CHEMISTRY IN THE BOILER ROOM.

PART II.

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BEFORE we proceed to the study of what takes place during combustion, it it necessary that we should briefly consider certain substances called "elements." An element is a substance that cannot by any means known to chemistry be reduced to a simpler substance. Iron, for instance, is an element—so is silver, carbon, oxygen, hydrogen, and many other substances which it is not necessary for me here to mention. In addition to the substances called elements, we have other substances called "compounds." A compound is a substance made up of two or more elements, held in mechanical or chemical combination, and can by certain processes be reduced to its simpler elements. For instance, water is a compound of the elements hydrogen and oxygen; coal is a compound of carbon, nitrogen, hydrogen and certain other elements; air is a compound of the elements nitrogen and oxygen.

Substances are said to be held in mechanical combination when the elements composing the compound are able to be separated or distinguished by mechanical means, and differs from a state of chemical combination inasmuch as the elements composing the compound are simply side by side. For instance, the elements iron and sulphur can be ground together in the finest possible atoms imaginable, still they form only a mechanical compound, as both the iron and sulphur retain their original properties and can be separated one from the other by simple mechanical means, and they have not really combined one with the other. But if you heat the substance they enter into chemical combination one with the other—the iron loses its properties as iron; the sulphur loses its properties as sulphur, and they can only be decomposed again by chemical means. The iron is no longer visible as iron, and the sulphur is no longer visible as sulphur—the two elements have combined together to form a new substance, a compound of iron and sulphur, known in chemistry as iron sulphide. Just so long as they were held in mechanical combination they remained iron and sulphur, each retaining its own peculiar properties, but when they were brought into chemical combination by means of heat the properties belonging to both the iron and sulphur disappeared, and a new substance was formed, with entirely new and different properties.

As the reader is no doubt aware, there are a great many different grades of coal, and generally divided into two distinct classes, known as anthracite (hard) and bituminous (soft), both of which are largely used for the production of power.

For our purpose we will take a sample of Welsh coal, the analysis being as follows: Carbon, 85%; hydrogen, 5%; nitrogen, 1%; sulphur, 1%; oxygen, 3%; and incombustible matter, called ash, 5%. This sample of coal then is a chemical compound containing these various elements in different proportions, and before it can be changed into any other substance, decomposition must take place.

Atmospheric air is composed of nitrogen and oxygen in mechanical combination in the proportion of 4 parts of nitrogen to 1 part of oxygen by volume, and by weight, 77 of nitrogen to 23 of oxygen.

To enter into the philosophy of chemistry in this article is not my intention, but to make the matter clear it will be necessary to discuss the properties of each element and also the properties of the different compounds when in combination with each other. We have the following elements to deal with, only two of which are solids, as follows: carbon, solid; hydrogen, gas; nitrogen, gas; oxygen, gas; sulphur, solid. The reader already knows that the bringing into combination of the atmospheric air with heated coal, causes the coal to burn and give out heat. This is, however, far from being the mechanical operation so often imagined. What really does take place is that the oxygen of the air enters into chemical combination with heated coal, and this very act of combination gives out the light and heat so often noticed. When chemical combination between substances has taken place, new substances are formed, just as when iron and sulphur are chemically combined iron sulphide is formed. Let us now review briefly the properties of each element when dealt with separately. To do this properly requires a certain amount of laboratory training, so that each element may be separately dealt with, and its various properties discovered. A description of experiments to be carried out is much too long for this article, so we will simply state well-known facts relating to each element in question.

CARBON is an element that occurs extensively in nature in many forms. The form in which we get it in the present instance is the well known substance "coke." Carbon has strong affinity for oxygen, and combines with it in two proportions under certain conditions.

HYDROGEN is a colorless, inodorous, tasteless gas, of a very light nature, being 14½ times lighter than air. It is combustible, but does not support combustion. It will combine with oxygen to form water, in the proportion of 2 parts hydrogen to 1 of oxygen by volume, or 1 part hydrogen to 8 parts of oxygen by weight.

NITROGEN, as already stated, forms four-fifths the volume of the air. It neither burns nor supports combustion, and acts as a diluting agent with oxygen. It has been said it is simply in mechanical combination in the air with oxygen; that is, the atoms of each are simply side by side, each retaining its own peculiar properties.

OXYGEN is in present instance our most important element, and a proper understanding of its power to combine with carbon forms the most important part of an engineer's education. Pure oxygen is a strong supporter of combustion, and combines readily with many elements, in each case giving off light and heat. With carbon it forms two highly important compounds, known as carbon dioxide and carbon monoxide—carbon dioxide being the result of perfect combustion and carbon monoxide the result of imperfect combustion. While oxygen supports combustion, it is not combustible itself, all its properties being practically the reverse of hydrogen.

Nature has provided that the elements will only combine together under certain conditions and in certain well-defined quantities, and it is the understanding of these conditions and quantities that makes the study of chemistry of any value to us. If carbon and oxygen simply united in any proportion, and when in combination each was destroyed, then we should require no knowledge of chemistry, but every fireman knows he must get so much air from the atmosphere, must kindle a fire before it will burn, and must maintain a current of air through his fires, and that the intensity of his air current enables him to burn a given quantity of coal in a given time. This simply goes to prove that there are conditions as to what oxygen shall be supplied, and governing the temperature at which the two elements will combine. For instance, just so long as iron and sulphur remained together at a low temperature no change took place, but as soon as a given quantity of heat had been imparted to the substance combination took place; and if we test carefully we shall find there is a certain fixed quantity of heat required, and that a certain temperature must be reached before chemical combination sets in, and that in every case these two elements require the same number of heat units and same temperature to be reached—enabling us to determine exactly what is required to change iron and sulphur into iron sulphide.

The same thing can be said regarding coal. Just so long as the compound remains at a given low temperature, decomposition and combination with oxygen will not take place. You can pass all the air you like over coal in its normal condition and you will get neither light nor heat, but heat the coal to a sufficiently high temperature and combination at once sets in, and decomposition of the compound of coal takes place. This is well illustrated in the manufacture of gas. A coal compound, chosen for its richness in gaseous elements, is placed in a closed retort, secure from admission of air, and a fire built underneath to heat the coal, which is decomposed, all the gases being liberated, the carbon and solids only remaining—proving that a compound of coal can be decomposed into its elements by heat, and that the element carbon is of such a nature that it will not pass into a gaseous state by the application of heat alone, as did the other elements contained in the coal. I want to impress my readers with the importance of this natural law, as it is of vital importance to engineers. I have said hydrogen combines with oxygen to form water, but only on certain defined conditions and in given quantities. Hydrogen and oxygen can be mixed together in exact quantities, and they will still remain in mechanical combination, but the moment they are heated up to a given point chemical combination sets in with such rapidity that an explosion occurs, and instead of the two gases we formerly had we have a liquid called pure water—very much smaller in volume but equal in weight to the weight of the gases before combination took place. Then we have a fixed point of combination and also a fixed quantity. If in the mechanical compound of the two gases we had an excess of hydrogen or oxygen the excess of either gas will remain behind in an uncombined state, showing that hydrogen will only combine with oxygen to form water in one fixed proportion, and hence excess of either of the elements can be considered as so much waste.

What I want to make clear is the important fact that carbon and oxygen will combine together in two different proportions and form two gases with entirely different properties, in each case giving out both light and heat, but in proportions that simply astonish the engineer, and the power to understand this fact is our most important duty.

(To be Continued.)