SMOKE AND ITS PREVENTION.[1]

UNDOUBTEDLY the most important question of the day from the sanitary and artistic point of view is how best to combat the smoke nuisance, which, like a cumulative poison, is slowly but surely saturating our lives and homes with its filthy dregs, and is at the same time like a cancer depleting and destroying our natural strength by the waste of our already rapidly diminishing fuel supplies.

When, in the thirteenth century, bituminous coal was first used for fuel purposes, the smoke to which it gave rise roused such indignation amongst the public that a decree was passed in 1306 forbidding its use; but fuel had to be found, and the supply of timber proving insufficient, once more attempts were made to introduce it, but again public opinion led to its banishment in the reign of Queen Elizabeth. The third attempt, however, to bring it into use proved successful, and slowly the consumption increased, until the last century saw coal firmly established, not only as a fuel for domestic consumption, but also as our great source of power, and it was the possession of great stores of the fuel that gave England her commercial supremacy.

The smoke from the few chimneys where coal was used by our forefathers, and which so shocked the sense of the observers of that day as to lead to its use being banned, was an absolutely negligible quantity as compared with the smoke belched forth into the air in any of the large cities of to-day, and the effect upon our climate, our health, and our buildings has so steadily risen with the increase in consumption that it is no exaggeration to speak of it as a cumulative poison.

It was only in the latter half of the last century that the cumulative effect of smoke began to make itself appreciable, and the 'eighties and 'nineties were marked by a diminution in the hours of sunshine in our big cities and by fogs of remarkable density and lasting power; but such legislation as was enacted and the efforts of those interested in smoke abatement have apparently had some slight influence in a reduction of the plague, and certainly during the past ten years the fogs have not been of the same density or so frequent as in the preceding twenty or thirty years, but how far this has been due to efforts at smoke abatement and how far to meteorological conditions I, at any rate, am unable to say. It is an absolute fact that even if a certain amount of work has been done, so much still remains to do that the subject is as important now as it was ten years ago, and my desire this evening is to attack the subject of smoke from the more chemical and physical side of its production, and to review those methods which are practically possible for its prevention.

It must be borne in mind that the smoke question not only affects the well-being of the country, but also implies a waste of fuel so great that with the problem of failing coal supplies looming on the horizon it behoves us to make a national matter of it, not only from a hygienic, but also from an economic point of view. Indeed, the whole question of fuel economy is so closely allied to the problem of smoke prevention that it is impossible to consider the one without the other, and if only rational methods of heat production were adopted, both economy of fuel and cleansing of the atmosphere would follow.

The principal source of the cloud which hangs over our big towns, cutting off the direct rays of the sun and ruining health, varies with the locality. In the south of England it is the domestic grate using bituminous fuel which is responsible for the major portion of this pollution of the atmosphere, whilst further north, in the great manufacturing centres, it is the factory shafts which emit the pall of black smoke that aids in shortening life and killing vegetation, and which begrimes and finally helps to destroy our public buildings.

Many estimates of the relative amount of pollution due to manufactories and to the domestic grate have been made, but as the question of what is the ratio of smoke production from the various sources varies enormously with the locality, no very satisfactory conclusion has been arrived at.

With regard to London, Dr. Shaw's estimate that 70 per cent. of the smoke is due to the domestic fire would probably be about correct, but in Sheffield or Birmingham the figures would most likely be reversed. But it is a certain fact that domestic smoke is produced throughout the whole length and breadth of the land, whereas the factory chimney concentrates its attention on the more limited area of the manufacturing districts.

Although it is difficult to gain any idea of the ratio of blame to be given to the two greatest sources of smoke production at any one spot, yet it is easy to obtain an insight as to the relative total amount of smoke so produced from the uses to which our coal is put, and the Royal Commission on Coal Supplies arrived at the conclusion that, of the 167 million tons of coal burnt in this country in 1903, 36 millions were used for domestic heating, whilst, after deducting the coal used for gas making, it would probably be near the truth to say that the domestic use of bituminous coal is responsible for one quarter of the smoke pollution of the country, the responsibility for the remainder being split up amongst the various manufactures and railways.

