

Charles F. Brush, inventor of the modern electric arc lamp.

## Converting Night Into Day

### Artificial Lighting Problems and How They Have Been Solved

#### What the Inventor Has Done for Oil, Gas, and Electricity in Illumination



Carl Auer von Welsbach, inventor of the Welsbach system of gas lighting.

WHEN Col. E. L. Drake "struck oil" in Pennsylvania in 1859 he also established the lamp oil industry. As soon as it was found that Pennsylvania had abundant supplies of oil the inventors began to file their applications for oil lamp patents. They began in 1859 itself and kept on for many years. Literally hundreds of lamps were invented. It was no mean problem to burn oil safely and efficiently in a lamp. Circular wicks and flat wicks, single burners and double burners, wicks of peculiar plaiting, were patented to feed the oil in just the right quantity to the burner head by capillary attraction. It is hardly worth while here to trace the course of development of the kerosene lamp. The simplest lamp soon proved the safest, all the more so since laws were passed in almost every country to prohibit the sale of oils with too high a flash point.

Arthur Kitson in 1885 patented a system of feeding the oil under pressure to a chamber where it was heated by the flame of the lamp itself and volatilized. The vapor thus produced was then fed to a kind of atmospheric burner, being automatically supplied by its suction with sufficient oxygen from the air to produce a very hot blue flame. Kitson employed a platinum gauze which was heated by this flame to incandescence, that being a time when the Welsbach mantle had not yet been commercially introduced. The gauze answered well enough for a time; but it became useless when soot was deposited upon its meshes.

But even if Kitson had been able to utilize the Welsbach mantle, his lamp might not have been successful in its early form. It is difficult to mix air with the high-pressure vapor so intimately that carbonization will not result, and a carbonized mantle is robbed of its luminosity. Even when the desired intimacy of mixture is obtained there is difficulty in maintaining it automatically. The difficulty was ingeniously overcome by F. Altmann, among others, who devised an arrangement in which water and oil were vaporized by a burner in a small separate chamber, whereupon the mixture of vapor and steam was fed to a special burner head, supplied with air, and used to heat a Welsbach mantle to incandescence. Such lamps are remarkably economical. They yield three times the amount of light which can be obtained from oil when consumed under ordinary conditions.

The invention of the Welsbach mantle served not only to improve the oil lamp, but also to revive "air gas"—air mixed with volatile hydrocarbons and burned in an Argand burner like ordinary illuminating gas of the present day. When the general extension of coal gas and electricity had practically relegated air gas to the place of an abandoned illuminant the Welsbach mantle gave it a new lease of life. A. I. van Vriesland, Hooker, and De Laitte are among the inventors who improved air gas generating apparatus so that the Welsbach mantle could be effectively employed.

#### The Development of Gas Lighting in Our Time.

Although towns were lighted early in the nineteenth century by gas, it was not until the last four decades that rapid progress was made in gas lighting; for in that brief period there were great improvements both in the manufacture of gas as well as in the methods of

burning it. The London Argand burner of 1875 was considered the last word in illumination in its day—something that could not be surpassed. But when the incandescent mantle came, six times as much light was obtained from the same amount of gas. By 1845 most of the burners with which we are familiar had been invented and fairly well standardized. William Murdoch himself, the first man to use coal gas in his house (1779), devised the "cockspur" burner. J. B. Neilson devised the "fishtail" burner. Sir Edward Frankland in 1853 brought out his burner for utilizing the heat of the flame to raise the temperature of the air supply for the combustion of the gas. A similar regenerative system was that of the Rev. W. R. Bowditch (1854). By far the best of these regenerative burners was that of Friedrich Siemens, who came out with his invention in 1879. These ingenious burners, efficient as they were, never succeeded in supplanting the ordinary fishtail and batwing burner, simply because of their initial cost. The Argand burner, too, more than held its own.

It is obvious that these various burners depend for their efficiency on different principles. The ordinary fishtail or flat flame burner must be fed with a gas very rich in carbon particles. In the regenerative burners the temperature to which the carbon particles are heated is raised as high as the material of the burner will permit. It was the effort to increase this temperature and with it the efficiency of the gas flame that led to the evolution of the modern system of incandescent gas lighting.

While the principle underlying incandescent lighting—that of raising the temperature of refractory substances to a point where they emit light—is old and may be traced back fully a hundred years, it was not until our own time that it was successfully applied. To be sure, Gillard had tried to use platinum gauze so that he might increase the utility of his water gas, introduced in 1848, but his scheme failed because the platinum was coated with a deposit of carbon in a short time. Bunsen's invention of the burner that bears his name—a burner which produces a very hot, blue, almost non-luminous flame as a result of the mixture of air with gas—really made incandescent gas lighting possible. After that it was easy for Clammond, a Frenchman, to suggest the use of calcined magnesia as a refractory material to be heated by a Bunsen burner. Clammond created a sensation in the early eighties when he exhibited his system of incandescent lighting

in London and Paris. He even used something like the modern mantle or stocking, although he called it a basket. What is more, he devised a creditable system of inverted incandescent lighting.

