# Here are Highlights of Lamp Development — 1879 to 1929

## DEVELOPMENT OF INCANDESCENCE.

### Chronicled Most Spectacular Progress of History.

### LIGHT THE MODERN MIRACLE.

### Search for Perfect Filament Material Covered Entire World.

**When Thomas Alva Edison, five decades ago fed electricity into that first successful incandescent lamp, he began what has proved to be the most spectacular period of progress ever chronicled in the history of the world.**

**To be sure, the art of lighting, prior to 1879, had advanced from the crude torch to superior forms of the open flame—to the stone lamp, to whale oil, to candle and gas. With these the world has smoked, sputtered, and flickered through a thousand centuries.**

**Take the last half century, filled to overflowing with its contributions—by Edison, by a host of inventors all over the world, and particularly in the last two decades, by the Mazda Research Laboratories.**

**First, of course, came Edison's famous lamp of October 21, 1879. A bottle, a vacuum; a carbonized piece of cotton sewing-thread, the filament or burner. Came next, in rapid succession, a host of burners infinitely better than carbonized thread. Enter paper. Enter bamboo; squirted cellulose; metallized carbon; osmium; tantalum; tungsten; "drawn" tungsten; "non-sag" wire and the coiled filament.**

**Enter, too, the so-called "getter;" perfector of vacuums and arrester of bulb-blackening; enter hydrogen, nitrogen, and argon gases into the bulbs of high-powered lamps.**

**Enter sweeping improvements in lamp-making machinery; the tipless bulb; inside-frosting; and finally, the miracle of 1929—the 100-watt inside frosted Mazda lamp—giving 26 times as much light for the same money as the miracle lamp of 1879!**

**Indeed, so much lighting progress has been crowded into the last 50 years that this brilliant period of incandescence outshines the eons and eons of the open flame as the noonday sun outshines the feeble stars.**

**SEWING THREAD TO "BRISTOL BOARD" PAPER**

**Edison's original sewing-thread lamp had no sooner gone out after its forty hours of continuous burning than the Master Inventor instituted one search after another in quest of a more efficient burner.* Carbonized thread had showed him he was on the right track. But the filament would have to be improved upon if his lamp was to be a commercial success. It would have to burn much longer than forty hours. Forthwith, he collected and tested every available carbon-containing substance from boxwood to the red hairs out of a man's beard. "Bristol board" paper, however, proved to be best. And it was this material (carbonized) that served as the filament in the lamps which a marveling public came to see on December 21, 1879. (See New York Herald article reproduced on second page.)**

**FROM PAPER FILAMENTS TO BAMBOO**

**But Edison was still not satisfied. A sturdy filament would have to be found that would last at least 500 hours. So, after testing 1,600 species of plant fibre collected from every corner of the globe, he found that a certain variety of Japanese bamboo worked admirably. The improved lamps not only burned for 600 hours, but also consumed far less current than their paper filament predecessors. They gave the light of 16 candles and consumed 100 watts of electricity.**

**READY FOR MANUFACTURE**

**By 1881 Edison had supplanted his wooden lamp-stand with a screw base (essentially the same as the one of today) and began manufacturing two "Standard Edison Lamps"—a 16 candle power, 110 volt; and an 8 candle power, 55 volt. In these lamps, the carbonized bamboo filament was connected to the leading-in wires by copper plating. This method, incidentally, continued until 1886 when carbon-paste clamps were introduced. Bamboo, however, as a filament material continued for ten years. The lamps, when new, produced 1.68 lumens per watt; the pioneer lamp, 1.4 lumens per watt.**

**TREATED SQUIRTED CELLULOSE**

**As a result of considerable research on the part of Sir Joseph Swan, an Englishman, treated squirted cellulose was found to be an even better burner material for incandescent lamps than carbonized bamboo. Thanks to the new filament and to improvements in vacuum production, the treated squirted cellulose carbon lamp (1894) burned at an efficiency twice that of the early Edison lamps—giving the light of 16 candles and consuming only 99 watts.**

