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Acetylene Gas; Its Preparation and Value as an Illuminant

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Acetylene was first described and some of its properties were demonstrated in 1836, by Edmund Davy at a meeting of the Royal Dublin Society. For more than twenty years from this time nothing of importance developed concerning the gas till in 1859, Berthelot began a series of researches upon its formation and properties. His work extended over four years and furnished much information as to its practical value. Acetylene has been made in the laboratory for a number of years; but not until Willson's discovery of the method of making Calcium Chloride by means of the electric furnace did it become of commercial importance.

The methods employed in the production of acetylene in small quantities for laboratory use are as follows. Ethylene bromide is decomposed by dropping it slowly into a solution of alcoholic potash, and purifying the evolved gas by washing it through a second flask containing a boiling solution of alcoholic potash. In the second method there is the usual process of passing the product of incomplete combustion from a Bunsen burner, the flame of which has struck back through an ammoniacal solution of cuprous chloride, when the red acetylide of copper is formed, and this being washed and treated with hydrochloric acid yields a stream of acetylene gas. Again a stream of hydrogen is passed through a receiver containing an electric arc; the hydrogen combines with the vaporized carbon from the pencils and forms acetylene.

The gas is composed of two atoms of hydrogen united with two atoms of carbon according to the formula C_2H_2 and analysis shows it to contain in every 100 parts 92.3 parts of carbon and 7.7 parts of hydrogen.

It has a density of 0.92 on the air basis; and when prepared from calcium carbide,has a pungent penetrating oder. Acetylene is easily soluble in water which, at normal temperature and pressure, absorbs about its own volume of the gas. Water saturated with salt abrorbs very little and is used when acetylene is collected and stored over a liquid seal.

Acetylene combines and forms explosive compounds with both copper and silver. It can be condensed to the liquid state by cold and pressure. At 82°C. it becomes a liquid with a pressure of one atmosphere. Its critical temperature is 37° C. It inflames spontaneously when brought into contact with chlorine gas; and if pieces of calcium carbide are dropped into water saturated with chlorine, the bubbles will spontaneously ignite on reaching the surface.

For its complete combustion acetylene requires twelve times its volume of air. In small quantities, incomplete combustion results with the formation of carbon, carbon mon-oxide, carbon dioxide, hydrogen, and water vapor.

A mixture of air and acetylene containing from 2 to 80% of the gas is explosive, the maximum explosive force being obtained with a mixture containing about 8% of acetylene.

The carbides of the various metals have been known for a number of years. Edmund Davy in his address before the Royal Dublin Society, on acetylene spoke also of potassium carbide.

In 1861 the German chemist Wöhler prepared calcium carbide by heating a mixture of carbon, lime and zinc. The substance, on contact with water, decomposed easily, forming acetylene and calcium hydrate. Carbide of calcium was not recognized as a substance of commercial importance until accidentally made by Willson in one of his electric furnaces while conducting some experiments upon the alkali earths. He made the first large quantity in May, 1892.

The furnace used by Willson had an outer coating of brick in which was a corbon crucible, resting upon an iron plate; the plate being connected with one pole of an electric-current generator. The other pole was connected with a large carbon pencil which was lowered into the crucible. The mixture of carbon and lime was placed in the furnace and the carbon pencil lowered until an arc resulted. The pencil was raised from time to time as the carbide was formed.

