which he has accomplished during his fourscore years, we are again astounded that this man of mature years, but young in mental capacity and in resourcefulness, has within very recent years taken up a new line of endeavor and, we have every reason to believe, has brought to a successful conclusion an important development in one of the leading commercial industries of our times. Apparently there has been no limit to his possibilities. When those of us who knew him intimately and were inspired by his personality shall have faded from memory, the name of Edison will still live and grow with the years, an inspiration of the sons and daughters of every tongue and every nation who see the light and render thanks to him who invented it.

There are undoubtedly many of you who are listening to me to-day who either do not appreciate or who underestimate what this means. All I can say is that I am sorry for what you have missed. While all of us engaged in the public utility business are proud of our industry and really feel and believe that it is one of the most important as well as interesting businesses in the world, I want you to realize that there are some of us, perhaps few in number, who have a deeper feeling than that felt by the greater majority. It is a feeling of pride, experienced not so much on account of what Mr. Edison himself has done as for what he has inspired us to do. I do not think that any one could have been associated with him for a generation and not be influenced, perhaps unconsciously, by the spirit which has actuated him. It is hard to put into words just how we feel. Personally, I feel like bowing my head and being thankful that my good fortune enabled me to live my life in the atmosphere he has created and under the inspiration of his name.

EDISON'S CONTRIBUTIONS TO SCIENCE AND INDUSTRY

By Dr. F. B. JEWETT

VICE-PRESIDENT OF THE AMERICAN TELEPHONE AND TELEGRAPH COMPANY

To undertake, within a few weeks of his death, anything like a judicial appraisement of Thomas Alva Edison in the matter of his contributions to science and industry is to attempt the essentially impossible. Even had he been a man of lesser stature, insufficient time would have elapsed in which to develop a fair perspective of his achievements. In Edison's case a longer period than usual must ensue before we can see clearly just how his work has fitted in with that of his contemporaries and into the foundations on which subsequent structures of science and engineering and industry grounded in engineering have been built.

Despite the limitations which the undoubted greatness of Edison imposes on us at the moment, it is nevertheless fitting that a tribute to him and his work should be made at this the first meeting, following his death, of the American Association for the Advancement of Science. Clearly any tribute to the man or any appraisement of his work, if it is to be of real worth, should be by those having the right of classification among Edison's peers in his own field. In this respect I feel myself incompetent, and my sole justification for appearing before you is that I may have a right to voice an opinion of those who, while not of Edison's stature, were nevertheless his contemporaries and workers in the fields which he enriched by his contributions.

Because Edison's name has been a household word throughout the world for nearly half a century—a name to conjure with and to many that of a somewhat mythical personage against whose inquiry no doors of science were locked—one runs the distinct risk of overvaluing Edison's real achievements. On the other hand, one runs equally the risk of underrating these same achievements in endeavoring to avoid the obstacles of the first dilemma. If therefore any of you should feel at the conclusion of these remarks that I have erred in my appraisal, I trust you will appreciate the situation in which I am placed in attempting to do now, in respect to a man for whose attainments I have the highest regard, something which would best be done ten or fifteen years hence.

While the titles for Dr. Millikan's appraisement of Edison and mine are the same, we have agreed to approach the matter from different angles—he from the point of view of fundamental science, on which all engineering is founded, and I from the point of view of those practical applications of science which are peculiarly the province of the engineer.

Whatever additions to fame and recognition may have come to Edison in his more mature years, a survey of his achievements as an inventor, engineer and pioneer in industries grounded in engineering makes it clear that he did relatively little during the last forty years of his life to add luster to the fame of his earlier achievements. As a matter of fact practically all Edison's claim to the title of the greatest

American inventor grew out of his work and achievements in the decade between 1870 and 1880. One has but to look over the astounding list of his accomplishments in this ten-year period to appreciate the things which raised him to such a lofty and secure pinnacle—a pinnacle both lofty and secure not only in the estimation of his fellow Americans but in the estimation of men everywhere. In the years which followed this prolific period, and particularly in the decade between 1880 and 1890, Edison's contributions, while vast and important, were essentially different from those of the years in question. They were in the main contributions to the successful employment of his earlier work and were devoid of the brilliance of imaginative insight then so characteristically evidenced.

Nor is it surprising, when one comes to look back on Edison as he was at that period and on science and engineering as it then existed, that he should have been so enormously productive during these few years and that subsequently his life should have run in quieter waters, so far at least as concerned the making of substantial additions to the tools of engineering and industry.

Despite the fact that Edison was imbued to the highest degree with that characteristic which is the hallmark of science, namely, the characteristic of subjecting every theory to the acid test of controlled experiment, he lacked nevertheless the formal training which we normally associate with men of science and engineering. As an offset to this lack of formal training he had an intuitive insight which was unique, an insatiable curiosity and a dogged determination to overcome all obstacles. All these were associated together with a physique which permitted a punishment of the body that few men could have undertaken or stood.

In the decade of the seventies Edison was in his prime not only from the standpoint of his physical being but also from that of his creative imagination. Fortunately for him and for the world in which he lived, the development of science and engineering had during this era reached just to the point where men like Edison were required and where they could find the fullest possible play for their particular genius.