**ENTER THE METALLIZED CARBON FILAMENT**

**Scarcely ten years elapsed before Dr. Willis R. Whitney of the Research Laboratory, developed an electric resistance furnace which made possible the metallized carbon filament lamp, also called the "GEM." It burned 600 hours at an efficiency 25 per cent higher than that of the squirted cellulose lamp—giving the light of 20 candles and consuming 50 watts.**

**WELSBACH TRIES OSMIUM**

**About this time (1905) Von Welsbach of Germany invented the first commercial metal filament lamp, the Osmium lamp, which proved to be 75 per cent more efficient than the "GEM." The metal osmium, however, was both rare and very costly. The filament was extremely fragile and its resistance low. Although Welsbach's lamp was a failure, commercially, it excited a new interest in metals as a satisfactory filament material.**

**TANTALUM STEPS UP EFFICIENCIES**

**It was only a year later that Dr. Van Bolton, a Russian chemist, introduced a filament of tantalum metal into lamps in place of the metallized carbon burner. This burner not only vaporized less easily than the "GEM" filament, but it could also be operated at a higher temperature—thus giving a more brilliant light. This improved lamp with a filament half as thick as a human hair had a quality rating almost three times that of the "GEM."**

**THEN CAME "PRESSED" TUNGSTEN**

**Although the metal tungsten in combination with carbon had been tried as a filament for 17 years, it was not until 1904 that Just and Hanaman in Vienna produced a few pure ("pressed") tungsten lamps—giving nearly 8 lumens per watt—60 per cent better than the tantalum lamps.**

**Having procured Just and Hanaman's American patents (rights) there was marketed, after much development work, a 100-watt multiple tungsten lamp (1907) the advance of which over the tantalum lamp was ten times the advance of the tantalum lamp over the "GEM."**

**ENTER THE MAZDA "DRAWN" TUNGSTEN LAMP**

**But the pressed tungsten filament was at best a fragile and brittle thing. How to draw it into a fine, uniform wire!**

**With vast resources at his disposal, Dr. William D. Coolidge of the Research Laboratories of this company began his quest of a satisfactory process for producing ductile tungsten as early as 1906. After four years of seemingly endless disappointments he finally discovered a method for drawing tungsten into a wire, a process which would be commercially practical. This was in 1910. A marvelous step in lighting progress followed. But first, a word about "Mazda."**

**In 1909, the trade mark Mazda was adopted. "Mazda"—once it was the name of a god in a beautiful religion of the ancient Persians. Light was its dwelling place. In its adopted sense, however, Mazda became not the name of a thing, but the mark of a specific research service—as rendered to certain lamp manufacturers and to the public by the Research Laboratories.**

**Mazda Service explored the world for new ideas on incandescent lamps, and it worked out the scientific developments that have brought modern lighting to such high efficiency. The benefits of this research were given exclusively, as they are now, to those lamp manufacturers entitled to use the symbol Mazda on their lamps. The mark Mazda today, as in 1909, is a guarantee of a lamp of the highest quality.**

**Take for example the tiny Mazda flashlight lamp. It was Mazda Service that developed the filament less than a fourth the thickness of a human hair, coiled it, and centered it accurately to throw its beam correctly. Take the modern photo lamp. Though small, Mazda Service made it strong to withstand the jolts and bumps of day travel and continuous vibration. Or take the big Mazda lamps used to aid the men who fly.**

**For the airports, Mazda Service has developed Mazda lamps of 10,000 to 50,000 watts. Now, when a plane swoops down from the sky at night, it sees a flood of light that makes landing as safe as at noon.**

**Yet these are but a few of the countless contributions which Mazda Service has given to the progress of lighting since its inception in 1909.**

