

The only presses, of which the committee has knowledge, now commercially used are those of George A. Lowry, of Boston, Mass., and Magnus Swenson, of Chicago, Ill.

THE WELSBACH LIGHT.

[*Being the report of the Franklin Institute, through its Committee on Science and the Arts, on the exhibit of the Welsbach Light Company, of Gloucester City, N. J., referred by the Bureau of Awards of the National Export Exposition. Sub-Committee.—Arthur J. Rowland, Chairman; C. A. Hexamer, Wm. McDewitt, Frank P. Brown, Moses G. Wilder.*]

HALL OF THE FRANKLIN INSTITUTE,
[No. 2130.] PHILADELPHIA, May 2, 1900.

The Franklin Institute of the State of Pennsylvania for the Promotion of the Mechanic Arts, acting through its Committee on Science and the Arts, investigating the merits of the Welsbach Light, which was referred to the Committee by the Jury of Awards of the late National Export Exposition, 1899, reports as follows:

The procuring of artificial light by some means other than using the flame of burning carbonaceous material in the ordinary candle, lamp or gas burner, has been the aim of many investigators. As a result of this endeavor, we find on the one hand lamps in which carbon is heated to a point where it gives off light—or becomes incandescent—as by the passage of an electric current through an incandescent filament or arc lamp crater; or, on the other hand, lamps in which the incandescence of certain substances (oxides of certain of the elements for the most part) is produced by the application of a heating flame or the passage of an electric current to raise their temperature. Of these latter burners, the development of those using a heating flame applied to produce incandescence of rare earths is the particular thing dealt with in this report, but it seems impossible to avoid a mention of others when giving an outline of the chain of discoveries and inventions leading up to the Welsbach light of to-day.

It is probable that Drummond is one of the earliest discoverers of the fact that heated oxides of certain elements incandesce. Certainly he made the first practical application of the fact. Every one knows of the Drummond or lime light which has been so commonly used in the projection lantern. A piece of lime, or better, a piece of oxide of magnesium, or, most refractory of all, a piece of oxide of zirconium, has an oxyhydrogen flame play upon it and is thereby heated to a temperature at which it incandesces and gives off an intensely-bright white light. Lieutenant Thomas Drummond, in the English government service, made this discovery in 1826, and used it in connection with his heliostat in surveying work, and afterwards proposed the same arrangement for lighthouse service.

In 1868, Le Roux, Professor at École Polytechnique, Paris, discovered that a brilliant incandescent light might be procured from a rod of lime or magnesia, by heating it until an electric current passes, this afterward maintaining the light.

In 1879, Jablochkoff patented the use of a piece of kaolin as a source of light, making it incandesce by passing an electric current through it. He had noticed that the kaolin he had placed between the carbons of his arc lamp assisted the illumination.

These inventions show something of the development of knowledge regarding materials which might be made incandescent, and the means taken to make them incandesce.

Several years later, in 1881, W. M. Jackson (an American) invented the device of a lamp made of platinum, iridium or other materials non-oxidizable at high temperatures, in the form of wires of small section which were heated to incandescence by the use of a heating flame. He discovered that the finer his wires, the more intense the light produced. Here is a beginning of a mantle light.

In 1881, Charles M. Lungren, of New York, patented in the U. S. Patent Office an improvement in illuminating apparatus, which consisted in passing a non-luminous gas flame through a heater of clay or similar material highly

heated by jets of the non-luminous gas, and forcing atmospheric air through the heater and causing it to mingle with the non-luminous gas issuing in one or more jet flames against lime, magnesia, zirconia or similar material, producing incandescence.

In the same year (1881) Mr. Lungren filed an application in the Patent Office for a means of illumination which consisted in forming a filamentary body of refractory material, said body having the structural form necessary to envelope a gas flame and to be rendered incandescent by such flame.

This application, after allowance by the Patent Office, was permitted to lapse, and no patent was then issued.

Mr. Lungren, however, renewed his application in August, 1885, and the patent, which embodied improvements upon his unissued patent of 1881, was issued July 5, 1887 (No. 365,832). Subsequently, a second patent (No. 367,534), describing specific features of his incandescent lighting method, was issued to Lungren under date of August 2, 1887.