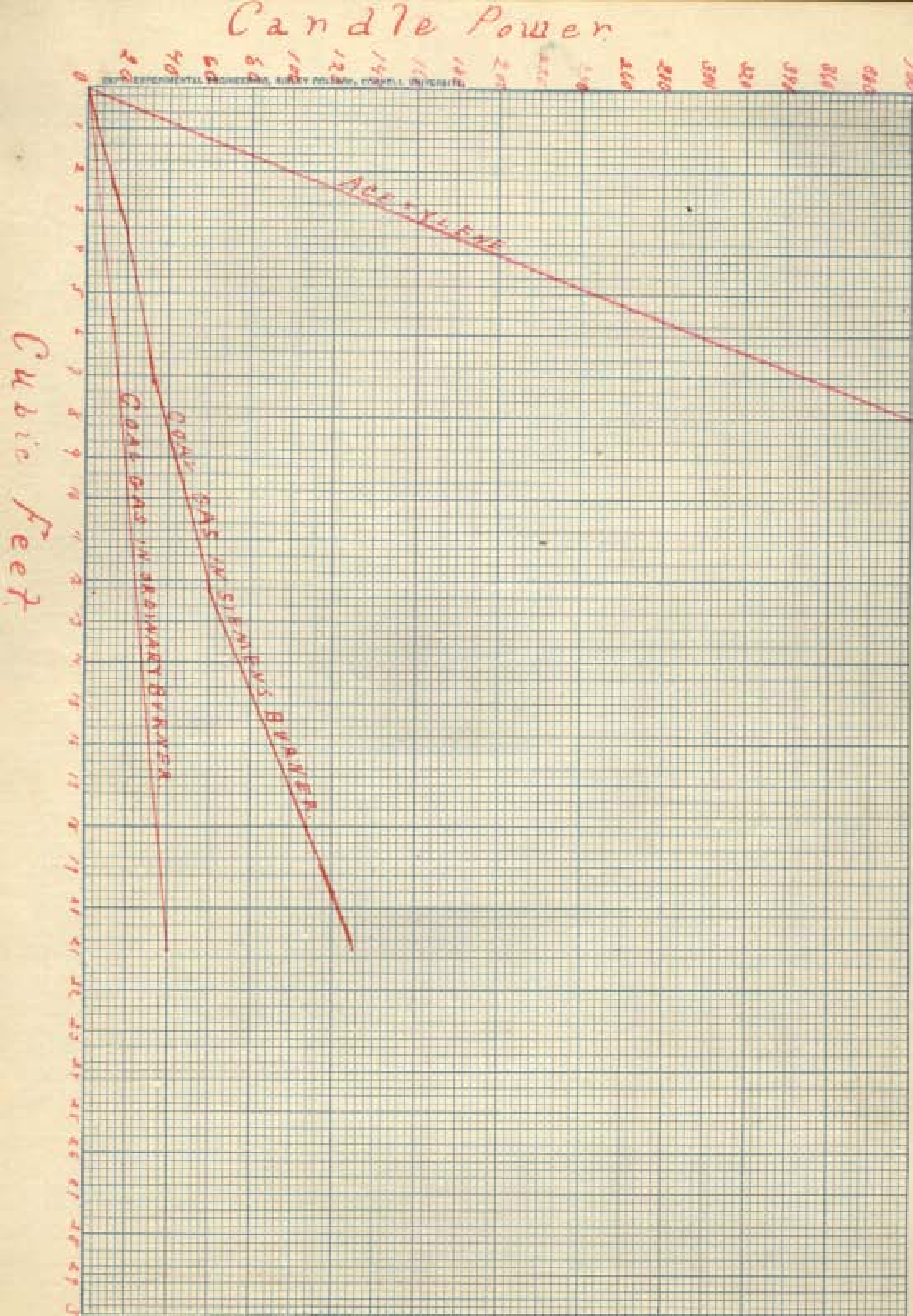
The carbide as first made for commercial purposes contained many impurities, which, upon contact with water, formed gases. These mixed with the acetylene not only lowered the candle power but in some cases made an explosive mixture, or one which might ignite spontaneously. The carbide upon the market to-day contains so few of these impurities that they may be overlooked. Carbide has a specific gravity of 2.26 and is very hard. It is disintergrated by moisture in any form, and is infusible at a temperature of 2,000°C. Acted upon by water it yields acetylene gas and calcium hydrate. The theoretical yield of acetylene from one pound of carbide is 5.9 cu.ft.; but in practice the yield is about 5 cubic feet. When carbide is acted upon by water, considerable heat is evolved, one gramme of carbide liberating 406. calories.

Many experiments have been conducted upon acetylene, the most noteworthy of which is that of liquefying the gas. This can be done by cooling it to -82°C., when it becomes a liquid at normal atmospheric pressure. When liquid acetylene is allowed to escape under great pressure into the atmosphere, a portion evaporates rapidly, taking enough heat from the rest to solidify it. Mercury may be frozen by this acetylene snow. Thrown upon water and a lighted match applied, the solid is changed into a gas and burns readily. Liquid acetylene is very dangerous and explodes if confined in metal tanks, upon receiving a shock of sufficient strength to generate a spark.

