ELECTRIC LAMPS IN THE MAKING.

BY FREDERIC BLOUNT WARREN.

Very few persons out of the great number who are familiar with the many uses to which electricity may be put know how the bulbs are made. In the Philadelphia plant here illustrated and described, 7,000 lamps are turned out daily, and each lamp must be handled sixty-four times. Sixty-four handlings seem an incredible number for so small an article. Many of the handlings are relatively unimportant to the layman, and will be eliminated from this article.

First of all, no lamp manufacturer makes his own bulbs, since only about one-half or six-tenths of the glass product of a factory is of the requisite standard for bulb making. Fortunes have been spent to bring the lead glass standard up to this requirement.

The bulb is first blown into a divided iron mold. When the "dip" or mass of nearly molten glass has been twirled a moment at the end of a tube, the operative inserts it into the mold, and gives the tube a puff of air until the glass bubble on the end fills out to the limit of the mold. An assistant reaches over and cuts the tube away from the now hardening bulb; the iron mold is divided, and the hardened glass bulb is thrown out. Its shape is about like that of a young leek or onion—much enlarged—and with the sprouts or stem nearly all cut away.

In all there are three glass parts that enter into the manufacture of a lamp. These are the bulb itself, the stem, and a top tubing through which the air in the bulb is extracted. When the air has been removed and the bulb sealed, this tubing is cut off with a jet of flame and thrown away. The parts are all made by the same formula; otherwise, when heated, they would not join together. Filaments of the type in general use are made from ordinary absorbent cotton, reduced by a chloride process to a thick liquid state. By this process the silicon in the cotton is removed, leaving a residue of cellulose, which is treated for carbonization. Under air pressure this liquid is squirted through a glass die, emerging in the form of thread or string. After this fiber has been passed through a number of hardening chemical baths, it is wound on spools for drying. When thoroughly dried, it is about as strong as a catgut violin string and is cut in desired lengths, ranging from 2½ to 7 mils. A mil is a unit used almost exclusively in electric wire measurement.

The next step is to form the thread in the shape desired, there being several different-shaped carbons on the market. The one in general use is known as the oval-anchored filament. Formerly a pure black carbon was used on which to form and carbonize thread, but the more recent method is to use a compressed low temperature and then, after forming, to carbonize the thread. Carbonization requires high temperature, and when the thread comes out of the oven it is pure carbon, possessing a higher resistance than any other known carbon.

From the baking oven the carbons come out jet black and about two-thirds of their original length. On account of their shrinkage and uneven air pressure when being forced through the die—and from a liquid to a stringy state—the carbons are rarely, if ever, of equal diameter throughout their length. These weak spots are corrected by a process known as flashing or treating, the object of which is to make the carbons of uniform diameter and resistance throughout their length. It is not merely a question of filling up the cavities, as the provision of a uniform resistance in the carbon is of equal importance.