In the first of these patents Lungren describes his method of making refractory filaments for lighting composed of "lime, magnesia, zirconia, etc.," by preparing a plastic mass of these materials, or mixtures of them by kneading them with water, or preferably, a solution of a mucilaginous binding material, such as glue or gum, or other combustible material which will be consumed in the further treatment of the filament. When the mass is of the proper consistence, it is put in a press and the filament is obtained by expressing the material through a die. Immediately after their formation, and while still moist, the filaments are formed up into various shapes desired by bending or coiling over a mandrel of wood coated with plumbago, or other device, and then dried, when they are ready to apply to a support and to be used in connection with a gas flame, in substantially the same manner as the well-known Welsbach mantle.

The Lungren incandescent lighting system was the subject of investigation by the Committee on Science and the Arts of the Franklin Institute in 1891. Prolonged practical

tests of the Lungren filaments showed that they possessed unusual life duration in service, with satisfactory lighting quality, and the award of the John Scott Legacy Premium and Medal was made to the inventor.

For reasons unknown to your committee, this promising invention was never commercially exploited.

The next year (1882) a Frenchman, Charles Clamond, invented a lime light operated without oxyhydrogen flame by intensely heating the air used and directing the flame of his air and gas mixture against the refractory oxide chosen. He knew of the possible use of certain other metallic oxides to produce an incandescent light, and even invented a basket or mantle of magnesia threads, supported in an enclosing platinum mantle of small wire and large mesh, which was hung below the lamp and the heating flame directed down into it. The threads were made from magnesia which was calcined and pulverized, then made plastic by mixing with salts of magnesia, which may be afterwards decomposed by heat, then squirted through a die, woven into a basket form and dried and baked.

In 1885, Otto B. Fahnehjelm, a Swedish inventor, secured an American patent (see U. S. Patent No. 312,452, February 17, 1885) for an incandescent light which consisted in the combination with a suitable gas burner and a shade holder of means for suspending an incandescent body in the flame of the burner, and for adjusting the incandescing body horizontally and vertically in relation to the flame. The Fahnehjelm light consisted substantially of a series of rods of calcined magnesia, resembling the teeth of a comb, held in a suitable frame and suspended in a non-luminous flame of gas.

In 1886, Galopin and Evans (in Australia) produced a lamp burning hydrocarbon vapor mixed with air to produce a heating flame, directed downwards into a woven platinum mantle, which was thus made incandescent.

About this same time, or even a little earlier (1885), Carl Auer von Welsbach announced the invention of a lamp in which the rare oxides of lanthanum, yttrium, zirconium, etc., in a finely divided condition, were rendered incandes-

cent by heating to a high temperature. The source of light was a light network of cotton thread impregnated with a solution of the salts of the combined nitrates, oxides or bromides. After being saturated with these, upon exposure to heat, the supporting cotton network was burned out, the salts converted into the oxides and a skeleton hood or cap thus prepared, which would incandesce when a heating flame was applied to it.

The absolute originality of this form of mantle and method of manufacture should be carefully noted.

The nitrates of the metals, being very soluble, were especially adapted to the process, although sulphates, iodides or bromides could also be used.

Welsbach found that this mantle, as it came to be called almost from the first, could resist the action of all atmospheric air fit to breathe for an indefinite length of time, was not changed by exposure and would remain effective for a long time.

For the next five years or more von Welsbach was constantly at work making elaborate investigation of the properties of all oxides of metals which would incandesce when used separately, and when combined in various mixtures. He invented processes whereby the salts of the metals required for impregnating mantles might be prepared from the natural ores, originated means for strengthening the frail mantle, arranged the mantles for transportation in safety, and perfected many details making the lamp practical.

It is interesting to notice that the form of mantle and the general process of manufacture have remained up to the present precisely as von Welsbach originally planned them, without improvements or essential modification of any kind.

One or two of the discoveries of von Welsbach are necessarily mentioned a little in detail, to explain the magnitude of the investigations he conducted and the sort of results he procured.