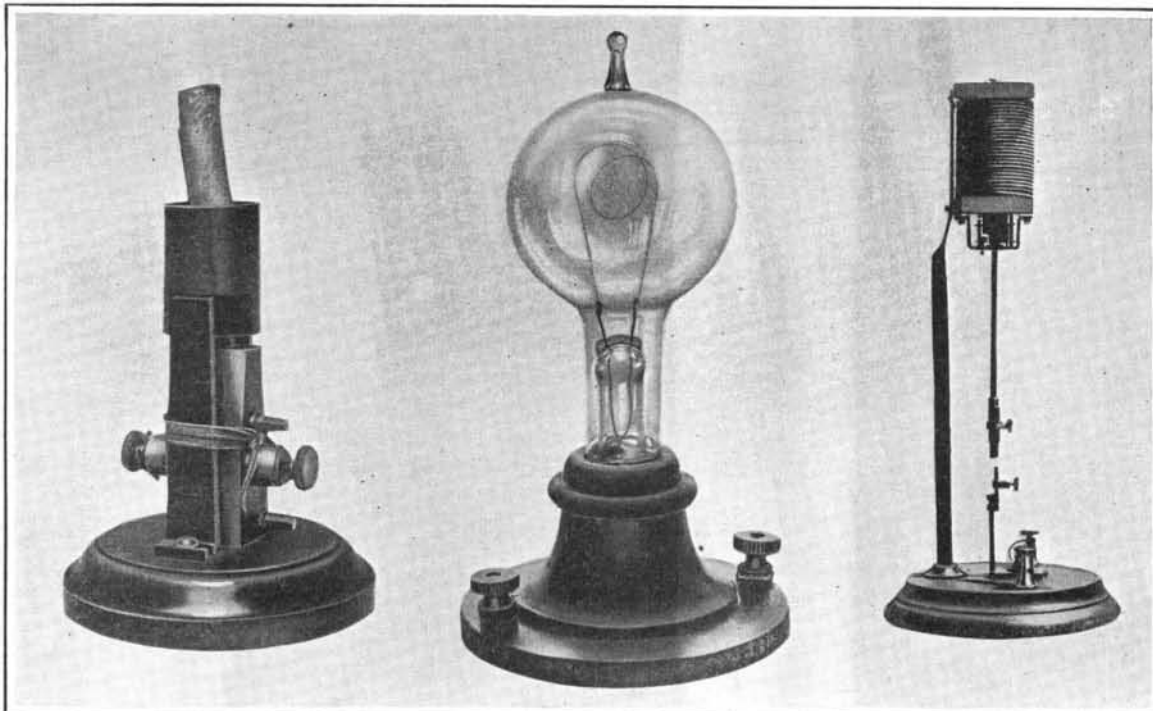
But it was not until Auer von Welsbach, a brilliant Austrian chemist, conducted his study of the rare earths that modern incandescent lighting was created. Although his discovery was to a certain extent accidental, still only a clear-seeing investigator could have seized upon that accident and turned it to practical account. During his spectroscopic study of the rare earths he used the platinum wire in the time-honored way. It occurred to him that he might obtain a more brilliant effect for his momentary purpose if he immersed a piece of cotton in the solution which he was investigating. To his astonishment, he found that while the thread was burned completely away, the salt of the solution into which it had been dipped still remained in the form of the original thread. What is more, that salt continued to glow with a wonderful brilliancy. Another experimenter might have passed the discovery by and continued with the main investigation. Welsbach realized the meaning of that brightly glowing thread, which was no longer cotton, but a metallic oxide. He set about the task of devising a fabric of cotton which could be used to soak up a solution of rare earth (zirconium, lanthanum, yttrium), and after much experimenting arrived at a mantle impregnated with thorium oxide mixed with other oxides. The really serviceable mantle came when he found that a little ceria must be added to the thorium in order to obtain a mantle capable of shedding the most light. All this investigation was conducted in the middle of the eighties.

#### The Evolution of the Welsbach Mantle.

When it was placed upon the market over twenty-five years ago the Welsbach mantle consisted of a knitted hose-like fabric of cotton, which was soaked in a liquid called lighting fluid—a solution of thorium and cerium nitrates in water. The cotton was burned out, leaving the thorium and cerium in the form of an ash, which was then hardened and shaped. To form a protective coating during shipment the mantle was dipped in a collodion solution.

The ash of the finished mantle has the same physical structure as the original fabric from which it was made, whether it be cotton or any other fiber. It is obvious, then, that the strength and other physical properties of the mantle depend very largely on the nature of the original thread. For perhaps a dozen years after the

discovery of the incandescent mantle all mantles were made from cotton. In those days it was a miracle enough to make any kind of a mantle. The industry was absolutely new and was beset with numerous difficulties, both chemical and physical, and one of the earliest difficulties was the finding of a suitable fabric. Ramie was first introduced in mantle-making by Buhlmann in 1898. It has certain marked advantages over cotton, particularly in maintaining its candle-power, and to this day many mantles are still made from ramie. It was found by Knöffler in the early nineties that artificial silk (nitro-cellulose) was better than cotton for the manufacture of mantles, because the life of the mantle was more than doubled. It would be out of the question to use a material as inflammable as



The Jablochkoff "candle."

