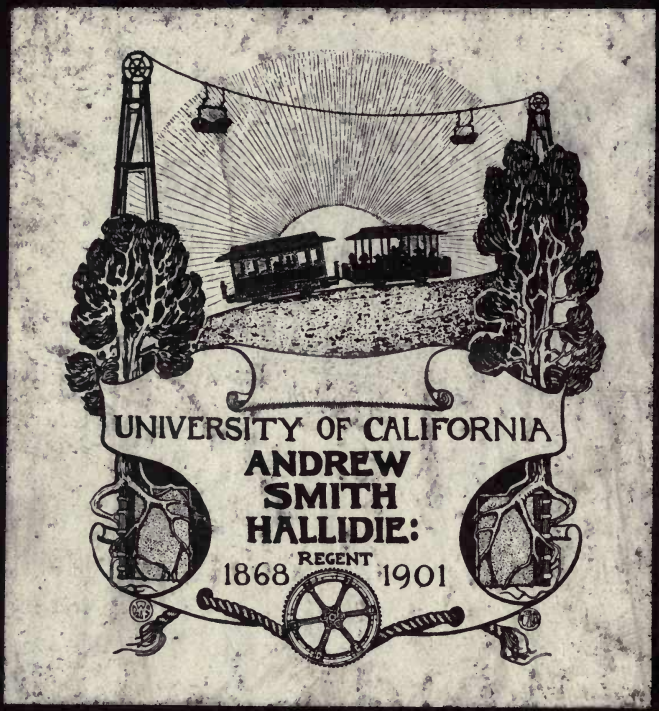
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SMOKE ABATEMENT

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SMOKE ABATEMENT.

A MANUAL

FOR THE USE OF MANUFACTURERS, INSPECTORS, MEDICAL OFFICERS OF HEALTH, ENGINEERS, AND OTHERS.

BY

WILLIAM NICHOLSON,

CHIEF SMOKE INSPECTOR TO THE SHEFFIELD CORPORATION.

With 59 Illustrations.

LONDON:
CHARLES GRIFFIN AND COMPANY, LIMITED;
PHILADELPHIA: J. B. LIPPINCOTT COMPANY.
1905.

Printed by BALLANTYNE, HANSON & Co.
At the Ballantyne Press

PREFACE

In preparing the present volume it has been the object of the author to give, as concisely as possible, an account of the smoke abatement movement, and to indicate the means by which the smoke nuisance may be combated, and, it is to be hoped, finally overcome.

The present age is essentially one of industrial growth and expansion; it is also one in which there may be detected the gradual awakening of a national conscience in regard to questions of hygiene and to all that concerns the well-being of the community. This being so, no excuse is needed for calling attention to the serious harm which results from the unrestricted emission of smoke, and it has been the aim of the author to show that, so far from its being a necessary evil, it is one that is easily remediable, and for the removal of which adequate legal machinery actually exists. The emission of smoke is unsound both economically and hygienically; economically, inasmuch as it involves a direct waste of valuable fuel, and hygienically, as it is a direct cause of lowered vitality in those compelled to breathe the vitiated atmosphere, and hence increases their susceptibility to infectious disease.

The legal aspects of the smoke nuisance have been made the subject of three chapters giving the various

enactments which, from time to time, have been made in our own and in other countries. The causes of smoke are next described, both from a theoretical and from a practical standpoint, and the remedy indicated. Succeeding chapters deal in detail with the various appliances now on the market for the dual purpose of smoke abatement and fuel economy, the leading types being illustrated and described. The author desires in this connection to express his indebtedness to the manufacturers who have kindly placed at his disposal valuable information, and supplied blocks as noted in the List of Illustrations.

In conclusion, the author hopes that this book may be the means of directing increased attention to a question which, although of urgent public importance, has hitherto been unaccountably—and culpably—neglected by many of those public authorities upon whom the duty of dealing with it devolves.

W. N.

June 1905.

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SMOKE ABATEMENT

CHAPTER I

INTRODUCTION

History and Growth of the Smoke Nuisance—The Combustion of Coal—Nature and the Results of the Smoke Nuisance.

History and Growth of the Smoke Nuisance.—The history of the smoke nuisance during the last hundred years proves that there have always been a few persons possessed of a clear conception of the enormity of the evil, and who have resolutely set themselves the task of bringing about its abolition. To these persons the public as a whole is deeply indebted. The greater portion of the community has, however, shown a spirit of indifference which, on the part of those who are directly responsible for its continuance, or upon whom devolves the duty of dealing with it, is distinctly reprehensible. The reasons for this apathy are many, and are both direct and indirect. It is a *silent* nuisance, hence it escapes the notice of many, while many of those who do see it, and have some conception of the damage it is doing, imagine it to be a necessary nuisance. There are numerous other reasons which are constantly being put forward as a justification of the *laisser faire*, which are all, however, untenable when subjected to examination. Of reasons which, on the other hand, can be put forward in favour of its

abatement, the following are surely sufficient to compel action:—

The smoke nuisance is a nuisance, 80 per cent. of which can be practically prevented, and in many instances an even higher percentage can be reached.

There is in existence sufficient legal machinery to enforce prevention.

A proportion of the physical degeneracy of the human race, of which so much has been said during the last few years, is directly traceable to the constant inspiration of impure air, and the nuisance is on the increase.

Amongst existing organisations which should be able to aid in the task of smoke abatement may be cited the Local Government Board. This Board consists of medical and other experts appointed by the Government on account of their special fitness for the work they have to do. They are the guardians of the public health, whose duty it is to see that the provisions of the Public Health Act are carried out. If an epidemic of smallpox or of any other infectious disease breaks out, an inspector of the Board at once visits the Local Authority, institutes an inquiry, finds out the cause, takes steps to stamp out the disease, and issues instructions to the Local Authority, which aim at preventing, as far as possible, a recurrence. The Board has done, and is doing, excellent work by effectively dealing with impure water supplies, unwholesome food, the housing of the poor, defective drainage and ventilation, building construction, refuse disposal, the sanitation of factories and workshops, offensive trades disinfection, zymotic diseases, and almost every other condition which has any bearing on public health.

The smoke question has, however, received no attention at the hands of the Board, although the unrestricted emission of smoke alone is more injurious to health than many

of the above conditions put together. The question of economy is not one that should be seriously entertained in this connection. If necessary, the staff should be increased, an expert engineering official or officials appointed, and a Smoke Department established. The duties of such a department would be to make model bye-laws or regulations for the Local Authorities respecting the construction of furnaces and fireplaces and their working, the nature of the smoke nuisance, and the number of minutes which should be allowed in a specified time for one or more boilers or furnaces of different kinds to emit smoke, as well as for the accumulation of the general information essential for the guidance of Local Authorities in the administration of the Smoke Acts. Regulations on the above-mentioned lines would be sent to each Local Authority with instructions to carry them out. The officials would occasionally visit cities and towns, especially those where heavy trades were carried on, to ascertain if the regulations were being enforced, and to note if any improvement in the atmospheric conditions had resulted. If the Local Authorities ignored the instructions as they have the Public Health Act of 1875 (which deals with the smoke question), it would be the duty of the Smoke Department, in the interests of public health, to carry out this important work themselves, by mapping out the country into districts and sub-districts, appointing district inspectors and assistant inspectors, and empowering the inspectors to take proceedings against any preventable nuisance in their districts, and to conduct the said proceedings in court. Such steps would prove most salutary, for justice would be done both to the smoke maker and to the public. If the Local Authorities refused to do their duty, which would hardly be likely if they found the Board to be really in earnest, it would be the duty of the Government to see they are done, as is the case in the administration of the Factory Acts, which are carried out without reference to local opposition.

Public health experts are now mostly agreed that the time has arrived when a Minister of Public Health should be appointed, and made responsible for the public health of the country. A minister possessed of special qualifications for office would very quickly find out whether the departments now in existence under the Local Government Board are being worked efficiently, and if not, he would be able to institute the necessary reforms. He would also give prompt attention to questions which to-day demand it (but which have hitherto been ignored), and establish not only a Smoke Department, but other departments to deal with important matters regarding health.

The Local Authorities are elected by the public to look after their interests and to legislate for them. They comprise men from all classes of society: doctors, lawyers, manufacturers, shopkeepers, artisans, and others. Election imposes upon those who seek office many legal and moral obligations, which must be faithfully discharged in the interests of those represented. One of the most important of them is the "abatement of the smoke nuisance." Every member of every Authority in a district where trade is carried on knows of the existence of a smoke nuisance, but it has been in existence so long, that most of them have come to regard it as a necessary nuisance. They are not acquainted (nor is it reasonable to expect them to be) with the sections of the Public Health Act of 1875, which give them power to deal with the nuisance.

Section 92 of this Act lays it down that "it is the duty of a Local Authority to inspect the district for the detection of nuisances." This necessitates the appointment of a nuisance inspector. If the district is a very small one, then one inspector may deal in a fairly satisfactory manner with all nuisances arising. But in a large district divided into a number of sub-districts, a single inspector individually charged with the super-

vision of all the nuisances does not prove satisfactory. It has been found better for the district inspector to deal with general nuisances in his district, and to appoint special inspectors for special duties, viz., the inspection of meat and other foods, of cowsheds, of canal boats, and of lodging-houses, swine fever, of consumption cases, of plumbing, and of workshops. Lady inspectors have been appointed to advise on the cleanliness and feeding of children, and smoke inspectors, and other inspectors of special nuisances have been found necessary. To make a general nuisance inspector efficient, he must have had some practical experience in building, joinery, plumbing, and kindred trades, but an efficient smoke inspector must have had some practical experience in engineering.

The inspectors appointed should be practical engineers, with special experience in the working of various kinds of boilers, engines, and furnaces. To obtain the most suitable and competent men it will be necessary to pay a reasonable salary. The best men will then be willing to take up the work, which is often very difficult and distasteful. It will be of very little use, however, to appoint special smoke inspectors unless the Local Authorities are determined to enforce the law, and to assist the inspectors in every way possible.

The inspectors appointed would take observations of chimneys, and ascertain the amount of smoke emitted during stated periods; visit works and find out what the offending chimneys serve, and have the boilers and furnaces fired and thoroughly tested to decide how much smoke it might be necessary to emit in a specified time for their effective working. The working limits of smoke emission could then be fixed, and if the limits were exceeded, a nuisance would be established within the meaning of the Act, for which it is necessary to serve a notice to abate within a reasonable time. If by subsequent observations it was found that the nuisance had not been abated, the works should be again visited,

and if it were found that there was no necessity for the continuance of the nuisance, proceedings should be taken, a magistrate's order made to abate, and a penalty imposed for non-compliance with the notice.

Some Authorities have proceeded, or have attempted to proceed, on the lines laid down, but have met with much opposition from manufacturers' associations, by whom they have been charged with pursuing a policy of persecution, and obstructing and interfering with trade, threats being made that a continuation of the policy would compel the manufacturers to seek some other town for their works.

Offenders have claimed full liberty to construct their furnaces and fireplaces as they pleased, either on ancient or modern principles, and to erect chimneys twenty-five feet high, or even lower if they choose; and exemption from interference with the way they worked the fireplaces and furnaces, and freedom to emit smoke for longer periods than those specified. They have also claimed to be informed when the inspector was going to make observations, or after every observation of excessive smoke emission, which, they contend, would do more to prevent smoke than prosecutions.

To emphasise their charges, and to obtain the concessions claimed, they have threatened to take their business outside the city boundary, where they could carry on their business just as they pleased. This attitude has frightened many Local Authorities, and they have conceded everything asked for, though there was not the slightest prospect of the business being removed elsewhere, and even if it had been the Authority into whose district they had removed would have been equally compelled to proceed against them for making an unnecessary nuisance.

On the other hand, there are manufacturers who do everything practicable to prevent smoke. New boilers are put down, furnaces rearranged, costly appliances attached,

good coal bought, experienced men, liberally paid, put in charge, in fact, everything is done to stop smoke. Some firms have spent thousands of pounds on smoke prevention, and are entitled to the highest praise for their endeavours to minimise the evil. There are also many who do a little toward smoke prevention to escape prosecution, which, although not perhaps a very worthy motive, is better than none at all.

There exists an organisation well-fitted to cope with the problem. The Sanitary Institute was founded in 1876 and incorporated in 1888, and its object was the dissemination of sanitary science, especially amongst those who occupied official positions, and whose duty it was to administer the laws relating to public health, and to render them better qualified to efficiently discharge their duties. Sanitary experts at once appreciated the objects of the Institute, became members, and to-day there are thousands of public health experts within its ranks who are working zealously to carry out the objects for which it was founded. Courses of lectures are given by specialists on the leading health questions, examinations held at the close, and certificates given to those who procure the requisite number of marks. The inefficient manner in which many sanitary inspectors carried out their duties to the detriment of public health, compelled the Institute to establish special examinations in sanitary science for sanitary inspectors, or others who desired to qualify for the work. The examinations embrace a number of questions completely covering the general work of an inspector, the examiners being medical officers of health and other specialists, and a certificate is awarded those who pass.

The experience of Sheffield with regard to the value of the certificate for sanitary science is the general experience of the country, and is a very striking testimony in favour of the great and good work done by the Institute.

Much has been done by the Institute, but not enough, for it has practically done nothing on the smoke question, with the exception of one or two papers dealing with the subject having been read at the annual congresses. This attitude is unfortunate, as it is to a large degree responsible for so little being done by Local Authorities, who argue that if the Sanitary Institute as an expert body refuses to do anything on the question, they are justified in letting the matter alone.

The time has now arrived for the Institute to deal thoroughly with the question, because of the enormous injury it is doing to health and property. It might proceed on the same or on similar lines to those it has adopted in regard to other questions, viz., arrange for courses of lectures to be given by specialists at various centres of industry on the subjects of: "Smoke and the Injury Therefrom"; "The Causes of Smoke"; and, "The Practical Prevention of Smoke," &c.; after which examinations might be held, and certificates of competency given to all who satisfied the examiners.

If such facilities were offered, hundreds of engineers and others would avail themselves of them, and would not rest satisfied until they procured a smoke inspector's certificate, which would become as popular and as valuable as the sanitary inspector's certificate. Having obtained the certificate, and possessing the theoretical as well as the practical knowledge, they would quickly be on the look-out for official appointments, and if there was an unwillingness on the part of Local Authorities to appoint them, the necessary pressure to compel them to do so would be forthcoming.

Years ago the Press proclaimed a crusade against an atmosphere polluted by smoke, and articles, speeches, and letters full of sound arguments against it were published. But in the main there was no response from the public, so they let the matter drop, as it was not a very profitable crusade to fight capitalists who were

in many instances their largest supporters. It is the duty of the Press to revive the agitation; and to persist in using all the power it possesses in denouncing the nuisance until smoke abatement is an actual fact throughout the country. Finally, if the public itself, which, after all, is the body chiefly concerned, could only be roused to a sense of the many evils arising from the unrestricted emission of smoke, strong measures would soon be brought to bear upon its abatement.

Combustion of Coal. — Although much has been written about combustion, comparatively little is known about the precise conditions under which coal is imperfectly or perfectly burned. In a general way it is quite clear what the principal conditions for perfect combustion should be, viz. (1) The temperature should be raised as quickly as possible to that at which the oxygen combines with carbon and with hydrogen, and be steadily maintained within the combining temperature range; (2) the oxygen in the air supplied should be brought into the closest possible contact with the fuel both as coal and as gases from the coal; and (3) the air supply should be just sufficient to convert all the carbon and oxidisable carbon compounds to carbon dioxide (CO_2).

These conditions are never fully realised, but the aim should be to make the nearest practicable approach to them in each particular case.

The chief consequence of the imperfect combustion of carbonaceous fuel is the formation of smoke, which means a corresponding waste of fuel. Hence smoke abatement and fuel economy necessarily result from the attempts made to obtain perfect combustion.

In burning coal, very nearly all the available heat is due to the combination of oxygen with carbon. It is not a case of simple combustion of free carbon in oxygen gas. It is a much more complicated process, as coal is a variable mixture of substances, which have to be gasi-

fied and reduced to a fine state of division before oxygen highly diluted with nitrogen can combine with them. The air consists of 23 parts by weight of oxygen, and 77 parts by weight of other elements, mainly nitrogen. One part (say, a pound) of carbon in uniting with oxygen to form carbon dioxide liberates in round figures 14,650 British thermal units, but only 4400 such units if carbon monoxide (CO) is the combustion product; while the combination of oxygen to form water (H_2O) yields about 62,100 such units. An ordinary good coal with, say, 80.5 per cent. of carbon (free and combined) would give a calculated yield of 13,793 B.T.U., which for the present purpose may be called 14,000 B.T.U. The heat of combustion of the sulphur is small, and may be left out of consideration in these rough calculations. As 2.66 pounds of oxygen are needed to burn 1 pound of carbon to CO_2, the quantity required (after deducting the oxygen used in uniting with hydrogen) for 1 pound of the coal specified above is 2.53 pounds. This amount is contained in 9.8 pounds, or about 122 cubic feet of air, but as some of the air always fails to come in direct contact with the fuel, a larger quantity is required in practice, say, about 150 cubic feet; very much larger quantities are often used. As the average stoker knows little about the chemistry and physics of combustion, it is useless to give lengthy chemical and physical details, or to notice minutely the difficulties usually met with. All that can be done is to state some generalities bearing upon the subject worth bearing in mind when studying the descriptions given of feeding and of smoke-preventing apparatus.

The oxidation range for converting coal into CO_2 lies roughly between 752° and 1292° F., or an average approximating to 1000° F. The fire should be kept as uniformly as possible at about this temperature, and the proportion of black coal to red coal should never be locally excessive. The coal should be so supplied as

to reduce the temperature as little as possible. The draught should be so regulated that (1) about 150 cubic feet of air pass in at the same rate as 1 pound of coal is burnt; (2) the air should be made to come in contact with as much of the fuel as possible, especially at the places where the combustible gases are being given off; and (3) such contact should be sufficiently lasting for all the oxygen to be utilised. If all the oxygen enters into combination the flue gases will have about 19 per cent. by volume of CO_2. It is generally much less than this owing mainly to an excess of air having been supplied, and partly to some of the fuel not having been burnt. In the latter case the result is more or less smoke. Smoke varies inversely as the CO_2, so that when the amount of carbon dioxide is unknown the smoke is the best guide as to the firing. If smoke is being formed the fuel is being supplied faster than the air can oxidise it.

