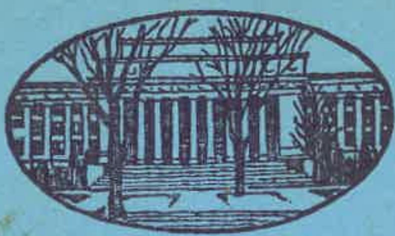
Complete

MICHIGAN ALUMNUS

VOLUME LV | MAY 7, 1949 | NUMBER 20



QUARTERLY REVIEW

NUMBER

SPRING · 1949

THE ALUMNI ASSOCIATION OF THE UNIVERSITY OF MICHIGAN
PRICE 60 CENTS

Two Articles Commemorating the Centenary of a Distinguished Engineering Graduate of '69

CHARLES F. BRUSH

1. MY FRIEND, THE MAN AND THE INVENTOR

By Fred C. Kelly

THE big fellow being bedeviled by a gang of boys was an especially desirable target because he was disinclined to hit back. Always embarrassed about his size, he was for peace at almost any price. Any other boy in the schoolyard had rare opportunity to show his bravery by picking on one larger and more powerful than himself, for he could do so with what he believed to be safety.

But one day something totally unexpected occurred. One of the boys threw a rotten apple at the big fellow and hit him in the eye. Instantly he forsook his pacifism. He seized the boy who had thrown the apple and gave him a wallop which nearly put him to sleep. Then he promised similar retribution to every boy who had urged on the apple hurler or who had joined in the general hilarity. Before hitting anyone else though, he paused to make this proposal:

"If you'll all stand up against the fence and let me throw rotten apples at you as long as I want to, then I won't clean up on the rest of you."

The whole group accepted the offer. There were nine of them and any two could have restrained the big boy, but all were too astonished to think of that.

Their submission marked the turning point in his career.

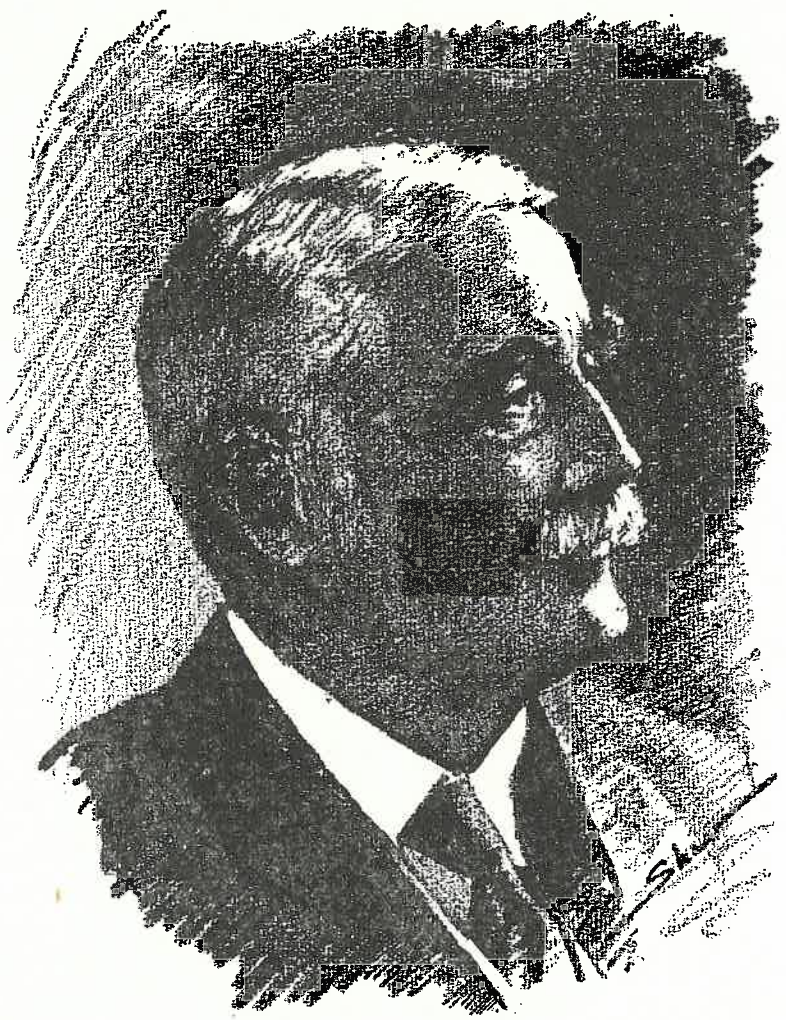
None was more surprised than he over his ability to assert himself. From that day on he had all the self-confidence he could use. He had no more fear of people nor of *any* kind of obstacle. Parenthetically, he no longer felt embarrassed over being larger than most people, and he grew into one of the finest physical specimens of the race—six feet two, broad-shouldered, with a deep chest, straight as an arrow. There was something regal about his appearance. When he was receiving his decoration as a Chevalier of the Legion of Honor, at Paris in 1881, Gambetta, the French statesman, remarked: "I do not know which to admire most, his extraordinary mental talents or his magnificent physique."

