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PRACTICAL EXPERIENCE WITH ACETYLENE GAS.

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You are no doubt well acquainted with the theoretical side of Acetylene, which has been fully dealt with in nearly all the scientific papers of the day. A few words about its history are, however, necessary by way of introduction. This gas was first discovered by Edmund Davy in 1836, from a compound of potassium and carbon. In 1859, Berthelot, the well-known French chemist, discovered another way of making Acetylene, namely, by passing an electric current through a stream of hydrogen, and he gave the gas its present name, Acetylene. In 1862, Woehler made amorphous carbide of calcium. Since then eseveral methods of making Acetylene had been discovered, but, owing to the cost of the materials, no progress was made with the gas from a commercial standpoint.

It was not till Willson made his discovery at Spray, North Carolina, U.S.A., that the gas attracted general attention. Through Willson's discovery, Acetylene had become a practical illuminant—a commercial success. Willson discovered that, by taking sixty parts of lime and forty parts of carbon, intimately commingling the same, and submitting the mixture to the intense heat of the electric arc, an entirely new product—crystalline carbide of calcium—is formed.

This discovery was made in 1892, and it took till 1895, or nearly three years, to perfect the invention, and produce carbide of calcium successfully as a commercial article. It required much time and experimenting to arrive at the right proportions of coke and lime, the right amperage and voltage, the most suitable kind of limestone, the best form of carbon, etc. All these details had to be thoroughly thought out before the applications for the complete patents were made. In this connection it is rather amusing to watch the tactics of those on the outside of this business in their efforts to steal other men's brains for their own advantage. Statements are made by these people that the well-known French chemist, Moisson, also invented carbide of calcium, but, luckily for Willson, abundant evidence exists that his carbide was in the hands of such men as Lord Kelvin and other well-known scientists before Moisson announced his discovery It might be interesting on this point to quote from a lecture given before the Society of Arts, London, in November of last year, by Prof. Vivian B. Lewes, F.I.C., F.C.S., Chief Superintending Gas Examiner to the Corporation of the City of London and Professor of Chemistry at the Royal Naval College, Greenwich. "During the past few years," the lecturer said, "a wordy war has raged as to whether the discovery of the process by which calcic carbide is now produced, is due to the French chemist, Moisson, or to the Canadian experimentalist, Willson, and many still seem to imagine that it is the discovery of calcic carbide and Acetylene that is in question. In point of fact, our knowledge has advanced by little, save in details, since the labours of Davy, Woehler and Berthelot clearly defined the preparation and properties of this beautiful illuminant, and the only question in dispute is, who translated the preparation of carbide and Acetylene from the ranks of a laboratory experiment (and of mere scientific interest) to a commercial success." Carron, in 1860, obtained an alloy of calcium and zinc by heating lime and zinc to a high temperature, and Woehler made his calcic carbide by heating to a very high temperature a mixture of lime, zinc and carbon, which first formed the calcium zinc alloy, and then carbide, the zinc being volatilized. The compound which he obtained was impure, and very unlike the beautiful crystalline substance obtained at the present time.

It was Sir Humphrey Davy who first demonstrated the heat and light of the electric arc, and it was late in the seventies that Sir William Siemens inaugurated an entirely new era in experimental and metallurgical work, by patenting his electric furnace, in which the electrical energy could be converted into heat, thus yielding a temperature which had never before been available, and which has been estimated by Violle as approximating to 3,500 centigrade. As gradually the utility of the electric furnace began to be recognised, other patents were taken out. Bradley patented a furnace in 1883, while Cowles took out his patent in 1885, and in 1886 patented a lining of lime and carbon for the electric furnace, as being more refractory. Although these furnaces were used for making aluminium, large quantities of carbide of calcium were accidentally formed by the action of the heat on the furnace lining, and during 1886 and 1887 the lads employed in the works used often to amuse themselves in the dinner hour by putting water on the old crucible linings, and igniting the gas which was set free. Even before that date it was recognised and published that in the

Cowles electric furnace the oxides, not only of the alkaline metals, but of calcium magnesium, aluminium, silicon and boron, could be reduced in the presence of carbon, and could be made to form alloys with other metals present, while with aluminium and other metals the crystalline compound made with carbon could be obtained, and further, that silicon and the compound of silicon with carbon could be produced. It is clear, therefore, that as early as 1886 calcic carbide was made in the electric furnace, but its formation was merely accidental, and no commercial importance was attached to it.

