Edison, His Life and Inventions by F.L.Dyer and T.C.Martin

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CHAPTER XXII - THE DEVELOPMENT OF THE EDISON STORAGE BATTERY

IT is more than a hundred years since the elementary principle of the storage battery or "accumulator" was detected by a Frenchman named Gautherot; it is just fifty years since another Frenchman, named Plante, discovered that on taking two thin plates of sheet lead, immersing them in dilute sulphuric acid, and passing an electric current through the cell, the combination exhibited the ability to give back part of the original charging current, owing to the chemical changes and reactions set up. Plante coiled up his sheets into a very handy cell like a little roll of carpet or pastry; but the trouble was that the battery took a long time to "form." One sheet becoming coated with lead peroxide and the other with finely divided or spongy metallic lead, they would receive current, and then, even after a long period of inaction, furnish or return an electromotive force of from 1.85 to 2.2 volts. This ability to store up electrical energy produced by dynamos in hours otherwise idle, whether driven by steam, wind, or water, was a distinct advance in the art; but the sensational step was taken about 1880, when Faure in France and Brush in America broke away from the slow and weary process of "forming" the plates, and hit on clever methods of furnishing them "ready made," so to speak, by dabbing red lead onto lead-grid plates, just as butter is spread on a slice of home-made bread. This brought the storage battery at once into use as a practical, manufactured piece of apparatus; and the world was captivated with the idea. The great English scientist, Sir William Thomson, went wild with enthusiasm when a Faure "box of electricity" was brought over from Paris to him in 1881 containing a million foot-pounds of stored energy. His biographer, Dr. Sylvanus P. Thompson, describes him as lying ill in bed with a wounded leg, and watching results with an incandescent lamp fastened to his bed curtain by a safety-pin, and lit up by current from the little Faure cell. Said Sir William: "It is going to be a most valuable, practical affairas valuable as water-cisterns to people whether they had or had not systems of water-pipes and water-supply." Indeed, in one outburst of panegyric the shrewd physicist remarked that he saw in it "a realization of the most ardently and increasingly felt scientific aspiration of his lifean aspiration which he hardly dared to expect or to see realized." A little later, however, Sir William, always cautious and canny, began to discover the inherent defects of the primitive battery, as to disintegration, inefficiency, costliness, etc., and though offered tempting inducements, declined to lend his name to its financial introduction. Nevertheless, he accepted the principle as valuable, and put the battery to actual use.

For many years after this episode, the modern lead-lead type of battery thus brought forward with so great a flourish of trumpets had a hard time of it. Edison's attitude toward it, even as a useful supplement to his lighting system, was always one of scepticism, and he remarked contemptuously that the best storage battery he knew was a ton of coal. The financial fortunes of the battery, on both sides of the Atlantic, were as varied and as disastrous as its industrial; but it did at last emerge, and "made good." By 1905, the production of lead-lead storage batteries in the United States alone had reached a value for the year of nearly ,000,000, and it has increased greatly since that time. The storage battery is now regarded as an important and indispensable adjunct in nearly all modern electric-lighting and electric-railway systems of any magnitude; and in 1909, in spite of its weight, it had found adoption in over ten thousand automobiles of the truck, delivery wagon, pleasure carriage, and runabout types in America.

Edison watched closely all this earlier development for about fifteen years, not changing his mind as to what he regarded as the incurable defects of the lead-lead type, but coming gradually to the conclusion that if a storage battery of some other and better type could be brought forward, it would fulfil all the early hopes, however extravagant, of such men as Kelvin (Sir William Thomson), and would become as necessary and as universal as the incandescent lamp or the electric motor. The beginning of the present century found him at his point of new departure.

Generally speaking, non-technical and uninitiated persons have a tendency to regard an invention as being more or less the ultimate result of some happy inspiration. And, indeed, there is no doubt that such may be the fact in some instances; but in most cases the inventor has intentionally set out to accomplish a definite and desired resultmostly through the application of the known laws of the art in which he happens to be working. It is rarely, however, that a man will start out deliberately, as Edison did, to evolve a radically new type of such an intricate device as the storage battery, with only a meagre clew and a vague starting-point.

