Furthermore, the shops were important customers for the laboratory and now Edison became dependent on EGE for a large part of his research business.

NOTES

1) Tate Open Door, pp. 141-142.

2) Edison annotation on Johnson to TAE, 21 Feb 1889, electricity.

3) W.J. Jencks to Lab, 10 July 1889, electricity.

4) Meadowcroft, fol 3, 52.

NOTES FOR CHAPTER FIVE.

1) C.E. Chinnock to TAE, 17 April 1888, Electric light.

2) 1889 EGE prospectus.

3) Meadowcroft box #84, 10 May 1895.

4) 1889 Electric Light, EGE.

5) F. Upton to TAE, 26 April 1889, Elec Light.

6) J.H. Vail to Edison, 28 Dec 1886, Electricity.

7) Lab notebook N 880001.

8) E.H. Johnson to TAE 10 June 1889, Electricity, says "the board considers you the umpire in all such matters."

9) N 880315.2.

10) TAE to Lamp Works, 18 June 1890, Elec Light.

11) F. Upton to TAE, 20 April 1889, Elec Light.

12) Edison memo to Villard 23 March 1889, Villard collection, Harvard Business School, MS 78, box 63.

13) Explanation of Experiments, 14 May 1890, Lab experiments.

14) Edison Electric Illuminating Co. of New York, Annual report 1886, Electricity.

15) Explanation of Experiments, 14 May 1890, Lab experiments.

16) W.J. Jencks to TAE, 12 May 1888, Electricity, Edison Electric Light Company (EELCo).

17) The Pearl Street operation provides us with the first examples of disputes between a utility company and its customers, see Francis Jehl, <u>Menlo Park Reminscences</u> (Dearborn, Mich.: Edison Institute, 1941), III, 1085-1086.

18) EGE to TAE, 11 Dec 1890, Electricity, EGE.

19) In 1900 Edison received patents on several meter designs, including balance-beam, electromagmetic, and electrochemical. Electric Light-Meter.

20) 1887 Electricity, general.

21) The work on the municipal lamp had begun in 1886, when Edison had his laboratory at the Lamp factory, J.H. Vail to TAE, 22 May 1886, Elec Light.

22) Patent # 369,439 patented 6 Sept 1887.

23) Siemens & Halske Report of November 1886, Elec light.

24) E.H. Johnson Letter, undated 1888 Phono general.

25) TAE to Villard, 24 Feb 1891, Villard papers, HBS, fol 475, 63.

26) A. E. Chandler, The Visible Hand (Cambridge: Harvard Univ Press, 1978), p. 194.

27) S. Insull to TAE, 6 April 1888, 1888, Laboratory Bills.

28) Tate, Open Door, p. 128.

29) Upton to TAE, 1 Aug 1889, Elec Light, filament.

30) R. Fessenden, "The Inventions of R.A. Fessenden" Radio News, 1925, Part VIII.

31) TAE To Villard, 23 March 1889, Villard collection HBS MS 78, box 63.

32) TAE to Villard, 8 Feb 1890, Villard Papers, HBS, fol 473.

34) E.H. Johnson to TAE, 1 June 1889, Electricity.

35) Thomas A Edison, "The Dangers of Electric Lighting," North American Review, LXLIX (Nov, 1889), 625-634.

36) The Electric Lighting Act had placed all public supply in England under the Board of Trade. Each local authority had veto power over lighting projects and the companies were subjected to vigorous regulation of every aspect of their operations. In comparison with the great increase in electricity supply in the United States, England was lagging behind. Many blamed this lag on regulation. See A.J. Millard, A Technological Lag (New York: Garland, 1987).

37) TAE to Insull, 3 May 1888, LB 970929, p. 254.

38) "Plans of the Wizard," newsclipping, in 1891 Electric Railroad folder.

39) Cited in Josephson, p. 346.

40) Advertising material in 1888 Electricity folders.

41) Letter from New Orleans Edison Company, 12 May 1887, 1887 Electric Light.

42) "Confidential Sheet for Agents," 1888 Electric Light; Electrical World, XI (February, 1888), XVII. Advertising materials, 1888 Electric Light.

43) Eaton to TAE, 7 Oct 1889, 1889 Electric Light.

44) TAE to H. Bergh, 13 July 1888, LB 870929, p. 273.

45) Kennelly's record of the battle are to be found in a series of note and letter books called the Kennelly Reports, in letterbook LB 870929, and his evidence to the hearing on the electrocution of William Kemmler, New York State Court of Appeals, 1847-1911, DCCCXCIII (Buffalo, New York, 1890), Vol. 2.

46) Circular letter of H.P. Brown, 1888 Electricity.

47) Kennelly to F.S. Hastings, 25 Feb 1889, Kennelly Reports, 06/07/88, p. 350.

48) Ibid.

49) LB 900412, p. 190.

50) See Kennelly Reports for 1888.

51) Hastings to Kennelly, 20 Nov 1888, 1888 Electricity.

52) Letter of 22 April 1889, 1889 Electricity.

53) Insull to A. Tate, 17 June 1889, 1889 Electricity.

54) Johnson to TAE, 22 August 1888, 1888 E.H. Johnson.

56) "Explanation of Experiments," 1890 Laboratory.

57) Report of Annual Meeting of Edison Illuminating Companies in Electrical World, XIV (Aug, 1889), 136.

58) Harold Passer, The Electrical Manufacturers (Cambridge: Harvard Univeristy Press, 1953), p. 174.

59) "Mr. Edison's reply to Thomson-Houston Memo," 1 April 1889, Villard Papers, MS 78, box 63, 472.

CHAPTER SIX

THE FRESH PULL: DIVERSIFICATION IN THE 1890S

The first anniversary of the laboratory marked a period of intense experimental activity. Edison's ambitious plans had led to an overflow of work, and several important experimental campaigns were in progress by the winter of 1888/1889. The work on long distance transmission systems was sandwiched between the efforts to perfect the phonograph and the development of a magnetic ore separation technology. Edison had told his financial backers, and an expectant public, that the phonograph was "perfected" in 1888. Nothing was further from the truth; while Harold Brown conducted his notorious electrocution experiments in the fall of 1888, Edison was shifting his research effort from electricity to the phonograph. By the end of the year expenditure on phonograph experiments had hit a peak as great efforts were made by the laboratory staff to eliminate the "bugs" in the machine.[1]

With his time fully occupied at the laboratory, Edison let Edison General Electric determine the pace of alternating current development. The new formal relationship between Company and laboratory aggravated the logistical problems of producing new designs at West Orange, supervising the work from Company headquarters in New York, and testing the equipment at the Schenectady machine works. Edison was trying to do too many things at once and his work suffered from the usual delays. His eagerness to design a new a/c high voltage system played a part in delaying its production because all other work on it was stopped while the "old man" finished the drawings.[2]

The problems of coordinating the research effort at West Orange and the manufacturing at Schenectady proved the wisdom of setting up Edison's own manufacturing facilities next to his laboratory. All the projects which involved cooperation between the laboratory and machine works suffered from long delays. Even the high voltage municipal lamp, an invention which Edison favored and one which he had repeatedly promised to the utilities, was not delivered on time.[3] The Edison General Electric Company was unconcerned with the delays in developing high voltage technology because it wanted to avoid expensive investments in new systems, especially those which made existing inventory obsolete. The impending union with Thomson-Houston removed the need to bring out an a/c system because Thomson-Houston already had a proven one on the market. Amalgamation and agreement had replaced competition and strife in the electrical industry.

When Edison General Electric finally prepared to introduce an alternating current system in 1890, Insull advised Edison that they should withdraw from the "battle of the systems" before this was done.[4] Although development work on this system was carried out at the West Orange laboratory and a small test installation made, it was never formally introduced by EGE. For his part, Edison was still ready to develop the new technology needed to meet the competition. In the beginning of 1889, he thought the phonograph campaign was coming to an end and told his associates that as soon as he finished with the phonograph he would take a "fresh pull" at electricity.[5]

The new campaign in electricity was hampered by several new developments at the laboratory: more problems with the phonograph, the beginning of motion picture experiments, and a realization that ore separation might bring fabulous profits. Edison's fascination with ore milling began to dominate his affairs in 1889 as he shifted his attention and money to ore separation experiments. The laboratory was carrying over 70 experimental projects on its books at this point and the "old man's" time was spread thinly over many different experiments. His secretary thought that Edison had taken on too much: "I often have wondered if Edison might not have accomplished more if he had attempted less." [6]

In the middle of the crowded summer of 1889 Edison left the laboratory for Europe. He had promised his wife a European vacation and he also planned to visit the Paris Exposition where he had a large display. That he should take a trip to Europe in the middle of several important experimental projects is a measure of his confidence in his staff. The phonograph, alternating current, and ore milling experiments had all reached critical points. While Edison was feted in Europe his laboratory staff strived to bring these projects to successful conclusions. Edison had set up a management system at his West Orange laboratory and his departure in the middle of 1889 was a real test of its efficiency and stability. One of the office staff noted that everything went on in a "hum drum kind of way" while the "old man" was absent, each experimenter with his allotted task and Edison's lieutenants sending regular reports to the boss.[7] Although it needed Edison's mercurial presence to galvanize the lab into action, the facility could, and did, function successfully without him.

Charles Batchelor was in charge of the lab in Edison's absence. He supervised research, made all the business decisions, and managed the Edison Phonograph Works. Batchelor personified the duality of manager and experimenter that Edison required from his chief lieutenants. He took an active part in experiments on ore milling, phonographs, and kinetoscopes, working on them simultaneously as his notebooks show. He supervised the experimenters at work in Building 5 on various aspects of the phonograph. Their goal was to put an improved model into mass production by the beginning of the Christmas sales season. Batchelor reported to Edison that progress was being made on the toy doll and long playing phonograph. He assured Edison that production of wax cylinders was underway at a new building in the Phonograph Works. The manufacture of primary batteries was also going very well, and Batchelor had plans to sell the surplus to outside customers. [8]

In Building 1, Arthur Kennelly led the development work on an alternating current machine and the high voltage municipal system. Both were eagerly awaited by the Edison Machine Works and the utility companies. Work continued on the Edison traction system with Batchelor supervising experiments on a car brake and motor. Reginald Fessenden directed a team of experimenters in the chemical lab (Building 2) in the search for a better insulation material for electric wires. Finally, W.K.L. Dickson supervised research into magnetic separation in Building 4 in which he had installed several ore separators.

Dickson divided his time between Building 4 and the photographic room in the main laboratory building where he carried out the historic development of the motion picture camera. With Edison in Paris, he persuaded Batchelor to erect a new building designed for the motion picture work and a two-storey photographic studio was quickly erected adjacent to Building 4. This was one of many new structures added to the laboratory complex. The lean-tos, shacks, and other temporary buildings, each designed to suit an experimental project, formed a congested "suburb" around the laboratory.[9]

Europe's technological elite met at Paris, in the shadow of the newly constructed Eiffel Tower, to celebrate the wonders of industrial technology. The Paris Exposition was a tribute to the technological advancements of the Second Industrial Revolution, its Eiffel Tower a symbol of the confidence and power of the machine age.

The exhibit for the Paris Exposition was a major project for the laboratory. Work began in December 1888 on the design of the display and construction was done in the machine shops and Phonograph Works. It was then crated up and shipped to Europe, accompanied by some of Edison's laboratory staff under the leadership of William Hammer who had successfully installed Edison displays at previous exhibitions. Edison's electricity display was one of the centerpieces of the exhibition. It featured thousands of electric light bulbs, a complete electric power station, and numerous electric signs and displays. The Edison exhibit at the Paris Exposition illustrated the wide range of experimental activities carried out in his laboratory at West Orange, and it took up a whole acre of fair grounds. (Illus 6-1, Edison exhibit at Paris Exhibition, 18.100 # 6612.) In addition to the electrical, phonograph, and ore milling displays, Edison showed many different types of telegraph apparatus and some unique inventions like the Edison-Sims torpedo and the pyro-magnetic generator.[10]

Edison's enthusiastic reception in Paris underlined his international status as a great inventor. A constant flow of visitors arrived at his suite in the Hotel du Rhin. He was honored by many professional and scientific groups, and throughout his trip was able to gather information that had relevance to the work being done at West Orange. The French Academy of Sciences gave him a warm welcome and such was Edison's delight at this reception that he promised them all

Illustration 6-1

Edison Exhibit at Paris Exposition

phonographs! Wherever he went, Edison exchanged information with the European scientific community and often got an opportunity to see the latest advances in important technologies. At a dinner to honor the fiftieth anniversary of Daguerre, he talked with Etienne Marey who had considerable experience in photographing motion. Edison's visit to Marey's laboratory in Paris was an turning point in the development of motion pictures.[11] (See kinetoscope section.)

Edison made several business deals while in Europe, notably the purchase of the Lalande battery rights which provided his phonograph with a reliable source of electricity and was the beginning of an important business for him. The collection of scientific information from all parts of the world was the foundation of Edison's method of innovation at West Orange. The 1889 exhibition had attracted many companies to Paris and no doubt Edison gathered information on the competition as assiduously as he collected foreign technical journals.

His business activities during this trip illustrate the international nature of the Edison enterprise. The incandescent bulb had achieved successful diffusion throughout Europe and many countries had Edison lighting systems in operation. Edison visited some of the leading central stations in Europe and was given a tour of the great Siemens Works in Berlin where Edison lighting equipment was made. There was a strong link between Edison's work in the United States and the development of electrical technology in Germany. Edison had hired many German scientists and engineers, some of whom had gone on, like Johann Schuckert and Sigmund Bergmann, to build electrical manufacturing concerns in Germany. Edison had many friends and business connections in central Europe and used these to monitor the development of new technology. The German industrial laboratories, supported by the best technical education system in the world, were responsible for many important advances in electrical technology and it was Edison's policy to keep abreast of their work, exchanging information and new ideas for electrical equipment, especially in the area of incandescent lamps.

Edison also took time to promote his phonograph, which was a very popular part of the Edison exhibit at Paris, drawing the largest number of visitors after the Eiffel Tower. Foreign interest in his machine was at a high point and several companies had been created to sell the phonograph in Europe. Payments for the right to be agents for Edison phonographs and orders for machines made European customers the largest market for machines in the early 1890's. The English phonograph business was in the hands of George Gouraud who had been an agent for Edison in the 1870s. Gouraud's order for 1000 machines was the largest single order placed for phonographs at the West Orange Works.

Edison's strategy for foreign markets had always been to quickly sell the marketing rights to groups of foreign investors. He made the machine and then exported it to the marketing organization overseas. In the case of the electric light, the original generating equipment for the first European installations had been part of the Edison exhibit at the Paris exhibition of 1881. In a new strategy to control manufacture, Edison considered setting up plants in Europe, making his enterprise truly multinational. He planned to acquire a factory in Belgium to make his toy doll and use this facility as the base to distribute dolls on the Continent.[12] This project was never realized, but in later years he made agreements with his friend Bergmann to manufacture Edison storage batteries in Europe. Edison's motion picture and phonograph businesses were also multinational with the international interchange of money, machines, records, and talent. Many Edison movies and records were made in Europe and then exported to the United States. The West Orange laboratory was at the center of an international business enterprise in the 1890s.

THE LABORATORY IN THE 1890S

On his return to West Orange, Edison was greeted with good news about the experiments in hand: Dickson had made significant progress with the kinetoscope, and the pilot ore separation plants showed promising results. Progress in the phonograph experiments came at a good time; Edison returned from Europe impressed by the appeal of his phonograph and eager to perfect it. He had seen enough evidence to think that this product had a commercial future. The input from the North American Phonograph Company reinforced his decision to develop a smaller machine with better reproduction. Edison had also committed his laboratory to an experimental project to duplicate prerecorded cylinders--the vital part of an amusement phonograph business. In the meantime the business of selling phonographs as business machines was declining rapidly. The great problem facing Edison was paying for all his experimental projects. The 1890s were years of financial hardship for his enterprise. The long campaign to perfect the phonograph had almost exhausted his financial resources and there was little hope that more money could be raised in Lippincott's North American Company.

Edison's stake in the phonograph was a large one, larger than Lippincott's he would later claim, and he was bound to several expensive experimental projects. By his own estimation, he had invested $540,000 into the phonograph business by 1891. The North American company marketed both Edison's phonograph and Tainter's graphophone. Edison thought that his machine was better built than the graphophone and he knew it was more popular with the customers. Unhappy that the graphophone interests received a royalty on every phonograph sold, Edison soon began to feel that he got the worse part of the bargain. The financial weakness of the North American Phonograph Company meant that it could not support all the R&D effort carried out on the phonograph at the lab. It was, he felt, only a matter of time before the phonograph became a major product like the electric light and he had no intention of sharing this gold mine with the graphophone interest. He therefore began to manoeuvre himself away from the Lippincott organization while doing the research that would produce a successful product for the amusement market in the future.

In 1890 he instructed the Works to complete all machines ordered under the contract to both the North American and the Toy Phonograph Companies, "leaving nothing in the Works that has not been charged according to contract." Edison ordered the workforce to be cut back by the end of the year; only work on coin-in-the-slot machine and ore milling was to be continued. [13] (Illus 6-2, Men working on phonographs, 29.401, # 5955)

Edison had to conserve his resources. His grand plan for the laboratory was based on the idea of a diversified operation with several research and manufacturing operations running at the same time. Some projects would be practical campaigns, based on identified problems with known goals, and others would be more speculative basic research with no clearly defined objectives. Edison's strategy was to spread his money and experiments over a group of projects and use the profits of one to finance the development of another. Yet in order to finance the manufacturing as well as the R&D on the phonograph and ore separation, Edison had to cut back on some of the more speculative efforts underway. Work was ended on the cotton picker and the hearing aid. The pyro-magnetic generator was abandoned. Edison still maintained long-term speculative experiments for his own personal interest; including experiments in etheric force and other electromagnetic phenomena that had been suggested by his study of the "Edison Effect." Yet these type of experiments became rarer as the 1890s progressed; there was no longer the time or money to find a substitute for ivory, rubber, silk, or mother of pearl.[14]

The Edison enterprise began the 1890s on the foundation of three main businesses: phonographs, ore separation, and electrical products. The research effort was concentrated into these three basic areas, as Table 1 illustrates:

TABLE ONE

West Orange Laboratory 1890.

Estimated Cost of Experiments

BILLED TO

Edison General Electric	$17,045
Edison & Villard	$19,225
Phonograph Companies	$20,984
Ore Milling Companies	$21,465

Electrical experiments accounted for the largest expenditures on research. EGE commissioned many experimental projects in electricity, and Edison and Villard supported the costs of the remainder. The newly-installed management of EGE began on a cautious note, looking very carefully into the costs of experiments before they committed themselves to research at West Orange. The new company had gathered an impressive range of patents and now they had the power to choose from several different technological solutions to the same problem. Such was the case with electric traction. See Sidebar 6-1, ELECTRIC TRACTION AT THE LABORATORY

The ties between the West Orange laboratory and the electrical industry were not broken in the 1890s, in fact they grew even stronger. A new contract was made in 1890 in which EGE supported the costs of half of Edison's experimental time for the next five years. Three quarters of the laboratory's work time was to be devoted to electrical development and the company agreed to bear the expenses of this work up to a weekly limit of $1200. The annual report of EGE justified this expense by pointing out the great value of Edison's experiments on reducing the costs of incandescent lamps. It concluded: "in view of the value of Mr Edison's services, the Company has a new contract with him, under which he devotes a greater part of his services to the Company."[15]

The new contract stipulated that "the facilities of his (Edison's) laboratory are at the disposal of the company." The lab carried out work under contract for EGE on alternating current equipment, transformers, meters, motors, testing instruments, and arc lights. The most important work done for EGE at the laboratory was on the incandescent bulb. The court's decision of 1889 had confirmed Edison as the inventor of the electric light and Edison General Electric wanted the world to know that they had his patents and genius at their disposal. Edison's room 12 on the second floor of the laboratory was fitted out to work on filaments and nearby were the glassblower's room and the vacuum pump room which took their power from the overhead shaft running from the precision machine shop. His special expertise in the manufacture of incandescent lamps was a valuable asset to the company. In 1891 and 1892 he was called in to reorganize production at the Lamp Works, spending more than 500 hours getting the Works "out of the difficulties caused by failure of the employees to do their duties." [16]

The laboratory remained an important resource for the local Edison lighting companies who were pursuing a policy of expansion in the 1890s. Much of the planning for these larger systems was done by Edison's staff at West Orange, and in some cases Edison himself worked on designing larger central stations and distribution systems. The Chicago Edison system, under the direction of F.S. Gorton, quickly ran out of capacity to meet demand and Gorton was impatient to extend service. Edison and Kennelly devised a distribution system for all of Chicago, employing high voltage direct current and the municipal lamp which operated on 200 volts. Edison wrote to Gorton: "We...are planning for the future so that what we do put in will match the extended system 10 years from now."[17]

Although Edison could hardly have been pleased that his name was dropped from General Electric when it was formed in 1892, he did not sever relations with the company, as some have claimed. His secretary, Tate, stressed Edison's annoyance at the loss of his name from the industry he created, but the inventor was probably more upset at the high valuation put on the assets of Thomson-Houston in the terms of the amalgamation.

As expected, Henry Villard had watered the stock of the smaller Thomson-Houston Company to bring it up to par with that of EGE before the consolidation.[18] The formation of GE is often interpreted as a watershed in Edison's association with electricity. The press saw it as the "trust" versus the lone inventor, with the latter "frozen out" of the industry he had created.[19] Yet Edison had no reason to maintain an interest in electrical supply and manufacture. His whole purpose in founding the West Orange laboratory was to be able to move out of highly competitive markets into more profitable areas. Edison wanted to make money by innovating and saw few prospects in the reorganized electrical industry; it was too big and too competitive.

Whatever the personal differences between inventor and company, and precarious financial situation of GE, the Company paid handsomely for Edison's time in connection with lamp research and manufacture. Edison's laboratory was fitted into GE's corporate strategies. The search for the cheap, high performance electric lamp did not die in 1892 but went on with more financial support than ever. Over the five years from 1890 to 1895 EGE, and its successor GE, paid the laboratory over $121,000 for its work on improving and developing electrical equipment. This work formed the largest single project for the Edison laboratory in the early 1890s.[20]

The formation of General Electric in 1892 did not bring an end to the R&D on alternating currents at the lab, where work continued on transformers, alternators, rotary converters, rectifiers, and a/c meters. Despite the estrangement over the formation of General Electric, the electrical industry maintained its position as the single largest customer of the laboratory. In terms of the money spent on research, the West Orange laboratory was still primarily an electrical laboratory in the 1890s. Electricity was the important thread that ran through all the experimental projects--electromedicine, phonograph, kinetoscope, and ore milling. Of all the electrical technology that passed over the experimental tables at West Orange, Edison chose to develop the small electric motor, beginning on the design of a 1/2 h.p. motor. The electric motor played the major role in Edison's conception of a commercial electrical supply system, providing the profits that were not in lighting. The history of the utility industry in the 1890s proved him right: the motor load was responsible for improving the load factors of central stations and saved many from extinction.

The West Orange laboratory had attended to the design of all sizes of electric motors, from the large traction models in streetcars to the smaller motors used to power consumer durables. Edison had little success with traction motors and he could not afford the costs of developing such large-scale electrical systems. Only the fully-integrated "trusts," like General Electric could manage that. The small motor, on the other hand, was cheap and easy to produce and had a wide array of uses: this was the kind of electrical technology that Edison wanted to develop. The fan motor was the first of a long line of motorized products to be manufactured at the West Orange complex. Edison set up the Edison Manufacturing Company to manufacture his electric fan kit and it later added a line of electromedical equipment. These two products were the result of the West Orange laboratory's work in electricity, offering a vivid contrast to the products that were developed at Menlo Park.

While the daily work of the laboratory was dominated by electricity, Edison's personal attention was directed to the ore milling project on which his own personal fortune rode; he claimed to have put every cent he had in it. When shortages of money brought work at the mines to a halt, Edison returned to the laboratory to generate more funds in the electrical, phonograph or kinetoscope work: "I have no money...but am back in the lab making it" was the policy of diversification at work in the 1890s.[21] Edison was confident that he could quickly turn experiments at the laboratory into ready cash, picking the most promising, perfecting it, and then selling it quickly. The Phonograph Works gave him independence from venture capitalists and provided the means to generate income from manufacturing. In this way it could support the costs of long-term experimental projects that offered profits in the future, in addition to covering the ruinous expenses of "pioneering" a major project like ore milling.

SIDEBAR:ELECTRIC TRACTION.

The first commercial traction system was the work of Frank Sprague, an ex-Edison employee who successfully engineered the pilot system at Richmond, Virginia. He had formed a company with E.H. Johnson to promote his electric motors which were also used to power elevators. Edison had his own motors and he was most upset at Johnson's support of Sprague, which he considered treachery. EGE acquired the Sprague company and developed his overhead pickup system, while Edison concentrated on the use of a third rail to deliver the current to the cars. EGE were reluctant to support two competing traction systems and therefore Edison turned to Henry Villard for financial support. They embarked on an ambitious project to develop a direct current traction scheme and built a test track that went from the West Orange laboratory to the street car line running along Main Street. The track was about a quarter of a mile long and dotted with transformers which reduced the 1000 volt transmission to a safe 20 volts for the live third rail.[1] The problems with using such low voltage was to ensure a clean pickup from the third rail and obtain sufficient torque from the motors. The experimental results were not promising because mud or moisture on the pickups could easily cut off the power. Edison worked through 1890 on this problem without achieving success and finally shelved the project.[2]

Ironically, the policy of R&D for hire led to the laboratory improving the Sprague motor for EGE while experiments were being undertaken to produce a competing Edison system! The Sprague street car motor had been the starting point of Edison's researches into a new motor. Its unique construction put the motor on the driving axle of the vehicle, and used gearing to keep the armature far away from the motor. This design was compact and resistant to the dust and dirt that was the bane of the traction motor designer. [3] From 1889 to 1890 the laboratory examined and improved the Sprague motor under contract to EGE, altering the design and revising the method of its manufacture. This work also had spill-overs in general dynamo construction and manufacture. [4] EGE even took up Edison's diverse research into traction after he had given up on his low voltage system. They signed a new accord in 1890. Traction motors were designed at the laboratory and then built at the Schenectady Machine Works which had the large scale facilities to work on this technology, including an indoor test track. Edison and Kennelly often travelled to Schenectady to work on traction and high voltage distribution systems. [5]

TRACTION NOTES.

1) Electrical World, Jan 1892, XLX, p. 2;

2) Orange Chronicle, Nov & Dec 1889, May 1890, 1889 electric railroad.

3) Percy Dunsheath, A History of Electrical Power Engineering (Cambridge: MIT, 1962), p. 184.

4) LB 041289, p193, 25 April 1890.

5) B.E. Morrow to C. Wilson, 13 Mar 1918, TAE inc organization.

EDISON'S FOLLY:THE ORE MILLING VENTURE

The appeal of ore milling to Edison was its profit. He prided himself of the practicality of his innovations and in 1892 he claimed that ore milling was the most "commercial" thing he had ever done. The magnetic separation of ores had been one of the many experimental programs undertaken by the lab in its first decade. By 1889 Edison realized that it had the potential to become a revolutionary technology that could transform the production of iron and steel, one of America's major industries. What started as one more promising experimental result turned into a massive effort to reorient the slow westward shift of the iron and steel industry and revitalize Eastern blast furnaces, which were in steady decline because of the exhaustion of iron ores in the Northeastern corridor. Shortage of ore had forced iron masters to import iron ore from Cuba and Spain. New Jersey still had large deposits of low grade ore, and Edison thought his separating machines could make a paying proposition out of these dead mines, reversing the westward migration of steel mills and giving him a profitable monopoly of a major source of ore. His ore milling company would be his "Standard Oil"--a large, highly efficient operation with few competitors and incredible profits. At the height of the project he envisaged running 8 large mills in New Jersey with a total yearly output of over

$10,000,000 worth of ore, bringing an annual profit of $3,000,000.[22]

New Jersey's iron making industry had begun in colonial times, when the large deposits of magnetite iron ore in the north of the state attracted miners.[23] Edison's experiments in magnetic separation of ores had been started at Menlo Park and this led to Edison's first patents in this technology in 1880. His basic idea was to use a powerful electromagnet to pull iron particles from a falling stream of ore. It was simple and inexpensive and it appealed to him. Experiments continued at the Harrison lab and the new metallurgical building set up at West Orange. The project developed along familiar lines: research led to the granting of patents, a model separator was constructed, and attempts were made to sell the Edison ore separators to mines. The mine owners were a conservative group and this strategy failed. Edison then moved forward into establishing companies to run mines using his extracting and processing equipment. This was something he had done many times before.

Edison's agents were ordered to scour the country for deposits of iron ore, gold, and other precious metals that could be separated by his process. Ideal sites for magnetic separation were found in the ore mines of New Jersey and Pennsylvania that were exhausted of high grade ore. A pilot plant was established at Bechtelville, Pennsylvania in mid 1889 and from the first operations of this plant Edison was convinced that he could make enormous profits in processing low grade ore. Those close to him noted that he had become "intoxicated" with the profit potential of ore milling.[24] The comparative advantage of a laboratory built for flexibility and speed was that it could move quickly into profitable new ventures as soon as they were identified, and in 1889 Edison shifted his resources into ore milling. The historian Harold Passer's description of Edison as a "conservative defender of the status quo" does not fit his activities during the 1890s; instead we see a courageous inventor and reckless industrialist who went against the conventional wisdom of the iron industry and poured money "like water" into a revolutionary technology.[25]

Edison was not the only entrepreneur-inventor trying to magnetically separate iron from low grade ore for there were several other devices in the experimental or pilot project stage. The originality of Edison's idea was the sheer scale in which he intended to extract usable iron out of the ore and his grandiose plan to revolutionize the entire iron and steel industry with it. He argued that mining profits came not from the richness of the ore (the prevailing business strategy of the mining industry), but from the highly efficient processing of great amounts of ore. No one thought that very low grade ore (20% magnetite content of the ore) could be economically processed. Edison believed that the economies of large scale processing could make it a paying proposition. His ore milling technology was striking in its originality; the editors of Iron Age concluded: "he sweeps aside accepted practice in this particular field and attains results not hitherto approached. He pursues methods in ore dressing at which those who are trained may well stand aghast." [26]

Edison could embark on an original technological path because he had the resources of the West Orange complex behind him. Conventional ore crushing and grading equipment was not large enough for Edison's ambitious plans; his ore separation plants were custom built to his own design. He had the greatest laboratory in the world to devise and test new ideas. Nearby was the Phonograph Works that could manufacture the massive ore crushing machines. Edison's plans for magnetic ore separation were based widespread use of electric power and automatic machinery--the ore was not going to touch human hands from extraction to final loading--and the only way he could do this was with his own plant. The specialized equipment was designed and manufactured at West Orange, even down to the telephone communication system which was essential to manage this gigantic operation.[27] Edison planned to use his laboratory to turn iron mining into a high-tech industry, embarrassing the conservative mine owners and taking their profits.

The most promising vein of low-grade magnetite was found at Ogdensburg in northern New Jersey where abandoned mines dotted the sides of the Musconetcong Mountain. In 1889 Edison bought a mine at Ogden and began to equip it with his ore separation machinery. The Bechtelville and Ogden operations were set up as a pilot plants of a technology that would prove its worth to the mining industry in exactly the same way that the Pearl Street central station had shown the viability of the Edison electric lighting system. He naturally needed financial support for the project and tried to attract groups of investors into it. It was only when all these efforts failed that Edison took over the ore milling operation himself. He decided that it was a waste of time persuading mine owners to adopt the new technology. Instead he was going to run the mines himself and then negotiate with the mine owners, from a position of strength, once his method had been proven successful. He moved from selling separators to going directly into the mining and concentrating business.[28]

Everything connected with the ore milling project was massive, from the size of the machinery to the amount of ore processed each day. The ore seams at Ogden ran in a straight line so Edison used giant earth movers to cut open a huge strip mine in the side of the mountain, creating an enormous artificial canyon. Edison bought large steam shovels (one was the largest in America) and several travelling cranes to carry out this work. After the ground was torn apart, the huge chunks of rock were removed and carried on railroad skips to the large rock crushing machines where they were broken up into successively smaller lumps. The job of breaking up the rocks was done by giant cornish rolls which crushed the rocks as they fell between them. These machines were designed at the West Orange laboratory and were probably the largest ever built, each weighing thirty-five tons. The rock passed through several sets of rolls until it was graded finely enough to be dried and then taken to the separation phase. Here it was passed through Edison's "three high" rolls which produced a finer powder out of the crushed ore which could then be separated by hundreds of successively more powerful magnets. (See Sidebar on "Edison and the Boys at Work.")

This operation is a fine example of the nineteenth century confidence in economies of scale. Edison thought he could produce ore cheaper by processing more of it. Similarly, Andrew Carnegie and Henry Frick were confident that their giant steel works (another trademark of the Second Industrial Revolution) would drive down costs by integrating all steps of steel manufacture into one large organization. Carnegie's strategy was based on the proximity of the ore beds to his mills on the Great Lakes. He expected to cut costs by exploiting the rich ores of the newly discovered Mesabi range of Minnesota. On the other hand, Edison confidently expected that he could deliver ore to the eastern blast furnaces cheaper than ore from the midwest, and that the low price of his output would enable the eastern furnaces to compete with Carnegie's steel mills.

The great work of building the Ogden plant continued through 1890 and 1891. It was completed at the end of 1891 and the first order for iron ore was started. Edison now began to devote more and more of his time to the work at Ogden, which demanded his personal attention. He spent most of the week at the mill, returning to West Orange on Saturday and spending Monday at the lab, reviewing the weeks's experimental work, before returning to Ogden. Edison was an absentee manager of the laboratory which had to run without his daily direction. His absence from the experimental rooms of West Orange sharply cut back his output of inventions. A decade which started with an average of over 30 patents a year ended at a much lower level; no patents obtained in 1894 and 1895 and only one for 1896.

The first year of operations at the mine produced few results for the engineering problems of running the giant rollers overcame the workers at Ogden. The machines continually broke down under the tremendous strain of crushing rocks. The cost of failure was high; Insull calculated that the ore milling venture was running a loss of $6000 a week in the summer of 1891![29] Convinced that the engineering problems could be solved at Ogden, and confident that if this could be done the project would eventually be successful, he was determined to get the ore mill working whatever the cost. This project reveals Edison's unswerving faith in the technological solution. In 1892 he admitted that the ore milling process "is quite a problem" but optimistically thought that "when we get in working order we shall easily solve it."[30]

Once again, Edison had underestimated the number of technical problems to be solved. His attention was initially on the output of ore, but he soon had to come to grips with problems inside the blast furnace. The iron masters were not happy using powdered ore and it did not perform satisfactorily in their furnaces. The resources of the laboratory were applied to a process to mould the ore into briquettes. This improved the handling characteristics of the ore but did nothing to control its high phosphorus content--a major disadvantage in the market place. Edison was so absorbed in these engineering problems that he gradually lost sight of the economic parameters of the ore milling project. It had ceased to be a business venture and had become a technical challenge.

The financial strain of enlarging the Ogden works meant that Edison had to cut back expenditure at West Orange. He instructed his managers to reduce the labor force and obtain outside work for the Edison Phonograph Works to keep the machines running. The Bates numbering machine company was purchased and production was begun in 1892. The Bates numbering stamp was an ideal product for the Works, which was fully equipped for high precision manufacture. The great experience in producing small electrical equipment was also an asset for the Works, and much of 1892 was taken up in trying to win a large contract from the Thomson-Houston company to manufacture small motors. These fan motors had been designed at the laboratory and the Works contained all the machinery needed to manufacture them. This was an important contract for the West Orange complex.[31] The amalgamation of Thomson-Houston into GE brought Edison's hopes to manufacture electric motors to an end, but the Works continued to manufacture meters and instruments for GE.

At the end of 1892 Edison was back at Ogden, installing bigger and better equipment and confidently looking forward to success and great profits. His plan was formulated on the rapid conquest of the engineering problems and a great increase in scale. The cost of installing colossal machines was immense and Edison could only afford it by a gradual liquidation of his stock in GE. This was done because he needed money quickly and not because he was peeved over the formation of General Electric. The large investment in the Ogden operation was consistent with his strategy of becoming a manufacturer and not a response to the consolidation of the electrical industry that excluded him. Edison had few regrets in leaving this industry; the intense competition discouraged him and he expected few profits in such an environment.[32]

The 1893 depression hit the electrical industry very hard, it was "perfectly dead" according to Tate. While the electrical industry floundered, Edison was comforted by the money he was going to make in ore milling. He felt that this business would generate profits that "will outrank the incandescent lamp as a commercial venture".[33] He had lost control of the direction of electrical technology and he made that loss up by dominating all aspects of his ore milling venture. He told reporters that "in my future campaigns I expect to control absolutely such inventions as I shall make. Whatever the profits are I shall control them." This was a prophetic remark in view of his emerging business strategies. 34

The panic of 1893 that devastated the electrical industry also damaged the Edison enterprise, cutting back demand for phonographs and reducing the price of iron ore. Edison's calculations for profit in ore milling were based on a price of $6.00 per ton for midwestern ore. As the price of Minnesota ore dropped below $3.00 a ton, the chances of a successful conclusion to the ore milling venture grew more distant. Undaunted, Edison continued to rebuild the Ogden operation, at the cost of his holdings in the electrical industry. Meanwhile the Mesabi ranges could provide the cheap ore needed in Carnegie's furnaces: in 1893 600,000 tons were shipped, by 1894 the figure was 2,000,000. [35] The failure of the ore milling business intensified the depression at West Orange. The policy of cutting back the costs of running the Edison complex continued and many old hands were let go, further reducing the work force of the laboratory. By 1894 Edison was carefully conserving his finances, keeping his reserves for the main businesses, and preparing for another test run at Ogden in the spring of 1895.[36]

The shortage of money forced Edison to return to the laboratory. The policy of diversification gave him the means to overcome the disastrous losses in ore milling. The essence of this idea was to move from one experimental area to another in the hunt for the elusive breakthrough, the highly profitable new idea that could refill Edison's treasury. It relied on several experimental projects running simultaneously to generate at least one commercial success. The experiments underway at the laboratory gave him another chance to recover the fortune expended on "Edison's folly" (as the Press called it) at Ogden. The development work on the kinetoscope had reached a such a point in 1894.

SIDEBAR 6-2

EDISON AND THE "BOYS" AT WORK

Although his public image colors Edison as a recluse, a "wizard" alone in a laboratory, he enjoyed the outdoor life. Edison continued the ore milling project well after it was practical because the work gave him so much pleasure. He had often used prospecting trips as a vacation from the pressures of the laboratory, and the remote mountains of New Jersey provided the opportunity to mix business and pleasure. To a man fascinated with machines, the plant at Ogden was a paradise. Edison loved to watch the great shovels and cranes at work and felt at home in the uproar of the mine:

> On all sides the roar and whistle of machinery, the whir of conveyors and the choking white dust...Big wheels revolve in the engine house...little narrow gauge locomotives puff their way in and out between the buildings...with shrieking and whistling wheel and brakes. [1]

The scale of the operation also had great appeal: Edison erected scores of buildings at Ogden and soon created an industrial complex where hundreds of men worked. A post office was built and the name of the community was changed to "Edison." He revelled in the primitive life at the mine and the masculine world of the miners and mountainmen in the remote Jersey highlands. The spartan existence also invigorated

Charles Batchelor who joined Edison at the mine. Talking with the men all night, sleeping on floors, clambering in and out of the giant machinery, and surrounded by dirt and equipment, Edison was in his element. He wrote to Kruesi: "come with Batch and I into the mining business where you may be dirty but very happy."[2] Edison had by now given up on making the ore milling project a joint venture with investors or mill owners, intending to run the operation with his own funds. He told the Press that the profits were not going to be shared with outside parties, "except the boys here who own the thing with me." [3]

At Ogden Edison was able to recreate the close-knit comradeship of Menlo Park, where he and the "boys" had eaten, slept, and worked together. He brought several "muckers" with him from West Orange and worked closely with an assistant, Walter Mallory. After dinner at the mine, Edison would lead a discussion of the experimental and engineering work on hand. This was called "going to school," and every man was expected to talk about the areas he was involved in. The "old man":

> loved to nag his men, haze them with questions, just to see if they knew what they were doing.

When they were not hard at work, Edison and the "boys" occupied themselves with practical jokes, cockfights, rattlesnake fights and boxing matches.[4] For Edison, this was the life!

The great works at Ogden attracted many men looking for work and a chance to make money. One of them was Thomas Robbins, a rubber-goods salesman. Working with Edison, he built rubber conveyor belts to move the ore through the processing stages. Conveyance was one of the important engineering problems to be solved because it offered the greatest opportunity to decrease the cost of the operation. The rubber belts ran on rollers which were specially designed to resist dust and dirt. This automatic and self-lubricating system anticipating the assembly line of the twentieth century. Henry Ford later claimed that it was Edison's example at Ogden that inspired him to devise his assembly line for the Model T.[5]

ENDNOTES

1) T. A. Robbins reminiscence, quoted in M. Josephson, p. 368.

2) TAE to Kruesi, ND, Kruesi file

3) Scientific American, vol 66, 2 April 1892, p. 216.

4) Recollections of Dan Smith and Benny Odel, in Mary Childs Nerney's notes, N 281101.

5) H. Ford and S.G. Crowther, "Edison as I Knew Him," quoted in Josephson, p. 378.

Illustration 6-2

The Kinetoscope

MOVING PICTURES

The development of the motion picture is perhaps Edison's greatest inventive achievement at the West Orange laboratory. The motion picture--one of the most influential art forms of the twentieth century--began as a simple peep-hole machine which treated the viewer to a few seconds of silent moving pictures. The kinetoscope heralded a new era in mass entertainment and was the vanguard of a great new industry. Its development at West Orange is a revealing example of the character of work at the laboratory. The debate about the true inventor of motion pictures is academic: very many men made contributions to this technology within the fluid organization and cooperation of Edison's laboratory.

This was a team project carried out by several experimenters largely in Edison's absence and squeezed into a demanding schedule of many other duties. The basic team of one experimenter and an assistant was supplemented by mechanics from the machine shops, pattern makers and carpenters from Building 3, and muckers from the labor pool. Although the original idea was Edison's, the successful development of the kinetoscope was more a reflection of the skills of his experimenters and his ability to pick the right men for the job. The work on the kinetoscope shows the flexibility of Edison's workers who had to distribute their time over several different projects. Even the chief experimenter, W.K.L. Dickson, could not devote himself entirely to the project; as chief of the metallurgical laboratory in Building 4 he had to divide his time between ore milling and motion pictures.

The project that Edison turned over to Dickson in 1889 had begun as an adjunct to the phonograph. It was one of his "stunts"--an idea for an invention, a dream with a hint of practicality. Edison thought it might be possible to "devise an instrument that should do for the eye what the phonograph does for the ear." [37] This idea had come to him during the work of perfecting the phonograph. It brought together a store of experience in one technology and an interest in another; photography intrigued Edison and he had acquired equipment and plates before the move to West Orange. At the temporary lab at Harrison he had discussed his ideas for the possible uses of photography with Dickson, a fervent amateur photographer. Several experiments using photography had been undertaken at the Harrison laboratory, including an attempt to produce a photographic image of sound by means of a reflecting disc attached to a phonograph which projected the lines of sound waves onto a long strip of paper. Once at the new lab, Edison continued to think about photography; the shop order books for the lab show that general photographic experiments were begun shortly after the laboratory opened, probably in the photographic studio installed on the second floor. In December of 1887, he instructed John Ott to construct a shutter device which focused light on a chalk drum. This apparatus shows how Edison used photographic techniques in his thinking about recording and reproducing sounds on a revolving drum. [38]

In his attempt to join sight and sound, Edison naturally hoped to achieve visual reproduction in the same mechanical form as he reproduced sound, using the phonograph analogy in his first experimental apparatus. The revolving cylinder--a recuring motif in Edison's inventions--was often the format of toys that gave the visual impression of movement, such as the zoetrope. This device was the work of English mathematician W.G. Horner. It used the illusion of persistence of vision--when the eye retains an image a short time after it has disappeared. The zoetrope was comprised of a number of pictures viewed through slots in a cylinder; as the cylinder was turned the pictures appeared to move. Many other machines were available that used moving pictures to give the illusion of movement. Edison knew all about the zoetrope and had bought several other similar toys. His first experiments at West Orange were directed at finding a mechanical means to exploit the persistence of vision phenomenon by moving images quickly past the viewer's line of sight.

The rapid development of photography in the years after the Civil War gave Edison encouragement and inspiration. He was always alert to opportunities presented by technological advance and quick to exploit the work of others. The photographer Eadweard Muybridge greatly impressed Edison and encouraged him to pursue the idea of moving pictures. In February 1888 Muybridge visited the lab to demonstrate his sequential photographs of animals in motion. Muybridge had mounted these pictures on a zoetrope and successfully recreated movement. Later that year experiments were begun to duplicate this approach in a phonograph format. [39]

The early experiments consisted of laying microscopic photographs on a cylinder, slightly larger than the tinfoil phonograph but of the same general arrangement, which were viewed through a microscope. Dickson described the first apparatus as having the sound and picture cylinders running on the same axis and powered by the same electric motor. The motor came from the phonograph as did the general concept of this machine: Edison tried the obvious answer to the problem of synchronizing sound and pictures first. The cylinder had to move forward one frame for each exposure and then hold the image steady for a fraction of a second in order for eye to record the image. The problem with synchronizing sight and sound was that the former required intermittant motion while the latter needed continuous motion. This mechanical problem absorbed most of the attention of Edison and the experimental team. They experimented with break wheels, tuning forks, ratchets, and electromagnetic devices to achieve the intermittent rotary motion.

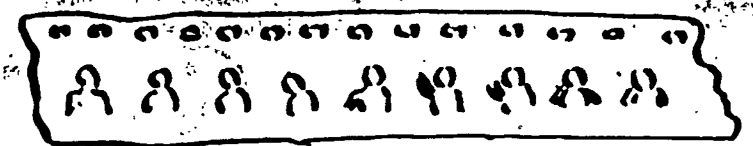
The first year of experimentation did not produce a working machine, but the experimental team and the "old man" were encouraged to think that images could be manipulated to show movement. A caveat was filed in October for a "Moving View" apparatus which could recreate things in motion. The basis of this invention was the cylinder format in which the rapid movement of many small photographs per second gave the illusion of movement. The series of pictures were photographed on the cylinder "in the same manner as sound is recorded on the phonograph." [40] The viewer looked through a microscope device to see the moving pictures and listened to the accompanying sound track through listening tubes attached to a phonograph. Many problems had to be solved before a commercial machine could be contemplated. The cylinder format had the disadvantages of requiring a very small image (impractical with the primitive film then available) and focusing on a curved plane which produced images with a fuzzy surround. Little progress had been made in achieving the intermittent motion which was the vital mechanical element of the machine.

In 1889 the kinetograph experiments moved out of the realm of speculation. A shop order was opened for the project in February 1889 and later that year a special studio was constructed next to Building 4. Dickson and an assistant, C.A. Brown, also worked behind a locked door in room 5 of the main laboratory building. Brown was a mechanic who had worked with Dickson in the ore milling lab in Building 4 and obtained Edison's permission to join Dickson in the Photography Room. [41] Dickson was later assisted by several other mechanics and experimenters, who joined the team when the need arose for their skills. Throughout 1889 they worked on several machines to take and show moving pictures. By the end of the year their efforts had brought forward the critical breakthrough in the development of motion pictures: the use of a perforated film strip in place of the pictures on a revolving drum.

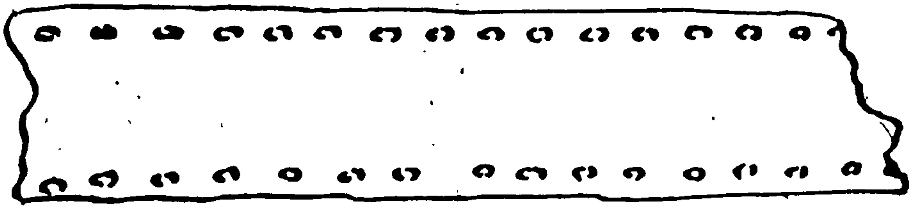
Dickson soon found that the microscopic photographs affixed to the drum were impracticable and began to increase the size, and improve the definition, of the image. He moved from fixing small photographs to coating the drum with gelatine containing silver salts. The most important contribution to Dickson's work at West Orange came from the manufacturers of photographic film: John Carbutt in Philadelphia, the Blair Company of Boston, and the Eastman Company in Rochester, New York. Here was the advantage of a wide information net that could give the workers at West Orange the benefit of technological advances elsewhere. As soon as Dickson found out about these strips of celluloid film coated with sensitive emulsion, he obtained some samples from John Carbutt of Philadelphia. The thick sheets of film were cut into strips and the top side of the strip was cut into the form of teeth which engaged a ratchet. This moved the film steadily past the lens. Celluloid film strip was also manufactured by Eastman's and the first order for this improved film was made by Dickson in September 1889. From then onwards the development of film technology was dependent on the film makers producing finer emulsion and faster film. It was only a short step to using a film strip with perforated edges. The specifications for film sent from West Orange defined the standard 35mm width of film used today.[42] (Illus 6-3 series of film strips) Eastman's film was thinner than Corbutt's and this permitted the development of a camera that worked with flexible film strip instead of thick sheets. Edison had considered the use of a "long, tape-like sensitive film" in his early sketches of 1887, and was able to exploit his telegraphic experience by considering the use of rollers to move the film in the same way that tape moved through an automatic telegraph.

The weight of the testimony given by Edison and the laboratory employees involved in the invention points to the development of a film strip with perforated edges before the trip to the Paris Exhibition. The film historian Gordon Hendricks is skeptical of this claim, believing that it was made to improve Edison's patent position. Hendricks argues that Edison got the idea for a perforated strip from the French inventor Etienne Marey. Hendricks' persuasive version of the invention hinges on Edison's trip to Paris where he saw the continuous film strip in Marey's laboratory. Edison is supposed to have said, "I knew instantly that Marey had the right idea."[43] The vital development work was carried out on Edison's return and resulted in another caveat of late 1889 which defined the new format.

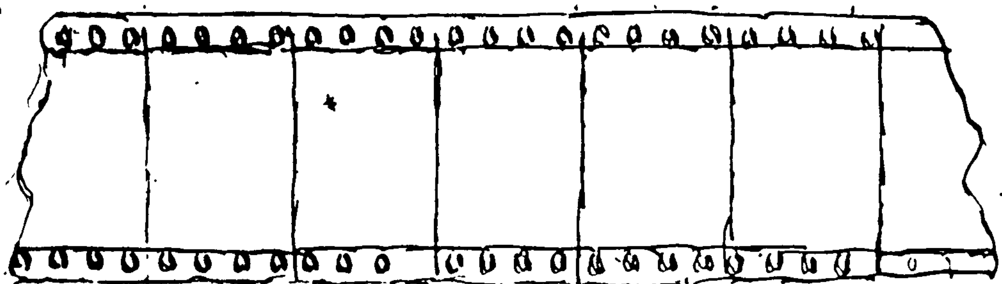
The development of film projection is also clouded in



First piece of Film from Mr Geo. Eastman
50 feet long – perforated one side – narrow
projected with the Kinetograph & also used in the Kinetoscope

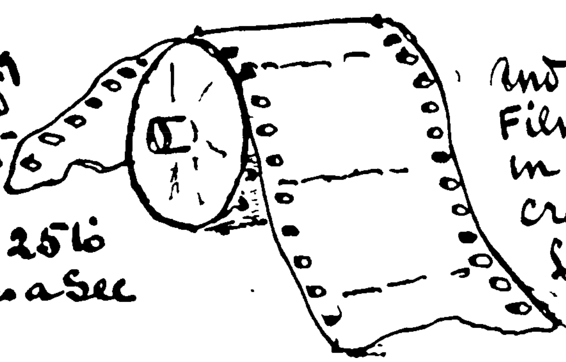


Cut wider & perforated both Edges to steady the picture – 1889 – Geo. Eastman supplied this film manufactured Exclusively for Mr. Edison



Cut Wider – perforated both Edges – Width Film size picture or phase – 4 oblong holes per picture
End of 1889 – same as now in use 1928 –

Showing standard Sprocket Wheel of 1889 – 25 to 30 pictures a Sec



And perforated Film same as now in use 1928 – created at Edisons' Labratory – Orange N.J. 1889 controversy. Many would deny Edison the priority of this invention but there can be little doubt that Edison saw the possibilities of projecting an image and devoted experiments to it. His first caveat of October 1888 mentioned that "the picture might be projected on a screen." Dickson claimed to have shown Edison a projected moving image, accompanied by sound, as a welcome to the boss on his return from Paris in the fall of 1889. Dickson recalled that he led Edison to the new photographic building and there the machine produced an image of Dickson, four foot by five foot, while a phonograph played the message: "Good Morning Mr. Edison, glad to see you back. I hope that you are satisfied with the kineto-phonograph."[44] Dickson also experimented with a tachyscope which enabled him to project images. His device was exhibited at the Lenox Lyceum in 1890. Finally there is Edison's marginal note to Terry Ramsaye's "A Million and One Nights:" "The facts are that Dickson and I had a machine projecting on a screen 5 foot square at the time we were making the kinetoscope."[45]

The development work on the kinetoscope continued through 1890, aided by better film strip and mechanical improvements in the machine. The laboratory's staff soon found that the thinner celluloid film produced by the Blair Company was best suited to moving pictures. New models were built that used 3/4- inch wide films with 1/2-inch square images; Dickson was slowly working toward best format for the film which combined the desirable mechanical and photographic properties. The ore milling project had the highest priority, however, and there was to be no patent application until 1891, when Edison filed a description of two machines: the kinetoscope for viewing pictures and the kinetograph for taking them.