Practically all the advances of late years have been in fuel consumption on the large scale, and the improvements brought about by stoking machinery and attention to air supply have been great, whilst some of the largest manufactures have demonstrated, not only the ease of obtaining smokeless factory shafts, but also the economy that accompanies them.

Little, however, has been done to improve the conditions of fuel consumption in the household, and in spite of the fact that the use of bituminous fuel in the domestic grate has been condemned for the part it has played in the pollution of the atmosphere from the earliest years of the fourteenth century to the present day, the ideas that exist as to its composition and method of production are still very vague, and it is this side of the question with which I now desire to deal. In an ordinary open fire radiant heat given by the incandescent fuel and heated grate warms the room, and although it is undoubtedly a wasteful method, owing to the largest proportion of the heat escaping up the chimney with the products of complete and incomplete combustion, yet it is so superior from the hygienic point of view, and so much more comfortable than any other method of heating, that it still holds the premier position in spite of the economic advantages of central heating systems or slow combustion stoves.

The production of smoke from the ordinary open grate using bituminous coal means a waste of fuel, but although this loss assumes grave proportions when the number of fires is taken into consideration, it is small as compared with the other losses due to actions taking place in the fire itself and the loss of heat escaping up the chimney. When bituminous coal is fed on to the burning fire, the action which takes place on the newly added portion closely follow the lines of action occurring during the distillation of coal, and it is during this period that a very large proportion of the heat units in the coal are lost, owing to the amount taken up in decomposing the coal and converting the volatile portions into vapours and gases. During this period the coal, heated by the fire from below and comparatively cool above, distils off tar vapours, coal gas, and steam in proportions which vary with the temperature. In the early stages, the surface of the fuel being too cool to lead to their ignition, they escape as vapours up the chimney, mingled with an amount of air which is dependent upon the draught of the chimney, and ranges from eight to thirty thousand cubic feet per hour. In an ordinary flue the composition of the escaping products may be taken as approaching to the following analysis :—

	Per cent.
Carbon dioxide	0·70
Methane	0·36
Hydrogen	0·29
Carbon monoxide	0·01
Oxygen	19·85
Nitrogen	79·79

and these gases, together with water vapour, escape up the chimney.

[1] A lecture delivered at the London Institution on December 8 by Prof. Vivian B. Lewes.

During this period of smoke production no soot is formed, and the physical properties of the cloud of vapour are an interesting study, as it explains one of the secrets of the lasting power of smoke and the way in which it acts. A most beautiful and instructive experiment is one devised by Mr. F. Hovenden, which shows to perfection the structure of smoke as it escapes from a burning object. A puff of smoke blown through a small glass cell illuminated from below by an oxyhydrogen or arc light, and examined under a low-power microscope, reveals the fact that it consists of excessively minute vesicles which are in a marvellous condition of motion, and which, owing to the gas within them being lighter than air, remain floating in the stream of air or gas until impact with a solid surface causes a bursting of the little liquid envelope, forming a microscopic drop of tar on the solid against which it has struck, and liberating the contained gases.

The wonderful movement of these vesicles is the most beautiful realisation that I know of our conception of molecular motion, and the marvellous way in which they keep up a continuous bombardment would be a perfect lecture illustration of kinetic energy if only it could be projected on the screen.

Given proper conditions, most condensing vapours seem to assume this form, and the small vesicular masses seem to retain the molecular activity of the particles that build them up, and there is little doubt that in fog or cloud it is this formation that gives the floating power, as the water vapour contained by the vesicle is only a little more than half the weight of air, and also explains the formation of rain by gun-fire and the dispersion of fog by electrical discharges, the bursting of the vesicle in each case leading to precipitation.

The tar vapour which escapes during the distillation of coal, either in the gas-maker's retorts or upon an open fire, consists of a mass of vesicles of this character, and this period is the one in which the most serious waste takes place, as not only is the greatest amount of heat being rendered latent by the distillation from the coal of these products, but they also escape unburnt up the chimney. After a while sufficient heat finds its way through the coal to the top of the fuel to ignite some of the escaping vapours, and the bright luminous flame then makes its appearance above the fire. This flame radiates a considerable amount of heat owing to the incandescent particles within it, and the waste of heat diminishes; but it will be seen that a large amount of vapour is still escaping unburnt, owing to the dilution of the hydrocarbon gases by steam and the cold air sucked in over the surface of the fire, which lowers their temperature below the point of ignition.