In view of the successful outcome of the problem which, in 1900, he undertook to solve, it will be interesting to review his mental attitude at that period. It has already been noted at the end of a previous chapter that on closing the magnetic iron-ore concentrating plant at Edison, New Jersey, he resolved to work on a new type of storage battery. It was about this time that, in the course of a conversation with Mr. R. H. Beach, then of the street-railway department of the General Electric Company, he said: "Beach, I don't think Nature would be so unkind as to withhold the secret of a GOOD storage battery if a real earnest hunt for it is made. I'm going to hunt."

Frequently Edison has been asked what he considers the secret of achievement. To this query he has invariably replied: "Hard work, based on hard thinking." The laboratory records bear the fullest witness that he has consistently followed out this prescription to the utmost. The perfection of all his great inventions has been signalized by patient, persistent, and incessant effort which, recognizing nothing short of success, has resulted in the ultimate accomplishment of his ideas. Optimistic and hopeful to a high degree, Edison has the happy faculty of beginning the day as open-minded as a childyesterday's disappointments and failures discarded and discounted by the alluring possibilities of to-morrow.

Of all his inventions, it is doubtful whether any one of them has called forth more original thought, work, perseverance, ingenuity, and monumental patience than the one we are now dealing with. One of his associates who has been through the many years of the storage-battery drudgery with him said: "If Edison's experiments, investigations, and work on this storage battery were all that he had ever done, I should say that he was not only a notable inventor, but also a great man. It is almost impossible to appreciate the enormous difficulties that have been overcome."

From a beginning which was made practically in the dark, it was not until he had completed more than ten thousand experiments that he obtained any positive preliminary results whatever. Through all this vast amount of research there had been no previous signs of the electrical action he was looking for. These experiments had extended over many months of constant work by day and night, but there was no breakdown of Edison's faith in ultimate successno diminution of his sanguine and confident expectations. The failure of an experiment simply meant to him that he had found something else that would not work, thus bringing the possible goal a little nearer by a process of painstaking elimination.

Now, however, after these many months of arduous toil, in which he had examined and tested practically all the known elements in numerous chemical combinations, the electric action he sought for had been obtained, thus affording him the first inkling of the secret that he had industriously tried to wrest from Nature. It should be borne in mind that from the very outset Edison had disdained any intention of following in the only tracks then known by employing lead and sulphuric acid as the components of a successful storage battery. Impressed with what he considered the serious inherent defects of batteries made of these materials, and the tremendously complex nature of the chemical reactions taking place in all types of such cells, he determined boldly at the start that he would devise a battery without lead, and one in which an alkaline solution could be useda form which would, he firmly believed, be inherently less subject to decay and dissolution than the standard type, which after many setbacks had finally won its way to an annual production of many thousands of cells, worth millions of dollars.

Two or three thousand of the first experiments followed the line of his well-known primary battery in the attempted employment of copper oxide as an element in a new type of storage cell; but its use offered no advantages, and the hunt was continued in other directions and pursued until Edison satisfied himself by a vast number of experiments that nickel and iron possessed the desirable qualifications he was in search of.

This immense amount of investigation which had consumed so many months of time, and which had culminated in the discovery of a series of reactions between nickel and iron that bore great promise, brought Edison merely within sight of a strange and hitherto unexplored country. Slowly but surely the results of the last few thousands of his preliminary experiments had pointed inevitably to a new and fruitful region ahead. He had discovered the hidden passage and held the clew which he had so industriously sought. And now, having outlined a definite path, Edison was all afire to push ahead vigorously in order that he might enter in and possess the land.

It is a trite saying that "history repeats itself," and certainly no axiom carries more truth than this when applied to the history of each of Edison's important inventions. The development of the storage battery has been no exception; indeed, far from otherwise, for in the ten years that have elapsed since the time he set himself and his mechanics, chemists, machinists, and experimenters at work to develop a practical commercial cell, the old story of incessant and persistent efforts so manifest in the working out of other inventions was fully repeated.