The strip kinetograph used two electric motors, one to drive the shutter and the other to advance the strip by means of perforations on each side of the strip. (Illus 6-4 strip kinetograph, #6571) The film was held steady by teeth which engaged the perforations while the exposure was made and then moved forward by an escapement mechanism for the next exposure. The image had to be held steady for a fraction of a second or the persistence of vision would not occur--all the viewer would see was a blurred image. The rate of exposure could be taken as high as forty per second and the strips were 20 to 50 feet long.[46]

The camera was conceived by Edison as the manufacturing part of the system which produced the film product. It was a totally different machine from the one people associate with the motion picture camera. Housed in a large rectangular box, it was intended to stay in the Works and produce the media for the new form of entertainment introduced as the kinetoscope. It was designed around the electric motor which powered the shutter and moved the film rapidly past it. The shutter and motor mechanism were assembled as one unit and positioned directly behind the single lens. The box was attached to a cast iron base (no doubt to dampen the vibration), and connected to

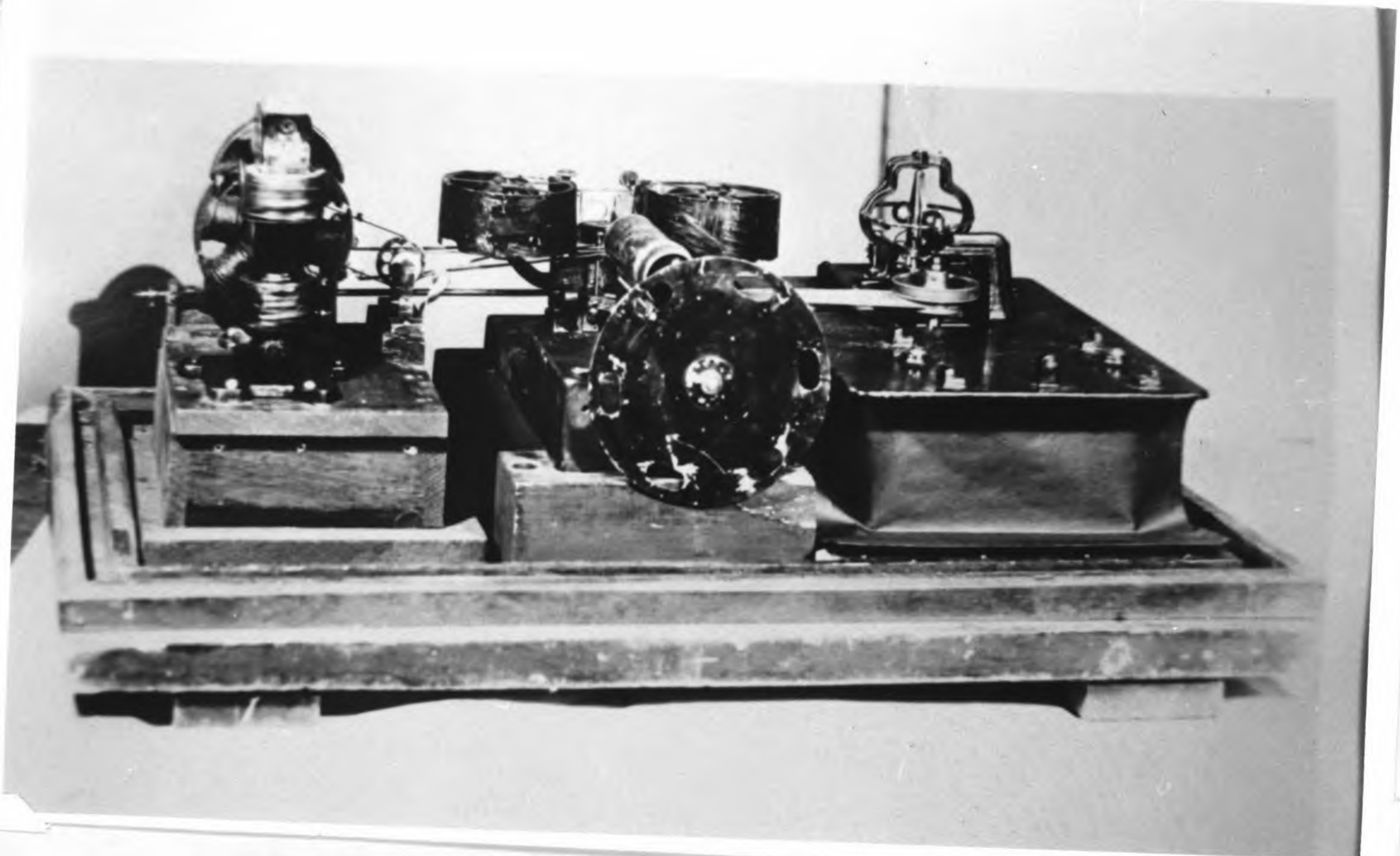


Illustration 6-4

Strip Kinetograph

a source of electricity. The kinetograph was fitted with a start and stop switch and a counter that showed amount of film used. The kinetograph was the truly original part of the motion picture system because although many had devised viewing machines, none had produced a camera like this before.(Illus 6-5, Dickson's drawing of kinetograph in operation.) [64] A special studio was built to make movies with the kinetograph. (See Sidebar 6-3, "The Black Maria.")

Dickson had achieved some success in taking pictures rapidly on the film strip, but there were still mechanical problems in the film feed mechanism which caused an unsteady, flickering image. The mechanics who worked with Dickson, chiefly William Heise, Henry Kayser, and the Ott brothers, had years of experience in the telegraph industry and were expert at the mechanics of moving a tape rapidly and exactly past an aperture. It was men like these who altered the feed to provide a more positive movement that would not shift the film around at high speeds. The addition, and subsequent modification, of a Geneva stop mechanism was a major step in developing a reliable camera and projector. Another area in which the mechanics made an important contribution was the synchronization of film and shutter. The motion picture benefitted immeasurably from the expertise gained in the telegraph and phonograph work.

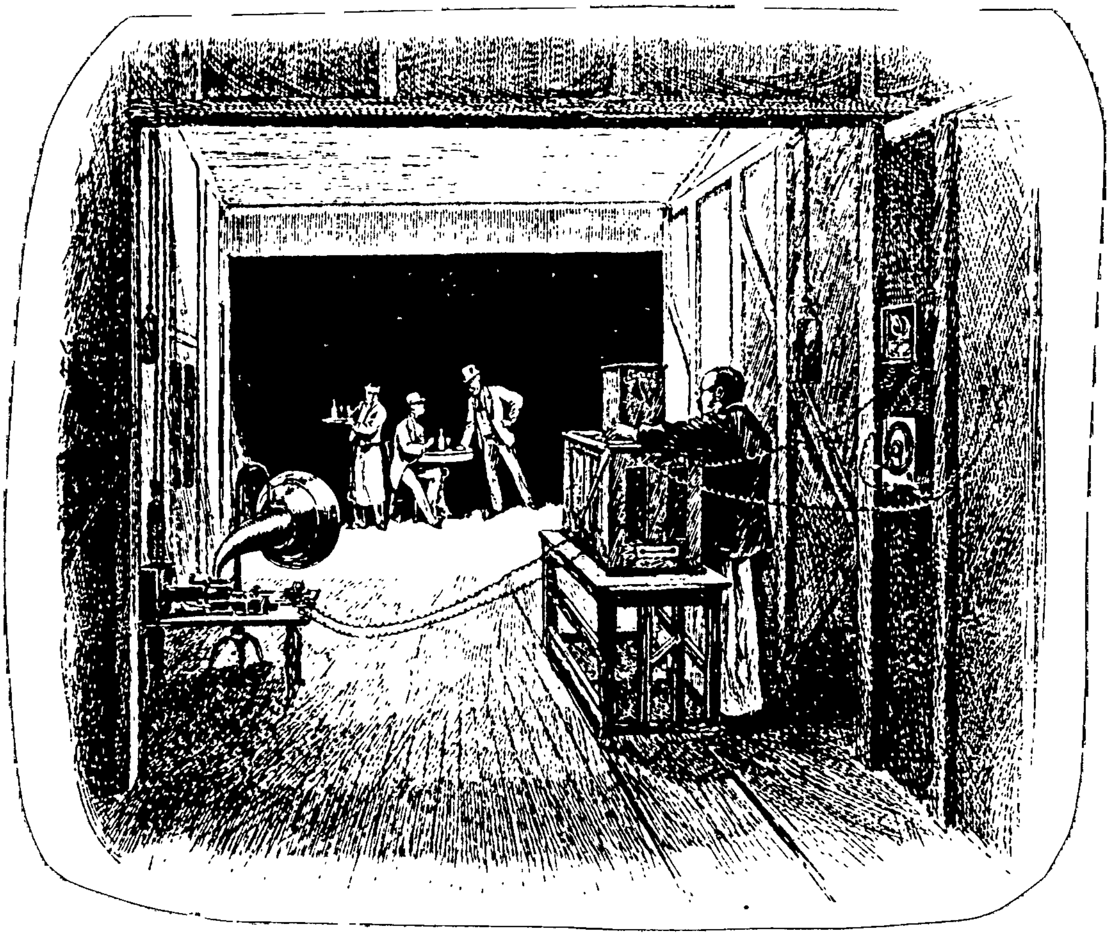


Illustration 6-5

Kinetograph in Black Maria

(Drawing from Dickson's Century Magazine Article)

THE KINETOSCOPE

The kinetoscope was the first attempt to get the new technology into a form suitable for commercial exploitation. It was designed as an arcade machine in which the customer paid to see a film strip and it was closely modelled on the coin-in-slot phonograph which was being developed at the same time. The two machines were being worked on concurrently at the lab and in the Works. Both projects suffered from delays. The kinetoscope was a pine box with a hole in the top for viewing. The upper part of the box contained an electric motor, shutter, and incandescent lamp to illuminate the images. The lower part of the box held the 50 foot loop of film which was arranged over rollers and then moved to the top of the machine for viewing. The electricity for the motor was provided by a primary battery, just like the phonograph.[48] (Illus 6-2, Kinetoscope # 7197)

The marketing of the kinetoscope also followed the example of the phonograph. Edison's idea was to exploit the novelty appeal of moving pictures and sell the kinetoscope to amusement parlors. This outlet had proved very successful for the phonograph. There was obviously no market for moving pictures at the time and Edison knew from the phonograph experience that selling the product as a novelty familiarized the public with it while making profits. Kinetoscopes were soon placed side by side with phonographs in amusement parlors and also installed in departments stores, hotels, and bars.(See Illus 6-6, Amusement Parlor, # 9218.)

The first entrepreneurs attracted to the kinetoscope came naturally from the phonograph business. A.O. Tate joined with Thomas Lombard of the North American Phonograph Company and E.A. Benson of its Chicago franchisee to acquire Edison's concession to market the kinetoscope. They saw the Columbian Exposition in Chicago as an appropriate place to launch the invention, but the Works could not supply the machines in time for the exhibition in 1893.[49] The first machines were sent from the laboratory in April 1894. Edison had reserved his right to sell kinetoscopes overseas and this turned out to be a wise move because Europe became an important market. A few months after the first kinetoscopes left the Works for an amusement parlor in Manhattan, 50 machines were sent to Europe. London, Paris, Rome, and Copenhagen soon had their own kinetoscope parlors.[50] Edison was sowing the seeds of another vibrant business in the same way that he had founded the electric light and phonograph industries in Europe.

His strategy for the United States was to use the Kinetoscope Company to market as many machines as possible, providing the income to support further development. He also wanted the profits from making films and kept strictly to a policy of controlling the movie camera, not letting it out of the hands of the cameraman during film production. Edison

IA RAILROAD TIME TABLES.
ATTENDANT IN CHARGE
FURNISH CHANGE.
ATTENDANT IN CHARGE
FURNISH CHANGE.
FURNISH CHANGE.

wanted a monopoly of the film media and a captive market in the peep show exhibitors who needed a constant supply of film. [51] He developed the same strategy for cylinder records--his moulding process would have given him a monopoly of the mass production of records, had his patents been unheld. The management of the motion picture project was governed by commercial considerations; the laboratory was busy devising a projector but Edison refused to introduce a model because he saw that it would ruin the peep show trade.

The kinetoscope was an instant success; its appeal was universal and it was a sight to see. Yet its novelty value was short-lived. Audiences began to dwindle in 1895 and one entrepreneur admitted in May of that year that: "our candid opinion is that the kinetoscope business will be a dead duck after this season." [52] By the end of the year the Works were only making a few kinetoscopes each month.

The kinetoscope did not have a long life but it was certainly an eventful one. The machine brought a new art into being and laid the foundations of a new industry. Although it suffered from constant neglect, the motion picture project was taken from an experimental device to a commercial product in about five years (1889-1894). This was not as fast as some in the Edison organization would have liked but it was nevertheless a considerable achievement for the laboratory. It was also an entirely new product for the Works; the labor had to be trained and new equipment designed and installed. The rapid development of a new line of business, carried out without a major hitch, proves that the West Orange workforce did have the speed and flexibility Edison expected of them. The kinetoscope provided plenty of value for the estimated $24,000 spent on experiments. As Gordon Hendricks has pointed out, the $7940 for machines and $369 for films paid to Edison by the Kinetoscope Company might seem insignificant compared to costs of today's movies, but it caused no less excitement among the audiences.[53]

Illustration 6-7

The Black Maria

SIDEBAR 6-3

THE BLACK MARIA

The fluid organization of the West Orange laboratory led Edison's secretary into the business of exploiting the motion picture. It was A.O. Tate who supervised the delivery of the first kinetoscopes to the Holland Brothers' parlor on Broadway near 27th street. His description of the first night of the kinetoscope gives an impression of its appeal and the profits that could be made with it:

> I wish now that I had recorded the face of the person to whom I sold the first ticket. I cannot recall even a face. I was kept too busy passing out tickets and taking in money...If we had wanted to close the place at six o'clock it would have been necessary to engage a squad of policemen. We got no dinner. At one o'clock in the morning I locked the door and we went to an all-night restaurant to regale ourselves on broiled lobsters, enriched by the sum of about one hundred and twenty dollars.[1]

$120 for one night's work was more than anyone made in a month at the laboratory! The public soon tired of the same films strips and demand for fresh film subjects rapidly outstripped supply. The technical limitations of the kinetograph defined the form of the film and limited its production. As the camera could only hold about 50 feet of film, film subjects were fixed at around 35-40 seconds. The camera was heavy and immobile and needed a solid platform to work on. A new building was therefore constructed in the grounds of the laboratory to make motion pictures. Although it was described as a "revolving photographic building," it has become famous under the nickname coined for it at the lab--"the Black Maria." The building was about forty feet long and ten feet wide. It was made of wood covered with black tar paper and it moved on a circular track to follow the movement of the sun. Part of its roof could be opened to let in light. This was the first motion picture studio built expressely for this purpose, replacing the film shed erected by Building 4. At one end of the "Black Maria" was the room in which film was loaded in and out of the camera. A set of rails ran the length of the building and the camera was run along this--achieving a steady picture. (See Illus 6-7, 23440, # 6570) Its interior was made completely black to create high contrast, giving a sharp, well-defined picture. The building cost $650 and earned its place in film history.

The subjects filmed in the "Black Maria" came from the vaudeville: the dominant form of public entertainment at the time and a favorite of Edison's. The vaudeville skit could easily be transferred to a 35 second film and the proximity of New York to the laboratory guaranteed a ready supply of talent. During 1893 and 1894 a procession of vaudeville performers made their way from Manhattan to West Orange to perform in the "Black Maria": animal acts, dancing girls, strong men, and famous figures such as Annie Oakley and Buffalo Bill. Edison took a personal interest in finding new talent; after a performance of the "Gaiety Girl" in New York, he went back stage and persuaded three of the ensemble to visit the laboratory and dance before his camera.[2] For the mechanics and laborers of the laboratory, who doubtless could not have resisted the temptation to peek, this must have been a rare treat!

ENDNOTES

1) Tate, Open Door, pp. 285-287.

2) Ramseye, p.84; Hendricks "Kinetoscope Fall Motion Picture Production," in Film Before Griffith, pp. 13-21.

NOTES FOR CHAPTER SIX

1) Accounts from Billbooks, 1888-1889, ENHS.

2) EGE to TAE, 10 Oct 1890, 1890 Electricity, see also annotation and answer of 14 October 1890.

3) TAE to F. Gorton, 24 Sept 1890, 1890 Electric Light.

4) Insull to TAE, 17 Oct 1890, 1890 Electric Light.

5) TAE to Edison Edison Manufacturing Co, 11 Jan 1889, 1889 Edison Manufacturing Co.

6) Tate, Open Door, p. 141.

7) Maguire to Tate, 30 July 1889, WO Lab general.

8) Batchelor to TAE, 19 Aug 1889, 1889 Lab.

9) Dickson's article in Century Magazine, V 48, June 1894.

10) Electrical World, V 14 (Sept 1889) 165-7; Josephson, p. 334.

11) See Gordon Hendricks, The Edison Motion Picture Myth (Berkeley: U of Calif Press, 1961), pp.82-83.

12) TAE to P.S. Dyer, 17 May 1889, LB 890408, pp. 434-5.

13) TAE to Edison Phonograph Works, 19 Nov 1890, Phono EPWks. Edison also told the companies that they would now have to provide their own recorded cylinders, TAE to EPW, 25 Jan 1890, LB 900111, pp. 335-338. This move was in response to many complaints about recordings from the companies. Edison had no intention of giving up the production of prerecorded cylinders, but wanted the companies to appreciate the difficulties of producing them. His secretary followed up Edison's blunt directive with a more diplomatic note which assured the companies that recording cylinders was not being discontinued at the West Orange Laboratory.

14) Journal #5, p.147.

15) 2nd annual report of EGE, 31 Oct 1890, quoted in Payson-Jones, p. 160; agreements are in D box D3, GE folder.

16) Bill book #9 , p. 489.

17) TAE to Gorton, Nov 10 1891, El lt central stations.

18) Tate, Open door, pp. 260-265; Batchelor journal 1337, p. 132.

19) The New York Herald reported that Edison was frozen out of the electrical trust, the New York Morning Post described the inventor as "worn out, shoulders drooped, hair grey" and spending more time at home! See 1892 Electric Light folders.

20) Accounts records in Billbook #13.

21) TAE to A Brady, 21 Dec 1898, LB 980131, p. 305.

22) Scientific American, V. 66:216, 2 April 1892.

23) Charles A Stansfield, New Jersey (Boulder Co.: Westview, 1983), p. 36.

24) F Maguire to A Tate, 30 July 1889, Lab Work in progress.

25) This was Passer's conclusion to the Battle of the Systems" in The Electrical Manufacturers, p.174; Tate, Open Door.

26) Cited in Vanderbilt, Edison the Chemist, p.154.

27) Telephone, shop order # 540. 1891; description of ore milling equipment in Iron Age, 59:1, 28 Oct 1897; see also W.B. Carlson, "Edison in the Mountains," History of Technology V.8 (1983), 37-59.

28) Annotation on J Birkenbine to TAE, 13 July 1889, Ore milling.

29) Batchelor diaries, 1337 21 Jan 1891, p. 154.

30) Electrical World, XLV, Jan 1892.

31) Tae to C. Coffin, 9 May 1892, LB 920309, p. 440.

32) In an interview published in the Albany Herald, 3 Nov 1895 described the electrical industry as a "commissary of wolves" and justified his departure from it because "there are too many in it, it offers no inducements."

33) Tate to F Jehl, 11 Sept 1893, saying industry is "perfectly dead," LB 930805, p. 91; Scientific American V. 66:216, 2 April 1892.

34) Scientific American V. 69:25, July 8 1893.

35) Charles Hoffman, The Depression of the Nineties: An Economic History (Westport, Conn.: Greenwood, 1970), p. 133.

36) Tate to F Van Dyck, 21 Feb 1894, LB 930808, p.668; and Open Door; TAE to A Elliot, 24 March 1894, LB 931030, p. 109; TAE to E.H. Lewis, 15 March 1894, LB 931030, p. 98. Edison cleaned up his affairs in 1894, withdrawing from many honorary posts and cutting back on his personal expenditures. The amount of work done in the lab declined significantly during the 1893/1894 depression. During one month in 1894 (May), the labor cost for work done on the phonograph was less than $100, Edison's personal experiments cost $460 and ore milling labor cost was over $1000. Total cost of the months work was $2883, of which GE paid $911. Billbook #12, p. 469. Research expenditure for 1893 probably did not excede $25,000--much less than the $75,000-$80,000 p.a. range at the beginning of the decade.

37) Edison Caveats on motion pictures are in the appendix of Hendricks, Motion Picture Myth; Dickson's article in Century Magazine, V 48, June 1894.

38) Electrical World, V VII 6 Jan 1886, p. 26; experiments are in Notebook 871210.2.

39) "Some Facts relating to Moving Photography" By W.K. L. Dickson, D Box D.

40) "A Brief Epitany (Sic--this could be "Epitamy") of all Facts relating to ...Invention of the Kinetograph" by W.K. L. Dickson, 21 April 1928, D 5 Motion picture; Edison caveat.

41) Brown's testimony in Edison vs American Mutascope Co, Complainants record, p. 143, LB 173.

42) The history of the celluloid film strip is told in Reese V Jenkins, Images and Enterprise (Baltimore: Johns Hopkins Press, 1975), chap 6. Eastman set up a laboratory in 1890, its purpose was testing. (p. 147).

43) This recollection is from Albert Smith, 2 Reels and a Crank (New York: Doubleday, 1952), cited in Hendrick's Motion Picture Myth, p. 171.

44) Dickson's version in his Century magazine article.

45) Terry Ramseye, A Million and One Nights (New York: Simon and Schuster, 1926), p. 68.

46) Patent # 589,168, filed 24 Aug 1891.

47) Description of kinetograph in Dickson Century Magazine, and Dickson to Meadowcroft, 1 May 1921, Biog files.

48) Electrical Engineer, v 18, 7 nov 1894, p.377.

49) Dyer to J Randolph, 1 Feb 1900, MP.

50) Shipments list, 1894 MP kinetoscope.

51) W Gilmore to TAE, 15 July 1895, 1895 Kinetophone.

52) Text of agreement Edison Manufacturing Co & Kinetoscope Exhibiting Co, 10 Sept 1895, MP Kintoscope

53) Robert C Allen, "The Movies in Vaudeville," in Tino Balio, ed., The American Film Industry (Madison, Wisc.: U of Wisconsin Press, 1985), p.60; G. Hendricks "The Kinetoscope" in John Fell, Ed, Film before Griffith (Berkely: U of California Press, 1983), p. 20.

CHAPTER SEVEN

R&D IN THE NINETEENTH CENTURY

Edison had little time or sympathy for the decline of the kinetoscope; the ore milling venture had reached a climax by 1895 and all his energy was devoted to the mill at Ogden. He had dug the largest hole in New Jersey and poured his fortune into it, gambling millions of dollars on his process of separating iron from low-grade ore. He admitted to the press that "it will either work or bust," and unfortunately it failed.[1] He was so involved with technical problems that the significance of the decline in price of Minnesota ore passed him by: there was no point in competing with the giant steam shovels that poured the Mesabi ore into waiting railroad cars. Edison once said that "I always invent to obtain money to go on inventing," and failure at Ogden brought him back again to the laboratory to make money.[2] In October 1895 Edison wrote to F. Fish, general counsel of General Electric: "I am getting close to the end of my mill biz and will soon be able to come back to work."[3]

The work he referred to in his letter to Fish was not the kinetoscope, in which he had taken only a small part, but the electrical research of the lab, most of which was financed by

GE. Getting back to work meant applying himself to the problems of commutator design, producing new meters and measuring instruments, and most of all, finding a better filament for the incandescent bulb. The central problem was to improve the poor efficiency of a bulb that converted most of the current into heat rather than light. The efficiency of the bulb had been greatly improved since 1879 but there was still a long way to go. Edison could only have experimented on filaments in the winter months when the Ogden mill was closed down, but he kept up a stream of enthusiastic reports to General Electric. In December of 1896 he wrote to Fish "I have reached a very curious stage in the lamp filament work...evidently I have a perfect filament." [4] The new agreement signed with GE in 1896 gave Edison $1000 a month to pay for the experiments on filaments and other electrical technology. There are few other details extant of Edison's "perfect filament" and it probably remained as an experimental proposition rather than a major innovation.

The amount of financial support from GE changed over time as company and inventor negotiated the costs of the experiments. Edison told GE in 1897 that "I hope to either succeed in the filament or come to an understanding with you to continue." Edison did contine the work on incandescent filaments and fluorescent lamps, with an average weekly expenditure of around $250--a reduction on the level of expenditure in the early part of the decade.[5] The policy of the electrical manufacturers during the 1890s was to engage individual inventors under contract to carry out research in their area of expertise. Westinghouse supported William Stanley's laboratory and GE retained Elihu Thomson as a consultant, in addition to their contract with Edison. The development of some revolutionary new lighting technologies in the scientific laboratories of Germany helped change this strategy of research under contract. German scientists were exploring the incandescent effect of certain ceramics and searching for metallic filaments with a higher melting point than carbon. Walter Nernst, a chemist, designed a lamp which outperformed the Edison lamp. The threat of a completely new lamp with increased efficiency and brilliance forced GE into action. Under constant pressure from Charles Steinmetz, the management of GE finally decided to establish a research laboratory to investigate new lighting technology. It would be staffed by trained scientists. They were naturally concerned with the cost of this kind of industrial research but appreciated that failure to control the new metallic filament lamps would be more expensive in the long run.[6] While GE built up their own laboratory at Schenectady in the first years of the twentieth century, the support of Edison's laboratory decreased to approximately $25 per week, which was no more than a token payment. The years of "research for hire" had come to an end.

The focus of GE's industrial research laboratory was narrow; it looked into metallic filaments, mercury vapor lamps, and the Nernst lamp. Steinmetz's original idea was to concentrate on these critical areas and then carry out general chemical research in any "spare time" that remained. [7] In contrast, the Edison laboratory pursued a much wider range of electrical experiments, spanning electric light, power, storage batteries, and measuring instruments. Edison also maintained an interest in more exotic technologies, such as "etheric force" and the "Edison effect." These discoveries were closely connected with his earlier experiments on the phenomenon of induction. In the 1890s he carried out more experiments on induction and on "etheric force," which he had discovered in the 1870s. Edison hoped to that these phenomena might be useful in a system of wireless telegraphy.[8] He did come close to developing a workable system, but a commercial product eluded him. The answer to this problem, (and several others, including the amplification of sound), was to be found in the "Edison Effect" which had been discarded previously. The development of wireless fell by the wayside as other projects--ore milling, phonographs and motion pictures--dominated the laboratory's time in the 1890s.

Edison had some important electrical interests of his own outside of the contractual work for GE. His laboratory had worked on every aspect of the system but slowly Edison chose to concentrate on some areas at the expense of others. The development work on electric motors, for example, had paid dividends in the 1890s when many Edison products contained small motors, such as drills, fans, kinetographs, kinetoscopes, medical equipment, and phonographs. This work had all the criteria of a successful project at Edison's laboratory: it was relatively simple with clearcut engineering goals, it had many applications, and it did not require great expenditure to test and manufacture. Edison was able to exploit the economies of scope in motor development by applying the laboratory's expertise to many different products and problems: the learning by doing of years of research and engineering was easily transferred. In the first decade of the West Orange laboratory, Edison produced a stream of electrically driven machines and spent years trying to improve the regulation of speed. This knowledge was then applied to other projects. After the first kinetoscopes had been introduced, one of the great difficulties experienced was to maintain constant speed of the motor moving the film through the machine. Consequently a shop order was opened in September 1894 to build a new motor. This general problem had been solved in the phonograph work; the new motor was a "walk-over" for Edison's men and an important improvement in the machine.

There were always plenty of technical choices at hand because Edison's fertile mind was continually coming up with new ideas for experiments. The flood of new ideas that emerged from the laboratory in the 1880s continued during the next decade. Edison was interested in everything and the laboratory's work in the nineteenth century is a testament to the breadth of his imagination. For example, he was intrigued by flying machines. He had been experimenting in this general area since the lab opened. A shop order was started in 1892, a model built, and Edison spoke enthusiastically about his experiments to the Press. He had several ideas for powered flight, including a disk of shutters which were moved up and down by a perpendicular piston.[9] In trying to find a mechanical duplicate of the flapping of a bird's wings, Edison was following the path taken by many inventors of flying machines and was destined for failure. The laboratory staff turned many of these ideas into reality, producing experimental models and factory prototypes in a short time.

The x-ray project shows that the laboratory had lost none of the speed and flexibility that had characterized operations in the 1880s. Wilhelm Roentgen discovered x-rays at the end of 1895. Edison claimed that he started experimenting on them only 10 hours after he saw the cable announcing Roentgen's discovery. He assembled all the equipment he needed in the lab; including the high vacuum tubes used to generate the rays. A typical burst of activity in the laboratory, with Edison and his team working night and day, duplicated Roentgen's experiments and produced a working device in 12 days. This was called the fluoroscope. It consisted of a wooden box coated with photographic emulsion and a vacuum tube that produced the x-ray. The object to be x-rayed was placed between the tube and the box, and the x-ray picture was viewed through a peephole in the box. Edison sent a working fluoroscope to Michael Pupin of Columbia University at the end of March 1896, and by July had completed a fluoroscope manufacturing plant at the lab.[10]

Much of the work of the lab was of a more mundane nature. Edison's men were generalists and had to be flexible enough to meet the challenge of different types of work. Improving, altering, and repairing Edison products were all in a day's work. Edison's men took a "hands-on approach" to the problems that came up in manufacturing, altering and modifying machines in the Works just like Edison had done in the 1880s. When the early spring motors developed problems for example, the "chattering machines" were put right on the bench in the Phonograph Works. Each product was built in many variations, such as the kinetograph. In 1899 for example, several new devices were produced to take large format pictures of the Klondike.[11] The phonograph line was full of "one-offs"--specially modified machines to the unique specifications of the customer. These were designed in the lab and then constructed in the Works.

Although the public's impression of the work of the West Orange laboratory was conditioned by the image of the flash of inspiration, it was, in fact, more like the 90% perspiration that Edison liked to talk about. The successful experimental project was more likely to be a long-term campaign with carefully defined goals than a short burst of inventive activity. This was certainly the case with the development of a successful phonograph product.

FINAL TRIUMPH OF THE PHONOGRAPH

After his European vacation in 1889, Edison went back to the drawing board and tried again to turn his tinfoil idea into a commercial machine. The 1890s were the real times of "perfecting the phonograph" for Edison turned the unreliable and over-complicated machine of the 1880s into "a first class, plain, practical machine" with a mass market. [12] The development of a low-cost phonograph for amusement use had begun in 1890 when Edison started work on several experimental projects aimed at producing a phonograph that could recreate the sound of music. The three main elements of this campaign, improving the wax compound, cheap duplicating of records, and more realistic sound, were continued during the decade. The West Orange laboratory had relinquished the production of recorded cylinders (handing this over to the Works), but continued to investigate the mysteries of sound recording.

This work was carried out by Walter Miller, under Edison's constant supervision. They examined the human ear to develop analogies between it and the recording diaphragm. They worked closely with experts on sound and hearing and made several experimental machines that were used in medical research.[13] They examined every aspect of sound to understand the different frequencies and changing tones of recreated music. The reproducer on earlier "perfected" phonographs had been specifically designed to record the human voice for dictation and was therefore unsuited to capture the tonal range of music. The goal of these years of research was a new reproducer that could recreate music. It was reached when the "automatic" reproducer was introduced on the new models of 1893. It had a glass diaphragm and a tiny sapphire ball served as the stylus. The use of a hard, jeweled stylus instead of a sliver of steel was a major innovation in phonograph technology; it was less liable to catastrophic damage and allowed better tracking and improved response in the higher frequencies.[14]

A harder stylus required a harder wax compound to stand up to the sharper point and the heavier tracking pressure of improved reproducers. The hardness of the wax was also a critical element in capturing a wider range of frequencies, especially the low, bass notes which cut a deeper groove in the record. The steady progress in reproducers and recording techniques in the 1890s made the work of Jonas Aylsworth central to the Edison phonograph business, for any improvement in these areas had to be matched by better wax compounds--or the benefits might be wasted. Aylsworth's research covered an immense range of organic and non organic substances, especially waxes and resins, in the search for the perfect compound for the cylinder. The ideal substance did not only have to be very hard, but also had to be easy to mould into cylinders.

Aylsworth therefore had to work closely with Charles Wurth and his duplicating team because each experimental project depended on each other; new compounds acted differently in the duplicating process and each compound performed differently in both recording and reproduction. Here was a chemical challenge that Edison enthusiastically took up. He spent many hours in the chemical lab in Building 2 working on this problem and enjoyed every minute of it.(Illus 7-1, Edison in chemical lab, 1908.) This area of research remained the vital part of phonograph technology into the twentieth century. The major development paths for phonograph technology--increased playing time and more fidelity--were dependent on a harder wax of the cylinder.

While the basic research on the amusement phonograph was undertaken at the laboratory, the business of the North American Phonograph Company declined. In 1891 only 19 franchisees remained out of the original 33 and their future looked bleak. There were only three companies with high sales and good management, the Columbia, New England, and New York Phonograph Companies. The mainstay of their business was the continued popularity of the coin-in-the-slot machines, which were normally converted Edison phonographs. [15] Lippincott's death in 1891 produced a vacuum in the management of the North American Company that Edison filled. He became president and made Tate vice-president. His first policy was to dismantle the franchise system and replace it by a national sales network.

Illustration 7-1

Edison in Chemical Laboratory

The franchisees were to become sales agents and receive a royalty on every phonograph sold in their areas. The switch to an amusement phonograph technology removed the need for the marketing system built for the business machine; the new amusement market could be reached directly and involved far less sales support. Edison's goal was to sell phonographs directly from the Phonograph Works to anyone who wanted to market them.[16]

Phonograph sales remained very low up to 1892 with most sales in the coin-in-the-slot market. Edison energetically promoted this use by direct sales to saloons, hotels, and restaurants. A typical Edison coin-in-the-slot machine cost $250 outright and could bring in up to $15 a day. Sales began to increase in the latter part of 1892, moving from 20 to 90 machines a month sold. [17] In his original concept of a phonograph industry, Edison had expected profits to come from the sales of machines. His experience in the 1890s made him consider the profit of monopolizing the production of prerecorded cylinder records because demand for prerecorded cylinders increased dramatically as the coin-in-the-slot business expanded. Recording was becoming a lucrative operation that would repay the time and trouble of recording with profits--it was estimated that the New York Phonograph Company spent $15,000 on records in the slow year of 1891. Edison had always wanted to monopolize the business of duplicating records but had let the local companies do their own recording because it was too time consuming to do it at his laboratory. In 1892 he moved to gain a monopoly of recording too; he had a large investment in the technology of sound recording and his staff at West Orange were the best in the business--here was another store of knowledge in the laboratory that Edison wanted to exploit.[18] Edison enlarged the duplicating department (for making blank cylinders) established at Silver Lake and prepared for mass production of records. In the meantime, the laborious work of copying prerecorded records continued on the top floor of the laboratory. Production was low--only 160 a day in 1892--and would remain that way until Edison's engineers perfected the duplicating process.[19]

A commercial product was at last in sight by 1893 when Edison exhibited both household and business phonographs. These were called the "M" types and were a direct descendent of the "perfected" phonograph of 1888--the top works remained essentially the same except for the new reproducer (Illus 7-2, Edison with late model Phonograph, 14.655) These machines were solid--weighing at least 50 lbs--and quite expensive, prices ranging from $150 to $200.[20] Development work on several types of phonographs continued at the laboratory while Edison considered an appropriate marketing system for his new machines. He planned to take full control over the North American Company when he was sure that his laboratory had developed an amusement phonograph with mass appeal. By 1894 he was convinced that his new phonograph reproduced music "almost

Illustration 7-2

Edison with Phonograph

perfectly" and confided to a business associate that this was the machine that would popularize the amusement phonograph. [21] He then made his move, instructing Tate to put the North American Company into bankruptcy and arranging to sell phonographs directly from the factory, bypassing the local companies. The National Phonograph Company was formed to manage the nationwide system of phonograph dealers and only the Columbia, New York, and New England Companies survived from the original North American Company franchisees. The price of developing a commercial machine had been high, and the payments from the North American company had not covered the cost of years of experiments at West Orange. [22] Edison now made sure he would reap all the returns of his labors for he kept all profits from the National Company. Once he gained control of the business, two new Edison phonographs were announced.

The first was an improved nickel-in-the-slot machine. Based on the M mechanism, it was battery powered and came with a horn. The second new model was a machine designed solely to play back Edison cylinder records. The phonograph was powered by a spring motor and the distinctive governor assembly of the old models was replaced with a simple belt drive. The machine was equiped with the Edison "automatic" reproducer and a recorder could be bought as an extra. Edison committed his company to the policy of compatibility between old and new technologies and made sure that the new machine could play all existing Edison records. A simple horn was attached to the reproducer to amplify the sound.

The spring motor phonograph had two main controls: a start-stop switch which activated the drive and a screw to retard or accelerate the speed of rotation. Edison had successfully reoriented the existing technology towards the user by simplifying the machine's operation, the user needed only to place the diaphragm on the record. In this way he eliminated many of the operating problems which dogged the business machine. There were still several adjusting screws on the reproducer assembly which were essential for precise reproduction. The spring motor machine was planned to retail at about $40 (equal to one years lease of the old business machine) and was aimed at the mass market.[23] It was simple, sturdy, and solid. The cost of manufacture had been reduced significantly by using many components of the old M type, including the top plate and reproducer holder.

The new models of 1896 were not radically new machines. They were not "inventions" and hardly justified the label of "innovations." Edison commented that the 1896 phonograph was the result of design changes rather than any patentable technology. [23] The all important musical reproducer had been developed by 1893, and all that was left after this was to engineer a commercial machine to exploit the better fidelty gained by improvements in the diaphragm and wax compound. The "perfected phonograph" was not the result of a flash of inspiration but the endpoint of years of basic research in sound and engineering new phonographs.

The latter was to become immensely important in the Edison laboratory; an increasing level of competition in the phonograph business made production engineering work as important as basic research. The National Phonograph Company was not alone in the phonograph industry. The Columbia Phonograph Company had acquired the rights to manufacture graphophones and placed a spring motor model on the market. In Europe, cheap French and German machines were outselling the phonographs sent from the West Orange Works. The Edison spring motor phonograph could not beat the competition in price and the National Phonograph Company was therefore pressed to re-engineer their new product into a cheaper, more competitive machine. [25] The laboratory was put to work on reducing the size and cost of the spring motor phonograph and in two years completed a smaller machine that was introduced as the "Home" model. It was a more compact phonograph, with the same reproducer and controls, but with a much smaller spring motor. This greatly reduced the bulk of the Home model which was approximately half the weight of the earlier machine. It retailed at $40 but still could not compete with the $25 Columbias. The Home phonograph, however, had Edison's name on it and quickly became a best seller. It was a step closer to Edison's goal of a phonograph in every home.

The success of the "Home" phonograph did not bring an end to the R&D on the phonograph at the West Orange laboratory for the picture at the end of the 1890s is of an enthusiastic exploration of all aspects of the basic phonograph idea. Edison even resurrected the toy doll experiments now that he was free from the Toy Doll Company; the idea of a very small, cheap phonograph mechanism still had an appeal to him. Much of the research effort on the phonograph was conditioned by the unexpected success of the kinetoscope. Edison now knew that his promised system of talking pictures--his original intent in the first experiments--had a large potential audience. Much of the experimental groundwork for sound motion pictures had been already done. The experiments on increasing playing time and producing a louder playback had payoffs in two markets; these features were desirable in an amusement phonograph and absolutely essential in sound pictures. Edison's exploration of the qualities of larger cylinders also promised solutions to several problems in different products. This experimental direction was therefore accelerated in the late 1890s as Edison anticipated returns in both talking pictures and long playing "concert" phonographs.

COMPETITION IN THE MOTION PICTURE BUSINESS

The work of producing talking pictures had been shelved in the early 1890s when Dickson and Edison finally realized that the problems involved in the synchronization of sight and sound were totally beyond their experimental resources. Edison returned to the problem after Dickson's departure in 1894. The next year Edison introduced the kinetophone. This was a kinetoscope with a cylinder phonograph added to the basic kinetoscope case. The viewer looked through the peep-hole to see the image and listened to sound on eartubes. The films were shot in the "Black Maria" using the kineotgraph linked to a phonograph fitted with a large horn to catch the sound. This machine was a stopgap novelty item based on the laboratory's expertise in coin-in-the-slot machines; it is highly unlikely that it successfully synchronized sound and image. [26]

The kinetophone avoided all the important technical problems but did establish the design precedent of a self contained sight and sound system in one machine. Edison's goal was to devise a product that could provide "honest workmen with grand opera at a price he can afford to pay." [27] The logical development of the kinetophone was a machine that reproduced the sight and sound of a live performance. Edison's ambitious goal was well beyond the technological means at his disposal.

The kinetophone had only limited commercial success and few were made. It was soon eclipsed by a new technology in the motion picture business.

Edison has been criticised for neglecting the development of film projection. Many writers on the history of motion pictures portray him as uninterested in this technology and slow to develop a projector that he really didn't think had a commercial future. Edison did, in fact, successfully develop a projector, but his top priority was the synchronization of sound and image. This was a much harder technological problem than projection, and one to which he was committed from the first days of research on the kinetoscope. His goals were much more ambitious than the comparatively easy technical task of projecting images, and his laboratory continued to chase the elusive goal of joining sight with sound.

Meanwhile, several other inventors, many of whom were in Europe, were concentrating on another aspect of motion picture technology--the projection of images. The transatlantic information network that Edison had so successfully exploited in the past now got the better of him. The kinetoscope had stimulated interest in motion pictures and Edison's failure to obtain foreign patents for his motion picture inventions gave European inventors a clear field to advance the technology. The most revolutionary innovation came from the Lumiere brothers in Lyons, France; their Cinematographe was portable and it could be used as a camera and projector. Work on a combined camera-projector was underway at West Orange, but the Lumiere brothers beat the Edison's laboratory to the marketplace. Their camera was light, compact, and could be easily moved, setting up many new possibilites for film subjects.

The introduction of the Lumiere camera in North America gave entrepreneurs the technology to enter into film production and ruined Edison's hope for a monopoly of films. The availability of film cameras unleashed a wave of cameramen/producers, some with imported cameras, some with copies of Edison cameras, and some with machines of their own invention. Many of the new entrants were men of mechanical bent hoping to break into a growing business by working up their own cameras in makeshift laboratories. If Edison had been born twenty years later he would have been one of them. They came from all walks of life and had the same idea of making some money from the motion picture. A travelling showman called William Selig saw the kinetoscope and was inspired to build his own camera in his small workshop in Chicago. The arrival of Lumiere machines in Chicago provided more ideas for Selig, and he went on to produce a camera and a projecting machine. The Selig Polyscope company was soon making films on location in the back streets of Chicago and showing them in Vaudeville houses. [28] Independent cameramen like William Paley, a recent immigrant from England with his own camera, took their cumbersome machines on the road and made the short-lived, flickering films which were the raw material of the new business.

The Latham brothers were typical of the "pirates" that Edison now had to face. They were businessmen with considerable vision who also produced some important technical innovations, with the help of William Laurie Dickson (who left Edison in 1894). They developed a projecting device, called the Pantopticon, in their laboratory in New York City and then exhibited their boxing films with it in 1895. As soon as this development was noticed at West Orange, Edison assigned Charles Kayser to the task of designing a projector superior to the Lathams'.[29] A much more dangerous competitor appeared in the form of the Biograph--the projection machine of the American Mutoscope Company. Formed in 1895, this company had the services of Dickson and its own laboratory, studio, and manufacturing facilities. It originally marketed Dickson's Mutoscope--a peep show machine along the lines of the kinetoscope--but quickly branched into projection. The Biograph projector was again the work of Dickson and its larger film format gave it a superior image.[30]

The proliferation of projection machines in the US forced the Kinetoscope Company (managed Norman Raff and Frank Gammon) into action to revive their flagging business. They saw the future in projecting pictures and when they found a good projector, in the hands of Thomas Armat of Washington, they quickly acquired it. In December 1895 Raff and Gammon brought Armat's machine to the lab and Edison agreed to manufacture the machine at the Works and have it sold as the Edison vitascope. There was good business sense in this as the business community had grown aware of the commercial potential of projection and were waiting for an Edison projection machine. In a letter written to Armat some time later, Edison acknowledged that the Armat machine was superior to the one Edison had at the time. He stopped Kayser's work to build Armat's machine, which was the first commercial projector on the American market.[31]

The debut of the Edison/Armat projector was at Koster & Bial's music hall in New York City on April 23 1896. This was a turning point in the history of the motion picture; interest was again at a high point and the motion picture had found a much larger audience than the customers for peep shows. Visual novelties were commonplace in vaudeville and the vitascope now found a place on vaudeville programs all over the U.S. Businessmen bought franchises from Raff & Gammon and took the vitascope on the road, spreading the fame of the moving picture and attracting more entrepreneurs to the industry. The newspapers, unconcerned with its true provenance, hailed Edison's latest invention as another marvel of the West Orange laboratory. The movies as mass entertainment had begun.

The popularity of the vitascope grew so quickly that Edison had to take notice. While the founder busied himself with planning spectacular train crashes to be filmed, the Kinetoscope department of the Edison Manufacturing Company struggled to meet orders for films. Despite having the largest production facilities in the industry, it could not keep up with the demand for films and had to turn to independent producers to supply them. William Paley, for example, was put under contract to supply films for the Edison enterprise. The impending Spanish-American War had caught the imagination of the American public, with the help of strident nationalism of the Hearst yellow press, and gave a considerable boost to the movie business. William Paley was sent to Cuba to make war films for the Edison company who quickly copyrighted them and put them on the market. These films had instant appeal and were shown continuously in theatres while the war was fought.

The motion picture camera changed politics as well as entertainment. America's "Manifest Destiny" was glorified on film, and Edison--like many of his generation--believed that his country could take on and beat the rest of the world. The great popularity of war films enabled many small producers to gain a foothold in the industry, either by filming their own subjects or illegally copying (duping) the Edison product. The American Vitascope Company staged the Battle of Manila with model ships for their films of the war, advertising them as "original and exclusive war films." [32] For American Vitascope and many other small producers and film exhibitors, like William Selig in Chicago, war was good for business. The wave of patriotism that swept the country helped increase the numbers of film exhibitors at a rapid rate. All needed a good projector, and the West Orange industrial complex was ready to meet this demand. Work on developing an improved projector was carried out in the lab under a veil of great secrecy.

The new projector was the key to the transformation of a novelty to an important industry. This machine signalled Edison's deepest involvement in the motion picture industry to date. In 1897 he introduced his own projector--the Edison projecting kinetoscope which was an improved vitascope. An 1898 Model Edison Projecting Kinetoscope came complete for $100. It could be used to project slides to keep the attention of audiences while the films were changed, and its advertising maintained that the vibration problem, which "has been the principal defect in projecting machines," had been solved.[33] Edison's laboratory had improved the basic projecting machine, made it easier to operate, and now it was on the market at a competitive price. Terrye Ramsey remembered that anyone who could turn a meat grinder could operate the machine.[34] The exhibitor could also purchase "Genuine Edison Films" which were sold by the foot. The ready availability and cheapness of the Edison projector stimulated the motion picture industry as a small investment was all that was needed to become an exhibitor of films. Small businessmen could offer a complete show to the theatre manager: film, projection, and accompanying patter.

Two new industries were being created with the output of the Edison Phonograph Works, providing many small businessmen with the chance to make money with Edison products, and Edison with the profits from sales of equipment. The flood of cheap phonographs, and the end of the franchise system, meant that anyone could create a small business with a store front and a few phonographs. Edison thought that the phonograph was the best business proposition in the U.S. at the turn of the century because it was easy to enter and profits were high, from $100 to $200 a week. [35]

The rapid growth of film exhibitors provided another opportunity for small businessman and a growing market for the Edison Manufacturing Company. In exactly the same way as he had bypassed the franchise holders of the North American Phonograph Company, he left Raff and Gammon high and dry and went into direct sales. Edison intended to sell his projectors to any showman and entreprenuer who could afford it. At the same time he instituted an aggressive campaign to enforce his kinetograph patents and drive all competitors from the field. Edison aimed to control the production of films and sell exhibitors the projectors to show them. The income from film and projector sales would go directly to him. This was an important step in the creation of his own industrial empire. He now had control of the ore milling and phonograph businesses and he owned the company which manufactured several of his inventions, including motion picture cameras, projectors, and films.

The industrial empire had begun to spread out from the West Orange complex. Edison had bought land at Silver Lake, New Jersey as part of his Edison Industrial Works scheme of 1888. When this plan came to nothing he built plants to produce chemicals for phonograph cylinders and Edison-Lalande primary batteries. The growing emphasis on manufacturing made the Edison Manufacturing Company an important part of Edison's industrial empire. It realized his long term goal of a separate organization devoted to manufacturing and marketing his innovations, and it was completely under his control. Unlike his earlier plans for a manufacturing operation, this company was run by Edison without outside investors. Edison's plan to gain full control of the Edison Phonograph Works was the last link in this strategy--the entire Edison manufacturing operation would be in his hands. After years of trials and tribulations, he no longer had to please the investors and venture capitalists. He was now in command of his business affairs and would tend to look to banks for capital rather than obtain it with joint-ventures with investors. The policy of gaining control of manufacturing certainly paid off by the end of the century. The profits coming in from phonographs and motion pictures offset the incredible losses of the ore milling venture. A decade that started with the grand industrial engineering of electric traction systems and ore separation ended with the cheap phonograph and the moving picture, two unlikely products for Edison but welcome nevertheless.

FORCES OF CHANGE IN THE WEST ORANGE LABORATORY

The great adventure of the nineteenth century ended with one last effort to turn the Ogden mine into a paying proposition. A slight rise in the price of midwestern ore encouraged Edison to return to the mine in 1897. He spent most of that year in Ogden, while William Gilmore ran the operation at West Orange.[36] Edison was convinced that he had "almost turned the corner" on the ore milling venture in 1898 and told his business associates that the work was finished. But the cold winter of 1898/99 forced him to stop work and he returned to West Orange, admitting defeat in private while maintaining a brave front to his business associates.[37] This was Edison's greatest failure both financially and technologically; he had been unable to produce cheap ore by his magnetic separation process and had lost a fortune in ore milling. Andrew Carnegie once said that "pioneering don't pay" and the ore separation venture proved him to be right, at least in the iron ore business. Edison's technical approach failed because it was unreliable and too costly. On the other hand, Carnegie followed the old fashioned wisdom of finding the cheapest source of raw materials and locating the plant next to it. Carnegie had achieved what Edison had only dreamed about--the radical reduction in the cost of producing a basic industrial good.

Undaunted by this colossal failure, Edison still continued to promote his system and finance companies to magnetically separate ore. He assigned his patents to a European ore milling syndicate which hoped to make them a success in Norwegian mines. But just like at Ogden, the giant undertaking at Dunderland ended in failure. After leaving Ogden for good, Edison went back to the laboratory and looked for ways of recouping his loses. His laboratory had developed skills in several commercial technologies which Edison hoped to exploit. He worked on the design of commercial crushing and screening machines, and planned to sell them to coal mines, cement manufacturers, and metal works.[38] Edison soon went into the cement business for himself, using equipment designed in his laboratory and experience gained in materials handling at Ogden. His efforts to make the most of the failure in ore milling illustrates the broad scope of his commercial outlook and the laboratory's strong engineering skills. He even found a use for the compressed air technology he developed to run his giant rollers. The lab carried out experiments on reheating compressed air and using it as a power source.

Had the mill at Ogden been a success, Edison's reputation as an inventor would have been superceded by his fame as an industrialist. His "rags to riches" story would have reached a new plateau from the immense profits of providing a cheap raw material to one of America's greatest industries. The years of the electric light would have paled against the wealth and power of his ore milling business. The end of this dream might have broken a lesser man, but Edison took the dissapointment with his customary good humor; he had other irons in the fire and he was, as usual, full of ideas for new projects. The failure at Ogden did not even tarnish his reputation--the vitascope had reaffirmed to the American public that Edison was still the "Wizard" capable of producing amazing new inventions.

The air of failure that shrouded the ore milling venture led to more cautious decision-making at West Orange at the end of the century, yet Edison's laboratory kept a much wider technical horizon than the new industrial research laboratories that were directed into proprietory technologies to achieve corporate goals. Edison's experimenters had a much wider choice of options to follow because they had covered so much ground in many different areas. Edison treated the years of experiments at the lab as investments in carefully chosen areas of technology, and any new experimental direction was determined by the store of experience and expertise at the laboratory.

The development of an alkaline storage battery--Edison's first experimental project of the twentieth century--was built on the strong foundation of years of research on electrochemical cells. The pressing requirement of a power source for the phonograph led to experiments on both non-rechargeable primary batteries and rechargeable storage batteries. These experiments began as soon as the laboratory opened and were continued through the 1890s. The West Orange laboratory staff had also considerable experience in the engineering of battery manufacture. The Edison Manufacturing Company produced thousands of Edison-Lalande primary batteries which were used to power phonographs, railway signals, and medical equipment. Every effort had been made to economize and streamline the production of cells at the Silver Lake complex.

The decision to find a better storage battery was not an act of incautious haste as Edison rebounded from the ore milling failure, but a rational decision based on the available resources of the laboratory and the commercial potential of the innovation. It did not begin with a unstructured search of every possible electrochemical combination but with the usual study of the technical literature.[39] Edison guided the project along familiar lines and across familiar territory. He was not charting new ground; he was convinced that an alternative to the lead-acid cell did exist and could be found "if a real earnest hunt were made for it."[40] The lab's staff were knowledgeable about the chemical reactions in cells and all the equipment was at hand. (See Sidebar on "The Changing Research Process at West Orange.")

From 1900 to 1909, Edison spent much of his time working with chemists in the search for the ideal electrochemical combination. Commercial considerations were uppermost in these experiments; as each electrochemical combination was tested, the experimenters also evaluated the cost and availability of its raw materials. Two promising combinations--one using cadmium and another employing cobalt--were rejected because these metals were too expensive to use in quantity.[41] Edison knew well that the commercial success of his battery depended on finding a cheap and efficient electrochemical reaction. He also emphasized economical manufacturing techniques. While the chemical research progressed, Edison had his men design special -purpose machines for each step in battery production. This work drew on his staff's experience in battery manufacture and ore milling. Since the storage battery required both powdered nickel oxide and ore, Edison's men were able to apply many techniques used in handling and processing crushed ore. [42] With this experience behind them, his staff were able to move the battery rapidly from laboratory bench to factory floor, providing the speed and flexibility demanded by the "old man."

Most of Edison's workers were expected to be able to carry out both research and everyday engineering. A typical report by A.M. Kennedy, an experimenter assigned to the motion picture product, covers work on a film splicing machine, film cement, and methods of sealing film cans. He designed a rheostat for kinetophone road shows, and a guide for lining up the sprockets of the machine with the aperture. Kennedy's experimental work for the same period included recording of kinetophone subjects and changes in lighting to make the figures stand out better in movies. He also inspected films.[43]

The daily work of experimenters like Kennedy shows that little had changed in the Edison laboratory from the 1880s. Yet a new direction in labor policy had begin at the the turn of the century when employees with specific skills and formal education were sought instead of the generalists of the nineteenth century. The lab was moving away from hiring generally trained experimenters towards professional engineers with commercial experience.