Self-confidence gained in the schoolyard episode may have had its influence in making Charles F. Brush the inventor of the first practical electric light and one of the important men of his generation. However, Brush's genius was not confined to inventing. He was a good philosopher, a shrewd psychologist, and had plenty of humor.

Fred C. Kelly is the author of a number of books—*Human Nature in Business* (1920), *You and Your Dog* (1926), *Why You Win or Lose* (1930), *How to Lose Your Money Prudently* (1930), *The Wright Brothers* (1943), *David Ross: Modern Pioneer* (1946), and *George Ade: Warmhearted Satirist* (1946)—but he began his career as a newspaperman. For five years he conducted a humorous column for the *Cleveland Plain Dealer*, and then in 1910 went to Washington, where for eight years he wrote the first syndicated daily column from that city. His name is frequently seen as the author of articles in leading magazines, and his paper, "Bill Nye's Humor," appeared in the Quarterly Review Autumn number of 1947. An Ohioan by birth, he was a University of Michigan student in 1900–02.

He was not one of those inventors who turn over all profits from their talents and efforts to others. He got a decent share of the rewards and became a multimillionaire.

His inventive genius gave him his opportunity, but it may have been his knowledge of human psychology that enabled him to turn that opportunity into wealth and power. When the electric lighting of city streets was first proved practical, neither the new lights themselves nor the inventor was popular with corporations that sold gas. They did all they could to discourage use of the new invention. They might have done more harm than they did if Brush had not quietly explained to them why they were wrong, even from their own selfish viewpoint, in fighting electric lights. His knowledge of crowd psychology was superior to theirs when he predicted:



Charles F. Brush, 1849–1929

> Electric lights will *increase* rather than decrease use of gas. People have been living in darkness so long that they have organized their lives on that basis. But when they get used to light, they are sure to want more of it. After seeing brilliantly lighted streets and stores, they'll want more light in their homes and will burn

more gas. As they use more gas for lighting, you can make gas cheaper and that will open up almost limitless industrial uses.

Another problem was to educate the public itself. Brush knew how conservative are the masses. He did not underestimate the slowness and tediousness of overcoming public suspicion of novelty. A frequent argument against the new lighting was that it would ruin eyesight. People stared at the brilliant arc and then complained that it was too dazzling.

"After looking at it, everything else looks dark," they said. "We'll ruin our eyes."

To which Brush calmly retorted: "The same objection may be raised against the sun!"

The habit of staring at the arc hung on for many years and continued to be used as an argument against electric lighting. Scientists themselves had promoted foolish beliefs. As late as 1873, Deschanel's *Natural Philosophy*, a well-known textbook, said:

> The light of the voltaic arc has a dazzling brilliancy, and attempts were long ago made to utilize it. The failures of these attempts were due not so much to its greater costliness in comparison with ordinary sources of illumination, as to the difficulty of using it effectively. Its brilliancy is painfully and even dangerously intense, being liable to injure the eyes and produce headaches.

One reason people stared was that they wondered where the light really came from. They thought there must be some trick to it. The light must come from *oil*, and where was the oil supply?