A great store of new facts in what we are now sometimes wont to consider as the grosser physics, in distinction to the more ethereal physics of our present time, had been assembled. To make these facts available for the everyday uses of society required just such an inventive genius and engineer as Edison proved himself to be. It was characteristic of Edison that he saw and seized the opportunity which was his to his own and the world's very great advantage. That the years of his life subsequently were devoid of spectacular achievements in the field of invention is not surprising. All the forces of life and society were against this. Fecundity in ideas is peculiarly the normal characteristic of man's earlier years. Further, in Edison's case—practical man that he was—the carrying out of the intricate details which were the normal fruitage of his own creations demanded a vast tax on his time and energy, which left him little of either to devote to new and untrodden fields. Also, as science itself developed, the practical application of new knowledge came to require a type of training which Edison did not possess.

That this is so, and that Edison during the last part of his life was not the same conspicuous producer of new things that he had been in his early manhood, is not in any way a detraction from his real greatness.

Coming back now more specifically to the things on which it seems to me Edison's claim to greatness is firmly grounded, we find them to be four in number. First, his work in the field of telegraphy in the very late sixties and early seventies; second, his production of the carbon telephone transmitter in 1876; third, his invention of the phonograph in 1877, and finally his development of a practical incandescent lamp and of the system of electrical generation and distribution needed to employ it practically, in 1879 and in the years immediately following.

Of the four, the invention of the phonograph is unquestionably his greatest single achievement from the standpoint of daring imagination, while his development of a practical incandescent lamp and of all the adjuncts that were required to make it commercially available, was his greatest engineering achievement. Since this last achievement marked the inception of a great industry which has carried his name to the far places of the world, it is probably the thing by which he will be longest and best known.

Outside the ranks of those in the communication field itself, the world now hardly thinks of Edison as a great contributor to the development of distant electrical communication. This is due to the fact that despite the importance of his inventions to the art of the period in which they were made, they have with the passage of time, for the most part, now passed into the oblivion of ancient things. Other developments and other applications of a science which did not exist when Edison was a young man have displaced them. The Edison quadruplex and the various other things which he devised were nevertheless marvels of ingenuity in their time and, while they lasted, greatly to the advantage of telegraphic communication and its development.

In the field of telephony Edison's work in connection with the development of a carbon telephone

transmitter—that device which was needed to give a mighty forward impetus to Bell's great fundamental invention—has had a more lasting life. Carbon transmitters in one form or another are still the basic instrumentalities for translating sound vibrations into electrical vibrations. Nevertheless, Edison touched the telephone art only at a point, and except for the lasting results which grew out of this contact, he did not influence the development of this art as he did that of the electric light or phonograph arts.

In his invention of the phonograph Edison displayed an imagination, a skill and a perseverance of the very highest order. This invention alone might well have inscribed his name indestructibly in the history of America and of the world. Just as Alexander Graham Bell's name will go down through the ages as the man who made possible the instantaneous transmission, to a distance, of the human voice, so the name of Thomas Alva Edison will go down as that of the man who first made possible the preservation in time of the human voice.

At a time when phonographs, both acoustical and electrical, are an everyday commonplace, and where most of those in the world who are less than forty years of age can hardly conceive of life without the phonograph, it is difficult to appreciate the degree of daring which Edison displayed in even imagining that he could imprison such a fleeting thing as the energy of the spoken word. Equally difficult is it for the average man of to-day to conceive of the daring involved in imagining that out of the prison thus created could come, at some remotely distant time, a reproduction of ancient words, possibly those of men long dead, with the full vigor and clarity of the original speech.

With the successful completion, in the late seventies, of his long and arduous quest for a suitable filament material and its incorporation in a properly designed and evacuated glass container, Edison turned a hitherto scientific oddity into a practical and commercial light-producing instrument. The carbon filament incandescent lamp as it came from Edison's hands contained in itself enough of ingenuity, painstaking research and clear insight into fundamental requirements, both scientific and practical, to have insured him a permanent place in the history of electrical development, had he done nothing else in the field of electric illumination. For Edison the incandescent lamp was but an incident, however. In itself it was useless for the purpose he had in mind. It was merely the first link in the chain which he was to forge in creating a great new industry of immeasurable benefit to mankind. The forging of this chain was to afford Edison ample opportunity to show himself a great engineer as well as a great inventor, and was to consume a major part of his time and energy for a decade or more.

As an inventor and experimentalist he had produced an ingenious and potentially valuable illuminating device, but the electrical art of 1879 was almost entirely devoid of the things to make it commercially available. Seldom has the creator of so perfect a new tool found the field so bare. More seldom still has one done so much to create an art around and for his tool as Edison did in the ten years following 1879.

Generators, systems of distribution and utilization, switchboards, auxiliary equipment and adjunct devices, large and small, in vast profusion flowed unceasingly from Edison and the group of intelligent young men with whom he surrounded himself. In the welter of this torrent of new things no one will probably ever know just who was initially responsible for each and every one of them. Three things are certain, however: first, Edison himself was the creator of the principal items; second, his was at all times the guiding mind and the driving force; third, the group of men who later came to be known as Edison Pioneers, and who were and in large measure still are dominating factors in the electric light and power industry, were youths of his discerning selection.