A new generation of workers were beginning to make their mark at West Orange, symbolizing the evolving functions of the laboratory in the Edison enterprise. Although mechanics like the Otts were still at Edison's side, providing a link of continuity with the past, there were many new faces at the lab in the late 1890s. The older generation of Edison associates was spent and a new one emerging, very much different. The ranks of the "boys" steadily diminished in the 1890s when several muckers went their own way and left Edison's employ. Edison had once commented that the "boys" worked with him for fame and fortune. Many of them saw their main chance in the 1890s and left the lab: Batchelor quietly disappeared from the scene and devoted himself to travel, looking after his health, and carefully tending his investments; Kennelly left to become Professor of Electrical Engineering at Harvard. Samuel Insull took a job a Chicago Edison and A.O. Tate resigned.

W.K.L. Dickson was a typical Edison employee of the nineteenth century--an ambitious young man of considerable skill as an inventor who hitched his star to Edison's. In 1894 he left the laboratory to join in the Latham Brothers. He took his laboratory notebooks with him and provided the new company with his considerable experience in motion pictures.[44] Dickson was not the only Edison employee to leave West Orange and take his technological knowledge to a competing company; skilled men could command high wages for their specialized knowledge and many were hired away from West Orange.

In place of the independently minded men who blended technical with entreprenuerial skills, Edison hired professional engineers and promoted the faithful. Fred Devonald had worked his way through the hierachy at West Orange and owed everything to Edison. He was finally made chief engineer but Devonald was only in nominal charge of the laboratory; Edison made all the important decisions. During the 1890s Edison began to make distinctions between technical considerations and business decisions. The latter were taken out of the hands of the technical staff (who had once been forced to wear both hats) and given to professional managers.

William Gilmore was brought in to manage the National Phonograph and the Edison Manufacturing Companies in 1894. He had been Insull's assistant at Schenectady and had been schooled by the Insull in the intricacies of the "old man's" business affairs. Edison put him in charge of his finances and told him to make some order out of the diverse operations at West Orange. Gilmore brought his great energy to bear on this problem and stamped his forceful manner on the management of the Edison Manufacturing Company. Tate's place as Edison's secretary was taken by Johnny Randolph, who had started as an office boy in the 1880s. Although Gilmore, Randolph and Devonald wielded considerable power within the organization, they were not given the same broad responsibilities as the old "boys" and they were constantly harried by the founder. They were employees. When their usefulness was over they were discharged.

SIDEBAR

THE CHANGING RESEARCH PROCESS AT WEST ORANGE

Much has been written over the years about Edison's method of invention. Most accounts have pointed out that Edison began with a specific commercial goal in mind and that he had his men conduct literature searches and market surveys. Some historians have claimed that Edison conceived and conducted his research efforts in a rational and systematic manner while others have insisted that his approach was much more random, shaped by inspiration and luck.[1] The storage battery project reveals that some of the elements of the rational Edisonian methodology are true, but more importantly, it shows that his approach evolved. In particular, as the size and cost of some of his projects increased, Edison was less inclined to rely on a handful of talented experimenters and instead chose to routinize the research process. In the course of this evolution, the West Orange lab moved gradually away from the free-wheeling style of Menlo Park and began to resemble some of the other corporate research laboratories that appeared in the early twentieth century.

Edison started his hunt for a new battery in 1898 not with random experiments in the laboratory but with a thorough search of the technical literature. Just as he had done during the electric lighting campaign, Edison had his assistants pore over scientific and engineering journals to collect information about all types of batteries. At his insistence, his staff cast a worldwide net, consulting not only American but also English, French, and German sources. Through this search, Edison learned that other inventors and scientists had identified alternatives to the lead-acid battery and kept their work in mind as he undertook his own investigations.[2]

After searching the literature for about nine months, Edison was ready to begin experimenting. In the spring of 1899, he assembled a research team by selecting men already at work at the lab and by hiring a new group of professional chemists and engineers. Significantly, with its preponderance of experimenters trained in science, the storage battery project differed from previous inventions in which Edison had used a mixture of college men and mechanics. Consisting of about a dozen experimenters, this team worked primarily in Building 2, where each man was assigned a table. For his own experiments, Edison set up a laboratory bench in the back room of Building 2. Large supplies of chemicals were purchased and stored in Building 3 and on the third floor of Building 5.[3]

Edison started this team off by having them investigate the familiar electrochemical combination of the primary battery. From there, Edison had his researchers vary one component of the cell and conduct tests until they obtained optimal results. Generally, Edison and his assistants tested different materials for the components of the cell by packing the selected material into porous carbon electrodes which were then placed in a test tube filled with the electrolyte, thus forming a small battery.[4] Following this strategy, Edison and his staff investigated several different electrochemical combinations from 1899 to 1904, and this research program is summarized in Table 1.[5]

This table shows that in taking this time-consuming, step-by-step approach to analyzing each component of the battery, Edison was organizing his research in a new way. In particular, he was dividing the project into a new set of tasks. Previously, Edison had used teams of experimenters to pursue simultaneously several different solutions to a technological challenge. For instance, with the electric light project, Edison and his men moved easily from working on the lamp to the dynamo to the meter; he designed a coherent system, in part, because his team worked on all fronts at once.[6]

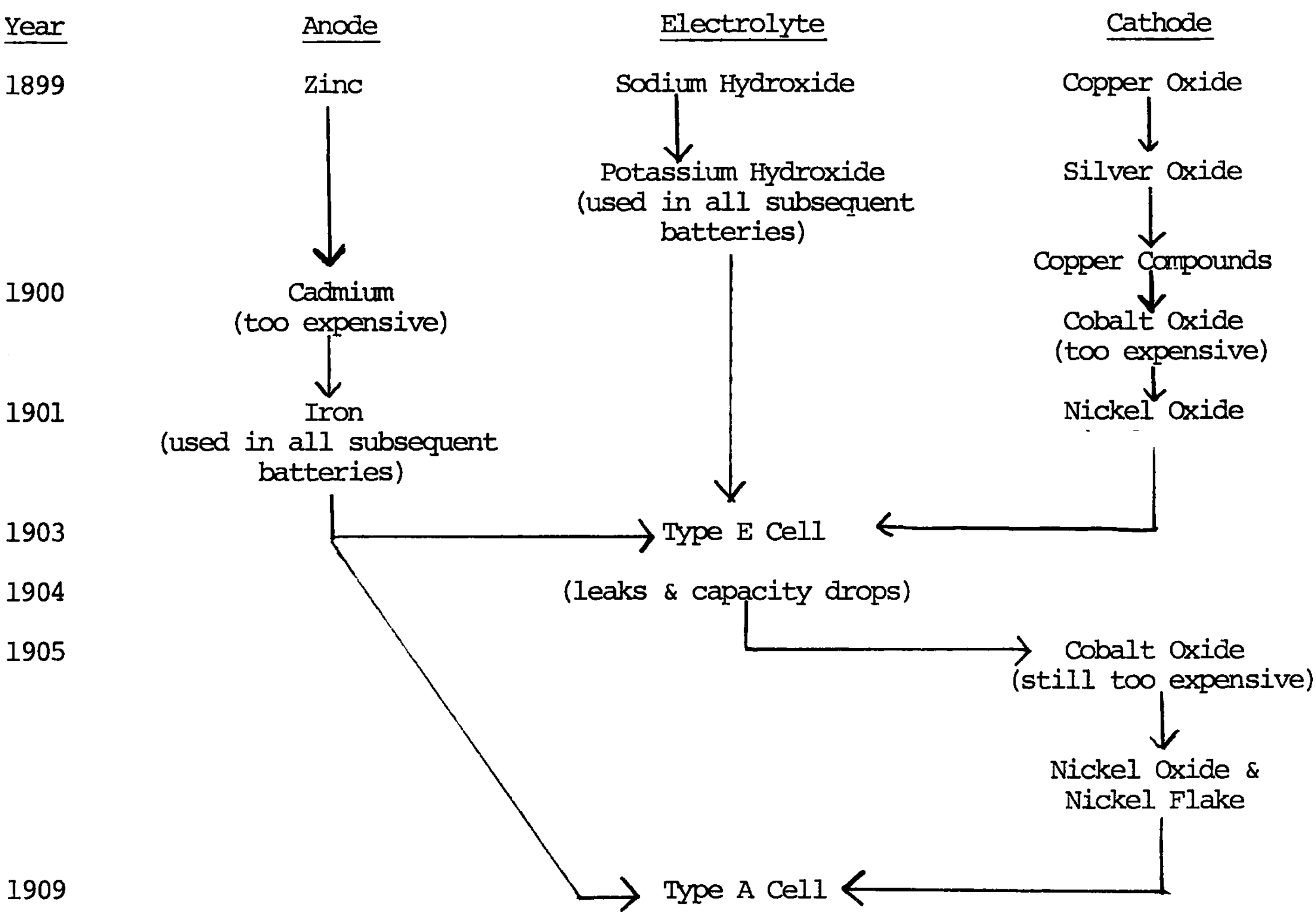
Likewise with the phonograph in 1888 and 1889, Edison and his experimenters did not systematically modify each component in an orderly sequence but rather experimented simultaneously with record cylinders, recorders, reproducers, and duplicating techniques.[7] In these projects, Edison allowed his experimenters to pursue divergent solutions to different aspects of the system, thus encouraging a range of creative responses. Eventually, Edison gathered these different ideas and shaped them into a coherent and successful invention.

In contrast to this free-wheeling and divergent approach,

Table 1

Flow Chart of Edison's Research

on the Storage Battery, 1899-1909



Richard H. Schallenberg, Botted Energy: Electrical Engineering and the Evolution of Chemical Energy Storage. (Philadelphia: American Philosophical Society, 1982), 355-366.

Edison organized the storage battery project as a convergent set of tasks. Rather than turning several imaginative muckers loose on the battery, he had his team thoroughly investigate each component of the battery. To each experimenter Edison assigned a specific material or arrangement, and the experimenter then conducted a long series of standard experiments until he secured the best possible results. Edison reviewed the results of different chemists and chose the material for that particular component. Edison and his team then moved to the next component or problem and attacked it in the same way. Proceeding in this manner, Edison thoroughly investigated several electrochemical combinations and determined the one best suited to his purposes. Furthermore, he was able to build on the results of one series of experiments, and thus converge on an ideal design for his battery.

While this convergent approach produced highly reliable results, it came at the price of requiring a huge number of individual experiments. According to one experimenter, the storage battery probably required over 50,000 experiments.[8] Yet even more significantly, this approach indicates that Edison had thoroughly routinized the innovation process. By breaking down the research into a sequence of small, standardized experiments, Edison had shifted the creative act away from mechanical ingenuity and careful observation to being based more on persistence and careful record-keeping. Gone were the last vestiges of the heroic myth of invention in which insight comes in a blinding flash; instead, results came by plodding through innumerable experiments.

In shifting from a divergent to a convergent style of research management, Edison's role within the laboratory changed. While previously he had been just "one of the boys" or the "head mucker," in the course of the storage battery campaign he clearly became a manager of R&D. To be sure, Edison performed his own experiments on the battery, but his major task was to coordinate and manage the project. Like the prinicipal investigator of a modern research project, Edison was responsible for monitoring each individual experimenter's line of research, identifying general trends, and shifting chemists to the most promising leads. He also regularly compared the laboratory results with commercial considerations, watching for the right combination that could be put into production quickly. In functioning as a manager, Edison altered the character of the invention process at West Orange. No longer was invention a mysterious, seat-of-the-pants proposition; instead it was an orderly, painstaking process which slowly but surely got results. In many ways, the convergent approach was probably appropriate for the large scale of West Orange since it permitted Edison to make efficient use of his large staff and substantial facilities. In a certain sense, the orderliness and routinization indicate that Edison had rendered the invention process predictable and manageable.

Significantly, as Edison grew older and "retired" from actively managing the lab and his business enterprises, it was the convergent approach that was institutionalized at the lab. The chief engineer and other Edison executives increasingly organized research along the lines of the storage battery project. They hired additional scientists and engineers and assigned them to the tasks of testing the materials and components of different Edison products. Because they were concerned primarily with maintaining the existing product lines and the overall business organization, Edison managers encouraged researchers to take the convergent approach and concentrate on modest improvements.

In this way the West Orange laboratory came to resemble the R&D labs established at other business firms. During the 1900s, General Electric, AT&T, and DuPont phased out individual inventors and gradually replaced them with professional scientists and engineers who took responsibility for technological innovation. Like the Edison organization, these firms had substantial administrative structures, established product lines, and sizable production facilities; while they often wanted new technology to maintain or expand market share, these companies frequently wished to avoid inventions that would suddenly render them obsolete. As a result, the newly hired researchers were often encouraged to work within existing product lines and modify products incrementally.[9] Given this outlook as well as the scientific training of many of the researchers, it is not surprising that many R&D labs took up a convergent research methodology, marked by numerous experiments and small innovations, much like the style that evolved at West Orange. Thus rather than being an unproductive anachronism centered around an aging inventor, the West Orange laboratory came to be very similar to the corporate labs, successful because Edison developed a research style that made technological innovation a reliable component of business strategy.

ENDNOTES

1. Frank L. Dyer and T. Commerford Martin, Edison: His Life and Inventions, 2 vols. (New York: Harper & Brothers, 1910), 596-628; Thomas P. Hughes, "Edison's Method," in Technology at the Turning Point, ed. W.B. Pickett (San Francisco: San Francisco Press, 1977), 5-22

2. Schallenberg, Bottled Energy, p. 353.

3. Shop order 935 "Storage Battery (Personal TAE)," June 1899 in N871124; "Minutes of the Mucker Society of Thomas A. Edison Laboratory at Orange, N.J.," Cat. 1269, 215-217; N020617.

4. N990606; TAE's sketch for caveat, 4 Apr 1900; Dyer & Martin, 556; N000123.

5. In reviewing Table 1, it is important to note that the chemical research on the battery was enormously complex and beyond the scope of this study. Those wishing to know the complete story of this chemical research should consult Richard Schallenberg's fine study of the battery, Bottled Energy, pp. 355-364, for a thorough discussion of Edison's chemical investigations with regard to the storage battery.

6. Friedel and Israel, Electric Light, pp. 3-88 and 119-145.

7. Mark E. Ham, "Edison and the Phonograph, 1877-1889," 10.

8. "Storage Battery Work," Meadowcroft Box 66.

9. Leonard S. Reich, The Making of American Industrial Research.

ENDNOTES FOR CHAPTER SEVEN

1) Albany Herald, 3 Nov 1895.

2) Josephson p. 423.

3) Annot on Fish letter Oct 11 1895, 1895 Electricity.

4) TAE to F.P. Fish, 15 Dec 1896, LB 931030, p. 241.

5) TAE to F.P. Fish, 10 Feb 1897, LB 931030, p. 318; Ledger #7 provides details of GE's payments, fluorescent lamp experiments cost over $11,000 from 1896 to 1899, filament experiments cost over $8,000 from 1897 to 1899.

6) See G. Wise, Willis Whitney, Chap 5.

7) Wise, p. 76.

8) Edison saw that the use of wireless communication would be between ships at sea, Electrical World, XIV (sept,1889) 165; TAE annotation on letter of 6 Feb 1893 in Tesla D, notes that wireless communication "may be done someday."

9) Albany Telegraph, 13 nov 1895.

10) TAE to W Bowen, 16 April 1898, X-Ray; Annotation on letter from O. Glasser to Meadowcroft, 9 Dec 1929; lab account books, sub-ledger #6, p. 240.

11) Shop order # 777, a contract for the manufacture of the models was given to one of the lab's machinists.

12) Edison note to Ed United Co, June 16 1893, 1893 phono foreign.

13) Tate to NY Phono Co, 1 June 1892, LB 920309, p. 579.

14) Frow and Selfi, Edison Cylinder Phonographs, p. 134

15) Read & Welch, Tinfoil to Stereo, p. 50.

16) TAE to Gouraud, 22 March 1892, LB 920304, p. 131.

17) Tate to Edison, record plant, 9 Jan 1893, 1893 phono.

18) Proposed letter to NE Phonograph Co, 1892 Phono; Tate to TAE, 13 Jan 1892, ibid.

19) Tate to TAE, 19 Jan 1892, 1892 Phono, EPWks.

20) Frow & Selfi, Cylinder Phonographs, p.19.

21) TAE to N Block, ND 1894 phono, Russia.

22) Edison claimed to have tens of thousands of invested in phonograph R&D in the 1890s which were called excessive in the various court cases fought over his phonograph business. In 1895 he claimed to have spent all the money he received from the phonograph companies on experiments and threw $45,000 of his own money into the pot. Evidence in American Graphophone vs Edison Phonograph Works, 25 April 1895, 1895, Phono Ed P Wks.

23) Read & Welch, Tinfoil to stereo, p. 63.

24) TAE to United Phono Co, 19 April 1897, LB 931031, p. 406.

25) German co to Ed United Phono Co 18 July 1896, Phono Forg Germany; Minutes of NPC meeting 9 july 1896. NPC.

26) This machine can be seen in a short movie, Walter Cronkite in The Twentieth Century series: "The Movies Learn to Speak."

27) St Louis Republican 3 July 1899, F Chrisman interview, 1899 Phono: "My kinetophone will provide "honest workmen with grand opera at a price he can afford to pay."

28) Ramseye, Million and One Nights, chap 26.

29) F.R. Fulton, "The Machine," in Balio, American Film Industry, p. 39.

30) Ramsaye, Million and One Nights, chap 16.

31) Annotation on T Armat to TAE, 11 May 1922, biog file.

32) C. Musser, "American Vitagraph," in Fell, Film Before Griffith, pp., 33-34.

33) Brochure for Edison projecting kinetoscope in primary printed.

34) Ramseye, p. 328.

35) TAE to R Miller, 2 Dec 1897, LB 931031, p. 612.

36) J Randolph to J Haines, 29 Dec 1897, LB 931031, p. 626.

37) TAE to Walter Cutting, 26 Oct 1897, LB 931031, p. 567; TAE to H. Dick, 12 Jan 1899, LB 980131, p. 319

38) Agreement with W S Pilling (& Crane) 1899, LB 980131,p.413.

39) Edison wanted to avoid the lead-iron combination because the patents were held the Electric Storage Battery Company. He again exploited the international information network by analyzing the progress of the Swede, Waldemar Jungner, who was developing a nickel-cadmium battery.

40) Dyer & Martin, Edison, p554.

41) Richard H Schallenberg, Bottled Energy: Electrical Engineering and the Evolution of Chemical Energy Storage (Philadelphia: American Philosophical Society, 1982), 357-358, 362.

42) TAE to Dick, n.d., 1903 TAE handwriting; TAE to Herter, 19 July 1901; TAE notes, n.d. 1907 Storage battery experimental.

43) A Kennedy to Hutchison, 11 Mar 1914, Motion Picture.

44) Claims were made that Dickson took his notes with him when he left during Edison vs American Mutascope trial, complainants record legal box 173. Edison said that Dickson was guilty of "double crossing me and selling me out to Latham for his own benefit." annotation on letter from T Armat, 11 May 1922, biog files.

CHAPTER EIGHT

AN INDUSTRIAL EMPIRE

Edison and his managers had every reason to be optimistic about the new century; the phonograph business had finally taken off and they were in a strong position to dominate motion pictures. The Edison Manufacturing Company was the foremost manufacturer of films and projectors in Europe and the United States. [1] Edison now saw his 1893 motion picture invention in the same class as his incandescent lamp. Taking a leaf out of the book of the Edison Electric Light Company, the Manufacturing Company energetically defended its patent rights. A court decision in 1901 upheld Edison's original patents and put his Company in an unassailable position to control the production of motion pictures; the patents could now be used to drive the competition from the field. "We have won" crowed the Edison Manufacturing Company, convinced that only they had the right to manufacture films and cameras. [2] Edison had given the public light, and now he was giving them entertainment; films and music for the masses would surely be more profitable than electric light and much less trouble!

The explosive growth of the phonograph and motion pictures at the turn of the century revived the West Orange complex and encouraged Edison to pursue an ambitious policy of expansion. (Illus 8-1) The year 1900 began with a labor force of 700 and by the end of the year Edison's secretary estimated that 1000 men were employed in the Works and 150 in the laboratory--a significant increase over the work force of the 1890s [3]

The experimenters and machinists at West Orange were busy with many different projects, ranging from a new electromagnetic meter to developing an alkaline storage battery to testing new kilns for manufacturing Portland cement. To undertake these different projects, Edison and his men reorganized several of the buildings at the laboratory and added new ones. Building 4, which had been the site of the ore milling research, was converted for experiments in duplicating record cylinders. Building 2, the chemistry lab, became a beehive of activity with a dozen chemists assigned to finding a lighter alternative to the lead-acid battery. Edison had decided to apply his electrochemical expertise to the newly developing automobile market. From 1895 onward, America entered into an automobile craze, with the popular press celebrating every invention related to the automobile. Edison too was fascinated by the potential of a self-propelled vehicle and as early as 1896 he had the lab experiment with a motorized tricycle. Believing that the future belonged to the electric car, Edison set out to develop a battery for it that was lighter and more economical than the traditional lead-acid battery. A garage was erected in the main laboratory yard to

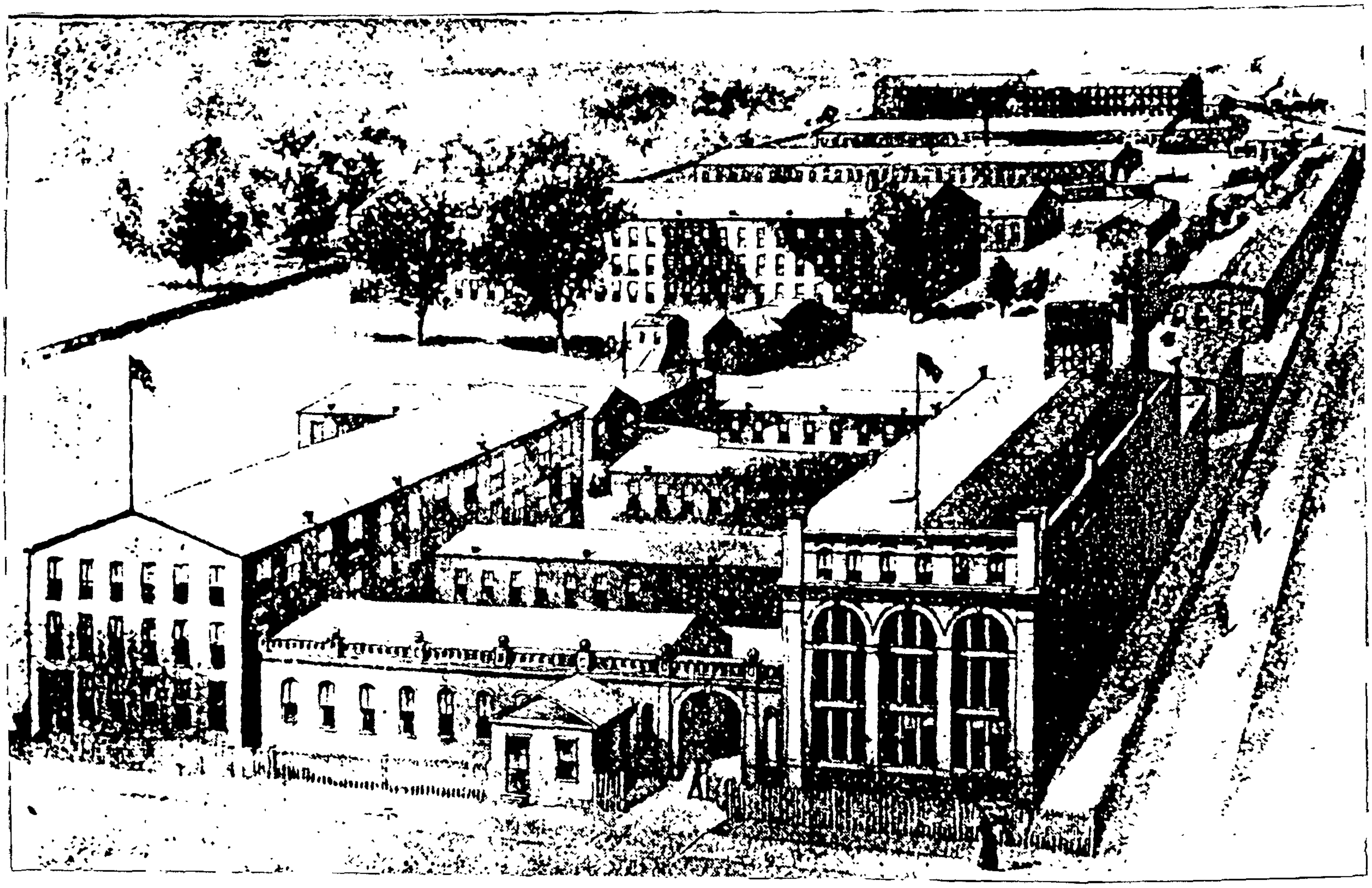


Illustration 8-1

West Orange Complex around 1900

(Artist's Impression)

accomodate the growing number of vehicles used in battery tests.[4]

Edison's great expectations for the storage battery business were further reflected in a rush program of creating new companies and building manufacturing facilities. The chemical works at Silver Lake were enlarged and a small laboratory was established there for conducting research on processing the basic materials needed for the storage battery. To assemble the battery, the Edison Storage Battery Company acquired an old brass mill in Glen Ridge, New Jersey.[5] This battery plant was only one addition to a growing industrial empire which was spreading its operations far from West Orange. Another far-flung enterprise was the Edison Portland Cement Company, which Edison organized in order to exploit the crushing machines and material-handling equipment he had developed in the ore milling project. After acquiring substantial deposits of limestone (the basic raw material for Portland Cement) in Western New Jersey, Edison had this company build a huge processing plant in Stewartsville, New Jersey. The scale and layout of this plant owed a great deal to Edison's experience at Ogdensburg; it contained numerous automatic machines and conveyor belts.[6]

The demands of the motion picture business led to the enlargement of the manufacturing plant at West Orange, and the construction of special facilities outside the complex. The increasing length of films and generally bigger film productions justified the construction of a studio on 21st Street in New York, the artistic center of the country, to make films. In both the motion picture and phonograph businesses it was found desirable to site studios close to the artistes and not force them to come to West Orange to perform. The laboratory played a critical part in the expansion of the Edison enterprise: The center of this sprawling industrial empire was the main laboratory building in the West Orange complex. The laboratory staff were not solely concerned with R&D; they planned the layout of new factories, designed the machinery, and often actually made equipment in the lab and then installed it in place. They were particularly busy with the job of creating the large scale facilities to produce storage batteries.

The research orientation of the laboratory in the 1890s was subtly changing to support of the manufacture of new products. The history of the duplication project is the clearest example of this process. Begun in 1888, the experiments had achieved success by 1891, when matrices were used to make records. The process involved coating the master with graphite and then electroplating a thin layer of gold on it. This matrix could be used to mould thousands of duplicates. Tate naturally expected that this duplicating process would be quickly put into operation, but he was wrong. [7] Edison's staff, especially Charles Wurth and his son Al, spent the next ten years trying to get a better quality duplicate with less unwanted noise. Edison insisted on a perfect duplicated sound, free from distortion and surface noise. He thought that the records made by other companies were low quality products with poor fidelity, and planned to enter the business with a superior record.

The Wurths' work on duplicating records could not remain exclusively in this narrow field because the overall goal was a better sounding duplicate. Charles Wurth subsequently spent much of his time experimenting in recording techniques and the design of recorders. In order for the masters to be improved, the recording process also had to be improved. In addition to the elimination of crackles, swishes and other surface noise, Wurth, Miller, and Aylsworth devoted many hours in experiments to get more volume from the playback. The West Orange laboratory was at the leading edge of phonograph technology because the layout of the laboratory, and the flexible organization, facilitated the cooperative efforts of three specialists in their respective fields.

As was customary in the Edison laboratory, the successful conclusion of the experimental project was followed by further experimentation to streamline the manufacture of the new product. In 1899 the laboratory staff were successfully using the matrices to make duplicates, but the work went on to eliminate the bugs in the moulding of duplicates.[9] It was not until 1901 that the commercial production of records began. The laboratory staff executed a shop order to double the capacity of Wurth's trial plant and began to design the automatic machinery for the duplicating facilities Edison planned.[10]

In 1902 The Edison Phonograph Works made nine phonograph models, their prices ranging from $10 to $100. [11] Ten years earlier Tate had seen that the business of selling machines was based on the availability of reasonably priced records. [12] In 1892 the records had been high priced and low quality. By 1902, with phonograph sales soaring, the National Phonograph Company could now deliver the right product at the right time. Output of records was 25,000 a day in 1903 and rising rapidly. The return on years of experiments in duplicating--carried out without interruption since 1888 according to Edison--had now paid off; the moulded cylinder records that sold for 50 cents, cost only 7 cents to make. [13]

Edison's phonograph business had moved from amusement parlors to the living rooms of average Americans. The first decade of the twentieth century marked the transformation of a novelty into an article of mass consumption, and one part of a diversified business to the core industry of the Edison enterprise. Phonograph sales in the 1890s started from a ceiling of $25,000 per annum and reached a quarter of a million dollars per annum by the end of the decade. Each year of the twentieth century brought an increase in sales. Edison realized the dream of one of his machines in every home, announcing that "There is no family so poor that it cannot buy a talking machine." [14]

The success of the amusement phonograph encouraged Edison to return to the idea of a phonograph for the business user. In 1903 he announced that a business machine, called the Edison Commercial Phonograph, was being developed at the West Orange laboratory. The years after 1890 had produced some important technological advances in the phonograph and some of these advances, such as better arrangements of the controls, could be applied to a phonograph for business use. The Edison business phonograph was formally unveiled in 1905. It was basically a modified amusement phonograph, rather than a completely new design, and still came in a handsome oak case.

The 1906 sales year broke all records for sales of phonographs and recorded cylinders. The Edison Phonograph Works was turning out 1000 machines and 100,000 cylinders every twenty-four hours but this still was not enough to meet demand.[15] This explosive growth of the phonograph business made its mark on the West Orange Complex which underwent a massive expansion program. The many shacks, lean-tos and other temporary structures--the architectural heritage of "research for hire" in the nineteenth century were swept aside and several new buildings were constructed from 1900 to 1906.

The first to be built were the facilities to produce records. Extensions were added to the back and sides of the Phonograph Works and a separate building to make records was constructed parallel to the laboratory on its North side adjacent to the ends of the satellite buildings. It was 240 feet long and by 1906 five storeys high. Building 24 (as it was called), contained the equipment to mould the records and also rooms for testing and experimenting. Edison could sometimes be found carrying out experiments in this building. A new front facade was erected to the Phonograph Works, crossing the T of the West end of the buildings. (See Illus 8-2, 10.380 # 9105.) The power house was re-sited at the end of this new structure which provided a massive concrete surround to the old wooden phonograph works, greatly enlarging the floor space of the Works and accomodating the growing work force which had swollen to 4000 by 1908. At the same time the Phonograph Works was enlarged, Edison began the construction of several large factories to make storage batteries across from the laboratory on Lakeside Avenue. [16]

A new office building was completed in 1906. It stood next to the laboratory on Lakeside Avenue, an easy walk from Edison's desk in the library. Four storeys high and 137 feet long, the new building housed all the office workers of the Edison companies. The National Phonograph Company was the core Edison enterprise and it occupied most of the administration building. It handled the sales of phonograph products and coordinated the flow of parts and materials through the Phonograph Works. As the phonograph industry became more competitive, the National Company extended its control of the Edison dealers, moving towards a policy of forcing them to sell Edison products exclusively. The administration at West Orange

Illustration 8-2

The Administrative Building

had to maintain both the morale and obedience of the Edison dealers, and its policy of tight control became well-known in the phonograph industry.

The introduction of new products led to the creation of departments charged with administering sales. A commercial department of the National Phonograph Company was set up to market the new business phonograph in 1905. Its manager was Nelson Durand, an Edison employee since the 1880s who had worked with Edison on filaments. Like many of the new corps of middle managers, Durand had worked his way up the Edison organization. His new department began on a shoe string; it had to use the system of dealers who sold and serviced the Edison amusement phonograph, rather than go to the expense of constructing a separate network. Durand was an energetic promoter of the business phonograph, tirelessly organizing exhibits and arranging demonstrations for potential users. His organization grew rapidly from five people at his New York office in 1906 to seventy-nine employees in nine sales areas by 1907. [17]

The small-scale administration of the nineteenth century was changing into a large organization of specialized departments. The Edison enterprise was moving from the personal endeavor of its founder to raise money for his laboratory to a organization of professional managers running a business that was international in scope. The unprecedented growth of Edison's phonograph business led to increases in the white collar work force at West Orange and the creation of specialized departments. The advertising, accounting, legal and purchasing departments administered a growing number of transactions in the first decade of the twentieth century. Each was run by a professional manager. The creation of specialized functions in the organization had the wholehearted approval of Edison, who viewed this as a more efficient way to do business. He stressed the economy of centralizing all purchasing, for example, into one centralized department that would administer the needs of the Edison enterprise.

The legal department grew out of Edison's close relations with his patent lawyers. It was devoted to obtaining and defending Edison's patents and its work in the 1900s made it a vital part of the organization. William Gilmore had initiated the "patent wars" in the motion picture business and this dominated its affairs until the creation of the Motion Picture Patents Company in 1908. Edison's strategy for this business was for a monopoly based on his patents and the legal department relentlessly harried the competition in the courts, driving many of them from business. The patent position was equally important in the phonograph business where several crucial Edison patents were disputed. His failure to fully protect his duplication and manufacture of records cost him dearly in the twentieth century. The complex legal arrangements of the companies formed to market phonographs in the nineteenth century provided plenty of headaches for the legal department in the twentieth, keeping it busy with financial negotiations and litigation.

The advertising department coordinated the promotion of Edison products nationwide. Edison had been his own promoter in the nineteenth century and had taken the work very seriously. The laboratory still played a significant part in moulding the public's impression of Edison and his work. In the twentieth century the Edison myth was promoted for the same ends but on a much larger scale. The market for phonographs covered all corners of the country and the National Phonograph Company supported newspaper and magazine advertising on a national basis. Marketing consumer durables brought Edison's name into millions of households and the advertising department worked to keep his name, picture, and signature in the public mind.

The growing size of the operation, the diversity of products, and the sheer number of transactions carried out by the Edison enterprises demanded a centralized administration of bookkeeping and information gathering. The accounting department labored in the herculean task of bringing all bookkeeping functions under one organization, and providing the information needed to coordinate production and sales. This department was to become vitally important as the hierarchy of managers grew and made more decisions in the organization; their need for information grew and so did the accounting department. Yet in the prewar years the Edison organization remained small-scale; the accounting department was centered on the work of one man. Walter Eckert did practically all the work of producing balance sheets and statements. [18]

The heads of the specialized departments formed a slim layer of middle management in the Edison enterprise. Many of these men were to become central figures in the business affairs of the Edison companies in the twentieth century. These men answered to Gilmore and sat on the committees which carried out the administration of the National Phonograph Company. They and other middle managers naturally began to work together in running the business. As early as 1908, the professional managers of the various Edison companies were coordinating their actions into an organ of central control. An executive committee was formed in 1908 to manage the business while Gilmore was away. Each head of department was in attendance to deal with business that affected his department, and collective decisions were made on important issues. [19]

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THE FORMATION OF TAE INCORPORATED

There had been little planning in the assembly of Edison's industrial empire. He pursued the policies of diversification and expansion without regard to the overall development of the organization, forming new companies and building factories as the need arose. Each new product led to a new company and often to a new manufacturing facility. This was the case with the storage battery and Portland Cement at the turn of the century. Edison also embraced the strategy of integration, acquiring the facilities to control each stage of production. There were good technical reasons to control the manufacture of chemicals, for example, because Edison's operations in batteries and records required high quality supplies.

Edison's strategy of vertical integration is well illustrated by the storage battery project. In May 1901, as he secured the first promising results in the laboratory, Edison organized the Edison Storage Battery Company which was capitalized at $1 million. With this company in place, he established a battery assembly plant in Glen Ridge. To supply high-quality raw materials for this factory, Edison integrated backwards and established chemical processing facilities at Silver Lake for producing the powdered nickel and iron needed for the battery's electrodes. Not satisfied with the available sources of nickel, Edison took a further step backwards and investigated new sources for nickel. From 1901 to 1903, he undertook an extensive search for nickel mines, reminiscent of the platinum searches of the electric light years and the survey of iron mines made during the ore milling venture. Edison greatly enjoyed the excitement of prospecting for new mineral deposits and he made several trips to the Sudbury district of Ontario during the summers of 1902 and 1903. Edison contemplated organizing his own company for mining and processing nickel ore in Sudbury, but he eventually decided against it since he found it difficult to secure reliable information about the character of the deposits. Consequently, Edison found it easier and cheaper to purchase nickel from established producers.[20]

Just as he integrated backwards toward the sources and processing of the battery's inputs, so Edison also integrated forward toward the marketplace. Edison took a keen interest in marketing the battery, and he worked closely with his salesmen and managers to plan advertising campaigns. Although his chief goal was to become the main supplier of batteries to the electric vehicle industry, Edison also considered manufacturing his own electric vehicle. Unsatisfied with the existing electric automobiles, Edison set out to design his own car and conducted numerous experiments at West Orange to develop a stronger chassis and improve the components of the automobile.

To help with this work, Edison encouraged John M. Lansden, Jr. to develop a delivery wagon or truck and he put the lab's machine shop at Lansden's disposal in December 1904. Lansden subsequently organized the Lansden Motor Car Company and set up a factory in Newark. After advancing money to Lansden for several years and seeing no improvement in the truck, Edison purchased Lansden's company in June 1908 for $35,000. Through closer supervision--particularly with the aid of Chief Engineer Miller Reese Hutchison--Edison hoped that he could force Lansden to improve his product, but he eventually concluded that "Lansden has no ability as an experimenter & allowing him to go ahead is throwing away money."[21] Disappointed, Edison concluded that it was best to concentrate on the battery and let others manufacture the vehicles. Although he was to learn that there were limits to the strategy of vertical integration, he nevertheless pursued the same policy with the phonograph and secured much greater success. He acquired the companies manufacturing the spring motor and eventually even controlled the construction of the wooden cabinets.

The impressive growth of the Edison enterprise came as a result of the phonograph boom at the turn of the century. The optimism and confidence of 1900 was gone by 1910. A series of difficult technical problems in experimental projects, damaging court decisions, and finally a depression in the core business forced attention to the organization of the Edison enterprise. In 1910 it was on the verge of a financial crisis. It was in this atmosphere that the policy of centralization was begun. The laboratory too underwent the rationalization and clarification of mission that marked the transformation of the Edison enterprise into a modern, multinational corporation.

Each of Edison's businesses suffered setbacks after the optimistic beginning of the new century. The first disappointment was in the motion picture business. By 1903 the business was at a low point; the public were tiring of the same film subjects--travelogues and topical films about natural disasters and current events--and the costs of litigation kept profits low. The efforts of the legal department could not prevent the activities of the many independent film makers and exhibitors who crowded into the field. Edison was still not fully convinced that this business was not just a "fad" and Gilmore recognized that it was now "a non-profitable field." [22]

The same intense competition marked the cement business. The Edison Portland cement Company had been successfully started but overcapacity on the industry led to price cutting which eliminated profits. The Company had begun with the good idea of exploiting Edison's patents and ore milling machinery, but it became a financial drain on the organization.

The storage battery project illustrated what could go wrong with an experimental campaign and the great risk of introducing a new product. By 1903, Edison had decided to use an electrochemical combination of nickel and iron with an electrolyte of potassium hydroxide in his battery and he pushed rapidly ahead in manufacturing and marketing this new product. Edison found that this new battery, which he dubbed the Type E, performed better than most of the competing lead-acid cells, but it cost more to manufacture. Nevertheless, the Type E sold well, and 14,000 cells were installed in electric cars and trucks in 1903 and 1904.[23] Unfortunately problems soon appeared in this product. The battery leaked because the caustic electrolyte ate through the solder along the seams of the battery's outer steel can. Even worse was the substantial drop in electrical capacity of the battery after a period of use.[24]

As customers reported these difficulties, Edison realized that he had not fully tested his new battery and he recalled all of the defective cells in November 1904. With characteristic determination, Edison set about finding the bugs which caused the leaks and the capacity loss. While he and his men easily eliminated the leaks by switching from soldering to welding the seams of the battery's outer can, the capacity problem proved far more vexing. Over the next five years, Edison undertook thousands of additional experiments to identify the cause of this problem.[25] Eventually, he traced the capacity problem to the nickel oxide electrodes. During charging and discharging, these electrodes would swell and shrink. Because of this continual change, electrical contact between the nickel oxide granules and the grid pockets was reduced, thus increasing the internal resistance of cell and lowering its electrical output.[26] Edison overcame this difficulty by alternating layers of very thin nickel flakes with nickel oxide in the electrode. To minimize any expansion or shrinkage during charging or discharging, Edison designed machinery which tamped down these layers with a pressure of 2000 pounds per square inch.[27] Edison called this new nickel flake cell the Type A and he began manufacturing it in 1909.

The enormous costs of this research and the construction of a new factory swamped the paltry finances of the Edison Storage battery Company and during the 1900s it became the financial weakling of the Edison business organization. From 1904 to 1909, it had no product to sell and yet it was burdened with the heavy costs of solving the problem of capacity loss. By 1905 it was carrying $154,693 of experimental charges, which was about equal to the value of machinery and tools at both West Orange and the Glen Ridge factory. [28] The financial position of the Edison Storage Battery Company was so poor that Edison decided that it would be unwise to release statistics to credit companies. It was feared that the fragile finances of the storage battery operation would destroy faith in the financial health of TAE Inc.

The failure to get the storage battery right the first time had put an unbearable strain on Edison's personal finances. Edison supported much of the Storage Battery Company through his own pocket, by 1910 its indebtedness to him was $1,300,000, a sum that was more than the capital stock of the company! It was estimated that he invested $1,900,000 in developing the battery and preparing it for manufacture. [29]

The storage battery research had a detrimental effect on both Edison's finances and health. The desperate search to find the bugs in the battery wore him out as he drove himself to the limit to save the project. Experimenting was dangerous work; Edison had been burnt by explosions, gased by toxic fumes, and exposed to radiation in the course of his work. Several of his men had been crushed in ore milling equipment, and one experimenter had died from radiation poisoning. The mental trauma of an unsuccessful R&D campaign also took its toll and Dickson was probably not the only mucker to suffer a nervous breakdown. The pressures of managing the Edison enterprise was too much for Johnny Randolph, who took his own life in 1908.

In 1900 Edison was a sprightly 53-year-old, but his health had begun to deteriorate and the early twentieth century marked a serious decline. He became seriously ill in 1900 and again in 1901. He underwent emergency surgery on an ear infection in 1906 and 1908. Such was the danger of this condition that Edison decided to "retire from commercial business altogether" in 1907. [30] Edison's business associates and the general public were told that he had retired from commercial work and was now going to devote himself to general scientific experimenting for his own personal enjoyment. In 1908 his secretaries announced in their correspondence that "we no longer do commercial work at the lab."[31]

The failing health of the founder presented an immediate problem for the management of the Edison enterprise for there was an urgent need to shape his sprawling industrial empire into an organization that could carry on without him. Edison had filled many vital positions within his companies: chief executive, inventor, chief engineer, and financial manager. Each of these functions had to be delineated and filled with a professional manager who could maintain day-to-day operations of his department if the "old man" were not around. By 1907 William Gilmore was running the Edison enterprise through the managers of each department. His authority extended from the administration building into the laboratory and Works. He instructed his subordinates "to act intelligently and wisely without disturbing or bothering Mr. Edison." [32] The goal of the administration was to keep operations running smoothly while Edison busied himself in the laboratory.

The administration had grown steadily from 1900 in the wake of the boom in phonograph sales. It had slowly evolved into an organization that could run the Edison enterprise in the absence of Edison himself, but the ramshackle nature of his diverse business operations prevented a truly efficient administration. Many of the operations were widely dispersed about New Jersey and New York, and the management of far flung units, like the newly constructed film studio in the Bronx, were free to become "a law unto itself." [33] The complicated legal and financial relationships between Edison's companies meant little organization and few clear lines of authority in his industrial empire. This was not seen as a problem in the balmy days of the phonograph boom, when profits were high, growth was spectacular, and the attention of the "old man" was on research rather than operations. The flood of profits from the phonograph business masked the structural weakness of Edison's empire, and it took a serious depression in this business to bring reform and rationalization to the organization.

The phonograph operation was the core business of the Edison enterprise in the twentieth century. The motion picture business had picked up as a result of the impact of the narrative film--pioneered by Edwin Porter of the Edison Manufacturing Company--and the success of the Nickelodeon theatres. But even the turnaround in this field and the subsequent rise in sales was no comparison with the sales of phonographs and records. The cylinder phonograph business reached its peak in 1907; the results for the first quarter promised a fifty percent increase in business over 1906. In one week in June of 1907, the Phonograph Works shipped 6151 phonographs and 591,000 records.[34]

The phonograph boom was stopped dead by the depression of 1907. What started as a financial panic in the fall of 1907 led to a serious decline in business in 1908 and the National Phonograph Company watched its market share diminish at a rapid rate. Yet all the reasons for the decline of Edison's phonograph business are not to be found in the financial panic

TABLE 8-1

SALES OF EDISON PHONOGRAPHS

(in thousands of dollars)

Sales Year	
1899	756
1900	1120
1901	11053*
1902	1866
1903	2629
1904	3244
1905	4762
1906	6852
1907	7105
1908	4831
1909	3990
1910	3640
1911	2627
1912	2218
1913	3688
1914	4144
1915	6790

*This figure is probably an estimate for total phonograph sales in the nineteenth century.

of 1907; they embrace the broad development of the phonograph industry from 1900 and the changing tastes of its customers. Competition increased steadily in the twentieth century as more companies entered the phonograph market. Foreign manufacturers quickly flooded Europe with cheap phonographs and threatened the American market. The introduction of the disc phonograph challenged the cylinder machine everywhere. The Edison company had to compete with cheap cylinder machines in the mass market and found their more affluent customers choosing disc phonographs. Even after the 1907 downturn was over, sluggish sales and high inventories continued to hurt the company.

More problems followed. The franchisees of the now defunct North American Phonograph Company sued Edison for a share of the profits of phonographs sold in their areas. They claimed that they had been illegally deprived of their franchises by Edison's manipulation of various phonograph companies. A court case dragged on from 1908 to 1909 and it was decided in favor of the franchisees who won $425,000 in damages. In 1908 Edison replaced Gilmore with Frank Dyer. Business remained poor in 1909 and the Edison dealers were becoming restless. Business and profits had still not returned to Edison's phonograph enterprise by 1910 and the National Phonograph Company had to quell rumors that Edison was getting out of the business.[35] There was no blue sky on the horizon. Sales of the Edison cylinder machine decreased rapidly while the disc machines marketed by its competitors were rapidly gaining acceptance and market share: ahead lay fiercer competition and difficult technological challenges. The National Phonograph Company was still the flagship of the Edison enterprise in 1910 but its sales had decreased every year since 1907.

The financial strength of the Edison enterprise was sapped by the failure of the storage battery project. The National Phonograph Company had to help support the ailing storage battery and cement companies which were hemorrhaging funds. It was taking over $100,000 a month to keep the weaklings' heads above water by 1910, and this soon began to put a great strain on the finances of the company, which was also meeting a large part of the laboratory payroll. [36] What was worrying Frank Dyer and the accountants of the National Phonograph Company was that "the earning power of the profitable companies here is not as great as it once was and the expenses of the unprofitable concerns are not diminishing." 37

It was probably the impending financial crisis in 1910 that hastened the creation of Thomas A. Edison Incorporated. The banks on whom the company depended were becoming nervous about extending any more credit. The problem for Dyer was to ensure that the profitable companies had enough funds to develop new products while avoiding financial disaster at the hands of the unprofitable cement, storage battery, and Lansden Electric Car companies. In addition to supporting the weak links of the Edison organization, the National Phonograph Company was also facing the great costs of developing a disc record and improving the battery. The executives of the National Company shared Edison's faith in the ultimate profitability of his storage battery and portland cement, but feared that lack of credit would stop the Edison enterprise completely if drastic action were not taken in 1910. They stressed the need for a sound financial base to support the weaklings and provide centralized management. They appealed to Edison to cut back on some of the highly unprofitable ventures, especially the cement company, and generally economize until the introduction of new products, then in the pipeline, could replenish the treasury. It was going to take time before promising new products could generate enough profits to cover the expenses of R&D that overburdened their financial statements.

Edison had successfully developed the improved A type battery by 1909, but unfortunately the market of electric automobiles had dried up. The internal combustion engine now dominated the automobile and Edison was forced to look for new markets for his battery. (See Sidebar 8-1, Marketing the Battery.) By 1911 the Edison Storage Battery was doing about $60,000 of business a month, yet its start-up costs were so high (a result of the years of R&D) that it had yet to record a profit. [38] The Edison organization had to be placed on a sound financial basis until new businesses such as the storage battery could return a profit. [39]

The development of a professional management structure in the Edison enterprise opened up a new information network. Information about financial strategies, accounting techniques, and company organization flowed between the staff of the National Phonograph Company and its contacts in banking and accounting. Professional accountants were a particularly fruitful conduit of information; they saw a great number of different companies in the course of their work and their detailed financial knowledge gave them valuable insights into organization.[40] Dyer probably originated the idea of a centralized organization and then sold it to the "old man." When Edison finally made the decision to merge several Edison companies in 1910 "to bring them under a single corporation," the National Phonograph Company was chosen to be the core of the new organization. [41] It had the largest administrative staff and its accounting, legal, advertising, and production departments were to be the building blocks of a new, more centralized management. Each product was supported by a department that attended to the paperwork of production and sales. The middle managers were responsible for the economical operation of the departments. A departmental committee for each product was created and here the department manager got together with representatives from advertising, production, and engineering to formulate sales plans and ensure concerted action from all departments involved. This body also listened to complaints concerning the product and took action to correct them. [42] Engineering problems often dominated the departmental meetings as salesmen and production managers strove to direct slender engineering resources towards their individual interest.

The newly reorganized National Phonograph Company was renamed Thomas A. Edison Incorporated and its stated capital was $12,000,000. The new administration added a layer of vice-presidents between the Chief Executive Officer and the middle managers. Edison stood as the President of the new organization, the executive management was carried out by two vice-presidents and a general manager who, with Edison, formed the executive committee which decided on all matters of business policy. The chief executive and general manager was Frank L. Dyer. He had become Edison's chief patent counsel in 1897 before replacing Gilmore in 1908. Gilmore's leaving was part of a dispute over Edison's abrupt dismissal of one of Gilmore's proteges. Dyer was much more suited to the legal maneuvering which played a major role in the Edison enterprise. The monopolistic Motion Picture Patents Company was in the planning stage at this time and Dyer was a suitable replacement for the combative Gilmore. It was appropriate that a lawyer now ran the organization because one of the great challenges ahead was the reform of the complex legal and financial links which bound Edison to his many companies. This had to be straightened out in order to avoid the painful kind of litigation the

National Phonograph Company underwent in 1908, and avoid any embarrassments in the future.

The corporation's initial press release stressed that it was a reorganized, rather than a new company, and that it was the beginning of a plan to bring all Edison companies under one corporation, for the purpose of "business convenience." [43] The National Phonograph Company absorbed the New Jersey Patents Company, the Edison Manufacturing Company, and the Business Phonograph company. Other (less profitable) companies were excluded at this time but gradually assimilated into TAE Inc. Several smaller organizations, such as the Bates Company, kept their corporate identities although TAE Inc. took over their management. TAE Inc. annexed certain functions, like advertising and purchasing, regardless of the legal independence of other Edison companies. The new corporation was financially strong, having $306,069 cash in hand, $349,237 invested, and its accounts receivable exceeded accounts payable by over $750,000. Its surplus of assets over liabilities was $9,752,556. This put it in a strong position to raise more money from banks and maintain financial support of the sickly cement and storage battery companies. One important function planned for the new corporation was that it should be a financial umbrella, supporting the weak members with the earnings of the strong. In 1911 it was due $879,456 from its affiliated companies, an indication of the financial strain of supporting the weaklings. [44]

The creation of TAE Inc. followed in the wake of a phonograph depression and its leaner and more efficient administration was seen to be "the wisest and most generally accepted cure for decreased profits." [45] Its formation provided some immediate financial relief in that one organization could do away with the duplication of functions within several Edison companies and provide cost-effective management. This involved taking away purchasing, advertising, accounting, and advertising functions from smaller companies and incorporating them into the departments of the main administration.

Arranging many jobs into a centralized organization also gave Edison's managers an opportunity to cut costs. The National Phonograph Company had begun this process when the bubble burst in 1907 and they found themselves in a depression. As the Edison Phonograph Monthly admitted, "from an organizational standpoint the depression has been advantageous, forcing us to reorganize and reduce." [46] TAE Inc. was to be the vehicle to bring this process to all of Edison's many business enterprises, and its early years were marked by vigorous reduction of the labor force and white collar workers. The central goal of the new organization was to reduce costs. Among the policies to achieve this end was a bylaw making any order or contract worth over $10,000 subject to approval and ratification by the Board of Directors and senior executives. The consolidation of many functions into one compact body increased the productivity of a smaller white collar work force. According to one historian of the organization, the slimmed-down administration of TAE Inc. was " a splendid example of what a vast amount of business could be accomplished with little or no office overhead." [47]

Changing the name of the National Phonograph Company to Thomas A Edison Inc. also had some publicity value, for Edison's personal reputation was very high; he was becoming an American folk hero in the twentieth century. Frank Dyer noted that the principal reason for changing the name was to "bring home more firmly to the public the fact that this is Mr. Edison's personal business and that his personality stands behind it." [48] Edison's name and reputation were to be of inestimable value in the growing competition in the phonograph and other high-tech markets in the years after 1911, when he became the advertising symbol of the company. There can be no doubt that Edison was the greatest asset of the new company. His patents were valued at $6,000,000 in the statement of the new corporation, and this represented over half its book assets. TAE Inc. was centered on the person, achievements, and future inventive potential of Thomas Edison.