A patent No. 409,531, August 20, 1889, explains that the illuminating power is greatly increased by adding thorium

oxide; that lanthanum oxide without sufficient thorium oxide crumbles when incandescent—with it the mantle becomes flexible. Later he found (patent No. 563,524) that thorium oxide, by the addition of a small per cent. of uranium or cerium oxide, has a very high illuminating power, producing a vivid and nearly white incandescent light, in spite of the fact that thorium oxide alone radiates little light which is yellow in color, and that uranium oxide alone radiates little light, and it is yellow reddish. Still later, he discovered that the illuminating power of lanthanum, cerium, yttrium, zirconium and other metals of the refractory earths is greatly increased by the addition of thorium oxide (ThO_2); that cerium not only gives a yellow light (very desirable color), but greatly increases the life of the mantle, causes it to hold its shape better, and makes it in every way stronger and more durable.

Thus we get a slight idea of the elaborate researches conducted by Dr. von Welsbach, and of the many difficulties which had to be overcome before the Welsbach mantle could become practical and commercial.

To complete the story of lights procured by the incandescence of metallic oxides, mention should be made of the lamp invented by Prof. Walther Nernst, of the University of Göttingen, early in 1899, the substance rendered incandescent being a magnesia rod through which an electric current is passed after preliminary heating. Not only is this light related to the same group as the Welsbach, not only does it give a very modern illustration of a sort of lamp mentioned earlier in the report, but (most interesting of all) in his latest work Nernst gives up the magnesia and uses the same mixtures of oxides as used in the Welsbach mantle—zirconium, thorium, cerium, erbium, etc.

A very brief description of the lamp and mantle made for use with illuminating gas by the Welsbach Light Company, of Gloucester, N. J., will give the best idea of present methods, and serve to bring out some important points with reference to the light-giving power, durability and economy of the mantle as put on the American market. The Welsbach "J" mantles (standard until very recently)

were made about as follows: A six-cord cotton thread was woven on a knitting machine forming a tube of knitted fabric of rather open mesh. This web has the grease and dirt thoroughly washed out of it, is dried, then cut into lengths double that required for a single mantle. It is then saturated in the fluid (described later), wrung out, stretched over spools and dried. Next, the double length pieces are cut into two, the tops of each piece doubled back and sewed with a platinum wire which draws the top in and provides a means of supporting the mantle when finished from the wire holder. After stretching the mantle over a form, smoothing it down and fastening the platinum wire to the wire mantle holder, the mantle is burned out by touching a Bunsen burner to the top. The cotton burns off slowly, leaving a skeleton mantle of metallic oxides, which are unconsumed, and which preserve the exact shape and detail of every cotton fiber. The soft oxides are then hardened by a Bunsen flame. During burning out and hardening, considerable shrinking takes place. This finishes the process, except the immersion of the mantle in crystalline, to prepare it for transportation, after which it is trimmed and packed. The fluid in which the cotton webbing is immersed is procured from monazite sand, which yields in the finished mantle oxides of thorium and cerium.

The candle-power of mantles of the sort mentioned is about 75 initial candle-power under gas pressure of Philadelphia illuminating gas. This means 20 candles per cubic foot per hour (an ordinary 8-foot fish tail burner gives not over 3 candle-power per cubic foot per hour). The life of the mantles is probably not much below 1,000 hours. The candle-power drops quite rapidly at first and more gradually afterwards, going as low as to one-half the initial candle-power before the mantle breaks.

It is hard to tell how much the perfection of detail in burner construction, a proper selection of chimney, and artistic features of design have contributed to procure the very large commercial use of the lamps. Without proper burners the mantle would be of small value. The details of the common burner, the peculiarities of which make it

different from the ordinary Bunsen burner in adjustment of gas and air; the gauge distributing device to spread the flame over the whole mantle and so fill the mantle are too well known to merit detailed description.

The mantle first made in America, in 1888, gave only 35-40 candle-power initial, under 10/10 pressure, using 3 to 3.2 feet of gas on 3-inch mantles, and under ordinary conditions not over 8 candle-power per cubic foot of gas used.

The new mantle, known as Balm Hill or, popularly, "Yusea" mantle, has a much more open mesh than the "J" mantle, and is made on lace-making machinery. It is thus supposed to be much stronger than the older mantle, and gives about 100 initial candle-power at the mantle when the gas and air are properly adjusted in the burner. Your committee has been unable to gather data of life or decline in candle-power in time to include them in this report.

