is admitted and the place of admission, that is, whether the air is allowed to pass into the furnace above the fire bars, below them, or both above and below at the same time. Not only is the smoke affected by the air supply but the economical working of the boiler depends to a great extent on this also.

The number of pounds of air required per pound of coal is somewhere in the neighbourhood of twelve, and does not vary greatly from this figure. An average value for the maximum weight of air per pound of coal may be taken as 11.5 pounds. This quantity is only that required under the most favourable circumstances, that is, when every particle of oxygen of the air supplied is completely consumed, and there is no waste oxygen carrying the heat away. These conditions are not possible of attainment in ordinary boiler furnaces, as it is not practicable to bring all the oxygen intimately in contact with the burning fuel so that it may be used.

If the air supply is deficient, either in the general supply or the quantity admitted to some important point of the furnace, the carbon does not take up its proper amount of oxygen, and carbon monoxide is formed instead of carbon dioxide. One pound of carbon completely burned to CO_2 gives out by its combustion about 14,500 heat units, where if partially burned to CO the heat yielded is only 4,500 heat units. It is therefore obvious that for every pound of carbon burnt to CO instead of CO_2 there is a loss of heat equal to about 10,000 heat units. For this reason alone it is absolutely necessary for economy that the carbon be fully burnt. This carbon may be free carbon in the incandescent fuel left after the hydrocarbons have been driven off, or it may be a combine carbon in the gases, and if the latter, the imperfect combustion may be accompanied by the evolution of smoke. In either case the remedy is more air, and consequently more oxygen.

The problem with which the engineers are confronted is not altogether a simple one, for if the air supply is deficient CO is formed in place of CO_2 and a consequent waste of heat takes place, and this may be accompanied by the formation of smoke, whereas if too much air is admitted to the furnace there is again a loss resulting from the excess of oxygen and nitrogen taking up heat and carrying it away from the boiler. There is a point where one loss ends and another begins, as the air supply is increased and in order to obtain the most economical results with freedom of smoke this point must be found. There is the farther question as to how far it is allowable to permit a large excess of air in order to force the boiler and so get a greater total evaporation from a given boiler but that point need not be considered at present.

The best indication of the quantity of air being used per pound of coal is that given by an analysis of the gases coming