If the operations of an ordinary stoker are watched, some such results as the following, given in fuller detail in Bryan Donkin's work on "The Heat Efficiency of Steam Boilers" (pp. 139, 140), will be found to occur:—There is a glowing fire 6 to 8 inches thick. Fresh fuel is shovelled on; there is a marked and sudden fall of temperature, and, owing to obstruction, less air passes in through the coal per unit of time. For some minutes much smoke is produced. Then for some minutes combustible gases are given off. These require a quicker inrush of air into the midst of them, but as the stoker rarely admits sufficient air, the combustion of them is generally very imperfect, and, as the fire burns and brightens, the air supply is, as a rule, most deficient just where the largest quantity is wanted. After some minutes the stoker mixes the black and red coal, the consequence being the production of more smoke. Then the combustion improves, the fire gets hotter and thinner, more air is able to penetrate, no black coal is visible, and the proper

conditions for combustion are at last attained. The air supply is now sufficient, the fire burns red and white, and there is no smoke. This lasts for a few minutes only. The fuel is now mostly coke, the fire is very thin, and too much air passes through; more coal is therefore wanted. Fresh fuel is supplied, and the same process is repeated, followed by the same results. Every four hours or so the clinkers have to be removed, as they obstruct the air; this process is accompanied by a great loss of heat.

In the case above described a great deal of smoke is produced, and perfect combustion lasts for a very short time. By a proper delivery of coal and a sufficient supply of air at the right place and time there would be very little smoke, and good combustion would be spread over a larger area for a longer time.

The art of stoking requires not merely physical strength and endurance, but also, in a much higher degree, skill, experience, and a keen appreciation of the multitudinous conditions depending upon the kind of fuel, weather, and the work expected from the apparatus. Further remarks on stoking are given at a later page.

Nature and Results of the Smoke Nuisance. — A nuisance is something which annoys, or is offensive, or is injurious to health. It is universally admitted that smoke is a nuisance, for it is not only responsible for one of the things named, but for all three, and many more of a similar nature, in fact, it has been considered a nuisance of the very worst kind during the last hundred years, judging by the Acts which have been passed to abate it.

Smoke is not only a local, but a national and world-wide nuisance which is increasing with the population and trade year by year.

Nature of the Nuisance.—Smoke consists of minute particles of carbon, together with a sticky, tarry matter, which settles and sticks to everything it comes in contact

with. It is dirt. Lord Palmerston's definition of dirt from a health point of view is "Matter in the wrong place," and carbon or coal in the atmosphere is matter in the wrong place.

Is Smoke Injurious?—Many have, and some even now do contend that it is not injurious, and people have lived to a ripe old age who have resided all their lives in very smoky districts. It may be true, but smoke has not lengthened their lives. Careful observation will positively prove to any unprejudiced mind that smoke is injurious to almost everything it comes in contact with.

The Injury to Buildings. — In a very short time buildings, whether of brick, stone, or other material, become covered with unconsumed carbon, and present a most dismal appearance. This is not, however, all. Damage is done to the fabric itself by impure air. Professor Church and other experts have often demonstrated the great injury done to buildings by smoke products which cause stone and other material to decay and crumble. Serious ravages have been occasioned by smoke on public buildings, such as St. Paul's Cathedral, Westminster Abbey, and Cleopatra's Needle.

The Injury to Vegetation.—Sir W. Thiselton Dyer, the Director of Kew Gardens, states that enormous injury is being done to plants and shrubs at Kew by the smoke from Brentford, where the District Council absolutely declines to enforce the law, and he remarks that it is strange that successive Governments should permit the finest horticultural gardens in the world to be injured by smoke. In 1901 the Commissioner of Works was requested to receive a deputation on the subject, in the hope that it might move the Government to action.

The visible smoke or particles of carbon are unquestionably most injurious to vegetable life, because the smuts close the pores of plants, and impede the respira-

tion necessary to a healthy existence. Thus plant life is interfered with, growth is impossible, and death very soon results. It is almost impossible, owing to the poisonous atmosphere, to maintain healthy tree life, for the bark is injured by the sulphuric acid. The plane tree alone seems able to withstand the effects of town life, and is planted in preference to others. The whole of the sulphuric acid is not deposited in the town of its origin; a great quantity is carried away by the wind, and the injurious effects are exercised on the vegetation in the surrounding districts.

The Injury to Health.—In districts where there is the most smoke, there is the least sunshine. Smoke is a barrier to the sun's rays, though the heat rays may pass through the smoke readily. In fact, smoke shuts out sunlight, which is so essential to life and health, and it also assists largely in the formation of fogs.

Air charged with soot, dust, and other injurious matter, must be unwholesome to breathe, and prejudicial to health, indeed Dr. A. Ransome, an authority on public health, declares that a smoky atmosphere increases mortality.

Sir William Broadbent, who is an active member of the Coal Smoke Abatement Society, also maintains that coal smoke is most injurious to health.

Eminent medical authorities, such as those named, and others, have spoken and written about the injury to health and the increased mortality, and medical officers of health have given the smoke question special attention, particularly in cities and towns where heavy trades are carried on.

Mortality statistics have worked wonders in relation to smoke. Considering the causes of increased mortality, it has invariably been found that where there was an increase of the nuisance, there were more deaths from lung troubles. These facts have convinced the few medical authorities who were inclined to disbelieve that black

smoke was injurious to public health to change their opinions, and it is pleasing to note now that they unanimously condemn it. Dr. Littlejohn, late Medical Officer of Health for Sheffield, says that the blue rays, which are of the greatest importance to healthy vitality, are kept back. This opacity of smoke to light is one of its most detrimental characters, as neither animals nor plants can thrive when deprived of light. All are aware of the inspiriting effect of sunshine upon the mental and physical energy, and how diminution of light tends to depress and lower vitality, thus rendering, no doubt, the body more susceptible to influences which otherwise would produce no impression. Practical demonstration of this can be seen in the poorer districts of every large town, where, owing to the narrowness of streets and overcrowding of dwellings, the inhabitants, deprived of light, to a large extent show a lower vitality and capability of resisting attacks of disease. Within the last few years another important fact has been demonstrated, viz., the powerful influence sunlight has upon the destruction of various forms of bacteria and disease germs, and in the case of one form in particular—the tubercle bacillus, which is the cause of a disease of great prevalence and fatality—it has been shown that this organism succumbs after a short exposure to light. Organic changes or oxidations which are impossible in darkness readily take place in sunlight, and this fact also is of great importance in the economy of human life.

Consumption.—A short time ago there was an outcry in the country about the alarming mortality from consumption. It was found that foul air was to a large extent responsible for the disease, and that, if it had not reached a very advanced stage, fresh air was a cure. In Sheffield the consumption cases were on the increase, and it was deemed desirable in 1901 to appoint a special inspector, whose duties were to find out such cases, and ascertain all particulars about the persons

suffering from the disease, and also to collect information about their families.

The cases were so numerous, the difficulty in getting information so great, that the medical officer of health was forced to the conclusion that compulsory notification was absolutely necessary, so that the Local Authority might take the necessary steps to prevent the spread of the disease. Powers of compulsory notification were sought and obtained from Parliament, and in November 1903 they came into force.

Dr. Robertson, Medical Officer of Health for Sheffield, in a lecture on the lungs at University College, pointed out that the number of people who died in Sheffield every year from lung diseases was enormous; that those who dwelt in cities cannot help breathing in soot and other dirt; and that little by little this soot was stored up in the lungs. A person with his lungs in this state is far more liable to contract disease of the lungs, so that in this respect the country dweller has a great advantage over the town dweller.

We find that the deaths from the most dreaded infectious diseases are exceedingly few compared with the deaths from consumption which are caused chiefly by the breathing of impure air.

The air of the workshop and home is foulest and poisoned for want of ventilation. The intelligent housewife knows the value of and the necessity for ventilation, but she keeps the windows and doors shut to keep out the soot and smoke, preferring the polluted air inside the house to that outside, which she considers the worse of the two.

Smoke, then, is largely responsible for poisoned air in the home, and if it were removed windows and doors could be opened, fresh air would take the place of foul, and better health would be the result.

Cost of the Smoke Nuisance.—It is estimated that coal smoke costs in London alone an unnecessary expenditure

of not less than £4,000,000 a year, the result of fuel wasted owing to defective combustion, the increased expense of cleaning and painting, and the permanent injury to furniture, books, pictures, public buildings, and decorations of all kinds. The cost of the nuisance to the country at large in money and in health must indeed be heavy!

CHAPTER II

GENERAL LEGISLATION AGAINST THE SMOKE NUISANCE

Select Committee on Smoke Prevention, 1819—Select Committee on Smoke Prevention, 1843—Select Committee on Smoke Prevention, 1845—Further Report of the Committee, 1845—Report of Sir Thomas de la Beche and Dr. Lyon Playfair, 1846—Report of General Board of Health, 1855—Letter to Local Authorities, 1866—Public Health Act, 1875—Suggested Amendment of the Act.

It is now five hundred years since coal made its advent as a fuel, and, while it has proved a very valuable friend to humanity, it has also proved a formidable foe in the form of smoke. When coal was first introduced into London there was a very strong opposition to its use in the city, its opponents believing it to be prejudicial to the health of the inhabitants, and in 1648 London petitioned Parliament against its importation from Newcastle. The petition failed, coal was imported, and the nuisance from coal smoke increased to such an extent that it is said a proclamation was issued forbidding the use of coal when Parliament was sitting.

It was at once recognised that coal possessed an indisputable value, and the impossibility of finding an efficient substitute soon left it in possession of a field where indeed there were no serious rivals. Its use, for a long time, was, however, very limited. It was a luxury, and therefore could only be enjoyed by a few, and the damage done by smoke was small. With an increased population, increased wealth per head, and greater spending powers for luxuries, the demand for coal for domestic purposes rapidly increased, and in

course of time it ceased to be considered a luxury and became an absolute necessity. Advances were made in manufacture by machinery, and coal became extensively used for the generation of steam to drive the machinery in the manufacture of iron, and of other metals, as well as for domestic purposes. With the extraordinary increase in consumption there came an extraordinary increase in the amount of smoke emitted into the atmosphere, which grew to be an intolerable nuisance, producing dirt and destruction on every hand. In fact, the nuisance increased to such an alarming extent as to arouse public opinion, which demanded that something should be done to prevent it.

Select Committee on Smoke Prevention, 1819.—As a result of the agitation a Select Committee of the House of Commons was appointed in 1819 to inquire how far it might be practicable to "compel persons using steam engines and furnaces in their different works to erect them in a manner less prejudicial to public health and public comfort, and to report their observations thereon to the House." Their Report was as follows:—

"That from the advanced period of the session at which the appointment of your Committee took place it was not to be expected that they could form any ultimate decision as to the precise object of their inquiry, but so far as they have hitherto proceeded, they confidently hope that the nuisance so universally and so justly complained of may at least be considerably diminished, if not altogether removed." They stated that they had had under examination men "whose minds have been long and practically directed to the extinction of the evil, and from their evidence, as well as from the plans which will be found in the Appendix, the House will be enabled to judge how far their opinions correspond with those of your Committee." The Report further stated that "the disinterested communications made by persons whose private interests might have led them to a different

line of conduct cannot be too highly valued or extolled."

Several kinds of apparatus for preventing smoke were submitted to this Committee, some admitting air at the bridge, and others in the form of mechanical stokers, founded on principles similar to those which underlie many of the forms of apparatus used at the present day.

The Select Committee continued its labours, and in the following year a further Report was published to the effect that they had had "full opportunity of ascertaining how far the reduction of smoke in furnaces of different descriptions can be practically accomplished, and the evidence detailed in the Appendix will show that the object the House had in view has been satisfactorily and effectively attained."

The Appendix contained much matter relating to various kinds of smoke-preventing appliances, giving details as to their application to boilers and brewing-pans, and the satisfactory results.

That there were difficulties to contend with thus early is shown by a letter included in the Appendix referred to. It was by a Mr. Wakefield, of Manchester, and was written "in order to show you the prejudices I have had to combat." It was said that burning the smoke was a loss of 10 per cent. on the most improved plan, as well as difficult to execute, and injurious to the pans by concentrating the heat; and when an engine was overloaded or the pan too small, that heavy smoke was unavoidable, so that the idea of burning smoke was given up and treated with contempt. Mr. Wakefield says that "the nuisance had become insufferable. Many persons were threatened with indictments to make them raise their chimneys, which answers no purpose, only carrying the smoke higher, so as to clear its own premises, but falls upon the next neighbour; besides, the lofty chimneys being dangerous, some have fallen, and persons been

killed by them." He claimed, however, to have succeeded in removing all these objections.

Even at this time the principles underlying smoke abatement had been grasped and put into execution by some persons. Thus we find Mr. Coombs writing a letter of such interest as to warrant the following lengthy extract. He wrote to recommend to the notice of the Committee an appliance he had devised:—

"In submitting my plans to the consideration of the honourable Committee, I beg leave to accompany them with a few remarks, which, although not so clear as I could wish, may still tend to elucidate the operations of the apparatus, and of exciting some ingenious artist to correct the existing evils, such as the immense waste of fuel, the inconsistent plan of erecting as also of feeding the fire of steam and other boilers, the obviation of which inconvenience has employed much of my time for upwards of ten years back; and, although I have succeeded in some points, yet there remains much to be done; and so convinced am I of its practicability, that I have looked with the daily expectation of some engineer producing a plan that would embrace completion. Steam engines are now brought to so high perfection that there seems nothing scarcely that cannot be performed by them, and I am of opinion they can be made their own servants, to supply their own fuel, and also to consume their smoke, on different plans; and I would remark a powerful drawback, namely, the door in front for feeding the fire, the removal of which I strongly recommend, well knowing its great mischief—every time the door is opened to supply the fire, thousands of gallons of cold air rush in, striking against the bottoms and sides of the boilers, cooling the flues, and most completely counteracting our grand object, of retaining heat, may I say, equal in effect almost to water. The usual method of supplying the boiler with fire, the door is opened every five minutes to admit four shovels of coals; by this method, out of twelve hours the door is

opened three hours, exposing the boiler and flues, which not only impair and damp the fire, but assists much to force up the virtue of the coals unconsumed. Within the bills of mortality, how many thousands of chimneys are at this moment emitting into the atmosphere their black and immense volumes, consisting of the strength and virtue of some hundreds of chaldrons of coal. May not this rouse the thinking mind to exert its energies to an application of this smoke, which is no other than an impure gaseous state of coal? The perfection of gas, and its usefulness, which is nightly before our eyes, convinces me that the smoke of steam and other boilers may be transmuted into fuel, and to a great extent of saving. Steam boilers require a strong heat and power to raise the steam to a certain force at first, then to maintain that force, continuing a solid and steady heat without so strong draft, or, in other words, without the extraordinary waste and consumption of coals. With my drawings and model I will more fully explain it. Brewers' coppers I have found much more difficult, as they must not only have a strong boiling heat, but also power to damp their fire with facility; this sudden change they require twice a day. With the power of moving the body of coal from the boiler, I consider we may, and I am emboldened to say, from late experience and observation, it can be accomplished; by igniting smoke we convert it into fuel. To convey an accurate description with my pen I find it difficult, but by a verbal explanation, I doubt not to make it evident the great advantage resulting in forcing the smoke through red-hot cylinders, pipes, or flues for ignition, and also in feeding the fire with hoppers and wheels, or either in a perpendicular, or in an oblique direction. That I may be more fully understood, I have given a section of a coke oven, the process of which has years back convinced me that boilers may be heated on the same principle, and with an extensive saving of time and fuel. Coal, like a cornfield on fire, will communicate

its heat and flame from one particle to another, as the currency of air drives it. The arrangement of air into all fires I consider of the utmost consequence, as I am confident that, with care, even our atmospheric air may be considered as fuel. In my specification 1813, I claim the shape of a boiler standing on an iron pillar at the back; also, on a plate of iron: for small boilers it answers; but it is the brewers' coppers that have baffled my efforts till within these three months."

Select Committee on Smoke Prevention, 1843.—No legislation appears to have resulted from the labours of the earlier Committee, and in 1843 a voluminous Report and Minutes of evidence of another Committee was issued. This Committee was appointed "to inquire into the means and expediency of preventing the nuisance of smoke arising from fires or furnaces," and was empowered "to report their opinion, together with the minutes of evidence taken before them, to the House." The ground covered by the evidence was exceedingly wide, embracing nearly every point involved in dealing with combustion and the action of smoke. Evidence was given by men eminent in science, manufacturers, and persons who had devoted themselves to studying the question, amongst them being Dr. Muntz, Dr. Reid, Michael Faraday, Dr. Neil Arnott, Mr. Houldsworth of Manchester, and the Rev. Dr. Molesworth, the founder of the Smoke Abatement Association of Manchester.

The Report of the Committee states: "That the attention of the parties called to give evidence has been principally directed to the consideration of the following heads on which their opinions were given:—

1. "Whether it was practicable entirely to prevent, or very much to diminish, the nuisance now so severely felt in large towns and populous districts from the smoke of furnaces or of steam engines.

2. "Whether, if this were practicable, it would be advisable to take any steps to prevent the nuisance, as so

doing might interfere with the property or interests of manufacturers, or of proprietors of furnaces.

3. "If, in the event of the two former questions being answered in the affirmative, they would recommend some legislative enactment to be framed to prohibit the nuisance of smoke.

"In regard to the first of these questions, it appears from the whole of the evidence of scientific and practical men, including master manufacturers, that smoke which is the result of imperfect combustion, may in all cases be much diminished, if not entirely prevented.

"It appears to be the unanimous opinion of the witnesses conversant with the subject, that imperfect combustion arises from a deficiency of air to mix with and act on the inflammable matter at a proper temperature, and under circumstances which must ensure its effective operation, but this admission of air properly regulated is the greatest if not the only principle of preventing smoke, which is generally applicable, and that all inventions for the prevention of smoke (except where the smoke has been separated mechanically by an artificial shower of water, produced from a flue constructed for the purpose) are only various applications in different forms of this general principle, even the flow or jet of steam, which has been applied by some persons to prevent smoke in furnaces, being merely a modification of this general principle, as, though steam may modify combustion, air must necessarily flow in with it, otherwise the combustion in the furnace is arrested."

The Committee urged the immediate introduction of legislation to prohibit the production of smoke from furnaces and steam engines.