Certain defects in the mantle light should not be entirely passed over. The mantle is exceedingly fragile and cannot be made to stand where it is subject to continued vibration; the quality of the light is such as to require the adjectives cold, ghastly, harsh, in describing it; and often a greenish tinge in the light is evident. The candle-power drops badly early in the life of a mantle, and is especially subject to this trouble where there is much dust in the air; the oxides seem to volatilize slowly from the mantles, as evidenced by the shrinking in size of strands of mantle and the white deposit on chimney, for platinum melts easily in the part of the flame where the mantles hang.

If the mantle breaks, a hole being thus produced in it, the hot flame strikes out through this, often breaking the chimney and as a secondary result destroying the mantle itself.

On the other hand, the advantages in the use of the mantle for lighting are shown not only by statements already made, but also by the fact that artificial lighting has been profoundly affected by the commercially-successful mantle. We have systems of lighting using mantles now in which the source of the heating flame is gas, gasoline, kerosene. There are systems using Welsbach mantles in

which pressure of large amount, and others in which low pressure is used. There are two great companies, the Welsbach Commercial Company and the Welsbach Street Lighting Company, that do an enormous business and deal only with the use of the Welsbach mantle in lamps using ordinary illuminating gas.

The patents held in this country by the Welsbach Light Company are very broad and fundamental, and have to do with all sorts of details of the system as well. The numbers of the patents of most importance are given below.* Over fifty in all were submitted to your committee. Some of these are not to Welsbach, and yet are for processes of importance in the manufacture of the present American-made mantle and lamp.

In consideration of the enormous advance in the art of artificial lighting made possible by the invention of the Welsbach mantle, the Franklin Institute awards the Elliott Cresson Medal to Dr. Carl Auer von Welsbach, of Vienna, Austria, for his discoveries regarding the metallic oxides which may become incandescent when heated, and for the invention of a mantle by the use of which these metallic oxides are commercially available as sources of artificial light.

*359,524,	March 15,	1887.	Carl Auer von Welsbach.
377,698,	Feb. 7,	1888.	" " " "
377,699,	" 7,	"	" " " "
377,700,	" 7,	"	" " " "
377,701,	" 7,	"	" " " "
390,057,	Sept. 25,	"	Harold J. Bell.
396,347,	Jan. 15,	1889.	Carl Auer von Welsbach.
399,174,	March 5,	"	" " " "
403,803,	May 21,	"	" " " "
403,804,	" 21,	"	" " " "
407,963,	July 30,	"	F. L. Rawson and W. Stepney Rawson.
409,528,	Aug. 20,	"	Carl Auer von Welsbach.
409,529,	" 20,	"	" " " "
409,530,	" 20,	"	" " " "
409,531,	" 20,	"	" " " "
438,125,	Oct. 7,	1890.	" " " "
463,470,	Nov. 17,	1892.	" " " "
563,524,	July 7,	1896.	" " " "
26,075 (design),	Sept. 22,	1896.	Geo. S. Barrows.

Also, in view of the many details wrought out by the Welsbach Light Company, of Gloucester, N. J., in putting a thoroughly practical mantle on the market, the Franklin Institute awards to them, the said company, in addition, the Edward Longstreth Medal of Merit.

Adopted at the stated meeting of the Committee on Science and the Arts, held Wednesday, June 6, 1900.

JOHN BIRKINBINE, *President.*

WM. H. WAHL, *Secretary.*

Countersigned by

H. R. HEYL,

Chairman of the Committee on Science and the Arts.

CHEMICAL SECTION.

Stated Meeting, October 25, 1900.

THE USE OF BLAST FURNACE GASES IN GAS ENGINES.

BY PROF. JOSEPH W. RICHARDS,
Member of the Institute.

Practical gas engines were first put into operation by Otto, in 1870. They were for many years made only of small powers, 1 to 10 or, at most, 20 horse-power. The fuel used was illuminating gas, which has the high calorific power of 4,500 to 5,000 calories per cubic meter. About 1886, experiments showed that weaker gas could be used, and that if the gas and air mixture was strongly compressed in the cylinder before explosion, the ignition never failed. This gave rise to the running of gas engines by producer gas, particularly that made by the auxiliary use of steam, and therefore carrying considerable hydrogen. Such gas is in reality a mixture of normal producer gas with water gas; it is sometimes called Dowson gas, after the Dowson producer. It may carry 5 to 15 per cent. of hydrogen, and its calorific power vary between 1,000 and 1,500 calories per cubic meter. The use of this gas in large engines, up to 200 horse-power, gave an efficiency of 1