APART from lighting outfits set up for experimental purposes, the first dynamo and lamp actually sold were shipped to Dr. Longworth, father of Nicholas Longworth, at Cincinnati, about January, 1878, and Brush went to Cincinnati to show how the machine should be operated. The light was exhibited from the balcony of the Longworth home on one of the principal residence streets. Brush, who went purposely into the crowd to hear comments, later described the scene:

"It was a four-thousand candle power light and, of course, attracted a large crowd. In the gathering were a few men of the type who, if they know nothing about a subject and find others who know nothing about it, will promptly explain it. One man who had collected a considerable audience called attention to the solenoid at the top of the lamp and said, 'That is the can that holds the oil,' and, referring to the side rod, said, 'That is the tube which conducts the oil from the can to the burner.' He said nothing at all about electricity—a little oversight apparently unnoticed by his hearers—and they went away happy in their newly acquired knowledge of the electric light."

Brush told also of an exhibit of one of the earliest four-light machines to a number of guests at a large factory in Cleveland:

"One man looked the whole apparatus over carefully and then, pointing to the line wire, asked, 'How large is the hole in that little tube that the electricity flows through?' "

Another early problem was that users of an electric-light apparatus could not be induced to let it alone. This was especially true when outfits were sold to cities for street lighting. Someone mechanically inclined was sure to try to "improve" the device. Nearly every workman thought he knew more about the mechanism than the inventor did. Complaining of a lamp which had not worked properly, one man said: "I've had it all apart four times, and still it doesn't work." If the lamps didn't work, and news of this became widespread, it would wreck the business. Brush saw that he must make the whole mechanism as nearly foolproof as possible. He put it together without screws or bolts of any kind that could be taken out and lost. All necessary adjustments were made at the factory when the lamp was tested and then the parts were riveted, to make further testing or tinkering impossible. Also they were assembled a little like a Chinese puzzle.

The high-tension dynamos for series lighting that came later did not suffer so much tinkering because, as Brush used to say, they were powerful and "able to look out for themselves; they discouraged familiarity."

Nevertheless, it was impossible entirely to eliminate difficulties caused by trivial accidents and the lack of trained men to install or operate lighting plants. Poorly insulated lines led to "short circuits." Since commercial electricity was just starting, not many experts were available to whom Brush could delegate important work, and he himself used to go about as trouble man. Once he traveled fifteen hundred miles to take a common double-pointed tack from the bottom of a dynamo where it had short-circuited a field magnet. Occasionally damage appeared to have been done maliciously—perhaps by an employee who disliked the mechanism because unable to understand it. Long, fine wire nails were sometimes discovered in the field-magnet coils.

Brush used to tell of one lot of sixteen lamps sent back to the factory by a Boston agent with a letter stating that no one was able to make them work. "I examined and tested the lamps carefully," said Brush, "and found them all right. Without making any change or adjustment whatever, except to change the numbers to conceal their identity, I sent the lamps back, with a letter stating I had personally examined and tested this lot and could guarantee them to be all right. They were put back in their original places, and worked beautifully, so the agent said; and he requested me as a personal favor to look over all lamps he might order in the future before they were shipped. He wanted to know what was the matter with the first set, but I never told him."

PERHAPS it was his experience, in the early days of lighting, with the seeming stupidity of a great mass of human beings that made Brush, all the rest of his life, dubious if not contemptuous of the intelligence of the average man. But no matter how much he may have doubted the average man's wisdom, he always retained his sympathy and kindliness and never lost the common touch. Certainly there was nothing intolerant or haughty about him. He never shut himself off from the public. True, he was fairly inaccessible, but he could always be seen by almost anyone who had a semblance of an excuse to take up his time.

My own first meeting with him was an example of his natural graciousness. One afternoon during my reporter days in Cleveland, while walking along an upper floor of the Arcade Building, which Brush owned, I noticed painted on the glass of an office door the astonishing statement: "Office hours, 12:30 to 1:00." Before I had even looked higher up on the door to see who had so short a working day, it struck me that here must be a man worth knowing. When I observed the name Charles F. Brush, I wanted to get acquainted.

A secretary peeked out at callers through a hole in the door before letting them in. When I told her I was a newspaperman, she said: "I'm sure Mr. Brush won't wish to give an interview."

"But," I told her, "this is not for an interview. Just tell him there's a reporter here who wishes to talk to him on a purely personal matter, not for publication."

Brush said I might come in. He arose with courtly courtesy and in a fatherly tone asked the purpose of my visit.

"I just happened to notice your office hours on the door," I said, "and couldn't resist the temptation to meet a man having such a genteel working schedule."

That amused him. "Do you know," he said, between chuckles, "I, too, have always thought that sign was funny."