Select Committee on Smoke Prevention, 1845.—A Bill had been proposed by Mr. Hall in accordance with the suggestion of the Select Committee of 1843, but in consequence of the opposition it excited, another Select Committee was appointed in 1845, "To inquire into the

means and expediency of preventing the nuisance of smoke arising from flues or furnaces." The proposed Bill provided "for the appointment of any police officer, or other competent persons, as Inspectors of Smoke Nuisances in any district," and that it should not be lawful for the occupiers of any furnace or chimney to permit opaque smoke to issue from such chimney for any longer period of time than was necessary for the "kindling of the fire of such furnace in connection with such chimney, and previous to the running of any engine connected therewith, which time allowed for kindling such fire shall not exceed . . . minutes." Penalties were proposed of not less than 20s. for a first offence, 40s. for a second offence, and a larger penalty for each succeeding offence, while it was also proposed that if it could be shown that the stoker, or other person, was at fault, the magistrates could order a part or the whole of the penalty to be paid by such person, and, if necessary, to be deducted from his wages. The evidence before the Committee came largely from Leeds, and dealt more with the question of legislative interference; the persons upon whom responsibility should rest, and the penalties that should be levied, than with the general question of smoke prevention.

The Committee reported that "opaque smoke issuing from steam-engine chimneys may be so abated as no longer to be a public nuisance.

"That a variety of means are found to exist for the accomplishment of this object, simple in construction, moderate in expense, and applicable to existing furnaces, and flues of stationary engines, as well as to those hereafter to be erected." They found there was sufficient evidence founded upon experience of practical men to induce them to form the opinion that a law making it imperative upon the owners of stationary steam engines to abate the issue of opaque smoke was desirable for the benefit of the community, but that in

the existing state of knowledge and experience upon the subject it was not desirable to extend the provisions of any Act that might be passed beyond the furnaces used for the generation of steam for the working of stationary steam engines. They also decided that in the provisions of an Act for this purpose the offence would be best described as "the issue of opaque smoke." They recommended that a penalty should attach to the occupier of the property, or to the person employed in the care of the furnaces, and that a public functionary or functionaries should be appointed, whose duty it should be to take cognisance of the nuisance, and to bring the offending parties before the constituted authorities in the locality in which the nuisance had been proved to exist.

The term "opaque smoke" in the proposed Bill was defined as smoke not transparent at the point of its exit from the chimney, a definition which was taken exception to by some of the witnesses, who held that the use of the term would lead to differences of opinion and a variety of interpretations; and it was suggested that the word "smoke" should be defined to mean smoke of a different quality and amount from that which would proceed from the chimney if the furnace were properly constructed, an efficient apparatus, and efficiently stoked; or in other words, the offence would consist of smoke issuing from a furnace chimney in the absence of the conditions specified.

Further Report of Committee, 1845.—In the same year the Committee issued a further Report to the effect that it was inexpedient under existing circumstances to apply the provisions of the proposed Bill to furnaces connected with the manufacture of iron, copper, and coal works, and with distilleries.

These exceptions were probably made on account of the opposition to the Bill shown by those interested in the trades named, many of whom gave evidence before the Select Committee after the publication of their first

Report. Amongst others, Mr. Thomas Dunn presented a petition from the Town Council of Sheffield against the Bill on the ground that "the process of applying steam to the purpose of Sheffield manufacture is peculiar, the power of the engine being of necessity applied in an irregular manner, not in the same manner as in a silk, or cotton, or woollen mill, when after the steam is first got up, the same amount is wanted till the engine is put down altogether. In Sheffield nearly all the processes to which steam is applied are powers that want irregularity, as in the rolling of iron or steel."

The proposed Bill was subsequently withdrawn upon an understanding that the subject should be left in the hands of the Government, and that some general measure, having for its object the supervision of smoke in towns and populous districts, should be submitted to Parliament. The Government considered that there were matters connected with the question which still required investigation, and therefore appointed Sir Thomas de la Beche and Dr. Lyon Playfair to make an inquiry into the means then adopted for the prevention of smoke in the various parts of the kingdom, with the view of ascertaining how far those means were generally applicable to large towns and populous districts.

Report of Sir Thomas de la Beche and Dr. Lyon Playfair, 1846.—The Report was published in 1846, and is a very valuable one, demonstrating clearly how well the difficulties of the subject were recognised at that time.

The Report stated :—"Although the smoke arising in many towns from the consumption of coal must be regarded as a nuisance, the consideration of that arising from a multitude of private fires, collectively producing a considerable volume of smoke in large cities, such as London, should be carefully separated from investigations respecting that evolved from the chimneys of steam engines, breweries, and other works generally. Due

caution is also required so to classify the latter, that while on the one hand those fires and furnaces from which a discharge of smoke can be prevented should be brought within the provisions of legislative enactments, the progress of important branches of our national industry should not, on the other, be impeded.

"The general principles upon which the combustion, or rather the prevention, of smoke may be effected are now well known, and admitted to be applicable in practice. Smoke consists of vapours produced by the partial combustion or distillation of coal, carrying up small particles of the fuel in mechanical suspension, and depositing, by the combustion of one of their constituents, carbonaceous matter in a fine state of division. The mode of preventing this smoke is to admit a sufficient quantity of air to effect the combustion of the carbonaceous matter when the vapours are of a sufficiently elevated temperature to unite entirely with the oxygen of the air. If the temperature be not sufficiently elevated, the hydrogen of the vapours alone is consumed, and the carbon is separated in the fine state of division referred to. The gases produced by the complete combustion of fuel are colourless and invisible, and therefore do not come under the definition of the term smoke.

"As the prevention of smoke implies the complete combustion of fuel, the result, as an abstract statement, always is, that more heat is generated, and a saving of fuel effected, when it is so consumed as to prevent the emission of smoke; but although this theoretical conclusion is undoubtedly correct, the practical results are not always consonant with this statement.

"In consuming smoke in the usual way a quantity of cold air is introduced into the fire, and as this must be heated up to the temperature of the surrounding fuel, the loss of the latter may be equal to, or even greater than, the saving of the fuel from the combustion of the products of distillation. This often results in the careless

use of furnaces constructed on the principle of smoke prevention, and thus leads to the contradictory statements given by those who have used such furnaces. But in all carefully conducted experiments the saving of fuel has been considerable, and the reason of this will be at once perceived, when it is considered that in addition to the combustion of the products of distillation there is a large amount of fuel saved by the combustion of a gas called carbonic oxide, formed by the proper product of combustion, carbonic acid, taking up in its passage through the incandescent fuel another portion of carbon, which escapes useless as regards the production of heat, unless burned by the air introduced at the bridge of the furnace, for the purpose of consuming the products of distillation.

"From these considerations and from experiments conducted under our inspection, with a view to determine this point to our satisfaction, we arrive at the conclusion that although from careless management of fires there is often no saving, and that indeed there is frequently a loss of heat in the prevention of smoke, still that with careful management the prevention of smoke is in many cases attended with, and may in most cases be made to produce, an economy of fuel.

"It may be unnecessary to remind your Lordship that the cause of the emission of smoke in manufactories may be classed under three different heads, the relative importance of which involves very different considerations in any attempt to legislate for its prevention. These are :—

1. "The want of proper construction and adjustment between the fireplaces and the boilers, and the disproportionate size of the latter to the amount of work which they are expected to perform.
2. "The deficiency of draught, and improper construction of the flues leading to a chimney of inadequate height or capacity.

3. "The carelessness of stoking and management by those entrusted with the charge of the fireplace and boilers.

"These differences in the causes of smoke have already induced the Legislature to proceed cautiously in the local Acts for its suppression. A fine inflicted and levied summarily is quite applicable when the emission of smoke is due to the carelessness of those entrusted with the management of the furnaces, and may with justice be levied on the master, who is responsible to the public that his servants act in such a manner as to prevent his establishment being a public nuisance. A fine thus summarily levied, when the cause of the nuisance is unconnected with carelessness of management, and depends on bad structural arrangements, becomes oppressive in cost of alterations by acting as a fine infinitely greater than the Legislature contemplated as a punishment for the offence."

It will be seen from the foregoing that the reporters were fully alive to the possible injury to trade from too exacting a measure for the repression of the nuisance, also they recognised the fallacies underlying many of the statements frequently put forward as to the economy of smoke prevention.

The Report also stated that in all towns referred to complaints were made of the absence of power to inflict a small fine upon the stoker for carelessness in managing any smoke-consuming apparatus, or even in stoking ordinary fires. Upon this point the opinion "is universally expressed that all Acts will be inoperative unless the stoker also, as well as the master, be made an interested party in seeing to the due execution of the Act."

No practical steps appear to have been taken by Government to deal with the question by the introduction of a Bill as promised, although Parliament

sanctioned clauses in Local Improvement Bills dealing with the abatement of the smoke nuisance. Among the towns which obtained such clauses were Leeds, Manchester, Liverpool, and Derby.

Report of General Board of Health, 1855.—In 1854 Lord Palmerston requested the General Board of Health to obtain information in regard to the consumption and means of prevention of smoke, and the following year the Board issued a long Report on the subject, in which many statements are, although founded upon more recent information and renewed investigations, only a reiteration of those which had previously been made in the published Reports of Select Committees. From inquiries made from fifty-six firms which had adopted various means for the diminution of smoke, it was found that in answer to the question, "Have you succeeded in diminishing smoke?" twenty-three replied "Yes," and eighteen replied "Almost entirely," while only three seem to have entirely failed. Replies by the same firms to other questions showed that in only eight cases was their difficulty one of maintaining the requisite heat without producing smoke, while in the majority of cases it was stated that a considerable saving of fuel had been effected. The Report states that "after such instances of success it is impossible to deny that smoke may be prevented. Numerous cases, indeed, of partial, and some of complete, failure have occurred, but these only show that proper means have not been used, or that the means employed have not been adapted to the particular cases."

The detailed conclusions arrived at by the Board of Health were as follows:—

1. "That the emission of smoke is the effect, and may be taken as the proof, of imperfect combustion, and is therefore always attended with waste of fuel.

2. "That the fuel wasted is not only the visible smoke, which is unburnt carbon, but generally a far larger portion in the form of gas, both common coal

gas and that called carbonic oxide, which is only half-burnt carbon, and which, therefore, has not produced the heat which it would have generated if it had been perfectly consumed.

3. "That the chief impediment to the prevention of smoke in manufactures is the insufficient boiler surface in proportion to the steam required; a deficiency which causes waste in two ways: first, because much of the heat produced escapes up the chimney uselessly; and next, because this deficiency has to be made up by overfiring, whence imperfect combustion and consequent waste of fuel.

4. "The employers of furnaces labour under great difficulty as to the best and most economical use of fuel, because ordinary makers of furnaces seem to be guided in their construction by little better than empirical rules, instead of acting upon well-established scientific principles or the results of accurate experiments.

5. "That notwithstanding this great difficulty many persons have succeeded in entirely preventing the escape of visible smoke, except whilst first lighting their furnaces, and many others have reduced the time during which smoke is emitted to a small fraction of its former amount.

6. "That experience has fully proved that there is no truth in the common allegation that if smoke be prevented, there must be increased difficulty in getting up and maintaining steam.

7. "That successful modes of preventing smoke, if there be proper boiler surface, may be adopted without the infringement of any patent right, the methods in question not having been patented or the patents having expired.

8. "That notwithstanding the great and obvious advantages of perfecting the combustion of fuel, and the certainty that the cost of doing so will be amply repaid by the saving effected, such is the indisposition

of practical men to depart from the beaten track, that nothing but the force of law is likely to ensure the care and attention necessary to protect the public from a grievous nuisance, the manufacturers themselves from heavy unnecessary expense, and the national resources from grievous waste of fuel to the amount of millions a year.

9. "That though the absolute and immediate prohibition of smoke could not be enforced without compelling most of the owners of furnaces to incur very heavy expenses, its reduction to a very small amount may be effected with comparative ease, and with very great benefit both to themselves and others; while it cannot be denied, that any who produce more smoke than others who use fuel for the same purposes, do produce more than is practically necessary.

10. "That the enforcement of smoke regulations can be most easily and quickly effected by the appointment of constables to keep a regular and constant watch upon all chimneys liable to emit much smoke; and that the prevention of smoke will be more quickly and certainly effected by constant supervision and immediate information of any breach of the regulations, than by heavy penalties irregularly imposed.

11. "That great facility in the prevention of smoke would be afforded by the publication of the specifications and descriptions of patented and other inventions for the prevention of smoke, by which those interested could be informed what they could and could not do in this matter without infringing upon any patent right.

12. "That great facility would also be afforded by the appointment of officers specially qualified, and *not connected with any patentee or manufacturer of boilers or furnaces*, to superintend the police officers employed to suppress the nuisance of smoke, and to advise owners of furnaces how best to comply with the provisions of the law, and to report upon cases of its infringement."

Letter to Local Authorities, 1866.—In 1866 the Secretary of State addressed a letter to the Mayors or Local Authorities of fourteen large towns in England with respect to the consumption of smoke, asking more especially for information as to the Act under which prosecutions were taken, the number of convictions obtained, and the effect produced in diminishing the smoke.

Almost all the towns, including Sheffield, stated that they proceeded under the "Towns Improvement Clauses Act," and that a diminution had taken place in regard to the nuisance. Birmingham, Liverpool, and Sheffield show by far the largest number of convictions obtained, those in Sheffield during the years 1855–1865 inclusive amounting to 445, the smallest number in any year being 4 in 1860, and the highest 74 in 1865. This shows remarkable activity in dealing with the nuisance during these years, but there has been a remarkable degree of apathy displayed in dealing with the nuisance since the passing of the Public Health Act, 1875, the reasons for which will be noticed later.

That there was a very popular and powerful demand for legislative action, is shown by the inquiries carried out by Government, and it is astonishing to find that the only results have been a clause in the Towns Improvement Clauses Act, 1847, and the Sections of the Public Health Act, 1875, under which proceedings to abate the nuisance are taken, and which are as follows:—

Public Health Act, 1875.

Section 91, Sub-section 7.—Any fireplace or furnace which does not as far as practicable consume the smoke arising from the combustible used therein, and which is used for working engines by steam, or in any mill, factory, dyehouse, brewery, bakehouse, or gaswork, or in any manufacturing or trade process whatsoever: and,

Any chimney (not being the chimney of a private dwelling-house) sending forth black smoke in such quantity as to be a nuisance, shall be deemed to be nuisances liable to be dealt with summarily in manner provided by this Act. Provided—

First.—That a penalty shall not be imposed on any person in respect of any accumulation or deposit necessary for the effectual carrying on any business or manufacture if it be proved to the satisfaction of the court that the accumulation or deposit has not been kept longer than is necessary for the purpose of the business or manufacture, and that the best available means have been taken for preventing injury thereby to the public health.

Secondly.—That where a person is summoned before any court in respect of a nuisance arising from a fireplace or furnace which does not consume the smoke arising from the combustible used in such fireplace or furnace, the court shall hold that no nuisance is created within the meaning of this Act, and dismiss the complaint, if it is satisfied that such fireplace or furnace is constructed in such manner as to consume, as far as practicable having regard to the nature of the manufacture or trade, all smoke arising therefrom, and that such fireplace or furnace has been carefully attended to by the person having the charge thereof.

Section 92.—It shall be the duty of every Local Authority to cause to be made from time to time inspection of their district, with a view to ascertain what nuisances exist, calling for abatement under the powers of this Act, and to enforce the provisions of this Act in force within their district requiring fireplaces and furnaces to consume their own smoke.

Section 93.—This section empowers any person who is aggrieved thereby, to give information of nuisances to the Local Authority.

Section 94.—Local Authority to serve notice requiring abatement of nuisance.

Section 95.—On non-compliance with notice complaint to be made to a Justice.

Section 96.—Power of Court of Summary Jurisdiction to make an order to abate the nuisance, and impose a penalty not exceeding five pounds.

Section 97.—Order of prohibition in case of house unfit for human habitation.

Section 98.—Penalty for contravention of order of court, not exceeding twenty shillings per day during such contrary action.

Section 99.—Appeal against the order to the Court of Quarter Sessions.

Section 100.—In certain cases an order may be addressed to and executed by the Local Authority.

Section 101.—Power to Local Authority to sell to defray expenses incurred by them with reference to such nuisance.

Section 102.—Power of entry of Local Authority at all reasonable hours until the nuisance is abated.

Section 103.—Penalty for refusal to obey an order for admission of the Local Authority not exceeding five pounds.

Section 104.—Costs and expenses of execution of provisions relating to nuisances.

Section 105.—Power of an individual to complain to a Justice of a nuisance, the same as a Local Authority.

Section 106.—Power of officer of police to proceed in certain cases against nuisances within the district of a defaulting Authority.

Section 107.—Local Authority may take proceedings in Superior Court for abatement of nuisances.

Section 108.—Power of Local Authority to proceed where cause of nuisance arises without their district.

Section 334.—Nothing in this Act shall be construed to extend to mines of different descriptions so as to interfere with or to obstruct the efficient working of the same, nor to the smelting of ores and minerals, nor to the calcining, puddling, and rolling of iron and other metals, nor to the conversion of pig iron into wrought iron so as to obstruct or interfere with any of such processes respectively.

Suggested Amendment of the Public Health Act, 1875.

Section 91, *Sub-section* 7, demands that every fireplace, furnace, and chimney (except the chimney of a private dwelling-house) shall be constructed in such manner as to consume as far as practicable the combustible used therein, having reasonable regard to the nature of the manufacture or trade. This is a very comprehensive clause, including every kind of boiler, metallurgical furnace, and fireplace, except the one named.

They must be constructed on the most modern principle, not simply and solely with a view to the particular kind of work they have to do, but with the object of producing complete combustion and preventing smoke, which must be considered first. Efficient construction is not all. The Act requires that they must be carefully attended to by the person in charge. This, too, is a very important clause, for unless there is careful firing and attention in the working of the furnaces, unnecessary smoke will be made even with an efficiently constructed furnace.

Any chimney sending forth black smoke in such quantity as to be a nuisance is, according to the Act, to be deemed a nuisance, and liable to be dealt with sum-

marily in the manner provided. Brown or any other kind of smoke, except black smoke, is outside the provisions of the Act, and is not a nuisance within the meaning of the Act. Not only must the smoke be black smoke to be a nuisance, but it must be emitted in a certain quantity. The Act provides for the emission of a certain quantity of black smoke which is not a nuisance. This permissible amount is the amount "necessary" in a given trade or process.

If it is positively proved to be absolutely necessary to emit, say for five, ten, or even fifteen minutes in the hour, black smoke for a particular process, then it is no nuisance, it being impracticable to prevent it, but any continuance beyond the time specified constitutes the emission a nuisance liable to be dealt with summarily.