THE COMPETITIVE STRUGGLE

TAE Inc. depended on the profits from two rapidly growing businesses, but unfortunately the phonograph and motion picture industries were volatile and highly competitive. In 1910 they were worth over a million dollars in sales to the Edison enterprise. The continual technological development of phonographs and motion pictures placed a premium on the work of the laboratory which had to counter the innovations of the competition. The "best lab ever" was now pitted against the engineering departments of companies like Columbia and Biograph--small, aggressive and highly innovative.

The technological battle was fought with both fair means and foul. Each side carefully examined the opposition's machines to try to gain the advantage. Edison was not above instructing the laboratory staff to copy the successful engineering of the opposition. Industrial espionage was common in both motion picture and phonograph industries, and it was said that each company mantained spies in the enemy's camp. The West Orange laboratory was now a security zone in the Edison complex, with secret projects going on behind locked doors.

The major technical goal of the competing phonograph companies was an extension of record playing time. The competition was gradually increasing the playing time of records--in both cylinder and disc formats--and the West Orange laboratory had to follow suit. In 1900 Edison's phonograph business was based on the soft wax cylinder that could play for about two minutes. The National Phonograph Company offered a wide range of two-minute selections, with an emphasis on traditional songs and humorous recordings. A longer playing record had more grooves cut into it per inch than the standard 100, and this necessitated changes in the wax of the cylinder (to make it harder), and in the design and weight of the reproducer (to avoid skipping from the smaller grooves). The laboratory staff had been experimented freely in this area since the 1890s, even going up to 400 threads per inch in experimental conditions. The problem here was the reproducer sapphire point skipping out of the groove. The closer grooves also cut down the frequency response because the needle could't fully capture the wide undulations of the bass notes.

The introduction of a 4-minute cylinder by the competition in 1907 not only threatened to cut into Edison's cylinder business but also to promote the sales of machines capable of playing it. This brought a concerted effort by the lab and the rapid introduction of the Amberol 4-minute cylinder in 1908. This was a premature debut of the new technology because the new cylinder was still made of the old wax compound and remained fragile and easily damaged. Repeated playback erased the high notes that were often the appeal of the recording. Edison and Aylsworth had experimented with celluloid--a much harder substance than the stearic wax compound--in the early years of the twentieth century but had not secured patent protection for this area of research. A legal solution was eventually found to this problem by the purchase of rights to foreign patents in celluloid, but until a harder material could be developed Edison's customers were not satisfied with the Amberol cylinders.[49]

Edison's response to growing competition in the phonograph industry was to improve the sound of his phonograph to make it recreate music more realistically. The Columbia Company gave the National Phonograph administration a fright by ruthlessly cutting prices during the first years of the new century. Gilmore confidently wrote to Edison that "I hope you have had good results with your new recorder experiments, and that you will soon be able to produce a much better record, which will offset this very radical move on their part." [50] The laboratory had made a considerable investment in basic knowledge in sound during the nineteenth century and Edison continued to exploit this information base in the twentieth. He tried many combinations of organic and inorganic materials in the reproducer design to achieve the right sound. He found that semi-viscous compounds--goo to the muckers--performed well not only as a seal around the vibrating membrane but also managed to dampen the sound to prevent excessive highs and lows. This line of experiments led to both improved reproducers and better cutters--the tool that incised the sound waves on the masters.

Increasing competition in the phonograph industry led to price cutting of both machines and records. Lowering the costs of production was essential in the phonograph business because TAE Inc.'s products faced a competition which invariably undersold them. Edison reduced the price of his "Gold moulded" cylinder from 50c to 35c in 1904 and the price of his phonographs was steadily decreased in the years before the Great War. The Edison enterprise was able to reduce the cost of its machines but its dominant position at the low end of the market was continually being challenged by even cheaper machines.

Edison considered that reducing the cost of manufacturing high-tech products was one of the strengths of his laboratory. This took the form of separating the machine into its component parts and working on the design of each part to make it easier and cheaper to assemble the whole phonograph. The plan was to produce a standard design and make each part to this standard. Production engineering also encompassed designing the machine tools to be used in the Works and streamlining the manufacturing process to cut out unnecessary (or costly) steps. The essence of mass production as practiced by Edison and his generation of engineers was to reduce the cost of making a product by standardizing its design and organizing long, uninterrupted manufacturing runs. Yet this goal was confounded by the growing line of Edison phonograph models and the practice of making design changes; the Edison Phonograph Works was called upon to manufacture a bewildering range of machines. Edison had a policy that his customers should not be left with obsolete machinery, and subsequently each new model or design change was accompanied by a conversion kit to adopt old machines. The introduction of the Amberol record, for example, led to the creation of mechanical devices to convert existing phonographs to play the 4-minute cylinder. This naturally added more variants to a phonograph line that was already crowded with numerous models and types. The conversion kits were difficult to make and install, making life more complicated for the Phonograph Works and the dealer network.

The Works was a loosely organized facility that manufactured everything from kinetoscopes to numbering machines. It was a production engineer's nightmare: a do-all general purpose factory, with no central task or stabilized engineering designs, and few long production runs. The Works was inundated with design changes and often had to manufacture products before the laboratory finished the design. Even after a design change was made, there still remained the long and arduous process of changing drawings and making sure the new product was standardized. The absence of a routine for making design changes and the lack of clear lines of authority created an atmosphere in the Works where standardization of design and manufacture was virtually impossible. It was a case of every foreman for himself and few records were kept. One engineer recalled that "New models chased themselves through the factory without red tape--that is, if they could find their way though the maze of cubby holes and partitions that formed the factory floor." [51]

The more new designs were produced in the lab, the more production changes had to be made. The chaos in the Phonograph Works became steadily worse in the early years of the twentieth century as the Edison laboratory pushed forward with several new phonographs. The work of product development was consequently plagued with delays; time-consuming engineering changes and the growing confusion in the Phonograph Works made it difficult to innovate to commercial schedules. The numerous delays were fatal in the growing competition of the phonograph market where the competition often beat the National Phonograph Company in introducing new technology. [52]

Edison was not slow to realize that organized and effective production engineering was the key to maintaining high sales. Yet the important job of production engineering was widely dispersed about the laboratory and Works. Although several experimenters worked on phonographs, there was no permanent position in the laboratory devoted to the production engineering of the phonograph. The work was carried on by Edison himself (when the mood caught him), and the managers and foremen of the Edison Phonograph Works.

The superintendent of the Works had a responsibility for tool design and manufacturing techniques. Peter Weber, who held the post in the early 20th century, carried out important work on the production engineering of the phonograph. He took the drawings and models produced in the lab and integrated all modifications and changes into the design of a production model that would be cheap and easy to manufacture. Weber and his assistants, especially E.L. Aiken, played a crucial role in developing new products and manufacturing existing ones. [53] Weber and his staff carried out improvements on machines, often at the request of dealer feedback. For example, they redesigned the horn of the phonograph to improve sound quality and give the phonograph a new look, working on a new design for horn and attachment brackets in 1907. These small design changes were often made to streamline production; but their number, and the number of people making them, led to more problems in manufacture. [54]

The transformation of all these design changes into new blueprints, tools, and manufacturing processes was as important as the actual engineering of the changes. The job of everyday production engineering went, by default, into the hands of the foremen of the machine shops and Edison Phonograph Works. These were the men who actually made the changes in design and manufacturing processes. This was done in an informal, haphazard way; there was no proper set of drawings kept and each foreman made his own changes to suit himself and usually failed to inform anybody else. The tools used in production were designed and made by Otto Weber "largely as he saw fit." No records were kept of this vital work. There was no centralized control of the production process apart from the superintendent of the Edison Phonograph Works who was unable to keep track of the many changes made by his foremen.[55] The lab and Phonograph Works certainly had the personnel and resources to continually redesign the phonograph, and they did!

The problem was to organize these forces to be able to make changes quickly and to readjust all manufacturing processes to suit. What was lacking was one authority to coordinate all the parts of the process (R&D, drafting, toolmaking, and production) and the organization to control it from laboratory to Works. There was no central authority or position in the Works or lab that could administer engineering changes, and no organization that could integrate the job of production engineering into the work of several different organizations.

The great number of design changes in Edison phonographs made life difficult for the dealers, who often found out that the "improvement" often led to a malfunction in another part of the machine. The dealers were confused by the continual modification of the product and in many cases they were not told about changes--they had to find out for themselves by examining the machine! Edison dealers had plenty to complain about: modifications that did not work, changes in the machine that made its operation difficult, and poor assembly. In many cases dealers had to overhaul and repair machines before they could be sold.[56] This haphazard approach to production engineering, typical of the Edison lab and Phonograph Works, could be tolerated in the boom days up to 1907. But after the depression came a great increase in competition, and it soon became evident that changes would have to be made to eliminate some of the abuses of manufacturing practice in the Edison Phonograph Works.

FORMING AN ENGINEERING DEPARTMENT

It was time to restructure the laboratory organization to meet the challenge of a highly competitive market. Engineering was another function to be bureaucratized and fitted into the work of planning, production, and sales. A new organization was created to bring the resources of the lab and Works together into a coordinated system of production engineering. Edison and his managers aimed to streamline the process of taking new designs and transferring them to the Works where tooling and production engineering would be carried out. Significantly, the core of the new organization came from the Phonograph Works and not from the laboratory.

The duties of the superintendent of the Works ranged over factory management, production engineering, and experimenting in the laboratory with Edison. Peter Weber did all these while serving as superintendent and he also supervised engineers attached to specific products. In 1909 Weber appointed an assistant (Charles Schiffl) to deal with engineering work such as design of new products and changes in old ones. When Schiffl was transferred from the Works to the main laboratory building, he was put to work on the design of a new business phonograph, on the request of the division manager. Schiffl's move to the lab was the first step in bringing many engineering functions under one centralized control.[57]

The next step was to create a department and give it the support facilities to enable it to operate independently. In 1910 Edison made the decision to install in the lab an "engineering and experimental department" which was to develop new machines from scratch and then send them to the phonograph works for manufacture. All new products had to be developed in the Engineering Department, to avoid some expensive "mistakes" which had occurred in the past. Any change in an existing product had to be approved by the new department.[58] The Engineering Department was given charge of production engineering: producing better designs for manufacture, and standardizing a design after improvements had been made. The products of the Engineering Department were to be models and blueprints of new phonographs.

A very important function of this department was to work with the other engineering and works departments--it was intended to be a permanent link in the chain of development that began in the laboratory and ended in the shipping department of the Works. This organization would present a working machine to the executive committee for approval before it was turned over to the drafting department for a complete set of blueprints to be made up and sent to the Works. The new organization was set up specifically to work on phonographs, and there was some discussion whether it should be put on the payroll of the National Phonograph Company. It was finally decided to put the Engineering Department onto the laboratory payroll because it was expected that the new department would be producing patentable designs and improvements to the phonograph.[59]

At first the Engineering Department consisted of Schiffl in the laboratory--this reflected the old system of the function residing with the man rather than in a position. But in 1910 the post of Chief Engineer was created, and he was the first to fill it. His duties and role in the organization were diverse. His main duty was to redesign phonographs to make them cheaper and easier to manufacture, for this was the central function of the Engineering Department.[60] When the European affiliates of the National Phonograph Company were troubled with low price competition, a number of very cheap machines were sent to the West Orange lab, and Dyer reassured them that the Engineering Department would be put to work to design a competitive, low priced cylinder machine. [61]

The need to develop new phonograph technology, in both business and amusement fields, led to a search for a phonograph engineer in 1910. Newman H. Holland was chosen for the job and joined the West Orange laboratory in March 1910. He had fifteen years experience in the design of electrical apparatus, including five years at Western Electric, where he had worked in the original design section and rose to head to experimental laboratory at Chicago. [62] Holland devoted his time to the business phonograph, probably because Edison was concentrating on the amusement phonograph at this time. Holland was placed under Schiffl's supervision for the Chief Engineer supervised the development work of the experimenters, consulting them before he designed new machines.[63]

The Chief Engineer was the important link between the researchers in the lab and the staff of the Phonograph Works. He designed new parts and improvements for machines and gave all relevant data and information to Weber, who then designed the machine tools. A major part of his job was recording and distributing information to the relevant production or research departments.[64] The Engineering Department became an important processing point in the ever increasing paperwork generated by the West Orange facility. By 1911 all requisitions for outside engineering or manufacturing work had to go through the Chief Engineer's office to be approved and recorded.[65]

The Engineering Department was an important part of the new bureaucratic organization of TAE Inc. Its work was overseen by a committee that managed expenditure on product development, production engineering and the manufacture of tools, and improvements in the manufacturing plant. All suggestions, requests, and proposals were first considered by the Chief Engineer and after his approval and estimate of the cost of changes, it was given to the manufacturing committee. This body was comprised of executives of the National Phonograph Company, the Chief Engineer, and other works staff. Its duties included gathering all data pertinent to the change, and then examining the impact of the change on the existing manufacturing situation. Formed in June 1910, the committee assessed the economic consequences of a proposed design change and decided if it was to be implemented. [66] The changes were authorized by Engineering Notices and carried out by the Chief Engineer and his assistants. Their work also involved the careful recording of all changes in design and production.

The Engineering Department soon enlarged its scope to cover more than the phonograph. Its staff worked on primary batteries and motion pictures, producing a series of improvements to the projector and designing one for use in the home. While the muckers in the laboratory were working with Edison on the revolutionary new technologies of sound and color for movies, the Engineering Department was given the important task of day-to-day production engineering. This involved very small, and seemingly inconsequential changes, in existing product lines such as a lock nut for the mandrel of the phonograph or a ridge on the primary battery jar cover in which a label could be placed. [67] Small changes indeed, but if the result was a cheaper and better product the Department was not laboring in vain.

SIDEBAR

MARKETING THE STORAGE BATTERY

Over the course of his career, Edison was a man of many talents. Not only was he an ingenious experimenter but Edison was also a good production engineer, and he designed the machines and layout of the factories in his industrial empire. In addition, however, Edison was able to look beyond the laboratory and the factory and concern himself with the marketing of his creations. When his first assumptions about a market for his inventions proved wrong, Edison was capable of identifying and stimulating new markets. This ability to be a market innovator is well illustrated by Edison's efforts with the storage battery.

During his long struggle to perfect his alkaline storage battery, Edison assumed that electric automobiles would be his major market. With characteristic exuberance, he predicted that "inside of 15 years the entire vehicle traction in large cities in the U[nited] States will be done electrically & I am now m[anu]f[acturin]g the battery that will permit this to be brought about commercially."(1) To secure sales contacts and marketing data, Edison sent men to different state capitals to collect the names of electric vehicle owners from the licensing bureaus. (This survey was a typical Edison business tactic; he had done the same in the 1880s to assess the market for incandescent lighting in New York City). Unfortunately, rather than reporting back a rosy future for the electric car, these investigators found that by 1910 the electric vehicle industry had begun to decline, losing out to gasoline-powered cars. In New Jersey for example, while Edison's men found that of the 800 electrics had been licensed between 1899 and 1906, 98% had been abandoned by 1910.(2) "The record is bad," admitted Edison, but it was

> not the fault of the vehicle but the lead battery....A great deal of work will have to be done by all of us to remove the bad impression. A satisfied & delighted customer is the only method that will build up a permanent business.(3)

However, try as he might, Edison was never able to remove the negative impressions associated with the electric car. With its cheaper fuel, higher speeds, and wider cruising radius, the gasoline car was quickly taken up by the American public. As a result, Edison was forced to look for new markets for his battery.

From the personal vehicle Edison moved to promoting his battery for other urban applications. The first of these was the electric delivery truck used by department stores. According to Edison, electric trucks were ideal for intraurban service since they could make their rounds by day and return to the garage at night for charging. Unlike gasoline trucks which had to be cranked to start, the electrics could be easily started and stopped for quick deliveries.(4) Throughout the 1910s several New York stores (including

Tiffany and Altman's) used electric trucks with Edison batteries. However, with the introduction of the electric starter for the gasoline engine in 1912, electric trucks lost much of their advantage and were gradually replaced by gasoline trucks.

Along with the electric truck, Edison pushed for a battery-powered streetcar. Edison realized that such cars were desirable for rush hours on mass transit systems since they did not use additional power from the main generating station and hence did not require expansion of the transit system's power plant in order to meet an increased peak load. To develop this idea, Edison built short railway line near the laboratory during the winter of 1909-1910.(5) To manufacture a special car, Edison gave a former General Electric engineer, Ralph H. Beach, the exclusive right to build streetcars using his battery. Beach established a factory adjacent to the Silver Lake Chemical Works. Unfortunately, after three years, the project died because Beach was unable to build a sales organization to promote the car and he failed to pay his debts to his suppliers.(6)

In some ways, the storage battery campaign had gone the same way as the ore milling venture; Edison had begun assuming that a large market existed for his products, only to discover that the market changed during the long years of development. But unlike ore milling, Edison persevered, and from 1910 to 1915, he devoted much effort to identifying and cultivating new markets for his battery. Optimistically, he made one list in 1911 of 64 different applications.(7) Included on this list were many of the tasks to which the Edison battery was successfully applied: lighting railway cars, providing back-up power for generating stations, lighthouses, miner's lamps, railroad signals, and lighting isolated houses and yachts. In addition, the list reveals many new applications for electricity which Edison investigated at the lab. He had his men experiment with using his battery to power bicycles, plows, and lawn mowers.(8) Finally, scattered throughout the list were schemes for using the storage battery to accumulate power from the sun, tides, wind, and rivers, all of which suggest Edison was sensitive to the America's growing appetite for energy.

To supplement these diverse applications, Edison pursued the military market through Miller Reese Hutchison. Having served as an electical engineer in the United States Lighthouse Service, Hutchison had numerous contacts in the Navy and among officials in Washington.(9) Through these contacts and his skillful preparation of advertisements, Hutchison arranged for the Edison battery to be used to power submarines, torpedoes, wireless sets, and electric motors in warships. To convey its reliability, Hutchison described the battery as being as "Rugged as a Battleship," and this subsequently came to be a major advertising slogan for the Edison Storage Battery Company. Although many of these military uses brought profits into the company, the most promising application, submarines, proved disastrous. In January 1916, Edison cells were installed in the U.S. Submarine E-2 which exploded while in drydock in the Brooklyn Navy Yard. Although the explosion was later attributed to the failure of the crew to open a hatch and vent the battery gases, the Navy subsequently demanded stringent testing of batteries which effectively prevented the purchase of any more Edison batteries for submarines.(10)

NOTES FOR SIDEBAR ON MARKETING THE STORAGE BATTERY

1. P. Manoury to TAE, 6 May 1908, 1908 SB, TAE's notes.

2. TAE to General Healey, 11 June 1910, 1910 Auto, TAE's notes.

3. TAE to Carlisle, 22 June 1910, 1910 Auto, TAE's handwriting.

4. TAE to Insull, 20 June 1910, LB100521, 204-205; TAE, Draft of "Talking Points" for selling electric trucks, 1910 SB, Wagons & TAE notes.

5. TAE to B.J. Arnold, 3 June 1910; TAE notes, n.d., 1909 Railroad, Elec., 1of2.

6. F.J. Lisman, Memo, 23 July 1913, Dyer Correspondence.

7. TAE, "Uses for Edison Battery," 11 Oct. 1911.

8. G.A. Halford to TAE, 24 Nov. 1908, 1908 SB, TAE's notes; Hutchison Diary, 7 Nov. 1911 and 22 Jan. 1912.

9. "Miller Hutchison, Inventor, 67, Dead," New York TIMES, 18 Feb. 1944.

10. M.R. Hutchison to TAE, 13 July 1910, 1910 SB, Boat; Hutchison Diary, 24 Aug. 1910, 12 June and 21 Oct. 1911; TAE to Bottomly, 28 Oct. 1911, 1911 SB, TAE's handwriting; Contract between Navy Pay Office and Edison Storage Battery Co., 13 May 1915, 1915 Submarines, E-2 Case.

NOTES FOR CHAPTER EIGHT

1) Benjamin Hampton, A History of the Movies (New York: Arno, 1970), p.18

2) Balio, American Film Industry, p. 23.

3) Batchelor diaries, J Randolph to S.G. Burn, 15 Nov 1900, LB 000608, 229.

4) Norman R. Speiden and William T. Ingersoll, "Historical Site Report--Part I: Metallurgial Laboratory, Historical Data," Unpublished Report, Edison NHS, 1961, 3-5; Shop Order 957, N871124.

5) TAE to Herter, 19 July 1901; TAE notes, n.d., 1907 SB, Experimental, TAE's notes; Batchelor Diary, Cat. 1345, 254-255; W. Mallory to Caskey, 23 Apr 1902, 1902 SB, ESB Co.

6) Conot, 347; TAE claimed in an interview with Harper's Weekly that "there would not be a belt in the mill." 21 Dec. 1901, 1901 SB.

7) A.O. Tate to W Stinson, 12 Feb 1891, phono gen.

8) Thomas Lambert Vs Edison, Brief for Edison, Legal Box 169, p. 25.

9) Ibid, p. 22.

10) Shop Order #1114

11) "Music Hath Charms" advert, 1903 Phono.

12) Tate to Insull, 12 Jan 1892, Phono, EdPwks.

13) Batchelor Journal 1338 p. 51, quoting Aylsworth, 1 Sept 1903.

14) Edison Phonograph Monthly, Feb 1907.

15) TAE to Gouraud, 30 May 1889, LB 890521, pp 153-170.

16) Ed Phono Monthly, IV #6 6 Aug 1906.

17) Durand to Gilmore, 9 Mar 1907, Phono NPCo Commercial dept.

18) Roundtable letter, (an informal history of the administration probably written by Charles Edison) Engineering Dept Files, 1920.

19) Memo 6/10/08 Dyer 1908 Phono Music Room.

20) TAE notes in 1901 Nickel Search file; F.R. Hanna to TAE, n.d., 1903 Nickel Search, Mines & Minerals file.

21) Lansden to TAE, 4 Aug. 1903; L.C. Weir to TAE, 24 Aug. 1903; MRH to TAE, 9 Nov. 1906; Memo of Agreement, 1908 SB, Gen.; TAE to Dyer, n.d., 1910 SB, Jan-May, 1of2.

22) Robert Anderson, The Motion Picture Patents Company, Phd dissertation, University of Wisconsin, 1983 p. 166.

23) TAE note, 18 Dec 1905, 1905 SB, TAE's notes.

24) TAE to Bergmann, 9 Nov 1904; Edison may have recognized the problem of the leaky cans early for in an undated note to Hays, the manager of the Glen Ridge plant, Edison wrote "eight out of 21 Baker batteries leak at Top where soldered You probably use too much sodium amalgam -- shoud use only enough to clean Iron-- Better look into this soldering question & improve it for it certainly is very bad." See TAE to Hays, n.d., 1902 TAE Personal Handwriting.

25) Memo, Edison Storage Battery Co., 1911 SB, ESB Co, Gen, 2of2; J.W. Allison to J.F. Randolph, 31 March 1906, 1906 SB, Ed. SB Co., Jan-June; TAE to Bergmann, 29 Nov 1904, 9 Dec 1904, and 21 Feb 1905; see also TAE notebook N041102, "New Experiments started at Laboratory in our new test room to discover why nickel elements in some cases lose their amp capacity after being in use and also to discover a remedy that is practical and commercial."

26) Dyer? to Meffert & Sell, 28 Nov 1905.

27) "The Edison Alkaline Storage Battery," (Orange, N.J.: Edison Storage Battery Co., 1924) in Warshaw Collection of Business Americana, National Museum of American History, Washington, D.C., 17-19.

28) Trial Balance, April 30 1905, 1905 SB.

29) Memo 9 May 1910, 1910 SB Jan-May

30) TAE to F. Comitot, 15 Nov 1907, LB 070701, p. 178.

31) TAE to F.T. Culliver, Oct 16 1907, LB 070701, p. 114. Asst Sec to F Scheffler, Nov 5 1908, LB 080919, p. 294.

32) Gilmore Memo, 1906, Phono

33) Roundtable Letter, 1920 Engineering Files.

34) Westee to Gilmore, June 11 1907, M.P. Sales; Edison Phonograph Monthly, April 1907, p. 1.

35) Edison Phonograph Monthly, Jan 1910, #1

36) Westee to Dyer, 30 March 1910, 1910 W.O. Lab .

37) Dyer to Ed 30 March 1910, 1910 Wo Lab.

38) TAE to W. Sloane, 30 Jan 1911, LB 101218, p350.

39) Dyer to TAE, 30 March 1910, 1910 Wo Lab.

40) W.M. Lybrand to F Dyer, 23 Mar 1910, 1910 WO Lab Employees. Lybrand was a partner in a CPA firm who was sending information about company organization to Dyer.

41) Dyer to NPC, 13 Sept 1910, TAE lab employees.

42) "Key to Office Organization Chart," 1912 TAE Inc.

43) Press clippings in 1911 TAE Inc 2 of 2 .

44) NPC to R.G. Dun Co, 31 July 1911, 1911 West Orange lab-general)

45) Roundtable letter, 1920 Engineering Files.

46) Edison Phonograph Monthly, Mar 1903, #3.

47) Roundtable letter, 1920, Eng Files.

48) E.J. Bergren to Dyer, 11 May 1911, 1911 TAE inc, 2 of 2; EPW Memo, April 15 1911, TAE Inc 1 of 2.

49) Welch & Read, Tinfoil to Stereo, p. 96. Thomas Lambert was granted a patent covering use of celluloid in recording media. The Indestructable Record Company was formed around Lambert's patents in 1906. John Wesley Hyatt developed celluloid and gained the important patents. His brother, Isiah Smith Hyatt coined the term, and the brothers set up the Celluloid Manufacturing Company which began operations in Newark in 1872, Robert Friedel, Pioneer plastic (Madison: U of Wisconsin Press, 1983), pp. 12-17.

50) Gilmore to Edison, 16 Sept 1903, Phono, NPco.

51) Roundtable letter, 26 April 1920, Engineering Dept files.

52) Wilson to Gilmore, 24 May 1907, 1907 Phono Sales; Weber Memo 10 July 1907, 1907 Phono Manu.

53) Nelson Durand to Gilmore, 9 March 1907, NPCo Commercial Dept.

54) Memo to Weber, 6 Feb 1907 --1907 phono Manu; Durand to Gilmore, March 9 1907--NPC commercial dept.

55) Anonymous History, (probably written by John Constable), 1919 TAE inc organization, undated.

56) J Scheerhorn to Gilmore, 19 Feb 1907, 1907 Phono manu; memo to Weber, 6 Feb 1907, 1907 Phono manu Jan to June 1 of 2.

57) Gilmore to Durand, 26 Mar 1907, NPCo Commercial Dept; P Weber to all Foremen, Jan 29 1909, TAE Inc organization; Durand to Dyer, 17 Dec 1909, Phono Ed Business Phono Co.

58) Dyer Memo, 3/25/10, 1910 WO Lab General.

59) 1908 sic! Doc file, W.O. Lab General, Dyer to Westee, Jan 26, 1910.

60) TAE to Dyer, 20 Jan 1910, Phono Manu.

61) Dyer to Graf(T) 21 March 1910, 1910 Phono Manu, J-J 1 of 2.

62) Holland to Durand, 10 Feb 1910, WO Lab employees.

63) N Holland to Schiffl, 1910 Business Phono.

64) C.H. Wilson Memo, 24 June 1910, 1910 Phono manu.

65) Wilson to Bliss, 10 Nov 1911, 1911 Engineering Dept.

66) Dyer Memo, 3 June 1910, 1910 Phono.

67) Minutes of Manufacturing Committee.

CHAPTER NINE: R&D IN THE TWENTIETH CENTURY

DEVELOPING THE DISC PHONOGRAPH

The development of the Edison disc phonograph was one of the most vital experimental projects carried out by the West Orange laboratory; the future of TAE Inc. depended on the successful introduction of a disc line. The rapid production of an Edison disc phonograph was the first test of the new engineering organization involving concerted action from both laboratory and Works. It was also a test of the administrative skills and marketing prowess of the new business organization. TAE Inc. had the unenviable job of breaking into a market that was completely dominated by Victor, and then facing Victor's angry response.

Sales of cylinder phonographs had slipped steadily after they reached a peak in 1907, and the steady decline in sales which followed alerted the National Phonograph Company to the realities of the phonograph market: the cylinder was in decline and the future belonged to the disc record. In the financial year ending February 1912 a total of 61,320 cylinder machines were sold, compared to the 289,822 sold five years earlier. The new disc machine was viewed within the Edison organization as the product which would "put new life into the business" and return the company to its former position of prosperity.[1]

Edison had anticipated the disc format in his earliest patents and thoroughly investigated it during the nineteenth and twentieth centuries. He discovered that the cylinder had several theoretical advantages over the disc: it could be turned at a more constant speed and the needle was not pressed into the groove by centrifugal force at the end of the recording. The cylinder format enabled better tracking at a more constant speed and this brought better fidelity. The phonograph buying public however were not concerned with matters of theory, but instead they were attracted to the longer playing disc, and its ease of storage. The pioneer disc instrument, called the Gramophone, was the work of the European immigrant Emile Berliner. He demonstrated a machine, with a laterally cut disc, at the same time that Edison was "perfecting" his phonograph at West Orange. He also devised a method of mass producing the disc record.

Within a short time of its introduction, the gramophone was being manufactured in Europe and the United States. The first hard rubber discs (measuring from five to six inches in diameter) were cheaper to produce than cylinders, and disc playing machines could also be made very cheaply. By the turn of the century, European manufacturers had successfully introduced disc machines selling for less than $10 and American manufacturers had produced $20 machines. The first gramophones on the American market were no match for the phonograph until Eldridge Johnson, a mechanic in Camden, New Jersey, made some significant improvements in the machine, including fitting in a spring motor. Johnson began, like Edison, by running a small machine shop. He went on to become a major inventor and entrepreneur in the phonograph industry. His modified Berliner machine became the Trade Mark model of 1896 and he later produced a smaller version, the Toy, in 1900. Johnson turned the gramophone into a serious competitor to Edison. In 1901 the Victor Talking Machine Company was formed on the Berliner and Johnson patents and the latter became the driving force of the new entrant into the industry.

While cheap disc machines competed with the Edison cylinders for the low end of the market, the Victor company introduced a machine that was aimed at the more affluent phonograph buyers. The Victrola was introduced by the Victor Talking Machine Company in 1906. It was Johnson's masterpiece. It embodied several improvements in phonograph design, not the least of which was the tapered arm which carried the sound from the sound box and reproducer. The Victrola was a remarkable innovation which combined technological and aesthetic innovations. Its horn was enclosed in the cabinet which gave it a completely different look. The Victrola became the phonograph of the twentieth century. It determined the development of talking machines for the forty years after its introduction, when many people came to call any phonograph a "Victrola". Its spring operated disc mechanism was fitted inside a handsome wooden casing and the horn of the machine was enclosed in the body of the phonograph, volume control being achieved by adjusting doors or louvres in the front of the machine. The enclosed horn gave phonograph design a new lease of life because the horn, overbearing, unsightly, and prone to collect dust, completely dominated the line of the phonograph. Unlike the Edison phonograph, the Victrola could be taken for a piece of furniture and many people bought it for exactly that reason. Priced at $200, the Victrola was aimed at the luxury market and quickly became the fashionable machine of the middle classes.

The Edison laboratory's first response to the challenge of the Victrola was a cylinder machine designed to play the 4-minute Amberol cylinder. The Amberola was announced in 1908, and introduced in 1909. It had a new diaphragm with a sapphire needle, and its promotional material naturally claimed better reproduction. It came enclosed in a cabinet which bore more than a passing resemblance to the Victrola, and the Amberola's price of $200 brought it into direct competition with it. The Victor Company claimed (with good reason) that the Amberola was a copy of their machine, even to the point of a similar name. The Amberola was not the only Victrola copy on the market, for the Columbia Company also had a luxury machine called the Grafonola. The Victor company believed that they held the key patents to the Victrola success and were prepared to license them, but at a very high price. Edison's lab was given the job of working around Eldridge Johnson's important patents, especially the enclosed horn innovation, while the Victor company continued to protest bitterly and threaten legal action.

The Amberola became very popular in the cylinder market with the introduction of the Blue Amberol records in 1912. This new record was made of a plaster of paris core covered with a hard celluloid that was made under license. This was much harder than the stearic acid compounds and therefore gave Edison's customers a clearer tone and improved reproduction of music. The surface also lasted a lot longer. The great improvement in the cylinder record boosted Amberola sales, while those of the other Edison cylinder models decreased. In 1913 the Company decided that the Amberola should be the only cylinder phonograph manufactured. Despite its popularity, The Amberola was no match for the Victrola which was steadily gaining in popularity and sales. By 1910 the affluent urban markets for phonographs were "Victrola Crazy" according to the Edison sales force. The Edison phonograph organization was in a state of disarray: chaos in the Phonograph Works, dealers depressed, sales force demoralized, and steadily falling sales. Its line of phonographs, "in worse condition than at any time in the last three years," could not compete with those of Victor and Columbia. [3] There was no doubt that "the Victrola is in the lead" and it was sweeping the Edison phonographs from the market. [4]

The Amberola was only the first shot of the Edison laboratory in the upcoming struggle with Victor, for preparations were being made for an fresh assault on the Victrola market, and this time with an Edison disc machine. Here began an experimental project which Edison claimed took five years and three million dollars! [5] This extensive R&D project marked Edison's active return after his "retirement" in 1908. In addition to directing the project he also played a major part in the experiments, working on several aspects of the disc in the lab, assisted by Sherwood Moore and George Werner. The latter had been assigned to the recording department of the lab in 1903 and had been trained by Walter Miller on recording techniques. Werner had worked with several experimenters on phonographs, including Newman Holland on the dictating machine. He took an important part in the disc project, assisting in the work on disc recording machinery.[6] Sam Moore was a tool-maker and designer who often worked closely with Edison and by the 1920s he was described as his "right hand man."[7] Edison oversaw every aspect of the disc's development, spending a good deal of time on the diamond point which was to be the selling point of the new machine.

One of the most important parts of the project was carried out in secret at the top of the Glen Ridge (storage battery) factory. Edison's experience in the phonograph business told him that the most important part of the new disc product was the duplication of records. This was the goal of the secret project at Glen Ridge. He used a familiar experimental team: Walter Miller was to design the disc recording machinery for John Ott to execute. Ott was also to make drawings of the plating apparatus (for duplicating) on Al Wurth's instructions. Miller was to make all the experimental master records for he was the recording expert of the West Orange laboratory. His work had been devoted to examining recording techniques and managing the Edison recording studios at West Orange and later in New York City. Wurth had been working on cylinder duplication since the 1880s and he was again in charge of producing the moulds from which records were to be duplicated. Ott was an old associate of Edison who had been a mucker since the Newark days, working closely with the inventor in phonograph development. This group was under the leadership of F.L. Aiken of the Phonograph Works. Although a Works employee, Aiken had been heavily involved in designing phonographs and later received patents on them. As assistant to Weber, Aiken was fully experienced in production engineering and running a "gang" of workers. [8]

Another vital part of this project was done outside the laboratory. This was the work of Jonas Aylsworth, who was charged with finding a harder compound for discs. Working at his house in Orange, where he had a fully equipped lab, Aylsworth experimented with compounds that could be moulded into shape. He examined the properties of phenolic resins which could be moulded by heat and pressure. A short distance away from the laboratory, Leo H. Baekerland was experimenting with the same resins in his efforts to find a substitute for shellac. He found that phenol resins could be mixed with binding agents and moulded into hard heat-resistant shapes. Aylsworth improved the phenol resins first developed by Baekeland and produced a material called condensite which was a purer resin with less by-products. (Condensite refers to the condensation of phenol and formaldehyde which produces the resin.) The development of condensite was a valuable contribution to the Edison phonograph business and a major chemical innovation. The excellence of the Edison disc records was directly attributable to Aylsworth's condensite surface.[9]

The West Orange laboratory was charged with the initial design of three disc machines--one of them to be a direct competitor to the Victrola. The specifications and drawings of the disc machines were to be the contribution of the new Engineering Department. The lab had to come up with a design that could compete with the Victrola while not infringing on its strong patent position. Much of the R&D work on the disc was done to circumvent the patents on the swinging arm (that carried the reproducer), and enclosed horn design. There can be little doubt that the Edison company copied the Victrola; in 1911 Edison was designing cabinets for the new machine "like the Victrola, but far finer." [10] In working around the important patents of Eldridge Johnson, the lab worked closely with the legal department of TAE Inc. When Edison thought about copying the Victrola spring motor, he first asked the legal department if it would violate Victor's patents. He also asked them "if we can use a swing arm of any kind" to move the reproducer across the disc. [11]

The Victor and Edison companies had nicely split the market for phonographs: the Victrola took the affluent classes and the city dwellers, while the Edison cylinder was the favorite of rural America. As long as Edison stayed away from the disc format, the two companies enjoyed a period of co-existence. In many cases a dealer carried both Victor and Edison lines to fit both ends of the market. A move into the disc business was a direct assault on Victor's market and TAE Inc. could expect a vigorous response. TAE Inc. had to be prepared for a fierce fight with Victor, for as the advertising manager put it in 1915: "It isn't sufficient for us to say we have the best machine. Victor have spent the last 14-15 years making this market and they won't let us walk in and take it." [12] Advised by its legal department that the commercial considerations of producing a disc warranted the risk of patent litigation, the Company braced itself for a long legal dispute over patents.[13]

The advertising department had already been employed in a campaign against Victor over the relative merits of the two systems of sound reproduction. The Edison side stressed the superiority of its phonographs' reproduction while the Victor company relied on the reputation of its recording talent. The

Edison phonograph used the unique method of making a vertical cut in the groove, providing a hill-and-dale path for the stylus to follow. The existing disc technology, and standard for companies manufacturing disc machines, was the lateral cut whereby the stylus moved from side to side in the groove rather than up and down. The vertical cut system had the advantage of better frequency response because the stylus could modulate at greater distances to capture the full effect of the bass notes.

The advertising department became very important in the fight against Victor, especially when the Edison company began to market unreliable (and often inferior) disc products. Edison's fame as an inventor made it easy to sell the phonograph on the basis of its advanced technology. "Every American citizen knows Edison and his work," said one advert in 1907, "and therefore feels convinced that the phonograph...must be better..because Edison made it." Edison's image as the great inventor and prophet of technological progress gained momentum in the twentieth century. The "Wizard of Menlo Park" combined success with some cherished American values, and his image gained international recognition--only the face of King Gillette was as universally known as Edison's. The convergence of his manufacturing strategy and the Edison image brought further exposure to the West Orange laboratory. Edison products were the result of his genius in the laboratory and subsequently they were advertised as "products of the Edison laboratory" (or "laboratories") rather than "Made in the Edison Phonograph Works, West Orange." [14]

Edison's laboratory had normally set the technical standards that the competition had to follow, but in the disc phonograph the shoe was on the other foot. Victor set the standards in disc machines. The Edison advertising department faced a difficult marketing task; the public had taken the Victrola to heart and its popularity made the name Victrola a household word, it came to stand for all phonographs---like Hoover did for vacuum cleaners. Edison's customers often referred to their machines as "Edison Victrolas" which greatly upset him. The Company had to convince the public that Edison disc phonograph was not just another Victrola but a completely new and different machine, and neither the lab nor the company wanted the Edison disc judged by Victrola standards. TAE Inc. had to convince people that the Diamond Disc was an entirely new product, a technological breakthrough in talking machines.

The marketing department pulled out all the stops of the Edison myth to do so; its advertising glorified the process of R&D and stressed the cost of developing "Edison's masterpiece." Research was not only used to produce the innovation, it was also used to sell it. The Edison disc phonograph was portrayed as the ultimate in sound reproduction which could capture the slightest nuance of sound, "the overtones," even in demanding classical music. Edison's own account of the introduction of the disc machine (produced for advertising purposes) was that he had labored for years before he came up with a disc technology that met his high standards for reproduction of sound. His new machine had to be free of the distortions and "irritating scratchy tone" of disc machines made by his competitors. [15]

A complete line of disc machines was planned, from the low priced $25 table model to very expensive machines with impressive cabinets and price tags. Thomas A. Edison Inc. aimed at the top end of the market with elaborately ornamented casings for the disc mechanism (including Louis XIX and Chippendale styles) and the price range went as high as $450. [16] (Illus. 9-1) Such was the urgency of the competitive situation that large-scale production of the disc was planned as soon as the prototype became available from the laboratory. The Edison Phonograph Works planned to manufacture 600 machines a day in 1910: this was a major undertaking done in a great hurry--much like Edison's first venture into the phonograph business in 1888.[17] This had ended in failure; but, no doubt, Edison believed that he had learned from his previous mistakes and now fully expected his organization to move speedily into disc production.

The decision to produce a disc machine did not mean the abandonment of the cylinder; experimental work continued on the Amberola and the Blue Amberol record with Edison and his staff applying for very many new patents on cylinder technology both during and after the disc campaign.[18] The cylinder remained at

Complete Line of Edison Disc Phonographs for 1913-14

MODEL A 450
Louis XVI
Circassian Walnut
PRICE, $450.00

Cabinet, Circassian Walnut; has large drawer holding 36 Edison Disc Records. Twelve-inch turn-table. Automatic record feed. Diamond Point Reproducer. Powerful spring motor with worm driven gears. Metal parts gold plated. Automatic stop. Dimensions: 49½ inches high; 22 inches wide; 22½ inches deep.

MODEL A 400
Louis XVI
Mahogany
PRICE, $400.00

Cabinet, Mahogany; has large drawer holding 36 Edison Disc Records. Twelve-inch turn-table. Automatic record feed. Diamond Point Reproducer. Powerful spring motor with worm driven gears. Metal parts gold plated. Automatic stop. Dimensions: 49½ inches high; 22 inches wide; 22½ inches deep.

MODEL A 425
Louis XV
Circassian Walnut
PRICE, $425.00

Cabinet, Circassian Walnut, has large drawer holding 36 Edison Disc Records. Twelve-inch turn-table. Automatic record feed. Diamond Point Reproducer. Powerful spring motor with worm driven gears. Metal parts gold plated. Automatic stop. Dimensions: 51 inches high; 23 inches wide; [illegible] inches deep.

MODEL A 375
Louis XV
Mahogany
PRICE, $375.00

Cabinet, Mahogany; has large drawer holding 36 Edison Disc Records. Twelve-inch turn-table. Automatic record feed. Diamond Point Reproducer. Powerful spring motor with worm driven gears. Metal parts gold plated. Automatic stop. Dimensions: 51 inches high, 23 inches wide; 28 inches deep.

MODEL A 290
Sheraton
Mahogany, Inlaid Marquetry
PRICE, $290.00

Cabinet, Mahogany, Inlaid Marquetry; has large drawer holding 36 Edison Disc Records. Twelve-inch turn-table. Automatic record feed. Diamond Point Reproducer. Powerful spring motor with worm driven gears. Metal parts gold plated. Automatic stop. Dimensions: 49 inches high; 21 inches wide. 23 inches deep.

MODEL A 275
Sheraton
Inlaid Plain
PRICE, $275.00

Cabinet, Mahogany, Inlaid Plain has large drawer holding 36 Edison Disc Records. Twelve-inch turn-table. Automatic record feed. Diamond Point Reproducer. Powerful spring motor with worm driven gears. Metal parts gold-plated. Automatic stop. Dimensions 49 inches high; 21 inches wide; 23 inches deep.

MODEL A 300
Circassian Walnut
PRICE, $300.00

Cabinet, Circassian Walnut; has two drawers each holding 36 Edison Disc Records. Twelve-inch turn-table. Automatic record feed. Diamond Point Reproducer. Powerful spring motor with worm driven gears. Metal parts gold plated. Automatic stop. Dimensions: 51[illegible] inches high, 21½ inches wide; 23 inches deep.

MODEL A 250
Mahogany
PRICE, $250.00

Cabinet, Mahogany, Semi-gloss Finish; has two drawers each holding 36 Edison Disc Records. Twelve-inch turn-table. Automatic record feed. Diamond Point Reproducer. Powerful spring motor with worm driven gears. Metal parts gold plated. Automatic stop. Dimensions: 51½ inches high; 21½ inches wide; 23 inches deep.

MODEL A 250
Oak
PRICE, $250.00

Cabinet, Quartered Oak, Golden Finish; has two drawers each holding 36 Edison Disc Records. Twelve-inch turn-table. Automatic record feed. Diamond Point Reproducer. Powerful spring motor with worm driven gears. Metal parts gold plated. Automatic stop. Dimensions: 51½ inches high; 21½ inches wide; 23 inches deep.

MODEL A 200
Mahogany
PRICE, $200.00

Cabinet, Mahogany, Semi-Gloss Finish; has large drawer holding 36 Edison Disc Records. Twelve-inch turn-table. Automatic record feed. Diamond Point Reproducer. Powerful spring motor with worm driven gears. Metal parts gold plated. Automatic stop. Dimensions 4[illegible] inches high; 20½ inches wide, 20[illegible] inches deep.

MODEL A 200
Oak
PRICE, $200.00

Cabinet, Quartered Oak, Golden Finish; has large drawer holding 36 Edison Disc Records. Twelve-inch turn-table. Automatic record feed. Diamond Point Reproducer. Powerful spring motor with worm driven gears. Metal parts gold plated. Automatic stop. Dimensions: 4[illegible] inches high; 20½ inches wide; 20[illegible] inches deep.

MODEL A 150
Mahogany
PRICE (including Six Record Portfolios), $150.00

Cabinet, Mahogany, Semi-Gloss Finish; has shelf for holding six record portfolios. Twelve-inch turn-table. Automatic record feed. Diamond Point Reproducer. Powerful spring motor with worm driven gears. Metal parts gold plated and oxidized bronze. Automatic stop. Dimensions: 46 inches high; 20½ inches wide; 20½ inches deep.

MODEL A 150
Oak
PRICE (including Six Record Portfolios), $150.00

Cabinet, Quartered Oak, Golden, Fumed or Weathered Finish; has shelf holding six record portfolios. Twelve-inch turn-table. Automatic record feed. Diamond Point Reproducer. Powerful spring motor with worm driven gears. Metal parts gold plated and oxidized bronze. Automatic stop. Dimensions: 46 inches high; 20½ inches wide; 20½ inches deep.

MODEL A 80
Mahogany and Oak
PRICE, $80.00

Cabinet, Mahogany, Semi-Gloss Finish, or Quartered Oak, Golden Finish. Twelve-inch turn-table. Automatic record feed. Diamond Point Reproducer. Metal parts nickel plated, buffed and polished. Spring motor. Turn-table stop. Dimensions: 17 inches high; 18½ inches wide; 22½ inches deep.

MODEL B 60
Oak
PRICE, $60.00

Cabinet, Quartered Oak, Fumed Finish. Twelve-inch turn-table. Automatic record feed. Diamond Point Reproducer. Metal parts Nickel plated, buffed and polished. Spring motor. Turn-table stop. Dimensions: 12 inches high, 17 inches wide; 21½ inches deep.

the focus of R&D on the phonograph; the diamond disc was an offshoot of the years of development on the cylinder phonograph rather than a change of direction by the Edison laboratory. The only part of the machine that could justifiably be called an innovation was the diamond point of the reproducer. This, in turn, was the logical extension of the success of the sapphire. Compared with the research work done at GE laboratories at this time, Edison's laboratory was embarking on an easier, and more mundane task; the important trade secret of the new Edison product was the method of fixing the piece of diamond to the shank of the reproducer.

After continually denying that it was going to introduce a disc machine, the Company announced the Edison disc phonograph in 1913. Yet it took more than two more years to introduce a whole line of disc machines, and even these models were not fully satisfactory, especially to Thomas Edison. The disc development encompassed two periods of intensive work: from 1909-1912 to produce the first models and then from 1912-1915 to improve them. During this period Edison gained over 70 patents and his researchers in the disc project were granted several more. Yet this intense R&D effort had not produced immediate success. Although the larger, free-standing cabinet models were well received by Edison's faithful customers, the low price models were heavily criticized as inferior. One dissatisfied jobber wrote that: "it does not give satisfaction...is not a credit to Edison disc line and should not be offered for sale."[19]

The first challenge to the newly reorganized system of producing models and then quickly putting them into mass production had failed. Despite the exhortations of the management, the process had been plagued with delays and disc production went forward very slowly. The speed that Edison valued so greatly was not there. Engineering problems with the lower priced phonographs had been a major reason for the delay in bringing out the disc line. The problem lay in the motor and feed assembly which did not maintain power to the end of the disc and thus could not maintain an even pitch. The design of the low-priced machines had given many problems and Edison's engineers could not produce a reliable machine that could be sold for less than $50. The target price of $25 dollars was not achieved and thus the new machine was aimed at $60 retail price. Yet the motors caused so many delays that the A 60s, as they were called, had to be withdrawn from the market. The Company struggled to produce a diamond disc machine below $100. [20] The low-priced machines caused so much trouble that Edison ordered the lab to start all over again in 1913. The Engineering Department had to redesign the motor and the drafting room was ordered to produce a new set of drawings.[21]

The failure to produce a successful low-priced disc machine must have been especially disconcerting to the management of Thomas A Edison Incorporated, for they had hoped to capture the low end of the market--where the Edison cylinder once reigned supreme. It was important for the company to have a competitive low-priced machine, especially when there was the constant threat of cheap machines imported from Europe. Extremely low-priced French and German products had swept Edison machines from Europe and the fear of both TAE Inc. and the Victor Company was that foreign competition would invade their home market. Edison believed that the American system of manufacturing was the best in the world and that American companies should become more export minded. The reality was that foreign competitors had successfully lowered the cost of manufacturing phonograph products, and that American companies could not compete with them. Edison, who had always prided himself on being able to produce cheaper and better than his competitors, now had to face the fact that he did not have a product to compete with even American manufacturers in the budget disc market.

Edison's image as inventor for the public good was recognized as an important marketing edge, and his managers and engineers knew that there were many corners they could not cut because it would sacrifice a level of quality that had become associated with Edison products. Nevertheless, this position limited the reduction of cost and inhibited competition with the very cheap European disc machines. Frank Dyer was impressed with the cheap disc machines sold in Europe and noted that all at West Orange were surprised that these disc phonographs could be sold at prices well below $10, commenting that "it would never do for us to attempt to put out work of this sort and lend our name to it."[22] Edison had to maintain his reputation for high-quality products, and continue the tradition of producing solid, well-made machines at West Orange.

Edison was very disappointed with the disc development, and he blamed the delays on "the incompetence of our men."[23] Yet the great haste of the project was certainly a factor in the failure of the work force to meet the "old man's" expectations. The line of disc machines was added to the growing list of products manufactured in the Works, including several kinds of film projectors and a series of Amberola phonographs which encompassed many different models. One historian of the disc machine, George Frow, points to poor liaison between the Engineering Department and the Works as a cause for the delay, and this was the area that had supposedly been streamlined. There were bad relations among departments in the Phonograph Works and personality differences hindered the cooperation that was vital for a speedy development job. The Works was called "more disorganized than organized," where foremen pursued their own politics and power struggles.[24]

The formation of a new organization, and the massive reductions that followed, had created a tense situation among the professional managers which naturally led to political struggles within the organization for power and survival. One engineer in the laboratory wrote in 1912 to Edison's son Charles, a student at MIT at the time, "every body is afraid that somebody else is going to beat them out of their job" and indicated that the atmosphere was not pleasant in the West Orange facility. He told Charles Edison that "your father knows this condition exists, and it disgusts him very much."[25]

EDISON AT THE HELM

Many of the changes in the structure of Edison's business organization had been made on the assumption that the "old man" was not going to be around forever. The first steps had been taken to establish a permanent bureaucracy to run the business. Several executive committees had been instituted, such as the manufacturing committee, which had broad powers in operating the organization. A stratum of middle managers had been formed, and senior managers had been admitted to the decision making process in which business strategy was devised. But formation of TAE Inc. was more a foundation for future change than an organizational revolution. Edison was still more important than the organization; his "retirement" was short-lived, and he returned to the laboratory to take a very active part in the disc project. In the years immediately after the creation of TAE Inc. the executive committees played a role that was mainly advisory--Edison still made the major decisions and decided on both technological and business policy.

One of the most important business decisions to be made about the new disc machine was its level of compatibility with the Victor discs already on the market. The strength of the Victor company was their impressive catalogue of recordings. They had set a course of signing the leading performers, such as Caruso, to record on their premium priced labels. Music lovers flocked to buy these historic recordings, and the general record buying public were impressed by the "quality" of Victor discs even if they didn't appreciate the music. The managers of TAE Inc. wanted to make a reproducer that could play the laterally cut Victor records, for this would considerably increase the market for the Edison machine. Yet Edison would have none of this suggestion even though it was obviously the right business strategy to follow; the Edison disc would immediately have an enormous selection of recordings available for its customers, in much the same way that an IBM compatible computer today has access to the extensive library of software written for the IBM machine. Edison had little sympathy with the arguments of his managers, for him it was a matter of pride: he could not let the Victor Company set the standards for all in the phonograph industry to follow. He wanted his disc machine to stand on its own merits and be quite different from the competition. The top level of management in TAE Inc. was therefore faced with the task of persuading the "old man" to see reason, bringing him around to their point of view before the forces of the marketplace did it for them. [26]

Edison enlarged his role in the phonograph business, taking over the vital area of music selection and recording. In the competition with Victor this was probably more important than the actual machine; many people bought Victor phonographs because they wanted to hear the famous singers who recorded on

Victor records. He acknowledged that the existing stock of recordings was poor and set out to improve both the technique of recording and the selections available on Edison records. The choice of selections and talent was crucial not only in the struggle against Victor, but also for the survival of the cylinder format; the increasing popularity of the recorded music on discs would ultimately lead to the demise of the cylinder and the trade built on it. Edison evaluated thousands of cylinder recordings before choosing the selections for the new disc.

His strategy was the opposite of Victor's: "I propose to depend on the quality of the records and not on the reputation of the singers."[27] Edison believed that music lovers would prefer a better recording rather than "a rotten scratchy record by a great singer," and maintained that many of the famous singers recorded by his competitors were better at acting than singing. The experience with motion pictures had made Edison and his managers wary of dealing with first-class talent--who invariably cost more money and were difficult to handle--and the strategy for musical talent was to keep them as anonymous, and as low paid, as possible, even to the point of leaving the singer's name off the recording! Edison's influence was decisive in putting the technology before the artist.