**Thus it came to pass, thanks to the first great triumph for Mazda research service—Dr. Coolidge's invention of drawn tungsten wire—that a new tungsten lamp, easier to make than its predecessor, far more rugged, and giving 25 per cent more light for the same current consumption as the pressed tungsten lamp, appeared on the market in 1911. Its efficiency was rated at 10 lumens per watt—25 per cent more light than the first tungsten lamps for the same amount of current consumption.**

**NON-SAG WIRE AND GAS-FILLED LAMPS**

**At about this time it was announced the discovery of a method for producing "non-sag" tungsten wire. More Mazda research developments followed, among them Dr. Irving Langmuir's invention in 1913 of a large nitrogen, gas-filled, tungsten lamp. It was twice as efficient as any large-size vacuum lamp, and had a coiled filament. The non-sag wire discovery allowed the coiling of a small filament into a large one. The presence of the gas in the bulb greatly reduced the evaporation of the tungsten, the phenomenon which causes bulb blackening. Here, then, was the father of a variety of high powered gas-filled lamps now used for street lighting, in motion picture production, in aviation and in many other fields. This lamp in 1913 gave 20 lumens per watt!**

**Mazda Service at this time had "getter"—a chemical used inside a lamp to improve the vacuum and also to prevent bulb-blackening—was used in Mazda lamps to improve their quality.**

**AUTOMATIC MACHINERY**

**Great strides in the development of automatic lamp-making machinery in the last fifteen years have not only greatly improved the quality of Mazda lamps but have at the same time lowered their cost to the consumer by more than fifty per cent. This is all the more amazing when you stop to consider that the price of goods in general is high above the 1913 level. Whether it be a bulb-making or a peeling and exhaust machine, a thousand "arms" and "fingers," timed to a hundredth of a second, perform more efficiently than human hands the innumerable operations involved in the blowing of the modern incandescent lamp. Bulb-blowing, Stem and Inserting, Cutting, Mounting, Sealing, Exhausting, Finishing. Yes, synchronous machinery virtually does everything—and in the wink of an eye!**

**How different from the expensive, painstaking, and less efficient methods of other days!**

**It used to take Edison five hours to exhaust a single lamp. Today it is done in a twinkling—and through the "stem" of the lamp. Gone is this needless waste of time. Gone, too, is the objectionable tip that once appeared on every "finished" lamp. For Mazda research removed it in 1913 when the new method of exhausting was discovered.**

**THE STANDARD LINE OF INSIDE-FROSTED MAZDA LAMPS**

**Without question the greatest single advance in lighting progress since Dr. Coolidge's discovery of a satisfactory method for drawing tungsten into a wire is the Mazda research contribution of 1925—the discovery, by Marvin Pipkin, of a satisfactory method for frosting lamp bulbs on the inside. A program of simplification and standardization followed which reduced the number of types and sizes of lamps, then 45, to a standard line of but five lamps. These new inside-frosted Mazda lamps gave twenty per cent more light than outside frosted lamps. They were more rugged, were easier to clean. Their pearl-gray bulbs harmonized with any surrounding.**

**And, at a new low price to the consumer, they gave the public the last word in lighting at the lowest cost in history.**

