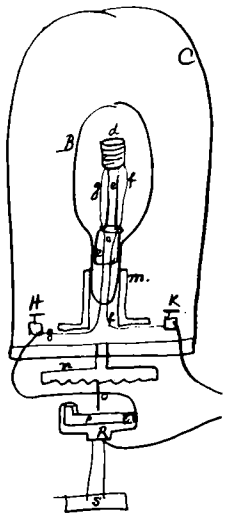

INTRODUCTION

History and Invention

In the nineteenth century, when "technology" was an intellectual concept and not a popular catchword of politicians and economists, "invention" was the widely accepted mainstay of material and industrial progress. For most of the century, the inventor was a figure worthy of both popular esteem and commercial respect, and the fruits of his labors were viewed as the symbols and sources of the new industrial culture's special strengths. In invention was seen that melding of brain and hand which betokened a new, more democratic and egalitarian world, in which material progress was simply the most obvious manifestation of a spiritual advancement that would eventually extend to all the races of the earth. At least, such was the American creed that propelled the unchecked expansion of industrialism.

The workings of invention normally presented no mystery to an informed citizen of the last century. "Ingenuity," and not "genius," was invention's parent, and ingenuity was within the grasp of any man who had his eyes open, his mind alert, and his hands ready. The same talents at work in the Yankee's marketplace sharpness or meetingplace glibness could be applied in the workplace and machine shop as well. To the ordinary American, the models that stood row on row in the Patent Office were more representative of his country's intellect than any books in a library or paintings in a gallery. After all, these models were generally made by common men (and a few women), graced by no special privilege or education, but simply a shade cleverer or a moment quicker or just a bit nimbler than their fellows. Americans shared something of the faith espoused by Samuel Smiles, when he ascribed the accomplishments of the great inventors and engineers of the day to clear thinking, hard work, and common virtue.

There appeared from time to time, however, exceptions—individuals whose inventiveness seemed to transcend the ordinary and place them

and their work on a higher plane. Such individuals were put into the pantheon of cultural heroes, their names to be conjured up to evoke the spirit of progress or, at least, the profitableness of creative enterprise. By the time America had reached its hundredth birthday, in 1876, a fair number of inventors could be said to have achieved such heroic stature and their names were familiar to every schoolchild—Franklin, Whitney, Fulton, and Morse were perhaps the most obvious examples. At that time, however, there was about to emerge another of these exceptional inventors, whose capacity for creating not only the useful and the clever but, occasionally, the miraculous as well, would earn him the title of "Wizard." This was, of course, Thomas Alva Edison, and it is in his wizardry, more than any other single thing, that we can see the beginnings of systematic invention that would regularly go beyond the limits of full comprehensibility for the common man. In Edison we find the transition from the common, ingenious invention that seemed to move much of the world forward in the nineteenth century to the specialized, scientific technology that was to be a dominating social and economic force in the twentieth.

It is important to remember that a transitional figure is just that—an individual who is neither consonant with the old order nor fully integrated into the coming one. This is certainly true of Edison. The "Wizard of Menlo Park" was quickly recognized (when he was barely thirty, in fact) as someone who did things differently than the inventors to whom he might be compared. The "invention factory" of Menlo Park was obviously unlike anything in the ken of even the best informed American. And the kind and number of things that seemed to emerge with diurnal regularity from that little New Jersey village simply brooked no comparison. There was certainly something at work here beyond ingenuity and hard work applied in a useful way.

On the other hand, those who would see in the self-taught, unpolished (and occasionally uncouth) former telegrapher, with his white-clapboard two-story laboratory and his "gang" of faithful mechanics and other helpers, a research and development manager in the twentieth-century mold are far from the mark. The workshops and men at Menlo Park did not constitute a technical laboratory of the corporate type, nor did their leader bear any resemblance in style or action to the successful technocrat of a later day. Edison, in fact, showed himself later in life to be constitutionally unable to operate in the style of the new century. There were others of his generation, such as Elihu Thomson or Frank Sprague, who proved to be better able to make the adjustment to the corporate and professional environment of the twentieth-century engineer. Edison's ambiguous position between the old and the modern ways of invention and progress was reflected in his own time by the picture, still familiar more than a half-century past his death, of the folksy, middle-American hero surrounded by the aura of technical genius.

