the front, just below the water line, and the space between the drum and shell is built up solid with fire-brick. The operation of the down-draught furnace is directly opposite to that of the ordinary setting. Comparatively little air is admitted below the water grates, and the entire supply of coal, and practically all the air, entering above. The fire burns downward, instead of upward, there being no passage except downward through the grates. The gaseous products of combustion, together with the finely diveded carbon particles which form the visible smoke, are forced through the incandescent mass of coals and are highly heated, after which they meet the equally hot flame from the lower grate, on which there is burning what is practically a coke fire. The combined water of the volatile matter in the coal, as well as its moisture, are decomposed into hydrogen and carbonic oxide gases, and these combine with the air supplied below the grate, or drawn downward through it, and burn, thus adding to the efficiency of the furnace. The separated carbon meanwhile is transformed into carbonic acid gas, and the result is almost complete combustion. Whatever additional air is required is furnished through registers in the doors between the two grates, or through those of the ash pit. This style of furnace requires a somewhat increased chimney capacity, if it is desired that the boilers be capable of doing as much work as those set in the ordinary way. If the demand for steam never greatly exceeds the rated capacity of the boiler, the ordinary chimney will answer, it simply being necessary to carry thinner fires. The best results, however, in efficiency and smokelessness, as well as in capacity, are secured by having a chimney of ample height, but this is equally true with regard to ordinary settings, which rarely have enough chimney. They claim a saving for this furnace of from 20 to 30 per cent.

The highest value that has been found by actual test of a pound of coal is 14,603 heat units, and each heat unit is equivalent to 778 foot pounds, so that each pound of coal furnishes the equivalent of 11,361,134 foot pounds per hour, but we only get back 1,980,000 foot pounds, or about one-sixth of the mechanical equivalent of the heat supplied.

A pound of coal or any other fuel has a definite heat-producing capacity, and is capable of evaporating a definite quantity of water under given conditions; this is a limit beyond which even perfection cannot go, and yet, I have heard, and doubtless you have heard, of cases where inventors have claimed that their improvements will enable you to evaporate from 16 to 17 pounds of water per pound of coal, and so-called engineers have certified to these results.

You all know that this is impossible, the highest value for a pound of coal being 14,603 heat units, and it is a known fact that it takes 965.7 heat units to evaporate one pound of water from and at 212° Fahrenheit, so that by dividing 14,603 by 965.7, we have 15.1 pounds of water per pound of coal, and then only when every heat unit is put into the water. The highest value of evaporation so far has been 11.5 pounds of water per pound of coal, per hour; but, as a general rule, it is from 7½ to 8 pounds per pound of coal, per hour.

In conclusion, I would say that in the combustion of fuel there is but one body combustible to be dealt with, carbon and hydrogen, and but one supporter, the oxygen of the air. That in combustion, atmospheric air is the principal element, but it is the one to which practically the least attention is given, either as to quantity or control, and that chemistry and experience teach us that combustion depends, not so much on the quantity of air passing through the incandescent fuel, as upon the weight of oxygen taken up in its passage through it. In fact, the quantity of air passing through it may be destructive of combustion if improperly introduced and distributed. That the quantity of heat generated depends upon the relative weight of carbon or hydrogen, and chemically considered, their equivalent weights of atmospheric oxygen, so also the quantity of steam generated does not depend so much upon the intensity of the fire as on the quantity of heat absorbed by the water. Now, it is well known that success in generating the most heat and steam, and consequently power, from a given amount of coal, depends upon a compliance with the necessary conditions to perfect combustion, which involves not only a theoretical knowledge of chemistry, but also a practical knowledge of the best methods of combining them with mechanical appliances, and the perfect mixing of the constituent elements with which we have to deal, in strict accordance with the laws of nature.

For the standard method of testing coal referred to in this paper, the following is the outline of procedure: For the moisture a finely ground sample is dried for one hour in an air bath at 105° to 110° C. For the other constituents a fresh sample is taken of about a gram in quantity and put in a platinum crucible, the crucible being covered; it is now heated for 3½ minutes over a Bunsen burner, followed immediately with the highest temperature of the blast lamp for an equal length of time. The loss in weight, less the moisture obtained, equals the volatile combustible matter. The fixed carbon is next burned off by removing the crucible cover and heating in the flames of a Bunsen burner, with access of air till the carbon is burned off; the loss of weight equals the carbon, the residue is ash.

THE FUTURE OF GAS ENGINES--WILL THEY SUPERSEDE STEAM POWER?

A very large amount of attention is now being given by mechanical and electrical engineers to the remarkable economical results developed in the working of gas engines of from 40 horse-power to 500 horse-power, run by Producer gas. In an economical sense, steam in comparison is not "in it." It now becomes a question as to how to adapt it to marine and locomotive practice. No less an authority than George Westinghouse is seriously looking into this important matter. He is materially helping the advance toward perfection. He, it is stated, has brought this matter before the directors of the Pennsylvania Railway, telling them that they are wasting on their steam locomotives at least 4,000,000 tons of coal per annum, or that electricity, obtained by Producer gas, would save them $5,000,000 per year, an amount that would justify any changes that might be required in their system. Attempts have been, and are being made, to produce electricity from the coal pile. The nearest approach to this yet arrived at is the generation of power by Producer gas applied to the dynamo, and from it to the modern electric motor. The electric motors on the locomotive at the Baltimore tunnel are run by a current developed by steam power. This locomotive is no doubt one of the most powerful in existence, as proved by its wonderful pulling power. It