The appearance of the flame itself is worthy of notice, as the chemical changes taking place within it make it red and lurid towards the top, and the particles of oily carbon which form the soot escape from it.

Flame is caused by the combustion of gaseous matter, and when the air supporting the combustion is supplied externally to the combustible gas, the resulting flame is always hollow, consisting of at least two parts, an outer zone in which combustion is taking place, and an inner zone in which, there being no oxygen to carry on the combustion, no such action can take place. The ordinary luminous flame, such as is employed for illuminating purposes, is divided into four parts, but for present purposes our fire flame may be looked upon as consisting of only three, the inner zone being an area in which no combustion is taking place, but in which the gases are subjected to the baking action of the heated envelope that surrounds it, and undergo many decompositions, the most important chemical change being the conversion of any hydrocarbons into acetylene. In the outer zone combustion takes place in contact with air, giving the hottest part of the flame, and as the result carbon dioxide, carbon monoxide, and water vapour are formed; whilst between the inner and outer zones is a brilliantly luminous sheath giving the major portion of the cheerful firelight, whilst higher up in the flame, if combustion is not complete, this luminous portion becomes dull red and gives out far less light, and above this again smoke begins to appear in considerable quantities. These gradations in appearance are due to the acetylene and kindred bodies formed by the baking action of the outer zone on the hydrocarbons in the gases and vapours passing through the dark inner zone, entering the heated zone of combustion, when the acetylene suddenly splits up under the influence of heat into carbon and hydrogen, the latter of which burns and adds to the general heat of the flame, whilst the carbon raised to incandescence partly by the heat generated during its own formation from the endothermic acetylene and partly by heat from the flame, as well as by its own combustion, gives out the light. If the combustion were completed no smoke would be formed, but the diluting influence of the nitrogen and other products from the fire beneath and the cooling influence of the chimney draught so check and hamper the completion of the combustion of the products from the decomposed acetylene that the top of the flame is cooled to a dull red, and the flame is finally extinguished before all the carbon particles can be consumed, this producing the sooty smoke which passes up the chimney. The smoke does not consist merely of the liberated carbon particles, but contains tar vapour, water vapour, products of combustion, and excess of air, together with the residual nitrogen from that portion of the air that has been used in the combustion, as well as particles of ash sucked up by the draught of the chimney.

In time the fire burns clearly, the amount of flame becoming extremely small, and consisting mainly of carbon monoxide, and practically smokeless combustion is attained. No further pollution of the atmosphere takes place until more coal is fed on to the fire, whilst the incandescent fuel is radiating out the heat given by the combustion of the carbon, and is doing more heating work than at any other period.

Such details of chemical and physical action as I have attempted to bring before you seem absolutely superfluous to the lay mind, but until they are recognised it is practically impossible to arrive at any true solution of the difficulty.

Take an iron flask, half fill it with pieces of bituminous coal the size of peas, and heat it up to the highest temperature you can obtain with an atmospheric burner, and you will find that, as the heat penetrates the mass of coal, first white and then brown vapours distil from the mouth of the flask. Ignite these brown vapours, and you will see the same phenomena that are shown by the luminous flame above the fire; stop the flame for a moment by closing the mouth of the flask by a damp plug, and, having extinguished the flame, pass the brown vapours through a condenser, and you find that black liquid tar condenses and a clear, colourless coal gas escapes, which when ignited gives a luminous flame with little or no formation of carbon. Moreover, if, having ascertained this fact, you remove the condenser and reignite the mixture of gas and tar vapour, you find it gives a flame which steadily becomes less and less luminous, and finally assumes the character of a yellowish flame incapable of forming smoke, and from which no tar can be condensed.

This flame gradually dies away, and if the residue in the flask be examined, it is found to be ordinary gas coke, which when burnt in air gives no smoke or soot, and only such flame as is due to the formation of carbon monoxide by the passage of air through the incandescent carbon, and which, escaping from the mass, meets more air and burns with a small non-luminous flame.