Very soon after he had decided upon the use of nickel and iron as the elemental metals for his storage battery, Edison established a chemical plant at Silver Lake, New Jersey, a few miles from the Orange laboratory, on land purchased some time previously. This place was the scene of the further experiments to develop the various chemical forms of nickel and iron, and to determine by tests what would be best adapted for use in cells manufactured on a commercial scale. With a little handful of selected experimenters gathered about him, Edison settled down to one of his characteristic struggles for supremacy. To some extent it was a revival of the old Menlo Park days (or, rather, nights). Some of these who had worked on the preliminary experiments, with the addition of a few new-comers, toiled together regardless of passing time and often under most discouraging circumstances, but with that remarkable esprit de corps that has ever marked Edison's relations with his co-workers, and that has contributed so largely to the successful carrying out of his ideas.

The group that took part in these early years of Edison's arduous labors included his old-time assistant, Fred Ott, together with his chemist, J. W. Aylsworth, as well as E. J. Ross, Jr., W. E. Holland, and Ralph Arbogast, and a little later W. G. Bee, all of whom have grown up with the battery and still devote their energies to its commercial development. One of these workers, relating the strenuous experiences of these few years, says: "It was hard work and long hours, but still there were some things that made life pleasant. One of them was the supper-hour we enjoyed when we worked nights. Mr. Edison would have supper sent in about midnight, and we all sat down together, including himself. Work was forgotten for the time, and all hands were ready for fun. I have very pleasant recollections of Mr. Edison at these times. He would always relax and help to make a good time, and on some occasions I have seen him fairly overflow with animal spirits, just like a boy let out from school. After the supper-hour was over, however, he again became the serious, energetic inventor, deeply immersed in the work at hand.

"He was very fond of telling and hearing stories, and always appreciated a joke. I remember one that he liked to get off on us once in a while. Our lighting plant was in duplicate, and about 12.30 or 1 o'clock in the morning, at the close of the supper-hour, a change would be made from one plant to the other, involving the gradual extinction of the electric lights and their slowly coming up to candle-power again, the whole change requiring probably about thirty seconds. Sometimes, as this was taking place, Edison would fold his hands, compose himself as if he were in sound sleep, and when the lights were full again would apparently wake up, with the remark, 'Well, boys, we've had a fine rest; now let's pitch into work again.'"

Another interesting and amusing reminiscence of this period of activity has been gathered from another of the family of experimenters: "Sometimes, when Mr. Edison had been working long hours, he would want to have a short sleep. It was one of the funniest things I ever witnessed to see him crawl into an ordinary roll-top desk and curl up and take a nap. If there was a sight that was still more funny, it was to see him turn over on his other side, all the time remaining in the desk. He would use several volumes of Watts's Dictionary of Chemistry for a pillow, and we fellows used to say that he absorbed the contents during his sleep, judging from the flow of new ideas he had on waking."

Such incidents as these serve merely to illustrate the lighter moments that stand out in relief against the more sombre background of the strenuous years, for, of all the absorbingly busy periods of Edison's inventive life, the first five years of the storage-battery era was one of the very busiest of them all. It was not that there remained any basic principle to be discovered or simplified, for that had already been done; but it was in the effort to carry these principles into practice that there arose the numerous difficulties that at times seemed insurmountable. But, according to another co-worker, "Edison seemed pleased when he used to run up against a serious difficulty. It would seem to stiffen his backbone and make him more prolific of new ideas. For a time I thought I was foolish to imagine such a thing, but I could never get away from the impression that he really appeared happy when he ran up against a serious snag. That was in my green days, and I soon learned that the failure of an experiment never discourages him unless it is by reason of the carelessness of the man making it. Then Edison gets disgusted. If it fails on its merits, he doesn't worry or fret about it, but, on the contrary, regards it as a useful fact learned; remains cheerful and tries something else. I have known him to reverse an unsuccessful experiment and come out all right."

To follow Edison's trail in detail through the innumerable twists and turns of his experimentation and research on the storage battery, during the past ten years, would not be in keeping with the scope of this narrative, nor would it serve any useful purpose. Besides, such details would fill a big volume. The narrative, however, would not be complete without some mention of the general outline of his work, and reference may be made briefly to a few of the chief items. And lest the reader think that the word "innumerable" may have been carelessly or hastily used above, we would quote the reply of one of the laboratory assistants when asked how many experiments had been made on the Edison storage battery since the year 1900: "Goodness only knows! We used to number our experiments consecutively from 1 to 10,000, and when we got up to 10,000 we turned back to 1 and ran up to 10,000 again, and so on. We ran through several seriesI don't know how many, and have lost track of them now, but it was not far from fifty thousand."