That such an individual should hold a fascination not only for his contemporaries but also for scholars and laymen of a later time is no surprise. Both the life and the myth are too rich and too important not to have a sustained influence. What is surprising, however, is the relative neglect of the internal workings of the Edisonian achievement and, in particular, of the very stuff of his contribution—his inventions. This is not to say that Edison's inventions have not been much written about, for they have, but rather that what has been written has too often belonged more to myth-making than to scholarship. But even when one enters the realm of Edison scholarship—a not inconsiderable territory—rarely can one find true probing questions asked about the act of invention itself, and the questions that are asked tend to be answered with less than reliable evidence.

The reasons for this neglect are complex. One contributing factor is the nature of historical scholarship, for only recently has the tackling of such technical issues become an accepted part of the historical enterprise. Another is in the nature of the evidence, for, while it is certainly available in great quantity, it is of a type that most humanist scholars instinctively shy away from, and it has long been organized in a manner uninviting to all but the most persistent researcher. But, ultimately, the primary reason lies in our cultural perceptions of invention. In the nineteenth century, invention called for no explanation, since it was not seen as an intellectual endeavor. In the twentieth century, attention is directed toward technology, and not invention, hence efforts are made to explain the institutional, economic, and social basis for technological change, but not the inventive act itself.

This work is, to an extent, an attempt to redress this neglect directly, not only to understand better Edison and the nature of his contributions, but also to suggest the extent to which invention—as an act and a process—may be scrutinized as a historical problem. It is fitting, therefore, that the subject under study here is the very epitome of invention in the cultural mythology of the twentieth century—the incandescent electric light. The electric light is, of course, seen as the pinnacle of Edison's inventive achievement. This is so in spite of the fact that other creations may be said to have shown more originality (e.g., the phonograph), more technical flair (e.g., the quadruplex telegraph), more persistence (e.g., the lead-acid storage battery), or a more ingenious combination of elements (e.g., the kinetoscope motion picture system). When it came time, toward the end of Edison's life, for the world to pause and applaud the Wizard's fantastic career, the occasion chosen was the "Golden Jubilee of Light," October 21, 1929, the fiftieth anniversary of the date that, Edison claimed, he invented the electric light. The primacy of the electric light in the constellation of Edison's inventions may be ascribed in part to the size and influence of the industry that grew from the light and its widespread use, in part to its omnipresence as a part of life and work

in the twentieth century, and in part to the almost spiritual significance that lamps and lighting have in human culture.

There are other reasons for making Edison's electric light the object of a study of invention. The general outlines of the invention of October 1879 are very familiar parts of each American's picture of his country's material progress in the nineteenth century, and yet the story that is such common knowledge is based much more on hearsay and foggy memories than on historical evidence. For the most part, it conforms with the traditional nineteenth-century image of invention, a story of persistence and sweat overcoming nature's intractability, of Edison and his faithful followers trying literally thousands of materials in the search for a suitable light bulb filament, guided by little more than the vision that nature had to provide some substance that would serve such a noble need. The electric light is, after all, the achievement most associated with Edison's famous aphorism defining invention as "99% perspiration." Little research is required to reveal how shallow and inaccurate an image this is of what was really going on at Menlo Park in 1878 and 1879.

There is, of course, a "revisionist" version of Edison's invention that tends, wrongly, to put the inventor into the mold of a twentieth-century manager of scientific and technical systems. This version, in its simplest form, would have us believe that, upon taking up the challenge of the electric light, Edison plotted out a research and development strategy encompassing available scientific knowledge about the subject as well as an understanding of the complex systems requirements of a complete electric light and power technology. This has served as a useful corrective to the naive popular view, but in fact reflects a naiveté all its own, casting Edison into a modern role he could never have assumed and making his achievement a far more straightforward and predictable act than it actually was. For Edison, the search for a practical incandescent light was a bold, even foolhardy, plunge into the unknown, guided at first more by overconfidence and a few half-baked ideas than by science or system. To suggest otherwise is to rob the inventive act of its human dimension, and thus to miss an understanding of the act itself.