Then he explained that he spent three or four hours a day at his office and shut himself in part of that time, but thought it only fair to have a brief period when he was known to be more or less available. Not until 12:30 did he unlock his outer door. As soon as the secretary had let enough people into the reception room to occupy him until two o'clock, he had the front door locked again.

I asked him if he had his office number listed in the telephone book.

"Oh yes," he replied, "it somehow doesn't seem right to keep one's telephone number secret. Occasionally someone comes along who is entitled to see me, and without access to the telephone number to make an appointment, how would he ever find me?"

In later conversations I had with him, he always showed great tolerance for human frailty. He had a large farm and met the annoyance landowners sometimes have with tenants. But he never showed any indignation about this.

"We expect too much of a tenant farmer," he used to say. "We expect him to conduct the most difficult business on earth in a manner to show at least a small profit for the owner, and to look after the owner's interest just as fairly as he does his own. Men of that combination of ability and integrity are so rare they would be worth fifty thousand dollars a year. Yet we expect to have such men as farm tenants, where the earning possibilities are only a few hundred a year."

He had contempt for men who followed a trade that they never made a real attempt to master. His greatest irritation was with certain men who represented themselves as capable of repairing copper roofs. He had a copper roof on his home, and it sometimes leaked. Repairmen came, walked over the roof, creating new leaks around the seams, but failed to find the original leak. One day he became so exasperated over his roof problem that he slapped his thigh and exclaimed: "I know what I'll do. I'll go up on the roof and chop a hole about six feet square. Then I'll send for roof repairmen, one after another. Maybe one of them will fall into the hole."

When I dropped in to see him one morning, he took from his pocket a handful of rubies, sapphires, and emeralds. They were all artificial. He had made them himself, just to see how well he could do it and how successfully he could duplicate the color of high-priced natural stones.

"How many people who say they wear costly jewels because of their beauty could tell that these are artificial?" he asked. "All these are worth probably less than one hundred dollars, but if real they would be worth two or three hundred thousand."

He took his best homemade example of ruby to a famous Fifth Avenue jeweler (I think he made a trip to New York just for this purpose) and asked him to appraise it.

"That stone, if genuine, as it looks to be," parried the gem expert, "would be worth a lot of money."

"But I'd like to know exactly how much," insisted Brush.

The gem expert reached for his magnifying glass, studied the stone intently, and then said, with a smile: "Not one person in ten thousand could ever tell you it's artificial. It's just as beautiful as any natural stone that ever existed and more free from flaws; but the fact remains that it is artificial."

Brush felt a profound respect for that man who knew his trade too well to be fooled.

He was free from fussiness about trivialities. I once wrote a brief sketch of him for a magazine, and the editor, seeking a picture, ordered one taken from a group of scientists. Somehow the art department made a mistake and copied one of Ambrose Swasey, another Clevelander, famous as a manufacturer of telescopes. Fearing Brush might be vexed over such carelessness and possibly blame me for the error, I rushed to call it to his attention before he heard of it elsewhere. When he saw the page with the wrong picture, he laughed uproariously and said: "What a joke this is on Swasey!"

This pioneer of electricity was of English origin; that is, both his parents traced their descent from English ancestry. His father was Colonel Isaac Brush, an early manufacturer of woolen products in Orange County, New York. He came to a farm in Euclid Township, Cuyahoga County, near Cleveland, Ohio, in 1846, and about three years later, March 17, 1849, Charles F. Brush was born. On the father's side, the first of the American branch of the family was Thomas Brush, who came from England and settled near Huntington, Long Island, in 1652. The first of his mother's ancestors to come to America was the Reverend George Phillips, an Episcopal clergyman, who arrived with Governor Winthrop and settled near Boston in 1630.

Almost from the time he could read, young Brush took great interest in all scientific literature and devoted himself to every book he could find on astronomy, chemistry, and physics. He kept this up all through high school days, then went to the University of Michigan, where he took a degree, in 1869, as mining engineer. Even though he was graduated a year ahead of his class, it is doubtful if his college career led his classmates to think they were in the presence of one destined to be among the great of his generation.

After leaving college he organized a laboratory and was an analytical and consulting chemist for three or four years, during which time he built a reputation for painstaking accuracy. He was often employed as "expert" in important litigations. In 1873 he formed a partnership for marketing Lake Superior iron ore and pig iron. While in this business he devoted his spare time to scientific research, and early in 1876 completed his first dynamo. A year later he closed his partnership to devote his entire time to his inventions.