**THE MIRACLE OF 1929!**

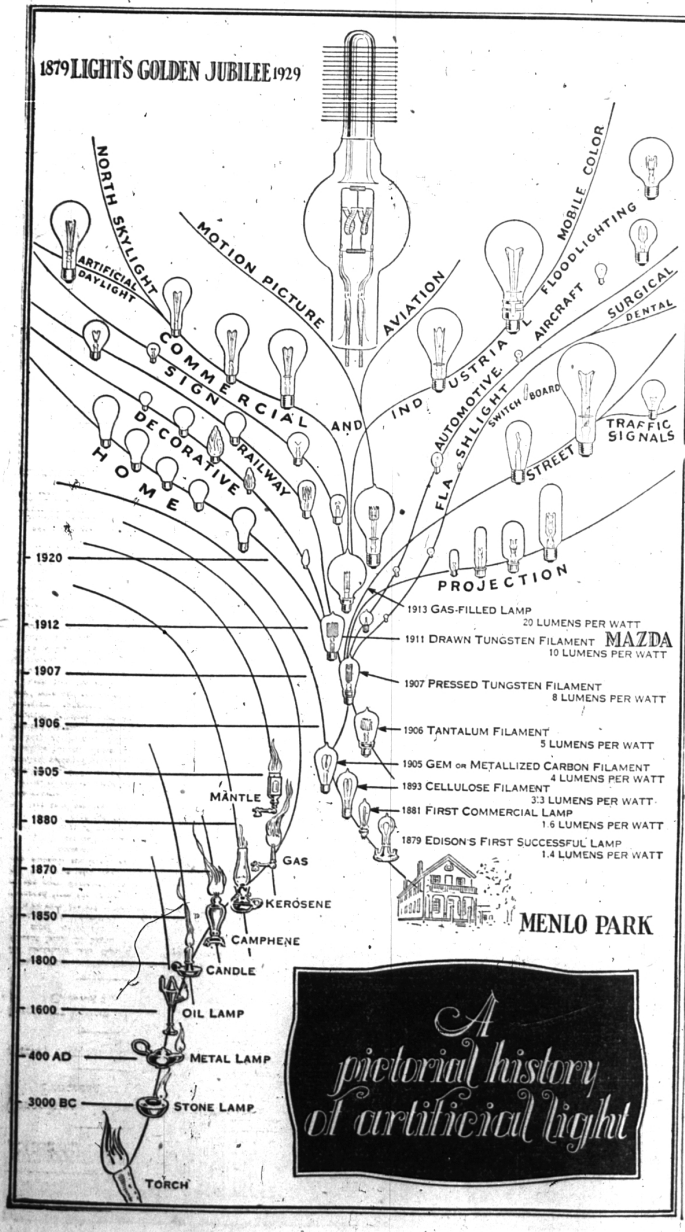
**Take, for example, the standard 100-watt inside-frosted Mazda lamp of today. Now compare its light with the light from the early Edison lamps of 1880.**

**Based on present money standards, these early lamps cost well over $2.00 each. They burned for only 600 hours. Each gave the light of 16 candles. The modern 100-watt lamp on the other hand costs but 35 cents. It burns for 1,000 hours. And it gives the light of 114 candles. Remember, too, that the cost of electricity has steadily come down from the start.**

**Thus within the brief span of fifty years, the lighting art has leaped ahead to the point where the 100-watt inside frosted lamp of today gives the consumer not only a light which is a hundred fold more kindly and pleasing than the light from the lamps of fifty years ago, but which gives him 26 times as much of this light for the same money.**

**Indeed, then, the progress made in the art of lighting and lamp making, in this brief span of years, has been nothing short of miraculous.**

**Lighting one end of this span is the miracle of 1879, the triumph of Thomas Alva Edison. Lighting the other end, is the miracle of 1929, the triumph of Mazda Service.**




### "THE EDISON BOOM. HOW LONG, HOW LONG!!"

(Under the above heading, The New York World in one of its early issues of January, 1880, runs the following comment):

Kirkland & Milliken, of 47 Williams Street, reported yesterday that speculators are anxious to trade in Edison Electric Light Company stock, and that investors are picking up five and ten share lots. Mr. Lapertas, of the firm, said to a World reporter that two shares were sold yesterday at $3,500 each, but that lots of ten shares, which are more desirable, are in strong demand and are worth $4,500 to $5,000 a share. One of the largest shareholders, who was offered $700,000 last week for 200 shares, was bid $900,000 cash last night, and says that he will not sell under $1,000,000.