As the luminosity of all hydrocarbon flames depends upon the formation of acetylene at the burner, the value of burning the gas in its pure state will be seen at once. My experiments in the physical laboratory show that the illuminating power of one cubic foot of acetylene is twelve times that of one cubic foot of ordinary illuminating gas. The vitiating products of combustion produced by burning one cubic foot of acetylene are greater than those produced by burning one cubic foot of coal gas; but compared candle power for candle power, acetylane off by far the smaller amount. The following table will contrast the products of combustion of ordinary coal gas with those of acetylene. The table also gives the number of adults who would exhale the same amount of carbon dioxide.

Burner	candle power.	cubic feet of gas.	carbon dioxide produced.	adults
Flat flame No. 6	48	19.2	10.1	18.8
" " " 4.	48	25.3	13.4	22.3
London Argand	48	15.	7.9	13.1
Acetylene	48	1.	2.	3.6

The accompanying diagram will show the candle power of acetylene as an illuminant on the basis of 30 C.P. per cubic foot, compared with the candle power of ordinary coal gas.


Candle Power
Cubic Feet
ACETYLENE
COAL GAS IN SIEMENS BURNER
COAL GAS IN ORDINARY BURNER

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If coal gas costs \$1.25 per 1000 cubic feet, the same amount of acetylene would cost \$8.00; but whereas 1000 feet of common gas gives 3,200 candle power hours of light, the same quantity of acetylene produces 50,000 candle power hours. From this it will be seen that 1,000 C. P. hours of coal gas costs 39¢ and 1,000 C. P. hours of acetylene 16¢. Incandescent lights cost 62 1/2¢ per 1,000 C. P. hours. This makes a saving of about 60% in favor of acetylene over coal gas and 75% over the incandescent.

The danger of explosions incident to the production of acetylene from calcium carbide for illuminating purposes are as follows;

1. Overheating of carbide with the gas about it confined under pressure.

2. Low ignition temperature of the gas which ignites at 480°C.

3. The extreme rapidity with which a flame is propagated under pressure.

4. The wide limit of explosibility together with the shattering character of the explosion.

5. The formation of acetylides of copper and silver, which are very explosive.

Compared with common gas, acetylene is by far less poisonous. It does not act on the haemaglobine as coal gas and carbon-monoxide do, but seems to be neutral in its action. The intoxi ting effect is very much less; and when carbon-monoxide and coal gas may not be noticed in the air, acetylene by its penetrating oder may be easily detected. The danger of asphyxiation is greatly diminished when acetylene is used for home lighting, because only 1/2 a cubic foot per hour escapes from an acetylene burner of 25 C.P. and 5 cubic feet per hour escapes from an ordinary coal gas burner of 16 C.P. Experiments upon the poisonous properties of acetylene prove that of the same amounts of acetylene and coal gas, the acetylene is not one-half so harmful as the coal gas.

A great deal of the safety in handling acetylene gas, or calcium carbide, for illuminating purposes depends upon the generator used. An ideal generator should satisfy the following conditions;

1. Low temperature of generator.
2. Low pressure in every part of the apparatus.
3. Simplicity, such that an unskilled person can handle the apparatus without danger.
4. Economy in the production of gas from the carbide such that the maximum yield of gas is obtained.

Generators are devided into three classes; the wet process generator, the dry process generator, and the plunger. In generators of the first class the water is allowed to rise in volume till is comes in contact with the carbide. The evolution of gas is regulated by the water being driven back from the carbide as the increase of pressure in the generating chamber becomes greater. In those of the second class the water is by several devices allowed to drip, or flow, in a small stream, upon a mass of carbide, the evolution of gas being regulated by controlling the water supply. In the plunger the carbide is dropped into an excess of water.

The wet process generators are the most dangerous because the gas is generated in such a way that a considerable pressure may sometimes be found in them. The plungers are the safest, but require more care and attention than the others; therefore are used very little. The dry process generators are the most used and are the simplist, most compact, and most easily worked. Experiments with a "Criterion" generator, one of this class, in the physical laboratory of the College, show that this generator fulfils all the conditions of a first-class machine. This type of generator is manufactured by J. B. Colt & Co., of New York, and is probably the most popular machine upon the eastern market.

Acetylene may be used in many ways. As an illuminant it has met with great success. It can be used with a special burner for laboratory purposes, giving by proper regulation, either an extremely smoky flame, a very bright one, or an intensely hot one. It is employed for optical projections with the best of results.

There are great possibilities for the practical application of acetylene; such as the lighting of railway cars, steamers and lighthouses. It is said that the calorific power of calcium carbide is so great that if it could be produced for one-quarter of the present cost, it might some day take the place of coal.