No better proof of the fundamental soundness of Edison's work in those early days of electric illumination is required than the knowledge that the basic things of the art he then developed are still the basic things of the vaster art which has evolved from it. New devices and applications, many of them involving scientific knowledge which did not exist when Edison was pioneering, have been made in inventions and uses, but still in its fundamentals the art of electric illumination is the art as Edison created it.

Nor was this art merely the result of happy chance shot through by flashes of brilliant imagination. Brilliant imagination there was in plenty, but at the bottom it was the result of clear thinking, untiring labor, faith and a willingness to face facts of every description and mold them all to an ordered progress.

Only a great engineer as well as a great genius could have done the things which Edison did in the electric light and power field. That his work and his preeminence were recognized by his contemporaries is evident when we come to examine the roster of names which make up the great electric light and power companies. Many of the most brilliant stars in the galaxy of these organizations have the name "Edison" as part of their title. Had these names been chosen in recent years one might attribute the choice to some desire to capitalize the popularity and mystery which has come to be attached to Edison and his work. The fact that the names go back in most instances to the very early beginnings of the electric

light and power industry, and so to a time when Edison was but little known outside of his own field, makes it clear that within that field he was even then recognized as master.

If one were writing a complete biographical appraisal of Edison and his works, pages could easily be filled with descriptions of the tremendous array of things which he produced and patented, and of the wide range of his interests. In so short a note even as the present one there is great temptation to expand the list to include a few more items, notably his work in the motion picture art. Some of this work is but little inferior to that which seems to me to constitute Edison's principal unassailable claim to fame.

The amazing variety of the things which Edison did and the fact that he seldom made contact with any art without contributing something to its advance lead one to speculate on what might have happened to the development of some of these arts had Edison concentrated his attention on them during the years of his greatest productivity.

In closing this brief appraisement of the engineering side of a man for whom I had the most sincere regard, I can not refrain from voicing a bit of regret that during his evening years his name should have been so frequently associated with inconsequential things or with personal idiosyncrasies, with which we are all amply provided. While these associations subtracted nothing from the judgment of men who knew Edison's real worth, they did unquestionably portray a great man in a somewhat false and belittling light to vast numbers of a younger generation.

EDISON AS A SCIENTIST

By Dr. ROBERT ANDREWS MILLIKAN

DIRECTOR OF THE NORMAN BRIDGE LABORATORY OF PHYSICS, CALIFORNIA INSTITUTE OF TECHNOLOGY

I AM asked to say something about the scientific qualities and achievements of Mr. Edison. But from my point of view the scientific influence of any man is so interwoven with his character, with his mode of thought, with his outlook on life as reflected in his acts, his words and his daily walk among his fellows that I prefer to let what I say about Mr. Edison's science grow out of a somewhat broader consideration of the qualities which made him the commanding figure that he was and that, as I think, he always will be.

I should like to raise first one very fundamental question. Is it merely an accident, a coincidence, that the two greatest scientists of the nineteenth century, the two who, the world over, would be first named as the most significant creators of the age of electricity with all that it has meant to the world, namely Michael Faraday and James Clerk Maxwell, were also great souls, possessors in peculiar measure of the virtues which in all times and all places have been regarded by mankind as the most fundamental, namely, modesty, simplicity, straightforwardness, objectiveness, industry, honesty, human sympathy, altruism, reverence and a keen sense of social responsibility. These qualities arise, I think, from one great all-inclusive quality, namely, balanced but penetrating and objective judgment, *i.e.*, from a correct understanding of relations between phenomena, social as well as physical, including that of one's own position in the scheme of things: and this quality, this perception is precisely what gives the great scientist his insight and his effectiveness. Smart rogues, clever scoundrels, gifted egotists, exist, no doubt; but do they do the things that live? I suspect not often. Certainly history is replete with the names of great scientists who have also been great souls—Copernicus, Leonardo da Vinci, Newton, Kepler, Faraday, Helmholtz, Pasteur, Maxwell, Kelvin, Lorentz, Einstein. What a galaxy of greatness not merely as scientists but as men!

Had Edison their quality and was this the reason of his greatness? I did not know him intimately, but I saw enough of him to be sure that I saw some of their virtues. He had not the educational background of most of them, and might therefore have been expected to be somewhat wanting in their breadth of vision, but the very exceptional minds—the really great—do not need the schools, for they appreciate what educational opportunity means, and have the capacity to become educated without the aid of the schools. This quality—the *sine qua non* for a scientist—namely, the appreciation of one's own ignorance and limitations coupled with the eternal urge to learn, and the will and power to follow that urge—I myself had the opportunity to see in Edison.

During the war when we were both engaged in Washington I spent an evening or two with him. He was then, at the age of seventy and more, reading some of the newer books that were then appearing in the field of pure science, and asking intelligent questions about them, too. His ears were gone, but there had been no crystallizing of his mind, such as occurs with some of us before we are born; with others, especially with so-called men of action, before we are forty; and with most of us, even with those who have learned to combine the art of knowing with