Edison's first lamp.

Brush's first arc lamp.

The Jablochkoff "candle" gave less light than many of the modern incandescents do. It embodied a "filament" at the top, the fusion of which started an arc. Edison's first lamp was the outcome of the most indefatigable experimenting in the history of modern invention. Brush exhibited his first arc lamp of the wonderfully simple and successful ring-clutch type in 1877.

Three interesting steps in the development of electric lighting.

nitro-cellulose for the manufacture of fabrics, without rendering it safe. Hence, the thread is denitrated. In other words, we start with cotton, change it to nitro-cotton, which we dissolve and form into threads, and then take out the "nitro" part, leaving the original cotton, but with an entirely different physical structure. Instead of the short, hollow, opaque fibers of the original cotton, we now have solid lustrous filaments of unlimited lengths. Changing the cotton to nitro-cotton is simply a trick to get it in solution. The remarkable nature of this material is realized when we consider that a thread weighing one pound will reach twenty miles. This thread in turn is composed of twenty strands, and if these could be separated and placed end to end, their total length would be 400 miles. Ten pounds would reach from Maine to California.

Simultaneously with Knöfler, de Lery (1897) and Plaissetty (1900) patented processes for mixing the thorium and cerium nitrates with a solution of nitro-cotton in ether and alcohol and squirting this solution through fine orifices. None of these schemes, however, turned out to be a commercial success. Plaissetty seems to have been the only one to persevere. Finally, he hit upon what seems the very obvious idea of making a knitted fabric of artificial fiber and saturating it in the lighting fluid directly. As nitro-cellulose is absolutely solid and rod-like in structure, it absorbs 50 per cent more than the sponge-like cotton and ramie, because it is colloidal in nature. To harden the mantle thus made Plaissetty used ammonia. He took out patents in Germany in 1902 and in this country in 1904. His process was a commercial success.

Since 1904 vast improvements have been made in the manufacture of mantles from artificial fiber. Nitro-cellulose fibers are much better than natural fibers, because they are absolutely uniform, because they are free from indissoluble impurities, because they can be made absolutely continuous, and because they are strong. An artificial fiber mantle will support a weight of one ounce suspended from its loop without breaking. This is a remarkable tensile strength for a product which, after all, is composed of nothing but ash. Cotton falls off in candle-power during the first 100 or 200 hours, and after 100 hours sustains a loss of about 25 per cent. Ramie depreciates less rapidly, but unlike cotton, the color of the light changes to a whiter shade. Artificial fiber mantles actually increase in candle-power during the first 100 or 200 hours, and there is no change of color in the light even after 1,000 hours of burning. Unlike natural fibers, artificial fibers do not shrink, nor do they deteriorate in strength nearly so rapidly as cotton or ramie mantles. Hence, the artificial fiber mantle may be said to mark a distinct advance in the art of mantle-making, perhaps the greatest since the introduction of the thorium-cerium mantle itself.

In the last twenty years high-pressure systems of incandescent gas lighting have been developed after much experimenting and study, the object, of course, being to obtain more light from a given amount of gas. Pumps are required to supply the gas under pressure, a floating bell being necessary to eliminate the fluctuations caused by the strokes of the pump piston. One of the principal systems of this type was invented by Sugg and is much used in Europe in cities where gas is on a competitive basis with the electric arc. Other systems have been devised by Lucas, Selas, and Keith.

To avoid the use of pressure apparatus, what are known as self-intensifying systems have also been invented. In these the lamp itself contains its own apparatus for supplying an increased quantity of air and gas. One of the most indefatigable inventors in this field is Lucas, who after much experimenting designed a chimney of such form that a very powerful draft is produced which acts on the gas flame and air, with the result that a very brilliant light is obtained. Other inventors depend on little pumps attached to the lamp to obtain their forced feed. Thus, in the Scott-Snell system the lamp's own heat drives a plunger, which forces gas to the burner under pressure.

Clammond, we have said, invented an inverted gas mantle during the course of his investigations. He

recognized the fact that a vertical burner throws its light above the horizontal, whereas it is needed below, and that objectionable shadows are cast by the mantle supports and lamp parts. It was easier with his type of mantle to invert it than with the Welsbach. Clammond used an inverted blowpipe above his mantle and forced the air and gas down. To convert the ordinary Bunsen burner into a blowpipe simply blackens the mantle and is otherwise objectionable. What was needed was evidently some form of Bunsen burner which could be placed over a mantle and still operate under the usual pressure. H. A. Kent dodged the problem by inventing in 1897 a siphon-like Bunsen burner with the inlets for gas and air below the burner head so that there was no tendency for carbon deposition.