This is a very practical piece of legislation, but, like many other Acts of Parliament, it is not quite perfect.

The following amendment is suggested:—"Any fireplace or furnace which does not, as far as practicable, consume the smoke arising from the combustible used therein, and which is used for working engines by steam, or in any mill, factory, dyehouse, brewery, bakehouse, or gaswork, or in any manufacturing or trade process whatsoever, and *any chimney sending forth smoke in such quantity as to be a nuisance shall be deemed to be nuisances liable to be dealt with summarily* in manner provided by this Act.

"Provided: *Secondly*, That where a person is summoned before any court in respect of a nuisance arising from a fireplace or furnace which does not consume the smoke arising from the combustible used in such fireplace or furnace, the court shall hold that no nuisance is created within the meaning of this Act, and dismiss the complaint, if it is satisfied that such fireplace or furnace is constructed in such manner as to consume, as far as practicable, having regard to the nature of the manufacture or trade, all smoke arising therefrom, and that

such fireplace or furnace has been carefully attended to by the person having the charge thereof."

The deletion of the words "not being the chimney of a private dwelling-house" would be no injustice either to the owner or the occupier of a house used as a private dwelling. There is no reason why such a chimney should be allowed to make a lot of unnecessary smoke, and it would be only fair and just to class them with other chimneys. It would be desirable to compel the owners to put in modern smoke-preventing stoves, which have been proved to be almost smokeless, in the place of the present antiquated stoves, which are far too general in use and are great smoke makers, and to make the occupier responsible for the careless use of the improved stoves, just as he now is responsible for the firing of his chimneys.

The deletion of the word "*black*" would meet with universal approval, not only from the administrators, but from every one desirous of improving public health. Black smoke is not the only kind of smoke which is a nuisance.

Dense *brown* and other coloured smoke is equally a nuisance, and practically preventable.

The inclusion of all kinds of smoke would remove a very strong temptation which now confronts the inspector, viz., to report preventable thick brown smoke and swear it was black. It would also remove many difficulties and doubts in the minds of magistrates respecting the *colour* of the smoke, making it much more easy for them to decide, on the evidence as to quantity, whether the smoke complained of was necessary. Finally, the striking out of the word *black* would bring within the section all practically preventable smoke, irrespective of colour, density, or opacity, sent forth in such quantity as to be a nuisance, while it would not in the slightest degree hinder or interfere with trade, as some persons have urged. There would be no cause for complaint on the

part of the smoke maker, but only cause for congratulation, as he would thus be compelled to save his fuel by stopping the emission of all unnecessary smoke. A most salutary step which would at once put an end to the pouring out of dense volumes of smoke would have been taken.

Section 92 says: "It is the duty of every Local Authority to inspect and find out if there are any smoke nuisances, and, if there are, to enforce the provisions of the Act for the prevention of the same."

There is no necessity for any amendment of this section, but it is *highly necessary* to put such pressure upon defaulting authorities as would compel them to discharge their duty, which has been neglected, to the detriment of public health, far too long.

Section 93.—There are many persons who have never heard of this section. Probably in many cases the Authority is more to blame, for not having given effect to the Act generally, than the aggrieved public. The section gives power to *any* aggrieved person to give information of the nuisance and demand from the Authority an abatement. By this means the public can compel action being taken by an Authority if the latter shows that it has no desire for smoke abatement.

Section 96.—This section gives the court power to make an order forthwith for the abatement of a nuisance, and to impose a penalty not exceeding five pounds.

The penalty might be increased to at least ten pounds, and imposed in order to prove a deterrent to a recurrence of the offence. The Bench have often remarked that a penalty of five pounds is a very trifling amount for a wealthy firm to pay, yet instead of imposing it, which might have induced the defendants to take the necessary steps to prevent a recurrence of the nuisance in the future, an order only has been made, and costs amounting to eight and sixpence charged.

Section 98.—For disobedience to a magistrate's order,

the court can impose a penalty not exceeding ten shillings per day during default, and not exceeding twenty shillings per day for wilfully acting contrary to the order.

For lack of due diligence the penalty ought to be at least sixty shillings per day, while for wilfully contravening the order not less than five pounds per day during default could, with advantage, be imposed.

Section 105, which empowers any person who is aggrieved by a nuisance, or any inhabitant within the district of the nuisance to prosecute, to obtain an abatement order and penalty, has proved a very salutary section, and has been constantly called into operation in districts where the Local Authority has refused to do anything toward abatement.

In *Sections* 100 and 101, power is given to Local Authorities (where the owner or occupier of the premises on which a nuisance exists is not known, or cannot be found) to abate the nuisance, and to seize and to sell articles to defray the expenses incurred thereby.

If Local Authorities will not proceed against nuisances, and the inhabitants are therefore compelled to do so, *Section* 105 ought to give additional power to enable them to procure, from the Local Authority, all costs incurred in obtaining an abatement of nuisances. This is only reasonable, and if the Local Authority objected to paying others for doing their work, they would have the alternative of doing it themselves. Such additional power might arouse Local Authorities to a sense of their duty, but if it failed in this, it would do justice to those who were determined to undertake the difficult and distasteful task.

Section 108.—The power given by this section ought more frequently to be used. It enables a Local Authority to proceed against an adjoining Authority for a nuisance in their district, though the nuisance is created within the district of the adjoining Authority. It is no unusual

thing for two chimneys to be within fifty yards of each other, and yet within different districts. Action taken by one district against another would very quickly cause Authorities to take steps to abate their own nuisances.

Section 334 is called the saving clause for mines, &c. The common and general claim is that the following industries are exempt from the provisions of this Act: Mines of different descriptions (including their steam boilers); the smelting of ores and minerals; the calcining, puddling, and rolling of iron and other metals; and the conversion of pig iron into wrought iron. This claim has for many years been so constantly put forward that it is considered by many to be a *valid* one, and that this section places outside the Act the special processes mentioned, and everything in connection therewith.

A careful perusal of the section proves that it does nothing of the kind. The intention of the section is to point out the difficulty of preventing smoke from the furnaces used in the processes named, and to provide that nothing be done to interfere or obstruct the efficient working of the furnaces. It is only the amount of necessary smoke, whether little or much, in the said processes that is exempt, and the emission of which does not constitute an offence within the meaning of the section. All smoke made by the processes named, in excess of what is absolutely necessary, is a nuisance for which proceedings can be taken in the ordinary way, with every prospect of a conviction.

The section is in harmony with *Section* 91, which demands *that everything be done, as far as practicable, to prevent nuisances.*

In Sheffield a number of proceedings have been taken against chimneys which serve three and more boilers, also two and more furnaces, the furnaces being used for annealing, forging, and rolling. The evidence of the Corporation has proved that for two years the chimneys have rarely exceeded the limits allowed, which are reasonable

for the efficient working of the boilers and furnaces, and have urged that the excessive emissions of smoke complained of was unnecessary. The defendants always claimed exemption under Section 334, but the magistrates, who have had a practical knowledge of the processes, have convicted. The decisions have been appealed against at the Quarter Sessions, the appellants' counsel arguing that furnace smoke was not a nuisance within the meaning of the section, and therefore exempt, but the court has in every case (after very lengthy hearings, occupying days) dismissed the appeals with costs, with one exception.

CHAPTER III

LOCAL LEGISLATION AGAINST THE SMOKE NUISANCE

Bolton Corporation Act, 1872—Edinburgh Municipal and Police Act, 1879—Edinburgh Improvement and Tramways Act, 1896—Glasgow Police (Further Powers) Act, 1892—Manchester Corporation Act, 1882—Leeds Improvement Act, 1866—Public Health Act (London), 1891—Salford Improvement Act, 1862—Sheffield Corporation Act, 1900.

MANY towns and cities have made provision in their own bye-laws, and local acts, for the abatement of the smoke nuisance. The measures taken with this object, by several of the more important municipalities, are appended, in alphabetical order, in the following pages :—

Bolton Corporation Act, 1872.—*Local Government Board's Provisional Orders Confirmation (No.* 15*) Act,* 1893. *Section* 2, *Sub-section* 1.—(*a*) If any fireplace or furnace for the time being employed within the borough in the working of engines by steam (not being a locomotive engine used on the railway of any company incorporated by Act of Parliament) or used for the purposes of trade or manufacture, or baths or wash-houses (although a steam engine is not used or employed therein), is not so constructed as to consume or burn the smoke arising from such a fireplace or furnace, the owner or occupier of the building or land in or on which such fireplace or furnace is situate, shall be liable to a penalty not exceeding ten pounds.

(*b*) If any such owner or occupier uses any such fireplace or furnace not so constructed as aforesaid, or if any such owner or occupier, or any engineer, fireman, stoker, foreman, or other person employed by such owner or occupier, negligently uses any fireplace or furnace so

constructed as aforesaid in such manner that the smoke arising therefrom is not effectively consumed or burnt, he shall be liable to a penalty not exceeding ten pounds, and to a further penalty not exceeding forty shillings for every day during any part of which such fireplace or furnace is so continued to be used after one month's notice in writing given by the corporation to the owner or occupier to remedy or discontinue the same.

(*c*) If any such owner or occupier refuses to allow such building or land to be inspected by a person authorised by the corporation, then any person so authorised may by warrant under the hand of a Justice (which warrant any Justice is hereby authorised to grant) enter into and upon such building or land, and examine any such fireplace or furnace.

Provided that these provisions shall not be held in all cases to mean that it shall be necessary to consume or burn all the smoke, but the court hearing an information of complaint against a person, shall dismiss the information or complaint if of opinion that such person has so constructed his fireplace or furnace, or fireplaces or furnaces, as to consume or burn, as far as practicable, all the smoke arising from such fireplace or furnace, or fireplaces or furnaces, and has carefully attended to the same, and consumed or burned, as far as possible, the smoke arising from such fireplace or furnace, or fireplaces or furnaces.

Sub-section 2.—(*a*) If from any chimney, not being the chimney of a private dwelling-house, black smoke is emitted either in such quantity as to be a nuisance, or where the best practicable means for preventing such emission are not in use, the corporation may on complaint by any person aggrieved, or by two inhabitant householders of the borough, cause notice to be given to the owner or occupier of the land on which such chimney is situate, or to the owner or occupier of the furnace or fireplace in connection with which such chimney is used, to discontinue such emission, and if after such notice the

emission is repeated, such owner or occupier shall for each such offence be liable to a penalty not exceeding five pounds, and on each subsequent conviction to a penalty not exceeding twenty pounds.

(*b*) Where more fireplaces or furnaces than one communicate with a single chimney, or a chimney is used with more fireplaces or furnaces than one, the names of the several owners or occupiers of the buildings or land on which such fireplaces, or furnaces, or chimney, are situate, may be included in one summons, and the Justice or Justices, before whom the case is brought, may in his or their discretion apportion the penalty between the several owners or occupiers, as the case may be, or impose a penalty on one, or more, of such owners, or occupiers, to the exclusion of the others.

The Edinburgh Municipal and Police Act, 1879.—*Section* 295.—Every furnace employed or to be employed in the working of engines by steam, or in any mill, factory, dyehouse, iron foundry, glasshouse, distillery, brewery, gaswork, or other building used for the purpose of trade or manufacture, shall be constructed so as, so far as practicable, to consume or burn the smoke arising from such furnace, and every person who shall use any furnace which shall not, so far as practicable, be so constructed and used as that the smoke arising therefrom shall, so far as practicable, be effectively consumed or burned, or shall carry on any trade or business which shall emit any effluvium offensive or injurious to the health of the inhabitants in the neighbourhood of the premises in which such trade or business is carried on, shall be liable to a penalty not exceeding five pounds, for, and in respect of, every day, or part of a day during any portion of which such use of such furnace or such emission shall be continued after one month's notice shall have been given by the Magistrates and Council to remedy or discontinue the same.

Sub-section 3, *Section* 87, *of the Edinburgh Improvement*

and Tramways Act, 1896.—"Section 295 of the Act of 1879 shall be read as if the following proviso were added at the end thereof: Provided always that where the emission of black or brown smoke from any furnace or fire is caused by excessive, careless, or inefficient firing, or by the mismanagement of any furnace or fire, the liability for the said penalty shall be incurred on conviction without service of any notice or requirement for its discontinuance or remedy being necessary."

Section 65 of the Edinburgh Improvement and Tramways Act, 1896.—"Every new and every existing chimney-stalk or flue connected with the furnace of a steam boiler or other furnace for commercial or manufacturing or other purposes shall be built of sufficient height, to carry off the smoke and other products of combustion without offence to the occupiers of neighbouring houses or buildings, and the Dean of Guild Court may on the application of the Master of Works or any person interested, after giving parties an opportunity of being heard, issue an order, requiring the owner of any such chimney-stalk or flue (new or existing) to raise the same up to a height sufficient in the opinion of the said court to carry off the smoke and other products of combustion as aforesaid, and such owner shall on failure to comply with such order be liable in a penalty as hereinafter in this Act provided."

Glasgow Police (Further Powers) Act, 1892.—*Section* 31.—"Every person who so uses, causes, permits or suffers to be used, any furnace or fire within the city (except a household fire) so that smoke issues therefrom, unless he proves that he has used the best practical means for preventing smoke, and has carefully attended to and managed such furnace or fire so as to prevent as far as possible smoke issuing therefrom, shall be liable for the first offence to a penalty not exceeding forty shillings, and for a second or any subsequent offence, if committed within twelve months of the immediately previous conviction, to a penalty not exceeding five pounds."

Manchester Corporation Act, 1882.—*Section* 44.—"For the purpose of more effectively carrying into effect the provisions of the Public Health Act of 1875, in respect to smoke nuisance, when an order of abatement or prohibition has been made under this Act, it shall be lawful for the Justices of the Peace for the city to impose any daily penalty not exceeding ten pounds in respect of any breach or non-observance of such order."

The Leeds Improvement Act, 1866 (29 & 30 Vict.).—*Section* 70.—This section states that every furnace must be constructed or altered so as to consume or burn its smoke as far as practicable without injury to the material worked therein, and used for the generation of steam.

For contravention of this section a penalty of five pounds may be imposed, but not less than two pounds; for the second offence ten pounds, and for every subsequent conviction twenty pounds.

For disobeying an order to reconstruct furnace, chimney, &c., the penalty must not exceed ten shillings per day during default.

For refusal of entry to the official of the Local Authority to inspect nuisance, &c., a penalty not exceeding twenty pounds can be imposed.

Power to appoint a fit person to be an Inspector of Smoke Nuisances, also power to the inspector to prosecute without any authority from a committee or the council of the borough, and the expenses incurred by the inspector to be paid by the corporation out of the improvement rates.

It also gives power to any person to prosecute at his own risk, providing such person is an inhabitant of the borough.

Section 59.—"The corporation from time to time may regulate the height of the chimneys of all buildings, or at any time after the passing of this Act, used for the purpose of trade or manufacture, or for baths and washhouses, and may by order in writing, direct that any

chimney shall be altered or built, so that the same shall be of the height specified in such order, and any person who shall not comply with such order, or who in the case of any new chimney shall neglect to give seven days' notice in writing to the corporation, or their surveyor, of his intention to build the same, shall for every such offence forfeit not exceeding twenty pounds."

Public Health (London) Act, 1891.—*Section* 23.—(1) Every furnace employed in the working of engines by steam, and every furnace employed in any public bath or washhouse, or in any mill, factory, printing-house, dye-house, ironfoundry, glasshouse, distillery, brewhouse, sugar refinery, bakehouse, gasworks, waterworks, or other buildings used for the purpose of trade or manufacture (although a steam engine be not used or employed therein), shall be constructed so as to consume or burn the smoke arising from such furnace.

(2) If any person being the owner or occupier of the premises, or being a foreman or other person employed by such owner or occupier—

(*a*) uses any such furnace which is not constructed so as to consume or burn the smoke arising therefrom; or

(*b*) so negligently uses any such furnace so that the smoke arising therefrom is not effectually consumed or burnt; or

(*c*) carries on any trade or business which occasions any noxious or offensive effluvia, or otherwise annoys the neighbourhood or inhabitants, without using the best practicable means for preventing or counteracting such effluvia, or other annoyance; such person shall be liable to a fine not exceeding five pounds, and on a second conviction to a fine of ten pounds, and on each subsequent conviction to a fine double the amount of the fine imposed on the last preceding conviction.

(3) Every steam engine and furnace used in the working of any steam vessel on the River Thames, either above London Bridge, or plying to and fro between London Bridge and any place on the River Thames westward of the Nore light, shall be constructed so as to consume or burn the smoke arising from such engine and furnace; and if any such steam engine or furnace is not so constructed, or being so constructed is wilfully or negligently used so that the smoke arising therefrom is not effectually consumed or burnt, the owner or master of such vessel shall be liable to a fine not exceeding five pounds, and on a second conviction to a fine of ten pounds, and on every subsequent conviction to a fine of double the amount of the fine imposed on the last preceding conviction.

(4) Provided that in this section the words, "consume or burn the smoke," shall not be held in all cases to mean "consume or burn all the smoke," and the court hearing an information against a person may remit the fine if of opinion that such person has so constructed his furnace as to consume or burn, as far as possible, all the smoke arising from such furnace, and has carefully attended to the same, and consumed or burned, as far as possible, the smoke arising from such furnace.

(5) It shall be the duty of every Sanitary Authority to enforce the provisions of this section, and an information shall not be laid for the recovery of any fine under this section except under the direction of a Sanitary Authority.

(6) The provisions of this Act with respect to the admission of the Sanitary Authority into any premises for any purposes in relation to nuisances, and with respect to the giving of information of a nuisance, shall apply in like manner as if they were herein re-enacted, and in terms made applicable to this section.

(7) This section shall extend to the port of London, and as respects the port shall be enforced by the port Sanitary Authority.

(8) Nothing in this section shall alter or repeal any of the provisions of the City of London Sewers Act, 1851, or of the Whitechapel Improvement Act, 1853.

Section 24.—(*a*) Any fireplace or furnace which does not, as far as practicable, consume the smoke arising from the combustible used therein, and which is used for working engines by steam, or in any mill, factory, dye-house, brewery, bakehouse, or gaswork, or in any manufacturing or trade process whatsoever; and

(*b*) Any chimney (not being the chimney of a private dwelling-house) sending forth black smoke in such quantity as to be a nuisance;

shall be nuisances liable to be dealt with summarily under this Act, and the provisions of this Act relating to those nuisances shall apply accordingly:

Provided that the court, hearing a complaint against a person in respect of a nuisance arising from a fireplace or furnace which does not consume the smoke arising from the combustible used in such fireplace or furnace, shall hold that no nuisance is created, and dismiss the complaint, if satisfied that such fireplace or furnace is constructed in such manner as to consume, as far as practicable, having regard to the nature of the manufacture or trade, all smoke arising therefrom, and that such fireplace or furnace has been carefully attended to by the person having the charge thereof.