It was ironic that the musical offerings of a leading phonograph company were filtered through the prejudices and damaged hearing of a sixty-year-old man. Edison enjoyed his job as music director, keeping a tight control of recording and the hiring of talent. All new recordings and signings had to be passed by him, and he pressed his musical opinions and choices onto his subordinates. [28] Walter Miller and George Werner were often subject to Edison's opinionated directives on recording music. To permit the recording of larger groups of musicians, a new studio was constructed in building 4 of the West Orange laboratory, to Edison's specifications. One of his great ambitions was to record classical music played by large orchestras and this new studio was designed to record chamber music. The "old man" devoted a great deal of his experimenting to the dynamics of sound recording in the quest for the perfect, realistic reproduction of sound. Many remember Edison as the man who brought the wonders of electric light to the world. Yet in terms of the amount of time spent on recording and the phonograph, Edison should be remembered as the man who labored for years to bring us the clear, faithful reproduction of music. The surface noise of the disc record became an obsession with him, and he worked for years in the lab to reduce the scratches and crackles.[29]

While the "old man" was well enough to manage the work of the laboratory, the framework of R&D by committee set up in the organizational changes of 1910 remained in the background. Edison was indispensable to the laboratory and he led it in person, telling a friend in 1911 that "I have 250 experimenters who depend on me daily for directions and when I go away it greatly disturbs the organization." [30] The new bureaucratic organization of the lab functioned at Edison's whim. Although the position of Chief Engineer had, in 1910, become part of the formal organization of the laboratory, it was filled at Edison's discretion. Edison directed the activities of the new Chief Engineer and was not above interfering in his work, sometimes taking projects from him to work on personally.[31] The Chief Engineer could not be a specialist because the work of his department was expanded to cover very many products. George Bliss had been brought to West Orange because his expertise in electric motors and regulators exactly fitted the direction of the Edison enterprise and supported the newly created small electric motor department in the Works. Yet Bliss was asked to undertake a great range of work of which electrical machinery was only a small part. His tenure as Chief Engineer spanned the work of production engineering on the disc and storage battery projects; this alone meant the design of several new machines. The department carried out work on the phonograph, primary battery and motion picture products. In 1911 his engineering department was responsible for designing a small electric motor for a prospective Edison lawn mower, a complete electric delivery wagon, and shaving machine for the business phonograph.

Edison's order that "if Bliss feels job is too big--give it to Weber" reveals that the pressure was too great for Bliss. [32] Edison gradually eroded the power of the Chief

Engineer and even ordered that all work carried out in the laboratory's machine shops needed his approval. Bliss only lasted one year before Edison removed him in 1912. The next Chief Engineer was Miller Reese Hutchison, a prolific young inventor who had gained the friendship of Thomas Edison and had gradually worked his way into the favor of the elderly inventor. Born and educated in the South, Hutchison had produced a hearing aid, invented the electric klaxon horn, and was in the process of developing a automobile self-starter when he first came to visit the West Orange laboratory. Hutchison had served as engineer of U.S. lighthouses and had valuable contacts in the Navy. Like Edison, he was both inventor and entrepreneur. His work in marketing the Edison storage battery produced some important sales and his growing friendship with Edison soon led to an invitation to work with him at the laboratory in 1911. By 1912 Hutchison was on very close terms with Edison and was soon made his Chief Engineer.[33]

Hutchison's comment that the job of Chief Engineer "seems to resolve itself into issuing engineering notices on screws, nuts, bolts, gears, etc" shows that a gulf had emerged between the purely experimental work of the laboratory and the production engineering of the Engineering Department. The leader of the laboratory had to be a generalist like Edison who could turn his hand to any technology. Hutchison was able to spread his time among the many projects in the laboratory but admitted to Edison that he found it difficult to successfully "make a number of inventions simultaneously." [34] This was Edison's great strength and an ability that few could match. Hutchison's association with Edison marked a tremendous burst of activity in the laboratory, where they worked on a broad range of experiments that covered all the new products being developed, from storage batteries to cement houses. The many problems with the disc phonograph soon began to dominate Edison's time and his protege was therefore directed into the motion picture business and the important kinetophone project.

THE KINETOPHONE

When Hutchison first came to work at the laboratory the motion picture business had become a major part of the Edison enterprise. With phonograph sales in decline and serious problems with the new disc machine, the returns from motion pictures supported TAE Inc. during the difficult years after 1910. By 1912 the motion picture department was the most profitable part of the Edison enterprise, as Table 9-1 indicates. The creation of the Motion Picture Patents Company in 1908 brought an end to the "unfair and ruinous competition" which had deprived inventors, like Edison, a fair return on their motion picture patents. [35] Although the agreement was signed in the library of his West Orange laboratory, Edison did not originate the idea or promote the Company--it was the work of some of his competitors, some of whom had put out feelers to make cross licensing agreements well before the Company was formed in 1908.[36]

The Motion Picture Patents Company (MPPC) was a monopolistic organization formed on the basis of the major patents in motion picture cameras and films. The ten members of the company, or Trust as it was called, comprised the leading members of the American motion picture industry. The MPPC issued licenses to film makers and collected the royalties from

TABLE 9-1

TAE INC SALES & PROFITS, MARCH-MAY 1912

(In thousands of dollars)

Product	sales	profit
Phonograph	475	16
Battery	202	34
Motion Pictures	318	83
Dictating Machine	96	5
Kinetophone	---	5 loss

the exhibitors who showed the trusts' films. It was similar to many other patent pools and monopoly organizations in American industry and finally achieved Edison's goal of monopoly of his film camera patents. He received the lion's share of the income of the MPPC which was about $1,000,000 a year from 1909 to 1914. [37]

Film historians have often interpreted the MPPC as a conservative monopoly that retarded the development of film both as art and mass entertainment. The members of the trust are sometimes depicted as conservative businessmen only concerned with mass producing standard lengths of film for a captive audience. The two important developments in film subjects during the heyday of the MPPC (1908-1913)--the development of longer, feature films and the star system--are ascribed to the independent film makers who finally broke the Trust. It can be argued that the MPPC had no incentive to innovate; they claimed to account for seven-eights of film production and distribution, and struggled to meet the voracious demands of the film exhibitors. Longer and more elaborate productions, with highly paid stars, would merely add cost to the product.

Recent scholarship has shown a different MPPC. Robert Anderson has shown that far from being a retarding influence on American film, the MPPC brought order to chaos and created a strong American industry that could compete with European film makers. The Trust was concerned not only with making profits but also raising the quality of the film subjects. In the wild competitive days before the Trust, poorly made foreign films were imported into the American market. These films accelerated the opposition to the moral depravity of the movies. The films of the MPPC were not mundane subjects without regard to content. The MPPC did its part to improve the quality of movies because respectability also meant the increased income of the middle class audience. The Nickelodeons certainly started as places of low repute, but were soon frequented by the middle classes. As the leading member of the Trust (with Biograph), the Edison company did its part in developing longer, higher quality film subjects and signing the stars of the Broadway stage. [38] Like the disc machine, Edison's motion picture business was increasingly aimed at the more respectable, and affluent, middle classes.

When the film exhibition business began in the late 1890s, Edison was primarily concerned with reducing the price of the standard film strips made for exhibitors--the artistic content of the film was not considered important. [39] Films were treated as a commodity at West Orange, as another product to be economically manufactured and sold. As the business grew from a novelty to an industry of international scope, the managers of the Kinetograph department, led by John White, took more attention to the quality of the film product. By the turn of the century, they were busy buying the rights to literature, including the work of Mark Twain, and signing well-known stage performers to appear in Edison films. The directors of the Edison company soon appreciated the advantages of making films for specific audiences. In 1909, for example, Frank Dyer pressed the Edison studios to make films about working class themes--"with young mechanics and their sweethearts"--which would appeal to the blue collar audiences of the Nickelodeon. [40] The evolution of film production from independent cameraman to the director working in the studio gave the Kinetograph department more control over film subjects. The Bronx film studio was the center of film production in TAE Inc., and by 1909 the department had nine directors making Edison movies there and on location. This operation was under the control of George Plimpton who attended to both content of movies and the production of negatives.[41]

The output of the Kinetograph department was not restricted to dramatic and comedy subjects; the Edison Manufacturing Company took an early interest in what it termed "Educational films" producing a wide range of subjects covering geographical, agricultural, industrial, historical, scientific and military topics. [42] Several industrial films came from contracts with companies to make films of manufacturing processes, a little known but important market for film makers. The Armour meat packing plant, Ford Motor Company's factories, and the Edison Phonograph Works were all filmed. This type of movie was comparatively inexpensive to make and a market was guaranteed. There were many profit opportunities in educational films and the entrepreneur in Hutchison saw potential in films for specific educational audiences. He joined with another experimenter in the laboratory to form a company devoted to making sound movies about scouting, expecting a large and profitable market in the Boy Scouts of America.

In the first years of the MPPC, TAE Inc. produced a varied selection of film subjects and was committed to a high quality of these Edison films. Although film production was no longer carried out at West Orange, the judgement of Edison movies was centered there in a film committee which included top management and experimenters from the laboratory. This group assessed all new movies and passed them for release. They had the power to reject unsatisfactory films or refer them back to the studios to be remade. Movies were judged on their content--acting and plot--and the technical concerns of lighting, photography, and the condition of the print. The film studios established outside the laboratory still took their orders from West Orange.

The benefits of the film monopoly did not end the R&D on motion pictures carried out in Edison's laboratory for work continued on improving existing equipment and developing new technology. Thousands of dollars were expended on experiments to produce revolutionary new technologies such as color films and talking pictures. The work of combining sight and sound was carried from the nineteenth to the twentieth century, experiments beginning on a new kinetophone in 1899 and continuing up to 1914. The tempo of research on the kinetophone picked up during the negotiations leading to the formation of the MPPC. By 1908 a man was working full time in the laboratory on this project and monthly expenditure on experiments grew steadily.

There were several difficult technical challenges in the development of sound films which were responsible for the long delays in introducing a commercial machine. The kinetophone was a film projector linked to a special phonograph. The two minute cylinder format was naturally unsuitable for 15 minute films and therefore the experimental team's first task was to develop a longer playing phonograph. Here they had the benefit of years of prior experimentation on larger cylinders and longer playing times. It is significant that Edison chose to remain with the cylinder format for the kinetophone, even though the disc offered greater playing time. The kinetophone finally came with outsize cylinders of 4 1/4'' diameter and 7 1/2 " long that played for six minutes. The kinetophone was another electrically powered machine to come out of Edison's laboratory. The playback machine was powered by an electric motor to run on house current (although the recorders seem to have been spring driven). The projector was hand cranked but needed electricity to power the lamp.

One of the toughest problems to solve in the kinetophone project was the synchronization of sound with the moving image; William Dickson could certainly attest to that after his years of experiments in the 1890s. The considerable distance between the film projector at the rear of the auditorium and the phonograph behind the screen added to the complications of adjusting the two machines to work in unison. A clutch mechanism was developed to alter the speed of the playback in order to synchronize it with the film but this was a very difficult mechanism to work. It was linked to the operator in the projection booth by a cord running on pulleys. The projectionist had to continually adjust the speed of the film and kinetophone playback to keep the sound in time with the image.

Edison's men not only had to design a commercial machine, they also had to produce a library of kinetophone film subjects. It was pointless trying to market a talking picture machine without movies to show with it. Recording the soundtrack to accompany the film presented another group of technical problems. Edison's recording staff had plenty of experience recording musicians, but actors and dancers presented a much more complex sonic environment and posed some tricky questions: How can you increase the sensitivity of the recording without also increasing the volume of background and reflected sound? How do you position the actors for best technical results without destroying the quality of the performance? The recording was done with a large horn on the phonograph which picked up and amplified the sound of the action on stage. It took an experienced man to keep the sounds of the actors clear without crowding the horn in their faces. The requirements of good drama and good technical reproduction rarely coincided. When sound recording of films was later tried with electrical equipment a generation of actors had to be trained in the technique of making sound movies which was much different from making silent pictures.

The final problem in the commercial kinetophone was to increase the volume of the machine's playback; it had to play the sound track clearly and audibly to every corner of a large movie theatre. The problems of increasing the volume of the phonograph playback had been of utmost concern to the experimenters in Edison's laboratory since popular music in the twentieth century was meant to play loud. They found that increased volume could be obtained by putting more pressure (tracking force) on the needle as it made its way through the grooves, but this increased wear on the cylinder surface which eradicated the highs and obscured fidelity. Patent considerations prevented the use of the harder, celluloid cylinders that could bear this abuse and therefore another solution had to be found. Several inventors had achieved higher volume by mechanically amplifiying the sound in the reproducer and horn assembly. Daniel Higham of Brookline, Mass. had patented a machine that produced very loud volume by means of a friction valve device built into a large reproducer. His services were acquired and he came to West Orange in 1908 to play a leading role in the development of the kinetophone.

The work on the experimental machine had reached a stage in 1910 when it could be successfully demonstrated to the Press. The laboratory was naturally the scene of this demonstration which included an announcer making various sounds and a dancer with musical accompaniment. Edison told the press that it would take about one year to finish the machine and perfect the recording of the soundtrack but when Hutchison joined the kinetophone work in 1911 it was not enjoying much success. As he told Edison "We are up against a pretty stiff proposition" in getting good results out of the machine. [43] He tried using several horns to get a more balanced and louder soundtrack but Edison told him that "thousands of experiments" with two or more horns had yielded no good results and "we always returned to one horn and threw away the rest." [44] Experiments continued on recording and on the synchronization device which was still not satisfactory. Hutchison felt that the synchronizing cord was hopelessly inadequate for the job and put too heavy a burden on the operator. He therefore worked on an electrical synchronizer which could be operated by remote control. The kinetophone team began 1912 as one of the longest running experimental projects on the laboratory's books. The thousands of dollars spent on years of experiments had not brought total success. The large team of experimenters finally succeeded in recording some kinetophone cylinders which passed the "old man's" scrutiny in the spring of 1912. Preparations were then made for the machine's commercial introduction but

Edison would not let it out of the laboratory until he was satisfied with it. [45]

Once the experimental model had passed muster in the laboratory, there still remained the work of producing a commercial machine. What Edison's experimenters were working on was more than a projector linked to a phonograph: it was a complete kit with rheostats to convert the house current to drive the machine. In addition to designing the machine there was also the long and expensive job of training the personnel to work the device. The kinetophone was too complicated a device to market directly to theatre owners and showmen; Edison planned to use his own men to take the kinetophone on the road to publicize the talking picture and manage its commercial introduction. Hutchison was given the job of training the operators. They were picked from the West Orange work force and underwent extensive education in the laboratory. They had to pass stringent tests, including written exams, before they were sent out with the kinetophone kits. Hutchison also had to write the direction sheets and perfect the method of setting the apparatus up in theatres. [46]

The work on the kinetophone reached a climax in the spring of 1913 when Hutchison noted in his diary that talking pictures were at last working properly.[47]. The machine was formally introduced with Edison's claim that he had perfected the talking film. His was not the only system of talking pictures on the market and Edison strove to persuade the press that his was the best. The first public performances in a vaudeville house in New York led the press to announce yet another marvel from the West Orange laboratory. Enthusiastic audiences thrilled to the kinetophone all over the country in 1913 as Edison's men took the kinetophone on the road. The high novelty value brought in the crowds and the New York Times noted "gasps of astonishment could be heard in the audience" as the pictures on the screen spoke.[48] The Talkies had begun well before "The Jazz Singer."

Edison had characteristically signed agreements for foreign exhibition of kinetophones which covered Europe, the Far East, South America and the Pacific. All the resources of the lab and Works were applied to this large order, which brought in thousands of dollars. The motion picture business involved the exchange of film subjects with European producers and exhibitors and the kinetophone was no exception. Edison made films for foreign consumption and acquired several kinetophone subjects from German studios. This business was truly multinational on the eve of the First World War. Unlike the debut of the kinetoscope in 1894, the kinetophone was of major commercial importance to TAE Inc. The financial strain of developing the disc made it imperative for the Edison laboratory to develop a winning product to recoup some of the losses. The kinetophone provided this for by 1913 it was the major profit maker in Edison's many companies.[49]

Unfortunately after a brilliant start, the kinetophone quickly declined and never fully paid back the expenses of experiments. As to be expected, the novelty value soon wore off, but the novelty of the kinetoscope, for example, lasted much longer than one year. The decline of the kinetophone is best explained in the problems of maintaining and operating a highly complex machine. One error in synchronization could turn a triumph into a disaster and cheers into jeers from the audience. More than one kinetophone show was booed off the stage! The problems could be traced back to the underpaid operators and the rats who ate through the control cords. The projectionist was too busy to run the machine and therefore the exhibitor had to hire an operator specifically for the kinetophone. The first talking picture was introduced in 1913, but met with little success; it was too difficult to control the kinetophone with a string that reached from the machine (which was next to the screen), to the projection booth. A further problem was the lack of enthusiasm and expertise on the part of the low-paid operators. [50]

Edison was embarrassed by the theatrical disasters of his new invention, but he was not going to let one failure stop him. In the beginning of 1914 he told Hutchison that the full resources of the Edison enterprise would soon be given over to talking pictures and that they were going to "perfect the kinetophone to the limit." Instead of filming around the existing schedule of the Bronx and 21 St studios, Hutchison was soon going to have his own kinetophone studio in West Orange specially built to absorb the reflected sounds that ruined sound tracks. Edison was going full out to improve the technical performance of the kinetophone. He had filled note book with fresh ideas because he had a point to make, telling Hutchison that "we are the only people who can do it...show the theatrical people that scientific people can beat them as their own business." [51] Here Edison revealed the basic strategy of the phonograph and film operations; commercial success could be attained with technical perfection that overcame aesthetic or dramatic considerations.

The overall concern with the technical rather than the dramatic was surely an appropriate one for "the best lab ever." The attention of the laboratory staff was on technical problems and technical merit, each man was concerned that his area of responsibility produced the right results and to Edison's standards. The kinetophone team in the laboratory soon discovered that technical considerations dominated sound motion pictures; the technical man, especially the recording engineer, had to dominate the proceedings or the result was a cloudy sound track. [52] The problems of reflected sound in the studio made it imperative that the actor directly speak into the horn to be heard. The short kinetophone subjects were therefore directed by technical staff who placed the actors and staged dialogue to achieve technical standards. Their efforts did not always meet with approval from the film committee in West Orange and Hutchison was forever complaining about the poor quality of the films. Even if the final film was a good technical accomplishment, as judged by the engineers at West Orange, it still could not compete with a professional entertainer who used other systems of sound motion pictures. It was a show that audiences wanted and not several unrelated technical demonstrations of the capabilities of the machine. One observer concluded that compared with a good showman with second rate equipment the Edison superior machine still looked "amateurish". [53] The kinetophone failed to entertain audiences and soon vanished from the scene. No further effort was made to develop talking pictures at West Orange.

The failure to produce a commercial system of talking pictures hurt the Edison enterprise and must have been a severe disappointment to the "old man." Technology had not triumphed over art. The kinetophone was the last of the highly ambitious experimental projects which had characterized the West Orange laboratory in the nineteenth century. Huge amounts of money, every possible resource, and the best brains in the laboratory had not brought success. There were to be no more highly expensive forays into new technologies at West Orange; the kinetophone was the last hurrah of the "best lab ever." Innovation at the Edison laboratory was taking a conservative and cost-conscious path away from the revolutionary technologies such as the talking picture and magnetic ore separation.

ENDNOTES FOR CHAPTER NINE

1) Dolbeer Memo, Jan 10 1910, 1910 Phon Manu.

2) "High Light History of Victor Phonographs," Victor file, Division of Mechanisms, Smithsonian.

3) Dolbeer to Dyer, 23 Dec 1910 : 1910 phono manu.

4) J Blackman to Dyer, 8 Dec 1910 Phono adv.

5) Frow, Edison Disc, p. 76

7) C H Wilson to Leeming, 12 Dec 1914, Phono Manu.

8) Dyer to Weber 15 Dec 1909, TAE Inc organization.

9) Vanderbilt, Edison the Chemist, p. 159.

10) TAE to Cunningham Piano Co, 19 Dec 1911, LB 111204, p.132.

11) TAE To legal dept, 6 Dec 1911, Legal Box 15 folder 2.

12) L. McChesney to W Miller, 24 Jan 1915, 1913 Phono Gen, 3 of 3.

13) L. Hicks to Dyer, 12 April 1911, Legal box 15, folder 2.

14) Advertising copy from proofs in 1907 Phono, advertising. Edison's image has been assessed and described by Wyn Wachhorst, <u>Thomas Alva Edison: An American Myth</u> (Cambridge: MIT, 1981).

15) Edison's notes for Hutchison, 1912, Phono Gen.

16) Price lists and promotional material in primary printed file.

17) Maxwell memo, 21 July 1910 Phono Manu 2 of 4.

18) W.L. Eckert to TAE, 16 May 1913, WO Lab gen.

19) Fred Babson to CHW, 29 Dec 1914, 1914 Phono manu.

20) HFM to Goldsmith, LB151216, p. 121.

21) Minutes of Amusement Phonograph, 10 July 1913- Phono Gen.
22) Dyer to Graf, 31 March 1910, 1910 Phono Manu J-J 2 of 2.

23) TAE to E.H. Johnson, 28 Oct 1912- 1912 TAE friends.

24) Frow, p. 38; C.E. Faibanks to Mambert 31 May 1917--W.O. Lab Eficiency Expert.

25) M.R.Hutchinson TO Charles Edison, 15 April 1912, 1912 Motion Pictures 2 of 4.

26) P Cromelin to Dyer 17 Aug 1911, 1911 Phono manu.

27) TAE to T. Graaf, 20 Nov 1911, LB 110628, p. 622.

28) TAE to Gallup & Alfred, 21 Feb 1916, LB 160127, p 387.

29) Meadowcroft to C Aston, 19 Feb 1917, LB 170122, p. 182.

30) TAE to H Byllesby, 2 Dec 1911, LB 110628, p. 695.

31) Minutes of Manufacturing Comm, 26 Jan 1911, 1911 Phono Manu, Nat Phono Co.

32) TAE memo, Engineering Dept files, 1911.

33) Obituary, New York Times, 18 Feb 1944; Hutchison Diary, 17 July & 12 Aug 1912.

34) Hutchison to TAE, 5 Nov 1913, MP adverts.

35) MPPC Circular, 1909 MP Sales.

36) Hutch to TAE 19 Jan 1914, MP Kp.

37) See Robert J. Anderson, "The Motion Picture Patents Company," Phd disseration, U of Wisconsin, 1983.

38) Balio, American Film Industry, p. 114.

39) TAE to H.P. Weidy, 29 June 1899, LB 980131, p. 66.

40) F Dyer to G. Plimpton, 19 May 1909, MP.

41) Memo in 1909 Motion Picture.

42) J W Farrell to F Dyer, 15 June 1909, MP

43) Interview of 27 Aug 1910, 1910 MP; Hutch to TAE, 19 Dec 1912, MP kp.

44) Annotation on 1913 Hutchison memo, Motion Picture.

45) F Dyer to R Cross, 22 April 1912, 8 July 1912, MP.

46) C. H. Wilson Memo, 18 Dec 1912, MP.

47) Hutchison Diary, 28 April 1913.

48) Art Shiffrin has written two excellent accounts of the kinetophone: "70th Anniversary of the Theatrical Release of Kinetophone," SMPTE Journal (92, July 1983, 739-751; and "Time Code and Mr Edison," db (16, Dec 1982), 30-37. These have been the foundation for this section.

49) Hutchison to TAE, 19 Jan 1914, MP Kph.

50) A. Shiffrin, "The Trouble with the Kinetophone."

51) TAE to Hutch, 14 Jan 1914, MP Kph.

52) Newspaper clippings, 5 May 1910, MP; Hutchison to TAE, 19 Jan 1914, MP Kph.

53) A. M. Kennedy to Hutchison, 20 May 1914, MP.

CHAPTER TEN

THE RISE OF THE ORGANIZATION

The years leading up to the First World War were marked by great activity in the laboratory as the Edison enterprise struggled to introduce several innovations. The laboratory's staff produced models of new kinetoscopes, disc phonographs, and dictating machines. The Engineering Department grappled with the work of turning these models into drawings and lists of parts. The profusion of new models was complicated by the many small additions needed to make them into commercial products. In motion picture projectors, for example, the new designs were accompanied by several accessories, such as rheostats, which had to be produced by the Engineering Department.

An Engineering Department committee meeting held in November 1914 discussed work on the disc phonograph, the super kinetoscope, the dictating machine, and the Amberola. [1] The introduction of the Blue Amberol cylinder had given new life to Edison's cylinder trade (see Table 10-1) and several new models were under construction in the laboratory as the Amberola mushroomed into a line of phonographs. The development work on a new dictating machine had also reached fruition by 1914. This market for the phonograph promised continued growth in the

TABLE 10-1

PHONOGRAPHS SOLD TO JOBBERS

Sales Year	disc	cylinder
1911	--	1081
1912	3833	1945
1913	16252	30188
1914	29079	20650
1915	52632	28759
1916	73346	40845
1917	76256	54295
1918	67405	51971
1919	121537	54178
1920	140149	44310
1921	32343	3090
1922	59608	22
1923	65925	2001
1924	31900	--

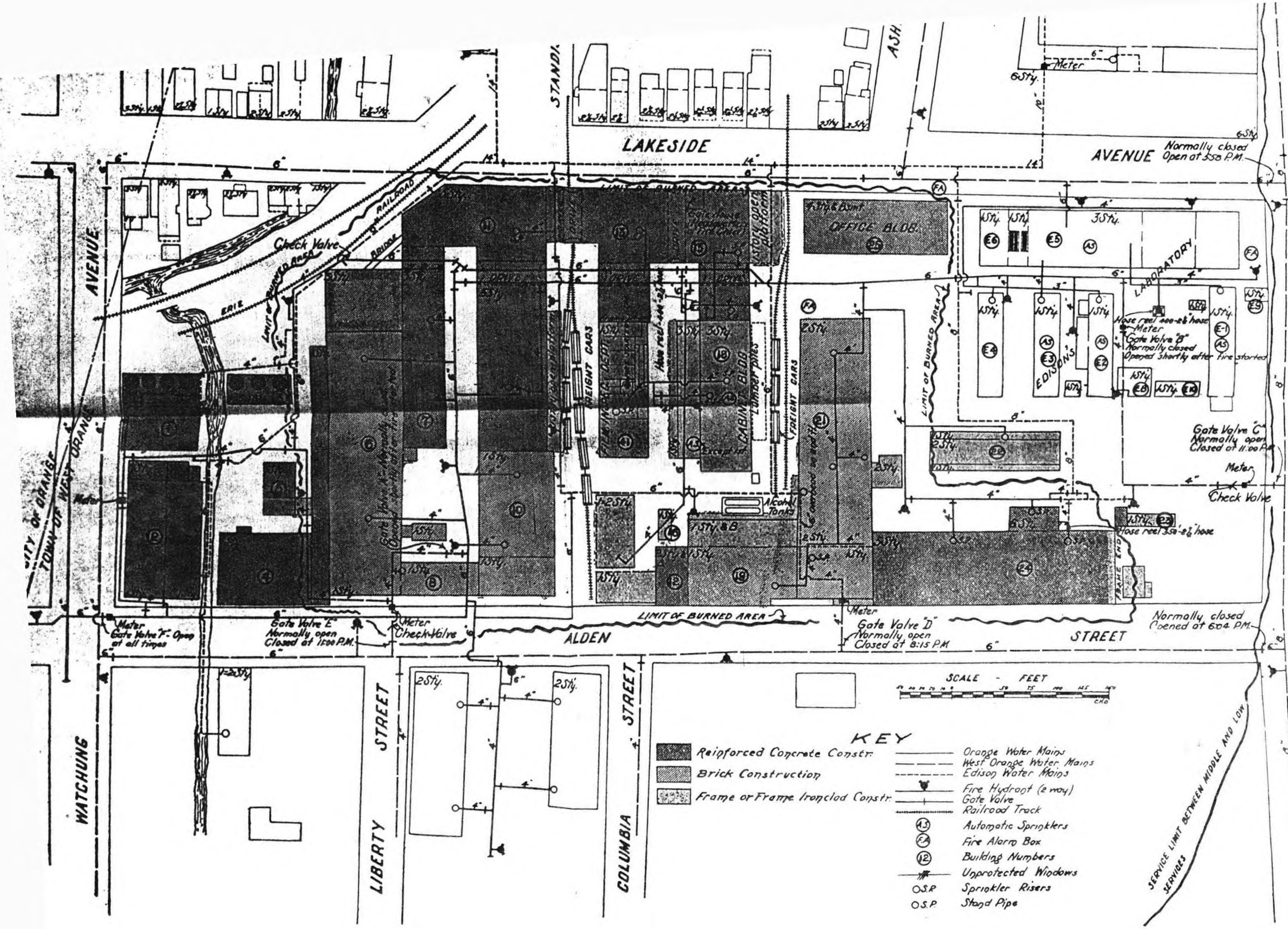
twentieth century. (See Chapter Eleven) Its potential had convinced TAE Inc. to devote a large-scale engineering effort to the dictating machine. The drawings for the new business machine were completed at the end of 1914 and then the tools were designed in the Phonograph Works. [2] In addition to completely new products, there were also a wide range of engineering problems connected with manufacturing existing products--especially storage batteries and motion pictures--that occupied the laboratory work force. The pressure of work at West Orange blurred the lines between experimenting and production engineering as Edison drove his men to complete the many projects at hand before the end of 1914.

The overflow of work at West Orange was caused by the problems with the first disc machines; this delayed their commercial introduction and created a bottleneck in the Works. The delays in the disc project disrupted the schedule of manufacturing the motion picture and dictating machine products. The diamond disc line that was finally introduced in 1913 had several more years of intense development on the disc record and reproducer before it could match up to the advertising claims of its makers. The disc machines and records suffered from the same "bugs" that had delayed the introduction of other innovations in phonograph technology. Sales of disc machines were dependent on the the growth of a library of Edison disc records, for the diamond disc machines could only play the Edison disc records.

The diamond point of the Edison disc phonograph was claimed to be superior to the competition's steel stylus because it not only sounded better but also did not have to be replaced. Unfortunately, the diamond point acted as an abrasive on the record surface and decreased its playing life. The search for an improved, lighter reproducer that would not damage records became a long and difficult one. The condensite recording media of the disc also had to be perfected. The resources of the laboratory were therefore committed to frantic efforts to solve these problems during the winter of 1914.

The year of great activity at the West Orange complex was ended on December 9, 1914 when a fire nearly consumed the whole area. The starting point of the fire was a shed containing highly inflamable motion picture film stock which stood in the middle of the old Phonograph Works buildings. The wooden factory structures soon began to burn furiously and the fire spread rapidly through the rest of the Works. The flames blazed for hours and could be seen seven miles away in Newark. By the time the fire had been brought under control the next day, thirteen buildings had been badly damaged or destroyed at an estimated loss of a million dollars.[3] (Illus.10-1)

Although the fire seriously damaged the West Orange complex, the laboratory was miraculously saved and with it the precious moulds and recordings for the phonograph business. The rapid recovery from this disaster is a testament to Edison's personal leadership of the organization. He led the clearing


LAKESIDE
AVENUE
ALDEN
STREET
VALLEY
WATCHUNG
AVENUE
LIBERTY
STREET
COLUMBIA
STREET
CITY OF ORANGE
TOWN OF WEST ORANGE
ERIE
RAILROAD
BRIDGE
Check Valve
LIMIT OF BURNED AREA
OFFICE BLDG.
LABORATORY
EDISON'S
FREIGHT CARS
CABINET BLDG.
Lumber piles
Alcohol Tanks
Meter
Normally closed
Open at 5:50 P.M.
Gate Valve "B"
Normally closed
Opened shortly after fire started
Gate Valve "C"
Normally open
Closed at 11:00 P.M.
Gate Valve "D"
Normally open
Closed at 8:15 P.M.
Gate Valve "E"
Normally open
Closed at 1:00 P.M.
Gate Valve "F" Open at all times
Normally closed
Opened at 6:04 P.M.
Hose reel 350-2½" hose
SCALE - FEET
SERVICE LIMIT BETWEEN MIDDLE AND LOW SERVICES
KEY
Reinforced Concrete Constr.
Brick Construction
Frame or Frame Ironclad Constr.
Orange Water Mains
West Orange Water Mains
Edison Water Mains
Fire Hydrant (2 way)
Gate Valve
Railroad Track
Automatic Sprinklers
Fire Alarm Box
Building Numbers
Unprotected Windows
Sprinkler Risers
Stand Pipe

ILLUS 10-1

and rebuilding work that began the very next day after the fire. Experimenters, managers, and laborers returned to pick their businesses out of the "fire swept Works."[4] Soon after the fire a document circulated the West Orange complex listing the "Manufacturing Resources for a Quick Resumption." At the top of the list: "Edison, himself--24 Hours a Day."[5] The great fire underlined the fact that Edison was still the driving force of his industrial empire.

The retirement of 1907 was forgotten. The challenge of the disc phonograph now turned into the fight to rebuild an organization that could survive the tempestuous business environment of the twentieth century. Edison's son Charles was now at West Orange, training to take over the business. A graduate of M.I.T., Charles joined the Edison enterprise in 1913. Edison must have been concerned to protect his business enterprise in preparation for the hand-over of power at his eventual retirement. He gave his son a personal demonstration of the courage needed to run a modern corporation after the fire. The "old man" did not have time to mourn the damage done, instead he reassured his son that "We'll have a much better plant when we get through. We've swept away all the old shacks, and now we can have a good plant."[6]

The fire did indeed do more to reorganize the Phonograph Works than all the administrative innovations introduced from 1900 to 1913. By destroying all work in progress, the fire gave Edison's engineers the opportunity to start again from scratch.

The fire was therefore a major turning point from the engineering and manufacturing standpoints. It also became the symbolic watershed between a period of intense development and a period of manufacture which followed.

The company told the Internal Revenue Service that the pre 1914 period was the "development" stage, when Edison, "being more interested in the perfecting of the product" directed the resources of his enterprise towards research. [7] After the fire of 1914, TAE Inc. prepared to concentrate on the manufacture of the new products. Edison had anticipated this shift as early as 1910 when development work in the three major businesses--phonographs, batteries, and motion pictures--were well underway. He wrote to Bergmann that "our pioneering and experimental period is now over and we are going for cost reduction."[8] The continuing problems with the disc machine spoiled this schedule, but production of the Edison disc phonograph was the first priority when the Works reopened in 1915. By the end of January 1915, the first disc was produced in the storage battery factory opposite the laboratory. A new era in the history of the laboratory was beginning.

TAE Inc. was now most concerned with the manufacture and marketing of the new products, and the focus of the laboratory turned from research to supporting manufacturing. This is not to say that experimenting ended at the laboratory or that the experimental period on the disc was over. For the bulk of the labor force, the work was shifting to production engineering.

Yet for Edison and the men around him, R&D on the disc product was a major project that was to preoccupy them until 1917. The first priority was to improve the disc and eliminate some of the surface noise. The more sensitive the recording diaphragm, the more surface noise was reproduced. Edison was determined to capture all the "overtones" of the recording but this forced him into the difficult task of reducing the loudness of the surface noise. He indulged in an orgy of all-night experimenting sessions throughout 1915 and 1916, vowing that "I shall never stop until I get rid of it altogether."[9] His large personal staff was fully occupied in assisting the "old man," and a great deal of time was spent on making minor improvements in disc duplication and the condensite recording medium. Edison's experts in the laboratory applied their knowledge of the phonograph and their experience with the cylinder format to the disc. It was only after the quality of the disc surface had been markedly improved that attention was given to the mechanical operation of the new phonograph. The C-250 Chipppendale model, introduced in 1916, was the first Edison disc phonograph to achieve widespread commercial success. (See Table 10-1.)

Edison supervised every major experimental campaign in the laboratory in addition to his work of rebuilding the Works and restructuring the organization. His secretary and biographer, William Meadowcroft, had been with the "old man" long enough to have seen many periods of frantic activity, yet he recounted that 1915 was the climax to many busy years at the West Orange laboratory. [10] Next to Edison in the chain of command stood Miller Reese Hutchison, chief engineer of the laboratory and confidant of the "old man." When he took over the position in 1912, Hutchison attempted to bring more order to the daily work of the laboratory, installing some new procedures and a time clock that still stands by the entrance to Building 5. Although Hutchison had some new ideas about managing the laboratory work force, he was strictly Edison's man who applied the "old man's" policies and decisions to the work at hand. No model ever left the laboratory without Edison's approval.

Hutchison was a "mucker" of the old school because he had business interests in the technology being developed at the lab. Like Tate and Batchelor before him, Hutchison stood to make money on the marketing of a new product. Edison had given Hutchison the rights to sell the storage battery and claim a commission. The work of selling the battery occupied much of the chief engineer's time and his duties were so extensive that they were delegated to other men during Hutchison's tenure. The job of managing the machine shops and scheduling work was given to a "superintendent" of the laboratory (C. Luhr) and much of the routine engineering work was assigned to an assistant chief engineer, John Constable.[11]

THE DIVISIONAL POLICY

The strategies of diversification and vertical integration of the nineteenth century had left Edison with a complex and confused industrial empire. The creation of TAE Inc. in 1911 had been a response to the falling profits and overextended finances of the Edison enterprise. It provided economical management to a broad range of operations and brought central control to the many parts of Edison's industrial empire. A level of middle management had been created and specialists hired, but their power remained circumscribed by the great informal influence of Edison and the shifting sands of many the committees which, in essence, left the decision making in the hands of a few senior executives around Edison. Proximity to the "old man" was still the key to power in the organization, as the meteoric rise of Hutchison had shown. (Illus 10-2, #14425)

The shift to marketing a string of new products made new demands on the administration. The Edison interests found themselves faced with selling new products in markets that were becoming increasingly competitive. They were still fighting on all fronts, and against a competition that was well-entrenched. Victor still dominated the phonograph business, the Dictaphone Company (a subsidiary of the Columbia Company) held sway in the

Illustration 10-2

Edison and Hutchison

dictating machine market, and the Electric Storage Battery Company was still the one to beat in this industry. The motion picture business had been taken up after the fire, when competition in this industry reached new peaks after the demise of the Motion Picture Patents Company. The Portland Cement Company faced falling prices in an overcrowded business.

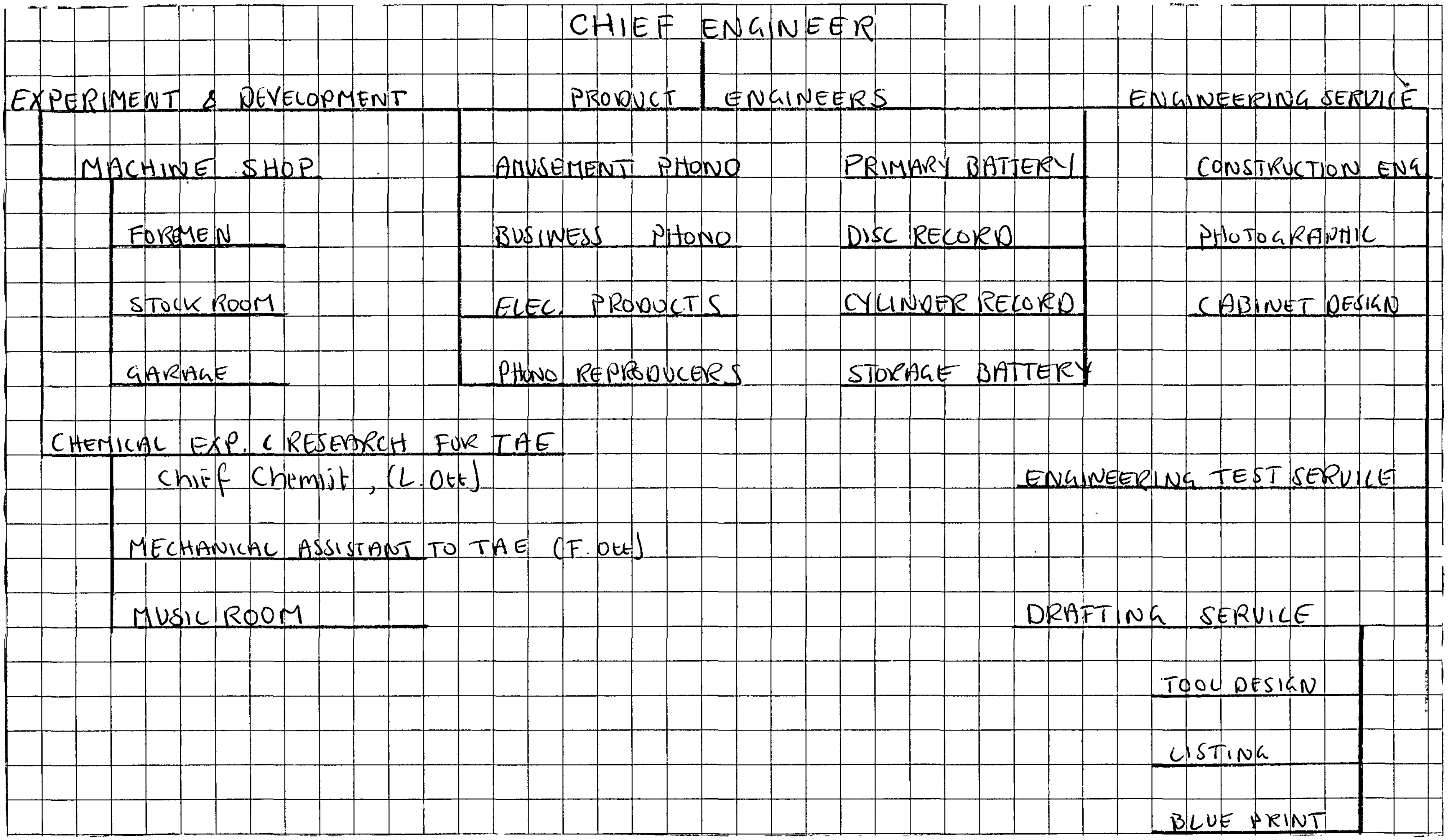
The surge of innovations from the laboratory had created many different businesses in the Edison enterprise and each one had its own unique technology and market. Each of the Edison products had a different market: primary batteries were sold largely to the railroad industry, storage batteries went to industrial users and delivery companies, the dictating machine was marketed to the business community, and the phonograph and motion picture were articles of mass consumption which demanded a special knowledge of the world of entertainment. The centralized organization of TAE Inc. was not suited to this broad range of products because it concentrated power in the upper level of management and distanced it from day-to-day activities. The administration of TAE Inc. had become top heavy and this was perceived as a disadvantage in selling a broad range of products in different markets. In the words of one manager, "we were suffering from having the brains all on top and the labor all underneath with nothing in between." [12] The men who were closest to the points of manufacture and sale did not have the initiative in the company.

It was recognized in TAE Inc. that each of the diverse products it produced would be better managed by somebody knowledgeable about the business. The divisional policy was a response to the perceived weaknesses in TAE Inc; a corporate dinosaur was not going to remove Victor from its commanding place in the phonograph industry. It made sense that products as different as cement and primary batteries should be marketed by independent organizations. The divisional policy was intended to move decision making closer to the market and give middle managers the opportunity to exercise their special technical or marketing skills.

The evolution of the modern business organization has been chronicled by Alfred Chandler. He has shown that the multidivisional, decentralized structure came as a response to problems of running a diversified business and remained as the standard of business organization in the twentieth century. Beginning with Du Pont and General Motors, Chandler has described how big business in America embraced this structure.[13] As Edison's policy of diversification came slightly before Du Pont and GM, his move to a divisional structure precedes theirs by several years. The policy was laid out by Edison and announced on March 15, 1915. It broke down TAE Inc. into separate divisions, each the responsibility of a division manager. The divisional structure was modelled on the United States government; the central administration was the federal government, each division was a state and the division manager was the state governor. [14] The central administration gave the Division Managers "as wide latitude as possible," setting general policy and coordinating their efforts. Edison did not concern himself with the day-to-day affairs of his companies, for as Meadowcroft wrote: "His forte does not lie in the lines of routine business methods." The job of strategic planning remained with Edison and a few key managers in the upper level of TAE Inc. The division structure was their idea and it was originated, planned, and installed from above with brutal speed.[15]

The move toward an organization made up of marketing divisions had begun after the creation of TAE Inc., when each product was controlled by a sales manager who ran a small marketing department. Many of the division managers were primarily sales orientated, including William Maxwell of the Musical Phonograph Division, and Nelson Durand of the Dictating Machine Division. The divisional policy was first introduced to the primary battery business, because this product was clearly independent of the others and its market was narrow. The other products followed. The laboratory was classed with the centralized administration as a service organization. Its work was to support the products and manufacturing activities of each division. Chart 10-1 shows the organization of TAE Inc. in 1916 in which the divisions represent the Edison product line: musical and business phonographs, disc and cylinder records, numbering machines, chemicals, primary batteries, and motion pictures. Some of the divisions were oriented toward marketing,

Chart 10-2
Organization of West Orange Laboratory circa 1917



such as the Musical Phonograph, and others concentrated on manufacturing, including all the disc and cylinder divisions. The Musical Phonograph Division was conceived as a jobbing organization that bought the machines and records manufactured by the manufacturing divisions, and then marketed them through a network of dealers. [16]

The divisional policy not only established the basic product divisions of TAE Inc., but also accelerated the policy of organizing each part of the manufacturing process into a separate unit, under the control of a manager. The manufacturing division was another milestone on the long road to increased output and productivity. Previously, the Phonograph Works was divided into several departments, including a cabinet department, numbering machine department, electrical department, and an assembly department. [17] Over time the departments that carried an increased load of business were turned into divisions, such as the Reproducer Assembly Division of the Phonograph Works, established in April 1916. [18] The central administration of TAE Inc. had also been broken down into departments. The great amount of new work to be done by the management led to the creation of many more departments, each carrying out a specialized function.

The divisional policy not only aimed at more informed and energetic management of each product division, but also established a management structure that was centered on costing. The division was created to establish cost; the division manager was made accountable for the costs of manufacture and sales. It was hoped that the division managers' concern with keeping costs down would prevent the administration from becoming large and inefficient. Under the old system at TAE Inc. there was no responsibility for following the costs of each product as all were manufactured under the same costing system. A highly dispersed industry, like motion pictures, defied accurate estimation of the costs of production, and the sheer volume of an operation such as record production made it difficult to verify the cost of a single disc. During the balmy days of the phonograph boom, TAE Inc. produced thousands of products with little knowledge of how much it was costing. "We never knew whether we were making or losing money," remembered one executive. [19] This situation could not be tolerated in the tight financial situation after the fire. The divisional structure was intended to identify and record costs for every business within TAE Inc.

The division manager was made responsible for the identification of costs in his division. All his transactions were filtered through the Financial Executive which was the central organ of cost control. The divisional structure put more power into the hands of the accountants and chief among them was Stephen Mambert. He began his career in the company as a cost clerk in 1913, and by 1914 was assistant to Charles Edison. Although he was being groomed to take over from his father, the twenty-four-year-old Charles found many distractions during his early years in the company, including the delights of Greenwich Village. [20] Mambert, on the other hand, was a conscientious worker with great ambition. He gained the ear of Edison and was soon promoted to "Efficiency Engineer" and placed in the lab organization. His power and jurisdiction steadily increased and so did the size of the Efficiency Engineer's department. Mambert was mainly concerned with controlling the spiralling costs of the organization; he was an administrator, not an engineer or a salesman.(Ilus.10-3, # 4660)

As head of the Financial Executive, Stephen Mambert implemented a much tighter purchasing policy on all parts of TAE Inc. Previously the purchasing policy was poorly defined and the department was small. In the new order of things requisitions for materials were funnelled through Mambert's organization and the enlarged Purchasing Department could not act until it received proper authorization. Mambert also had to approve the disposal of by-products and waste. The divisions were told that their dealings with outside manufacturers should be confined to information that was needed to make "an intelligent request" for goods or supplies. [21] The financial executive became the means to control the divisions. It relentlessly pressed each manager for the exact details of his operation. It scrutinized the payroll and hunted down "discrepancies." It checked, and double checked, accounts payable and receivable. It acted as the clearing house through

Illustration 10-3

John Constable, Charles Edison, and Stephen Mambert which all orders for materials, tools, and services had to pass. [22]

Although the divisional policy created several organizations (the divisions) for coordinating production and administering sales, it did not detract from the power of TAE Inc's central management. The divisional structure was still responsive to the economy drive of the central management, who made it known that it was Edison's "personal desire...to effect greater economies and properly conserve our finances." [23] The division managers were instructed to send copious information about their activities to the central management. When Edison began the divisional policy he instructed every divison to supply him with daily reports of orders and shipments. [24] The stream of information arriving on Edison's desk in the lab provided him with the means of staying in touch with operations. This policy was continued by his son, whose power was growing inside TAE Inc. Charles Edison requested the divisions to provide him with monthly reports about cost reductions and new methods of production. [25]

While Edison concerned himself with the pressing technical problems of the disc, professional managers took a larger part in running the new organization. Stephen Mambert reached the top of TAE Inc, by gaining the confidence of the chief executive. As Mambert got closer to Edison, his power grew until he portrayed himself as the means to translate "Mr. Edison's policies relative to Management, Labor and Sales" into action. Edison's attitude to labor at this time was not friendly and his instructions to Mambert were to reduce the payroll. [26] It was important to cut the cost of operations after the fire because the expense of rebuilding had increased the debt of TAE Inc. Mambert was useful to Edison as a liaison with the financial community, upon whom TAE Inc. was becoming more dependent. Edison thought that Mambert was the most valuable man he ever employed because only he ever managed to get credit from the banks. Edison claimed that "Mambert's methods and showings have now enabled us to borrow very large sums... and the banks have confidence." [27]

The increased control of Mambert's Financial Executive was built on a foundation of better record keeping within TAE Inc. The new purchasing policy created a massive amount of paperwork because even the smallest transaction between divisions and departments of TAE Inc., which had heretofore been informal and unrecorded, now had to be carried out under a purchase order, including all the work of the laboratory. The division managers also had the responsibility of reporting many new types of transactions to the central management in the forms of weekly and monthly reports. Consequently the Accounting Department was enlarged, and a new department, the Efficiency Department, was created. This was Mambert's domain. He also controlled the work of the accountants, bookkeepers, and statisticians in the Accounting and Auditing Departments. Mambert sent his men to every part of the organization, some acted as office managers, some operated the new mechanical accounting machines installed in all the divisions, and others simply carried out Mambert's dictum of "Better Financial Practices" which was based on copious business records and frequent audits. [28] As Efficiency Engineer, he was also an important member of the laboratory staff and as "Financial Executive" he was second only to Charles Edison in the hierarchy below Thomas Edison.

Not all the divisions were in the hands of professional managers; some were run by engineers. This was the case in the Primary Battery Division (managed by W. Hudson) and in the Disc Reproduction Division, which was headed by W.W. Dinwiddie. One of the main projects undertaken by Dinwiddie was the reproduction of cylinder records. Yet in the flexible arrangement of engineering at West Orange he was soon moved and given the task of making educational films, and in this position he gained management experience. He was then directed to work on the problems of duplicating discs and finally put in charge of the division that was to do this. Walter Dinwiddie was, at heart, an experimenter and it infuriated Mambert that he ran his division in a democratic and (to Mambert) unbusinesslike manner.

The Disc Reproduction Division became his target for financial reform. Mambert thought this to be the weakest division of TAE Inc., with the lowest profits and the sloppiest management. [29] The division did not make a profit in the first few years of operation as production methods had still not been perfected and the wartime disruption of raw materials made costs unstable. Dinwiddie was an expert in wax moulds and record manufacture, but he faced difficult technical problems in mass-producing disc records. Mambert set about changing this situation by financial and organizational reforms, insisting that Dinwiddie spend his time finding out the costs of producing the records.

One of the most important functions of the division management was to estimate the costs of producing the product. Previously this had been done in a haphazard manner, or not at all. Stephen Mambert was committed to exact records of cost. One of the first divisional policies, which was delivered down by Edison himself, was to make intensive studies of costs of operations of each division. The disc reproduction operation was a new business that produced 35,000 records a day and aimed to go much higher, yet the cost to make per disc was not known. [30] The cost of disc records was roughly estimated but when a fraction of a cent per disc record could alter the balance between profit and loss, only an exact estimate could indicate whether a profit was being made.

Mambert tried to install his men and his methods in the disc reproduction division, yet all his attempts were successfully resisted by Dinwiddie, who obviously did not share Mambert's enthusiasm for better financial practices.[31] Mambert also had little success in dealing with W. Hudson, the Division lc

Manager of Primary Batteries, who made a habit of ignoring Mambert's memos and committees. The duel between Mambert and Dinwiddie was ended when Dinwiddie was abruptly called back to the lab to carry out special research. This move was part of Edison's massive effort to improve the sound quality of the disc record. It was probably seen as a victory for Mambert. Mambert was able to institute cost studies of disc record production, and Charles Edison worked on this when he joined the company.

The Financial Executive continually stressed the need to project the costs of each divison in advance, and division managers were hounded to provide estimates. [32] It was Mambert's goal to institute a system of standardized costing of manufacturing. This is a modern accounting technique that involves intensive research of the manufacturing process and the creation of a set of estimated costs for each part of the manufacturing process. These standard costs make it possible to calculate potential overruns or cost reductions during manufacturing. [33] Although he appreciated that standard costing could only come after standardization of manufacturing, Mambert's speedy introduction of his financial reforms meant that the system of costing was established before a system of manufacturing could be instituted. This made standardized costing impossible. As John Constable reflected in 1919, the error of the divisional policy was to make men "responsible for the costs on operations and parts of which they knew nothing...There lies one of our greatest curses today." [34] This was certainly the case with Dinwiddie and the disc record divison. Mambert was trying to set up the cost system before Dinwiddie had worked out the manufacturing process.

THE REORGANIZATION OF THE LABORATORY

The organizational changes in the West Orange laboratory reflected its changing function within the Edison organization. The laboratory created by Edison in 1887 did not fit the needs of a large corporation that, by 1915, had become primarily concerned with maintaining market shares in established businesses. The primary goal in creating divisions was to efficiently manufacture and energetically market existing products. The work of the West Orange laboratory, as envisaged by Edison in the nineteenth century, was to develop completely new products. As the Edison concerns found themselves in more competitive markets, the pressure to provide engineering support for the manufacturing branch grew more powerful. The central lab that had been the moving force of the Edison companies in the nineteenth century had to assume a different role in the twentieth. Meadowcroft reported in 1916 that the laboratory's work was directed toward support of the Edison product line and "there is little of mere research done here." 35

The West Orange lab was no longer the only R&D facility in the Edison interests; the creation of a laboratory at Silver Lake in the 1890s started the process of establishing satellite laboratories in the Edison industrial empire. The expansion of

Edison's manufacturing plants had led to the creation of testing laboratories in the many factories built in the early years of the twentieth century. The divisional policy of TAE Inc. accelerated the growth of satellite laboratories in the various divisions of TAE Inc. By 1916 much of the experimenting and testing at West Orange was being done in the manufacturing buildings which clustered around the original Edison laboratory. [36] As the primary function of these separated laboratories was testing and quality control, they had to be close to the point of manufacture.