From the fact I have brought before you several points are clear:—

(1) That the smoke-forming portion of bituminous coal is the hydrocarbons, which on destructive distillation form the tar.

(2) That the true coal gas contains but little of these, and can easily be burnt with smokeless combustion.

(3) That the residue left after the destructive distillation of the coal, *i.e.* coke, burns without the formation of smoke.

(4) That tar vapour and white smoke escape in the form of minute vesicles, which will float in air until burst by violent contact with some surface, on which they then deposit as tar.

(5) That what we speak of as smoke consists of a mixture of (*a*) tar vapour; (*b*) water vapour; (*c*) tarry carbon particles; (*d*) products of combustion other than water vapour; (*e*) fine particles of ash.

Amongst the gaseous products of combustion also are to be found sulphur compounds, such as sulphuretted hydrogen and sulphur dioxide, the first formed during the distilling period when coal has just been fed on to the fire, and the latter during the combustion. Both these compounds are due to the sulphur always present in the coal, and whilst the former blackens white-lead paint and tarnishes silver, the sulphur dioxide, dissolving in water, oxidises to sulphuric acid, which is far more actively injurious, corroding and destroying metal work, retarding the growth of vegetation, and finally killing it.

Smoke thus formed finds its way from the chimney into the atmosphere, and is rapidly diffused through the air by means of the air currents, and it is manifest that if there were no means of removing it the air would soon become perfectly opaque from its accumulation in large quantities. When, however, rain falls, it rapidly washes the air free from such suspended solid and liquid impurities which constitute the visible portion of smoke. Snow is even more efficacious than rain in doing this; where the snow has fallen on the glass roof of a greenhouse it will be noticed that when it melts it leaves behind a black deposit consisting of the solid matter which it has collected during its passage through the air. An analysis of a deposit of this character formed on the glass roofs of some orchid houses at Chelsea gives a very good idea of the constituents of these solid impurities:—

	Per cent.
Carbon	39·00
Hydrocarbons	12·30
Organic bases	1·20
Sulphuric acid	4·33
Ammonia	1·37
Metallic iron and magnetic oxide	2·63
Other mineral matter, chiefly silica and ferric oxide	31·24
Water not determined.	

In cases where long drought prevents the rapid clearance of the air by this means, the heavier of the solid particles settle by gravity, whilst the particles of carbon and carbonaceous organic matter are slowly oxidised by the oxygen and ozone into carbon dioxide, in which form vegetation removes them from the air.

The solid particles suspended in air are, however, by no means confined to the products of our improper use of bituminous fuel, and mineral matter from the dust of our roadways and organic matter from animal and vegetable life all play their part in rendering town air deleterious to health; but it is the smoke "dirt" that is the most injurious factor.

The smoke from our grates is naturally discharged at a lower level than that from the factory shafts, with the result that it probably has a greater effect on our general health and buildings than the higher layers of smoke, which travel for miles with the wind and which act more by darkening the sky and cutting off the sun's rays; and it is also clear that the low-level smoke will not extend so far from the point at which it is formed as contact with buildings and vegetation rapidly rob it of the tar vapours, with the result that in a smoky town like Leeds it has been shown that at one mile out the solid impurities have fallen to one half, and at 2½ miles out to one-sixth.

Injurious as are the direct effects of smoke on health and property, they are small as compared with those brought about by dense fog, which may to a great extent be attributed to smoke, which acts partly by helping its formation and partly by retarding its dispersion.

Fog, whether it be in the form of white mist which is found in the country, or the yellow abomination which we know so well in London, is formed by the condensation of water vapour from the air, and this is brought about by any cause which rapidly cools a large volume of moist air. If, instead of the surface of the ground and the objects on it only being cooled the air for a considerable height above it is also lowered in temperature, then the moisture which is deposited from it, instead of forming dew, condenses in the air, forming minute vesicles that remain suspended and floating in the air, and constitute fog or mist. In pure air the mist so formed consists of little else than these minute bubbles of water, and has no irritating effect on the eyes or lungs. In a large town like London, however, the air is charged with an enormous number of minute particles, the heaviest of which settle on a horizontal or roughened surface in the form of dust, whilst the lighter particles continue floating in the air. These particles consist of a heterogeneous collection of all kinds of matter, amongst which "smoke" particles bulk largely, constituting more than one half. All these floating solids cool with great rapidity on account of the smallness of their size, and in doing so cause the rapidly cooling air to deposit moisture upon them, and so aid in the formation of the town fog, which appears long before the country mist.