From the very first, Edison's broad idea of his storage battery was to make perforated metallic containers having the active materials packed therein; nickel hydrate for the positive and iron oxide for the negative plate. This plan has been adhered to throughout, and has found its consummation in the present form of the completed commercial cell, but in the middle ground which stands between the early crude beginnings and the perfected type of to-day there lies a world of original thought, patient plodding, and achievement.

The first necessity was naturally to obtain the best and purest compounds for active materials. Edison found that comparatively little was known by manufacturing chemists about nickel and iron oxides of the high grade and purity he required. Hence it became necessary for him to establish his own chemical works and put them in charge of men specially trained by himself, with whom he worked. This was the plant at Silver Lake, above referred to. Here, for several years, there was ceaseless activity in the preparation of these chemical compounds by every imaginable process and subsequent testing. Edison's chief chemist says: "We left no stone unturned to find a way of making those chemicals so that they would give the highest results. We carried on the experiments with the two chemicals together. Sometimes the nickel would be ahead in the tests, and then again it would fall behind. To stimulate us to greater improvement, Edison hung up a card which showed the results of tests in milliampere-hours given by the experimental elements as we tried them with the various grades of nickel and iron we had made. This stirred up a great deal of ambition among the boys to push the figures up. Some of our earliest tests showed around 300, but as we improved the material, they gradually crept up to over 500. Just about that time Edison made a trip to Canada, and when he came back we had made such good progress that the figures had crept up to about 1000. I well remember how greatly he was pleased."

In speaking of the development of the negative element of the battery, Mr. Aylsworth said: "In like manner the iron element had to be developed and improved; and finally the iron, which had generally enjoyed superiority in capacity over its companion, the nickel element, had to go in training in order to retain its lead, which was imperative, in order to produce a uniform and constant voltage curve. In talking with me one day about the difficulties under which we were working and contrasting them with the phonograph experimentation, Edison said: 'In phonographic work we can use our ears and our eyes, aided with powerful microscopes; but in the battery our difficulties cannot be seen or heard, but must be observed by our mind's eye!' And by reason of the employment of such vision in the past, Edison is now able to see quite clearly through the forest of difficulties after eliminating them one by one."

The size and shape of the containing pockets in the battery plates or elements and the degree of their perforation were matters that received many years of close study and experiment; indeed, there is still to-day constant work expended on their perfection, although their present general form was decided upon several years ago. The mechanical construction of the battery, as a whole, in its present form, compels instant admiration on account of its beauty and completeness. Mr. Edison has spared neither thought, ingenuity, labor, nor money in the effort to make it the most complete and efficient storage cell obtainable, and the results show that his skill, judgment, and foresight have lost nothing of the power that laid the foundation of, and built up, other great arts at each earlier stage of his career.

Among the complex and numerous problems that presented themselves in the evolution of the battery was the one concerning the internal conductivity of the positive unit. The nickel hydrate was a poor electrical conductor, and although a metallic nickel pocket might be filled with it, there would not be the desired electrical action unless a conducting substance were mixed with it, and so incorporated and packed that there would be good electrical contact throughout. This proved to be a most knotty and intricate puzzletricky and evasivealways leading on and promising something, and at the last slipping away leaving the work undone. Edison's remarkable patience and persistence in dealing with this trying problem and in finally solving it successfully won for him more than ordinary admiration from his associates. One of them, in speaking of the seemingly interminable experiments to overcome this trouble, said: "I guess that question of conductivity of the positive pocket brought lots of gray hairs to his head. I never dreamed a man could have such patience and perseverance. Any other man than Edison would have given the whole thing up a thousand times, but not he! Things looked awfully blue to the whole bunch of us many a time, but he was always hopeful. I remember one time things looked so dark to me that I had just about made up my mind to throw up my job, but some good turn came just then and I didn't. Now I'm glad I held on, for we've got a great future."

The difficulty of obtaining good electrical contact in the positive element was indeed Edison's chief trouble for many years. After a great amount of work and experimentation he decided upon a certain form of graphite, which seemed to be suitable for the purpose, and then proceeded to the commercial manufacture of the battery at a special factory in Glen Ridge, New Jersey, installed for the purpose. There was no lack of buyers, but, on the contrary, the factory was unable to turn out batteries enough. The newspapers had previously published articles showing the unusual capacity and performance of the battery, and public interest had thus been greatly awakened.