Salford Improvement Act, 1862.—This Act gives the corporation power to compel owners of fireplaces and furnaces to so construct them that the smoke arising therefrom shall be effectively consumed or burnt.

If the owners refuse to so construct they are liable to a penalty not exceeding five pounds, but if the said fireplaces and furnaces are properly constructed and negligently used so as not to consume the combustibles used therein, they are liable to a penalty not exceeding ten pounds, and to a further penalty of forty shillings for

every day during any part of which such fireplace or furnace shall be so used after one month's notice in writing.

It also empowers the corporation to proceed against the fireman for excessive smoke if the owner has provided sufficient boiler accommodation.

Sheffield Corporation Act, 1900 (*Section* 105).—Where a person is convicted in respect of non-compliance with an order made under Section 96 of the Public Health Act, 1875, to abate a smoke nuisance within the meaning of Section 91 of the said Act, the court may, if they see fit, impose a daily penalty not exceeding five pounds during default: Provided that this section shall only apply to orders made in proceedings taken by the direction of the corporation, and shall have no application to reheating, annealing, hardening, forge, converting, and carburising furnaces.

CHAPTER IV

FOREIGN LAWS IN REGARD TO SMOKE ABATEMENT

Austria — Bavaria — Belgium—France — Germany — Hungary — Italy — Netherlands — Saxe-Coburg and Gotha — Saxony — Switzerland — United States — Würtemberg.

(*Extracts from the Parliamentary Paper, February* 1905.)

Circular addressed to His Majesty's Representatives at Paris, Berlin, Vienna, Buda-Pesth, Rome, Brussels, The Hague, Berne, Washington, Munich, and Coburg.

"FOREIGN OFFICE, *May* 16, 1904.

"SIR,—I request that you will furnish me with a Report respecting the laws in force in for the regulation, restriction, or prevention of the emission of smoke from factories and other business premises, and from private dwelling-houses, with such extracts from those laws as may be needed to explain their operation. The Report should, however, be complete in itself.—I am, &c., (Signed) LANSDOWNE."

AUSTRIA.

Many complaints have recently been made in Austria with regard to the emission of thick black smoke from factories and furnaces in various parts of the country. This has been especially the case in industrial centres, where there is a great consumption of coal and other

kinds of fuel, and in the various health resorts and watering-places, where it is of especial importance that the air should be kept pure and uncontaminated by smoke. This problem also presents itself in the case of railways, where the interests of the travellers and those of the residents in the neighbourhood of stations come into consideration. That no legislative measure exists at present to obviate this nuisance may be attributed to the following causes:—

In the first place it must be emphasised that the compulsory introduction of technical measures to procure smokeless or almost smokeless fires would only be practicable if thoroughly adequate appliances existed to ensure the desired result. In this connection experience shows that no system hitherto recommended and applied is exempt from serious disadvantages. The best laid furnace requires constant supervision and attention, nor will it burn properly unless carefully tended. There is a well-known saying to the effect that a good stoker is the best consumer of smoke.

It must also be taken into consideration that manufacturers oppose a justifiable resistance to the introduction of more or less expensive apparatus for the prevention of smoke, on the ground that the saving of fuel alleged by the inventors to be effected does not in reality take place.

In spite of these various difficulties the problem of finding the best means of combating the smoke nuisance has never been lost sight of in Austria, and it is at the present moment forming the subject of negotiations between the competent Government Departments. The Minister of Railways has also taken steps to deal with the question by encouraging the introduction of appliances for consuming smoke in the case of locomotives both on the State and on private railways, and he has had the appliances recommended for this purpose subjected to exhaustive tests. The result of the latter has been to show that there is no immediate prospect of a

satisfactory solution of the problem, and that further experiments will be necessary. As regards smoke coming from factories and other great furnace centres, and the emission of poisonous gases (such as sulphuric acid and carbonic acid gas) which are injurious to forests and vegetation, the sanitary laws contain general provisions which enable the administrative authorities to issue Regulations calculated to mitigate the evils arising from the emission of excessive quantities of smoke.

By paragraph 1 of the Law of the 30th April 1870, for the organisation of the public sanitary service, the supervision and direction of all sanitary measures are entrusted to the administrative authorities.

Paragraph 25 of the Law of the 15th March 1883, supplementing the Statutory Law for Trades, runs as follows:—

"Sanction for the establishment of factories is necessary in the case of industries where furnaces, engines, or other motive powers are employed, or which are calculated to endanger or harm the surrounding neighbourhood by the emission of an injurious quality of smoke or by excessive noise.

"Such factories may not be erected until the necessary permission has been accorded."

Paragraph 26 of the same Law provides as follows:—

"In the case of all factories belonging to the above-mentioned category it is the duty of the administrative authorities to examine the harmful conditions under consideration and to prescribe the necessary measures to be observed in the erection of the building, and to take especial precautions that churches, schools, hospitals, and other public buildings are not damaged in any way by the erection of these establishments."

It may be added that the provisions of these laws are strictly enforced by the administrative authorities, with

the object of diminishing as far as possible the evil arising from the emission of thick black smoke from factories, chimneys, furnaces, and other establishments of a similar character.

BAVARIA.

There are no laws in force in Bavaria which have been framed with the specific object of regulating, restricting, or preventing the emission of smoke from factories and other business premises, or from private dwelling-houses, but there are provisions both in the Imperial and Bavarian Laws which affect the question.

Thus smoke and soot are mentioned by the Imperial Civil Code among the nuisances which may be made the subject of legal action if material injury is done to the complainant's property; and further protection is given against this and other nuisances by a provision of the Imperial Law which requires official authorisation for the establishment of any business premises likely to constitute a danger or a nuisance to neighbouring property.

Local legislation has done something more to mitigate the evils of smoke, by means of Police Regulations, which have been issued in Munich and other cities. Under these regulations the police have considerable control over the construction of chimneys, and can enforce such alterations as they consider necessary to prevent annoyance to neighbours.

The General Building Law of 1901 for Bavaria, exclusive of Munich, and similar Regulations made for Munich itself, also lay down Regulations for the construction of chimneys so as to avoid danger from fire or serious nuisance to the neighbourhood; while a Law of the 28th June 1892, on the use of steam boilers, provides that in heating such boilers the smoke must be consumed as far as possible.

The last Law affecting the question was one of the

26th March 1903, on the duties of chimney sweeps; the Ministerial Ordinance which followed it laid down that the chimney sweep must personally satisfy himself of the good and proper condition of the flue before and again after sweeping, and that upon his report the police authorities should take such action as might be necessary. A chimney sweep is prohibited from practising any other trade in addition. Annexed will be found extracts of the principal laws and regulations:—

"*Imperial German Civil Code.*

"Paragraph 906.—The owner of a property has no right to object to the escape of gas, steam, or odours; to smoke, soot, heat, noise, shocks, or other nuisances from another property, unless such nuisance do materially injure his property.

"Paragraph 907.—The owner of a property can object to the erection or maintenance of any plant on a neighbouring property which can be foreseen with certainty to constitute a nuisance detrimental to the enjoyment of his property . . ."

"*Imperial Penal Code of the 17th May* 1871.

"Paragraph 366 (*c.* 10).—Any person contravening the Police Regulations in force for the safety, convenience, cleanliness, and quiet of the public on public highways, streets, squares, or canals, is punishable by fine not exceeding 60 marks (£3), or by imprisonment not exceeding fourteen days."

"*Police Penal Code of the 26th December* 1871.

"Article 94.—Any person contravening the local Police Regulations, over and above the provisions of paragraph 366 (*c.* 10) of the Imperial Penal Code dealing with public cleanliness in towns, markets, villages, and other places, shall be punishable by fine not exceeding 60 marks (£3), or by imprisonment not exceeding fourteen days."

"*Regulations issued by the Munich Police Authorities concerning the Abatement of Smoke and Obnoxious Gases, September* 11, 1891.

"The Magistrate of Munich has issued the following local Police Regulations, based on paragraph 366 (*c.* 10) of the Imperial German Penal Code, and on Article 94 of the Police

Code; these Regulations came into force on the 31st August 1891 :—

"Paragraph 1.—Flues and chimneys, which are erected in the proximity of inhabited quarters of a town, near public roads, streets, or squares, whether used for industrial or other purposes, must be so constructed, and such regard paid to the quality of fuel consumed, and care taken in heating, that the emission of smoke may be avoided as far as possible.

"Steam tramways and locomotives are also subject to the above Regulations.

"Paragraph 2.—Business premises, in which noxious gases are generated, must be provided with flues capable of rendering the gases harmless, and of obviating any danger to health or nuisance owing to the escape of gas.

"Paragraph 3.—The police authorities, in concurrence with experts, have power to require the owners of such flues and chimneys, as mentioned in paragraphs 1 and 2, to make such alterations in, and additions to, the construction as is deemed necessary to prevent annoyance from smoke; the said owners are bound to have the alterations carried out within the period prescribed by the police.

"Paragraph 4.—Wherever a technical examination of a flue or chimney shall be required before alterations can be made, the cost shall be defrayed by the owner thereof.

"Paragraph 5.—Flues and chimneys which do not comply with the requirements laid down in Paragraphs 1 and 2 must be altered not later than by the 1st October 1893, so as to satisfy those requirements.

"Paragraph 6.—Contraventions of the law by the owners or persons employed in heating are punishable by a fine not exceeding 60 marks (£3), or imprisonment not exceeding fourteen days.

"In case the removal of a defective flue has been ordered, or an addition has to be made, no punishment can be inflicted until the expiration of the period within which the work had to be executed.

"Paragraph 7.—The above Regulations come into force on the day following their publication."

"1. *General Building Law for Bavaria, exclusive of Munich, 17th February* 1901.

"Paragraph 17.—(1) Chimneys must be constructed of bricks, to project at least .80 metres (31.49 inches) above the roof, but the exact distance of the projection above the roof is to be determined by the police authorities with a view to the prevention

of fire and of danger to health, and to avoiding serious nuisance to the neighbourhood. They must be capable of being cleaned throughout inside and out, and must be fire-proof. They may not be placed one above the other horizontally.

"(2) Wood may not be used in the construction of the chimney walls, nor may they be lined with wood. No iron or stone supports of the chimneys shall rest on the naked rafters.

"(3) Detached chimneys for manufactories and other industrial establishments may be constructed of iron if the authorisation of the police authorities be obtained.

"(4) The requisite thickness of the chimney walls is to be determined according to their position and height, and the thickness and number of the connecting flues.

"In ordinary cases the thickness should not be less than .12 metres (4.72 inches), and in special cases not less than .25 metres (9.84 inches).

"(5) The width (inside measurement) of such chimneys as can be ascended must be at least .50 metres (19.68 inches) each way.

"(6) Cowls must be constructed of non-inflammable material."

"2. *Bavarian Law of the 28th June* 1892.

"Paragraph 1.—In heating fixed steam-boilers the smoke is to be consumed as far as possible.

"Paragraph 2.—The width of the chimney is left to the contractor, but the authorities may prescribe its length.

"Paragraph 4.—Should serious danger, prejudice, or annoyance be caused to the neighbours by a steam-boiler which has been erected, then the constructor shall be required to take steps to remove such danger, &c."

BELGIUM.

No separate law exists in Belgium having directly for its object the regulation, limitation, or prevention of the emission of smoke from factories and other business premises or from private houses, but the laws relative to establishments classed as dangerous, unhealthy, or objectionable ("incommode") and to steam engines and boilers give power to the authorities charged with the regulation of these matters to attach certain conditions to the licences they issue, notably as regards the prevention and restriction of the emission of smoke.

A Royal Decree, dated the 29th January 1863, provides that no establishment of a dangerous, unhealthy, or objectionable nature may be set up or transferred from one locality to another without permission of the administrative authority. These establishments are divided into two classes—(1) Authorised by the Permanent Committee of the Provincial Council, after consultation with the Executive Committee of the Communal Council; and (2) directly by the Executive Committee of the Communal Council, with the right of appeal to the Permanent Committee of the Provincial Council. In either case there is a right of final appeal to the Minister of Industry.

The request for a licence must be sent in to the competent authority, giving all details of the proposed installation, and the measures to be adopted with a view of preventing or diminishing the inconveniences attendant thereon, together with plans of the works and of the immediate surroundings within a radius of 200 yards. A notice of the request is then posted for fifteen days in the commune and in any neighbouring commune likely to be affected, after which a member of the Administration concerned, or a police official, collects any written objections which may be presented, and holds an inquiry *de commodo et incommodo*, during which any interested persons are heard. A report is also drawn up by the Government Inspector of such establishments. The decision is then given, and the grant of a licence may be made subject to any conditions considered necessary in the public interest.

These conditions are essentially variable, and differ according to the circumstances prevailing in each individual case. It is, however, generally specified that the chimneys must be sufficiently high to avoid all inconvenience to the neighbours from smoke. In some cases the actual height of the chimneys is prescribed (*e.g.* boiler factories 45 feet, glass factories from 90 to 120 feet); in

others it is fixed at from 3 to 15 feet higher than that of all chimneys within a hundred yards. Occasionally it is laid down that the fuel must be such as to give as little smoke as possible, and in the case of chalk-kilns it is provided that, if a new system of kiln be discovered giving out less noxious smoke, the manufacturer will be expected gradually to adapt his plant to it.

The competent authority has the right of inspection and the power to withdraw the licence if the conditions are not observed, and may always impose fresh conditions if necessity should arise. If any establishment is opened without a licence, the Burgomaster of the commune can suspend its working, or, in case of need, close it.

The penalties for the infraction of this Act are fines of from £1 to £4.

The Burgomaster is entrusted with the permanent supervision of these establishments. Their supreme supervision is in the hands of an official of the Ministry of Industry.

The regulation of boilers and steam engines is entrusted by Royal Decree, dated the 28th May 1884, to the Executive Committee of the Communal Council, and the procedure resembles in its general lines that adopted in the case of dangerous, unhealthy, and objectionable establishments, but the zone of persons interested is reduced to 50 yards, and in case of objection the matter is submitted to the Engineer-in-Chief of the Service of Steam Engines, who examines the objections in detail and reports to the Council.

It is specially provided by a Ministerial Instruction that it is necessary to prescribe measures tending to render the furnaces smoke-consuming, *e.g.* large gratings, furnaces, and high chimneys in proper proportion, and well placed, &c. If the measures taken are not efficacious, other means must be employed according to circumstances, such as the use of furnaces with a uniform consumption of fuel, the direct admission of air above the grating, the

division of the furnace into two parts to be stoked alternately, &c.

No law exists in Belgium for the regulation of the emission of smoke from private houses, but the above-mentioned Ordinance has been held to apply to any boilers or steam engines erected on private premises for any purpose whatever, whether commercial or not.

The portions of the Law on dangerous, unhealthy, and objectionable establishments relating to the regulation of smoke are annexed.

Article 1.—The factories, workshops, and warehouses indicated (designated as dangerous, unhealthy, or objectionable) in the annexed list,[1] may not be set up nor transferred from one locality to another, except by permission of the administrative authorities.

Article 2.—Applications for authorisation are to be addressed to the competent Administration.

They should indicate the character of the establishment, its object, the apparatus and processes employed, as well as the approximate quantity of produce to be manufactured or warehoused. They should further state the measures which it is proposed to adopt for the purpose of obviating or lessening the inconveniences which such establishment might cause to the workmen employed, to neighbours, and to the general public.

Article 4.—A notice specifying the object of the application for authorisation is to be posted during a fortnight in the commune wherein the establishment is situate, by direction of the Burgomaster and Aldermen.

Article 5.—On the termination of the fortnight, a member of the College of Burgomaster and Aldermen, or a police superintendent delegated for the purpose, is to collect written observations and to hold an inquiry in the commune wherein the establishment is situate, at

[1] The list has been replaced by one annexed to a Royal Decree of the 31st May 1887 (not printed).

which a hearing is given to all interested parties who may present themselves.

Article 6.—The authorisations are to be made subject to such reserves and conditions as public safety, health, and convenience, and the interest of the workmen employed in the establishment may dictate. The authorisations are to determine the period within which the establishment may commence work.

Authorisations for establishments of the first class may not be granted for a period exceeding thirty years. They may be renewed, if expedient, at the termination of that period.

Article 7.—Decisions granting or refusing authorisation are to be immediately posted by the communal authorities in the commune interested.

Article 12.—In case of infringement of the terms of Articles 1, 9, 10, and 11, the Burgomaster[1] may suspend provisionally the working of the establishment, and, if necessary, may close it and seal down the apparatus.

FRANCE.

There is no legislative enactment in France for the regulation, restriction, or prevention of the emission of smoke from factories, business premises, or private dwelling-houses, but a series of Police Ordinances has been published in Paris.

On the 11th November 1854, an Ordinance was published requiring the owners of steam engines to consume their smoke or to use fuel which would not produce more smoke than coke or wood. This Ordinance, which applied to Paris only, was premature and too absolute in its provisions, and consequently fell completely into desuetude.

On the 19th January 1865, an Ordinance was pro-

[1] Royal Decree of the 24th December 1898.

mulgated ordering the owners of boiler furnaces of every description to consume their own smoke, a delay of six months being given to allow them to effect this improvement. This Ordinance, which applied to the whole of France, was of too sweeping a nature, and owing to the passive resistance of manufacturers and the deficiency of smoke-consuming apparatus, was as unsuccessful as the previous one.

In 1894 a Commission was formed to consider some means of remedying the evil effects caused by the pollution of the air by smoke proceeding from coal burnt by industrial establishments in Paris.

The formation of a Special Technical Commission was decided upon in order to thoroughly examine the different apparatus for the consumption of smoke. After three years' investigation of the various methods submitted by different competitors, the Commission reported in October 1897 that it felt convinced that efficacious means existed for restricting in a large measure the emission of smoke from industrial establishments, and expressed the hope that an Ordinance would be published by the Prefecture of Police prescribing Regulations for this object.