Nor is it right to make Edison's invention simply one of many more or less equal steps in a long path leading from the first glimmerings of the theoretical possibility of electric lighting to the installation of the practical reality in homes, shops, and factories everywhere. The simple fact is that before Edison began his search in 1878, the world had nothing even resembling a practical electric lamp, and, when that search was largely over by the end of 1879 (and certainly by the time Edison's lamp was commercialized in 1882), the principles and form of the modern incandescent lighting system were established. It is not right either to make a great deal of the rivals Edison met in the field, whether in America or overseas, and to see in them equals in the enterprise. The evidence is simply not there to support the claim that any of these men possessed

more than a portion of the whole that emerged from Menlo Park as the decade of the 1880s began. It will not even do to make much of the notion that one or two of these portions were, at critical junctures, pieced into the Edison system from the reports of his rivals—once again, the evidence is not there.

The invention of the electric light was a complex, human achievement, and we shall not understand it unless we fully appreciate that fact. This may seem to be an obvious truth, but little that has been written about the event has taken it into account. This invention, like most inventions, was the accomplishment of men guided largely by their common sense and their past experience, taking advantage of whatever knowledge and news should come their way, willing to try many things that didn't work, but knowing just how to learn from failures to build up gradually the base of facts, observations, and insights that allow the occasional lucky guess—some would call it inspiration—to effect success. There is clearly something to be said for trying to understand this process better, not just because it has been one of the most important agents for change in the last two centuries, but because it is a part of the human adventure.

This account of Edison's invention was shaped not only by the thematic goal discussed above, but also by a methodological goal of almost equal importance. The first goal is a truer and richer story based on a more faithful reading of the evidence, as opposed to the usual perpetuation or arbitrary inversion of myth. The second is an experiment in archival historiography. The experiment derives its rationale from the sponsor of this study, the U.S. National Park Service, which is the custodian of one of the richest and largest collections of historical technological documentation in the world, the archives at the Edison National Historic Site in West Orange, New Jersey. Adequately understanding and taking advantage of this unique historical resource has become a significant priority for the administrators and curators of the Site, as evidenced by its partial sponsorship of the Thomas A. Edison Papers project. While, as a comprehensive archival and publishing effort of more than twenty years planned duration, this project may be expected to provide the most thorough scrutiny of the archives' resources and potential, it is appropriate that other, more modest, attempts be made to explore their value. We seek, therefore, in this work to understand how to use a large and complete body of technical records to answer interesting historical questions.

As a glance at the accompanying references and bibliographical note will suggest, this study attempts to rely exclusively on the contemporary archival record of the activities surrounding the electric light's development from 1878 to 1882. There has been, over the years, a great deal written about Edison's premier invention and the circumstances surrounding it. Such writings began to appear only a very few years after

the event and have continued up to this day, as exemplified by Robert Conot's well-received Edison biography of 1979, *A Streak of Luck,* and Thomas Hughes's study of electrification, *Networks of Power,* which appeared coincidentally with celebrations of a "centennial of light." The earliest works on the subject relied largely on the recollections of the still-living principals, for the archives were not available and Edison and most of his colleagues were usually quite ready to talk about their Menlo Park exploits. It took little time, however, for recollections to dim and for the complexity of events to be overshadowed in hindsight by the magnitude of the achievement. When, therefore, the stories and recollections of the pioneers, including Edison himself, are compared against the archival record, their completeness and accuracy are constantly found wanting. Later, more professional works, such as the biographies by Matthew Josephson (*Edison,* 1959) and Conot and more specialized studies by historians of science and technology, relied much more on the archival record and thus managed to avoid many of the more simplistic shortcomings of the earlier versions. Most of them, however, still relied in crucial places on recollections (most notoriously on Francis Jehl's *Menlo Park Reminiscences* of 1937–1941) or misinterpreted important technical elements of the record. In examining these accounts next to the Menlo Park notebooks, correspondence, and other documents, we have found none whose rendering of the events of 1878–1882 match our reading of the record. While, of course, some of these differences may be seen as simply matters of historical interpretation, we believe that many of them are due to differences in the degree to which the contemporary documentary record has been critically scrutinized.