The air of towns in which much coal is used also contains the volatile tarry matter distilled off during the imperfect combustion, and this, condensing with the moisture, coats it on the outside with a thin film, which does much to prolong the existence of the fog, as when the temperature of the air again rises the clean mist again evaporates into the atmosphere, but the tar-coated yellow fog has its power of evaporation retarded to an enormous extent. Experiments made by Sir E. Frankland show that the evaporation of water in dry air is reduced nearly 80 per cent. by blowing some smoke from burning coal on to its surface.

The statements made as to the enormous waste of fuel in the escaping smoke are, I think, often much exaggerated. In point of fact, the carbon wasted as soot is extremely small, and varies in smoke with the state of the fuel which is fed on to the fire. Under the ordinary conditions experienced in an open fire grate, in which the fire has just been made up with bituminous coal, the heavy smoke escaping will contain, on an average, 1½ per cent. of the total weight of fuel consumed, and as the temperature of the mass gradually increases this falls to less than ½ per cent.

A greater waste of the thermal value of the fuel takes place in the formation of the smoke, *i.e.* in the heat rendered latent in bringing about the decomposition of the coal, and the volatilisation and escape unburnt of the tar vapours formed.

Having gained an idea of the causes which give rise to smoke from the domestic hearth, we can now review the proposals which have from time to time been made for its prevention, and which may be classified under the headings:—

(1) The use of bituminous fuel in special grates.
(2) The use of solid smokeless fuel.
(3) The use of gaseous fuel.
(4) The combined use of gas and coke.
(5) Central heating by steam, water, or hot air.

In considering the claims of these various methods we must remember that the English open fire is undoubtedly the most comfortable and wasteful method of heating that could be adopted; but although by far the largest proportion of the heat escapes up the chimney, we must clearly bear in mind that this very factor makes it a most important engine of ventilation, and that at this time, when the ventilation of our middle-class houses is chiefly left to the jerry builder and the open fireplace, it is an important factor of health. Moreover, it heats the room in the only healthy way, that is, the radiant heat from it does not directly raise the temperature of the air, but is radiated to the floor, walls, and furniture in the room, which again part with their heat slowly to the air in contact with them and to the inhabitants, so that the walls and other solid matters in the room are at a higher temperature than the air.

Apart from its being more healthy to breathe cool than hot air, there is another important point to consider. The normal temperature of the body is 98° F., or 36·8° C., and this temperature is maintained by the slow combustion processes going on in the body. By the laws of radiation a heated surface parts with its heat more or less rapidly according to the temperature of the surrounding bodies, so that if a person be sitting in a room filled with warm air, but near a wall colder than the air, his body will rapidly part with heat by radiation to the wall, and a sensation of chill is the result; but with the open fire this is never the case, as the radiant heat from the fire heats the walls of the room to a temperature higher than that of the air. But when a room is heated by means of hot-water pipes or warmed air, the walls not being heated in the same proportion, although the air may feel warm the walls will remain cold, so that the heat of the body would pass by radiation to the walls and give rise to a chill.

If, therefore, one can retain the chief characteristic of the open-fire heating by radiation, and eliminate the smoke production and excessive waste of heat up the chimney, we should have the ideal conditions for house-warming.

Enormous improvements have been made in the domestic grate during the last fifteen years both from the artistic and economic point of view, and whilst with the older forms it was not unusual to find a coal consumption of 7 to 8 lb. of coal per hour, this quantity has been reduced in the more modern forms to about one half, and this in itself has been an important step in smoke reduction; but grates have long lives, and the capital outlay of putting in new ones results in the modern forms being chiefly found in new houses. There have been many attempts made to construct grates for the smokeless consumption of coal, but it is found in practice that when once the heavy carbonaceous smoke is produced it is very difficult again to burn the carbon particles completely, as the dilution caused by the large volumes of nitrogen present prevents their easy combination with the oxygen of the air; and there is no doubt that the best methods of preventing smoke from bituminous coal is to feed on the fresh coal only in very small quanties, and to supply the top of the fire with a sharp draught of hot air. Under these conditions complete combustion of escaping hydrocarbons is ensured, and very little carbon is allowed to be liberated in the solid form. In order to do this, however, the stove has to be to a certain extent closed in, which is a drawback, and it is also found that no grate for bituminous coal is absolutely smokeless.