Brush was often asked to explain exactly what started him on the invention of the first practical electric light. The fact is that an electric light was in his mind even in his early teens, when he was experimenting with Leyden jars, static machines, induction coils, and small motors. The electric arc, with its dazzling light and intense heat, as described in textbooks, was a little beyond his reach. But he read everything available about the first electric arc ever produced, by Sir Humphry Davy, in England, back in the early 1800's. Then came news of Wilde's experiments in London with a crude dynamo and single arc light. This interested Brush so much that he used the facts as a basis for his high school graduation essay.

After he had become wealthy, Brush built a house in Cleveland on seven acres of ground on Euclid Avenue, then considered one of the finest residence streets of the world. The place was six years in the building and required the services of many of the best mural decorators and other artists and designers from all over the United States. In the basement was a well-equipped experimental laboratory. He lived and worked in that home for many years and came to have a sentimental feeling against letting the place become rundown after he was gone. He had seen many homes, once beautiful, degenerate into ghoulish-looking rooming houses. He did not intend to have such a fate overtake a house he loved. In his will he provided that when members of his family ceased to use the house as a home, it must immediately be sold to house wreckers. After Brush's death in 1929, shortly after his reaching the age of eighty, the house was dismantled and torn down. The place which had cost a small fortune and had been one of the show places of the city went to wreckers for exactly three hundred dollars.

Brush held strongly to the belief that one of the most urgent problems confronting the world was the rapid increase of population "which threatens to overcrowd the earth in the not distant future, with resultant shortage of food and lower standards of living, which must certainly lead to grave economic disturbances, famines, and wars, and threaten civilization itself."

He believed, too, that beneficent scientific research has contributed to prolongation of life and preservation of the weak and the unfit, who under former conditions could not have survived nor added descendants to the race; and that scientific knowledge cannot safely be used for these humane objects unless it be used at the same time to improve the quality and reasonably limit the numbers born into the world. In his will he provided for the establishment of the Brush Foundation to carry on studies in genetics.

2. A PIONEER IN THE ELECTRIC AGE

By Benjamin F. Bailey

SAY, Bill, have we enough kerosene to last tonight?"

"Yes, Tom, I think so. There was some left last night."

Such a conversation seems fantastic today, but it was very common around the turn of the century, barely fifty years ago. Don't think that electric lighting was unknown. We had street lights, electric cars, and telephones, but private electric home lighting—no. In the first place, it was too expensive. A unit of electricity cost at least five times as much then as it does today and gave less than one-fifth as much light. A writer of that time described an incandescent light as a red-hot hairpin in a bottle. It gave little light of poor quality, and the bulbs were short-lived. The transformation which took place within the next few years was largely due to a few Michigan men—Charles F. Brush was one of them.

Although Brush studied metallurgy at the University in the late 1860's and was graduated as a mining engineer, he had an interest in electric lighting and apparently carried out many experiments pertaining to it. Of course at that time electrical engineering was not taught anywhere; in fact, engineers and inventors were just beginning to consider seriously the problems of electric lighting.

The electric arc had been known for a number of years, and even incandescent lamps in a very crude form had been invented, although not developed commercially. The great obstacle to electric lighting was the so-called subdivision of the electric light. Arc lamps had been used commercially in the operation of lighthouses, but always with one electric generator supplying the current to one lamp. We have in our museum at Ann Arbor one such generator, built in London by Ladd

Benjamin F. Bailey, '98*e*, A.M. '00, Ph.D. '07, has several claims to distinction. In college he was a track athlete; then, beginning in 1900, he was for forty-four years a member of the faculty of the University of Michigan and Chairman of its Department of Electrical Engineering from 1923 to his retirement in 1945; and in the meantime he gained wide recognition as the inventor of the single-phase capacitor motor used extensively by manufacturers of electrical household appliances, as a patent expert, as an authority on induction motors, and as a frequent contributor to scientific journals. He is a Fellow of the American Institute of Electrical Engineers and holds membership in other engineering societies.

in 1865 and purchased by the University in 1874. Nobody knew how to devise a system whereby a number of lamps could be supplied by one generator and at the same time allow any one of them to be turned on or off without interfering with the others. The problem seems simple to us, but at that time many eminent physicists believed that a solution was impossible.