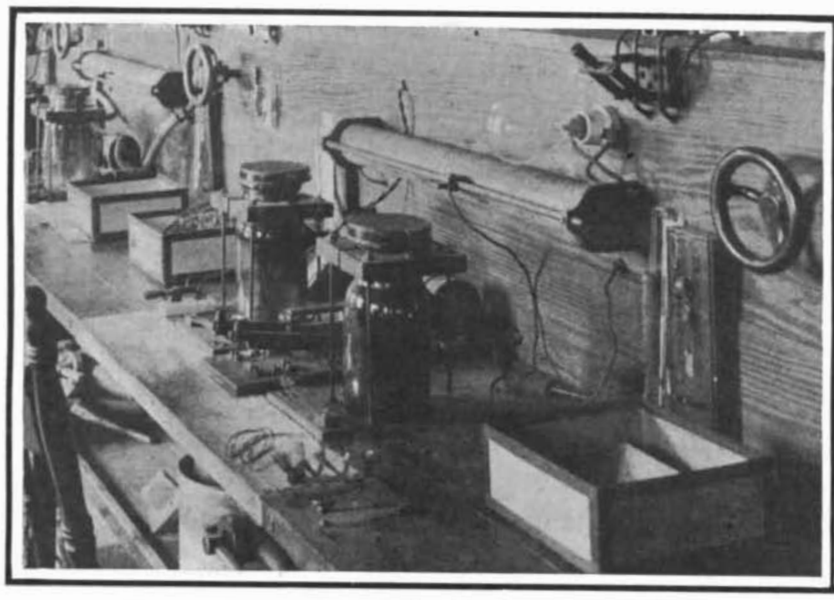
Carbons are treated in glass jars or vessels, electrically connected through the cover of the jars, through which a vacuum is drawn. When the vacuum has been produced, an electric current is turned through the carbons under test for the purpose of heating them. The temperature of the carbon is gradually increased until a pure carbon has been formed by the electrical vaporization of gas, derived from gasoline injected into the vessel. At this moment, when the filament under test is burning at a high temperature, the smallest parts of the filament are naturally glowing with the greatest heat. This attracts the newly-introduced carbon, which deposits itself in the parts of the filament possessing the greatest temperature. In this manner the cavities are filled out and the filament brought to an equal diameter throughout its length. When the filament under treatment shows the desired resistance, the current and gas flowing into the vessel are automatically cut off. After each filament has been tested and inspected it is passed on to the mounting department, where it meets a glass tube blown as a stem. This tube is flanged at one end and flattened at the other with a piece of platinum extending through the flattened end. To this platinum are joined two copper outleading wires. Platinum wire is the best material to which a filament can be attached, since it has a greater power of heat resistance than any other known metal. But platinum is very expensive. Its cost is seldom less than $27 an ounce, and it sometimes advances as high as $42.

The carbonized filament is next attached to the platinum ends of the wire, and then the stem with its wires and filaments is ready for insertion and sealing into the bulb. But before this sealing operation, the stems and their filaments are again "flashed" as a final test.

After the bulbs have been unpacked on their arrival at the lamp factory, they are washed internally with cold filtered water to remove the bluish cast which, from a cause unknown to lamp makers, comes in bulbs and must be eliminated before an undimmed light can be procured.

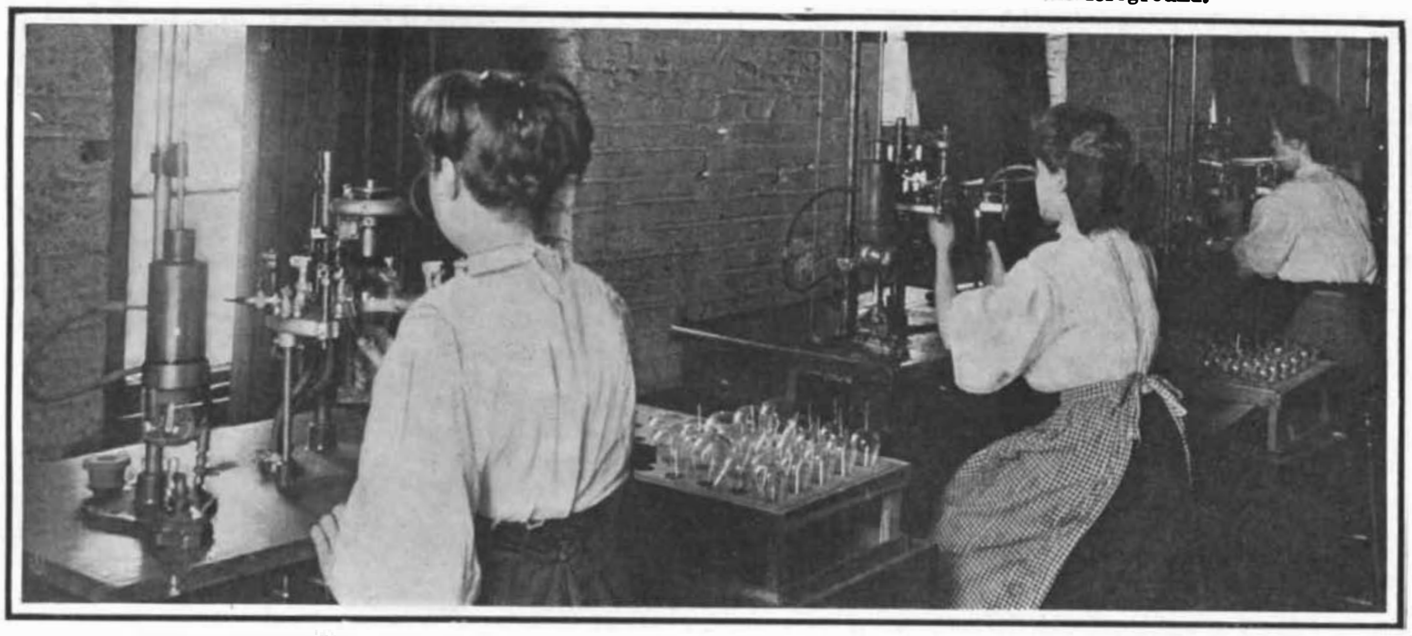
When the bulbs have been dried they are brought, in racks of fifty, to the tubulating machine, which first, by means of an air-driven jet of flame, melts a hole in the top of the bulb and, when this bulb has been set in another mechanical socket, drops a small tube through a magazine channel on the spot in the glass that was melted through. This tube and