Soon after this date, Willson conceived the idea of reducing aluminium in the presence of copper to make aluminium bronze, and he employed practically the same methods as that used by Cowles. But as his attempts to make the bronze were not successful and as he was unable to make aluminium owing to the Cowles patent, he endeavoured to reduce magnesium and calcium to the metallic state. It was in the spring of 1892 that he attempted to reduce lime by carbon, and he found that he obtained by this means a fused bath, the boiling of which caused the short circuiting of the electric arc. In order to prevent this spitting of the liquid, and the unequal loading of the dynamo which interfered seriously with the working of the machinery and water turbines, he added to it carbon, which prevented the splashing of the liquid against the sides of the electrode, the only portion of the surface exposed being in the immediate path of the arc.

It was in May of 1892 that carbide was obtained by Willson in quantity, and samples were forwarded by him to various scientific friends in America, and it was on September 16 of that year that he privately sent specimens of his carbide to Lord Kelvin with a letter—a copy of which the author had seen in Willson's letter book, and which amply proves that he was perfectly aware of the importance of the product. This was acknowledged by Lord Kelvin in a letter dated October 3rd, 1892. About this time M. Moisson was conducting his classical researches on chemical actions at high temperatures, using for his experimental work an electrical furnace almost identical with the one patented by Siemens in 1879, and while experimenting with calcium, he found that the vapours of the metal acted upon the carbon electrodes, forming calcic carbide in small quantities—a fact which he incidentally mentioned in a paper read before the Academie des Sciences on December 12th, 1892. This, however, contained no more of the germs of a commercially possible manufacture than had the discovery of calcic carbide by Woehler, of the attempts of Borchers to make calcic carbide in his experimental furnace which had extended from 1885 to 1891, and who had succeeded in making this body, though he had no idea of the importance of his investigations, which certainly were not of a practical kind. The history of the manufacture of the carbide was also added to in this year by Mr. L. Maquenne, who showed on October 17th, 1892. that barium carbide could be made by heating barium carbonate with magnesium in the state of powder and charcoal, while Mr. Travers, on February 6th, 1893, published his method of making carbide of calcium by heating a mixture of chloride of calcium with metallic sodium and carbon.

It is quite clear that, up to the end of 1892, it was Willson, and Willson only, who had made calcic carbide on anything like a large scale. Nothing would ever have been heard of this material on a commercial scale had it not been that he, in attempting to get capital invested in his process, came across several men of sound practical knowledge whose business instincts led them to grasp the possibilities of carbide and acetylene; and, no sooner had these commercial possibilities been noised abroad, than others began to try and make capital from them. In France, in 1894, Bullier took out a patent for the preparation of the carbides of the alkaline earths based on Moisson's researches. M. Moisson himself has never claimed priority in the manufacture of commercial carbide, and, indeed, while lecturing before the New York section of the Society of Chemical Industry, on October 26th, 1896, he distinctly stated that the credit of the first production of calcic carbide on a commercial scale, and the industrial utilization of acetylene, belonged to the Americans. It seems that, when this is shown on Moisson's own evidence, further comment is needless. The author could produce a number of other authorities who are all equally emphatic as to Willson's claims, but he would say no more on this point, as it will very shortly be found fully dealt with in the records of the Supreme Court; He would proceed at once to show you the different types of electric furnaces.

The illustration now before you is an exact representation of the furnace used by Willson when he discovered carbide of calcium at Spray. This type of furnace is now obsolete. It has been found impossible by its use to produce two samples of carbide alike, owing to the volatilization of the carbon. The difference in the amount of gas given off by different samples of carbide produced in these earlier furnaces had done the acetylene business much harm. Nothing so shakes the confidence of a consumer than to throw into his generator what he innocently supposes is first-class carbide, and to find that it gives no gas. The reason of this happening is, as already stated, that the whole of the coke has been volatilized in the furnace, and what the consumer has put into his generator is nearly all lime. This trouble has been got over in what is called the "continuous" furnace, illustrations of which he had unfortunately been unable to obtain.