Notwithstanding the establishment of a regular routine of manufacture and sale, Edison did not cease to experiment for improvement. Although the graphite apparently did the work desired of it, he was not altogether satisfied with its performance and made extended trials of other substances, but at that time found nothing that on the whole served the purpose better. Continuous tests of the commercial cells were carried on at the laboratory, as well as more practical and heavy tests in automobiles, which were constantly kept running around the adjoining country over all kinds of roads. All these tests were very closely watched by Edison, who demanded rigorously that the various trials of the battery should be carried on with all strenuousness so as to get the utmost results and develop any possible weakness. So insistent was he on this, that if any automobile should run several days without bursting a tire or breaking some part of the machine, he would accuse the chauffeur of picking out easy roads.

After these tests had been going on for some time, and some thousands of cells had been sold and were giving satisfactory results to the purchasers, the test sheets and experience gathered from various sources pointed to the fact that occasionally a cell here and there would show up as being short in capacity. Inasmuch as the factory processes were very exact and carefully guarded, and every cell was made as uniform as human skill and care could provide, there thus arose a serious problem. Edison concentrated his powers on the investigation of this trouble, and found that the chief cause lay in the graphite. Some other minor matters also attracted his attention. What to do, was the important question that confronted him. To shut down the factory meant great loss and apparent failure. He realized this fully, but he also knew that to go on would simply be to increase the number of defective batteries in circulation, which would ultimately result in a permanent closure and real failure. Hence he took the course which one would expect of Edison's common sense and directness of action. He was not satisfied that the battery was a complete success, so he shut down and went to experimenting once more.

"And then," says one of the laboratory men, "we started on another series of record-breaking experiments that lasted over five years. I might almost say heart-breaking, too, for of all the elusive, disappointing things one ever hunted for that was the worst. But secrets have to be long-winded and roost high if they want to get away when the 'Old Man' goes hunting for them. He doesn't get mad when he misses them, but just keeps on smiling and firing, and usually brings them into camp. That's what he did on the battery, for after a whole lot of work he perfected the nickel-flake idea and process, besides making the great improvement of using tubes instead of flat pockets for the positive. He also added a minor improvement here and there, and now we have a finer battery than we ever expected."

In the interim, while the experimentation of these last five years was in progress, many customers who had purchased batteries of the original type came knocking at the door with orders in their hands for additional outfits wherewith to equip more wagons and trucks. Edison expressed his regrets, but said he was not satisfied with the old cells and was engaged in improving them. To which the customers replied that THEY were entirely satisfied and ready and willing to pay for more batteries of the same kind; but Edison could not be moved from his determination, although considerable pressure was at times brought to bear to sway his decision.

Experiment was continued beyond the point of peradventure, and after some new machinery had been built, the manufacture of the new type of cell was begun in the early summer of 1909, and at the present writing is being extended as fast as the necessary additional machinery can be made. The product is shipped out as soon as it is completed.

The nickel flake, which is Edison's ingenious solution of the conductivity problem, is of itself a most interesting product, intensely practical in its application and fascinating in its manufacture. The flake of nickel is obtained by electroplating upon a metallic cylinder alternate layers of copper and nickel, one hundred of each, after which the combined sheet is stripped from the cylinder. So thin are the layers that this sheet is only about the thickness of a visiting-card, and yet it is composed of two hundred layers of metal. The sheet is cut into tiny squares, each about one-sixteenth of an inch, and these squares are put into a bath where the copper is dissolved out. This releases the layers of nickel, so that each of these small squares becomes one hundred tiny sheets, or flakes, of pure metallic nickel, so thin that when they are dried they will float in the air, like thistle-down.

In their application to the manufacture of batteries, the flakes are used through the medium of a special machine, so arranged that small charges of nickel hydrate and nickel flake are alternately fed into the pockets intended for positives, and tamped down with a pressure equal to about four tons per square inch. This insures complete and perfect contact and consequent electrical conductivity throughout the entire unit.