Stoves have been constructed in which the coal should be supplied to the bottom of the fire, so as to keep the top bright and clear, all the smoke having to pass through the clear fire above, where it is decomposed. Such grates are by no means novel, as one of the best was the "Arnott," and must be more than sixty years old; but for some reason they have never been popular with stove manufacturers, with the result that they have never reached the public, otherwise they are efficient and economical.

The great factor in making special forms of grate an ineffective solution of the smoke problem is that it involves large capital outlay on the part of the consumer, and my own experience is that unless the consumer can become a reformer without expense or extra trouble, the majority will talk but never act, and it is for this reason that the use of solid smokeless fuel, which can be used in all existing grates, appears the most likely solution of the great question.

Smokeless solid fuels may be classified as:—

(1) Coal which has been carbonised at a high temperature, so as to drive out practically all the volatile matter, and this class is represented by gas coke and Coalexld.

(2) Coal which has been partially carbonised so as to distil out the smoke-forming constituents, but to leave enough volatile matter to give a non-luminous flame and easy ignition, as seen in coalite and carbo.

(3) Non-bituminous coal, such as anthracite.

Coke, the solid product of high-temperature distillation, has never found favour with the middle and upper classes as a domestic fuel, owing to prejudice against it because of its being somewhat difficult to ignite and not burning freely, and its chief market has been for steam-raising and other manufacturing purposes, very little finding its way into the householder's grate. The result is that, had not carburetted water gas offered a convenient and economical way of using it in the gas works, many companies would have found great difficulty in keeping up the price during the years that coal was cheap.

It must be remembered, however, that during the past three years the great gas industry has been in a transition stage, and England is slowly following the lead of the Continent in recognising the fact that great economies are to be found in carbonising coal for gas-making in larger charges than have ever before been attempted, and the introduction of vertical and oven retorts is undoubtedly a step in the direction of making a coke which shall be more fitted for a domestic fuel than the over-heated product made in the horizontal retorts of late years.

The large amount of attention centred upon the production of a smokeless fuel during the past three years has led to the introduction of several processes for improving the coke during gas manufacture, which, although leading to little or no improvement, have enabled the product to be sold under a fancy name, and have done a certain amount of good by inducing consumers to try under another name the coke which prejudice would have damned untried.

The second class of smokeless fuel, and the one which many scientific men look upon as the most promising solution to the smoke problem, owes its inception to Colonel Scott Moncrieff, who many years ago suggested the use of a half-coked coal as a fuel supply, and tried to make a commercial article by carbonising coal at the ordinary gas-retort temperature, drawing the charge when half the usual volume of gas had been distilled out from it. Two factors, however, led to failure, the one being that the time was not ripe, and the second that the means by which he proposed to carry out his entirely admirable idea, being dependent upon the ordinary gas-works practice, had to be carried out under certain conditions which led to a want of uniformity in the fuel, and to certain difficulties which those who tried to make it failed to overcome.

The idea, however, of a semi-carbonised coke which should still contain enough volatile matter to give easy ignition and a cheerful flame without any smoke, was independently revived under the name of "Coalite."

This differs from the fuel proposed by Colonel Scott Moncrieff in that, instead of shortening the period of carbonisation at a high temperature, the temperature is reduced to one half the ordinary, and is continued in suitable retorts until a uniform coke, containing 12 to 15 per cent. of volatile matter, is formed. In both processes there is the fatal defect—from a gas manufacturer's point of view—that less than one half the volume of gas is obtained per ton of coal, and as the all-conquering career of the incandescent mantle has rendered a high candle-power gas unnecessary, the rich gas yielded is not looked upon as an equivalent attraction.