He would now proceed to show the different forms of generators. The generator which you now see illustrated shows the earliest method employed in manufacturing the gas from the carbide produced by the electric furnace. It is one of the automatic type. You will notice here that the carbide is placed in the top of the holder, either on a grating or in a basket. Some makers put the carbide down through the top., securing it with a gas-tight joint; others put the carbide in the basket and hang it up inside the holder. As soon as the bell of the gasometer is put into place the air tap is turned on, allowing the holder to fall until the carbide touches the water, gas is immediately generated and the holder rises, taking the carbide with it. Unfortunately, there are important and undesirable complications connected with this method of producing the gas. To begin with, generation does not cease when the gas lifts the carbide clear of the water, the damp carbide goes on evolving gas, and if the lights are suddenly turned out in the building, the holder will keep rising until it is full, and then the gas will bubble out through the seal. The second trouble is that with the carbide being constantly lifted from the water, intense heat is set up. This results in the polymerisation of the gas, that is to say in a doubling up of the atoms of the gas, forming such products as styrolene, benzine, tar, naphtha, etc.; these substances deposit in the pipes and burners causing endless trouble. Then again the heat generates steam, which mixes with the gas and deposits water in the pipes. Any one using this form of generator is liable to have all the lights go out suddenly. There are many forms of this type, and they are known as "Wet Automatic Generators." It is safe to predict that in a few years it will be hard to find any of these machines. They are undoubtedly the worst form of acetylene generator yet introduced.

The next type of generator to be shown you is what is known as the "Dry Automatic Generator." In this the carbide is put into a cylinder—in the one before us this is at the side. Water is allowed to rise on to the carbide from the bottom. The gas passes up through the pipe into a coil in this particular case, and as soon as the pressure rises beyond that of the column of water it drives the water back. After being cooled in the coil, the gas passes out of the generator from the governor at the top. These are very unsatisfactory forms of generators, inasmuch all the troubles of polymerisation occur just as in the last-named class—the governors are constantly getting out of order, the pressure of the gas in the building is ever-varying, the consumer is always subject to the annoyance of the lights bobbing up and down, and the burners, from the effects of polymerisation already mentioned, are perpetually in need of attention. This particular form of generator has been thoroughly worn to death by inventors; one maker puts the cylinder on the side, another on the side upright, another on the side horizontally, another puts it separate from the generator altogether, and another inside the generator within a water jacket; in fact, the carbide containers have been dodged around the generator until there is hardly a place you can put them without infringing on someone else's idea.

These are a few of the different ideas.

In the form of generator now before you, you will notice the same carbide cylinder appears, but instead of the gas going into a coil and being regulated by a governor, it goes into a holder and is regulated by the pressure of the whole of the water seal. This is a much better form than the last, inasmuch as the gas can be turned down into the water to purify it somewhat, and there is no danger of any great pressure, the highest that can be got being the weight of the holder. But in this form also there is the same danger of polymerisation.

It is now acknowledged by all gas experts that the best results can only be obtained from carbide of calcium when it is kept cool during the process of generating the gas; just in proportion as the carbide gets hot are by-products formed which impair the illuminating quality of the gas and cause trouble and annoyance to the consumer. The automatic generators are largely used in England, but in other countries where acetylene has been longer in use, as in the United States or on the continent, the consumers invariably go in for non-automatic machines—that is to say, machines in which the whole of the gas is made at once, the charge of carbide being dropped into an excess of water. There are no dangers of polymerisation with this method of making the gas. The management of the machine is far more simple, and can be entrusted to any person of ordinary intelligence. The only drawback with these generators is their bulk. It is necessary with this type to have a holder which will store enough gas to supply the building for at least one night without recharging; but as the insurance regulations insist that all acetylene generators must be outside the building, and at least ten feet from it, it is a matter of very small moment whether they have a diameter of two feet or four feet.