Otto Mannesmann, Bernt, and Cervenka discovered independently in 1903 that in the inverted incandescent gas lamp it was necessary to feed the mantle with a stream of mixture of smaller cross-section than that of the mantle itself and the importance of conducting the secondary air (air of combustion) toward the descending gas-air mixture. Not until this discovery was made could the inverted incandescent gas lamp be considered really practical.

#### The Evolution of Arc and Incandescent Lighting.

The arc lamp and the incandescent lamp bore many more points in common in the early days of electric light-

over their history we need not draw too sharp a line of demarcation between them.

In our historical review it is not necessary to follow the precedent of Irving, who starts his *Knickerbocker History of New York* with the creation of the world. Save for a passing reference to Benjamin Franklin's kite-flying experiment (1752), which may be regarded as the connecting link between electric light in nature and electric light as produced by man, we may start with Sir Humphry Davy, who in 1801 first observed and studied the phenomenon of the electric arc. At this time there was not a single central lighting station—either gas or electric—in the world; even matches were undiscovered. For his electrodes, Davy used rods of wood charcoal, heated and plunged into mercury to make them better conductors. The arc light was not publicly exhibited until 1809, when, the dynamo being unknown, Davy's mammoth battery of 2,000 primary cells at the Royal Institution, London, served as a cumbersome source of current.

We now pass to the fourth decade of the nineteenth century—a decade the discoveries and inventions of which were destined to advance electric lighting tremendously. The most important of these discoveries, without doubt, was the principle of electromagnetic induction, announced by Michael Faraday in 1831, while Director of the Royal Institution. Details of the

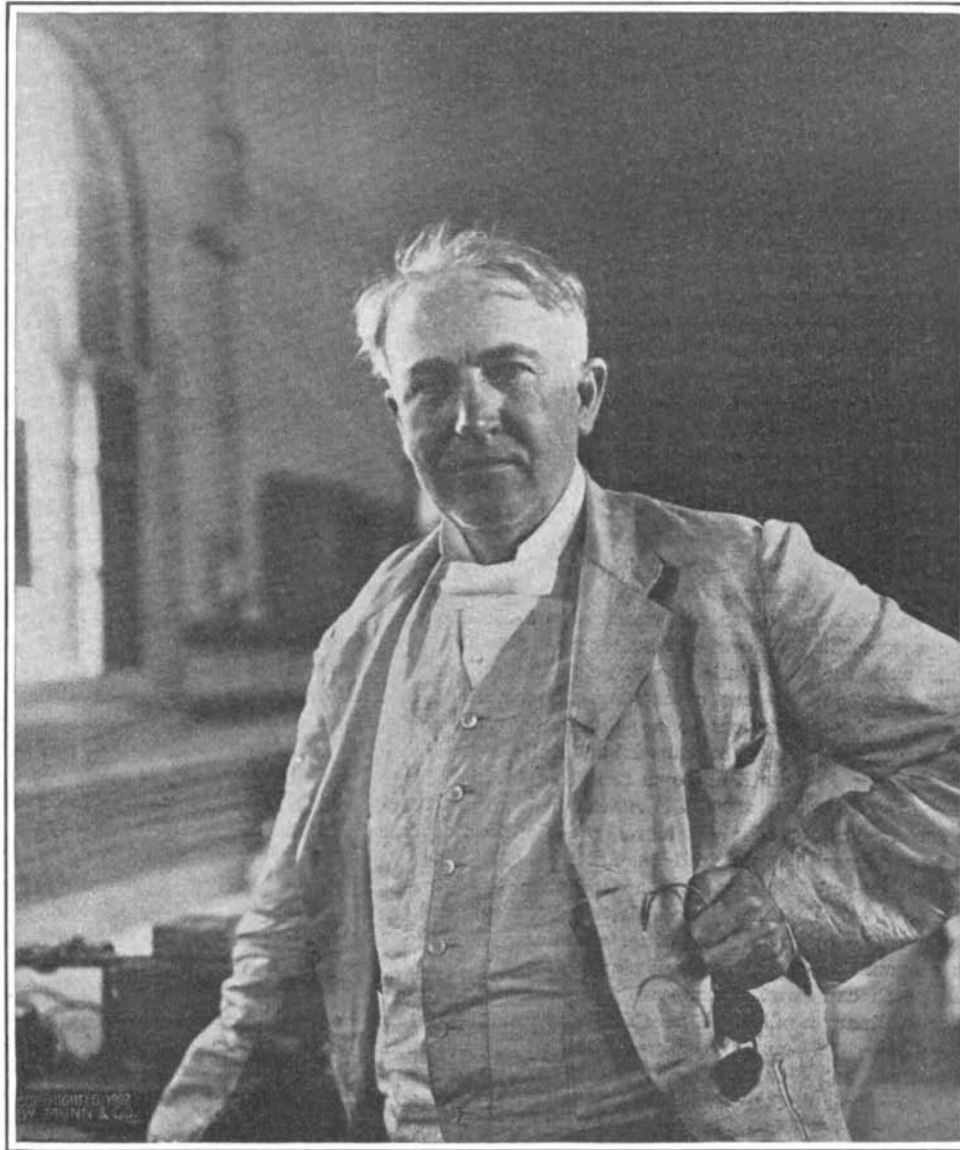
experiments that Faraday made in arriving at this grand underlying principle on which electric generators depend are preserved in his laboratory note-books, and may be read in the published accounts of his life. The principle was not to find its broad commercial application, however, until several decades later. The year after Faraday's epochal observation was made, Hippolyte Pixii constructed a "dynamo," one of the first on record, consisting of a stationary electromagnet in which currents were induced by the rotation of a permanent horseshoe magnet.