The coalite process has the great advantages over the older process that the fuel is of greater uniformity, and that the yield of tar is doubled instead of being decreased, and is greatly enhanced in value.

Coalite has created so much interest that, as was only natural, the Moncrieff process was revived, and the product is well known under the name of "Carbo."

Coalite appears at present to be labouring under difficulties, but I am convinced now, as I was when I first examined the process, that when its manufacture is properly handled coalite will be the ideal fuel, and will not only solve the smoke problem in the easiest possible way, but will also be an important economic advance in our treatment of coal.

The use of a non-bituminous coal like anthracite would result in smokeless and very hot combustion, but here again the objection is that stoves with a special draught would have to be used, and the initial cost would prevent its use ever being adopted, besides which any great demand for this kind of fuel would at once send up the price to a prohibitive figure.

If the consumer can be induced to take the trouble, a very good semi-smokeless fuel can be made by using a mixture of two-thirds coke to one-third coal, and instead of piling up the grate with cold fuel when the fire burns low, to add the fresh fuel frequently in small quantities, so as to prevent the deadening of the top heat of the fire; but this is diminishing, not killing, the evil.

Leaving the smokeless solid fuels, which I believe will in the future play a very big part in the cleansing of town air, we now come to the gaseous fuels, and here at once we have ready to hand a solution of the difficulty in the use of coal gas. Gas fires, gas cookers, gas water-heaters, gas engines, have all been developed to a point which leaves no valid excuse for overlooking their claims, and ever since Bunsen in the early 'fifties gave us the atmospheric burner, in which non-luminous combustion is obtained and smoke rendered impossible, coal gas has steadily progressed in favour for heat and power as well as light, until at the present time nearly as much is used for the one as for the other.

What, then, stands in the way of its universal adoption? First and foremost, initial cost crops up, as although much has been done by the companies in popularising gas stoves by letting them out on hire, by easy payment systems, and by looking after their maintenance, the consumers must pay something, and that is sufficient to damp their ardour as smoke reformers. Secondly, gas is a little more expensive for continuous heating than coal, although when used for short periods, as for fires in bedrooms, &c., the fact that you turn it on when you want the fire and turn it off when it is done with brings the fuel cost to nearly the same as coal, whilst in such places as Widnes and Sheffield, where the price has been reduced to a minimum for heat and power, the gas engine and gas fire well hold their own.

The chief sentimental objections to the gas fire—its non-pokerbility and one's not being able to throw cigar stumps and ash into it—are disposed of by a suggestion made first, I believe, by Sir W. Siemens some thirty years ago, and that is to decompose bituminous coal into coke, tar, and gas in our gas works, and to reunite the true heat producers, coke and gas, in our fire grates sans the smoke-producing tar—to do, in fact, with coal what was done by Chevreul a century ago with tallow, when he converted the tallow dip into the composite candle.

All the initial outlay needed for this is to fit the atmospheric burner arrangements of the gas stove to any ordinary fire grate, so arranging them that they can be made to swing back clear of the fire when they have done their work of bringing to bright combustion the gas coke used as fuel in the grate. This has always seemed to me to be the best economic method of using the products of gas manufacture, because it would be impossible to use either gas or coke alone to entirely supplant the use of bituminous coal; a market must be made for the by-products if prices are to be kept down and, as we hope, still further reduced, but if the use of gas and coke could both be increased, the gas manager could afford a diminution in the price of tar from over-production, as he has already ruined the tar market by overheating his retorts, and so loading the tar with free carbon and naphthalene as to make it nearly worthless.

As I have before pointed out, to my mind the best solution of the dual question of the most economical use of coal and the cleansing of our atmosphere is to be found in low-temperature carbonisation and the production of such fuels as coalite, because every constituent of the coal is utilised in the best way; but when we see how little expense and personal trouble is needed to attain smokeless combustion in other ways, it becomes evident that the mere provision of means to bring about the desired end is entirely insufficient. How can the societies interested in smoke abatement influence the hundreds of thousands of small consumers whose chimneys make the morning cloud; they may make their doctrines felt in the West End, but will they ever touch the seething population of the workers' quarters of the town?