This record has presented problems that have inhibited scholars from fully exploiting it. The first problem is the sheer size of the Edison archives. The document holdings at West Orange are said to contain more than three and a half million pages—as formidable a collection centered around the work of one man as exists anywhere. While there is no estimate of the size of the record that concerns the electric light alone, one can imagine that a four-year slice out of Edison's most productive years constitutes no small body of material. A better idea of just what this consists of may be found by a look at the Bibliographical Note following Chapter 8.

The second problem, related to the first, is organization. A fraction of the Edison archives is arranged by subject, but even that fractional arrangement was, at the time this study was undertaken, a somewhat unreliable and haphazard organization. Most of the relevant material on the electric light must be gleaned from amidst records dealing with other enterprises being carried on at Menlo Park. Some of the problems encountered here are also suggested in the bibliographical note. As well-meaning and willing as the custodians of the Edison archives have been

over the years, we can hardly wonder if they have been unable to fully allay the difficulties posed to scholars by such records.

Yet another problem is posed by the nature of the material itself. While there is nothing inherently incomprehensible about the notes, correspondence, and other papers generated in the Menlo Park laboratory, they are definitely not like the more literary records usually left by a political figure, writer, or businessman. They are the creations of men, immersed in the mechanical, electrical, and chemical knowledge of their day, attacking some very bedeviling technical problems. If the record they left behind them is generally without comprehensive explanations for their activities and ideas or interpretations of their abbreviated notes and scribblings, it should be no surprise. Indeed, those few documents that do seem to delineate more fully the ideas and purposes behind laboratory activity must be looked upon with suspicion, for they often turn out to be creations after the fact, put together for purposes of publicity or legal convenience. The papers actually produced in the course of laboratory activity are frequently but rough drawings of a new idea, quick calculations (with little or no labeling), lists of materials or devices, or descriptions of a laboratory procedure or observation without why or wherefore. All of this, it must also be remembered, is in the technical terminology of the nineteenth-century electrician or mechanic, an argot that can be as strange to the modern ear as the jargon of a computer programmer would be to one of the Menlo Park "gang." Therefore, most scholars and writers have understandably retreated to the much more straightforward accounts of the reminiscences for their image of the laboratory's workings and achievements.

We cannot claim that we have overcome these difficulties as completely as we would like, but we have made the effort to meet them head-on. The size of the record required the efforts of a full-time researcher for about eight months, spent searching out and noting down every relevant piece of data in the notebooks, correspondence files, scrapbooks, and other sources described in the bibliographical note. The organization of the electric light items necessitated a broad sweep through the documents of the 1878–1882 period. And the mass of technical arcana was dealt with forthrightly, with every effort made to comprehend and respect the technical milieu in which the men at Menlo Park worked. The extent to which we have in fact succeeded is, of course, a judgment we must leave to the reader.

Finally, a word should be said about illustrations. Because we are dealing here with mechanics, chemists, electricians, and other practical men, we must recognize that their most important form of communication was frequently not in words but in the quick sketch, the hasty set of figures, the finely detailed drawing, and the products of their workbench or laboratory table. Because history is largely a literary activity, often

these records are translated here into descriptions, but such translation is never completely accurate and is frequently impossible. As a number of historians of technology have been at pains to point out, "nonverbal communication" is an essential part of the technical culture, and any student of that culture ignores this at great peril. We have attempted here to suggest the wealth of the nonverbal sources that are such an important part of the documentation of the electric light, but it must be remembered that our inclusions are but a fraction of the total nonverbal archival record.