### "GAS AND ELECTRICITY"

When, a number of months ago, Mr. Edison gravely assured the public that he had solved the whole problem of electric lighting; that he had experimentally demonstrated the feasibility of dividing and sub-dividing the electric current at will, and that his plans gave promise of greatly reducing the cost of illumination, the public hailed the announcement with delight, and the price of gas-stocks everywhere rapidly declined. But the rosy promise of the wizard of Menlo Park still remain unfulfilled, and the indications, both at home and abroad, seem to warrant the opinion that gas corporations are yet to have their way for an indefinite number of years.

Leslie's Illustrated Newspapers, April 5, 1879.

### THE PESSIMISTIC WORLD

Has Edison at last solved the problem of illuminating anything but the columns of our esteemed contemporary, the **Herald**, with electricity instead of gas? This is a question which will very soon be practically settled. The incandescence of paper in a vacuum is certainly a solution of the problem not to be credited to anybody but Mr. Edison. Is it a real solution? We shall see—if we see! . . . Of course, Mr. Edison will confuse all his critics, theoretical and otherwise, if he exhibits to mankind on New Years Day a New Jersey village lighted up like the New Jerusalem at a total cost of 10 cents a month. In the meantime, it behooves all critics to "unload" their objections, which, like their gas stock, will be of no use to them or to anybody else after Mr. Edison achieves that result.*

The World (N. Y.) Tues., Dec. 23, 1879.

### FOREIGN COMMENT

The London **Standard** published the following:—Electricians generally entertain the idea that Mr. Edison is wrong in attempting to produce a cheap supply of the electric light by means of incandescence. . . . Mr. Edison seeks to supplant gas altogether, and perhaps he has satisfied himself by this time that he is to succeed in such an attempt he must provide a wick for his lamp which shall be cheaper than a quick burning carbon. . . .

### "NOT SCARED"

The Superintendent of the Manhattan Gas Works, at the foot of East Fourteenth street, said:—"The gasmen are not a bit scared at Edison's latest discovery. When he first started out with his electrical experiments there was considerable of a flutter, but they are getting used to being agreeably disappointed and they don't think he is any nearer the thing he is after now than he was in the beginning. There was the phonograph that he was to make such improvements on and render highly useful, but it remains only a mere toy. Our opinion is that Edison has failed, and we think Professor DuMotay explains clearly how he cannot effect a success with his latest plan, because the carbon, whatever it may be, volatilizes by the prolonged action of the electric current, and because the glass globes of the lamps, even if they are hermetically sealed, will expand and contract by the cold of the surrounding atmosphere, and thus the air will be allowed to filter into the globe, and the incandescent carbon will be consumed.

**New York Herald, Wed., Dec. 24, 1879.**

Yet these are but a few of the countless contributions which Mazda Service has given to the progress of lighting since its inception in 1909.

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## EDISON A HERO FOR YOUTH.

### Overcoming Obstacles His Foremost Quality.

### YOUTH WILL EMULATE.

### Middle Age Needs Inspiration to Rekindle Enthusiasm.

### CREATE OPPORTUNITIES.

Youth needs a hero. Grown-ups have a tendency to be so occupied with the "serious" things of life that they overlook the all-important needs of the man of tomorrow. If youth is not exposed to the accomplishments of truly big men, youth will make it its business to find a hero of its own. And he will succeed, even though it becomes necessary for him to follow the adventures of his hero in some obscure corner behind the barn.

Youth may have a very thrilling hero. Look upon the life of Thomas Edison and its possibilities as an example for the young man whose tomorrows still lie in the future. No author has created a fiction hero who has been the principal performer in so many fascinating achievements. Turn the eyes of the growing boy upon the adventurious boyhood of the illustrious inventor.

For the story of Edison's life is the record of dragons slain, enemies defeated, battles won.