Of non-automatic generators there are a large number in the market. In some of these the carbide is fed in by the action of the holder, as in the one now before you. As the holder rises the valve at the bottom of the carbide retainer closes, and as the holder falls the valve gradually opens. Two years' experience with the different forms of generators shown you this evening has, however, brought the speaker to the conclusion that any mechanical contrivance is apt, sooner or later, to get out of order, and generally at the most awkward time, and that by far the better plan, and the plan which in the long run gives the most satisfaction to the consumer, is to throw in the whole of the carbide required to fill the holder at one time, and be done with it. If one wants to have the least possible trouble, and make the gas—say, only once a week—it only necessary to have a holder large enough to carry the week's supply. He had therefore adopted the machine which you now see at work; before passing to the consideration of it he would show you illustrations of a few more of the different types he had been describing.

In this machine you will notice that the carbide is fed through the top, dropping by its own gravity through a tube fitted with discs at top and bottom for opening and closing the tube. To charge the machine, the two discs are opened by the handle at the top, the carbide is thrown down the tube and allowed a second or two to sink through it; the two discs are then closed again by the handle on the upper one. There is a slight waste of gas whilst the carbide is sinking through the water in the tube, but as carbide has almost the density of granite it sinks very quickly, and the loss is not so much as would at first be supposed. In actual practice it is found by measuring the gas produced by a given weight of carbide that hardly any loss occurs at all. If necessary the carbide can be kept in oil, in which case it will sink through the tube before the water has time to penetrate the oil. When the carbide leaves the tube it drops on to a grating, as shown in the illustration. This enables the dissolution of the carbide to take place quickly and without generating heat. Were the carbide allowed to drop into the exhausted lime deposited at the bottom by previous charges, it would quickly form a crust around itself and become extremely hot as the decomposition proceeded. This, as already shown in connection with the automatic generators, is a condition which must certainly be avoided. As the carbide decomposes and its carbon unites with the hydrogen of the water to form acetylene, the calcium falls to the bottom in the form of hydrate of ime. This is run off periodically by simply opening the cock at the bottom of the generator; a guttering can be laid from the cock to a hole in the ground, and the residue itself need never be touched.

There is no danger in working this machine. In actual practice the servant girl is given a small tin, which she has to fill every day with carbide and then drop this quantity down the tube. The operation is simplicity itself, and anyone can understand it. There is nothing to weigh, no taps to turn on or off, no valves or governors to look after or to get out of order, no cylinders to attend to; simply some pieces of carbide to be dropped down a hole and the hole closed by drawing a disc over it, and the operation of charging is done. The tests of practical everyday use which this machine has now had in all parts of Australasia prove it to be one of the best yet introduced.

The illustration now before you represents one of the numerous table lamps placed on the market. According to the manufacturers of these lamps they are going to supersede kerosene, coal gas, electric light, and in fact every form of light known or likely to be known. But, as a matter of practice, the perfect table lamp has yet to be invented; all that have been so far introduced present very serious defects. The invention of a satisfactory acetylene table lamp is a most complicated problem, the whole operation of making the gas has, of course, to be performed within a very small compass, so that the only possible method of manufacture seems to be that of dropping the water on to the carbide. Then commences all the troubles already described in connection with automatic generators, the gas polymerizes, the burners choke, the pressure varies, and the light is constantly throbbing, the smell in the room becomes very offensive, and the acetylene table lamp generally gets carried outside and left there. There are several table lamps on the market, but they all adopt the principle of dropping the water on to the carbide. Attempts have been made to coat the carbide with a preparation of oil or other fatty substance which would retard the rapid decomposition of the carbide, but none of these are a success, as it stands to reason that as soon as the outside skin of oily substance is penetrated by the water there is nothing to further deter the rapid decomposition of the carbide. We are therefore reluctantly compelled to pass table lamps for the present as being too unsatisfactory for every day use.

With bicycle lamps, the case is different. The cyclist, who wants a light at night, wants it for one of two reasons, either to give him a light along a bad road, or to evade the police regulations. For the latter purpose an oil lamp is quite good enough but if the cyclist wants to light up the road in front of his machine, there has been no lamp yet introduced that will do this for him except the Acetylene lamp. With this lamp riding at night becomes a pleasure, for the rider is enabled to see obstacles long before he reaches