(*Concluded on page 100.*)

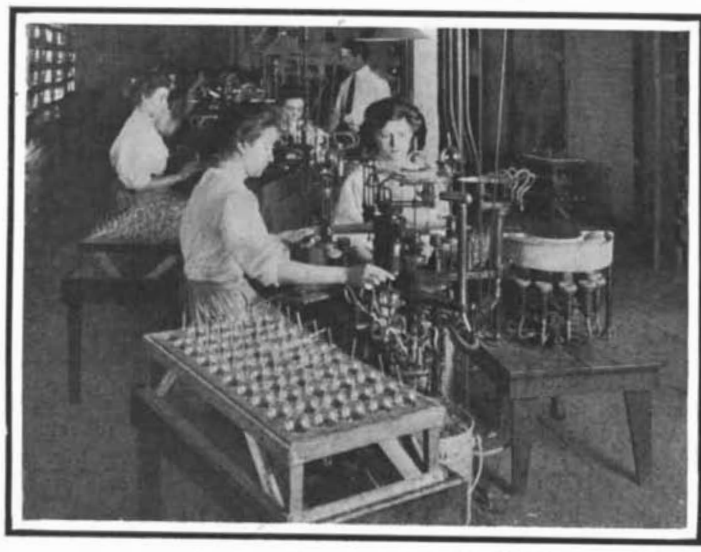


Treating machines for carbonization and equalization of filaments.

Pasting and straightening tables—straightening in the foreground.



The "tubulating" m chines melt a hole in the top of the bulb and attach a small glass tube thereon.



Sealing the stems into the bulbs.

Placing the threaded brass colla s on the necks of the bulbs.

ELECTRIC LAMPS IN THE MAKING.

the practicability of his machine. Soon after he started up again, Bleriot passed Toury and Dambron. As he came in sight of Artenay, which was the half-way point of the cross-country flight last year, a rather strong wind from the west caused him to make a semi-circle. He flew sufficiently high to clear the telegraph wires and then came to earth on the selected spot at Croix-Briquet-Cheville. The start was made at 4:44 A. M. and the landing took place at 5:40. Deducting the 11-minute stop, the net time was 45 minutes and the distance 41.2 kilometers (25.58 miles). The average speed was therefore 34.1 miles an hour. In making this flight Bleriot received a prize of 5,000 francs as pilot and 4,000 francs as constructor. The motor manufacturer received 3,000 francs and the designer of the propeller 2,000 francs. All these prizes are conditional upon the performance not being beaten before the first of next January. The practicability of Bleriot's machine is shown by the fact that 35 minutes after he had alighted the machine had been taken apart and shipped back to his factory at Neuilly, near Paris.