The storage battery business required extensive testing services and initially this was carried out at the West Orange laboratory in the battery research department and later in the small cell test department. The pressure of work led to the formation of a separate testing department with its own facilities at the storage battery factory. The test department of the Edison Storage Battery Company slowly enlarged its functions and by 1913 a research department was created at Silver Lake. Testing was considered a vital part of battery manufacture because the end product had to be reliable and free of defects. One tester argued that "the importance of the work here, as related to the marketing of the product, is to my mind unquestionable." [37] In 1917 the Silver Lake laboratory was enlarged, and it soon became a competitor with the West Orange laboratory for chemical testing work.

Several other operations had been taken from the West

Orange laboratory and transferred elsewhere. Recording had always been a function of the lab, but the need to place the studio close to the artistic community resulted in a studio established on 5th Avenue in New York in 1906. The studio not only recorded but also tested records and equipment. Movie making had also been taken from West Orange and placed closer to the artists in Manhattan. The Bronx studio, like all the other film making and recording facilities, was theoretically under the control of the main laboratory at West Orange. The final approval of all Edison records and movies lay in the committee of lab personnel who sat in judgement at West Orange.[38] (Illus. 10-4, # 0454) Yet the management of the studios often tried to assert their independence. This was especially the case of George Plimpton at the Bronx studio. Plimpton fought to keep artistic autonomy over the production of negatives at the Bronx.

The relationship between central laboratory at West Orange and the satellites was more than one of master and servants. Many projects required the coordination of effort between the two. Special equipment that was designed and built at the central lab needed testing in situ. This had to be done in the manufacturing plant and was normally carried out by the staff of the satellite laboratory. Perfecting the technology required close cooperation. In some cases, techniques and processes that had been developed in the satellite laboratories were transfered to the central lab at West Orange. The

Illustration 10-4

The Recording Committee

continual improvement of the phenol resins used in disc manufacture was dependent on good communications between the experimental rooms at West Orange and the vats and ovens of Silver Lake. Harmony and cooperation were often lacking in the relationships of laboratories in the Edison enterprise. There were doubtless many personality conflicts, but underneath these squabbles was the growing rivalry among laboratories and the natural feeling of superiority of those closest to the "old man."[39]

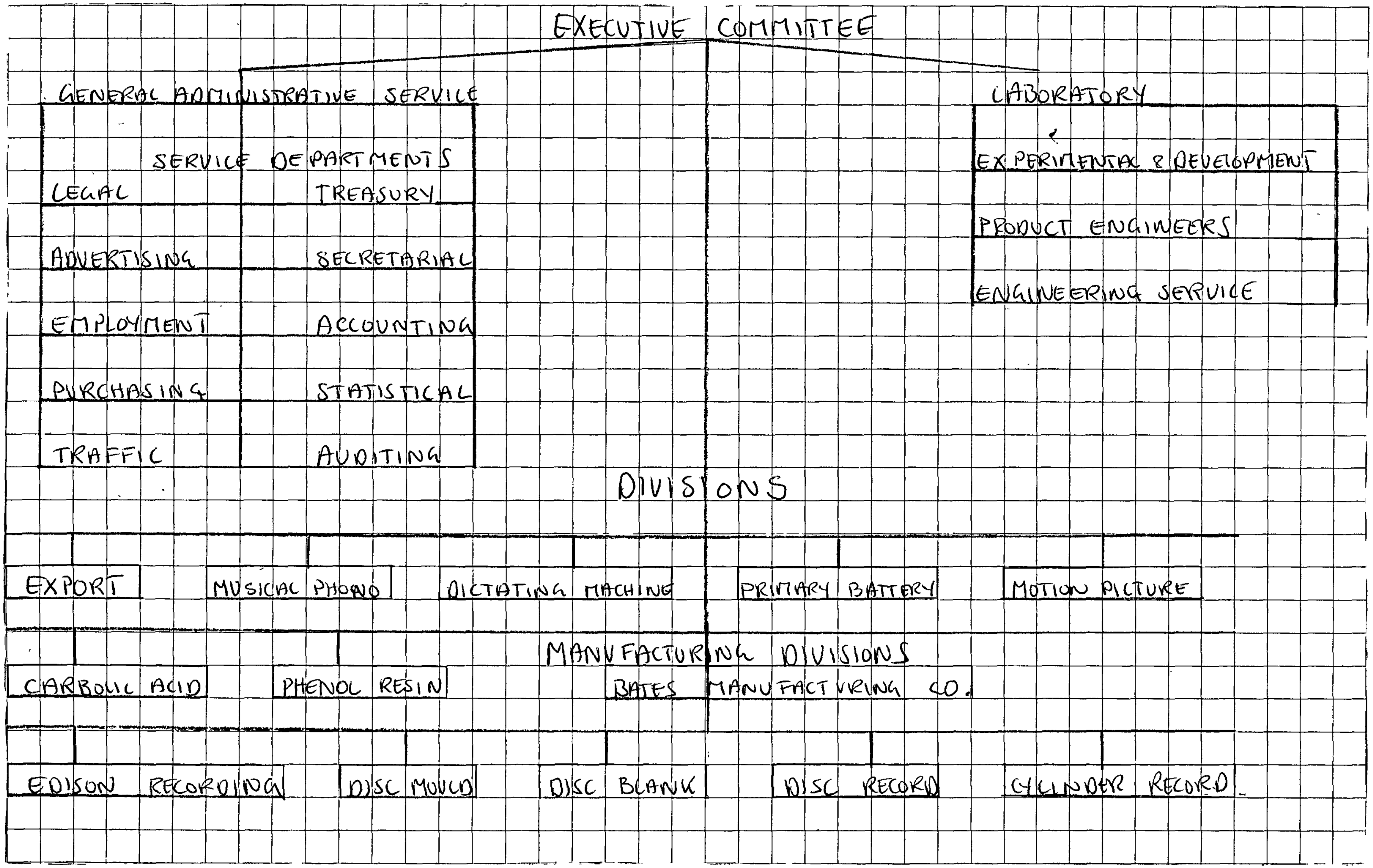
Many of the disputes would have been resolved if there had been lines of demarcation between the functions of the main West Orange laboratory and those in manufacturing sites. Yet true to the original intention of the "old man," the West Orange laboratory did a little bit of everything. Much of the twentieth century growth of Edison's laboratory was in testing and tool making, and these were functions that were the bread and butter of other laboratories in the organization. A primary role of the West Orange laboratory had been enforcing Edison's standards on the manufacturing operations. This had begun with phonograph manufacture (see Chapter Three) and had been extended to cover the diverse product range of the Edison enterprise. Consequently the testing staff at West Orange grew. Over time the value of neutral testing was appreciated and this led to the creation of a new department in the West Orange laboratory under the control of "Doc" Halprin.

Drafting and toolmaking were two other important jobs that had assumed more importance in the twentieth century. The destruction wrought by the fire in the Phonograph Works, combined with the increased demand for drawings and blueprints, forced a concentration of the drafting effort in the main laboratory building (Building 5). The drafting service of the Works was combined with the laboratory's drafting department and the new organization was housed in the main laboratory building. Werner Olson was given control of the new department. Olson had begun his work for Edison as a tool designer and . was more of a team player than independently-minded Otto Weber whom he replaced. Olson sat on several manufacturing committees, and as chief draftsman he was an important member of the laboratory. The formation of a central Drafting Department reflected the centralizing policies of TAE Inc. The laboratory was subject to the same reorganization that had changed the administration. The new policy gave the chief draftsman control of the drafting process and the power to schedule drafting work in an orderly manner. This replaced the initiative of one man working on his own in the Phonograph Works. The drafting department had been independent of the Engineering Department, but after the reorganization it was placed under the jurisdiction of the chief engineer. Edison's exalted position had always justified his own draftsman, yet the reorganization of drafting gave Edison's personal drafting to the main department.[40]

The emphasis in manufacturing resulted in an increase in the staff of the laboratory who were involved in production engineering. The divisional policy was reflected in the creation of service departments in the laboratory. The shift in engineering responsibilities from the Works to the lab is revealed in the number of employees who were taken from the Works payroll and transferred to the lab. Engineers like Doc Halprin had always been Works employees in the years up to the creation of TAE Inc. Yet the clearer definition of their duties led to a realization that they should be managed by the chief engineer rather than the Works superintendent. They were therefore transferred to the lab to staff the new service departments. Other engineers were brought in from the divisions. Adolph Gall, for example, was moved from the Motion Picture Division to the lab in 1917 and given the job of production engineering for phonograph reproducers.

Chart 10-2 shows the organization of the laboratory. The drafting, tool design, and testing departments were part of the Engineering Service, which also included the construction and maintenance departments. The Experiment and Development organization included the management of the laboratory's machine shops, the music room, and Edison's personal staff. The latter were the "muckers" experimenting with Edison. They were the remnants of the nineteenth century Edison laboratory. The music room was the site of experiments connected with recording techniques and the testing of phonographs and reproducers. It was under the control of Clarence Hayes who was also

Chart 10-1
Organization of TAE Inc in 1916



responsible for scouting out new musical talent, purchasing music, and making up the listings of Edison records.[41] (Illus. 10-5, #4632)

The divisional policy had divided TAE Inc. along product lines and it was inevitable that the engineering services provided by the laboratory should follow suit. In the years before the divisional policy, the lab had begun to organize engineering services around each product; the lab's work was becoming product specific. Engineers with specialized knowledge of a business were hired and permanently allotted to a product, such as Newman Holland with the business phonograph. The product engineer was a specialist who devoted his time to a single product, such as the disc phonograph or the motion picture. The essence of his job was to focus the services of the lab onto his specific product; he was able to use all the service departments of the lab--toolmaking, drafting, testing--in his work. The product engineer was a member of the laboratory staff and he was supervised by the chief engineer. He was expected to remain in close contact with the manufacturing and sales departments of his product, and initially this was the rationale behind the creation of the job. A memo of 1917 classified the duties of the product engineer in experimental, development, manufacture, and sales. The emphasis at first, however, was on the latter two categories, and the engineer's duty "to keep your product one jump ahead of the sales requirements" was stressed.[42]

Illustration 10-5

The Music Room

The creation of the job of product engineer illustrates the shift of the laboratory's effort to support the manufacturing effort of the divisions. The product engineer was the logical outcome of the product specific work that the lab had done since the formation of TAE Inc. In the case of the business phonograph, Holland had been acting as the product engineer since 1910, and the changes of 1915/1916 merely confirmed his role in phonograph development. The product engineer grew out of the laboratory's commitment to standardize manufacturing methods. The attempt to formalize production engineering with the creation of the Engineering Department was described in Chapter Eight. Despite the efforts of this new department and several committees, the liaison between the West Orange laboratory and the Phonograph Works was poor and the development of the disc machine had underlined this deficiency. Each part of the production process was carried out by a different worker; from the researcher who produced the first rough design to the clerk in the Phonograph Works who listed the parts, the new product passed through many different hands. The engineers developing the Amberola phonograph in the years before the fire decided that one person should be made responsible for all stages of a product's development; the man who made up the model should also lay out the method of its manufacture and supervise its routing through the works. John Constable, a phonograph engineer, was given the responsibility for taking the Amberola from the lab to the Works. The experience with the Amberola showed that this policy was sound, and it was soon extended to other models, such as the disc phonograph. [43]

This work was progressing slowly when the fire intervened and presented an opportunity for a complete reorganization of the Works. The multitude of various products made in the Phonograph Works had presented a barrier to standardized engineering practices and long production runs. The fire destroyed all the work in progress and enabled Edison's engineers to consolidate the product line when the Works reopened. It also gave Constable the chance to standardize the Amberola line into three main models which all used the same mechanism, with the exception of an extra spring in the most expensive model. The new line of Amberolas was designed to use as many standard parts as possible. [44] In this way the phonograph business was centered on a smaller number of models. Many other products, such as the Bates Numbering Machine, were not manufactured in 1915. By forcing the engineers to begin again from scratch, the new systems and procedures envisaged in 1911 could be instituted from the bottom up, and the result was more orderly production engineering.

Initially the product engineer was to have a foot in both camps; he carried out experimental and development work in the laboratory, at the same time he kept a close watch on problems in manufacture and feedback coming from sales. An important part of his job was setting up the purhase orders which requisitioned the services of the laboratory. The lab's shop order system was reformed at this time and the management stressed the importance of understanding and using the system. The total number of purchase or shop orders was the means to estimate the value of the laboratory's work. All product engineer's work was billed to the relevant divison managers, and they were normally the ones who initiated his line of research.

The changing role of the lab in the Edison enterprise can be gauged by the reorganization of the third floor of Building 5 in 1916. Chart 10-3 shows the floor plan before the changes, the Music Room at one end and Dinwiddie's experimental room at the other. The main office of the lab was on the third floor and adjacent to it was the room of Harry Miller, secretary and treasurer of TAE Inc. The administrative offices take only a small part of the floor space; most of the third floor was taken up with experimenting.

Chart 10-4 shows the new floor plan. The Music Room was maintained and two small offices were created for recording research and the disc experiments of Dinwiddie. Next to these rooms was the office of R.W. Kellow, one of Edison's secretaries who also handled all the bookkeeping and work scheduling of the lab. Miller's staff was housed in Kellow's office. At the other end of the third floor was a complex of the drafting and testing services and the office of the chief engineer; the Engineering Department was therefore brought

Chart 10-3
Floor PLan of Third Floor of Laboratory

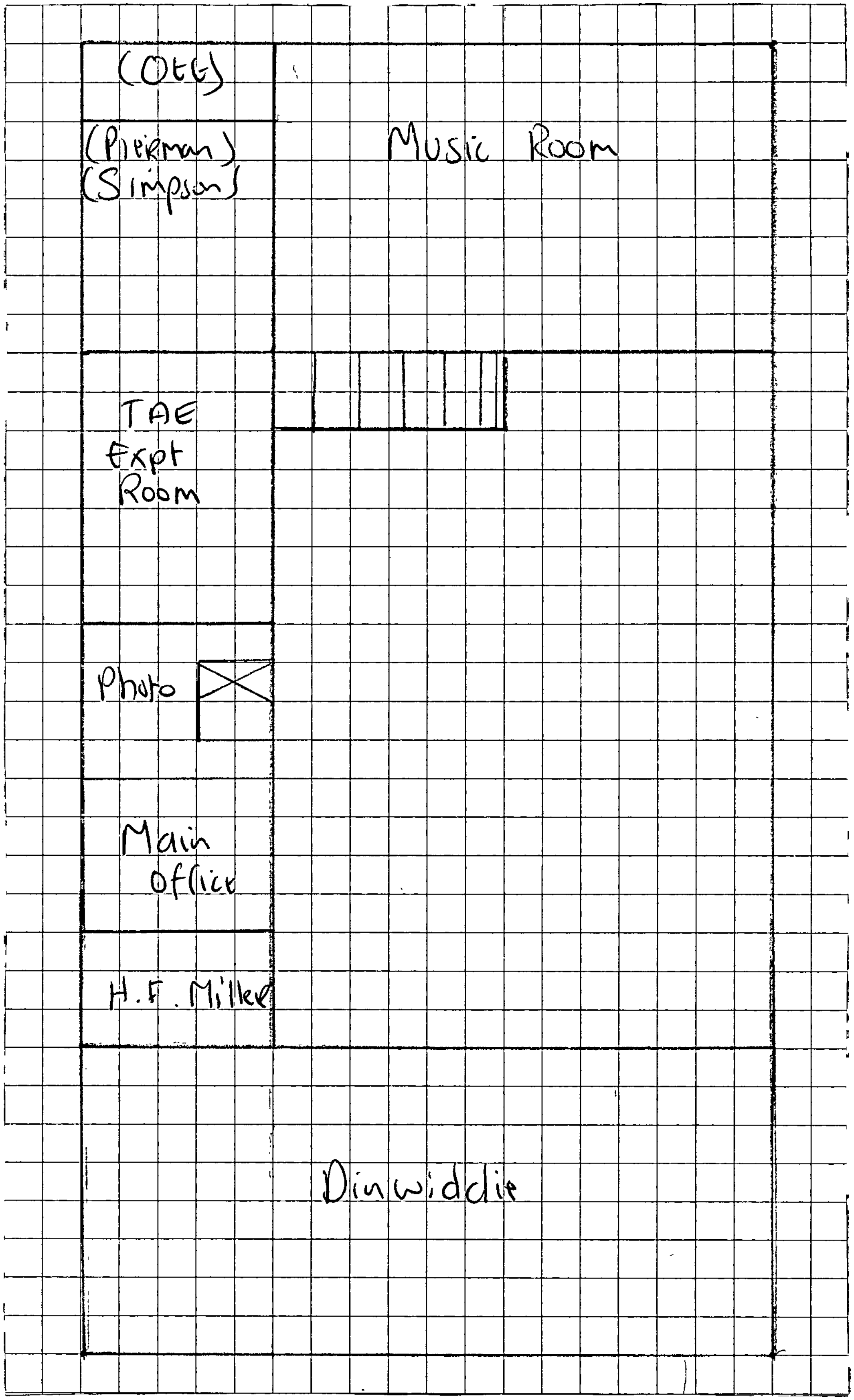
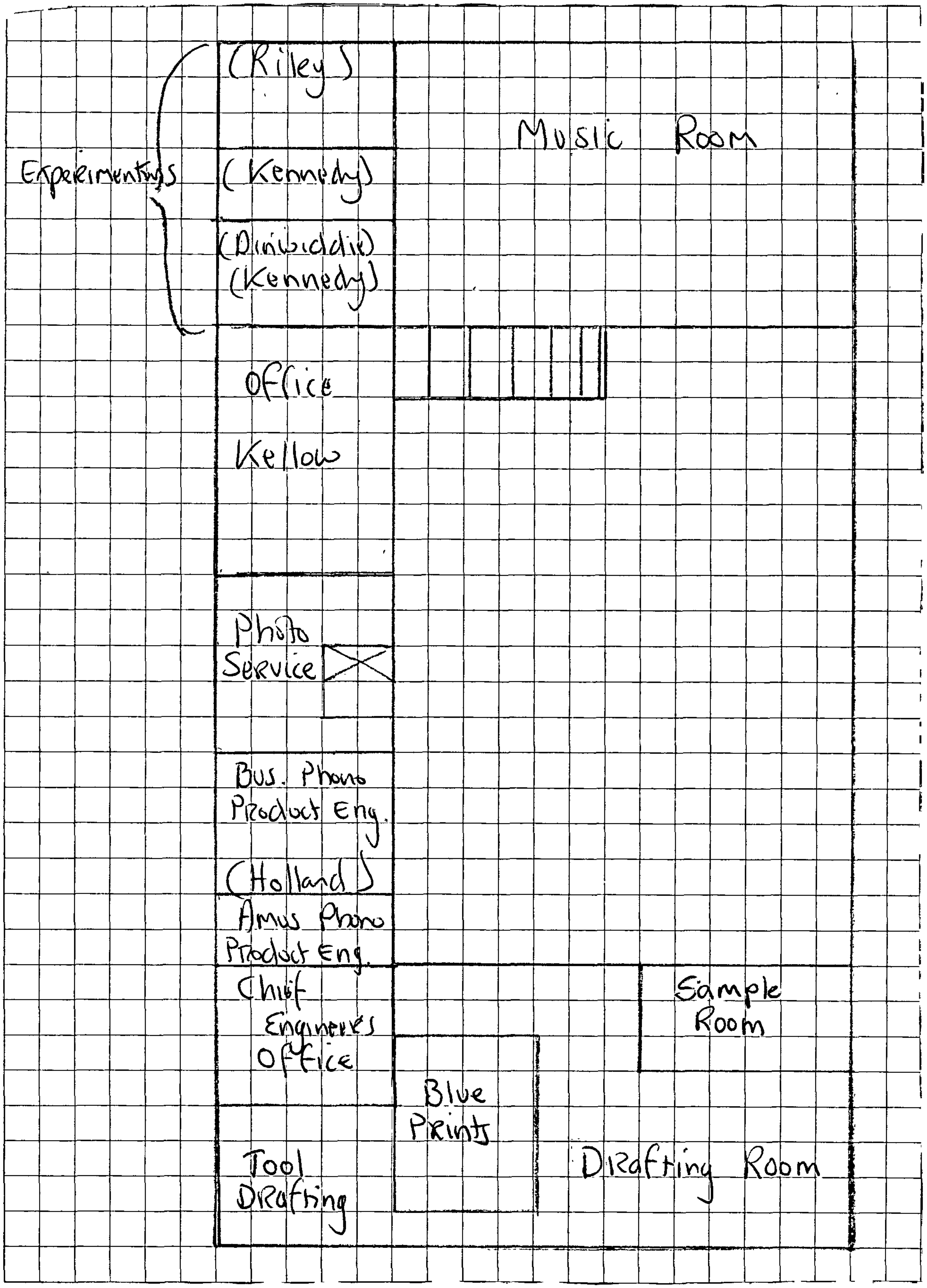


Chart 10-4
Floor Plan of Third Floor of Laboratory



together and next to it were the offices of the two phonograph product engineers. The new floor plan shows a work space that was once used for experimentation was now devoted mainly to administration.

The emphasis on engineering services at the lab brought more draftsmen and clerks to Building 5, In addition to the offices on the third floor, drafting was also carried out on the second floor, close to the office of the superintendent of the laboratory's machine shops. The second floor also housed the Construction Engineering Department which attended to all changes and repairs in the physical plant at West Orange. The smaller rooms at the library end of the second floor contained the Jewel Department (for reproducer needles) and the cabinet design team. [45]

Edison used rooms on all three floors of the lab, and the elimination of his room on the third floor did not leave him without a place to work. His research on perfecting the disc record led him to spend more of his time in the Chemical Building, where he labored from 1912 to 1916 to eliminate the surface noise of the disc. Meadowcroft noted that "Edison is enjoying himself hugely on some chemical problems" and that the Chemical laboratory in Building 2 was his favorite place to work in the whole West Orange complex. [46] Building 4 was also taken up with Edison's work: half was devoted to experimenters under his direction and the other half was the disc record experimental room. [47]

The rooms of the product engineers on the third floor were probably offices rather than experimental rooms. Most of their work was done in the manufacturing plant of the products for which they were responsible. Newman Holland was moved to his office on the third floor from Building 1, where Mambert's men were housed. The fact that this building, once a main attraction of Edison's laboratory, was now occupied by bureaucrats is evidence of the changes at West Orange. [48]

The creation of the product engineer formalized the lab's engineering support for manufacturing. Their work of developing new technology was framed by the division manager, and the resulting designs were defined by the needs of the market. This is evident in the development of the dictating machine, where Newman Holland had to work to the requirements of Nelson Durand. In stark contrast, the engineering criteria for the disc phonograph were developed by Edison in the laboratory. Failure in the market place can be directly attributed to Edison's technological choices. The business phonograph was developed in a totally different manner and it reflected the control exerted by division managers over the work of the product engineers. The fact that the dictating machine went on to become a highly successful (and long-lived) product shows the advantages of the new ways at the Edison laboratory.

ENDNOTES FOR CHAPTER TEN

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2) R.A. Bachman to Mambert, 31 Dec 1914, Phono Manu.

3) Conot, p. 408.

4) Hutchison Diary, pt. 2, 10 Dec 1910.

5) 19 Dec 1914, Phono Ediphone

6) J Venable, Out of the Shadow, p. 76.

7) R.H. Allen to IRS, 1 Oct 1920, TAE Inc. Organization.

8) TAE to Bergmann, 24 Dec 1910, LB 101208.

9) TAE to S.W. Cutting, 20 Oct 1916, LB 160913, p. 516; Meadowcroft to Delaney, 8 Jan 1916, LB 151216, p. 330.

10) Meadowcroft to Dickson, 30 Dec 1915, D box, bio D.

11) Hutchison minutes, diary entries, and letter to TAE, 5 Nov 1913, Motion Picture.

12) Roundtable Letter, 26 April 1920, vol 1, #3, Eng Dept files.

13) A Chandler, <u>Strategy and Structure</u> (Cambridge: MIT, 1962).

14) Dinwiddie Memo, Cylinder Div Blue Book, 21 April 1917.

15) Round Table Letter, (Charles Edison), 1920.

16) Mambert to Musical Phono Div, 5 Feb 1916, TAE Inc financial executive.

17) I.A. Ventres to C. Edison, 17 Mar 1914, Phono Manu.

18) Mambert to divisions, 26 April 1916, TAE Inc Organization.

19) Round Table Letter.

20) John Venable, Out of the Shadow, chp.4

21) Financial Executive memo # 3602, 5 June 1916,

22) C Wilson to all Division heads, 14 Dec 1914, TAE Inc plant

and equipment.

23) Financial Executive memo # 3602, 5 June 1916.

24) Mambert to Edison Storage Battery, 22 Jan 1916, TAE Inc financial executive.

24) Meadowcroft "Edison Industries" MB 78.

25) C. Edison to Managers, 25 June 1917 TAE Inc adminsitration, C.Edison memos.

26) Mambert Report, Financial Executive memo # 3497, 6 March 1916, TAE Inc organization.

27) Conot, p. 422.

28) R.H. Allen to Mambert, 3 Years Report, 3 April 1919, TAE Inc. financial.

29) Financial Executive Memo # 3497, 6 Mar 1916.

30) Disc Record Division Blue Books.

31) Mambert to C. Edison, 30 Jan 1918, TAE Inc organization.

32) Mambert to W. Stevens, 26 Aug 1918, TAE Inc financial.

33) Mambert to Robinson, 16 Nov 1918, TAE Inc financial.

34) Anon History, 1919.

35) Edison Lab to A. Fleming, 24 July 1916, LB 160630, p. 302.

36) Edison's Lab to A Fleming, 24 July 1916, LB 160630, p. 302.

37) C.E. Mitchell, January 1918, Blue Books, Employment ratings.

38) Edison Phongraph Monthly, Nov 1906.

39) George Clark to JP Constable, 16 July 1918, Disc Record Division files.

40) J. Constable to W.O. Lab, 24 Oct 1919, TAE Inc organization.

41) J. Constable to C. Hayes, 27 Nov 1917, Lab Business.

42) Lab blue Book memo of 11 September 1917.

43) Anon History 1919.

44) J Constable, Report on New Model" 9 Nov 1914, Phono Manu.

45) TAE Personal, lab floor Plan, 25 Nov 1918, WO Lab

46) Meadowcroft to C Goodwin, 20 Oct 1916, LB 160913, p. 520.

47) TAE Personal, Lab Floor PLan, 25 Nov 1918.

48) TAE Personal, Lab Floor Plan, 25 Nov 1918, WO Lab.

BUSINESS AND TECHNOLOGY

THE DICTATING MACHINE

The product that gained the most from the reorganization of the Edison enterprise was the business phonograph. Edison's first intention for his phonograph was to develop it for business use, but all his efforts to market a business machine had met with failure. Preceding chapters have discussed the technological development of the phonograph, what Edison called the "perfecting" of the machine. These advances were applied to the dictating machine, but this alone did not ensure sales. The marketing effort also had to be perfected for this was the key to success. It was only after the formation of TAE Inc. that adequate resources were given to promoting the use of the Edison business phonograph and selling them to businessmen. The dictating machine was a highly complex product, probably the most complicated machine in the American business office, and it demanded a knowledgeable salesforce and support organization. Marketing a dictating machine required a very large investment in R&D and sales staff. Edison's goal of putting one of his machines in every office was not realized until the 1920s, when two criteria were met: the laboratory had produced a machine that was easy to use, and the divisional policy of TAE Inc. had created the large sales organization that was essential to succeed in this business.

When Edison re-entered the business machine field in 1905, his laboratory staff had improved the orginal phonograph format considerably. His recording experts now knew more about recording the human voice and achieving a loud and distinct playback. The introduction of the 4 minute cylinder was especially suited for the dictation of business letters. Finally, the basic phonograph format had evolved into a lighter, more compact machine. The development of the Home model opened the way to a series of designs in which the length of the mandrel assembly was shortened. The Standard and Gem models had short mandrels with the drive screw assembly parallel and to its rear. This was the general arrangement of the Edison business phonograph, which still retained the wooden base of the amusement model. (Illus 11-1.)

The Edison business phonograph of 1905 was not specifically designed for the business user. According to Durand, its basic format was no different from the graphophone, the dictating machine that had first been introduced in the 1880s. [1] (See Illus 11-2, Graphophone ad.) No effort was made to make the business phonograph any easier to use than the amusement phonograph and there was no correction device nor means of measuring the length of the dictated message. The new Edison product was priced at $70, significantly less than the $100 to $150 price range of the nineteenth century but still $10 more than the price of the Graphophone.[2]

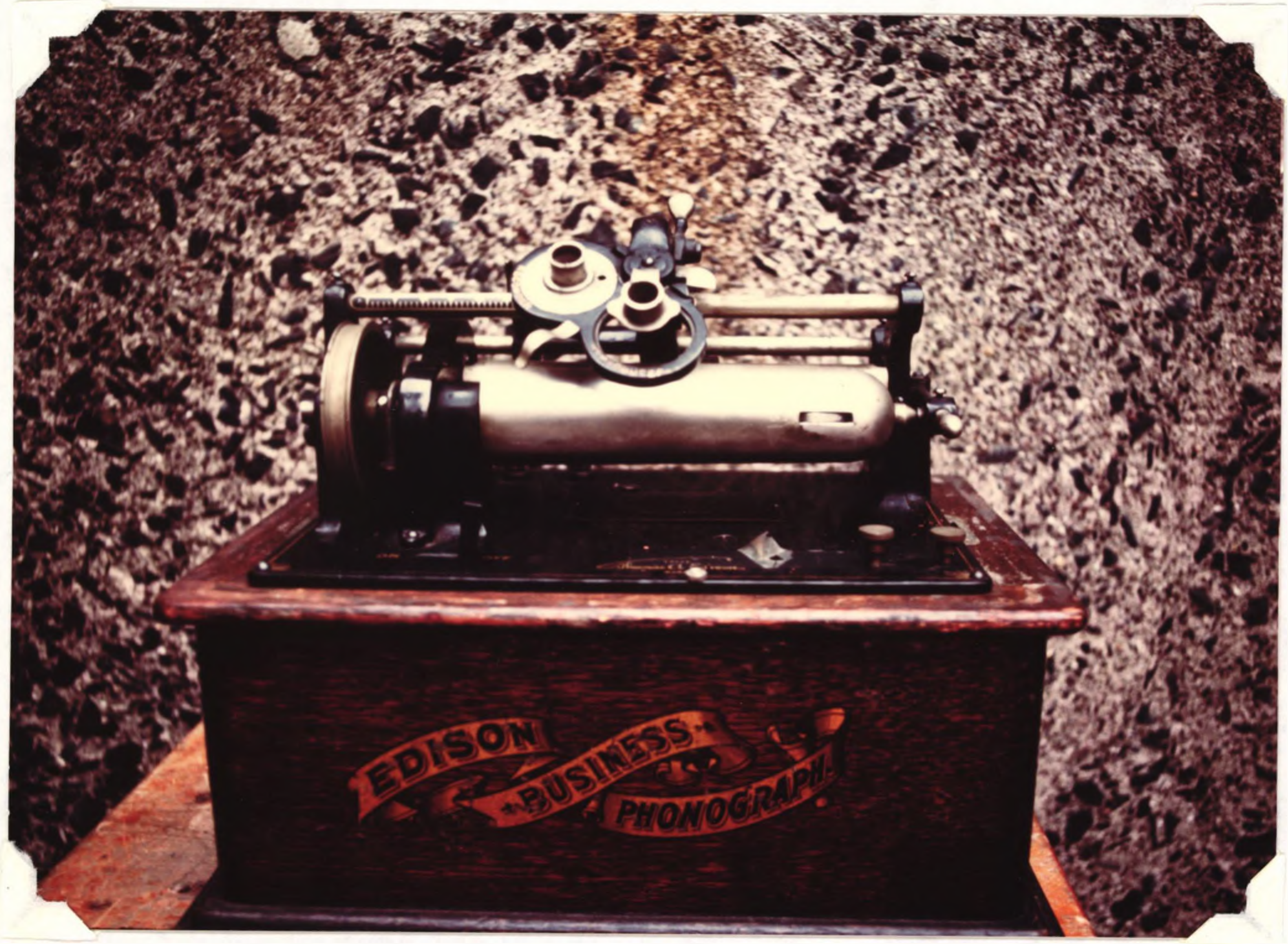


Illustration 11-1

1905 Business Phonograph

Illustration 11-2

Graphophone Advert

Although Edison once told his English agent, Gouraud, that "all my experience with marketing novel machines points to the need of experts," the National Phonograph Company had been unable to provide the skilled salesmen needed to market the machine. [3] The problem in the 1880s and 1890s was that the Edison organization was too lean to support the costs of training experts and could not keep a large sales force in the field. After Edison had tried to market a dictating machine in the 1880s and 1890s he recognised that "a little instruction and practice are needed to operate." As usual he had underestimated the amount of effort needed to train both salesmen and potential users. The operation of the recording and reproduction diaphragms of the business machine required a gentle touch and good hand-eye coordination. The user had to be trained in the correct method of speaking into the recording diaphragm and it certainly was not just a matter of "talk into a tube as fast as you can rattle it off--that's all."[4]

The creation of the commercial department of the National Phonograph Company in 1906 was the beginning of the formation of a special organization, staffed by specialists, to support the manufacture and sales of the business phonograph. But these were small beginnings; the amount of user instruction offered was slight because the dealers were given only a minimal education in the operation and selling points of a dictating machine. The sales network at this time were dealers of amusement phonographs who were trying to make some money in the off-season. Durand said of them in 1909: "the large majority of these dealers are handling our product as a sideline." [5] The most that the commercial department could offer them was a few pamphlets explaining the operation of the machines and its uses!

Although the efforts of the commercial department did not bring a great deal of success (only 3000 serial numbers were used in the 1905-1909 period), there was an identification of some vital goals that shaped the future development of the business. The first of these was that the business machine had to be designed on a completely different set of criteria than the amusement phonograph--it had to be a different machine, from casing to recorder/reproducer. It also needed some important new features--such as the universal motor and an easy correction device. Frank Dyer noted in 1907 that despite the competition of Dictaphone, the successor of the Graphophone, "we are beginning to succeed" in this business. [6]

Sales increased every year in the years before the First World War, but Durand knew that the dictating machine would have to be greatly improved to achieve mass acceptance in American business. In this area, the skilled phonograph men in the laboratory provided valuable assistance and helped develop specifications for a new dictating machine. In 1906, Charles L. Hibbard was brought to the laboratory to experiment on dictating machines. He stayed at the lab until 1910 and gained several phonograph patents. He worked on all aspects of the machine and produced some innovative new designs, including a machine employing discs instead of cylinders. [7] The high price of the business phonograph was a disadvantage in the struggle with the Dictaphone, and consequently the reduction of its cost was also attended to by Hibbard. This was not an easy task. Although its advertising bravely stressed the reduction in price brought about by "economical manufacture" in 1907, the business phonograph still cost more than the average typewriter and the machines of the competition.[8] It took many years before a dictating machines cost less than other common office equipment like typewriter and duplicating machines.

In the years leading up to the formation of TAE Inc., the business phonograph gained more scarce experimental time. In 1910 Newman Holland replaced Charles Hibbard. When Holland joined the Edison organization, the important decision had been made to produce a new business phonograph. Encouraged by the growth of sales, and mindful of the competition, the Edison interests decided in 1909 to develop a completely new business phonograph which would be the basis of a complete office system. The business phonograph department aimed at producing an "office appliance" of unique new design which would set the standard in dictating machines for years to come. [9] Holland worked on the three machines which would constitute the Edison dictating system: the "executive" dictating machine, the "secretarial" machine, which was used for transcribing only, and a shaving machine to recycle used cylinders. (Illus. 11-4,


Edison

29.320)

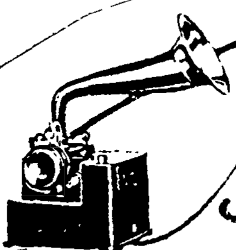
Holland's work at the West Orange laboratory covered all parts of the Edison dictating system: he developed new reproducers, designed many different machines (including a spring driven portable machine), and produced a range of controls. [10] The input from the marketing force was an important determinant of the focus of his work. Nelson Durand insisted on modifications of the machine and engineering work to meet the needs of the user. This led to years of R&D on the design of a sturdy recording/reproducer assembly which would not break with use, and the development of a correction feature. [11] Despite the long delays, which were compounded by Durand's constant interference in development work, new business designs were slowly introduced onto the market in 1911 and 1912.

The correction device was a major selling point in the marketing of a dictating machine; the difficulty of making corrections provided a great deal of sales resistance. Although the promotional literature for the business phonograph claimed that it had a correction device and a repeat function, these important features were add-ons to the existing machine rather than a new design begun with these goals in mind. By 1911 the only significant change in the design of the machine was the introduction of a steel case and an improved electric motor. The correction device was still the clumsy scale and marker on the cylinder. [12] The improved dictating machine of 1912 came with a better correcting device and the new pneumatic control mechanism that was attached to the speaking tube. This was a distinct improvement on the foot peddle used to control the machines. [13]

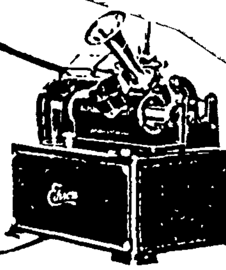
Typically, Holland's work at the West Orange laboratory was not confined to one model or one job. He set to work on a broad range of different technical problems and production jobs. Much of his experimenting was devoted to a completely different concept for the dictating machine--the Edison telescribe. This machine could record telephone messages automatically. Edison had envisaged this application of the phonograph in 1878, "so as to make that invention an auxiliary in the transmission of permanent and reliable methods, instead of being the recipient of momentary and fleeting communication." [14] The telescribe brought together two inventions: the phonograph and the carbon microphone. It was a complex machine which amplified sound from the telephone and recorded it on the phonograph. The user operated the machine by remote control and could also dictate using a separate transmitter. After extensive R&D work, the first models were brought out in 1914 and an improved machine was introduced in 1918. [15] (Illus 11-5, telescribe ads)

The telescribe was an ambitious project in the Edison mould. It was too ambitious for both the available technology and the patience of the user. Edison was again attempting to steal a march on the competition by a technological innovation.

Illustration 11-4



The Edison Telescribe



THE name Telescribe is derived from *tele*, far, and *scribe*, write—meaning, literally, to write from afar.

The Telescribe consists of a sensitive telephone for convenient desk use, with controlling buttons to operate a special recording machine, placed on a floor pedestal nearby.

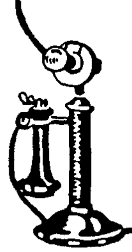
With this electrical arrangement we are able to magnify the voice so that dictation may be performed at conversational distance; or, without delay, we can record all the words passing over the ordinary telephone by lifting the horn (hinged for the purpose), resting the telephone receiver in its place, and listening through a small receiver attached to the Telescribe.

Briefly, the Telescribe is a more sensitive recording instrument, adjusted to receive the same impressions of sound as the human ear. The comparatively faint vibrations through a telephone are now for the first time transferred to a record; or, in dictating, where we formerly held our lips inside a tube to obtain a sufficient volume of sound, we may now speak with even less physical force at a considerable distance, with freedom approaching human conditions.

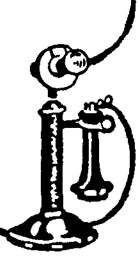
For business dictation, the older form of Edison Dictating Machine will still be available and useful in many instances where the maximum convenience and scope of the Telescribe's operation is not essential.

However, the recording of both sides of our telephone talk is so desirable that the Telescribe will naturally be adopted by many for its universal ability to record all three means of distant communication—*letters*, *telegrams* (by 'phone), *and telephone messages*.

The efficiency of machine dictation is well established, and standard literature describes the operation, but the uses of the Telescribe for telephone recording, while offering even a greater opportunity, is a more unfamiliar field.



The following pages are consequently rather devoted to Edison's method of employing the Telescribe so that it will be profitably used in business for recording telephone talk.



Thomas A. Edison

INCORPORATED
ORANGE, NEW JERSEY

Yet trying to transmit telephone messages to the phonograph acoustically, via an amplifer on the telephone and a sensitive recorder, was patently unpractical in the average business office. Nevertheless, Holland and other Edison engineers devoted much time to this project. There was probably nobody in the Edison organization who could dampen the ambition and the optimism of the "old man." While the resources of the laboratory were being wasted on a product that would never achieve any commercial success, the competition was moving forward on lower priced machines and extensive advertising. The Edison dictating machine was always more expensive than the Dictaphone, because the years of improvements and new features had gradually increased the price of the Edison product from the \$60s up to the \$80s and \$90s. On the other hand, the Dictaphone Company was able to keep to the \$60 price tag for many years. [16]

Holland's work at the lab also involved long-range development of a totally new dictating machine. In considering the design for a new machine, Holland started by reviewing all the previous ideas for business phonographs. The crucial element of the design was the arrangement of the recorder/reproducer. Many designs had been considered, including one by Hibbard in which all the working parts except the recorder/reproducer had been placed beneath the level of the base plate. The great advantage of this format was that the machine was better protected from dirt and abuse from the user.

This decreased breakdowns and promised to make the machine more reliable. The main criterion developed by Holland for the new business machine was simplicity of operation and appearance--all working parts should be concealed in the housing. The essence of the new business phonograph was a simple, sturdy machine that minimized the number of breakdowns in the hands of a careless user. Here was the basic concept of the modern dictating machine. [17]

Newman Holland worked on this machine for several years and did not complete his design until late 1912. [18] By 1914, the management of TAE Inc. had decided that as soon as the disc machine tooling was complete, the Works would turn its attention to manufacturing business machines. The name of the Edison dictating machine was changed to the Ediphone in 1916 and a completely new machine introduced shortly afterwards. The first innovation of the Ediphone was the much cleaner design of the top plate. (Illus 11-5, Ediphone photo) Gone is the clutter of the spectacle arrangement of two diaphragms and the many adjustment screws. The Ediphone was designed primariy as a dictating machine and it had one totally enclosed diaphragm and one lever arrangement to lower it on to the cylinder. The heart of the new machine was the electric motor which could operate on several different voltages, including alternating current. Production of these motors was under the control of the new small motor department which was producing about 100 a day in 1916.[19] The belt drive and gearing was enclosed in a metal

Illustration 11-5

Ediphone

casing. The Ediphone came with a long mandrel for the 5 inch cylinders. It had an ejection device to move the cylinder from the mandrel when dictation was over.

The Ediphone incorporated several years of improvements and modifications, such as the new glass mouthpiece which made it easier to dictate and a semi-automatic correction device. The rubber tubing of the earlier machines was replaced with a flexible metal one which gave better recordings. One outstanding feature of the later Ediphones was the electrical control device which gave the user complete control of the machine via a switch on the mouthpiece. The transcribing machine had the electrical control on the secretary's typewriter which greatly increased ease of use and speed of operation. [20] The correction system marked some improvements over earlier ones but was still a comparatively troublesome process involving marking a guide band attached to a holder on the machine.

CREATING AN OFFICE SYSTEM

The introduction, and steady improvement, of the Ediphone finally provided the right machine for the job, yet it was only part of the systems approach that was the most important innovation in the dictating machine business. In selling a dictation system rather than just a machine, the commercial department needed to integrate a highly complicated technology into the work habits of the American office. This latter task could only be accomplished by a layer of administrative staff and a large sales force. In this way the triumph of the organization would also be the triumph of the business phonograph. Durand and his men took this product from being the lame duck of the nineteenth century and made it a winner in the twentieth.

The original marketing strategy for the Edison Business Phonograph was a primitive attempt to replace the stenographer with a dictating machine. Edison naively believed that the businessman would jump at the opportunity to save money with a machine:

> Your stenographer goes to lunch, goes home, needs a day off occasionally...The phonograph don't eat, is on hand at all times, is always ready.[21]

In the nineteenth century, the stenographer was normally a male who could command high wages for his services, up to $20 per week according to the Edison advertising literature. Replacing a stenographer might reduce labor costs, but it also put the burden of operation on the businessman, and this placed unacceptable demands on his time and patience. The problem with the early dictating machines was their difficulty of use. One demonstrator said that the machines "were so complicated that the average man would have to keep his eye constantly on the book of directions while working them." [22] The slightest mechanical failure brought this technological revolution in the work place to a halt. Even if the dictation was successfully recorded on the 2 minute cylinder, there were no assurances that the stenographer, and later the typist, would be able to understand it.

Edison's return to this market in the twentieth century marked a more realistic approach to sales; the business phonograph was marketed as a means to make the stenographer more productive. The argument used by Edison salesmen was that the phonograph could be used to replace an expensive stenographer, skilled in short hand dictation, with a typist who would transcribe the correspondence taken with the phonograph. The latter need only be able to type, and the slogan of the Edison company was "You can secure half-priced typists to take the place of your experienced stenographers." [23] The company no longer talked about displacing skilled stenographers, for these could be used to manage the correspondence process and also dictate to the machine.

The most important innovation in marketing was the realization that what was needed in the office was a complete system of dictation and transcription, rather than just a dictating machine. In 1905 Durand tried to persuade the managers of the National Phonograph Company that the business phonograph should be sold as a system rather than as a single machine. [24] The conception of introducing new technology as systems rather than independent products had been the hallmark of Edison's business strategies. The design and marketing of the Edison incandescent lighting system has been correctly described as his great innovation in this industry. The concept of a business system was equally important in the successful introduction of a dictating machine; this complicated device had to be marketed as a range of products which complemented each other and the work place into which they were introduced. Edison himself shared this belief, and around 1910 he was thinking about producing a range of machines to suit each customer.[25]

The change of strategy from marketing a single machine to producing an office system was the crucial step in breaking into the business market. The systems approach allowed the separation of the functions of dictating and transcribing. This gave Edison's engineers the leeway to concentrate on one main function in the design of each machine: the dictating machine no longer had to be able to do everything. Now there were different machines for dictating, transcribing, and shaving functions. This technological division had advantages in sales because the businessman who made the decision to buy was relieved of much of the tedium of operation. The dirty work was done by those lower on the pay scale.

The new dictating system was based on the creation of three levels in the office hierarchy: executives at the top, typists who transcribed, and office boys who shaved the cylinders and helped maintain the machinery. The essence of the system was a central transcribing department which would handle all the correspondence dictated to the machines by managers and stenographers. Marketing the business phonograph in this manner involved a careful assessment of the organization of the user's office before centralizing the flow of correspondence into one transcribing department. The Edison salesman had to be trained to arrange the offices of their customers and identify the dynamics of office politics. In many cases it was unwise to suggest that a stenographer should be replaced by a typist. If the former carried out clerical work in addition to correspondence, then the executive would resist replacing a valuable employee. Each office situation had to be treated differently.[26]

The Edison promotional material stressed the uniqueness of the Edison system and proudly claimed that it was "not sold in stores." The customer was visited by an Edison representative to study the work place and "adapt the Edison business system, of which the phonograph is a part," to the existing office arrangement. Customers were told that in buying a machine they were assured of more than the expertise of the Edison laboratory, but also the support of "Our Local Service Organization for maintenance and ...daily attention." Durand told the sales force that "people don't buy it (the dictating machine) for the motor or the other parts, but for the service." [27]

It was only with the creation of the Commercial Phonograph Division that Durand finally had the money to build up his own network of dealers and mould the sales force into an organization that could sell and maintain dictating machines. He aimed at keeping over one hundred salesmen in the field at all times. There was still a great deal of resistance to the dictating machine in American offices. Businessmen preferred to dictate to a stenographer, rather to a machine. Edison's executives were no exception. Charles Edison was most annoyed that the division managers of TAE Inc. did not use the Edison dictating machine.[28]

There were many good reasons for the sales resistance to dictating machines. The machines might be efficient, but they could not replace the personal relationship of businessman and stenographer. The latter--now normally a woman--often played an important part in composing the letter. She was more forgiving of frequent errors and corrections than a machine. Many businessmen preferred to dictate to office girls. Many users of dictating machines dropped them when the secretarial staff decided that they did not like to use them. Many felt that they did not generate enough correspondence to justify mechanizing letter writing, and many would not use dictating machines because they thought their work was too technical.[29] (This last reason was probably the excuse of the managers of TAE Inc.) Durand had to keep up a large-scale sales effort and relentlessly badger prospective customers. He was tireless in organizing exhibits and shows to convince businessmen of the advantages of the dictating machine.

The dictating machine business enjoyed steady growth from 1910 onwards; that year about 6000 machines were sold and by 1918 the figure had exceeded 10,000 for the year, total sales volume reaching over $1,000,000. [30] With a growing organization and a adequate technology in hand, Durand could look forward to the future. Yet he still leaned heavily on the Edison laboratory to maintain market position and even challenge the lead of the Dictaphone. Durand's division was depending on the West Orange laboratory to keep improving the product and lessen the costs of production.

By the time of the great fire of 1914, the business phonograph was a permanent job in the laboratory, financed and controlled by the managers of the business phonograph department. The story of development work on the dictating machine is one of increasing control of experimenters by managers in the Edison organization. The work on the business phonograph had always been more like product engineering than "mucking", for even the experimental work of Holland--a man who preferred to experiment--was directed by Durand. Hibbard too had been controlled by Gilmore who swiftly curtailed the experimenter's foray into the disc format. Holland's tenure as Product Engineer on the business phonograph illustrates the change from the traditional experimental outlook of the laboratory to the new emphasis on engineering support of manufacturing and marketing. The success of the dictating machine was based on the primacy of business over technical considerations.

The successful marketing of the business machine demanded close cooperation between the salesmen in the field and the engineers in the lab. Durand's division was in hot competition with Dictaphone, who buttressed its position of market leader by continually lowering prices and making small improvements. The men in the field brought back information needed to make technical improvements in the machine, and the organization of resources at West Orange allowed Durand to direct the laboratory staff to meet his requirements. The rising costs of R&D made it imperative to efficiently manage these resources. The annual salary of experimenters and mechanics was rising inexorably in the inflation of the First World War.[31]

The reform of engineering at West Orange, including the creation of the Engineering Department, made Durand's job much easier. The divisional policy and the creation of the position of product engineer put Durand firmly in control of R&D and engineering work. The development of the dictating machine ranged from minor changes, such as improving the headband holding the earpiece of the transcribing machine which caught in the typists hair, to exploring completely new designs. Durand's mission to lower the cost of the Ediphone was aided by better cooperation between laboratory and Works and more formal engineering practices in the Works. Laboratory men such as Constable worked with engineers in the Works to apply cost reductions developed in phonograph manufacture to business phonographs. In this way, parts of the Amberola phonograph were successfully used in dictating machines. [32]

Improved communication between the various engineering activities of the Edison enterprise offered division managers valued economies of scope in the technical improvement of their products. The dictating machine division was the beneficiary of sound experiments made in the Columbia St. phonograph recording studio and studies of electric circuits made in the laboratories of the primary battery division.[33] Cooperation between engineers in the West Orange complex finally led to the development of a successful correction device in 1918. This was based on an electromechanical start, repeat, and stop mechanism. This project was under the general control of Holland, but it was dependent on considerable feedback from the users and the cooperation of Sam Langley, the engineer in charge of the motor department of the Phonograph Works. [34]

This steady increase in sales up to 1918 had not convinced Durand that this business was secure. He was concerned with the steady increase of production capacity in the industry and predicted that the post-war market would be highly competitive. To meet this threat, he envisaged a completely new machine that would be designed for the cheapest possible manufacture.[35] The development path of the dictating machine in the 1920s was toward a smaller, cheaper, and simpler machine. A portable spring-driven model was added to the line of Edison machines in anticipation that the busy executive would want to dictate at home or on the road. Over twenty years of experience with spring motor phonographs was obviously a help in creating this new product. About twenty years of experience in selling dictating machines was behind a new design finally introduced in the 1930s. (See Illus 11-6) This Voicewriter model achieved great success and was the machine that finally brought substance to Edison's ambitious claims that there would be a dictating machine in every American office.

The Voicewriter reflected a new movement in design that was gaining momentum in American industry. It was sleek and streamlined. Its spring-loaded hood automatically closed down over the top works. Although the format and the controls were the same as the Ediphone, they were all enclosed. Only the lever on the recorder assembly was changed to make it easier to reach. A revolution in industrial design took place in America in the 1930s and this dictating machine is an excellent example

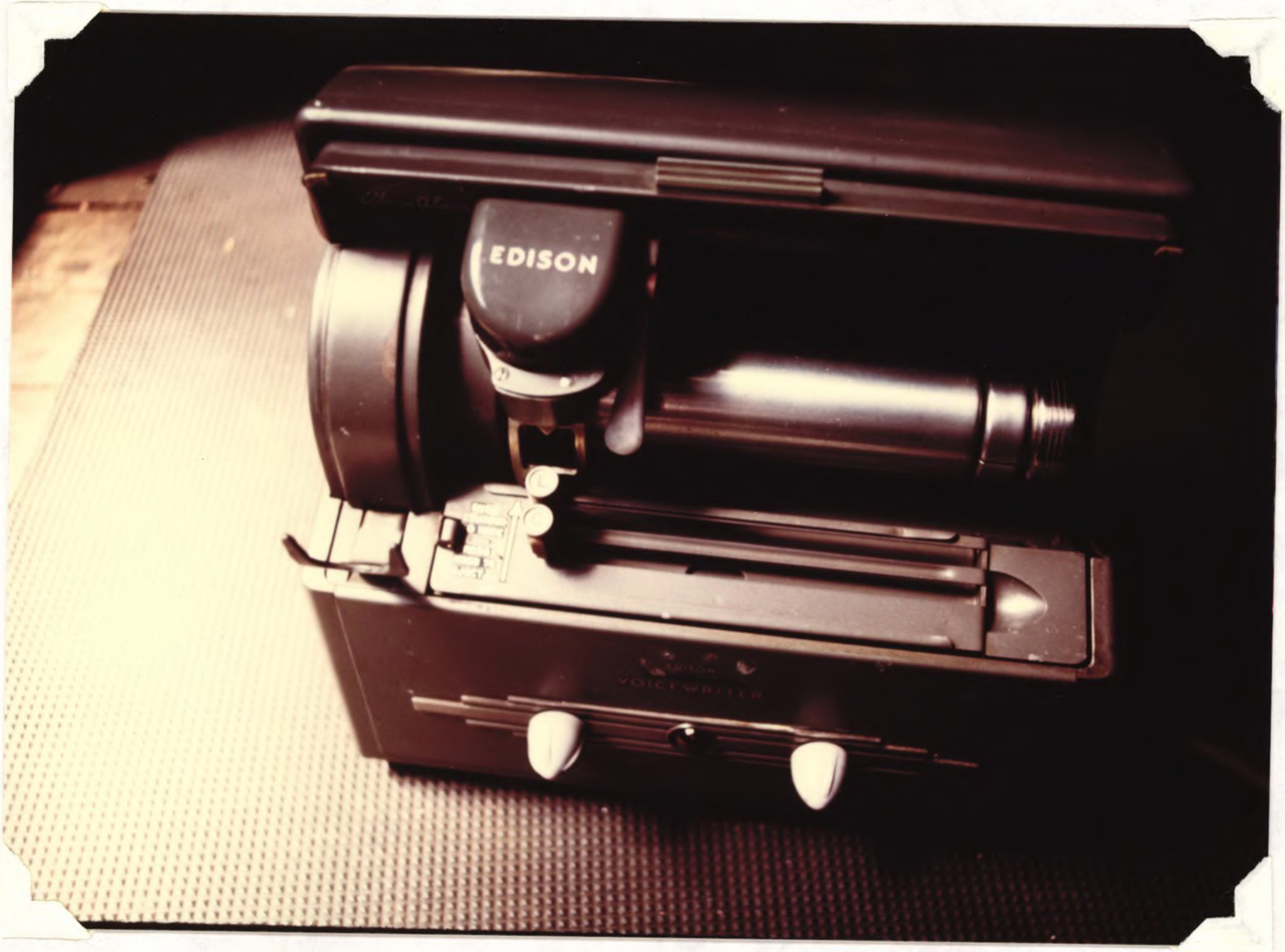


Illustration 11-6

Voicewriter

of it. The first Edison business phonographs reflected a craft style of the nineteenth century that can be appreciated in the design of telegraph equipment and sewing machines. From the polished wood base to the exposed metal parts of the top works, Edison's phonographs followed this style. His first dictating machines were solid, heavy, and built so that the many controls could be adjusted.