The development of the nickel flake contains in itself a history of patient investigation, labor, and achievement, but we have not space for it, nor for tracing the great work that has been done in developing and perfecting the numerous other parts and adjuncts of this remarkable battery. Suffice it to say that when Edison went boldly out into new territory, after something entirely unknown, he was quite prepared for hard work and exploration. He encountered both in unstinted measure, but kept on going forward until, after long travel, he had found all that he expected and accomplished something more beside. Nature DID respond to his whole-hearted appeal, and, by the time the hunt was ended, revealed a good storage battery of entirely new type. Edison not only recognized and took advantage of the principles he had discovered, but in adapting them for commercial use developed most ingenious processes and mechanical appliances for carrying his discoveries into practical effect. Indeed, it may be said that the invention of an enormous variety of new machines and mechanical appliances rendered necessary by each change during the various stages of development of the battery, from first to last, stands as a lasting tribute to the range and versatility of his powers.

It is not within the scope of this narrative to enter into any description of the relative merits of the Edison storage battery, that being the province of a commercial catalogue. It does, however, seem entirely allowable to say that while at the present writing the tests that have been made extend over a few years only, their results and the intrinsic value of this characteristic Edison invention are of such a substantial nature as to point to the inevitable growth of another great industry arising from its manufacture, and to its wide-spread application to many uses.

The principal use that Edison has had in mind for his battery is transportation of freight and passengers by truck, automobile, and street-car. The greatly increased capacity in proportion to weight of the Edison cell makes it particularly adaptable for this class of work on account of the much greater radius of travel that is possible by its use. The latter point of advantage is the one that appeals most to the automobilist, as he is thus enabled to travel, it is asserted, more than three times farther than ever before on a single charge of the battery.

Edison believes that there are important advantages possible in the employment of his storage battery for street-car propulsion. Under the present system of operation, a plant furnishing the electric power for street railways must be large enough to supply current for the maximum load during "rush hours," although much of the machinery may be lying idle and unproductive in the hours of minimum load. By the use of storage-battery cars, this immense and uneconomical maximum investment in plant can be cut down to proportions of true commercial economy, as the charging of the batteries can be conducted at a uniform rate with a reasonable expenditure for generating machinery. Not only this, but each car becomes an independently moving unit, not subject to delay by reason of a general breakdown of the power plant or of the line. In addition to these advantages, the streets would be freed from their burden of trolley wires or conduits. To put his ideas into practice, Edison built a short railway line at the Orange works in the winter of 1909-10, and, in co-operation with Mr. R. H. Beach, constructed a special type of street-car, and equipped it with motor, storage battery, and other necessary operating devices. This car was subsequently put upon the street-car lines in New York City, and demonstrated its efficiency so completely that it was purchased by one of the street-car companies, which has since ordered additional cars for its lines. The demonstration of this initial car has been watched with interest by many railroad officials, and its performance has been of so successful a nature that at the present writing (the summer of 1910) it has been necessary to organize and equip a preliminary factory in which to construct many other cars of a similar type that have been ordered by other street-railway companies. This enterprise will be conducted by a corporation which has been specially organized for the purpose. Thus, there has been initiated the development of a new and important industry whose possible ultimate proportions are beyond the range of present calculation. Extensive as this industry may become, however, Edison is firmly convinced that the greatest field for his storage battery lies in its adaptation to commercial trucking and hauling, and to pleasure vehicles, in comparison with which the street-car business even with its great possibilitieswill not amount to more than 1 per cent.

Edison has pithily summed up his work and his views in an article on "The To-Morrows of Electricity and Invention" in Popular Electricity for June, 1910, in which he says: "For years past I have been trying to perfect a storage battery, and have now rendered it entirely suitable to automobile and other work. There is absolutely no reason why horses should be allowed within city limits; for between the gasoline and the electric car, no room is left for them. They are not needed. The cow and the pig have gone, and the horse is still more undesirable. A higher public ideal of health and cleanliness is working toward such banishment very swiftly; and then we shall have decent streets, instead of stables made out of strips of cobblestones bordered by sidewalks. The worst use of money is to make a fine thoroughfare, and then turn it over to horses. Besides that, the change will put the humane societies out of business. Many people now charge their own batteries because of lack of facilities; but I believe central stations will find in this work very soon the largest part of their load. The New York Edison Company, or the Chicago Edison Company, should have as much current going out for storage batteries as for power motors; and it will be so some near day."

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