M. Bleriot's two latest aeroplanes have been illustrated and described heretofore in our columns, but it would perhaps be well to give the particulars of these machines again at the present time. The spread of the "No. XI." is 7.8 meters (25.58 feet) and the length of the body 7 meters (22.96 feet). The lifting surface is 14 square meters (150.69 square feet). The machine is equipped with a 3-cylinder Anzani air-cooled motor which weighs 60 kilogrammes (132.27 pounds) complete in running order. A 2.1-meter (6.88-foot) diameter Chauviere wood propeller is driven direct from the motor. Complete with Bleriot (whose weight is said to be 195 pounds) and with fuel sufficient for a two-hour run, the "No. XI." machine weighs but 300 kilogrammes (661.38 pounds). It rises in the air at a speed of 55 kilometers (34.17 miles) per hour when the surfaces are loaded to the extent of 22 kilogrammes per square meter (4.46 pounds per square foot). This is about double the weight carried per square foot of surface by most bi-planes. It is probable that this machine, which is the smallest and lightest that Bleriot has built, is able to raise even a greater weight. It might perhaps carry an extra passenger, although this has not yet been tried. The plane is said to be warpable, somewhat similar to those of the Wright bi-plane. Consequently, there are no wing tips. The "No. XII." monoplane, on the other hand, has rectangular balancing planes attached to the body framework just below the aviator's seat. It is somewhat surprising that planes so near the center of the machine will work satisfactorily for this purpose, but photographs of the "No. XII." making a turn show that it tips very little. Bleriot has two vertical surfaces on each side of the body at the front end and he has also covered the framework about half way back to the rear end and placed a fin keel above it. As a result of all this vertical surface the machine does not tend to skid very much in making a turn, and consequently it does not have to be tipped inward to counteract the effects of centrifugal force.

The "No. XII." monoplane has a spread of 9 meters (29.52 feet) and a surface of 22 square meters (236.8 square feet). It is equipped with an 8-cylinder V-type E. N. V. motor of 30-35 horse-power. The total weight of the monoplane in running order with water in the radiator, but without fuel, is 350 kilogrammes (771.61 pounds). With Bleriot, Santos Dumont, and A. Fournier on board, and with 16 kilogrammes (35.27 pounds) of fuel, the total weight was 560 kilogrammes (1,234.58 pounds). Therefore this machine, which weighs only 350 kilogrammes (771.61 pounds) carried a dead weight of 210 kilogrammes (462.97 pounds). The total weight lifted per square foot in this instance was 5.21 pounds—an altogether unprecedented amount. The machine rises at a speed of 55 kilometers (34.17 miles) per hour with 25 kilogrammes per square meter (5.12 pounds per square foot) loading of its single surface. The weight lifted per horse-power varies from 35 to 41 pounds, according to whether the motor is taken as developing 35 or 30 horse-power. This monoplane is therefore by far the most efficient aeroplane flying machine that has ever been constructed.

After his record flight M. Bleriot was presented with a gold medal by the Aero Club of Great Britain and also by the Aero Club of France. A few days before, he and Gabriel Voisin had been awarded the Osiris prize, which is given every three years to the men who make the greatest advance in science. He was also decorated with the ribbon of the French Legion of Honor, as were the Wright brothers. In addition to winning the prize of the London Daily Mail ($5,000), Bleriot also won a prize of $2,500 offered by a French wine firm two years or more ago. The Alaska-Yukon Exposition has put up a prize of $25,000 for a race between Bleriot and the Wright brothers.

ELECTRIC LAMPS IN THE MAKING.

(Concluded from page 89.)

the bulb are then joined together. The operation is known as "tubulating," and the tube thus made temporarily a part of the bulb furnishes the means for the removal of the air inside at almost the final stage in the manufacture of the lamp.