It is undeniable that much more honor is generally due to the man who actually accomplishes a task than to him who first suggests the possibility of its accomplishment; nevertheless a great amount of credit rightly belongs to the theorist who has the insight or originality to suggest a certain line of activity. Thus, the carbon-filament incandescent lamp may be said, without detracting a whit from the labors of those who invented it, to have been born in the brain of Prof. Jobard of Brussels, who in 1838 suggested that a small piece of carbon, if incandesced *in vacuo* by electricity, might be employed as a lamp. He transmitted this idea to his pupil, De Changy, who did considerable experimenting without, however, producing a commercially successful lamp.

Coming to the fifth decade, we find commercial arc lighting dimly foreshadowed in 1844, when Foucault, experimenting with gas-retort carbon and using this in connection with a galvanic battery, produced such a steady and continuous light that he was able to use it for photographic purposes. Foucault's arc was the forerunner of a great many types of arc lamps that were to make their appearance from this time on until about 1860, none of which, however, combined the commercial requirements of simplicity and reliability to a sufficient degree to bring them into widespread use, especially at a time when the dynamo was idling away a protracted infancy in its cradle, the laboratory.

Among the freak types of arc lamp that passed into history during this early development period may be mentioned the Wright arc of 1845—the first arc lamp patented in England. This curious machine consisted of five circular carbon disks in series, of which two were movable by means of hand-screws serving to draw out the four arcs. No less awesome was the American arc-lamp of Wallace, in which the arc flame played back and forth over a linear space of about a foot, along a narrow gap between the opposed edges of two immense rectangular carbon slabs. One of these Wallace arcs is preserved in the National Museum at Washington; they were used commercially, in conjunction with the Wallace-Farmer dynamo, for street lamps in Baltimore

(Concluded on page 575.)



To my friend Munn

Thomas A. Edison

Orange, June 10 1903.

Emil Rathenau, founder of the great *Allgemeine Elektrizitäts Gesellschaft*, once told how he went to Paris in 1881, and at the electrical exhibition there saw the Edison exhibit. "The Edison system of lighting was beautifully conceived down to the very details and as thoroughly worked out as if it had been tested for decades in various towns. Neither sockets, switches, fuses, lampholders, nor any of the other accessories necessary to complete the installation were wanting; and the generating of the current, the regulation, the wiring with distributing boxes, house connections, meters, etc., all showed signs of astonishing skill and incomparable genius."

ing than they do now. "Early days" should be construed electrically, of course—say the seventies and eighties. For example, the first arc lamp to be extensively commercialized was the "candle" of Jablochhoff (1876), which gave less light than many of the modern incandescents do, and embodied a "filament" at the top, the fusion of which started the arc. On the other hand, among the earliest incandescent lamps were the so-called "incandescence-arc" lamps, based on the principle of an arc playing between two incandescent wires in a partially evacuated bulb.

Then, too, the "active material"—to borrow a battery term—of both families of lamps was basically the same, being carbon both for lamp filaments and arc electrodes for many years; but later invention and development have caused the two families to grow apart, introducing filaments of osmium, tantalum and tungsten, and arc electrodes of metal or of carbon impregnated with various salts. However, arc and incandescent lamps have for a long time been developing contemporaneously, side by side as it were, so that in looking back



## The Patent Office and Invention Since 1845

(Concluded from page 534.)

shown by the large number of very important contributions she has devised in the last 35 years, and the increasing number of patents she has taken out in this country in recent years, now exceeding those applied for by any other foreign nation. To her sons is due the gas engine, the gasoline motor; the crude oil engine (Diesel motor); the automobile; the Welsbach lamp; the Tungsten lamp; the X-Ray machine; the utilization of blast furnace gases for operation of gas engines; the superheating of steam in locomotive practice, the synthesis of indigo; the contact method of making sulphuric acid, the Goldschmidt thermite process, and the innumerable and radical innovations in dye making, drugs, and chemicals.

