lbs. of nitrogen, and the products will be a chemical combination of 3·66 of carbonic acid—the nitrogen, 8·94 lbs., passing off in an unaltered state, excepting that it is heated and expanded to about double its volume. The total weight of the product of the combustion is 12·60 lbs., but we have left out the sulphur contained in the coal. We will now supply 1 lb. of sulphur with 4·35 lbs. of atmospheric air, making 5·35 lbs. in all. Of this 1 lb. of sulphur and 1 lb. of oxygen unite and make 2 lbs. of sulphurous acid, leaving 5·35 lbs. of nitrogen aga n unchanged after passing through our fire. It then follows for the perfect combustion of 1 lb. of carbon, 1 lb. of hydrogen, and 1 lb. of sulphur, the quantities of air, chemically consumed, are for the hydrogen 34·8 lbs., or 475 cubic feet, and the product is water. For one pound of carbon, 11·6 pounds, or 152 cubic feet, product carbonic acid; the sulphur uses 4·35 lbs. or 57 feet, product sulphurous acid. If we should cut off our supply of air to one-half for the 1 lb. of carbon, using 5·7 lbs. or 76 cubic feet, the product would be carbonic oxide, sometimes called marsh gas, which is inflammable and a great detriment to the heat, in fact, a perfect waste of the coal and heat. It is then evident the chief governing element for the perfect combustion of the coal is that the amount of air passing through the coal be sufficient, and in order to be sure that we may have enough, we must construct our furnaces and openings therein to carry an excess of air, the amount of which can only be determined by experiment at each furnace. In tests conducted in Germany, and also at the Centennial in 1876, it was found that passing 24% more air through the fire than was theoretically required, had no effect on the evaporative efficiency of boilers. The heat of the fire is received by the boiler, first by radiation, then by convection. Experiments conducted by Williams and other English experts, show that the water evaporated by radiation is very much more than that by convection. Take for instance one of our ordinary return tubular boilers, and the evaporation per square foot of tube surface will be less than one-fifth of that at the fire sheets, thus showing the absolute necessity of designing our boilers to secure perfect circulation, and of carefully proportioning the amount of grate surface to the heating surface. In the great test of boilers at the Centennial Exhibition at Philadelphia in 1876, where fifteen boilers were tested as to their capacity to make steam and as to their economy, it was found that by reducing the rate of combustion thirty per cent. the quantity of water evaporated was only reduced 23 per cent., and at the same time the evaporative efficiency was increased 8½ per cent. The difference in the temperature of the escaping gases was 56° F., being only 409° at the most economical point, and 465° when steaming to their greatest capacity. This · oes to prove that forcing a boiler is a great detriment, in fact that it is one of our great wastes of heat. The average of a continuous test conducted in Germany is reported in D. K. Clarke's "Steam and the Steam Engine." The test was conducted for nearly four years on two tubular boilers steaming night and day, when it was shown that about sixty per cent. of the heat was utilized for the formation of steam, and that more than half of the remaining fortv per cent. was lost by conduction and radiation through the brick walls. The average heat of the escaping gases was 360° F., and carried off 5½ per cent., while the losses due to ungenerated heat and escaping carbon particles did not exceed one-half of one per cent. The proportion of grate area to heating surface was changed during this test three times the most economical point being 1 sq. ft. grate surface to 34 sq. ft. The duty of boilers is generally expressed by the number of pounds of water they will evaporate by the combustion of 1 pound of coal, and that all may be treated alike, we say from a temperature of 212°, and under atmospheric pressure. In this case the temperature is not raised, the water is merely passed from a liquid to a gaseous state and the heat to be imparted is that of vaporisation only. The number of thermal units necessary to produce this change diminishes considerably as the temperature increases, being at 32°, 1091.7, and at 212°, 965.7, while at a pressure of 210 lbs. and a temperature of 385.67, it is only 440.4 under atmospheric pressure. The total heat units contained in the steam is 1178.6, of which 965.7 is to be imparted. In coal of a good average quantity the percentage of hydrogen, whose heat of combustion is 4½ times that of carbon, will nearly compensate for the incombustible ingredients, so that for our purposes we may consider that a pound of good coal is about equal to one pound of carbon, and as one pound of carbon will give as the heat of its combustion 14,500 thermal units of heat, which if divided by 965.7, the amount of heat to be imparted, we have a result of 15 lbs. of water evaporated by one pound of coal. Now, in practice, if we could show an evaporation of 12 lbs. we should do fairly well, but in many cases we do not show more than 6 lbs. in ordinary practice. Evaporation from different temperatures and under different pressures, the equivalent of this theoretical duty is ascertained by the following rule: The weight of water evaporated by the combustion of a pound of coal varies inversely as the quantity of heat necessary to be imparted, thus—to take an extreme case, let water at 32° be evaporated under a pressure of 120 lbs. per square inch, counting from perfect vacuum. The number of thermal units contained in the steam is 1217.94, the number in the water 32. Now, then, as 1158·94:965·7:: 12:9·77, which is therefore the equivalent number of pounds of water evaporated by the combustion of a pound of coal under these conditions. The evaporation duty performed in evaporating from feed waters of a given temperature into steam of any pressure having been ascertained, the equivalent evaporation from 212° and under atmospheric pressure is found by reversing the proportion just illustrated. As an example, let 9 lbs. of water be evaporated from a feed water temperature of 130° into steam of 100 lbs. pressure, by the combustion of one pound of coal, then the total heat units contained in steam at that pressure is 1213·850, of which the water contained 130·192, leaving to be imparted 1083.658 and as 965·7:1083·658 :: 9: 10.1, which is therefore the equivalent evaporation from 212° under atmospheric pressure. In connection with heating of feed water, it should be heated up nearly to the full heat of the exhaust steam by waste heat from the engine, each 9·50 of heat added to the feed water, results in a saving of one per cent. of the fuel used. It is reasonable to suppose that many of our wastes can be remedied. Let every member start at once to study up his furnace, his coal, his feed water, and the amount of air he is using; see that you are not distilling marsh gas in your furnace; see that the brick work is tight and in good order, so that all air admitted must pass through the fire; see that the surface of the boiler and flues are clean, that they may readily take up and conduct the heat to the water. Experiment a little in your own