Every one in the world of youth had a hero. This hero may have been some other boy—probably a little older—whom he enshrined as an ideal. That other boy may have been an athletic marvel, a baseball player, or a fighter. Along with this qualification, he may have been an apt mechanic, or a good horseman. If you now stir up your memory, you can probably remember how you used to imitate him in all of his characteristics because of some one outstanding quality that appealed to you. You may have failed in your emulation of this particular appealing characteristic, and forged to success as the result of patterning after his general characteristics.

Your ideal, your hero, touched you at many points and a certain contact here and there stirred up latent possibilities within you that went a long way toward making you what you are today.

Your hero may have been a boy a little older than yourself. He may have been your dad, he may have been your uncle, he may have been a mythical story book hero. He may have been some well-known historical or contemporary celebrity. But just as sure as your name is whatever it happens to be, that character years ago took you by the shoulder, changed the course of your footsteps, and established the direction of the path you have been travelling for many years.

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But it is not youth alone that needs this sort of inspiration. Middle age needs it to rekindle the enthusiasm it felt in earlier years. Old age will rejoice in hearing told the lessons of this life as a vindication of the principles taught many years ago and learned under the strenuous tutorings of long years on years.

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Looking upon this life over its crowded span, certain qualities stand out in compelling relief. Foremost among these, perhaps, is a revivifying of the trite and almost bromidic teaching that obstacles were made to be overcome. Edison saw obstacles in his way toward a particular objective. Instead of choosing an easier path which may or may not have led him to his objective, he overthrew the barrier. And in so doing he uncovered new truths which pointed the way to new objectives. A veritable geometrical progression of new opportunities opened up as the result of this blasting away one stubborn barrier after another.

When wrestling with the problem of making a filament glow in a vacuum, Edison, years ago, observed and recorded a certain phenomenon which has since been termed the "Edison effect." Edison, at the time, of course, was searching for a way to produce light electrically. Ask any radio engineer how far-reaching has been this by-product discovery, resulting from breaking down obstacles in his path.

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Edison created his opportunities. He did not wait for the proverbial knock. Rather, he met opportunity more than half way.

An unused corner of a baggage car on a speeding train supplied the necessary location for a publishing plant or a laboratory.

His days, like his life, each and re-teach the lesson that if a thing is worth doing, there is no time to begin like the immediate present. And further, the time to quit, preferably, is when the job is done.

Let young America have that lesson. Let him have it not in prosaic and dry preachments, but direct from a life that illustrates the glory of achievement. Let him have it from a life that exemplified its own teaching, that inspiration and perspiration go hand in hand, but that also illustrates at many turns, that hard work is in many respects a glorious kind of fun.

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This life teaches us that to dream dreams—and what boy will not understand—is a wonderful thing. But it teaches us further—and here the boy's understanding may part company with the fact—that to dream aimlessly without giving direction to one's dreams, results in ineffective, sedative wool-gathering. But we soon learn that dreams can be given direction; they can be pointed to definite objectives; they can be wrestling alternately with their ethereal delicateness and the world of fact, be made to come true.

Your hero may not be a potential inventor, but whatever the future may hold in store for him, the lessons of inventiveness, resourcefulness, rugged determination that he will learn from this romance outstripping all fiction, will prove invaluable to him. We learn a wonderful lesson of application.

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When we speak of Edison as the hero of modern youth, we do not use the term in a sense that those of us who are older to forget that Young America has no conception whatsoever of what living was like before Edison gave the world his inventions. Youth takes for granted things that were here when he arrived. Even an object of such recent obsolescence as a hat pin is unfamiliar to the oncoming generation. All the more reason why the story of Edison's achievements should be told this year of the fiftieth anniversary of the lamp in a manner long to be remembered, and in a manner which will portray unmistakably the extent of the debt the world owes him.

