In 1785 the first smoke-abating invention was patented by James Watt, who, as the inventor of the steam-engine, is responsible for so many boiler fires and so much consump­tion of coal. In 1815 Cutler patented the first would-be smokeless grate for domestic purposes ; and his principle of feeding underneath was afterwards adopted by Dr Neil Arnott in a grate which has now been in use in one form or another for more than half a century. There is now a vast number of such inventions, good and bad. In 1819 the attention of parliament was directed to the question, and a select committee was appointed “ to inquire how far persons using steam-engines and furnaces could erect them in a manner less prejudicial to public health and comfort.” This committee gave an encouraging report. In 1843 another select committee recommended the introduction of a bill prohibiting the production of smoke from furnaces and steam-engines. In 1845 yet another select committee reported that such an Act could not in the existing state of affairs be made to apply to dwelling-houses. The Acts of 1845 and 1847 followed as the results of these inquiries ; and since then there has been much legislation brought to bear on factories and railways. The results have been most beneficial ; but very much still remains to be done. One is apt to think that, because steam-engines and fac­tories consume individually much more coal than dwelling- houses, they alone are responsible for the smoke nuisance, forgetting how greatly the dwelling-houses outnumber the factories. In reality there is little doubt that domestic fires are mainly responsible for the smoky condition of the atmosphere of our towns; and they for the most part continue to evolve smoke undeterred by legislation or scientific invention. In 1881, however, a movement was commenced by the National Health Society and the Kyrle Society, which resulted in a great smoke-abatement exhi­bition being held at South Kensington. At the close of the exhibition a national smoke-abatement institution, with offices in London, was incorporated by authority of the Board of Trade.

A knowledge of the nature of coal and of the chemical changes that it undergoes when burnt is essential for an understanding of the smoke problem. More detailed in­formation on these points is given under Coal, where the several varieties are described. For the purposes of this article coals may be classified as smoke-producing and smokeless, the former including all those varieties most commonly used as fuel. The elementary constituents of such coals are carbon (generally about 80 per cent. of the whole), hydrogen, nitrogen, oxygen, and sulphur ; and they also contain a varying quantity of earthy impurity or ash. The process which occurs in a coal fire consists of two dis­tinct operations. The first, which requires a comparatively low temperature and is independent of the presence of air, is one of destructive distillation, and is similar to that which occurs in the retorts of gasworks. It results in the decom­position of the coal, and in the rearrangement of its con­stituent elements and the formation of the following sub­stances :—(1) hydrogen, marsh gas, carbonic oxide, olefiant gas, benzine, other hydrocarbons of the type of marsh gas or of benzine, water,—all of which are either gaseous at the temperature at which they are formed or capable of being converted into gas at somewhat higher temperatures, and all of which are combustible except the water ; (2) ammonia and other compounds of nitrogen, and certain compounds of sulphur, which are also volatile and combustible ; (3) coke, which consists of carbon (and ash) and is non­volatile but combustible. It is these products of distilla­tion, not the coal itself, that burn, in the strict sense of the word ; and this second process requires the presence of air and also a much higher temperature than the first. If the combustion is perfect, the only products are (1)

water-vapour, (2) carbonic acid, (3) nitrogen, and (4) sulphurous acid, the first of which contains all the hydro­gen originally present in the coal, the second all the carbon, the fourth all the sulphur, while the nitrogen is liberated as such together with the very much larger volumes of nitrogen derived from the air which has sup­plied the necessary oxygen. All these products of com­bustion are discharged through the chimney.

Two things are necessary for the ensuring of such com­plete combustion, viz., an adequate, but not too large, supply of air, properly administered, and the maintenance of the requisite temperature. In practice, however, these conditions are never perfectly fulfilled, and consequently the combustion of coal is always more or less imperfect and gives rise to a complex mixture of vapours. This mixture contains not only the combustion products already mentioned but also the following unburnt or partly burnt distillation products :—(5) hydrogen, (6) hydrocarbons, (7) carbonic oxide, which contains a lower proportion of oxygen than carbonic acid, (8) unburnt carbon in a very finely divided state,—and also considerable volumes of unused air.

Usually the name “smoke” is applied to this vaporous mixture discharged from a chimney only when it contains a sufficient amount of finely divided carbon to render it dark-coloured and distinctly visible. The quantity, how­ever, of this particular ingredient is apt to be overrated. It always bears an extremely small proportion to the vast volumes of water-vapour, carbonic acid, and nitrogen with which it is mixed ; it probably never amounts, even in the worst cases, to 3 per cent. of the weight of the coal from which it is formed ; and its importance, reckoned in terms of so much fuel wasted, is certainly not greater than that of the unburnt hydrogen and hydrocarbons. It is per­haps best to use the name “ smoke ” for all the products of imperfect combustion (5 to 8) which are avoidable, as con­trasted with the necessary and unavoidable ingredients (1 to 4) of the mixture. The problem of smoke abate­ment is thus seen to resolve itself into the problem of the production of perfect combustion.

The first advantage to be gained by the solution of this problem is an important saving in fuel. It has been cal­culated that at least twice as much coal is used in boiler fires and six times as much in domestic fires as is theore­tically required for the production of the effects obtained. A considerable portion of this loss is due to causes other than those that can be treated of here, and some is cer­tainly unavoidable ; but there is no doubt that much of this enormous waste could be prevented by improved methods of combustion, such as would solve the smoke problem. The second advantage to be looked for is a great gain in cleanliness and public convenience. Not only would there be an end to sooty chimneys but the atmo­sphere of towns would no longer be polluted as it is now by the discharge of unburnt carbon, whose total quantity is enormous, though the amount contained in any given puff of smoke is very small. The “ London fog ” would be a thing of the past,—not because fogs would become any less frequent than now in London and other large cities, but because they would lose their distinctive char­acter of grimy opacity. It is often stated that these fogs are *caused* by the smoke that blackens them ; but this is an error. The combustion of coal is certainly responsible for their existence, but it is the sulphur of the coal (oxidized ultimately to sulphuric acid), and not the carbon, that is the active agent. And so long as coal is burnt at all this manufacture of sulphuric acid and of fogs must continue ; it is not to be got rid of by improved methods of combustion, though the character of the fogs may be materially altered for the better. The evil effects of town