In consequence of this Report, the Prefect of Police published an Ordinance on the 22nd June 1898, prohibiting the prolonged emission of thick black smoke from industrial establishments. Six months were allowed to manufacturers to carry out the necessary improvements, but the Prefect of Police has refrained from a rigorous application of the Regulations owing to the impossibility of finding an absolutely perfect apparatus for consuming smoke. Choice of fuel, care in stoking furnaces, well-constructed chimneys may contribute largely to the restriction of smoke, but cannot entirely prevent its emission. After stoking furnaces every morning, and after each successive stoking during the course of the day, the Inspector allows an emission

of smoke three times as long as that allowed in London under the Law of the 5th August 1891. Great difficulties were met with by the municipality in carrying out the Regulations owing to the bad example set by many public buildings, the managers refusing to comply with the provisions in the Decree of 1898.

The statistics show, however, a continued increase in the number of manufacturers who comply with the Regulations. In 1899, 240 well-founded complaints were lodged; in 1900, 104; in 1901, 88; and in 1902, 84.

No regulations have been issued with regard to the emission of smoke from private dwelling-houses.

The Ordinance of the Prefect of Police of June 1898 is annexed.

PREFECTURE OF POLICE.

Ordinance Prohibiting the Prolonged Emission of Black Smoke in Paris.

By us, Prefect of Police,

In view of the law of the 16th–24th August 1790;

The Government Decree of the 12th of Messidor of the year VIII;

Article 471, § 15 and 474 of the Penal Code;

In view also of the reports of the Council of Hygiene and Public Health of the Department of the Seine of the 15th June 1890, and the 1st of April 1898;

Also the Report of the Technical Commission established by the Prefect of the Seine in order to carry out the competition between the different inventors of smoke-consuming apparatus, organised by the Paris Municipal Council on the 19th March 1894.

In view of the observations addressed to the Paris Municipal Council on behalf of the Second Commission on the 21st June 1898;

Considering that the increasing number of fires burning large quantities of mineral fuel has seriously increased the unpleasant effects of smoke in Paris;

That this smoke darkens the air, penetrates into the houses, blackens and clings to the front of houses and public monuments, and contaminates the atmosphere of the town;

Considering that there are various practical and efficacious methods in existence of attenuating, as far as possible, this serious inconvenience;

That recourse may be had, either to increasing the height of chimneys or to the choice of proper fuel, or to the employment of smoke-consuming chimneys;

We Decree as follows:

Article 1.—After six months from the publication of this Order, the emission is forbidden of black, thick, and continuous smoke of a nature to reach the neighbouring dwellings or contaminate the atmosphere of the streets of Paris.

Article 2.—Any failure to comply with this Order shall be stated in *procès-verbaux* or reports which shall be submitted to competent Tribunals.

Article 3.—The principal Technical Inspector of Factories and the Inspectors under him, as well as the Mining Engineers charged with the supervision of steam engines, and the agents under their direction, are directed to ensure the execution of this Order, which shall be printed, published, and posted up.

GERMANY.

There are no actual laws in force in Germany for the restriction of the emission of smoke from business premises and private dwelling-houses. For the erection of any new building in a town the permission of the local police authorities must be obtained, and special sanction

is required for the erection of premises which, by their position or their nature, might cause considerable danger or annoyance to the owners or inhabitants of neighbouring property or to the public generally. Should it be shown that any such "prejudice, danger, or annoyance" would be caused, permission for the erection of the premises may be withheld altogether or given with the necessary preventive conditions attached to it, the reasons being assigned in each case. Special sanction is also required for any important alterations in premises, the original erection of which had been permitted. Under these regulations due consideration is given to the question of the emission of smoke.

Although no actual laws are in force, great attention has in recent years been paid to this question by the Prussian Department of Trade and Industry, and a Commission was appointed a few years ago to examine into and report upon the means generally adopted for the consumption of smoke. The Commission having reported, the Department sent circular instructions to the various Local Authorities requesting them to see that measures were taken in all works belonging to the State with a view to restricting excessive emissions of smoke. They, at the same time, embodied the principles by which the Authorities were to be guided in a document of which a translation is annexed. In the instructions it was stated that "it is not for the present proposed to issue Police Regulations against the emission of smoke, as it is hoped that manufacturers will, on their part, pay greater attention to the question. Whereas, however, the State authorities have given evidence of their earnest desire to show the way in their works, manufacturers must not expect that excessive emissions of smoke will in future be regarded with leniency, especially in view of the fact that it may be assumed with certainty, from the Report of the Commission appointed to test and examine appliances for the consumption of smoke, that in using

proper restrictive apparatuses owners of furnaces do not suffer any considerable pecuniary loss."

From the enclosed Regulations it will be seen that the emission of black, thick, and continuous smoke is, in State premises, first of all to be avoided as far as possible by expert management of the furnaces, proper supervision over the firemen, and careful selection of fuel. Reports on various points are asked for, and an expression of opinion as to what, if any, special measures should be introduced for the restriction of smoke in the case of premises where expert management of the furnaces, selection of fuel, &c., have failed to produce the desired effect. These reports are now coming in, and I have been informed at the Department of Trade and Industry that, as far as they go at present, they are all opposed to the introduction of any special police regulations.

One of the main objections seems to be the difficulty of deciding as to what constitutes "black, thick, or continuous smoke," and the experiments that have been made in taking observations of smoke emissions from various points and in various conditions of the atmosphere have shown that it is exceedingly difficult, even for experts, to agree. It would be almost impossible to furnish police or other officers with the instructions necessary for their guidance.

In the opinion of the Prussian Government the employment of proper firemen will go far to minimise excessive emissions of smoke. In 1902, therefore, they introduced a course of instruction for firemen, and £2000 is for the present allowed in the Budget annually for this purpose. The motives which induced the Government to ask for the grant are stated in the 1902 Budget as follows:—

"The preliminary condition for the prevention of excessive emissions of smoke is, as experience has shown, the instruction of capable firemen. This would also have the advantage of leading to better insurance against boiler

explosions and to economy. In view of the general State interests which are here in question, and of the proven failure and insufficiency of efforts on the part of persons interested, it is desirable that the State should take the proper steps for such instruction to be given. By way of experiment, and for at least two consecutive years, itinerant courses of instruction will be instituted for firemen and engineers. The instruction will be given once a fortnight by academically educated instructors paid by the State, according to a uniform system, but taking into consideration the different local requirements of the industry prevailing in the several districts of the country; the classes will be held, first in connection with the existing engineering and technical schools and making use of their appliances, and then in other places where suitable rooms can be found.

"In addition to the instructor a capable superintendent will give practical lessons. . . .

"In addition to this the Boiler Supervision Societies will employ firemen instructors, who will give the necessary lessons at the boiler and the engine to the firemen and engineers who are employed in the country districts less developed industrially, and who cannot avail themselves of the courses of instruction that have been instituted."

Against the emission of smoke from private dwelling-houses there are also no laws in force in Germany. Largely owing to the almost universal use of coal-dust bricks, and to a system of central heating for which coke is generally employed, comparatively little smoke is emitted, certainly not sufficient to render it necessary for any legislative measures to be taken.

In order to avoid the annoyance and damage which may be caused by smoke from stationary furnaces, care should be taken in all works under State control that the emission of black, thick, and continuous smoke be avoided in the first instance by expert management of

the fires, proper supervision over the firemen, and careful selection of fuel.

The emission is to be regarded as continuous if black impenetrable smoke proceeds from a chimney for more than five minutes without interruption.

As far as is in any way feasible, care should be taken that only such persons as have satisfactorily managed furnaces for a considerable time shall be employed as independent firemen. If these persons have not gone through a satisfactory course at a firemen's school, opportunity should be given them as far as possible to attend one.

The authorities who have furnaces under their superintendence should, moreover, see that firemen are instructed as to the cause of the emission of smoke, and that sufficient control is exercised over them.

In choosing fuel the guiding principle should not as a rule be that the emission of smoke is to be prevented by the acquirement of expensive kinds of coal, or of coal that gives out little smoke without particular care, or by replacing coal by coke (except when the latter cannot be dispensed with on account of the nature or object of the furnace), but rather that the fuel is to be obtained which is generally used at the works, even if difficulties in the way of preventing smoke are thereby incurred.

If excessive emissions of smoke cannot be sufficiently prevented by careful management of the fires, supervision over the firemen, nor by the selection of fuel, without considerable increase in the cost of fire, a few furnaces should be provided with special tried appliances for the prevention of smoke in all places where this may be desirable in view of the situation of the works.

. . . . . .

When new furnaces are to be built a condition should be inserted in the invitation for tenders, in all cases where the restriction of smoke is desirable on account of the situation of the works, that they are to emit as little

smoke as possible with the fuel that is obtainable on the spot, and that the appliances to be provided for this purpose should be mentioned in the tender. Before the acceptance of a tender it should be ascertained by careful testing that the appliances suggested seem sufficient. Care should also be taken that the size of the furnace suffices to meet possible greater requirements without strain and without causing too heavy smoke as a result.

After the close of the financial year, 1903, reports should be furnished by all officials who have large furnaces under their supervision, as to the result of their efforts for the prevention of smoke, from the following points of view:—

(*a*) Number and nature of the larger furnaces and the fuel used for them;

(*b*) Volume of the smoke emissions observed;

(*c*) Nature of the measures adopted to restrict the emission of smoke when this was necessary;

(*d*) The expenses incurred in providing appliances for the restriction of smoke and any economy in working resulting therefrom.

An expression of opinion should also be furnished:—

1. As to whether it would be desirable to introduce special measures for the prevention of smoke in the case of those works in which all efforts to that end in the way of proper management of the fires, selection of fuel, &c., have failed.

2. If so, what measures should be adopted.

HUNGARY.

At Buda-Pesth chimneys used for boilers having a heating surface of 3 square metres or upwards, or for furnaces consuming 44 lbs. of coal, or more, per hour, must be furnished with smoke-consuming appliances. The exact nature of these appliances is not prescribed,

but they must be approved by the Engineering Department of the municipality.

It should be added that the results obtained have not been commensurate with the expense incurred, and it is considered by experts that careful stoking, which is not at present enforced, would be as effective in preventing smoke as any apparatus yet discovered.

As regards household fires, no regulations are required, as stoves are in universal use.

ITALY.

The Department of the Director-General of Public Health of the Italian Ministry of the Interior is responsible for the control of the emission of noxious fumes from factories and other business premises in large towns. There are, however, no special provisions on the subject of smoke in Italian sanitary legislation. The Sanitary Law speaks in general terms of industries which diffuse unhealthy exhalations, and of industries which may be dangerous to the public health.

Those in the first category must be established in the country and at a distance from inhabited houses. Industries in the second category may be carried on in towns or near inhabited houses, but with the precautions necessary for avoiding all danger to the public health.

The question of the emission of smoke from chimneys is of very small importance in Italy, as the majority of Italian industries are established in the country outside towns, and continue to make increasing use of electric energy produced by water power.

NETHERLANDS.

There are in the Netherlands no special laws in existence with regard to the regulation, restriction, &c., of the emission of smoke from factories and other busi-

ness premises; and the only law that has any connection with the subject is the Hinderwet of the 2nd June 1875, lately re-enacted and amended by the Law of the 24th June 1901, which deals with the conditions upon which factories and other buildings, employing smoke, gas, or steam, may be erected.

In Article 1 of this Law it is decreed that "no building which may cause danger, damage, or annoyance may be erected without the permission of the Gemeente-bestuur (municipal authorities)," who (Article 6) "shall give written notice to the owners and tenants of all properties bordering directly on that whereon the building is to be erected, and to the authorities of all hospitals, places of public worship, and schools within 220 yards of the site of the proposed building;" and that placards must be set up on this site for the information of the public.

On the fourteenth day after public notice has been given, any objections may be brought forward, at the time and place mentioned in the notice, against the erection of such building, before the members of the municipality; and the petitioners as well as the complainants shall have this opportunity of explaining any such objections verbally or in writing.

The grounds of refusal of permission to erect must be based on the fear either—

"1. Of danger;

"2. Of damage to property, trade, or health; or,

"3. Of nuisance of some serious nature; such as rendering uninhabitable dwelling-houses, or parts of dwelling-houses, interfering with the use of hospitals, places of public worship, and schools situated within 220 yards of the site of the building, and the emission of foul or obnoxious smoke."

Fear of competition on the part of rival manufacturers cannot be assigned as a ground of refusal.

By Article 17, the authorities who granted the per-

mission may impose fresh conditions upon the grantee if experience shall have been found to necessitate such imposition; but the reasons must be set forth in a Decree, and the grantee may appeal from them within fourteen days after they have been made known to him.

A building erected without permission may be closed, its contents sealed, and the work stopped by the municipal authorities; and infringements of the provisions of the Law are punishable with fines of from 50 cents to 200 gulden (10d. to £16, 13s. 4d.), or from one to sixty days' imprisonment.

Fresh permission is required—

1. To build on to or alter the character of any building;

2. To renew work in a factory that has been closed for four years;

3. To restore a building that has been destroyed through any accident occasioned by the use or nature of the building itself.

With regard to the regulation of the emission of smoke from the chimneys of private dwelling-houses there exist no legal stipulations whatsoever in the country.

Subject to the conditions laid down in the Hinderwet, the various municipalities have, as occasion required, drawn up purely local regulations, which, however, refer chiefly to the height of the chimney; for example, in the Police Regulations of The Hague of the year 1894, still in force, it is enacted that chimney-pipes built from the top of the roof must be raised at least 3 ft. 3 ins. above the roof; if built on any other part of the roof, they must be raised to a height to be specified by the police; chimneys which are lower than the top of the neighbouring roofs must, at the instance of the Burgomaster or Wethouders (County Council), be heightened or altered, as these authorities shall prescribe; chimney-pipes next to any building which is altered or heightened

must, by the owner of such building, be altered or raised 3 ft. 3 ins. above the gutter of such heightened building, and no chimney may be built or altered without giving previous notice and receiving permission from the police.

In Rotterdam there are no municipal regulations with regard to chimneys, and in Amsterdam the Police Regulations of 1902, which are now under revision, only decree that chimneys of buildings shall be raised 3 ft. 3 ins. above the top of the building to which they belong, and, if required, must be raised above the top of the neighbouring buildings.

But all these regulations are purely local, and are drawn up as necessity dictates, and are being constantly altered; and it would appear that the nuisance of factory smoke in the towns of the Netherlands has as yet not reached such dimensions as to call for any special legislation on the subject.

SAXE-COBURG AND GOTHA.

Regulation and Prevention of Smoke in the Duchies of Saxe-Coburg and Gotha.

In the case of already existing premises where a nuisance is caused by the emission of smoke, the intervention of the police can be obtained, and alterations in such premises be enforced, but compensation for the expense to which he may thereby be put can be claimed by the owner from the complainant.

With regard to the erection of new buildings, whether private dwelling-houses or factories, the following provisions of the Building Act of 1884 apply:—

In the chapter entitled "Limitation in the Public Interest of the Freedom of Construction," sub-section "Chimneys," it is enacted that—

"Every fireplace must be connected with a chimney of the width required by the rules of construction. The

lighting of fires must be so managed, and conducted through chimneys of such height and construction, that smoke, soot, or sparks may not escape in a manner calculated to cause a nuisance or danger to the neighbourhood."

In the chapter "Premises Liable to Special Danger of Fire," it is enacted that—

"All premises exposed to special danger of fire, and of large extent, such as yards for storage of timber or building materials, must be situated at a certain distance from other buildings, or from special kinds of buildings, and in premises where some industry is carried on by which smoke or evil-smelling fumes are likely to be given off, it is forbidden to make openings from such buildings on to the street, through which these fumes would escape."

SAXONY.

Laws in force in the Kingdom of Saxony for the Regulation, Restriction, and Prevention of Smoke.

According to the General Building Law of 1900, care must be taken in the construction of any building that no serious inconvenience will be caused to adjoining properties by the escape of smoke and soot.

Local Authorities may determine what positions are specially suitable for manufacturing premises, and may forbid their erection in certain localities.

All chimneys, besides conforming to detailed Regulations as to solidity of construction, width of the flue, &c.—intended to avoid danger of fire—must be of a height corresponding more or less with that of others in the immediate neighbourhood, and the authorities can enforce the heightening of any chimney if deemed necessary. The communication of one chimney with another is to be avoided.

A Decree of 1890 respecting furnaces enacts that the

stoking must be so managed that adjoining properties suffer as little as possible from the emission of smoke or soot.

Should, however, inconvenience be caused in this respect, the owner of the engine-house has, at his own expense, to apply remedial measures, such as the heightening of the chimney, the introduction of special contrivances for the avoidance of excessive smoke, or the use of another kind of fuel, and these measures must be carried out, within an appointed time, to the satisfaction of the Inspector of Factories.

The powers placed by these Acts in the hands of the Local Authorities have been exercised in all the larger towns of Saxony.

There are, however, some special provisions which apply only to the capital of this kingdom.

In 1887 the Municipality of Dresden passed the following bye-law, which subsequently received the sanction of the Ministry of the Interior:—

"§ 1. In all manufacturing and industrial premises, the construction of the furnaces must be of such a nature, and their stoking so regulated, that no smoke containing visible particles of soot is constantly emitted.

"Where this happens only occasionally and exceptionally, the omission must not last longer than is absolutely unavoidable even with the most careful stoking and the employment of coal of at least medium quality.

"This paragraph applies to steamers, traction-engines, &c., but not to railway locomotives.

"§ 2. In the case of already existing premises, such alterations must be made as will ensure compliance with the terms of this bye-law within two years.

"§ 3. The sanction of the official Inspector does not relieve the proprietor or occupier of the works—should it later on appear that they do not comply with the

provisions of this bye-law—from making the necessary alterations within a certain time.

"§ 4. In private dwelling-houses the heating arrangement must be so contrived as to produce as little smoke and soot as possible.

"§ 5. Disregard of paragraphs 1, 2, and 4 render the proprietor or occupier liable to a fine not exceeding 150 marks (£7, 10s.)."

To ensure the observance of these provisions an Inspector was appointed by the municipality and subordinated to the body known as the Fire Police.

His functions are:—

1. To inquire into the causes, generally and in individual instances, of nuisance arising from smoke.

2. To report all premises which do not comply with the bye-laws.

3. To hear complaints against the practicability and onerous nature of these bye-laws.

4. To suggest any improvements in the means devised for combating the smoke nuisance.

His authority extends to municipal and even Government undertakings and works, as well as to private establishments.

He is also entrusted with the task of supervising and instructing the whole class of stokers, so as to ensure a due amount of proficiency on the part of all men engaged in attending to furnaces.

To afford him assistance in the discharge of his duties he has under him an expert foreman stoker, who is frequently called upon to give practical illustration of the effect of skilful stoking in reducing the volume of black smoke.