With the filament now made and the bulb washed, cleaned, dried, and tubulated, the filament-bearing stem and the bulb proper are assembled at one machine. The operation of sealing these two parts can best be likened to inserting a stopper in a bottle; the bulb being the bottle, and the stem the stopper. A girl inserts this stem into the neck of the bulb, and both parts are revolved on the sealing machine into jets of flame, where they melt together. Knowing the exact amount of glass that must be melted away and the shape the molten glass will assume when it cools, the operative is able to unite the stem and bulb skillfully.

Then the bulb goes into another tray along with other bulbs, and is taken to a girl in the vacuum room. This girl is seated before an earthen pot in which there is a bubbling liquid—phosphorus in a liquid state—which is kept stirred by a jet of water. She takes the bulb, and with a brush hardly larger than a knitting needle coats the air-extraction tube with a phosphorus solution.

After this the bulb is ready for the exhaustion of the air and final sealing. Already the air has been drawn from the bulb several times in the processes of manufacture, but each time the bulb has been left unsealed. It is now ready for the final air test. The tube at the big end of the bulb, through which the air is withdrawn by a most ingenious pump, is to be sealed by melting.

When the bulb is placed in position for exhausting the air, the wires running through the neck are connected with an electric current, which causes the filament to glow. If it were allowed to glow more than a few seconds with oxygen present in the air, the filament would burn up and collapse. So, while the tube is connected with the vacuum pump, the operative touches it with a blue flame spray which melts bulb and stem apart, and the melted end next to the bulb draws up and closes automatically, leaving the little point seen in the finished bulb over your desk or table. Before the sealing is completed the light within the bulb has a bluish cast, and this reveals the fact that all the oxygen has not yet been withdrawn from the bulb. It is then that the coating of phosphorus in the air extraction tube plays its part. The heat upon the tube converts the phosphorus into a phosphorescent gas, and this gas, entering the bulb, neutralizes the oxygen in the bulb. Almost instantly the color of the bulb changes from blue to white. In this manner the operative

(Concluded on page 101.)

knows that the effect of the oxygen has been overcome.

The bulb is next taken into the photometer room for the purpose of making final tests. It is a large dark room divided into several small stalls. In each stall is an induction coil, from which the bulb is held about two feet away. The induced current from the coil passes through the body of the operator to the bulb, and causes the filament to glow faintly. If the glow is bluish gray, it shows that there is still a leak somewhere; although it may be so infinitesimal that it can scarcely be measured by mils. If the glow is of a purplish hue, it shows that there is air still within the bulb and that the bulb must be further exhausted. This means an operation involving many more handlings.

The next process is the measurement of the bulbs for voltage, a work of the greatest possible delicacy. Two girls, working together, do the measuring. One places the bulb in connection with a current that lights it, and the light from it shines through a small aperture upon a white paper screen. In the center of this screen is a faint star-shaped spot. It requires a certain voltage in the light to bring out this spot.

When bulbs pass the tests and measurements successfully, they are then ready for the appliances with which they are attached to the current-carrying fixtures in general use. They are taken to another part of the factory, where a girl places them in a tray. Threaded brass collars are placed about the necks, and the space between the collars and the necks is filled with plaster cement. The tray revolves through a heating oven that bakes the cement into a hard and holding mass. The ends of the wires running through the necks are cut off; small round brass plates are placed on the ends, the wires are soldered fast, and the lamp is completed.

Once more there is a sort of farewell test for leakages that may have escaped notice or may have developed from the last handlings. This final test is very quick and simple. The sealed ends of the bulbs are held against two electric poles. If the lights are white and perfect, the lamps are considered ready for the last cleansing of the glass, classification, and shipment. Throughout the entire process of development of the bulb into a perfect lamp there are scarcely ever any broken. This is really remarkable when it is remembered that the bulb is not only picked up many times and placed in machines, but is heated and cooled many times.

THE FIGUREHEAD AND ITS STORY.