An interesting confirmation of the changing character of our population may be made by comparing the names of inventors prominent in the earlier periods of the country's history with those which are found frequently scattered through the later additions of the Official Gazette. Fulton, Whittemore, Bigelow, Blanchard, Hoe, Campbell, Ames, Fairbanks, Howe, Colt, McCormick, etc., testify to the complete Anglo-Saxon predominance of former times, while such names as Bettendorf, Mergenthaler, Pupin, Tesla, Christensen, Doherty, Frisch, Gallagher, Conner, Monnot, Krakau, Mesta, Steinmetz, Sauveur, and Lindenthal, which are abundantly sprinkled among the names listed in recent Official Gazettes, offer proof of the leavening that is going on in all departments of American life.

## Converting Night Into Day

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during the late seventies. We have already referred to the so-called "incandescence-arc" lamps, which mark the off-shooting of the incandescent lamp from its parent stem, the arc. Numerous attempts, some of them involving much ingenuity, were made to produce a successful lamp of the "incandescence-arc" type, and much money was sunk in valueless patents, as Dredge's classic tome, "Electrical Illumination," containing records of all these early patents, abundantly testifies. One lamp of this sort was De Moleyn's. It comprised a glass globe with plugged openings for connection to a vacuum pump; into the upper part of the globe a tube containing finely powdered carbon was sealed; a movable copper wire ran through this tube and protruded through the orifice at its lower end (inside of the globe), this orifice being exactly large enough to let the carbon dust trickle through slowly, forming an "incandescence-arc" between the copper wire and a platinum spiral that came up through the bottom of the globe.

J. W. Starr of Cincinnati, Ohio (a protégé of George Peabody, the philanthropist), tackled in grim earnest the job of inventing a practical incandescent electric lamp, and his efforts resulted in the so-called Starr-King lamp, patented in 1845, when its inventor was only twenty-three years old. Two years later—in the very year, by a singular coincidence, that Edison was born—the ill-starred Starr had worked and worried himself to death; had he lived to complete his experimenting, the successful incandescent lamp might conceivably have been brought forth some thirty years sooner than it actually was. Starr's lamp had a Torricellian vacuum, the vacuum chamber, like that in a barometer tube, being formed by the inversion of a glass tube containing mercury; the "filament" consisted of a stick of retort carbon about one eighth inch square in cross-section. The lamp gave a good, bright light when new, but blackened rather quickly, and was further handicapped by the lack of a cheap, practical system of electricity supply.

Incidentally, we are told that the first electrolier for incandescent lamps was made by Pearce of Boston, about 1842, on George Peabody's order, and was used to interest capital in Starr's inventions.

Electroliers were also shown in England by Starr and Faraday.

A period of comparative stagnation in electric-light development, relieved to be sure by Planté's invention of the storage-battery (1860), ensues for the next twenty-five years, but with the seventies the flood-tide of modern discovery sets in. In 1870, three years after Faraday's death, Z. T. Gramme received a patent on a really practical direct-current dynamo. In 1875 the Sprengel vacuum pump, which became almost immediately an important factor in solving the problem of successful incandescent lamp manufacture, was introduced. In the following year Lieut. Jablochkoff patented his famous "candle," consisting essentially of two vertical sticks of carbon separated by a thin fusible insulating barrier, across the top of which an electric arc played. The rated life of the various types of Jablochkoff candle, which worked on a voltage of about 42, varied from 1 hour and 20 minutes to 3 hours and 20 minutes. Thousands of these candles were sold, although comparatively few found their way to the United States, before they were driven out by the more modern arcs and incandescent lamps.

Meanwhile Charles F. Brush and Thomas A. Edison had applied themselves to the stupendous and hitherto unsolved problem of utilizing electricity for general lighting purposes. Brush exhibited his first arc lamp of the wonderfully simple and successful ring-clutch type in 1877, and in the next year produced that other indispensable feature of his system, the series arc dynamo, and started arc lighting campaigns all over the world. Four years later Brush arc lights, made in Cleveland, were in nightly operation in Shanghai and Tokyo.

The history of the arc seems incomplete without mentioning the early work of Elihu Thomson. He invented a generator, absolutely unique. In connection with it he developed the magnetic blow-out, which has been extensively employed ever since in controlled, lightning arresters and circuit breakers. He also invented an arc lamp and regulator. Indeed, the Thomson-Houston and Brush arc systems were active competitors.

In 1879 several inventors were working on the incandescent lamp problem, among them Sawyer and Man, who experimented extensively with filaments of carbonized paper; Lane-Fox, who used vegetable fibers; Swan, who in February of that year publicly exhibited a lamp with a filament of parchementized tread; Weston who worked even at that early date with squirted and cut nitrocellulose, and Edison, who tried out substances far too numerous to mention here, but including platinum, lamp-black, tar and paper. One might, perhaps, think that the failures of De Changy, De Moleyn, Starr, and others would have had a discouraging influence on these inventors in the late seventies, but they regarded them merely as light-houses, showing what to avoid. Edison's famous exhibition of his complete incandescent lighting system, when the laboratory grounds were illuminated by seven hundred lamps, took place late in December, 1879, and attracted prominent visitors from all over the country. This may be considered the crowning, as it was the closing, event in the progress of illumination during the eighth decade.