### AN ENGLISH ASTRONOMER'S APPRAISAL

**PROF. PROCTOR FORETELLS NEED OF REFLECTING DEVICES AND POSSIBILITY OF DAYLIGHT EFFECTS.**

"My faith in Edison subjected me to ridicule once or twice. I remember hearing it said that Mr. Proctor would believe in a plan for galvanizing the dead if that Yankee inventor proposed such a thing, and would credulously contemplate the possibility of shaking his deceased grandfather by the hand or bidding his sires of past generations time of day."

"Reporter:—"Is the new light apt to be injurious to the sight?"

Prof. Proctor:—"That depends upon its arrangement. The electric light can be so arranged, of course, as to be painful to the eyes, but it can just as readily be made far more pleasant than the yellow glare and flicker of gas. In fact it can be made to resemble sunlight as closely as any artificial illumination."

**New York Herald, Mon., Dec. 22, 1879 (report of an interview at the Westminster Hotel, New York).**

## EARLY ELECTRIC LIGHTING.

### Herald of 1879 Tells Story of Electric Lighting Before Edison

### INTERESTING STORY.

**Among its other properties electricity has that of developing heat. A substance through which an electric current is made to flow becomes heated to a degree proportioned first to the strength of the current and second, to the size and character of the substance. Substances which readily convey electricity, or, in other words, which offer but little resistance to the passage of the electric current, such as copper, silver or iron, are unsuitable for exhibiting the heating power of electricity, while substances which offer much resistance to the passage of the current, such as platinum or carbon, show this heating power quite strongly. Either of the latter substances becomes heated to incandescence the moment a strong current of electricity is passed through it, which incandescence gives out a beautiful and pleasant light. This method of obtaining light from electricity has been known for many years, and is called the incandescent method.**

**A second method known is that the voltaic arc, which, from Volta, an eminent electrician, is the passing of a powerful electric current between the points of two sticks or rods of carbon slightly separated from each other. The passage of the current, between the two, causes an intensely brilliant light, many times more intense than that produced by incandescence. It is estimated to be of about one-half the intensity of sunlight on a clear day.**

**When carefully studied on a screen, for the brilliancy of the light prevents continued observation by the naked eye, there will be seen hosts of little jets of carbon constantly passing in the form of an arc between the two carbon points. This method, then, of utilizing electricity for purposes of illumination presents two avenues of attack—one by way of the voltaic arc or intense light, and the other by way of incandescence or milder light.**

**THE VOLTAIC ARC LIGHTS.**

**Considering first the voltaic arc system we find that as early as 1840 it began to attract the attention of inventors. Probably its first use outside the laboratory and class room was in the year 1845, when it was employed at the opera in Paris to produce the effects of the rising sun. Its success in this role of "Apollo" was so satisfactory that before long enterprising managers had extended its field of usefulness by means of lenses and prisms to the production of luminous fountains, artificial rainbows and lightning. At this period, however, facilities for obtaining steadiness and uniformity of the light were exceeding crude, and some mechanical device to keep the carbons at the same relative distance from each other was indispensable. The first contrivance or regulator, as it was called, for this purpose was made in 1845 by Wright, of London, and consisted of disks of carbon having their circumference cut to a V shape and receiving motion from well known mechanism. The following year Staite and Edwards, in London, patented several regulators, the principle underlying them being the enclosing of the carbons in small cases, which made the carbon points meet obliquely. In 1848 Foucault, in France, and Petrie, in England, made further improvements by which the adjustment of the carbons was made quite reliable. Then followed numerous others, extending to the present time, of more or less perfection. Among them may be mentioned Archereau's, Lacassagne's, Thiers', Serrin's, Duboscq's, Farmer's, Brush's, Maxim's and Fuller's.**

**THE JABLOCHKOFF CANDLE**

**In the year 1876 a new departure in the form of regulators was made by Jablochkoff, a Russian engineer, who, instead of placing the carbon rods vertically to each other, placed them side by side, with a thin insulating substance between them. In this form the voltaic arc, playing between the extremities of the carbons, gradually consumed them downward, like a flame consumes a candle. Indeed, so analogous was the invention to a candle that it soon became known as the Jablochkoff candle—a name it still bears.**