With regard to the sweeping of chimneys, the town is divided into districts, each of which is placed under the charge of a certificated chimney-sweep, who has given proof of his proficiency by passing an examination on the subject, and who is alone responsible for the

condition of the chimneys in his district. In some instances, for example, where only brown coal is used, the chimney has to be swept once in every month.

SWITZERLAND.

There are no special laws, Federal or Cantonal, for the regulation, restriction, or prevention of the emission of smoke, in force in Switzerland.

As a matter of fact, therefore, the question of the abatement of smoke is one which has never yet been raised in Switzerland, and, consequently, no legislation bearing upon it more than upon any other possible form of nuisance connected with the working of factories has been enacted. Factories are to a large extent driven in Switzerland by water power or by electric power generated by water power; they are consequently, as a rule, situated in the country, and often on the banks of rivers, at considerable distances from the towns and even from one another. This is probably the reason why they give rise to few, if any, complaints on the ground of smoke nuisance.

The only enactment which might be held even indirectly applicable is the Law of 1877, regulating labour in factories, which refers, among other things, to nuisances endangering the health of the neighbouring inhabitants.

It would be possible to apply for an Administrative inquiry in any case where a nuisance occasioned by smoke gave cause for complaint, or legal proceedings could be taken in the Cantonal Courts, when the case would be decided by the Judge on its merits, but there seems to be no record of any such action having been taken.

UNITED STATES.

State of Pennsylvania.

There is no general legislation in the State of Pennsylvania on the subject of smoke abatement, but the larger cities and other municipalities have in some cases adopted local regulations controlling the matter. Inquiries in the towns of Erie, Reading, and Lancaster prove that they have no restricting or regulating Ordinances whatever.

At Pittsburg there is a similar absence of regulations. The Mayor states that an Ordinance does exist, but that the courts have declared it to be unconstitutional, and that no further action has since been taken.

At Philadelphia there is an "Ordinance to regulate the smoke from chimneys, stacks, flues, or open spaces within the city." Copy is annexed. This Ordinance provides a colour scale for the measurement of the degree and darkness of smoke, making it unlawful to permit the escape of smoke of certain degrees of darkness, and fixes a penalty for the violations of its regulations.

"An Ordinance to regulate the emission of smoke from chimneys, stacks, flues, or open spaces within the city of Philadelphia, providing a colour scale for the measurement of the degree and darkness of such smoke, making it unlawful to permit the escape of smoke of certain degrees of darkness, and providing a penalty for the violation of this Ordinance.

"Section 1.—The Select and Common Councils of the city of Philadelphia do ordain:

"That for the purpose of regulating the emission of smoke from chimneys, stacks, flues, or open spaces within the said city, and to determine by comparison the degree of darkness of smoke so emitted, a colour scale shall be, and the same is hereby, adopted as follows:—

"One thickness of grey glass of sufficient capacity to cut off 60 per cent. of the light from a flame having a lighting power of sixteen candles shall be taken as the basis of this scale;

"Two thicknesses of said glass shall be known and designated as No. 1 scale;

"Four thicknesses of the said glass shall be known and designated as No. 2 scale.

"Section 2.—It is forbidden, and hereby declared to be unlawful, to suffer or permit the emission or escape of smoke from any or all fires not in motion, or fires banked or in a state of rest, or through any burning or active fire through a stack, flue, or chimney less than 50 feet high of a colour greater than No. 1 scale.

"Section 3.—It is hereby forbidden, and declared to be unlawful, within the limits of the city of Philadelphia, to suffer or permit the escape or emission of smoke of a degree of darkness in excess of scale No. 2 for a period of more than five consecutive minutes from any locomotive or river steam craft standing with banked fires or engaged in shifting, or for a period of more than ten minutes from any locomotive or river steam craft whose fire may be in process of cleaning or preparing for starting. Provided, however, that none of the provisions of this Ordinance shall apply in the case of a locomotive or locomotives or river steam craft in continuous transit through or across the city or entering or departing therefrom.

"Section 4.—It is hereby further ordained that smoke may be suffered or permitted to escape from any puddling, open-hearth, or forge furnace now erected to a degree of darkness not exceeding No. 2 colour scale through a chimney 50 feet high, and from any puddling, open-hearth, forge, or other furnace hereafter erected of a degree of darkness not exceeding No. 1 colour scale, with a chimney not less than 150 feet high; but that the emission or escape of smoke of a colour degree of darkness greater than that provided respectively in this section is hereby prohibited and made unlawful.

"Section 5.—It is hereby further ordained that no fumes of a sulphurous or obnoxious odour occasioned by the melting of scrap tin or other metal shall be permitted to escape from any foundry or furnace within the built-up section of the city.

"Section 6.—The provisions of this Ordinance shall not apply as to the colour of smoke between the hours of 4 A.M. and 7 A.M.

"Section 7.—Any person or persons who shall violate any of the provisions of this Ordinance, or suffer or permit any of the acts hereby forbidden or declared to be unlawful, shall be subject to a penalty of 25 dollars for each offence, such penalty to be collected and recovered by and at the suit of the city of Philadelphia, for the use of said city as debts of like amount are now by law recoverable. Provided, however, that any suits for the

violation of the terms of this Ordinance must be brought within five days after the offence shall have been committed, and within forty-eight hours after the commission of the offence a notice shall be mailed to the offender by the Bureau of Boiler Inspection, notifying the offender of the violation of this Ordinance and the details of such violation.

"Section 8.—The provisions of this Ordinance shall become operative and effective on the 1st day of October 1904, and the enforcement of said provisions shall be, and is hereby, made the duty of the Bureau of Boiler Inspection, subject to such incidental Rules and Regulations as the said Bureau of Boiler Inspection may establish and provide."

The city of Alleghany has an Ordinance, copy of which is annexed, dated 1897, prohibiting the emission of dense smoke from engines, stacks, and chimneys within the city, but excluding from its provisions private residences, unless using steam boilers.

"*Department of Public Safety, City of Alleghany.*

"An Ordinance relating to and prohibiting the emission of dense smoke from engines, stacks, and chimneys within the city limits.

"Section 1.—Be it ordained and enacted by the Select and Common Councils of the city of Alleghany, and it is hereby ordained and enacted by the authority of the same:

"That six months after the approval of this Ordinance the emission or issuing of dense smoke from the stack of any locomotive, stationary or portable boiler, anywhere within said city is hereby prohibited and declared unlawful; chimneys of buildings used exclusively for private residences shall not be deemed and treated as within the provisions of this Ordinance unless using steam boilers in said private residences.

"Section 2.—The owner or owners of any locomotive and the proprietors or lessee or occupant of any building who shall permit or allow dense smoke to issue or be emitted from the stack or chimney of any stationary or portable boiler within the corporate limits of the city shall be deemed and held guilty of creating a nuisance, and shall for every such offence be fined a sum not less than 10 dollars or more than 100 dollars, to be recovered summarily before the Mayor or any Police Magistrate of Alleghany City. In default of payment of any such fine or fines so imposed, the person or persons so fined shall be

imprisoned in the county gaol for not less than forty-eight hours, nor more than ten days, at the discretion of the Mayor or Magistrate hearing the case.

"Section 3.—It shall be the duty of the Director of the Department of Public Safety of said city to cause the enforcement of this Ordinance in all cases of its violation.

"Section 4.—This Ordinance shall be held and construed as including, under the words 'owners,' 'lessee,' and 'person,' all Corporations or partnership associations, as well as natural persons.

"Section 5.—That so much of any Ordinance as may conflict with or be supplied by the foregoing be, and the same is hereby, repealed."

State of New York.

The emission of smoke from buildings is not specifically dealt with in any of the laws of New York State, but comes under the provision of the Public Health Law, as constituting a nuisance.

This law provides for a State Board of Health, whose duty it is to take cognisance of all matters affecting the health and life of the people of the State. It may compel the attendance of witnesses for this purpose.

The State Board may reverse or modify any order or regulation made by a Local Board of Health concerning a matter which, in its judgment, affects the public health beyond the territory over which such Local Board has jurisdiction.

It has power to deal with nuisances, or questions affecting the security of life and health in any locality. (See Article 1, Section 6.)

If any municipality fails to establish a Board of Health, the State Board may, in such municipality, exercise the powers of a Local Board of Health.

Minute provisions are made for the establishment of Local Boards of Health in the several cities, towns, and villages of the State.

These Local Boards of Health meet at stated intervals. Special meetings may be called by the presiding officer

when he deems necessary and must be called upon the requisition of at least twenty-five residents of full age. They will direct the duties of their Local Health Officer, who shall be the chief executive officer. The Local Boards make and publish all requisite orders and regulations for the preservation of life and health, and make, without publication, orders and regulations for the suppression of nuisances in special or individual cases, and not of general application. (See Article 1, Section 21.)

The Local Boards receive and examine all complaints made by an inhabitant concerning nuisances, and may enter, for the purpose of inspection and examination, any place or premises where nuisances are known or believed to exist. (See Article 1, Section 25.)

If the owner or occupant of the premises fails to comply with an order to remove the nuisance, the Local Boards may enter and suppress or remove it themselves, at the expense of the owner or occupant. (See Article 1, Section 26.)

This Public Health Law does not affect the laws nor the Sanitary Codes now in force relating to the Boards of Health of the cities of New York, Brooklyn, Buffalo, Albany, and Yonkers.

"*State of New York Public Health Law.*

"ARTICLE I.

"Section 6.—*Nuisances.*—The State Board of Health shall have all necessary powers to make examinations into nuisances, or questions affecting the security of life and health in any locality. Whenever required by the Governor of the State, it shall make such an examination and shall report the results thereof to the Governor, within the time prescribed by him therefor. The report of every such examination, when approved by the Governor, shall be filed in the office of the Secretary of State, and the Governor may declare the matters public nuisances which may be found and certified in any such report to be nuisances, and may order them to be changed, abated, or removed, as he may direct. Every such order shall be presumptive

evidence of the existence of such nuisance; and the Governor may, by a precept under his hand and official seal, require the District Attorney, Sheriff, and other officers of the county where such nuisance is maintained, to take all necessary measures to execute such order and cause it to be obeyed, and the acts of any such county officer in the abatement of any such nuisance, reasonable or necessary for such abatement, shall be lawful and justifiable, and the order of the Governor a sufficient protection to such officer. The expense of such abatement shall be paid by the municipality where the nuisance occurs, and shall be a debt recoverable by such municipality of all persons, maintaining it or assisting in its maintenance, and a lien and charge upon the lands upon which the nuisance is maintained, which may be enforced by a sale of such lands to satisfy the same.

"Section 21.—*General Powers and Duties of Local Boards of Health.*—Every such Local Board of Health shall meet at stated intervals, to be fixed by it, in the municipality. The presiding officer of every such Board may call special meetings thereof where, in his judgment, the protection of the public health of the municipality requires it, and he shall call such meeting upon the petition of at least twenty-five residents thereof, of full age, setting forth the necessity of such meeting. Every such Local Board shall prescribe the duties and powers of the Local Health Officer, who shall be its chief executive officer, and direct him in the performance of his duties and fix his compensation. Every such Local Board shall make and publish from time to time all such orders and regulations as they may deem necessary and proper for the preservation of life and health and the execution and enforcement of the Public Health Law in the municipality. It shall make, without publication thereof, such orders and regulations for the suppression of nuisances and concerning all other matters in its judgment detrimental to the public health in special or individual cases not of general application, and serve copies thereof upon the owner or occupant of any premises whereon such nuisances or other matters may exist, or post the same in some conspicuous place thereon.

"Every such Local Board may prescribe and impose penalties for the violation of, or failure to comply with, any of its orders or regulations, not exceeding 100 dollars for a single violation or failure, to be sued for and recovered by it in the name and for the benefit of the municipality; and to maintain actions in any Court of competent jurisdiction to restrain by injunction such violations, or otherwise to enforce such orders and regulations.

"Section 25.—*Nuisances.*—Every such Local Board shall receive and examine into all complaints made by any inhabitant

concerning nuisances or causes of danger or injury to life and health within the municipality, and may enter upon or within any place or premises where nuisances or conditions dangerous to life and health are known or believed to exist, and, by its members or other persons designated for that purpose, inspect and examine the same. The owners, agents, and occupants of any such premises shall permit such sanitary examinations to be made, and the Board shall furnish such owners, agents, and occupants with a written statement of the results and conclusions of any such examination. Every such Local Board shall order the suppression and removal of all nuisances and conditions detrimental to life and health found to exist within the municipality. Whenever the State Board of Health, or its President and Secretary, shall, by notice to the presiding officer of any Local Board of Health, request him to convene such Local Board to take certain definite proceedings, concerning which the State Board of Health or its President and Secretary shall be satisfied that the action by them is necessary for the public good, and is within the jurisdiction of such Board of Health, such presiding officer shall convene such Local Board, which shall take the action recommended.

"Section 26.—*Removal of Nuisances.*—If the owner or occupant of any premises fails to comply with any order or regulation of any such Local Board for the suppression and removal of any nuisance, or other matter in the judgment of the Board detrimental to the public health, made, served, or posted as required in this Article, such Boards, or their servants or employees, may enter upon the premises to which such order or regulation relates, and suppress or remove such nuisance or other matter. The expense of such suppression or removal shall be paid by the owner or occupant of such premises, or by the person who caused or maintained such nuisance or other matters, and the Board may maintain an action in the name of the municipality to recover such expense, and the same, when recovered, shall be paid to the Treasurer of the municipality, or, if it has no Treasurer, to its chief fiscal officer, to be held and used as the funds of the municipality."

For the purposes of local government, New York and Brooklyn have been amalgamated with the Borough of the Bronx, Queens, and Richmond, forming the "city of New York," all under one Department of Health, and with the same Sanitary Code.

Sanitary Code of the City of New York.

With regard to the emission of smoke as a nuisance, Section 96 of the Sanitary Code of the Board of Health of the Department of Health of the city of New York states as follows:—

"*Sanitary Code of the Board of Health of the Department of Health of the City of New York.*

"Section 96.—The owners, lessees, tenants, occupants, and managers of every blacksmith or other shop, forge, coal-yard, foundry, manufactory, and premises where any business is done, or in or upon which an engine or boilers or locomotives are used, shall cause all ashes, cinders, rubbish, dirt, and refuse to be removed to some proper place, so that the same shall not accumulate at any of the above-mentioned premises or in the appurtenances thereof, nor the same become filthy or offensive. Nor shall any owner, lessee, tenant, occupant, manager, engineer, fireman, or any other person cause, suffer, or allow any cinders, dust, gas, steam, or offensive odour to escape or be discharged from any such building, place, or premises, to the detriment or annoyance of any person not being therein or thereupon engaged.

"Nor shall any owner, lessee, tenant, occupant, superintendent, manager, engineer, fireman, or any other person, cause, suffer, or allow smoke to escape or be discharged from any such building, place, or premises, or from any engine or locomotive used therein or thereon."

Section 1229 of Chapter XIX. of the Charter of New York City (Chapter 466 of the Laws of State of New York of 1901) defines the word "nuisance," and amongst its provisions declares whatever renders the air or human food and drink unwholesome to be a nuisance. Its wording follows:—

"Section 1229.—The word 'nuisance,' as used in this Act, shall be held to embrace public nuisance, as known at common law or in equity jurisprudence; and it is further enacted that whatever is dangerous to human life or detrimental to health, whatever building or erection, or part or cellar thereof, is overcrowded with occupants, or is not provided with adequate

ingress and egress to and from the same, or the apartments thereof, or is not sufficiently supported, ventilated, sewered, drained, cleaned, or lighted in reference to their or its intended or actual use, and whatever renders the air or human food or drink unwholesome, are also severally, in contemplation of this Act, nuisances; and all such nuisances are hereby declared illegal; and each and all persons and Corporations who created or contributed thereto, or who may support, continue, or maintain or retain them, or any of them, shall be jointly and severally liable for, or toward, the expense of the abatement and remedying of the same; but as between themselves, any such persons and Corporations may enforce contribution or collect expenses, according to any legal or equitable relations existing between them; but nothing herein contained shall annul or defeat any common law liability or responsibility in respect of nuisances. Whenever the words 'place, matter, or thing,' or either two of said words, are used in this Act, or in titles 1, 4, and 5 of this Chapter, they shall, unless the sense plainly requires a different construction, be construed to include whatever is embraced in the enumeration with which they are connected."

Ordinance of the City of Buffalo.

Chapter XLII. of the Ordinance of the city of Buffalo is more stringent in its regulations than the above sections, making it unlawful for any person or persons, firm, or corporation, or for any of their servants, agents, or employees, to allow the discharge or escape into the open air of large quantities of smoke, soot, &c., in such quantities or in such manner as to cause injury, detriment, or annoyance. It is as follows :—

"The city of Buffalo, by its Common Council, hereby ordains and enacts the following Ordinance, the same to be known as Chapter XLII. of the Ordinance of said city:—

"CHAPTER XLII.

"Section 1.—It shall not be lawful within the limits of the city of Buffalo for any person or persons, firm, or corporation, or any servant, agent, or employee of any person, firm, or corporation, to permit or allow, or cause to be permitted or

allowed, the discharge or escape into the open air of large quantities of smoke, soot, dust, gas, steam, or offensive odour, or to permit or allow any smoke, soot, dust, gas, steam, or offensive odour to escape in such manner or in such quantities as to cause or have a natural tendency to cause injury, detriment, or annoyance to any person or persons or the public, or to endanger the comfort, repose, health, or safety of any person or persons or the public, or in such manner as to cause or have a natural tendency to cause injury or damage to business or property.

"Section 2.—Nor shall any person or persons, firm, or corporation owning or operating any boat, locomotive engine, or other engine, or any machinery used or employed in said city, nor shall any servant, agent, or employee of any such person, firm, or corporation, permit or allow, or cause to be permitted or allowed, the discharge or escape into the open air of large quantities of smoke, cinders, soot, dust, gas, steam, or offensive odour, or to permit or allow any smoke, cinders, soot, dust, gas, steam, or offensive odour to escape in such a manner or in such quantities as to cause or to have a natural tendency to cause injury, detriment, or annoyance to any person or persons, or to endanger the comfort, repose, health, or safety of any person or the public, or in such a manner as to cause injury or damage to business or property.

"Section 3.—No person or persons, firm, or corporation shall in the said city permit or allow, or cause to be permitted or allowed, the escape into the open air of quantities of fine sand, dirt, or particles of earth or other material, in such manner as to cause or to have a natural tendency to cause injury, detriment, or annoyance to any person or persons or to the public, or to endanger the comfort, repose, health, or safety of any person or persons or the public, or in such a manner as to cause or to have a natural tendency to cause injury or damage to business or property.