As is usually the case when many men turn their attention to a problem, a way was found; in fact, in this case, two solutions were proposed. One was to regulate the dynamo supplying the current in such a way that the two conductors leading from it would be kept at a constant difference of potential. If this could be done, each lighting unit could be designed for this potential and could then be connected across the wires without interfering with the other units. This method is now in almost universal use.

About 1875 the other solution was proposed—namely, that the dynamo should be so regulated that the current would remain constant but the voltage would vary, depending upon how many lamps were inserted in the circuit. This is a constant-current system in contrast to the other, which is a constant-potential system. At the time mentioned, this seemed a suitable solution, and, in fact, it was widely used until comparatively recent years. This system was particularly applicable to arc lighting, and the Brush arc system was developed and put in commercial use as early as 1878, whereas the first real central station operated on the constant-potential system was started in New York City by Thomas Edison in 1882. Unfortunately, Mr. Brush decided to develop the constant-current system rather than the constant-potential system. At the time the two paths seemed to be equally inviting. Both led to fame and fortune, but as it turned out, Edison's path allowed of indefinite expansion; Brush's ended in an impossible swamp.

In 1875, John W. Langley had just been appointed Professor of General Chemistry and Physics in the University of Michigan. He was thirty-four years of age at the time and had graduated from the University in 1861. Later he studied in the Medical School of the University and received an honorary M.D. After graduating, he had been an Acting Assistant Surgeon in the United States Navy, Assistant Professor of Physics at the United States Naval Academy, and Professor of Chemistry in the Western University of Pennsylvania. Charles F. Brush was eight years younger than Langley and graduated from the University in 1869.

When these two men met in Ann Arbor in 1875, Dr. Langley had become interested in arc lighting and had apparently formulated some opinions as to the best methods to be used in making it practicable. He talked it over with Mr. Brush, and probably it was this conversation which started Brush upon his distinguished career. Langley always claimed that he should have received a great deal more credit than he did for his part in the development of the series arc-lighting system. At this late date it is obviously impossible to formulate any accurate opinion as to the justice of these claims, and it is a source of regret to the writer that he has not been able to obtain more detailed information regarding just what Dr. Langley did.

The problem which Brush and Langley attempted to solve involved many difficulties, some of which they undoubtedly did not appreciate when they started work. Probably the greatest was the fact that the carbon arc is inherently unstable. In the case of an ordinary resistor, such as an iron wire or an incandescent lamp, more voltage must be applied if more current is desired. With an electric arc, however, the larger the current the less the voltage, so that if an attempt is made to supply an arc at a constant potential, either the current will immediately rise to an enormous value or the arc will go out. The difficulty was cleverly solved by so designing the generator that the larger the current the lower the voltage; thus matching the characteristics of the generator with those of the arc.

Both the Langley and the Brush generators were of the series-wound type. If such a generator is driven at a constant speed and the current taken from it gradually increased by decreasing the external resistance, the voltage and current will at first rise together and nearly in proportion to one another. As the current is increased, however, the voltage rises more and more slowly and finally, if the current is made large enough, the voltage decreases. Ultimately it will become zero when the external resistance is zero. By making a machine with enough internal reaction, this current, even on short circuit, can be limited to a safe value, and by operating the machine with a comparatively low resistance in circuit, the desired characteristics can be obtained, mainly that the voltage of the machine decreases with increased current. In this way the combination of the arc light and the generator can be made stable. If the current tends to increase in the arc, the voltage of the generator decreases and checks the tendency; on the other hand if the current in the arc tends to decrease, the voltage of the generator rises and prevents the arc from extinguishing itself. Whether this clever solution was due to Brush or to Langley or to someone else is not clear from the records available.

The design of the mechanism of the arc lamp presented many difficulties, and there is no doubt that Brush contributed more than any other man to its design and invention. The requirements are not easily met. The two carbon rods must be in contact when the lamp is extinguished, otherwise current could not pass over the gap to start the arc, the voltage being insufficient to cause the current to jump through even a very short air gap. When the arc is in normal operation, the carbons should be kept a constant distance apart. If this distance varies, the light will flicker. The carbons must be automatically fed toward one another, since they burn away at the rate of about one inch per hour. In case it should happen that the lamp is kept burning until all the carbon is consumed, it is necessary to provide some automatic method of short circuiting the carbons in order to prevent all of the lamps in the circuit from being extinguished. Brush was apparently the first inventor to develop a simple and successful method of accomplishing all these objects.