One is gravely told that legislation should be passed dealing with the question, and that the use of bituminous coal should be forbidden; but I think this is scarcely feasible, and unless we revert to the conditions of 1306, when a citizen of London was executed for using bituminous coal, I doubt its being effective; but I do believe that if a future Chancellor of the Exchequer would put a 5*s*. tax on bituminous coal, exempting that used for gas-making, smokeless fuel manufacture, and for use by those burning it in smoke-preventing forms of grate or furnace, the question would quickly be solved, coal economised, and smoke abolished.

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

SIR T. CARLAW MARTIN, editor of the *Dundee Advertiser*, has been appointed by the Lords of the Committee of Privy Council on Education in Scotland, director of the Royal Scottish Museum, Edinburgh.

PROF. G. R. THOMPSON, professor of mining, University of Leeds, has been appointed professor of mining at the South African School of Mines and Technology, Johannesburg, and principal of the college.

THE Department of Agriculture and Technical Instruction for Ireland has issued in pamphlet form an illustrated account of technical instruction in Londonderry, by Mr. G. E. Armstrong, principal of the Londonderry Municipal Technical School, which was published recently in the Department's Journal (vol. xi., No. 1).

THE report of a higher education subcommittee of the London County Council Education Committee, recently prepared, provides interesting information as to the allocation of grants to secondary schools aided by the Council. The income of aided secondary schools is derived from four main sources:—endowment, Board of Education grant, fees, and grants from the Council. The actual receipts for the school year 1909–10 under the four headings in order were 45,132*l*., 52,326*l*., 101,256*l*., and 37,398*l*., making a total of 236,112*l*. The estimated receipts for 1910–11—for the aided schools, which number forty-two—are, under the same headings, 46,589*l*., 52,653*l*., 97,181*l*., and 38,203*l*., amounting to 234,626*l*. The amounts mentioned under fees include the fees of London County Council's scholars, which in the forty-two schools mentioned were in 1909–10 37,938*l*., and are estimated for 1910–11 at 37,144*l*. It will thus be seen that the total Council grant to aided secondary schools in London was in 1909–10 75,334*l*., and will be in 1910–11 75,347*l*.

A COPY of the annual report of the 114th session of the Glasgow and West of Scotland Technical College, which was adopted by the governors last September, has been received. The progress of the college in regard to the number of students, as well as standard of work, continues to be satisfactory. While the number of individual evening students has increased in five years by 30 per cent., class enrolments and "student hours" have increased by more than 45 per cent. The fourth and last section of the new buildings has now been completed, and provides accommodation for the department of textile manufacture. The new school of navigation, to which the Glasgow City Educational Endowments Board has undertaken to make an annual subsidy of 500*l*., has now been organised and opened. In their report the governors acknowledge the receipt of additional grants, amounting to 26,866*l*., from the Scotch Education Department towards the building and equipment fund, and a grant of 3000*l*. from the trustees of the late Mr. Alexander Fleming.

THE eighteenth annual distribution of prizes and certificates was held at the Borough Polytechnic on Monday, December 19. Mr. J. Leonard Spicer (chairman of governors) presided, and in the course of his opening remarks referred to the great progress made by the institute during the year, the record number of class entries being more than 5000, showing an increase of more than 500. That the work was appreciated was shown by the numerous visits paid by persons from all parts of the world interested in education, and as a result of one of these visits a request had been received from the High Commissioner to the Australian Commonwealth for a set of specimens of metal work executed by the boys of the day school, and the Japanese Commissioner, on behalf of his Government, applied for the metal work of the boys' day school, the specimens from the printing classes, and the work of the oils, colours, and varnish department, that had been displayed at the Japan-British Exhibition. The principal, Mr. C. T. Millis, reported the satisfactory examination results, and stated that thirteen medals had been gained in examinations conducted by the City and Guilds of London Institute, the Royal Society of Arts, and other public bodies. Lord Lytton urged the students of the polytechnic to do their utmost to realise the ideals which the founders of that institution had in mind when the polytechnic was first established. Was there ever a more pathetic sight, he asked, than to see a man who had suffered all through his life from lack of opportunity, and he thought the polytechnics were established with the object of equalising opportunities for all in the competition in life. The polytechnics should in addition stimulate among the students a sense of the duties and responsibilities of citizenship.