Development during the years 1880 to 1889 was rapid and important. Lamp costs were brought down, as ways of simplifying and standardizing lamp parts were discovered. The price of arc light carbons was gradually reduced from \$240 per thousand to about \$10 per thousand. The art of "pasting" carbon filaments to the lead wires was discovered; previously, the filaments had to be attached by expensive mechanical devices, such as tiny bolts, nuts, washers, sleeves, and clamps.

The three-wire system of direct-current distribution was first put into commercial operation in 1883 at Sunbury, Pa. Who invented it is almost impossible to determine. Edison certainly developed it as part of his commercial system of incandescent lighting, and so did Edward Weston, long before, in the days when he first

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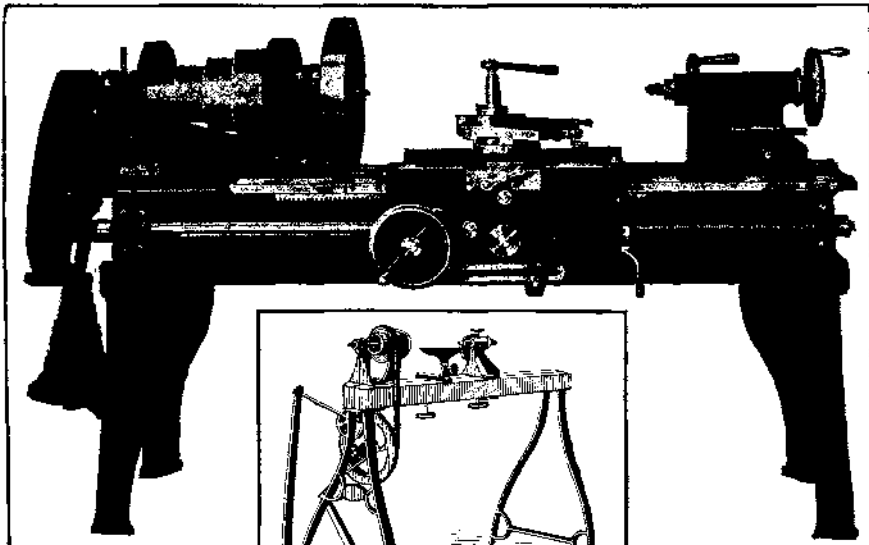
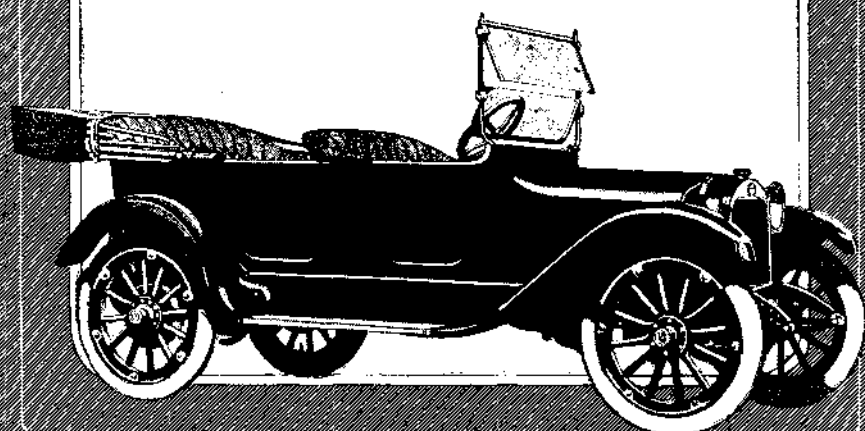
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used the dynamo in electroplating on a large scale. In 1866 Mr. George Westinghouse installed the first regular alternating-current central station in America at Buffalo, N. Y., and during the entire ten years under consideration the central station industry was rapidly extending its roots and branches. By 1890 electric lamps—incandescent and arc—had made their way into every civilized country.

The nineties, too, were prolific of discoveries. In 1891 the cellulose or "squirrel" process of making carbon filaments was commercially introduced. Two years later the cellulose filament generally supplanted the bamboo. In 1895 came the "chemical exhaust" for incandescent lamps, which improved their average quality, at the same time reducing their cost, and was largely responsible for the reduction in price of carbon lamps in 1895 from 32½ cents to 20 cents each. Meanwhile the process of "treating" filaments in hydrocarbon vapor, rendering them more uniform and improving their radiating properties, had been introduced, although that, too, had been discovered very early by Edward Weston.

As experts and facilities for research multiplied, improvements, first of minor importance, but more recently of a revolutionary nature, were evolved. The substitution of molded bulbs for "free-blown" bulbs, about 1892, and the invention of the turn-down lamp by Phelps in 1898, belong, relatively speaking, in the category of minor improvements. The first indication to the world that the metal-filament lamp might eventually supersede the carbon came about 1898, when Dr. Welsbach produced his first osmium filament lamp. Curiously enough, tungsten had been tried for filaments as early as 1889 by Lodge and Tibbets, but unsuccessfully, as these workers did not realize the importance of having the metal extremely pure. The mercury arc lamp was originated by Arons in 1892 and later developed to a point of greater commercial practicality by Cooper Hewitt.