It must be remembered that all this work was done at a time when very little was known about electricity. Even suitable measuring instruments were not available. The best current-measuring device, for example, was the so-called tangent galvanometer. This consisted merely of a compass needle in the center of a coil of wire, the current being proportional to the tangent of the angle by which the needle was deflected. To overcome all the inherent difficulties at such a time and with such meager equipment was a very brilliant accomplishment.

The Brush system was commercially introduced in New York City in 1878 and was an important factor in electric lighting for many years thereafter. It was, however, ultimately superseded by the constant-potential system. There were several reasons for this. Gradually, incandescent lamps were improved until they were equal or superior to the arc in efficiency—from 7 to 1 watts per candle power. Also it was found impossible or impracticable to make arcs giving a small amount of light such as is necessary in house lighting. A standard arc, for example, gives about 2,000 candle power, which is entirely too much for many purposes.

A third difficulty lay in the fact that the current used was about 10 amperes, and each arc required about 50 volts. Since the arcs were operated in series, one hundred arc lamps required about 5,000 volts. On account of insulation difficulties, it was found impracticable to go much farther than this. The maximum output of an arc generator was therefore only about 50 kilowatts. Today generators of 100,000 kilowatts and larger are common. We can faintly imagine the added complication and cost that would result if we attempted to replace each of our 100,000 kilowatt units with two thousand Brush arc machines.

Moreover, great difficulties were encountered in attempting to operate motors on constant-current systems. Suitable motors were ultimately produced and used, but it was necessary to equip them with mechanical governors. They were consequently far less simple than constant-potential motors, which are inherently self-governing. Remember that the current remained constant at all times. The motors therefore gave at all times a constant torque. If overloaded, they merely stopped and were not injured in any way and no fuses were blown.

They had one peculiar and dangerous feature. If a brush dropped out, or the circuit became otherwise broken, the voltage of the circuit would rise so as to maintain the current, even though the gap became several feet in length. This of course was a decided fire hazard, and it became necessary to inspect these motors every few days. This type of motor disappeared about fifty years ago, and I have not even seen one since the beginning of the century.

After the successful introduction of the arc system, Brush turned his attention to the storage battery. Up to that time the lead plates of the storage battery had been formed by repeatedly charging and discharging a battery consisting of plain lead plates in a solution of sulphuric acid. Ultimately a layer of sponge lead was formed on one plate and one of lead peroxide on the other. Brush conceived the idea of the pasted plate in which the active material was spread upon perforated lead plates. This process made possible a much cheaper and lighter battery, and it is in universal use today.

Brush's work was given wide recognition. He became a Chevalier of the Legion of Honor in France in 1881 and received the Rumford medal in 1899. He also received a number of honorary degrees, including an LL.D. from Western Reserve University in 1900 and an Sc.D. from the University of Michigan in 1912.

Apparently street lighting by arcs was not in regular use in Detroit until August 1, 1883, when the Brush Company started operating twenty-two lights from a powerhouse on Third Street between Fort and Congress. In 1884 a fantastic experiment was tried. Seventy-two towers from 104 to 150 feet high were built and a cluster of arc lights placed on each. The first tower was erected in Cass Park, and the writer can well remember as a small boy the large crowd which turned out to see the light. When all of the lights were put in operation, the effect was beautiful as one neared the city from Lake St. Clair, but as a means of illumination on the street level, they were a flat failure. It became apparent that the tops of the trees were well lighted, but the streets were left in darkness, and ultimately the towers were junked.

In the light of our present knowledge it is evident that arc lighting could not long survive. Thomas Edison started to develop his lighting system about 1876. His plan was superior to that of Brush's in two vital respects: first, his lighting unit, the incandescent lamp, could be made as small as one wished, and secondly, the constant-potential system admitted of unlimited expansion which the constant-current system did not.

Today the constant-potential system has spread out until it has covered the entire country. Voltages have increased from 115 to 300,000, and generators have grown in size from 10 kilowatts to 200,000 and the end is not yet in sight. The constant-current system is now only a memory in the minds of a few old-timers.