supplied to the furnace if admitted only in front, and accordingly there have been many plans devised for supply­ing it also at the back. In some cases currents of air are induced by steam-jets ; but this plan has not proved very successful. The best inventions are on the regenerative principle. In them the air, before entering the furnace, is made to circulate through chambers heated externally by the products of combustion, and, having thus acquired a high temperature and absorbed heat that would other­wise have been lost, is admitted through openings at the bridge. Many of these appliances are almost absolutely smokeless, and they are much in use.

The advocates of the total or partial disuse of smoke- producing coals are variously in favour of the following substitutes—anthracite, coke, liquid fuel, and gas.

For some purposes anthracite and other coals containing a high percentage of carbon may be, and have long been, advantageously used as fuel. They yield a much smaller percentage of distillation products than ordinary coals, and produce no smoke, or almost none. But they are difficult to ignite, and in small fires difficult to keep burning; they give very little flame, and are comparatively expen­sive, so that they are under considerable disadvantage as compared with the usual kinds of coal. Many of the grates and stoves exhibited at South Kensington were specially devised for burning anthracite, and some of them are decidedly successful ; but it is not likely that anthracite will ever take the place of bituminous coal to any great extent in the British Isles. There the great coal-fields undoubtedly are the natural sources of fuel, and no pro­posal involving a complete neglect of this fact can ever be successfully carried out.

This remark, however, does not apply to the use of coke and of gas, which are themselves made from coal. Coke is produced in large quantities both for its own sake and as a bye-product in the manufacture of gas for lighting purposes, and is largely used in various kinds of furnace. It gives no smoke ; but it resembles anthracite also in being but ill adapted to use in open grates on account of the difficulty of ignition and the absence of flame (see Fuel).

In America, where natural petroleum is obtained in such enormous quantities, the experiment has been made of using it as the source of heat for boilers. A jet of superheated steam (at about 600° Fahr.) is blown into the hot combustion chamber and the oil and air enter mixed with it. The results are said to be excellent,—the fire smokeless and the efficiency high. The residue from coal- tar, after the naphtha and light oils have been recovered from it, can also be advantageously used in this way. The chief disadvantage attending the use of liquid fuels such as petroleum seems to lie in the fact that they are some­what dangerous, fatal accidents having occurred in America; and the range of their application is necessarily limited. To use them for the heating of houses is of course quite out of the question.

Of all the schemes and inventions for the abatement of smoke that one which proposes to distil coal in one opera­tion, and to burn the products of the distillation in another and quite separate operation, is without doubt the most thoroughly scientific ; and to it, rather than to patent grates and furnaces, we must look for the ultimate solution of the question. Many arguments may be adduced in favour of gas-heating as opposed to coal-heating, the most important of which are here briefly given. (1) Coal gives, on distillation, not only gas and coke, which are both good heating agents, but intermediate products, many of which are of commercial value ; these include ammonia, benzine, carbolic acid, anthracine, &c. As science advances the value of coal-tar will probably be enhanced by further dis­coveries ; already it gives the raw material for the pre­

paration of numberless beautiful dyes, of antiseptics, and of some drugs, and quite lately a substance described as an admirable substitute for sugar has been prepared from it. All these intermediate products are now, according to our barbarous methods of burning coal, used simply as fuel. (2) Gas can be laid on in pipes to any spot, can be lit or turned out at any moment, and can be so managed that less heat is frittered away and more applied to the specific object than in the case of coal-burning. (3) It produces no smoke and leaves no ash or cinder, so that cleanliness is attained and much labour and expense are saved. (4) The coke produced during the preparation of the gas has uses of its own as solid fuel and for other purposes. (5) As has been already said, sulphur is an ingredient of all coals, and sulphuric acid is one of the necessary results of burning them, not to be got rid of by “smoke abatement.” Coal gas, however, can to a great extent be freed from sulphur compounds, and it is possible that the purification methods in vogue may hereafter be improved, so that we have here a means, if any exist, of curing the chief evils of our present system,—injury to our respiratory organs, production of fogs, and destruction of vegetation in towns. The principal disadvantage of the proposal is to be found in the high cost of coal gas, which now varies generally from 3s. to 4s. per 1000 cubic feet, whereas it has been calculated that it would have to cost not more than 1s. or at most 1s. 6d. to compete success­fully with coal. There is no doubt, however, that the cost might, and it probably will, be brought down to this, as the high rate is due to causes not inherent in the nature of things. Sir William Siemens proposed that two sets of mains should be laid in English towns, one for heating and one for lighting gas, and showed that the first and last portions of every preparation of gas are possessed of very low illuminating power, but if collected apart would do excellently for heating purposes, while the rest would be improved for lighting. It is probable, however, that electricity will ultimately drive gas out of the field as an illuminating agent and that it will then be relegated to its true place as a heating agent. When that is done coal will no longer be burnt as a whole, but only those of its products (gas and coke) which are good for heating and for nothing else.

Meanwhile, ordinary coal gas has already, expensive as it now is, been largely applied to certain purposes, notably to cooking stoves and other domestic requirements, to gas- engines (in which the generation of steam is unnecessary), and to bakers’ ovens ; and these inventions are calculated materially to diminish the smoke nuisance. In order to obtain an economical gas capable of being generated on the spot and used for operations on a large scale, Sir W. Siemens devised a gas-producer in which coal is partially burnt in a limited atmosphere and is wholly converted into gaseous products (chiefly carbonic oxide), only the ash being left. This “producer-gas” is a weak fuel, being largely diluted with atmospheric nitrogen, and is therefore in­applicable to domestic purposes ; but for many others it suits admirably, one of the best examples of its application being Siemens’s own regenerative gas furnace for melting steel (see Siemens). Other gas-producers have been patented, and the cost of the gas so made is as low as 4d. per 1000 cubic feet, or even less. It is probably, however, but a temporary substitute for true coal gas. In the use of this latter we shall, without doubt, find the true scientific solution of the smoke-abatement problem. As an example of what gaseous fuel can do, it may be mentioned that in Pittsburgh in Pennsylvania the furnaces are now being fed by natural oil gas and that that city, once one of the dirtiest of manufacturing towns, is be­coming one of the cleanest.