The invention of the inclosed arc lamp in a practical form was announced at an electrical convention in 1894, when L. B. Marks described the first inclosed arc lamp embodying the points that made it, for a period of about ten years, the favorite unit for high candle-power lighting in America.

In 1899 the Bremer flame arc was announced, and in the following year Bremer exhibited at the Paris Exposition a model having four impregnated carbons, so arranged that the light produced was reflected downward. The modern "yellow-flamer," with carbons impregnated with calcium compounds, is an outgrowth of Bremer's lamp. Flame carbons giving light of various colors have also been developed, such as those containing salts of strontium, giving a pink light, or those of barium, which give a white light. The best-known of all the luminous arcs, however, is Steinmetz's invention, the "Magnetite," the electrodes of which are composed of metals and metallic oxides, without any carbon "body." It is essentially a direct-current lamp.

The discovery of ductile tantalum came from a German laboratory in 1901, and the first experimentally successful tantalum lamp was constructed a year or so later, although tantalum lamps were not in a condition to be placed on the market for several years more.

Meanwhile, in 1905, the "metallized" carbon lamp, in connection with which notable work was done by J. W. Howell in one of the laboratories of the largest American electrical manufacturer, made its appearance and served as a sort of stepping-stone to the lamps of still higher efficiency that were about to make their appearance.

In 1907 came the pressed-filament tungsten lamp, for which we are indebted in a great measure to two European inventors, Just and Hanaman. This lamp, under the hands of such men as Dr. W. D. Coolidge, Dr. A. Pacz, and a host of other experts, has gradually evolved into the strong, durable, cheap drawn-wire lamp of to-day.

The very newest line of development,

due in the first place largely to Langmuir and Orange, working under the direction of Dr. W. R. Whitney in the Research Laboratory of the General Electric Company, has given us non-vacuum incandescent lamps with efficiencies deemed utterly impossible a few years ago. Some of these big lamps, the bulbs of which are filled with inert gases, actually take less than half a watt per candle. They are giving the arc lamps, particularly of the old open and inclosed types, a hard race just at present.

Although there have been wonderful accomplishments in arc and incandescent lighting during the past century, yet we all share more or less the attitude of Mr. Edison, who, in the course of a conversation with the writer, remarked: "I don't like to go into things connected with ancient history, or the dead past—what I am interested in is the future; in what is going to happen to-morrow." And assuredly there is much to be done. Scientists find that the most efficient arc and incandescent lamps of to-day waste something like 85 per cent of their incident energy in other forms than light—from an efficiency standpoint they are outshone by the common firefly. So the curtain of mystery still veils the lamps of our descendants.

### Some Personal Recollections

(Concluded from page 537.)

a lightning flash. In an instant I saw it all, and I drew with a stick on the sand the diagrams which were illustrated in my fundamental patents of May, 1888, and which Szigety understood perfectly.

It is extremely difficult for me to put this experience before the reader in its true light and significance for it is so altogether extraordinary. When an idea presents itself it is, as a rule, crude and imperfect. Birth, growth and development are phases normal and natural. It was different with my invention. In the very moment I became conscious of it. I saw it fully developed and perfected. Then again, a theory, however plausible, must usually be confirmed by experiment. Not so the one I had formulated. It was being daily demonstrated every dynamo and motor was absolute proof of its soundness. The effect on me was indescribable. My imaginings were equivalent to realities. I had carried out what I had undertaken and pictured myself achieving wealth and fame. But more than all this was to me the revelation that I was an inventor. This was the one thing I wanted to be. Archimedes was my ideal. I admired the works of artists, but to my mind, they were only shadows and semblances. The inventor, I thought, gives to the world creations which are palpable, which live and work.

The telephone installation was now completed and in the spring of 1882 an offer was made me to go to Paris, which I accepted eagerly. Here I met a number of Americans whom I befriended and to whom I talked of my invention, and one of them, Mr. D. Cunningham, proposed to form a company for exploitation. This might have been done had not my duties called me to Strasburg, Alsace. It was in this city that I constructed my first motor. I had brought some material from Paris, and a disk of iron with bearings was made for me in a mechanical shop close to the railroad station in which I was installing the light and power plant. It was a crude apparatus, but afforded me the supreme satisfaction of seeing, for the first time, rotation affected by alternating currents without commutator. I repeated the experiment with my assistant twice in the summer of 1883. My intercourse with Americans had directed my attention to the practical introduction and I endeavored to secure capital, but was unsuccessful in this attempt and returned to Paris early in 1884. Here, too, I made several ineffectual efforts, and finally resolved to go to America, where I arrived in the summer of 1884. By a previous understanding I entered the Edison Machine Works, where I undertook the design of dynamos and motors. For nine months my regular hours were from 10:30 A. M. till 5 A. M. the next day. All this time I was getting