The dictating machine moved from an expensive instrument to a mass-produced staple in every office. Sheet metal replaced fine wood and heavy castings. Lighter and more utilitarian materials were sought by a new wave of industrial designers, and the new Bakelite plastics were found to be ideal. These plastics were used in Edison products, including the Voicewriter and a telephone number index made under the Bates Manufacturing Co.name.[36] The Ediphone and the Voicewriter were based on a new aesthetic, a machine aesthetic that was clean, simple, and beautiful. The style that originated in the German Werkbund was based on the efficiency of form and not cosmetic decoration. It was a style that consciously reflected modernity and technological progress. The goal was a machine that was simple to operate and easy to clean. A smooth shell that enclosed the operating parts was perfectly suited to the function. Beauty of form was found in the continuity of line and the contrasts of color. In the dictating machine, form followed function perfectly.

NOTES FOR CHAPTER ELEVEN.

1) Durand in Ediphone Minutes, 1 M37, 27 Dec 1916. Charles Edison fund.

2) TAE to Gouraud, 30 May 1889, LB 890521, pp. 153-170.

3) TAE, "The Perfected Phonograph," North American Review June 1888, 641-650.

4) North American Phonograph Advertising, D box phono; Business phonographs account sheet, 19 May 1905.

5) N Durand to Dyer, 17 Mar 1909, Phono Ed Business Phono.

6) Dyer to F Scribner, 18 April 1907, Phono sales.

7) Gilmore to Durand, 26 Mar 1907, N.P.co Commercial Dept

8) Advertising material, 1907 Phono Comm Dept.

9) N Durand to Dyer, 17 Mar 1909, Ed Business Phono

10) Holland to Hutchison, 31 Oct 1912, Phono Ediphone.

11) Holland to Hutchison, 5 Dec 1913, Phono Ediphone.

12) Edison Business Phonograph promotional material, 1911 Phono General.

13) Holland reports, 1918 Phono Ediphone.

14) D Box 8, Phono 2.

15) Ibid, & J Constable to N Durand, 1 April 1918, Phono Ediphone.

16) Ediphone minutes, 27 Dec 1916, Charles Edison Fund, East Orange New Jersey.

17) Holland to Schiffl, 1910 Phono Business Phono.

18) Holland to M.R. Hutchison, 31 Oct 1912, Phono Ediphone.

19) Meadowcroft to F Kimball, 2 May 1911, LB 160314, p. 663

20) Ediphone Buyers Guide, Warsaw collection, Smithsonian.

21) N Am Phono Co advertising, D Box phono.

22) Miller reminiscences, New York Public ledger, 22 Mar 1925, 1925 Radio.

23) 1909, Phono Edison Business Phonograph.

24) Durand to Gilmore, 9 Mar 1907, Phono N.P. Co Commercial dept.

25) Dyer to Durand, 29 April 1910, Phono, BB ph.

26) Ediphone Competition Bulletin, #179, 6 April 1931.

27) Buyers Guide, Warsaw collection .

28) Charles Edison to Division Managers, 4 Sept 1917, TAE Inc.

29) National Ediphone Sales Conference, 9 Jan 1925, D7 Phonograph.

30) MB 78, Ediphone Business, 6 May 1918, TAE Inc. organization.

31) Experimental costs on the Ediphone rose from around $9,000 p.a. in 1913/1914 to $15,000 p.a. in 1920. This was the cost of one experimenter, half time for an assistant or Works engineer, and a skilled mechanic. Ediphone minutes, experimental lists, accounts.

32) N Durand to C Edison, 31 Jan 1918, Phono Ediphone.

33)Memo to Constable, Development Work for Ediphone, 1 Nov 1919, Phono.

34) Ediphone Buyers Guide, Warsaw collection.

35) N Durand to J Constable and C Edison, 22 Aug 1918, Phono Ediphone.

36) J.L. Meikle, Twentieth Century Limited Industrial Design in America 1925-1939 (Philadelphia: Temple U, 1979), p. 82.

CHAPTER TWELVE

THE WEST ORANGE LABORATORY IN WAR AND PEACE.

Edison had always seen military applications for his inventions. Electricity offered many opportunities in this field: it could be used as a weapon--sprays of water linked with high voltage alternating currents, for example; as a means of power; and for communications. The first military customers for electricity were modern navies who used isolated plants to light and power their iron warships. Edison had a special interest in electrically-powered torpedoes and experimented on them at the West Orange laboratory. He formed a company with Gardiner Sims, (the Edison-Sims Electric Torpedo Company) to design and manufacture submarines, torpedoes, and other naval weapons. This company is credited with the design of the first remote-controlled weapon, a torpedo powered by electricity and guided through an elaborate cable system. [1]

The West Orange laboratory was built at a time of revolutionary changes in military strategy and technology. There were a growing number of businesses, such as Vickers Armstrong and Krupps, who depended on military orders to maintain their rapid multinational growth. The twentieth century opened in an atmosphere of international tension and rearmament. The United States was no exception; after the

Spanish-American war it was a world power and needed a modern navy to match. Edison had no objections to becoming part of this process and making money from it. The Navy offered to be a major customer for Edison storage batteries for their submarine fleet. They had also employed Edison motion picture equipment to film projectiles in flight. A patriot and a scrapper, he was not going to be left out of any conflict entered into by the U.S. As early as 1895 he publically announced his intention "to drop everything and serve the country" should there be a war.[2]

The outbreak of war in 1914 probably came as no surprise to Edison, but unlike many other Americans he could not afford to ignore it. His multinational enterprise was immediately affected by the war. After a burst of profits from the European market eager to see patriotic war films, Edison's overseas moving picture business disappeared and with it an important market. (See SIDEBAR 12-1: End of Edison's Motion Picture Business) The Allied blockade cut off the supply of chemicals from Germany on which his phonograph and storage battery businesses depended. The continuing conflict in Europe greatly influenced life and work at West Orange until 1919.

Although the United States did not immediately enter the war, its economic impact was soon felt as American industry took part in the policy of "preparedness" to ensure that if war did come, the U.S. would be ready. The factories of West Orange were fully involved in this by 1915. Edison commented that "I am in that (preparedness) with both feet and hands."[3] The West

Orange laboratory's contribution to the war effort was not restricted to supporting the factories around it; for the first time industrial research was applied to warfare on a grand scale. The First World War marked the beginning of the service of science to the state. Observers on both sides of the Atlantic had noted Germany's use of its scientists and research facilities in preparing for war, and Edison was not alone in advocating that the United States should follow suit.[4]

The U.S. government soon decided to mobilize the industrial and scientific resources of the nation. The Secretary of the Navy, Josephus Daniels, approached Edison in 1915 with the idea of a braintrust of technical experts who would advise the armed forces in matters of military technology. The Naval Consulting Board, as it was later called, rested on the belief that science had an important part to play in the war. Secretary Daniels not only wanted Edison to advise, but also to employ his "own magnificent facilities" at West Orange in important experimental work that the Navy was not equipped to handle.[5] Edison enthusiastically embraced this idea. His attitude can be summed up in the illustration "The Impending Conflict" which symbolizes the role of science in the service of democracy. Edison was particularly pleased with the message of this cartoon and had it mounted on the wall of the laboratory library. [6]

The Naval Consulting Board (NCB) was officially formed in the fall of 1915 and Edison was appointed chairman. Many of

America's greatest minds were involved in the NCB, including Frank Sprague, Willis Whitney, Leo Baekeland, and Elmer Sperry. A early meeting of the Board resolved that its work would best be served by the creation of a naval laboratory that would test new equipment and carry out experiments in naval technology. This facility was intended to make sure that the Navy got value for money on its contracts and that it would have the best equipment available, and at a fair price. A secondary task was the development of new technology to fit the Navy's requirements. Edison took a leading role in the committee that considered the makeup of the laboratory. The recommendations of this committee described an installation that bore a close resemblance to his West Orange lab. It was to contain a machine shop, pattern shop, foundry, drafting rooms, testing rooms, and a motion picture developing department. It was to have electrical, chemical, and physical laboratories. [7] Edison planned this laboratory along the same lines as his own; it was to be large enough to benefit from economies of scale and it had to be situated close to New York City, "the great mart" where supplies could be quickly obtained. Edison insisted that the lab be stocked with supplies of every kind so that it could work quickly. [8] He described it as "Not a research laboratory; it is a construction laboratory--more properly a universal machine shop" that could produce "anything from a submarine to a microscope." [9] Edison envisaged a facility that could work in a broad spectrum of different experimental projects. Speed of innovation was again an important consideration in the design of the laboratory: "the value of the lab is to turn things out quickly." [10]

The experimental directions of the naval laboratory were dominated by the submarine. Chief among the proposed projects considered by the NCB were: motive power for torpedoes and submarines (including storage batteries), improvements in submarine attachments and guns, and submarine detection. The laboratory they planned included a facility big enough to build experimental submarines. The West Orange laboratory was already involved in the development of this weapon; Edison storage batteries were powering the Navy's new submarine, the E2. Edison's involvement in the development of a modern American submarine came to a sudden end when the E2 blew up. Several men were killed. The cause of this accident was traced to hydrogen build-up from the batteries which then exploded. Ironically, at the same time that the Navy was proudly announcing the great inventor's connection with them, his batteries were blamed for the tragic accident.[11] This accident killed any hope of developing the submarine market for Edison's alkaline battery. 12

The war came at a busy time for Edison who was spending much of his time on the storage battery and on resolving problems with the disc record. Nevertheless, he threw himself into the creation of the Naval Consulting Board with his usual enthusiasm. His deafness made him a poor choice for a leader of a committee and he soon asked to be relieved of this duty in order to concentrate on experimental work. Edison gave up all other research activities and war work took up all his time until the end of 1918. [13] Edison was joined in this endeavor by experimenters on his payroll and volunteers from universities and industry. His expenses were forwarded to the Department of the Navy, but Edison did not charge for his time.

After the explosion of the E2 events turned Edison's attention to detecting submarines. The research effort of the Naval Consulting Board, and several other research facilities, was directed towards the threat of the submarine. This "new and terrible engine of warfare" had figured in Secretary Daniels' plans for the Board.[14] Although Edison undertook over forty experiments between March 1917 and November 1918, ranging from plating search light reflectors to airplane detection, he concentrated his efforts on the submarine menace.[15] The German U-boats were disrupting the vital lines of communication that stretched across the high seas. The sinking of the Lusitania in 1915 was a portent of things to come, but the authorities on both sides of the Atlantic did little to counter the threat until the Germans began unlimited submarine warfare in early 1917. Within a very short time the German U-boats severed the flow of supplies into the Allied ports and the British Admiralty secretly concluded that unless the submarine could be stopped, the war was lost.[16]

Unrestricted submarine warfare was the final straw that brought the United States into the War in 1917. It also energized the NCB into action. Edison typically approached the submarine problem from all angles, experimenting on finding and destroying submarines, attempting to prevent torpedoes from hitting merchant ships, and finally devising methods to make shipping harder for the submarine to see. He had all sorts of ideas to evade a German torpedo: he suggested laying a film of oil on the surface to obscure the submarine's periscope, he toyed with the idea of a protection system for ships using nets fired into a torpedo's path, and he designed a sea anchor to rapidly change a vessel's heading once a torpedo was sighted. His work on ship camouflage was the beginning of a strategy that had great success in two world wars.

The majority of the experiments carried out by Edison were on submarine location. At the beginning of the war the best way to locate submarines underwater was to listen for them. Ships used hydrophones to detect the sound of submarine engines and screws. Edison was no stranger to the science of sound and he concentrated on tracking the noise of submarines by amplifying the sound waves as they came through the water. He tried telephone amplifiers, audions, resonators, and other devices to pick up and amplify the sound of the submarine's screws. None of these approaches could locate submarines at a distance--the vital prerequisite of a submarine detection system. His next plan was to locate the submarine by measuring changes in magnetic fields caused by its metallic bulk passing through the water. He devised an induction balance to achieve this end but it was not sensitive enough. The idea was good--it is the basis of an excellent modern submarine locater--but the right technology was not available.

Edison gave up trying to locate submarines at a distance and concentrated on detecting torpedoes as they came close to merchant ships. Employing technology that had been developed for the phonograph and telephone, Edison constructed simple listening devices based on a phonograph reproducer attached to a long speaking tube which was connected to an amplifying device on board ship. Much of this experimental ground had been covered by the disc experiments and the development of special dictating machines. The problems Edison faced were to increase the scale of the technology and work for a corresponding increase in sensitivity. The Navy gave Edison the use of a vessel and during the summer of 1917 he cruised the Long Island Sound testing his listening devices.The listening device was placed in the water about 20 feet from a ship and in perfect conditions could detect a submarine at 5000 yards. [17] Edison found out that the problem of this type of locater is that conditions are never perfect. All the locaters then under development could not distinguish between the noise of a submarine's screws and the background noise of the search vessel screw's and water turbulence.

Several other teams engaged in the same line of research found this out. A group, including scientists from the research laboratories of GE and AT&T, attacked the problem of submarine location at an experimental station at Nahant, Massachusetts. Instead of an acoustic amplifier, as found in the phonograph diaphragm, they tried electronic amplification with an oscillator designed by Reginald Fessenden. At one time a "mucker" in the West Orange laboratory, Fessenden was now a pioneer of radio and the first man to transmit music by radio waves. He had successfully used his device for detecting icebergs after the tragic sinking of the Titanic. GE and AT&T were highly interested in the potential of radio and their laboratories were well versed in this new electronic technology. Yet they met with the same problems as Edison and had the same lack of practical results. The most successful submarine detection device that came out of all this research effort was still an acoustic device--the broca tube which resembled an elaborate stethoscope. [18]

An electronic device did finally produce the important breakthrough in submarine detection. This was the development of an active sonar system which used reflected sound waves to detect submarines instead of the passive system of listening for them. The essence of this idea was to electronically generate ultrasonic waves and bounce them off metal objects underwater. This was achieved by the scientists of the Allied Submarine Detection Investigation Committee in England who named their creation ASDIC. This method was considered to be the ultimate in submarine detection, but the experience of the Second World War showed that it suffered from the same operational problems as all other detection equipment.

The best solution to the submarine problem was a very simple idea that banked on the vast area of the sea to hide merchant ships. The naval authorities were unreceptive to the idea of convoys, but not Edison. He had investigated the statistics of ship sinkings and come to the conclusion that merchant ships were making it easy for the U-boats to find them.[19] By grouping ships in convoys, the Allies made it harder for the U-boats to find a target and also forced them to engage the armed escorts. The introduction of the convoy system in 1917 radically reduced the number of sinkings and held the U-boats at bay until the war ended.

The role of science in this partial victory was not decisive and the achievements of the Naval Consulting Board were slight. The one lesson that emerged from this massive R&D effort was that scientific research was often an expensive failure. Despite years of effort, Edison was never able to cut through the bureaucratic red tape of the Navy to build a naval laboratory. As usual, the difficulty with establishing the lab was finance; Congress did not appropriate enough money to suit Edison's grand design--he estimated that the lab would cost $5,000,000 fully equipped. He vigorously opposed the establishment of the lab near Washington, arguing that it could only be a success if it was far away from Washington. His own choice of a location was Sandy Hook, New Jersey.[20] His grand design for the "Naval Lab" came to nothing although a laboratory was built for the Navy in Annapolis in the 1920s.

THE WEST ORANGE LABORATORY DURING THE WORLD WAR.

The Edison enterprise was founded on the international flow of information and materials. The war severely disrupted this network and placed TAE Inc. in a precarious position. Edison's phonograph business had made him a major importer of chemicals from Germany, for example. The sudden elimination of this source of raw material might have crippled another company. But Edison had built his laboratory to meet the demands of this situation. He quickly made made TAE Inc. self-sufficient in strategic chemicals and made handsome profits selling off his surplus. At West Orange Edison had an excellent chemical laboratory, and a staff with considerable experience in finding substitutes for chemicals. The demands of quality control in record manufacture had led to an thorough investigation of the chemistry of the raw materials. The experiments to diminish the surface noise on disc records had pointed to the poor quality of the phenol used in manufacture. Edison's chemists knew that this was an area for improvement.

The shortages of chemicals became evident at the very beginning of the war, in the fall of 1914.[21] Edison was concerned with good reason; he was the largest importer of phenol in the U.S. and the brilliant tone of the diamond disc records depended on their condensite finish. Edison mobilized the resources of the West Orange laboratory to find a way to make synthetic phenol, assigning about 40 men to work on the process. The experimental and design stage was concentrated at West Orange, as usual, and the pilot plant was erected at the Silver Lake complex under direction of the laboratory, and with equipment fabricated in the machine shops of West Orange. Edison and his men took great pride in the rapid establishment of phenol plants and their successful operation. The phenol that Edison produced was of higher quality than the phenol obtained previously. The result was better sounding records![22]

The laboratory staff also found a way to produce paraphenylene, which was also needed to make disc records. A manufacturing process was devised for paraphenylene and a small plant was constructed at the laboratory. [23] Edison started an experimental program to find a substitute for potash and eventually found that caustic soda would do the job. Many of the chemicals needed in Edison's factories were by-products of the carbonization of coal to make coke, such as benzene, phenol, toluene, and aniline. These were produced in chemical plants that Edison constructed next to the furnaces of the Cambria Steel Company of Johnstown, Pennsylvania.[24]

As to be expected, Edison's engineers streamlined the manufacture of chemicals and soon began to increase output. His plants were soon making 6 tons of phenol a day to meet a daily requirement of 1 ton a day. Phenol had some strategic value as it could be used to make explosives, and Edison was able to sell his surplus, and many other chemicals he made, at great profit. The venture in chemical manufacture showed that the West Orange laboratory could move quickly to exploit an opportunity to turn innovation into a paying business.

The entry of the United States into the World War in 1917 had an immediate impact on the Edison enterprise. The photographs of the West Orange lab reflect the surge of patriotism that swept America: buildings covered with patriotic buntings, victory parades passing outside on Main Street, War Bond drives in the great factories, and workers in uniform, ready to go to war. (Illus. 12-1, #496) The work force decreased rapidly as men joined up. Mambert's department estimated that by 1917 the administration had lost 50% of its staff.[25] The lab's staff played their part in the war effort by designing a special phonograph, the Army and Navy model, for the American troops on active duty. The recording studios in New York and Columbia Street, West Orange, produced patriotic records of marches and sentimental favorites for the "doughboys." The armed forces were quick to adopt the dictating machine and a special portable model was developed for use in the field. Edison batteries were used in many different roles during the war, from powering turrets on ships to providing the weak current for the signal corps.

Edison was also swept up in the war effort. He was so involved in the submarine location project that he had to forgo his annual camping trip with Ford and Henry Firestone. Yet his

Illustration 12-1

Lab Staff Ready for War

war research was not all hard work. He wrote to Firestone that he could not possibly evade the work for the government, but enthusiastically described his experiments on " a big submarine chaser" and invited Ford and Firestone to man a yacht and join him in the Long Island Sound. 26

While Edison chased submarines in the waters of the Sound, the Edison complex at West Orange also devoted itself to the war effort. It had very little choice. The First World War marked the increasing power of the U.S. Government in the economy. Federal authorities placed limits on phonograph production and requisitioned key raw materials. The US Government became the leading purchaser of goods and services in the economy. The Phonograph Works manufactured several military products under government contracts, including a bomb sight, Gibbs rescue apparatus, Shear Wire pistols (to cut through barbed wire) and several types of adapters. 27 The resources of the laboratory were directed into supporting this war work. The government contracts called for precision products demanding a level of competence in design and manufacture, and only the laboratory could ensure this. The government devised specifications and the Engineering Department in the laboratory made up blueprints and drawings for the Phonograph Works. Here was another opportunity to continue the work of standardizing production engineering. F.J. Riker was appointed product engineer for the government work and given the power to approve all drawings, parts, and raw material orders. [28] Before the fire most planning for manufacturing was done in the divisions. The lab took over this function after the fire and planned out four successive government jobs, introducing control sheets to keep track of all stages of production. [29]

The laboratory's machine shops were also kept busy with Edison's experimental work. Between the beginning of 1917 and the end of 1919, almost $250,000 was spent on Edison's experiments, the largest amount going to the submarine location project.[30]

The many government contracts accounted for most of the capacity of the Works by 1918 and Mambert soon became anxious that the war work was holding up production of the more profitable phonographs and dictating machines. Yet with the reduced manpower of the lab and the delays inherent in instituting a new organization and new methods, there was little possibility of speeding up production. [31] The work force and resources of the West Orange complex were directed into the war effort and the business of making phonographs and other products had to wait.

Although the administrative staff was greatly reduced, the management of TAE Inc. operated smoothly through the war. The disruption of the divisional policy had dissipated by 1917; the years of complaints and political infighting were over and the lines of financial responsibility had been established. [32] In the long absences of the "old man," Charles Edison governed the various Edison interests. He had been an early advocate of the divisional system and the War gave him the opportunity to put his ideas into practice and fine-tune the organization. Charles Edison established a large personnel office and other service departments in TAE Inc. Charles was proud of his achievements and his style of "modern" management. Alfred Sloan, of General Motors, sent his men to study the West Orange operation before carrying out his own divisional policy. Sloan's reorganization of General Motors is taken as the pioneering divisional structure that laid the basis of modern management of large business organizations. Sloan inherited a situation much like the position of the Edison enterprise in 1911:

> We were short of cash. We had a confused product line. There was a lack of control and of any means of control in operations and finance, and a lack of adequate information about anything.[33]

He created a structure that managed to keep control of the direction of the organization without losing the advantages of decentralization. The new GM organization was based on the Edison example, with divisions centered around each product and central service departments, such as a research laboratory, which was run by Charles Kettering. Charles Edison felt complimented.[34]

The final tribute to Charles Edison's administration came from the "old man." On his return from Florida, where he had been carrying out submarine detection experiments at the Key West Naval Station, Edison told the press that he was "very pleased" with his son's work, adding "I have gradually developed an organization which relieves me from the details of business." [35] Edison was preparing to spend more of his time in Florida at his fully equipped laboratory in Fort Myers. With all his businesses showing profits in the post war boom, the time seemed right for the greatest inventor of his age to take a well-earned rest.

THE WEST ORANGE LABORATORY IN THE 1920S

After the War Edison became increasingly isolated from the general work of the laboratory. When all the leading managers of the company (including the chief engineer) came together in a meeting of the Executive Committee in 1918, nobody had any idea what the "old man" was doing on the top floor of the laboratory. 36 Edison had completely withdrawn from the running of the laboratory on a day-to-day basis. A memo sent by Edison's secretary in 1919 informed company executives that communications about laboratory operations should be sent to J.P. Constable, manager of the laboratory, and not to Edison. 37

John Constable had replaced Hutchison as chief engineer in 1918 after the latter's activities as salesman for storage batteries had caused much trouble within the organization. Hutchison's personal concession to market the battery was a relic from the old days at the West Orange laboratory when trusted "muckers" got the commercial rights to Edison's inventions. Yet it was totally unsuited to the operations of a modern business. Hutchison's wheeling and dealing undermined the efforts of the storage battery company and its network of sales agents.38 Hutchison and Edison parted company and an era came to an end at the laboratory.

Constable's position as chief engineer was supplemented by a new title of division manager when the laboratory was made into a division. His assistant, A. Weinert, was superintendent of the lab's machine shops, giving Constable control over all the activities of Building 5.[39] Constable was an engineer, not a professional manager, and he came under constant pressure from Mambert to run the lab as a business rather than an engineering service. Mambert believed that the laboratory should be supported by the income it earned and argued that it should be operated "a little more on the business principle," especially when it came to giving priority to different types of work.[40] This was not a new idea for the financing of the West Orange lab; it had been Edison's original intention that the lab should be self-supporting. But many things had changed since 1887 and few people in TAE Inc. had ever suggested that the laboratory should pay its own way. Mambert wanted financial results first and was not a supporter of long-term projects or the many small jobs done for Edison's personal interest. Running the lab on business principles implied giving highest priority to the work with the greatest return.

Mambert assured Constable that the division manager was responsible for the organization and management of the lab, but when Constable tried to exert his authority over Edison's secretary, R.W. Kellow, he was promptly rebuffed. Mambert was instructed to remind the chief engineer that he was hired to run the engineering effort and not the business of the lab. Kellow remained in charge of the business affairs of the lab, including billing, scheduling, and accounting, and Constable was ordered to give him full cooperation. Edison's comment that "if he is a good engineer, he will be a poor biz man as a rule" reveals something of his attitude to the engineers in his laboratory [41] After Edison relinquished his control over the R&D effort there would never be an engineer or experimenter who had the power to make business decisions in the laboratory; the new divisional structure of TAE Inc. had divided the functions of engineering and administration.

The major customer of the lab was the Phonograph Works. The bulk of the work of the machine shops and engineering services, especially the Engineering Department, was in support of the manufacture of phonographs. The work of the Engineering Department was totally devoted to the phonograph product and it was distinguished from R&D in the accounting system. The Engineering Department was charged with improving details in design to effect more economical manufacture. The first duty of this department was to "record, systematize and issue information to the manufacturing organization." [42] This information was needed for modern manufacturing methods using interchangeable parts, and it was the responsibility of the Engineering Department to keep the drawings and specifications up-to-date. The Engineering Notice had become the main product of the West Orange laboratory. It was the formal instrument to make changes in a product and then record them. These notices were listed by part and product number, and they were used to augment the parts lists and sample boards held in in Building 5.[43] Record keeping was now a major function of the West Orange laboratory, the third floor of the lab housing lists of parts, blueprints, and bills of materials used in manufacture.

The other important role played by Edison's laboratory was as a central testing facility. The Testing Department of the lab grew steadily after the War as its staff and functions increased. It began as one man in the days before the fire, but in 1918 it consisted of a staff of ten people, each of whom tested a specific product. It was then named the Engineering Test Service Department. Its initial job was to carry out tests on phonographs but it soon expanded its testing and inspection services to cover all manufacturing activities at West Orange. It held the sample boards that established the standard for each product. The testing rooms on the third floor contained special equipment that could check the accuracy of all the meters and measuring instruments used in the many Edison factories. The head of this department, F.S. Povah, advertised his services and invited all division managers to inspect the facilties and send their testing work to the lab. [44] The work of this department was vital to quality control. A sample of its reports indicates that up to 50% of the phonographs and dictating machines it tested were defective.[45]

The R&D work in the lab was carried out by the product engineers for the divisions. Their work was initiated by the division manager and controlled by the various committees on which they sat. Their activities in the lab were closely supervised by the chief engineer who had to render frequent reports to the Board of Directors. In 1919 six product engineers were employed at the lab and each had an assistant. The exception was Holland who had 4 helpers on his dictating machine experiments. Most of the six were permanently allocated to one product; only one man was a free-lance engineer at this time. [46] They were known as the "experimental staff" although much of their work was routine engineering. In each product engineering group there was normally one experimental man and the rest devoted themselves to production engineering.

By 1918 the division managers were able to exert a close control over the direction and costs of development work through their manufacturing committee. This committee was chaired by the division manager and comprised of several representatives of the manufacturing division (management, planning and production), and the product engineer. It is clear that "R&D by committee" put all the important decisions into the hands of division managers.[47] The managers were convinced that the work of product engineering was vital to their success in the marketplace and soon began to argue for complete control over their product engineers. A letter from the manager of the Primary Battery Division to Carl Wilson, Vice- President of TAE Inc., argued: "the foundation stone of our success is the engineering division...it must be reorganized...The development (product) engineer must be placed under my jurisdiction and I must govern his research and development activities and control expenditures. He is working exclusively on articles whose sales I control." [48]

The division managers wanted to direct the product engineer's work with financial rather than engineering criteria. The changing structure of TAE Inc. forced the lab to justify its existence and the money spent on research. It was no longer the sole source of engineering and R&D for the Edison complex and had to compete with other laboratories for testing and chemical analysis business. The laboratory at Silver Lake had begun with testing raw materials used in record and storage battery manufacture. By 1918 the laboratory was also carrying out analysis for several other divisions, research work on the primary battery and Amberol records, and electrical testing. Its manager hoped to take over some of the electrical testing work done at West Orange.[49] John Constable was forced into selling the services of the West Orange lab to the divisions of TAE Inc. In some ways this was a return to the "research for hire" strategy of the 1880s. The customers of the laboratory had changed. Instead of a broad range of high tech industries, the customers were now the division managers of a large integrated corporation.

The policy of giving financial responsibility to the division managers often made them reluctant supporters of R&D.

For much of the work of the laboratory, billing (and in turn financing) did not present a problem. Testing, tool-making, pattern-making, drafting and other engineering support of the manufacturing branch were clearly identified and accounted for. It was the more general basic research that was harder to finance. This involved high-risk research, perhaps to develop a totally new product or to discover a completely new way of making a product. It demanded a long-term commitment of funds and resources, and in a tighter corporate structure in which division managers had to watch their costs very closely, it was sometimes hard to justify the expense of experimental work.

The central issue between the laboratory and the manufacturing divisions was who was going to decide, and pay for, experimental and development work. The divisions wanted to know how much of their money was being spent, and on what. The divisional policy required purchase orders for every service performed by the laboratory and the years after 1915 were marked by interdivisional squabbles over who should pay for the lab's work. The divisions often claimed that they had been billed for work done for other people.[50] (This kind of complaint was not new to Edison; he had been answering charges like this since he managed machine shops in Newark.) The division manager had to keep his eye on the bottom line and therefore resisted spending on R&D. On the other hand, the laboratory had to charge even the smallest job to a purchase order--and somebody had to pay it.

A case in point was the inspection of reproducers used in wear tests by the disc division. This was a crucial part of quality control for records and only the lab could ensure that the right standard was maintained. It also provided useful data on the wear of diamond points. Yet the division resisted issuing a purchase order and Constable had to appeal for a ruling from the central administration. [51] Another sore point was the purchase of equipment used in the laboratory for experimental purposes. When this was billed to the relevant division it normally led to a heated dispute over who should pay. It was finally decided that the lab could not order or build specialized equipment without the knowledge and consent of the division affected. [52]

The divisional policy led to the introduction of modern management and accounting practices and this forever changed the nature of research at West Orange. In question was the relationship between expenditures on R&D work and the benefits that accrued to the manufacturing divisions. According to division managers, the benefits were frequently out of proportion to the costs. This new corporate environment made it very difficult to finance long term R&D projects. For example, Nelson Durand had long been agitating for a new design for a business machine that could compete with the cheap models produced by the competition. The development of a new product involved an extensive research and development project that Durand was reluctant to support, instead he argued that this campaign should be made an "Edison family affair," supported from the treasury of TAE Inc., and not from the budget of the Dictating Machine Division. 53

The implementation of financial controls after 1911 created a division between the short-term engineering services and the long-term experimental and development work carried out by the lab. In the years that followed Edison took over the basic research that did not have an immediate payoff. In 1919 he reviewed the activities of the lab and concluded that it was "mostly routine work," adding that he would personally attend to the development work with his present staff of experimenters. John Constable stated in 1919 that "the only experimental work I know of now is carried out under the direct supervision of Mr. Edison." 54 This split of the R&D effort mirrored the situation in other companies organized around several manufacturing divisions. In GM the basic engineering work was carried out in each divisions, while Kettering and his team worked on entirely new technology in a separate laboratory. 55

Before the divisional policy, the support of basic research and development had not created problems. Edison was, in fact, spending his own money and the lack of adequate financial controls had enabled him to experiment without counting the cost. Edison still kept his personal finances separate from the corporate finances of TAE Inc. The chemical plants, for example, were not part of TAE Inc. but were operated and owned by Edison personally. Much of the financing of the West Orange laboratory at this time was coming from Edison's purse. He funnelled several sources of income into the finances of the lab, including salaries from his various companies, royalties from his inventions, and private research projects. One of the most important of the latter was the work done for the Ford Motor Company. Henry Ford advanced Edison large sums of money for experimental work and this became an important part of his personal finances.

Edison was in an excellent position to look into the future and decide on the development paths of his businesses. Unfortunately, the division managers had to concentrate on the short-term, and in the difficult financial conditions after the War they often refused to pay for Edison's experiments. The lack of divisional support for Edison's experiments meant that more and more research was supported by him personally. This applied not only to personal projects, such as the work for Ford, but other long-term R&D ventures, especially the research into recording and reproduction which offered great potential for the future of the phonograph business. Consequently, the development of new primary batteries and dictating machines was supported by the financial reserves of the laboratory.

The increased financial stringency brought on by the high price of capital in the early 1920s, accelerated by a postwar depression, led to important changes both in the structure and the financing of the lab. A bureacratic arrangement had to be found to replace Edison's informal financing of R&D. Changing economic conditions meant that the Edison organization had "to get the most out of every dollar we spend", especially in experimental work. 56 The most pressing consideration was to develop the system of financing the laboratory that would support long-term experimental work and at the same time impose financial discipline on experimental expenditures.

A scheme to rationalize the laboratory was therefore undertaken in 1920. Henceforth all major experimental projects needed the approval of the Board of Directors who appropriated the funds. The direction of the research effort was now in the hands of men like Stephen Mambert, Carl Wilson, and Charles Edison. The new system introduced in the 1920s gave a much more formal and closed structure to laboratory finance. One standardized shop order system was used by which the managers of the lab could bill work ranging from experimenting, research and supervison to the more easily billed activities of tool-making, drafting, and blueprinting.

THE CHANGING STATUS OF THE LAB

The lab's work become more mundane and orderly in the 1920s. Instead of the chaos of the 1880s, there was routine and order. No more would gentlemen travel to West Orange, drawn on by the fame of Edison's laboratory, and carry out their own experiments with the inventor's permission. Even the work of the professional engineers in the laboratory was so closely controlled that they could not carry out research on their own volition. The product engineers had to obtain purchase orders for any experimental work, and this required the approval of the management. The lab no longer employed "experimenters" and muckers but experienced engineers who came to the lab from academia or business. [57] This policy was a contrast to employment of inexperienced, but flexible, help that characterized hiring practices in the nineteenth century. The policy of employing specialists at West Orange paralleled the national tendency toward professionalization of work. By 1920 the lab employed 17 categories of workers paid on an hourly basis and over 30 on a weekly basis. Included in the latter were librarians, stenographers, and engineers. [58]

In the old machine shop culture at West Orange the engineer was a law to himself and the laboratory was the guiding force of the Edison enterprise. Now the engineer was a corporate employee in a service organization. Instead of the "old man," he had to answer to administrators and division managers who let him know that the old "aloof and scientifically impersonal viewpoint" was inappropriate for a modern business organization. [59] The laboratory had once enjoyed the highest status in the organization, its work a source of pride and confidence. In the twentieth century it was forced to justify its existence, and overcome the prevailing attitude within TAE Inc. that it was an expensive luxury. A measure of the status of the lab in 1920 is revealed in the following comments made by Edison's secretary: "the laboratory has been quite popularly conceived to be a place where sundry mysterious experiments are carried on by Mr. Edison and charged to other Edison functions arbitrarily without any corresponding advantage to them." [60]

In physical terms, the changing status of the laboratory can be seen in the transition from a free standing structure of 1887 to a small part of a great industrial complex in 1920. Illustration 12-2 is an aerial view of West Orange. The laboratory is dwarfed by many factory buildings, its brick construction a contrast to the modern cement-clad buildings around it. The life of West Orange had been dramatically changed by the growth of Edison's plant. Once a rural retreat for affluent New Yorkers, it was now an industrial suburb of Newark. The labor force included many immigrants--Italians, Greeks, Poles, Ukrainians--who spilled into the Oranges from

Illustration 12-2

West Orange Complex in 1920s

Newark and New York. Its numbers had grown from a few hundred men in the nineteenth century to thousands in the twentieth. In 1900 there were about 3,000 men, and by the time of the World War there were about 8,000. Around the factories, a rough and ready community had sprung up, with bars and boarding houses. Weekend nights were punctuated by the drunken rowdiness of the workers.[61]

The focus of the West Orange complex and the lab had turned to "steady output of manufactured articles" and Edison claimed "I have no dept in which men are employed to perfect inventions." Instead, trained engineers examined the performance and cost of the hair in the brushes sold with phonographs. [62] Long gone were the days of experiments into pyro-magnetic generators and flying machines. The equipment of the West Orange laboratory had once been the envy of other the research institutions, but it was the other way around. While industrial research laboratories of GE and AT&T spent freely on new scientific equipment, Constable had to continually petition the management for new machines. He tried to persuade Edison to buy more modern machinery for the machine shops, arguing that the lab should be "the last word in high class machine shops." His appeals fell on deaf ears. Edison told him to repair the old machines and prohibited the purchase of new ones. As a result of Edison's parsimony, visitors to the Edison National Historic Site can view the same machine tools first installed in the lab in 1887. [63]

SIDEBAR

THE END OF EDISON'S MOTION PICTURE BUSINESS

The dissolution of the Motion Picture Patents Company in 1913 led to a more crowded and competitive movie industry. The trust (as the MPPC was called) and its short program films had had their day, and now it was the turn of the longer movie that told a compelling story. As America took the movies to heart, America's favorites became stars. Edison pictures had their own stars who were taken from the Broadway stage, such as Mary Fuller. She was a big hit with her "What Happened to Mary" adventures which were the first serial pictures.[1] Yet Mary left to get more money in the large film production companies who were paying higher wages to film actors and actresses. Viola Dana, the next big Edison star, could not match the poularity of Mary Pickford nor could any Edison comedy compete with the Chaplin shorts which were sweeping all before them. The Edison company was against the star system not so much because it cost too much money but rather that the organization put a higher value on technical excellence.

Longer movies with big name stars rapidly forced up costs. In 1909 it might cost about $200 to make a one reel feature, with the more expensive multi-reelers reaching $2,000 per film. In 1912 TAE Inc was making over 150 short films per annum. The average cost of Edison movies had moved to the

$20,000s by 1916, and much fewer were made each year.[2] Film making was becoming more of a gamble, costs were going up alarmingly but the returns of a successful movie were astronomical; one block buster could justify the enormous expense of film making with established stars. Some of the larger exhibitors had joined together and moved into film production with massive financial resources. TAE Inc. did not have the money to play this high stakes game--all its capital was in disc phonographs and storage batteries--instead it concentrated on shorter films with uplifting themes. Its "Conquest" series of pictures were advertised as "clean and wholesome" fare that would entertain and educate, but not provide the titilation and violence that sold seats in movie houses.[3]

While its marketing experts claimed that the public were tiring of longer films, the Motion Picture Division of TAE Inc. watched its sales slump. The "Conquest" films were an expensive failure and only a few melodramas--such as "The Cossack Whip"--caught the public's fancy.[4] Many of the original members of the MPPC had gone bankrupt and the survivors struggled on as KESE, Kleine, Selig, Essanay, and Edison. The world war struck a sharp blow to Edison who leaned heavily on foreign distribution. It also added to the costs of making pictures and showing them. The distributors were taxed after the US entered the war and this dampened down optimism in the industry.

The first Edison motion picture product to go was the film projector. Rising competition and falling prices forced Edison out of the market by the end of 1916. During 1917 the management of TAE Inc. pondered the question of abandoning the business or putting more resources into it. The war provided the answer. On one hand was the threat of more regulation and taxation and on the other were the bright prospects of procuring government contracts. In the first months of 1918 the entire motion picture business was sold to the Lincold & Parker Film Company.[5] The last sets were struck in October. In the meantime the motion picture equipment had been moved out of the Works and government contracts were underway. Manufacturing anonymous equipment was far less glamourous than making movies, but it was a predictable and highly profitable business. It was ironic that the man who had done so much to create a motion picture industry in the nineteenth century could not stand the competition in the modern industry of the twentieth.

NOTES

1) Ramsaye, Million and One Nights, p. 655.

2) Film lists of 1909 and 1912, Plimpton to Dyer 24 April 1912, Memo to Lanahan, Dyer Corres. 2 Sept 1916.

3) Advertising Circular in 1917 Motion Picture.

4) Memo of 13 June 1917, 1917 Motion Picture, closing down.

5) Charles Wilson to Charles Edison, 23 & 25 March 1918, 1918 Motion Picture.

ENDNOTES FOR CHAPTER TWELVE.

1) Conot, Streak of Luck, p. 414.

2) Newspaper Interview, 18 Nov 1895, Torpedo

3) Wm Maxwell to E.T. Grundlach, 27 Nov 1915, TAE Inc.

4) In 1903 Admiral Melville pointed out the advances of Germany's fleet and the connection with industrial research. His arguments were summarized by Willis Whitney on 20 Dec 1915, and a copy given to Edison, NCB Box 1.

5) J. Daniels to TAE, 7 July 1915, Naval Consulting Board (NCB) records, Box 1

6) 75) TAE to Rollin Kirby, 10 May 1917, LB 170426, p. 90.

7) Lloyd N. Scott, Naval Consulting Board of the United States (Washington: Government Printing Office, 1920), p. 111.

8) TAE to Tillman, 1916, NCB box 4.

9) TAE to J. Daniels, 4 Mar 1918, NCB Box 22.

10) TAE to C Harwood, 6 April 1917, LB 170122, p. 571.

11) The New York Sun, 7 Feb 1916, pointed out this contradiction in Edison's naval service, and blamed him for installing a dangerous technology on the submarine

12) Hutchison Diaries, 31 Dec 1916, noting "We were in no way to blame but the odium has gone all over and has hurt our business some."

13) Meadowcroft to N Pratt, 11 June 1917, LB 170426, p. 226.

14) J Daniels to TAE, 7 July 1915, NCB Box 1

15) List of experimetal work, NCB box 22, Experiments finances.

16) Vanderbilt, Edison the Chemist, p. 264.

17) Edison Work during the war, Mcft D box bio.

18) Wise, Willis Whitney, pp. 187-191.

19) Edison went to Washington with three assistants to make the statistical survey, "Strategic Plans for Saving Cargo Boats

from Subarines," NCB Box 21 TAE's War Work.

20) TAE to Robins, 13 Oct 1916, NCB Box 5.

21) Hutchison's diary notes Edison's growing concern with shortages of chemicals; H.T. Leeming to dept heads, 18 Aug 1918 tells of shortages causing layoffs, 1914 Ed Manu Co

22) Meadowcroft to C. Aston, 19 Feb 1917, LB 170122, p. 182; Vanderbilt, Edison the Chemist, pp. 248-251.

23) Meadowcroft, Edison's work during the war, D Boxes, Bio Files.

24) Newspaper cuttings, 1915 Benzol; Meadowcroft to Emery, 31 Oct 1916.

25) Allen to Mambert, Three Years Report, 3 April 1919, TAE inc financial.

26) TAE to Henry Ford, 18 Aug 1917, D box bio.

27) H.H. Eckert to Mambert, 18 July 1919, WWI experimental work.

28) J Constable to Luhr, 28 Dec 1917, 1918 TAE Inc organization.

29) J Constable to W. Maxwell, 27 Oct 1919, Phono E Phono Wks; J Constable to TAE, Outline of Lab's activities, 25 Nov 1919, Eng Dept files.

30) Cost sheets, NCB Box 21

31) Mambert Verbatim minutes, # 104, Executive Committee meeting, 16 May 1918.

32) Three Year Report.

33) Alfred P. Sloan, <u>My Years with General Motors</u> (New York: Doubeday, 1964), p. 42.

34) Venable, Out of the Shadow, pp. 78-79.

35) Edison Herald, vol. 3 #2, 25 Feb 1919.

36) Minutes of executive commitee, 23 May 1918, verbatim minutes, #102 vault 33.

37) 1920 Doc. file, TAE Inc Organization.

38) Memo to TAE, 29 April 1918, D box "D".

39) Notice of 11 April 1918, TAE Inc organization.

40) Verbatim minutes of 23 May 1918, #102

41) Undated copy in Engineering Dept. files probably Dec 1919.

42) JP Constable to W.Maxwell, 27 Oct 1919, Phonoe, EPWks.

43)JP Constable to Luhr, 19 Oct 1917, Eng Dept files

44) F.S. Povah to all Division Managers, 2 April 1919, TAE Inc Engineering test Service dept.

45) Povah to Constable, Monthly Record of Reports, 1918 W.O. Lab Experimental work.

46) Functions of the lab, 24 Oct 1919, TAE Inc organization.

47) J.W. Robinson to S Mambert, 2 Dec 1918, TAE Inc Financial.

48) Lepreau to C.Wilson, Primary Battery Division Blue Book, memo of 28 June 1918.

49) V.T. Stewart to JP Constable, 15 Feb 1918, WO Lab experimental work.

50) G.T. Owen to W Maxwell, 3 July 1918, Phono manu EPWks.

51) JPC to Kellow, 8 Nov 1917, Eng Dept files.

52) J.W. Robinson to SM, 2 Dec 1918, TAE Inc Financial.

53) N Durand to CE, 4 Sept 1918, Phono Ediphone.

54) Comments quoted in JPC to CE 26 Nov 1919, Eng Dept files; JPC memo, 31 July 1919, TAE Inc organization.

55) Sloan, Years with GM, p. 82; Stuart Leslie, Boss Kettering (New York: Columbia Univ Press, 1983), chap 5.

56) Mambert memo, 1920 Doc. file, TAE Inc. Organization, financial statement.

57) Meadowcroft to Applegate, 23 Mar 1917, LB 170122, p. 471

58) G. M. Ryder to FR Shell, 2 Dec 1920, TAE Inc payroll.

59) Maxwell to JPC, 2 February 1920, Constable file Eng Dept files.

60) Kellow memo 1920 Doc. File, WO Lab Financial.

61) F Dyer to A Jaynes, 16 Mar 1911, TAE Inc.

62) TAE to J Franklin, 12 Dec 1916, LB 161107, p. 331; C. Huenlich to N Durand, 3 May 1920, Eng Dept, subject folders.

63) JPC to C Edison, 15 Aug 1918, WO Lab.

CHAPTER THIRTEEN

THE DECLINE AND FALL OF THE PHONOGRAPH.

The war years had brought increased sales and profits to the Edison enterprise. Table 13-1 shows the wartime prosperity and the boom that came immediately after the cessation of hostilities. During the war, Americans had been unable to buy phonographs, and many other consumer durables, because the factories were devoted to war production. Demand soared after the war when American industry returned to peace time production. The steady flow of government contracts had provided jobs for an increasing number of workers at West Orange, and the booming phonograph business kept them there. The labor force had grown to around 4000 in the first decade of the twentieth century. There was a rapid increase in size during the War, with total number of employees around 10,000 by war's end. The increased demand and output of the war effort had caused a period of sharp inflation. The Phonograph Works had correspondingly increased its prices to the Amusement and Business Phonograph Divisions. This was not a matter of great concern when profits were high and demand increasing. There seemed to be an upward trend in phonograph sales. The industry as a whole had increased its output considerably. The decade of 1899-1909 saw a 250% increase over the previous decade, while

TABLE 13-1

SALES AND PROFITS OF TAE INC

(in thousands of dollars)

Sales Year	Sales	Profits
1916	13201	936
1917	18002	1663
1918	20629	1166
1919	22992	291
1920	30252	2930
1921	34371	820
1922	13833	1311 loss

that of 1909-1919 recorded an increase of 520% [1]

The boom year of 1920 came to an unhappy end for the Edison enterprise as the economy suffered a sharp downturn. The international economy had been shattered during the World War and the United States now stood as the leader of a weakened world economy, and vulnerable to its ups and downs. In early 1920 the danger signs were apparent: a collapse in the currency markets, rising interest rates, and some steep declines in share prices. [2] The US government embarked on a policy of sharp deflation, and cut its budget by about $6 billion. The money supply decreased alarmingly. At the end of 1920 the West Orange complex reeled under the shock of a drastic decrease in sales of phonographs. Many other manufacturers suffered the same fate, and had to watch the rapid collapse of their markets. [3]

Edison returned to the helm as his enterprise lurched towards a major crisis. He had given control to his son Charles, but the latter was brushed aside as Edison senior began a campaign of reducing costs by cutting staff. Edison's enormous energy was applied to resolving the crisis. He noted that "these hard times keep me busy day and night, and I have to work about 18 hours a day to keep the ship afloat." [4] The shock of the post-war depression intensified the cost reduction program that had Edison had tried to execute earlier. He returned to West Orange at war's end convinced that a deflationary financial policy was imminent, and ordered cutbacks in his organization to face the uncertain future. [5]

Little had been done to reduce the payroll and in 1921 drastic steps were taken. Every division was ordered to cut back its men, including the West Orange laboratory. Edison told Mambert that this kind of directive was never carried out and he went on a rampage through the Works, firing men right and left, including John Constable, chief engineer of the lab.[6]

Edison's already low view of labor deteriorated through the period of inflation and labor strife during the War. He had no sympathy for the working man who wanted his wages to keep pace with inflation. He told Mambert in 1919: "Wages are certainly up with more loafing than ever...Only remedy is automatic machinery and less men." After Edison's great purges of 1920/21, it was estimated that less than 2000 remained. [7] Charles Edison recalled the pain he felt at the decimation of the management organization he had assembled and perfected. [8] Mambert survived the crisis of 1921 but could not maintain his powerful position much longer. In 1924 Edison personally removed him from office. The man who had done much to modernize the administration was scorned by Edison who vindictively asserted that Mambert, once a vice president of TAE Inc., was only good enough to be a $60 a week clerk.[9]

An economy program was administered to those who remained in the West Orange labor force. Administrative positions were abolished or merged into others and the work of departments amalgamated. The services of the laboratory were more vigorously marketed and the machine shops did more routine work for the divisions to avoid the cost of sending it to outside contractors.[10] The Engineering Department concentrated on lowering the price of existing models, but the attention given to this particular problem was too little and too late. The Edison phonograph organization was ill-equipped to survive in the highly competitive post-war market. Experienced managers such as Nelson Durand, division manager of the dictating machine operation, had anticipated a drastic decreases in prices as competition heated up after the war. Despite the many warnings, the engineering effort at West Orange had not been directed into a special low-priced phonograph to use if a price war erupted.

Edison's original plan for the disc phonograph was to produce a machine priced for each pocket. Chapter 9 showed that engineering problems forced him to pitch the diamond disc machine to the upper end of the market. A continuing stream of improvements slowly increased the price of Edison phonographs and dictating machines. The same problem affected his other products. The cylinder business was reported to be in a "critical condition" as early as December 1918 because the price of the Amberola was too high.[11] The primary battery was slipping from its dominant position in the market because of its high price. The division manager admitted that he had been unable to reduce manufacturing costs to keep up with the competition. The Edison product was losing ground because of "our inability to maintain our old position...of furnishing practically the best cell for equal or less money than the bulk of our competitors." [12]

The Edison industries, especially the phonograph divisions, were shocked by the severity of the competition after the 1920 depression. The recession of 1920/1921 hit the sales of medium and expensive models because the public now wanted low prices and better value. [14] Just at the time when the selling divisions needed to reduce prices, they were were being forced up by the costs of manufacture. After the War the phonograph market shifted from the high priced Victrolas to the very cheap disc machines. Again Victor had beaten TAE Inc. to the largest segment of the market, in this case the low-priced machines. The laboratory and Works struggled to make this transition while the sales force rethought its marketing strategies. Salesmen had always stressed the quality of the Edison phonograph and had been instructed to sell it as "the superior instrument...because of its superior musical merit." This line was now outdated because from 1920 onwards TAE Inc. had to look for sales in the mass market.[14] In belated response to market conditions, TAE Inc. introduced a new line of disc machines in 1922. The London series were the first to include an upright model selling at $100, yet this was still over the ideal price range of $75-80 needed to compete with Victor and Columbia, whose prices were dropping. The Edison machines were still not cheap enough to sell in a sluggish market. Many of Edison's customers lived in rural areas and their Great

Depression began early in the 1920s.

Table 10-1 shows the steady downward trend of phonograph sales, which no amount of cost reductions in the Works, or improvements in the lab, could halt. A world-wide recession after the disruption of the World War quickly turned into a depression at West Orange as the phonograph business, the main profit maker of TAE Inc., went into a slide, "a terrible slide into the valley of depression," from which it never recovered.[15] After years of declining sales and tremendous losses, TAE Inc. finally threw in the towel. In October 1929 manufacture of phonographs and records ceased. All recording was stopped. The Great Depression had truly begun at West Orange.