**INCANDESCENCE.**

**The incandescent method of electric lighting was first successfully shown by King in 1845. He placed a rod of carbon in a globe of glass from which the air had been extracted, and passing a current of electricity through the rod caused it to become heated to such a degree that one could read large print a considerable distance away by the light emitted. His labors, however, were productive of no practical results, and while his theory for producing light was regarded as a pretty one, few were so bold as to predict that it would ever develop into an economical and efficient method of illumination. The following year Greene and Staite filed a patent for a lamp analogous to that of King, pointing out that they freed the carbon before use from impurities by treating it with nitro-muriatic acid.**

**PETRIE'S IRIDIUM LIGHT.**

**In 1849 Petrie obtained patents for the same purpose, concerning which he wrote as follows:**

**"A light may be produced by passing an electric current through a short and thin conductor, which heats and becomes luminous; but the majority of substances fuse and burn rapidly. However, I obtain a good light by using iridium or one of its alloys. Iridium may be fused so as to produce an ingot while it is submitted to the heat of the voltaic arc, afterward it may be decarbonized and rendered more malleable. It can be cut into small pieces, that can be fixed upon two insulated metallic supports which are in connection with the two wires of a battery. Then there is produced a beautiful light."**

**LODYGUINE'S LIGHT.**

**From this time until 1873 electric lighting by incandescence made but little progress, inventors regarding the incandescent method as much inferior to that of the voltaic arc. In the latter year, however, interest in the incandescent method was a little revived by an invention of M. Lodyguine, who made a lamp that overcame many of the difficulties previously deemed insurmountable. Concerning this invention the report to the Imperial Observatory of Paris said:**

**"The sole inconvenience of the use of carbon instead of platinum consists in the fact that in the combustion the carbon combines with the oxygen of the air and is thus gradually consumed. M. Lodyguine has avoided this inconvenience by enclosing the carbon heated to whiteness by the electric current in a glass vacuum, theoretically sealed, and from the interior of which the oxygen is expelled by a most simple process."**

**But improved as was this arrangement over those that had gone before, practice demonstrated that there were still many serious difficulties it did not meet. Among other things carbons presented obscure spots indicative of non-homogeneity; minute cracks also occurred in the carbon and rapidly disintegrated the same. The vacuum likewise was very imperfect, and there was produced within the glass globe a kind of evaporation that tended slowly to deposit the carbon rods. This evaporation also left a pulverized deposit of sublimated carbon on the inside of the glass globe. Within the past few years various English and American inventors have overcome many of these difficulties, but these still remained enough to render incandescent electric lighting impractical.**

**ELECTRIC GENERATORS.**

**While inventors were busy both on the voltaic arc and incandescent methods, progress was far from slow on the means for producing or generating the electric current. At an early day it was evident to experimenters that to produce either the voltaic arc or incandescence with any degree of economy a different method of generating the electricity than that afforded by the chemical batteries in use was necessary. An important discovery by Ampere in 1820, developed almost simultaneously by Oersted and Arago and later by Faraday, to the effect that powerful currents of electricity could be produced by the rotation of magnets near each other, opened an opportune field for purposes of electric lighting. Pixii, a manufacturer of physical instruments in Paris, in 1832, was the first practically to apply the discovery. He constructed a machine consisting of an electro-magnet and a permanent magnet, with mechanism for revolving one directly in front of the other, which revolution induced strong currents of electricity that could be carried off by wires and made to give light. The invention of Pixii was followed by improvements by Nianlet, Holmes, Ladd, Wilde and Siemens, and in late years by Gramme, Fuller, Brush, Maxim and others. The invention of Gramme, owned and used extensively in this country for the voltaic arc system by the Fuller Electrical Company, involved several important new principles that gave a marked impetus to the system and made possible the production of currents of electricity at comparatively small cost.**