(*Concluded from page 92.*)

other meaning of the word dragon denotes watchfulness, so that it is not surprising to find that the *drakkars*, or dragon ships of the Vikings, generally belonged to their chieftains and were the largest ships in their fleets. The next largest were generally *esnekkers* or "long serpents" with snake figureheads. In both cases the hull of the vessel played the part of the monster's body, the stern often terminating in a representation of its tail. But although the dragon and serpent were the favorite devices they were not the only ones that did duty at this period as figureheads. When Sweyne, King of Denmark, made a descent on the Norfolk coast in 1004, his own ship "The Great Dragon" was made in the form of the animal whose name it bore, but the bows of the other vessels of his squadron were adorned with the figures of lions, bulls, dolphins, and men, all made of gilded copper.

After the Norman conquest the figurehead disappears from view for some centuries, and it is not until the reign of Henry V that we again find references to its use. Images of the saint after whom a ship was named used, it appears, to be sent on board in the time of Edward III, but there is no record of their having been utilized as figureheads. The reason of their temporary disappearance was the gradual changes in the status of navies and in the build of the ships of which they were composed. The fast oar-propelled long-ship, built only for speed and for war, gradually gave place to the round-ship, relying on her sails and built primarily for commerce and the conveyance of mail-clad nobles and their men-at-arms to the country where they intended to carry on a campaign. Fierce sea fights certainly took place from time to time, but for this purpose any ships that could be assembled together were utilized and prepared for action by the addition of stern and fore castles, built-up stages or platforms which overhung the actual stem and stern of the ships and left no place for a figurehead. In process of time the square bow platform or forecastle became triangular and its foremost extremity once more offered a suitable position for the figurehead. Gradually, too, the king became possessed of a certain number of ships of his own, the nucleus of a royal navy. These vessels, though occasionally hired out as merchant ships, were more or less elaborately decorated, and among other decorations the figurehead reappeared. Thus in the year 1400 the "Good Pace of the Tower" had a large golden eagle with a crown in his mouth as figurehead, and in representations of ships during the fifteenth century little, insignificant figureheads are here and there to be met with. The famous "Henri Grâce à Dieu," built in 1514, had a squatting lion as figurehead, while the big French man-of-war "Grande-Françoise," built at St. Nicholas de Leure in 1527, was decorated forward with a salamander above which was placed a statue of St. Francis. The Elizabethan men-of-war seem generally to have been ornamented with figureheads, but with some exceptions they were neither very large nor very noticeable. At this time a long, almost straight projection ran abruptly out from the bow of the ship a little way below the bowsprit. It was very different from the gracefully curved stem which in the seventeenth and eighteenth centuries replaced it and would not, in all probability, support any very great weight at its extremity. Still it often carried a figurehead of sorts. Thus the "Ark-Royal," Effingham's flagship in the Armada fight, had a mild-looking bird as figurehead. The "Bonaventure" and others had dragons on their beakheads; others had lion figureheads, one, at any rate, being gilded. The "Mary Rose" had a unicorn, the "Swiftsure" a tiger, while the "White Bear" was adorned with "an image of Jupiter sitting upon an eagle with the cloudes." In Holland the "Finis Belli," the earliest ironclad, bore the figure of a man in armor at her bow. About the time of James I equestrian figures were introduced as figureheads, and in succeeding reigns these were surrounded with other figures, forming a most elaborate bow decoration. Thus the famous "Sovereign of the Seas," launched in 1637, had on her beakhead the figure of King Edgar on horseback trampling upon seven kings. The figurehead of the Commonwealth ship "Naseby" was equally exuberant, consisting as it did of the Protector on horseback "trampling upon six nations." It was evidently a colorable imitation of that borne by the "Sovereign of the Seas." Curiously enough this was the ship in which Charles II returned to England at the Restoration. In honor of this she was renamed the "Royal Charles." She was fitted with a new figurehead, which is now in the museum at Amsterdam, the ship having been captured by the Dutch when they came up the Medway. Furtenbach in his "Architectura Navalis," published a few years earlier, gives an engraving of a very peculiar figurehead which terminated the beakhead of a Turkish pirate brigantine of a class known as *caramunzels*. It is probably intended to represent a drag-

(*Continued on page 102.*)