Although the diamond disc had eventually been turned into a commercial success after the First World War, the Edison phonograph business as a whole was weak. Sales of the Edison cylinder machine, the Amberola, were declining because the Edison dealers took the introduction of the disc as a signal that TAE Inc. would soon desert the cylinder. This was not true, for Edison had a policy not to leave his customers with obsolete technology and had no intention of abandoning the cylinder format. In fact the lab had continued research and development into Blue Amberol records, and several patents were awarded to Edison and his co-workers on cylinder records and machines. The steady improvement of cylinder technology made little impression on a declining trade. The depression of 1920/1921 finished off Edison's cylinder business for good. The

Amberola was the last of the cylinder machines and it was contemptuously regarded as obsolete by the competition. Despite tumbling sales, TAE Inc. stayed true to the "old man's" philosophy and supported the cylinder users to the very end, incurring heavy loses throughout the 1920s.[16]

Yet the greatest problem of the Edison phonograph business was in the records rather than the machines; the selections on Edison discs were not as appealing as those of the competition. This weakness had been identified by William Maxwell, who led the musical phonograph division. Maxwell was a professional salesman who had made a living as a business consultant before joining TAE Inc. Well before the War, he had argued that most effort should be put into the choice of recordings, rather than in the design of the machine, but unfortunately the management of TAE Inc. paid little attention to him. It was Maxwell who saw the future of the industry in the quality of the recorded music and not the quality of the recording. Edison concentrated on the latter and his meddling in the former was ultimately disastrous for the amusement phonograph. Maxwell predicted that "our commercial success will hinge upon our production of recorded music," but this was the weakest part of the Edison organization which shunned the famous names and musical "fads" to concentrate on the truest reproduction. The phonograph was no longer a novelty depending on a brand new technology, but an article of mass consumption. Maxwell as a salesman could see the writing on the wall well before Edison. Maxwell realized that manufacturers had to pander to changing musical tastes. Edison preferred to educate the user into the joys of "good music" (as defined by Edison) as he had educated customers before in other new technologies he introduced. While Edison experimented on the design of reproducers, Maxwell was thinking about the psychological and philosophical problems involved in catering to the public's musical tastes. He accurately predicted that "the company who correctly solves these problems will dominate the trade." [17]

Victor's domination of the disc market rested not only on an excellent machine but also on a successful marketing strategy. Their premium recordings brought the company brand recognition, and although not every record buyer wanted to hear a classical record, they did buy Victor recordings of more popular singers, such as Michael McCormack, and jazz records. Victor, Brunswick, and Columbia gradually cornered the market on records and the big three had the additional advantage that their machines could play each other's laterally-cut recordings. On the other hand, the Edison company maintained its position of splendid isolation with its hill-and-dale records which were unique in the industry. Edison records had to be twice the thickness of the competition's discs in order to take the vertical cut. The need for an absolutely flat surface to take the vertically-cut groove meant that the Edison records were larger and heavier. This did not bother Edison, whose prime concern was fidelity, but his customers were more concerned with ease of handling and storage.[18] The decision to keep a unique format for the Edison records was a serious disadvantage in the 1920s. When the Edison machines had dominated the market there was a reason to make them play only Edison records, but when the majority of recorded music was available in lateral cut format Edison customers had to buy attachments to play Victor or Columbia records. The rigid adherence to an outdated standard cost the Edison company many customers, yet it perfectly suited the disposition of its founder--Edison was loath to change with the times. The 1920s were years of great social change in the United States and the jazz craze was just one indication of new American tastes. The Edison company did not exploit the popularity of jazz because the chief executive hated the sound and was most interested in recording more cultivated music. Edison's great ambition was the accurate reproduction of classical and operatic music, although his own taste was more mundane; his favorite song was "I'll Take You Home Again Kathleen," and he claimed that this was also the most popular Edison recording. [19] Americans were becoming more eclectic in their choice of music. The word from the customer was "the Edison is a good machine, but has a very limited selection of records." [20]

The record buying public was becoming younger, and they wanted to dance to their phonograph and not listen intently to its lucid sound, as depicted in the Edison advertising. Even the vaunted Edison phonograph technology was out of step with the market; it was designed for accurate reproduction rather than loudness and the finely crafted reproducer tended to "blast" the sound at high volume. Edison's goal for the phonograph was the most realistic recreation of the sound of the soloist and accompaniment. He had labored for years to produce the the right combination of reproducer technology, record quality, and recording technique. As soon as he returned to West Orange after the war, he resumed the work of reducing the surface noise of the diamond disc. He directed the staff of the recording studios built in the West Orange complex, a few blocks from the laboratory. The Columbia Street studios produced both disc and cylinder masters. Edison and the recording staff carried out research to advance the science of acoustics and apply it to the phonograph. Their success can be measured in the Tone Tests in which thousands of listeners were unable to distinguish between the live performance and the recreation of the Edison Diamond Disc Phonograph. (SEE SIDEBAR, The Tone Tests.) Edison and his laboratory had advanced the science of acoustical recording almost to the point of perfection, especially in reproducing the brilliance of the upper registers of the human voice. Yet Edison's market research showed that the customer wanted loudness first and a good tone second. Edison's quest for the perfect sound was not in tune with a changing market place; the development work done at the laboratory was driven by the inventor's own technological perfectionism rather than his customer's musical needs.

SIDEBAR

THE TONE TESTS

The Tone Tests were part of the extensive promotion of the Edison diamond disc machine. During the 1920s advertising expenditure for amusement phonographs increased rapidly. The competition, especially Victor, were heavily involved in national advertising campaigns in newspapers and the new popular magazines. TAE Inc. had to follow suit, even though the "old man" was discouraged at the cost of national advertising. Edison took a personal interest in phonograph advertising, planning special promotions and exhibits. "I have strong ideas regarding advertising" he told a subordinate in 1913 and during the 1920s he became heavily involved in marketing schemes.[1] His ideas naturally leaned more towards technical demonstrations of the merits of diamond disc recreation.

The idea of the Tone Test was to show the customer that the phonograph reproduction was so lifelike that it was impossible to distinguish it from the actual performance. This was a precursor to the "Is it live or is it Memorex" type of advertising line of today. The Edison diamond disc machine was designed to achieve just this effect and did so very successfully. Thousands of people went to concert halls to hear the Tone Tests and were amazed that the talking machine did sound just like the singer. There was certainly more than a little stage craft involved in convincing the audience that the machine could perfectly mimic the human voice, yet Edison did prove his point that the diamond disc was the ultimate in sound reproduction.[2]

The Tone Tests were one of many promotions to sell the machine on its superior sound. TAE Inc. devised various comparison tests and free trials of Edison disc machines. Edison devoted more time to marketing in the 1920s--after he had solved the technical problems. In 1922 he was busy working out new ideas for demonstrations and sales promotions.[3] Free trials of the new disc machines were offered to prospective customers in the belief that one listen to the sound would make the sale. Unfortunately, perfect recreation failed to impress the many customers who were looking for the largest record library. Here is another example of Edison's reliance on technical features to the detriment of the commercial realities of the phonograph business.

NOTES

1) TAE annotation on Amusement Phonograph Committee minutes, 17 Jan 1913.

2) Frow, Edison Diamond Discs, pp.236-242.

3) Meadowcroft to Mallory, 11 May 1922, D box, bio M.

THE CHALLENGE OF RADIO.

The introduction of radio produced drastic changes in musical tastes and signalled the end of the phonograph's dominant place in home entertainment. It was partly responsible for the end of Edison's phonograph business and the decline of the whole industry. After the boom years up to 1920, the output of phonographs declined. The gains of the 1909-1919 period (a 520% increase) were followed by a 45% decline from 1919-1929. [21] The phonograph industry became a highly competitive business, fighting off the technological challenge of an invention as revolutionary as Edison's electric light. The 1920s provided a stiff test of the innovative powers of the phonograph manufacturers. The decline and fall of the Edison phonograph is a testament to the failure of innovation at West Orange.

The West Orange lab had been the starting point of the radio story but "the father of electronics" had not exploited his early work on the "Edison Effect." When a glowing history of Lee DeForest's work on radio arrived at the West Orange laboratory, Meadowcroft told Edison that the radio was "another one of your stunts gotten away from you." [22] That this should happen at all is evidence that Edison's powers of rapid exploitation of a new technology had diminished. But when it occurred more than once in the post-war period there are grounds to suspect a general ossification of the innovative structure at West Orange.

The use of the "Edison Effect" bulb as a rectifier of alternating current had followed the initial discovery of 1883 and several tubes demonstrating this function had been distributed to scientists. A British scientist, Ambrose Fleming, used an "Edison Effect" bulb as the basis of his "valve" (or diode) which could detect high frequency waves used in wireless telegraphy. Several inventors and scientists were active in this area, including Reginald Fessenden. Edison followed the development of wireless technology but did not become involved in either the commercial or technical side of the innovation. He believed that someday there would be wireless communication, but thought (at the end of the nineteenth century) that it would be well in the future.[23]

The critical innovation was the work of the inventor-entrepreneur Lee De Forest, who added a third element to the Edison-Fleming rectifier tube, and connected it to an external supply of electricity. His "audion" (or triode) could be used not only to detect radio waves, but also as an oscillator to generate them. Fessenden had also developed an oscillator to transmit high-frequency waves. This work was carried out with the cooperation of GE's research lab who built the oscillator. In 1906 Fessenden successfully transmitted music with this equipment, and in the same year De Forest set up a commercial system of radio telephony.

The Bell system could not ignore this threat and redoubled the efforts of their industrial laboratories into electronic technology. A special research branch of Western Electric's Engineering Department was established to examine the possibility of an electronic amplifier for long distance telephone circuits. When De Forest and other experimenters found that the triode could act as an amplifier AT&T acted quickly to acquire the audion patents. This became the basis of their involvement in radio and their dominance of long distance telephony.[24] GE's involvement in incandescent light bulbs had brought its research organization into the field of electronics. The lab designed improved diodes and GE manufactured these vacuum tubes during the war for wireless telegraphy. In 1919 GE and AT&T pooled their patents and formed the Radio Company of America to hold them. Both companies prepared themselves to manufacture radio equipment in the 1920s.[25]

The basic elements of radio had been assembled by the time of the World War: oscillators to generate waves, electronic detectors to pick them up, and the triode to amplify them. The first commercial radio station began transmission in late 1919. By 1921 there were over 250,000 sets in the US and sales increased to 400,000 sets in 1922.[26] The first radios were primitive crystal sets, but these were soon replaced by radios with several vacuum tubes and loud speakers. The Edison laboratory had done little work on radio waves since the 1880s, because the "old man" was reluctant to enter a business where the patent situation was complex. Edison did not see his way clear to develop a product without considerable conflict with other inventors. He was afraid that moving into the radio would be "going against the boys on wireless." [27]

Radio soon began to cut into the sales of pianos, sheet music, and phonographs, but Edison labeled it a passing craze and would have nothing to do with it. He told Charles to stay away from the "radio gang of crooks" and predicted the imminent demise of the chaotic industry, where many small companies had entered and were struggling for survival.[28] Radio promised to be the great new consumer technology of the twentieth century, and many inventor-entreprenuers were attracted to it. Miller Reese Hutchison was typical of the men who thought that a fortune could be made in radio. His small company was also typical of the many drop-outs in the industry. Edison's stubborn opposition to radio was not unusual in the phonograph industry for all the leading companies opposed radio and would not let their stars perform on the air. His opposition to radio was based on both commercial and technical considerations, in the same way that he opposed alternating current for its economic and technological drawbacks. Edison doubted that radio had a commercial future; he was unable to see its great market potential and hear its sound. Edison judged the radio as a musical instrument and not as the great communicator, and was convinced that the speaker on the first radio sets badly distorted the sound. He felt that radio could never be more than a novelty, forgetting the enormous novelty appeal of his own phonograph which kept it going in the very early years of technical problems. [29] Just as people were impressed that sound could be reproduced in the 1880s, Americans in the 1920s bought radios because of the wonder of wireless. There was a great appeal in listening to a live performance on the air and the show was free! Edison had trained his ear to listen to the phonograph and consequently he could not bear to hear the rasping sound of the first radio loudspeakers. He was full of criticism of the radio, arguing that the amplification distorted the sound of music. The radio industry shot back that Mr. Edison might be the world's greatest inventor, but he was also deaf. [30]

Although Edison was totally opposed to radio as a product for the mass market, he had not ignored the technology of the wireless. His lab experimented in several areas involving the electrical recording and reproduction of sound. Edison was intrigued by the audion and asked Lee De Forest what parts of the invention were free and open for development. Edison was interested in the audion as an amplifier and made it clear to De Forest that he was not interested in its application to radio.[31] The lab had provided De Forest with phonograph parts for his experiments with wireless telephones and had taken part in the development of a lighthouse warning device. [32] Several of the engineers at West Orange took an interest in radio, buying books on the subject and making up experimental apparatus.[33] Holland and Constable obtained one of the early audions, "a very delicate little affair," which they rigged up to a disc machine. The audion acted as an amplifier and was connected to a loudspeaker. This experimental apparatus obviously had important applications in the business and amusement phonograph fields, but it remained an "experimental proposition" and was not developed further. [34] Edison did not ignore the electrical recording of sound, although it did take a back seat to his life-long quest to perfect acoustic recording. In 1927 he listed his research goals for his son. Electric recording was second on this list, first was "I want to perfect Super phono." [35]

Radio had a strong supporter in Charles Edison who summoned all the good reasons why Edison should enter the business. Yet Charles failed to convince his father who declared that "I do not intend making radio sets."[36] While Edison adamantly refused to go into radio, his phonograph business rapidly lost its customers. While many industries began a recovery in 1923, the phonograph business of TAE Inc. posted only small gains. The cylinder business was very poor as customers deserted the Edison amberola for disc machines. In 1924 sales slumped and crisis returned again to West Orange. The amusement phonograph business lost $1,000,000 in 1924 and the level of loss was expected to continue. [37]

INNOVATION IN A DECLINING INDUSTRY

The decline of the phonograph business, and the frequent crises it created, had an effect on the morale of the Edison enterprise. The future, which had once been bright and full of opportunities, was now viewed with anxiety, and in some cases, fear. Instead of brave new experimental projects, the "old man" seemed obsessed with cutting costs and saving money. Edison's overall strategy for the 1920s was financial retrenchment and cautious support of the existing product line. His research agenda had been set in the nineteenth century for he still labored to improve the sound of records and the quality of the duplicates.

By 1925 radio had captured the entertainment market and was beginning to redefine musical tastes. Customers were clamoring for the loudness and strident bass notes that characterized electrical amplification of sound. Edison's recording techniques, on the other hand, emphasized the clear reproduction of each sound as it left the instrument. Yet such was the demand for the radio sound that electrical amplifiers were quickly put onto the market to attach to acoustic phonographs. This produced the high volume and extenuated bass notes that were fashionable, but it is doubtful that they added new fidelity and beauty to acoustic recordings as claimed by the manufacturers. [38] All phonograph manufacturers were struggling to come to terms with the new radio environment and this led to a wave of innovation in this declining industry. The desperate situation of the Edison phonograph business required radical innovation. William Miller told Edison, "under the present conditions, I feel that we have got to come out with some improvement." [39]

The technological response to the phonograph depression was the development of a louder "dance" reproducer and a 12-inch long-playing disc record. The latter was a double sided disc which was cut with 450 grooves to the inch instead of the normal 150. This was a difficult technical task because the record material had to be very hard to prevent the stylus from breaking down the walls of the grooves. The long-player was touted as a "revolutionizing invention" that would permit the reproduction of entire symphonies in the 40 minute playing time of both sides. In fact the innovation was a failure. Technically the long-playing record could not stand up to repeated play and its sound was too faint to please the customer. Commercially the Edison library of recordings did not include complete symphonies or operas that could be played on the long-playing machines. [40] Edison had produced the wrong technological response to the demand for louder recordings. The long-playing record indicates the gulf between his objectives in the laboratory and the needs of the market place. In the 1920s he was no longer the commercial inventor he had been in the 1880s.

No amount of inspired advertising or innovation was able to wrest sales from the competition while the Edison phonograph technology remained conservative. At the time that Edison tried to increase sales by improving the tone of his disc and developing a long-playing record, Victor met the radio challenge head-on by adopting a system of electrical recording--the technology which took the talking machine from the acoustic phonograph of the nineteenth century to the high fidelity of the twentieth. Edison had anticipated electrical recording when he stated, in 1877, that a telephone repeater could be used to record and reproduce sound. The development of electrical recording required an extensive knowledge of acoustics and electronics--and here the research laboratories of GE and AT&T had the advantage. Experiments carried out by J.P. Maxfield in the Western Electric laboratories resulted in the introduction of a method of electrical recording in which sound is picked up with a microphone, amplified by a vacuum tube, and then inscribed on the disc with an electromagnetic recorder.

The Victor company had agreements with AT&T which enabled it to take advantage of the research being carried out in electrical amplification and acoustics in the laboratories of Western Electric. Initially, Victor was slow to see the advantages of electrical recording and procrastinated in their negotiations with AT&T. Then the forces of the market took charge. An aging record library and the growing popularity of radio hurt Victor's sales which declined by 60% in 1924. Its response was swift. [41] It obtained the right to the new process and began to record music electrically in 1924 but did not publicise it, with the result that its customers were appalled at the harsh sound coming from an electrically recorded disc played with an acoustic reproducer.[42] A new machine was designed to play the electrically recorded discs. The Orthophonic was a dramatic departure from existing technology, employing a new design of reproducer which produced a clear tone throughout the volume range. It had a radio timbre which made it acceptable to a public that had become enamored with the radio sound. The Orthophonic was another important innovation from Victor, its performance was exceptional and it quickly became a highly successful product, maintaining Victor's preeminent position in the phonograph industry and setting the standard in acoustical reproduction. It was later judged to be "The First Modern Phonograph." Introduced in 1925, the Orthophonic led Victor to its most profitable year in its history; in 1926 the company made $8,000,000 profit on $20,000,000 sales. [43] Victor also took the step into radio and introduced a receiving set, the Radiola, in 1925. On the other hand, Edison was pleased that his was now the only "straight phono" company in the running.[44] Orthophonic machines had been examined in the laboratory and Edison's engineers had devised electric reproducers, but in secret. [45] Miller and Holland had continued their work on electrical recording without the knowledge or consent of the "old man." The facilities at the West Orange laboratory were in no way comparable to the advanced testing and measuring devices of the Western Electric laboratories. This serious disadvantage hindered the development of electrical recording. While the competition charted new waters, the Edison line remained unchanged; Edison phonographs still came equipped with the standard, floating-head reproducer first introduced before the War.

The Edison phonograph suffered from several disadvantages: narrow record selection, recordings that could not meet the public's demand for increased volume, and inability to play the competition's records. Efforts were being made to develop new technologies in the West Orange laboratory, but progress was slow. Edison's technological perfectionism played its part in delaying the rapid introduction of innovations, such as the automatic changer, that might have given the Edison phonograph more commercial appeal.[46] This device was under consideration and test at West Orange for years. TAE Inc. stood by and watched the competition introduce this important innovation. Edison's opposition to laterally-cut records delayed the introduction of a universal reproducer for his phonographs that might have turned the tide in the phonograph business. In consequence, by 1927 the Edison company only accounted for 2% of the total sales of records! Pressure was growing within the amusement phonograph division for the development of a universal reproducer and the manufacture of lateral cut records, but little was done.[47] When the Brunswick record company came up with a universal reproducer--that would play any record--it quickly gained a large section of the market. A competitor had again taken the technological initiative.

Edison was by now a technological conservative, and TAE Inc. was being beaten in the marketplace by a more innovative company. TAE Inc. was a follower rather than a leader in phonograph technology, lagging behind in key innovations such as electrical recording and a universal reproducer, and had paid the price in the marketplace. On the other hand, Victor had wasted no time in responding to the challenge of radio, quickly producing a new phonograph and a radio and rushing them into production. These new products exploited the public acceptance of the Victrola while making that technology obsolete! A burst of innovation in the mid 1920s gave Victor an opportunity to reclaim much of their phonograph market. One year after Victor had crossed the Rubicon in 1925, the louder Edison dance reproducer was announced. Its advertising still referred to the "volume fad"--anything that diverged from Edison's conception of the phonograph was likely to be called a fad.[48] Edison's plan for the West Orange laboratory lay in speed, flexibility, and control. The experience of the phonograph in the 1920s shows that this was no longer present in the R&D effort. Only the control remained.

Although the most profitable division had taken a beating, the Edison enterprise went forward bolstered by the highly profitable battery operations. The primary battery division enjoyed a dominant share of the market; and, after a slow start, the storage battery had gained a market niche in industry. The trials and tribulations of producing a superior storage battery were finally justified by strong sales in the 1920s. The decline of the phonograph was partly offset by the growing acceptance of the Ediphone in American offices, as Table 13-2 indicates.

Table 13-2

Sales of TAE Inc, in $000ths

9 Months ending 30 Sept 1926.

Product	Sales	Profits
Phonograph (disc)	1157.	-527.
cylinder	623.	-414.
Storage battery	4915.	1486.
Primary battery	1634.	248.
Cement	N/K.	824.
Ediphone	991.	278.

The basic strategy of having five different product lines--storage batteries, primary batteries, cement, and business and amusement phonographs--paid dividends in the 1920s. It enabled TAE Inc. to ride out two business depressions and survive into the 1930s. The company even managed to produce a yearly surplus during the dark days of the decline of the phonograph. Outside work was found for the Phonograph Works to make up for the lack of phonograph sales, and several new Edison products were manufactured there, including rectifiers, electrical instruments, and dental drills.[49]

The 1920s saw the forces of change working at West Orange. Immigrants had provided the bulk of the workers in the factories around the laboratory. The decreasing rate of immigration into the United States after the War slowly cut down the number of immigrants working in the Edison industrial complex. By the end of the 1920s there were shortages of skilled labor. This had been offset in many factories by the introduction of labor-saving, automatic machinery. This shift to a more capital-intensive mode of production had been resisted by Edison who was loath to spend the money. This was in direct contradiction to his well-publicized support of the "Machine Made Freedom" which would follow the automation of the work place.[50]

The keenest felt shortage was in the skilled mechanics that had staffed Edison's machine shops since the 1870s. The personnel office had to begin a program of training apprentices to fill the requirement for skilled workers. The very low wages of West Orange reduced the flow of highly skilled machinists and engineers to the laboratory. The weekly wage of a mechanical engineer was fixed at \$35-\$40--the same amount as fixed scale wages for laborers, electrician's helpers, and derrick men.[51] Bureaucrats and clerks could earn more than the men who actually did the engineering work in laboratory and Works. It was a greatly reduced Edison organization that survived the phonograph depression of 1921. The great purges had cut a deep scar in the organization. It added to Edison's reputation for firing men whenever there was a slackening off of demand, and probably encouraged many of the professional staff to look elsewhere for employment.[52] Several senior executives left of their own accord to find better, and more secure, positions in the 1920s. The Edison enterprise lost skilled managers, such as William Maxwell, that it could ill afford to lose.[53]

Edison's prestige could no longer offset the low wages and job insecurity and attract first-class men to the West Orange laboratory. In fact there was little need for them in the mundane daily work of the laboratory in the 1920s. Edison still maintained his personal staff of muckers, but they were there to do his pick and carry work rather than challenging experiments. He still employed professional chemists when needed, and many were trained in German universities. Several product engineers had academic credentials, including Dr. Gibbs of the amusement phonograph, but the work force of the West Orange laboratory in 1920s was relatively untrained and underqualified when compared with other industrial research laboratories. GE's laboratory at Schenectady, for example, had a staff of around 300 in 1920, including about 50 scientists and engineers. Western Electric's Research Branch had 234 employees in 1921, many of whom were Phds and professional engineers. In the early 1920s the West Orange laboratory employed around 200 men, yet only about 10 to 15 of them were formally trained.[54]

Despite the decline in the work force during the purges of the 1920s, the West Orange lab was still a major important research facility. There were several laboratories that had smaller staffs and budgets. Eastman Kodak, for example, increased the staff of its laboratory from 20 in 1913 to 88 in 1920. Its work force and expenditure in that year, $338,680 were much less than the Edison laboratory.[55] Yet in terms of quality and quantity of staff, Edison's laboratory could not compare with the front rank of GE and AT&T industrial research. During the 1920s, research expenditures at GE and AT&T rose steadily. On the other hand, the expenses of Edison's laboratory decreased. By 1926 it had dropped to below $150,000--one tenth of GE's costs. The "best lab ever" was now a shadow of its former stature as the leading research institution in the United States.

ENDNOTES FOR CHAPTER THIRTEEN

1) Soloman Fabricant, The Output of Manufacturing Industries (New York: National Bureau of Economic Research, 1940), p. 578.

2) Mambert memo, 16 Feb 1920, Mambert corres, letter #6966.

3) Robert Lacey, Ford (Boston: Little Brown, 1986), p. 268, Chandler, Strategy and Structure, pp. 128-129

4) TAE to A. Williams, 5 Jan 1921, D box bio.

5) Minutes of Executive committee, 1 May 1918, 102 verbatim minutes.

6) Hutchison Diary, 1 Jan 1921. Hutchison also notes that Edison "clipped Charles' wings."

7) TAE to Mambert, 16 Dec 1919, Mambert correspondance; Business Activities of M. Jones, MJ Box 13.

8) John Venable, Out of the Shadow, p.80.

9) TAE Annotation on Mambert's letter for a reference, 1924.

10) Minutes of Executive committee, 21 Aug 1921, reserve microfilm

11) W. Maxwell to C. Edison, 13 Dec 1918, Phono.

12) F.J.Lepreau quote in minutes of a special meeting of Board of TAE inc. with executives of primary battery division, 9 April 1918, Primary Battery Div Minutes, Vol 1, C Edison fund

13) Mambert Correspondence, vol 1, 26 July 1920.

14) W. Stevens to C Edison, 23 Sept 1918, Blue Books financial cabinet.

15) Art Walsh to Charles Edison, 25 April 1927, phono closing down.

16) Memos in 1925 Phono sales about plans to get out of Amberola business because of "heavy losses."

17) Maxwell report, 1911 Phono Manu 2 of 2.

18) H.C. Brainerd to TAE, 16 Nov 1926 in Phono LP record.

19) Questionaire answered by TAE, 1926 Phono adv.

20) W. Mallory to Meadowcroft, 7 Jan 1922, D box bio.

21) Fabricant, Manufacturing Industries, p. 578.

22) See Harold G. Bowen, The Edison Effect (West Orange: Thomas Alva Edison foundation, 1951) for a history of Edison's role in wireless; Meadowcroft annotation on "The Story of a Great Achievement" in D10 Radio.

23 Edison annotation on 19 May 1898 letter, 1898 Radio.

24) Reich, pp. 157-159.

25) Wise, pp. 218-219.

26) C.J. Pusateri, A History of American Business (Arlington Heights, Ill.: Harlan Davidson, 1982), p. 243.

27) W. Miller to G.H. Mann, 21 May 1910, LB 100521.

28) To Chas Edison in 1926 Radio cabinets.

29) TAE annotation on Sun Radio Data Sheets, "Speaker Distortion;" TAE to H. Phillips, 29 Dec 1925, Radio.

30) New York Times, 3 Oct 1926, Radio.

31) TAE to DeForest, 17 June 1926, D box bio.

32) Feb 1917 General Correspondence, subjects.

33) John Constable letter, 13 May 1919, Edison General Correspondence, subjects.

34) JPC to E. Boykin, 25 Oct 1918.

35) Chas Edison to TAE, 21 June 1927, TAE Work outline.

36) TAE to H. Phillips, 29 Dec 1925, Radio.

37) R.A. Allen to Charles Edison, 22 April 1925, Phono Manu.

38) Gradeon advertisment, New York Times, 2 July 1926, p. 9.

39) W Miller to TAE, 25 Oct 1925, Phono Victor.

40) TAE Inc minutes, 1 feb 1926, RR 68.

41) H Miller to H. Heifman, 24 Dec 1909, LB 090927, p. 433.

42) Frow, Edison Disc Phonographs, p. 68.

43) "Excerpt from Mr de la Chapelle's talk," Script for tour of Victor Works, 1/15/27, 1927 Phono Victor.

44) Annotation on 1925 Radio newspaper cutting

45) Notes in 1925 Phono Victor.

46) TAE annotation on 17 Mar 1926 letter, phono manu.

47) Art Walsh to CE, 25 April 1927, Phono closing down.

48) Phonograph advertising in Frow, Edison Discs, pp. 70-71.
49) 1928 Edison Industries Products, promotional booklet.

50) Edward Marshall, "Machine Made Freedom," Forum, Oct 1926.

51) Anon to TAE inc., 31 Dec 1919, M Jones Collection, Box 11

52) "Personal Audit," Jones Collection, Box 19, 1920.

53) Maxwell resigned 8 Mar 1922, Edison Phonograph Works minutes, Charles Edison fund, East Orange NJ.

54) Wise, Appendices; Reich, pp.181-182; Acounts records and W.O. lab folders for 1920-1922.

55) Jenkins, Images and Enterprise, p.312.

CHAPTER FOURTEEN

THE END OF AN ERA

Edison's advancing years slowly loosened his grip on the management of TAE Inc. As he approached his 80th birthday in 1927 his health deteriorated seriously. He was totally deaf by the mid 1920s and increasingly troubled with stomach pains. When he came to the West Orange laboratory, he stayed on the ground floor, working at his desk in the library. (Illus. 14-1) In 1926 he relinquished control of the company to Charles Edison; the latter became President and Edison took the nominal title of Chairman of the Board. In the same year Edison sold his remaining patent rights to TAE Inc. for $78,200. [1] Thereafter Edison spent more of his time in Florida at his Fort Myers home. He had acquired the property for his winter home in 1885 and gradually built it up, erecting houses, providing it with a pier, and constructing a laboratory. Edison and his wife customarily spent the winter months at Fort Myers, but Edison did not take a break from experimenting; he equipped his laboratory with everything he needed to continue work and often took assistants to Florida with him when he was involved in an experimental campaign. The experiments on the storage battery and phonograph record continued there, and postal communications were maintained with the laboratory at West

Illustration 14-1

Edison in the Library

Orange.[2]

With Charles Edison running the business affairs of the company, Thomas Edison could spend more of his time experimenting. In the late 1920s he continued his research on the recording of sound and the battery for the Ford automobile. The eighty-year-old inventor even began a new experimental project. During the First World War, the United States' dependency on foreign raw materials was underlined to industrialists like Edison. Many strategic materials were concentrated in a few places and subject to being cut off in wartime. In the early 1920s the US consumed about 70% of the world's rubber, mainly for the growing automobile industry. The supply of rubber was largely in British and Dutch hands, and they were not above exploiting their monopoly of rubber production. Subsequently several attempts had been made to produce synthetic rubber, but with little success. Another solution was to find another source of organic rubber which could be grown in the US. This became Edison's goal. His friend Henry Ford was partly responsible for the increased demand, and subsequent increased value, of rubber; and it was Henry Ford, along with Harvey Firestone of the Firestone Tire and Rubber Company, who persuaded Edison to look for a domestic source of rubber. The idea was not to substitute American for Malayan and South American production, but to ensure a supply of domestic rubber in an emergency. The Edison Botanic Research Company was formed in 1927. Ford and Firestone provided the capital and

Edison agreed to donate his time.

Edison 's involvement with rubber went back well before the late 1920s. It had begun, in fact, when the laboratory first opened in the late 1880s. Several of Edison's competitors in the phonograph business were using records made out of hard rubber, which offered a durable recording medium. In 1888 Jonas Aylsworth experimented with hard rubber records in the West Orange laboratory. [3] The interest in rubber continued into the 1900s when it was an important part of the storage battery project. The containment of the chemicals used in storage batteries was a major research problem for the laboratory. By 1920 the laboratory staff were well acquainted with this material and the "old man" had a knowledge of the chemistry and botany of rubber that impressed Harvey Firestone.[4]

Typically the rubber project began with a thorough search of the literature and several trips to obtain information and examine botanical operations. Many studies had been carried out on native plants that might contain rubber but Edison wanted to go one further and mount a systematic search that would cover thousands of plants, ever hopefully that kindly nature might have provided a substitute for the latex of the Hevea tree. Here was a perfect research project for Edison. It was totally financed by his two friends which enabled him to run the program outside the checks and controls of TAE Inc. The search for a domestic source of rubber suited Edison's experimental style; it was clearly a line of research that needed an empirical approach and it combined the adventure of the hunt for bamboo filaments with an opportunity to develop his botanical skills. Finally, the project could be carried out in the balmy weather of Florida. Edison began the search for a new source of rubber with his usual gusto, gathering a library of books on rubber at Fort Myers and planting many different species in the gardens around his home. He built a new chemical laboratory across the street from his home and soon filled it with supplies and equipment.[5]

Edison cultivated rubber plants in the gardens around his house and also found time to develop Fort Myers as a garden community, planting trees and shrubs in the land around his property. He enthusiastically turned his property at Fort Myers into a large experimental farm, and proudly showed off his results. It was reported that he had 4800 varieties of shrubs and trees under cultivation. He also had a small army of amateurs and professionals in the field collecting samples. In a very short time his assistants had gathered over 3000 examples of wild plants and tested them for rubber content. Meanwhile the flow of specimens collected by well-wishers increased as the West Orange laboratory was innundated with plants.[6]

Much of the testing work was done at the laboratory. Building 4 was converted to receive the incoming flow of plants and shrubs gathered from all parts of North America. (Hundreds of the specimens are still stored with the Edison archives.)

The rubber project not only involved finding a source of rubber but also encompassed the development of an economical production process. Edison was again in his element; he had considerable experience in chemical engineering and the First World War illustrated how quickly he could set up chemical plants. He worked on a rubber extracting machine to extract the sap from his specimens. The rubber project shows that time had not altered Edison's approach to innovation and his inventive style. His staff were directed by a steady flow of written notes. He worked with a small team of experimenters and brought in chemists and botanists when needed. His deafness did not interfere with the management of the experimental team, for written communication proved adequate. Even the men in the field were instructed to keep in constant contact with the West Orange laboratory by mail.[7] Edison was totally absorbed, some might even say obsessed, with the work.

After exhaustive testing, the goldenrod plant was found to offer the most rubber content. Two varieties, solidago rugosa and solidago leavenworthii, were singled out for intensive cultivation and crossbreeding. Edison spent all his time on this project, studying botany in the house at Fort Myers along with his family, examining specimens in the special lab built across the street, directing a small staff of chemists and botanists in the crossbreeding program, and examining the progress of the goldenrod plants in the gardens. In 1929 he acknowledged that "I can't get my mind off rubber just now." [8] He was able to produce a strain with high rubber content, but the results gained did not justify production. Yet the rubber project kept the aged inventor busy and content. The staff at West Orange were instructed not to send him any bad news. He took pride in telling the press and his associates that he was busy "getting rubber from weeds," and what could be more appropriate a task for a patriot and a practical man.[9]

The experimental projects undertaken by Edison in his last years show no divergence from his earlier work; he stayed in the same general areas--storage battery, phonograph, and chemistry. Nor did he not alter his approach to the problem or his experimental method. The West Orange laboratory also continued along the conservative paths set in the twentieth century. Production engineering was the order of the day and the new products developed in the laboratory were hardly revolutionary. Radios and consumer durables, such as toasters and coffee percolators, were new departures for TAE Inc., but they were in no way radical new products. Instead of leading the pack, the Edison industries were entering fields that had already passed through the pioneering phase. Both the radio and Edicraft appliances leaned heavily on the appeal of Edison's name without advancing the technological boundaries of these products.

Edison's stubborn opposition to radio had been overcome by 1928. The Board of Directors of TAE Inc. allotted a large sum of money for R&D and the setting up of manufacture. The

Splitdorf Radio Company was purchased in order to give TAE Inc. access to the RCA pool of radio patents.[10] Theodore Edison was put in charge of the development project. A graduate of M.I.T., Theodore was well qualified for the task, and his brother recalls that Theodore, in the same way as his father, worked day and night to produce the Edison radio in a remarkably short time.[11] Theodore was a talented engineer who had been instrumental in the development of an Edison phonograph with electromagnetic rather than acoustic reproduction. He invented a pick-up that could play both hill-and-dale and laterally-cut records and these were installed in the Edisonic line of phonographs. The Radio-Phonograph Division of TAE Inc. (once the Amusement Phonograph Division) planned to market a radio receiver and also an Edisonic radio-phonograph combination, beginning in 1928. These products were pitched at the high end of the market and were intended to be "the Steinway of the Radio business." Their striking wooden cabinets and impressive bulk added to their cost, and the top of the line sold for more than $1000. Naturally they were advertised as the highest stage of sound recreation with a superior tonal quality, "The New Voice of the Skies" offered the kind of quality that had become synonymous with the Edison trademark. The promotional material emphasized Edison's pioneering role in the technological development of radio and immodestly claimed that it was his research that made it all possible.[12]

In reality, TAE Inc. brought out its radio line with the work of college-trained engineers and experienced marketing men. Edison's insistence that the radio business was too chaotic and dangerous to enter was probably ascribed to the obstinacy of the "old man" who could not see, or hear, its advantages. Yet Edison's jaundiced pessimism about radio proved to be correct: the industry was marked by overproduction and competition between many small players. As early as 1925 the signs of an overcrowded industry were present as many of the financial weaklings went bankrupt .[13] The Splitdorf Company had warned its investors that the radio business was a "hazardous one," but nothing seemed to dampen the enthusiasm of the management of TAE Inc.[14] The marketing problems were many; the technology was new and no one could predict how the customer would respond. The Edison company used the same strategy adopted for the phonograph by aiming at the high end of the market. This had shown some results in the early twenties, but unfortunately the company entered the radio market just as the competition became intense and a vicious price war began. In 1929 the first indications of the Great Depression were present: sluggish demand, soft prices, and growing unemployment. The radio business was hit hard because the market was flooded with very cheap radios produced by the many small companies struggling to survive. This was the death knell for TAE Inc.'s ambitious marketing strategy; only the low-cost producers had a chance to make a profit. After losing about $2 million dollars, the company withdrew from the industry. The "old man" had been right about the dangers of getting into the radio business, but he never said "I told you so" to his sons.[15]

This sad story was repeated with the other new product line of TAE Inc. The decision to manufacture electrical appliances for the kitchen was made by the management who then earmarked a fixed amount for R&D work. Theodore Edison again carried out much of the research and development. In 1926 the Board of Directors appropriated $20,000 to investigate electrical refrigeration.[16] But this was insufficient for an adequate R&D program that might end in a commercial product. When Charles Kettering and an experimental team at GM's research laboratory undertook this task, it took several years and false-trails before a commercial technology was developed. The project began at GM's lab in 1920 and continued throughout the decade. GM and Du Pont finally pooled their technical talent into a joint operation to produce a new system of refrigeration based on freon. [17]

TAE Inc. had neither the time nor resources to mount such a venture. The management of the Edison enterprise were looking for some new products to replace the earnings lost in the declining phonograph business. And they needed them in a hurry. The lab was put to work to designing electric coffee makers, waffle irons, and toasters. These were simple products that could easily be manufactured in the Phonograph Works.

Thomas Edison Junior returned to the West Orange lab to work on developing the line of consumer durables. The son of Edison's first wife, Mary Stillwell, Tom Jr. had achieved little in a troubled life which was littered with failed businesses and health problems. Edison allowed him to come back to the laboratory in the 1920s. Tom Jr.'s careful drawings of toaster filaments and heater elements bear a signature that is quite similar to that of his famous father. His notes tell us something of the daily work of experimenters in the lab of the late 1920s. He carried out endurance tests of all the electrical components of the toaster and continuously monitored repeated toasting of all kinds of bread, "this test to be conducted by someone unacquainted with such devices-who will represent the public."[18] The experiments of the new Edisons have none of the ambition and scope of the "old man;" these drawings provide a symbolic commentary on the new role of the West Orange laboratory. It was a long road from the incandescent bulb to the electric toaster, and the only truly innovative part of the Edicraft range of appliances was their design. Appearance had become an important consideration in the phonograph business and it took a greater importance in the new consumer durable line. The engineering effort was conditioned by the goal to "improve the appearance " of the products.[19] The marketing strategy was again aimed at the most affluent households and subsequently a free-lance designer was hired to give these products a distinctive look. The toaster was described as resembling "a beautiful metal book" and even the advertising material is a striking example of tasteful art deco.[20] Although these designs were simple and elegant, they were in no way revolutionary. They do not have the flair of the work of Peter Behrens for AEG, or the dramatic clarity of Gerhard Marck's designs for coffee makers. The Edicraft products are conservative renditions of a new style in industrial design.

The Edicraft products were to be the ultimate in style and performance, representing "the final achievement of years of research and experiment." [21] The products were two years in the development stage and claimed to be radical improvements on the existing toasters and coffee makers on the market. The new feature of the toaster was that it could toast both sides of two pieces of bread simultaneously. The siphonator was portrayed as "the first real improvement in coffee making in 25 years." [22] These products bore Edison's image, his famous signature, and his personal assurance that these were the only toasters and coffee makers developed in his laboratories. After years of relentless exploitation, this advertising line was beginning to lose its appeal. The public did not seem to care that these were Edison toasters and the hard times of the Great Depression reduced the market for premium priced kitchen appliances. The great future for consumer durables did not materialize. The Edicraft division did not meet the expectations of the management of TAE Inc.

Failure followed in the wake of R&D by committee. The expenditure had been agreed upon, the research controlled and placed within well defined limits, all expenses had been accounted for and the result had been mundane products with little appeal. TAE Inc. had charted a course of conservative technology: no great experimental campaigns into totally new areas, no irresponsible spending without limits, and no new products to excite the customer. While the Engineering Department labored diligently to make small improvements in the Edison phonograph, a small number of experimenters--including a few Edisons--worked in a tightly controlled environment to produce slightly better versions of existing products. The revolutionary new technologies, such as the talking picture, had all fallen by the wayside, victims of technological problems and conservative financial policies. The attempts to develop innovative new products were half-hearted and small scale. The Ediscope, for example, tried to utilize the long-playing record in a motion picture device which flashed still pictures on the front screen of the machine. It was a fusion of two partly developed technologies into one complicated machine. Little thought had gone into its potential market, and the best the Edison company company could do was claim that it would "entertain and educate children." Not surprisingly, it failed to achieve any commercial success.[23]

THE EDISON LEGEND

While innovation at the West Orange laboratory declined, Edison's image as a great inventor grew. The myth of the heroic inventor who went from rags to riches was described in a growing number of books and articles. It read like a Horatio Alger story. Edison's long career bridged two Americas: the nineteenth century world of his mid-western upbringing and meteoric rise to fame and fortune, and the modern industrial society of the twentieth century that his inventions had helped create. The appeal of the Edison legend was that it managed to combine the values of rural America with the trappings of an industrial state.[24]

The image of Edison the great inventor, and of his famous laboratory, had served the Edison industries well. TAE Inc. always claimed that "Ours is the best machine" because Edison's genius, and the great resources of his West Orange laboratory, stood behind it. The standards of the laboratory were the highest, and in this way the Official Laboratory Model phonograph was advertised as the ultimate in reproduction. In the same way the Diamond Disc machine was portrayed as Edison's masterpiece; after years of work in the laboratory, Edison and his assistants had produced a superior means of reproducing sound. It was his "supreme effort" and his "latest and greatest triumph."[25]

Edison's name had become a valuable asset. As one executive of the New York Consolidated Edison Company put it:

> The use of the name EDISON in our business relations and corporate title is of inestimable value. Everyone is familiar with the name, his accomplishments, and the standard of apparatus, equipment, of service, and performance implied in the use of the name Edison, gives it a very great commercial advantage.[26]

It stood for innovation with integrity. It was associated with radically new products that embodied the founder's ethic of safety and value. This image of benign technology and quality products was the most valuable asset he left to his company. The Edison name was jealously guarded by "the old man" and the companies that bore his name.

The lessons that Edison learnt in the years of introducing the lighting systems were carried with him for the rest of his life. He realized that the public would buy a new product if a familiar face, and international reputation, stood behind it. His great public visibility led him to take personal responsibility for his companies and the technology they introduced.[27] His technological choices had to err on the side of safety and reliability for one mistake could lead to disaster in all his many businesses. The E2 explosion was a case in point. The destruction of an experimental submarine--caused not by technical failure but by human error--cost Edison a valuable market for his battery and placed his reputation under a cloud. The company did not feel that they were to blame but nevertheless made a cash settlement with the relatives of the deceased.[28] Edison was well aware that a loss of public confidence in the salutary effects of new technology would hurt his businesses. This lay behind his opposition to alternating current and his devotion to low voltage electric traction.

The solid reputation of quality goods was a great asset in the long run, even though short-term profits often had to be sacrificed to meet Edison's demanding standards. The storage battery is a case in point. The recall of his first attempt was an expensive business for TAE Inc. that came while financial reserves were low--the worst possible time. Many other companies would have kept this product on the market while improving it in their laboratories. But Edison was adamant: "We have to get it right" he insisted, and only then was it to be sold. Every Edison product had to meet the high standards of its maker. Harry Miller expressed this sentiment perfectly: "If it wasn't far superior to other batteries," he told a prospective customer "we would't make them."[29] The Edison name stood for quality.

It was the job of the West Orange laboratory to maintain Edison's standards. His policy was simple: "The Edison product must be of the highest quality." It was hammered home in countless memoranda and meetings. The laboratory's work in testing, production engineering, and new product development was the key to maintain Edison's standards. The product engineers were instructed to maintain Edison's basic policy of QUALITY FIRST: "It is up to you to uphold his standard of perfection in every detail."[30] In the 1920s Edison was no longer around to approve every machine leaving the laboratory for the Works. But even when the "old man" was long gone, the engineering organization he guided for so long continued work in his image: "The Engineering Department represents Mr. Edison in safeguarding the standards of quality."[31] The process of testing and quality assurance had become a long and complex one. But normally it was an engineer from the main lab who had the last word. Phonograph mechanisms, for example, were tested by a staff of inspectors in a special room in the Phonograph Works. Their work was monitored by a chief inspector and he, in turn, was under a man from the laboratory, who double checked the checkers and tested a small sample of the daily output.[32] Although the function of the laboratory had moved from the driving force of the Edison enterprise in the 1880s to an advisory role in the 1920s, it still played an important part in quality assurance.

FINALE

Edison's insistence on retaining his good name, his image of benign technology, became stronger as he grew older and the pressures of business were doubtless molified by thoughts of his place in history. As the years went by he forgot the questionable business manoeuvrings and the painful litigation, and concentrated on the good his innovations had done. His companies proudly stated that "Edison has invented no machine that will do you harm. All of his inventions are for the benefit of humanity."[33] In later years, Edison spent more time on innovations that he claimed were for the public good. His cement houses, for example, were not only a means to find a market for his cement but also a force of social improvement. Edison thought that they would provide low cost housing for the working classes. The urban poor were also the beneficiaries of another idea--automatic vending machines. These were intended to sell coal and the necessities of life at low prices. Edison was all for "businessmen (to) use their brains ...to help the hard working man with a family who is doing the best he can with limited intelligence."[34] The great irony is that Edison seemed to have cared more for the unknown working man who was going to benefit from his inventions than he did for his own workers at West Orange.

The particular ironies of Edison's situation were lost on the general public, who still imagined him working through the night in the small lab in rural New Jersey. It irked "the old man" no end when letters arrived at West Orange addressed to the "Edison laboratory, Menlo Park." The Edison laboratory existed in the minds of the public as the Home of the "Wizard," and he never did shake this image, still being known as the Wizard of Menlo Park up until his death. The fact that he moved from Menlo Park and become a great industrialist was lost on many Americans.[35] "The Edison laboratories" which were claimed as the starting point of all his products were as mysterious as the process of innovation that created the products.

However abstract their idea of innovation and Edison's genius, Americans took Edison the man to heart. His cavortings with fellow millionaire industrialists Harvey Firestone and Henry Ford captured the public's imagination. Here were the heroes of capitalism enjoying the simple life of camping and hiking, and newsreel audiences were led to believe that these great men acted no differently from the average American. The climax of Edison's popularity came with the Festival of Light, a celebration marking the opening of Henry Ford's Greenfield Village. This carefully-choreographed exercise in public relations was promoted by the electric utilities, who had come to appreciate the value of a good image. While the ceremonies at Greenfield Village were underway, the United States Congress passed a resolution expressing the nation's thanks to Edison "whose conquests in the realm of science have enriched all human life." [36] Ironically, while Edison was being lionized at the Festival of Light in 1929, his customers were deserting the products based on his traditional values and aesthetics. The phonograph business shows that he was out of step with the consuming public of the 1920s. The fact that he had to close down the phonograph operation--a humiliating step for the inventor of the talking machine--while being honored as the great innovator, is an indication of the gulf that had arisen between between the Edison image and reality.

The newsreels taken at the Festival of Light show that age and illness had begun to take their toll. Yet Edison was still determined to keep on experimenting. By 1930 he was confined to a wheelchair but still continued working on the rubber experiments. He normally returned to West Orange from Florida in the spring, around March. But in 1931 his health was so poor that his return was delayed until June. When his staff asked him what was to be shipped back to New Jersey, a one word answer indicated that the end was near: "Everything." [37] Edison did return to the laboratory in the summer of 1931 and reported for work several times. Some progress was being made in producing rubber from goldenrod and he was well pleased.

In September Edison was confined to his bed and the family began to prepare for the funeral arrangements. He died on 18 October 1931. A national outpouring of grief followed. The great inventor's last days had been followed by the world's press. President Hoover had asked for daily bulletins. It was as if America and the world sensed that an era was coming to an end. There was no question that Edison should lie in state to receive one last round of homage. There was no question that his body would lie in the laboratory and not Glenmont. Thousands of people came to pay their last respects. (See Illus. 14-2, 14,500.)

The Great Depression was two years old when Edison died. The first shocks to the Stock Market had struck while Edison, Ford, and President Hoover were parading through the streets of Detroit during the Festival of Light. Charles Edison had a difficult task ahead of him as chief executive of TAE Inc. Yet the organization did survive the Great Depression, just as it had survived the Great Depression of the nineteenth century and the depressions of 1907-8 and 1920-21. Edison senior had turned over a resilient and financially strong business to the next generation. In 1887 Edison had looked into the future and envisioned a great industrial complex. He told a financial backer that "I honestly believe that I can build up a works in 15 to 20 years that will employ 10 to 15,000 men and yield 500 per cent to stockholders."[38] He had gone a long way in achieving this goal. At the time of his death, TAE Inc. was returning a dividend and had an average yearly surplus of $7,000,000. The indebtedness of over $2,000,000 that had been acquired during the war years and post-war depression was fully discharged. TAE Inc. had over $5,000,000 invested in Liberty Bonds in 1931.[39]

Illustration 14-2

Mourning Edison at the Laboratory

The divisional structure of TAE Inc. had helped it weather the storm of the Depression and the decline of its core phonograph business. As one product reached maturity and then began its decline, another came to take its place. The storage battery and Ediphone kept TAE Inc. solvent in the 1930s. The instrument division matured in the 1940s and helped arm America during the Second World War. The division of function between R&D and production engineering was finalized during the 1930s and 1940s: the lab was devoted to research while product development groups worked in the operating divisions. Building 5 of the West Orange complex still contained the personnel and equipment of the research effort until 1953, when a modern facility was built on nearby Watchung Avenue. The new laboratory was an unexceptional, one-story building in the international architectural style. It contained 9 experimental rooms and began with only 28 employees--a far cry from the grandiose plans and impressive size of Edison's laboratory in 1887. R&D still played an important part in the organization. The Annual Report of 1948 stressed that "Research Assures Progress and Quality."[40]

Charles Edison sold TAE Inc. to the McGraw Electric Company. McGraw Edison, as it was then called, slowly dismantled the West Orange complex. Today all of the factory buildings are gone except the storage battery plant across the road from Building 5. The Edison laboratory sits alone, still giving the mistaken impression that the lab was free standing and not part of a great industrial complex. To those who have visited the Edison National Historic Site, his spirit lives on; if not in the hallways and machine shops, then in the wide eyes of the children as they are shepherded through "the best lab ever."

ENDNOTES FOR CHAPTER FOURTEEN

1) TAE Inc minutes, 1 feb 1926, RR 68.

2) H Miller to H. Heifman, 24 Dec 1909, LB 090927, p. 433.

3) N 880102, pp. 101-105.

4) Vanderbilt, Edison the Chemist, p. pp.281-282.

5) Robert C. Halgrim, The Edison Record (Fort Myers: Edison Museum, N.D.), p. 12; Fort Myers Press clippings, 2 Aug 1927, Rubber.

6) Brooklyn Times, 1928 Rubber, clippings.

7) Instructions for Collecting and Shipping Latex Bearing Plants, 1 July 1927, Rubber.

8) Annotation on a letter of 2 Dec 1929.

9) Mambert correspondence, 27 Mar 1922.

10) Splitdorf Co Stockholder circular, 25 Jan 1929, D10.

11) J Venable, Out of the Shadow, p. 82.

12) Advertising Notes to radio announcer, 10 June 1929, D9 radio; promotional material, primary printed.

13) Standard Daily Trade Services, 21 July 1925, Radio.

14) Splitdorf Co Stockholder circular, 25 Jan 1919, D10.

15) J Venable, Out of the Shadow, p. 83.

16) Minutes of Board meeting, 8 Aug 1928, RR 68.

17) Leslie, Boss Kettering, pp. 219-227.

18) Notes and sketches in D26.

19) Meeting of Electrical Products Division, 1928 Toaster.

20) Advertising material in primary printed.

21) Ibid.

22) Press release, TAE Inc., 22 Nov 1928.

23) Advertising for long playing record, 1926, D8 phono.

24) See Wyn Wachhorst, T A Edison: An American Myth (Cambridge: MIT Press, 1981).

25) Promotional material, 15 May 1912, Phono Disc.

26) Testimony of John W Lieb, 13 April 1925, D box bio L.

27) "The rule that has been adopted not to permit your name to be used in connection with any enterprise except those which you control and for which you feel a personal responsibility, is a safe one to follw, Dyer to TAE, 11 July 1910, 1910 SB.

28) TAE to F.D. Roosevelt, 10 Sept 1915, Bio file R; Hutchison diary, 31 Dec 1918.

29) H Miller to C Flint, 9 Mar 1909, LB 090115, p. 360.

30) JP Constable to Product Engineers, 11 Sept 1917, Lab bb.

31) JP Constable to G L Clark, 29 Jan 1920, Constable files Eng Dept.

32) Constable to R Hudson, 28 Sept 1917.

33) H Miller to H Tasker, 19 Aug 1909, LB 090507, p. 521.

34) TAE to N.F. Brady, 14 Dec 1910.

35) P. Sutcliffe to H.M. Scott, 27 Nov 1918, " a lot of people think that he (Edison) is still working at a small lab in Menlo Park," 1918 Phono Gen.

36) Congressional Record, vol 71, no. 97, Resolution of 21 Oct 1929.

37) Vanderbilt, p. 299.

38) TAE to Hood Wright, Nov 1887, N 871115.

39) Conot, p. 448.

40) TAE Inc. Annual report, 1952, Charles Edison fund.