"Section 4.—It shall be the duty of the Department of Public Works to investigate all complaints made to it of a violation of any of the provisions of this Ordinance, and report the same to the Corporation Counsel; it shall be the duty of each inspector connected with the Bureau of Streets of said city, and of all police officers of said city, to immediately report to said Department all persons, firms, or corporations guilty of a violation of this Ordinance, together with the names and addresses of all witnesses having knowledge concerning or being in the possession of facts showing such violation; each and every such inspector or police officer shall have the right and authority at all reasonable hours to visit and inspect premises

and all machinery, boilers, furnaces (or other appliances connected therewith, necessary to such inspection) for the purpose of ascertaining the kind or character of fuel used and the manner of using the same, and any other fact or facts showing compliance with or violation of this Ordinance.

"Section 5.—A violation of this Ordinance shall be punishable by a fine of not to exceed 250 dollars for each and every offence."

Sanitary Code of the City of Albany.

The provisions of Section 8 of the Sanitary Code of the city of Albany are similar to those of the city of New York :—

"Section 8.—No person or Company shall erect or maintain any manufactory or place of business dangerous to life or detrimental to health, or where unwholesome, offensive, or deleterious odours, gas, smoke, deposits, or exhalations are generated, without the permit of the Department of Health, and all such establishments shall be kept clean and wholesome so as not to be offensive or prejudical to public health; nor shall any offensive or deleterious waste substance, gas, odour, sludge, refuse, or injurious matter be allowed to accumulate upon the premises, or be therein or allowed to run into any public waters, streams, water-course, street, or public place. And every person or Company conducting such a manufactory or business shall use the best approved and all reasonable means to prevent the escape of smoke, gas, odours, and to protect the life and safety of all operatives employed therein.

"Any violation of any of the provisions of this Ordinance shall be punishable by a penalty of 25 dollars."

Sanitary Code of the City of Yonkers.

Section 81 of the Sanitary Code of the city of Yonkers is similar to the above. It is as follows :—

"*Sanitary Code of the Board of Health of the City of Yonkers.*

"Section 81.—*Ashes, Cinders, &c., to be removed.*—Every owner, lessee, tenant, or manager of every blacksmith or other shop, forge, coal-yard, foundry, manufactory, or premises where

any business is done, or in or upon which an engine or boilers are used, shall cause all ashes, cinders, rubbish, dirt, and refuse to be removed to some proper place so that the same shall not accumulate on any of the above-mentioned premises, or in the appurtenances thereof, nor the same become filthy and offensive. Nor shall any smoke, cinders, dust, gas, or offensive odour be allowed to escape from such building, place, or premises to the detriment or annoyance of any person not being therein or thereupon engaged. Any violation of the provisions of this section shall subject the offending party or person to a fine of 100 dollars for the first offence, and a further fine of 50 dollars per day after service of a notice on the offending party, person, or persons to abate the said nuisance."

State of Illinois.

There are no State laws containing regulations relative to the emission of smoke in Illinois.

Ordinance of the City of Chicago.

Extracts are given below of the Ordinance governing the Department for the Inspection of Steam Boilers and Steam Plants in the city of Chicago :—

"Section 7.—*Chief Smoke Inspector.*—There shall be a Chief Smoke Inspector, who shall be appointed by the Chief Inspector of Steam Boilers and Steam Plants, from the eligible list prepared in accordance with the Civil Service Act and the Rules of the Civil Service Commission.

"Said Chief Smoke Inspector, before entering upon the duties of his office, shall execute a bond to the city of Chicago in the sum of 5000 dollars, with two or more sureties to be provided by the Comptroller, conditioned for the faithful performance of the duties of his office.

"Section 8.—*Board of Inspectors of Steam Boilers and Steam Plants.*—The said Chief Inspector of Steam Boilers and Steam Plants, Supervising Mechanical Engineer and Chief of the Deputy Inspectors of Steam Boilers and Steam Plants, and Chief Smoke Inspector shall constitute the Board of Inspectors of Steam Boilers and Plants. . . .

"Section 10.—The emission of dense smoke from the smoke-stack of any boat or locomotive, or from any chimney anywhere

within the city, shall be deemed, and is hereby declared to be, a public nuisance; but no prosecution for the emission of dense smoke shall be commenced unless within ten days prior thereto at least three notices shall have been mailed to the offender that dense smoke has been seen emitted from his premises.

"The owner or owners, lessee, agent, or manager of any boat or locomotive, and the proprietor, lessee, or agent of any building, factory, mill, works, or other establishment having smoke-stack or chimneys within the corporate limits to exceed three minutes (excepting in cases where the fire-box is being cleaned out or new fire built therein, in which case the limit shall be six minutes) in any hour of the day or night, shall be deemed and held guilty of creating a nuisance, and shall for every such offence be fined a sum of not less than 10 dollars nor more than 100 dollars. It shall be the duty of the Board to see that the boiler or boilers, boiler-setting, means of producing draught, smoke connections, and furnace or fire-box of each boiler inspected by it are of sufficient capacity and so constructed as with proper management to avoid the emission of dense smoke.

"Prosecutions for all violations of this Ordinance by persons allowing dense smoke to issue from any chimney shall be brought by the Chief Smoke Inspector, and the prosecutions for all other violations shall be brought by the Chief Inspector of Steam Boilers and Steam Plants, Supervising Mechanical Engineer, and Chief Deputy Inspector of Steam Boilers and Steam Plants, in the name of the city of Chicago.

"Provided that no prosecution under this Ordinance shall be commenced against the owner, or owners, lessee, agent, or manager of any boat, locomotive, or the proprietor, lessee, or agent of any building, factory, mill, works, or other establishment having smoke-stacks or chimneys, the plant of which shall have been installed prior to the passage of this Ordinance, until the expiration of one year after the passage of this Ordinance, within which to build and re-equip the same in accordance with the provisions of this Ordinance: Provided further, that no such owner, owners, lessee, agent, or manager shall be entitled to one year unless he shall at once commence his plans for the rebuilding and re-equipping of such plant, and shall proceed with said work to the satisfaction of the Board upon inspection at intervals of three months during said period of one year.

"Section 12.—. . . If at any time when inspecting a steam boiler, generator, or other apparatus used for generating steam for power or heating purposes, the Inspector of Boilers shall find that the furnace or fire-box in which fuel is used for the purpose of generating steam is so constructed or operated as to cause the

emission of dense smoke from the chimney connected therewith, he shall report to said Board the condition of said plant. The owner of said steam boiler, generator, or apparatus shall have the right to put in such appliance or put in such alterations or use such fuel as in his judgment will prevent the emission of dense smoke, but this shall not constitute a compliance with this Ordinance unless such appliance or such fuel shall actually prevent the emission of dense smoke.

"Provided, however, that this Ordinance shall not apply to tanks, jacket-kettles, or reservoirs of under 75 gallons capacity, hot-water tanks used for domestic purposes, boilers on locomotives or boilers, generators, or other apparatus used in private residence for generating steam solely for heating purposes; and for the purpose of this Ordinance flat buildings or apartment buildings with more than three apartments shall not be classed as private residences, and any steam boiler, generator, or other apparatus carrying other than city pressure in flat buildings or apartment buildings having more than three flats or apartments shall be subject to inspection as hereinbefore provided.

"Provided also that any boilers for heating purposes only, in which the permit specifies that not more than 10 lb. of steam pressure to the square inch shall be carried, shall be known as 'low-pressure boilers.'

"After the next inspection of such boilers shall have been made, following the adoption of this Ordinance, inspection shall be made thereafter once in every three years. But all of such low-pressure plants may be inspected at any time thereafter, and without charge, with reference to the provisions for draught, complete combustion of fuel, and prevention of the dense emission of smoke.

"Section 13.—*Certificate; Record.*—When an inspection of a boiler or boilers, tank or tanks, jacket-kettle, generator or generators, superheater or superheaters, or any apparatus under pressure has been made, and the same shall be approved by the Chief Inspector or Supervising Mechanical Engineer and Chief Deputy Inspector of Steam Boilers and Steam Plants, he shall make and deliver to the person for whom the inspection was made, upon the payment of the fees hereinafter mentioned, a certificate of such inspection, which shall contain the date of inspection, together with a general description, for what purpose used, the number of try-cocks, steam and water gauges, the pounds pressure at which they may be safely used; which certificate shall be framed and put up in a conspicuous place in the engine or boiler room, and a record of the same shall be made and kept by said Board in a well-bound book or books, indexed alphabetically or by locality. But such certificate shall

not be a waiver of liability in the case of any prosecution for the making of dense smoke.

"Section 24.—*Salaries.*—The salary of the Chief Inspector of Steam Boilers and Steam Plants shall be 3600 dollars per annum; that of the Supervising Mechanical Engineer and Chief Deputy Inspector of Steam Boilers and Steam Plants, 3600 dollars per annum; and that of Smoke Inspector of Steam Boilers and Steam Plants, 2000 dollars per annum. There shall be appointed, in addition to the above-named officials, a Chief Clerk and such other assistants, inspectors, and employees as the City Council may by Ordinance prescribe and establish. It will be the duty of the Assistant Inspectors to report defects in furnaces and smoke-stacks, as well as in boilers, and it shall be the special duty of the Deputy Smoke Inspectors to report dense smoke emitted from chimneys, together with the probable cause therefor, determined by them on investigation of the plants connected with such chimneys."

The Smoke Ordinance of the city of Chicago came into effect on the 1st May 1903, but has been amended several times since, and other amendments are expected.

In dwelling-houses in Chicago very few ordinary fireplaces are used, the houses being generally heated by furnaces. In most of these furnaces anthracite coal is used entirely, but in stoves used in smaller apartments inhabited by the poorer people the very cheapest soft coal is used.

The fault found with the present Ordinance is the difficulty of securing conviction against railroad engines and steam vessels, as they have to be found committing the nuisance on three different occasions within ten days.

The use of under-fed automatic stokers has been found to be the most effective manner of preventing smoke, and in old-fashioned furnaces the Inspectors have proved to the owners that if the stokers are careful only to put about two shovelfuls of coal on at a time, there is practically no smoke.

The first Ordinance issued in Chicago gave no length of time for the emission of smoke to become an offence, the whole matter being left to the discretion of the Inspector. Now, notices of violation of the Ordinance

are never sent out unless dense smoke has been seen issuing for more than five minutes.

Copies of the Chief Smoke Inspector's Notice to violators of the city of Chicago Ordinance are annexed.

CHIEF SMOKE INSPECTOR'S NOTICE.

No._____ CHICAGO,_____ 190—

To_____ as proprietor, lessee, agent, or manager.

_____

DEAR SIR,

You are hereby notified that the following_____ owned and operated by_____ been reported by Inspectors of this Department as violating the city Ordinance regulating steam plants as to the emission of dense smoke. Unless the violations are promptly discontinued and steps taken to correct existing defects either of construction or operation, prosecution will follow. The following violations were observed:—

No._____

_____

No._____

_____

No._____

_____

Provisions of Section 10, *City Ordinance, regulating Steam and Power Plants.*

"Section 10.—The emission of dense smoke from the smoke-stack of any boat or locomotive, or from any chimney anywhere within the city, shall be deemed, and is hereby declared to be, a public nuisance; but no prosecution for the emission of dense smoke shall be commenced, unless within ten days prior thereto at least three notices shall have been mailed to the offender that dense smoke has been seen emitted from his premises.

"The owner or owners, lessee, agent, or manager of any boat, or locomotive, and the proprietor, lessee, or agent of any building, factory, mill, works, or other establishment having smoke-stacks or chimneys, who shall permit or allow dense smoke to issue or be emitted from the smoke-stack of any such boat or

locomotive, or the chimney of any building, factory, mill, works, or other establishment having smoke-stacks or chimneys within the corporate limits to exceed three minutes (excepting in cases where the fire-box is being cleaned out or a new fire built therein, in which cases the limit shall be six minutes), in any hour of the day or night, shall be deemed and held guilty of creating a nuisance, and shall for every such offence be fined a sum of not less than ten dollars ($10.00) nor more than one hundred dollars ($100.00).

"Prosecutions for all violations of this Ordinance by persons allowing dense smoke to issue from any chimney shall be brought by the Chief Smoke Inspector, in the name of the city of Chicago."

Yours truly,

Chief Smoke Inspector.

State of Massachusetts.

An Act of the Commonwealth of 1901, Chapter 427, provides for the abatement of the smoke nuisance. Its provisions are annexed, also those of Chapter 102 of the Revised Laws of Massachusetts of 1902, which were passed during the coal strike in Pennsylvania, when a large quantity of English coal was imported into Massachusetts for general use, thereby increasing the smoke nuisance. It is stated, however, that these laws are now practically a dead letter, which may be attributed to the fact that smokeless anthracite coal is almost entirely used except for the production of gas.

Smoke Nuisance.

Act of 1901.

Chapter 427.—*An Act to provide for the Abatement of the Smoke Nuisance.*

"Be it enacted, &c., as follows:—

"Section 1.—The emission into the open air of dark smoke or dense grey smoke for more than five minutes continuously, or the emission of such smoke during 12 per cent. of any continuous

period of twelve hours, within a quarter of a mile of any dwelling, except under a permit granted as herein provided, is hereby declared a nuisance.

"Section 2.—Whoever commits such nuisance, or suffers the same to be committed, on any premises owned or occupied by him, or in any way participates in the same, shall be punished by a fine of not more than 100 dollars for each week during any part of which such nuisance exists.

"Section 3.—The Mayor of any city or the Selectmen of any town may, in January of each year, designate some proper person or persons who shall be charged with the enforcement of this law during the year in which they are appointed; but such designation shall be subject to change at any time.

"Section 4.—Any officer so designated may apply to the Supreme Judicial Court, or to the Superior Court, or to any Justice thereof, for an injunction to restrain the further operation of any furnace, steam boiler, or boilers which are being operated in such a manner as to create a nuisance as herein defined, and the said Court or Justice may, after hearing the parties, enjoin the further operation of any such furnace, boiler, or boilers.

"Section 5.—Permits for the production and emission of smoke in the manner described in Section 1 may be granted annually by the Mayor and Aldermen of cities or the Selectmen of towns to persons duly applying for the same. Every such permit shall be signed by the Mayor or by a majority of the Board of Selectmen and by the City or Town Clerk, and shall be recorded in the office of said Clerk. Such permit shall name the person, firm, or corporation to whom it is granted, and shall definitely and clearly describe the location and limits of the premises to which it applies, and shall remain in force until the 1st day of May next ensuing, unless sooner forfeited or rendered void.

"Section 6.—Notice of all applications for such permits shall be published at the expense of the applicant in the manner prescribed by Section 6 of Chapter 100 of the Public Statutes relative to applications for liquor licences.

"Section 7.—If before the expiration of the ten days following the publication of the notice, as required by the preceding section, the owner of any dwelling within a quarter of a mile of the premises described therein gives written notice to the Board having authority to grant the permit that he objects to the granting of the permit, no permit shall be granted, unless said Board, after a public hearing of the persons interested, shall decide that no just ground for objection exists, or that the public good requires the granting of such permit; but the

granting of a permit shall not prejudice any right of damages which any person may have under the laws of the Commonwealth against the person or persons receiving the permit. In case a permit is granted after objection is filed, and without a hearing as aforesaid, or without proper advertisement as herein provided, the owner of any such dwelling may apply to the Police, District, or Municipal Court, or to any trial Justice within whose jurisdiction the premises are situated, for a hearing in the case; and said Court or trial Justice, if it appears that said permit was granted without compliance with provisions of this Act, shall revoke the permit, and notice of such revocation shall be sent to the Board granting the permit and to the person receiving the permit.

"Section 8.—The Board granting the permit may establish fees for the issue of permits under this Act, not exceeding 1 dollar each, to be paid to the Treasurer of the municipality.

"Section 9.—This Act shall not apply to the emission of smoke by locomotive engines or by brick kilns.

"Section 10.—This Act shall take effect in any city when accepted by a majority vote of the City Council of the city, and in any town when accepted by a majority of the voters of the town meeting thereon at an annual town meeting."

Smoke Nuisance.

Chapter 102.—*Revised Laws of Massachusetts*, 1902.

"Section 122.—The emission, except by locomotive engines or by brick kilns, into the open air of dark smoke or dense grey smoke for more than five minutes continuously, or the emission, except as aforesaid, of such smoke during ninety minutes of any continuous period of twelve hours within a quarter of a mile of a dwelling, is hereby declared a nuisance, unless such emission is under a permit, which may be granted annually by the Mayor and Aldermen of cities or the Selectmen of towns.

"Section 123.—Such permit shall be signed by the Mayor or by a majority of the Board of Selectmen and by the City or Town Clerk, and be recorded in the office of said Clerk. It shall name the person, firm, or corporation to whom or to which it is granted, and definitely and clearly describe the location and limits of the premises to which it applies, and shall remain in force until the 1st day of May next after its date, unless sooner forfeited or rendered void. Notice of applications for such permit shall be published at the expense of the applicant in the manner prescribed by Section 14 of Chapter 100, relative to applications for liquor licences. The Board granting the

permit may establish fees for its issue, not exceeding 1 dollar each, to be paid to the Treasurer of the municipality.

"Section 124.—If before the expiration of the ten days following the publication of the notice the owner of a dwelling within a quarter of a mile of the premises described therein gives written notice to the Board having authority to grant the permit that he objects to the granting thereof, it shall not be granted, unless said Board, after a public hearing of the persons interested, decides that no just ground for objection exists, or that the public good requires that it be granted; but the granting of a permit shall not prejudice any right of damages which a person may have under the laws of the Commonwealth against the person receiving the permit. In case a permit is granted after objection is filed, and without a hearing as aforesaid, or without proper advertisement as herein provided, the owner of such dwelling may apply to the Police, District, or Municipal Court, or to a trial Justice within whose jurisdiction the premises are situated, for a hearing in the case; and said Court or trial Justice, if it appears that said permit was granted without compliance with the provisions of this and the preceding section, shall revoke the permit, and notice of such revocation shall be sent to the Board granting and to the person receiving the permit.

"Section 125.—The Mayor of a city or the Selectmen of a town may, in January of each year, designate some proper person or persons, who shall be charged with the enforcement of this section, the three preceding sections, and the following section during the year in which they are appointed; but such designation shall be subject to change at any time. An officer so designated may apply to the Supreme Judicial Court, or to the Superior Court, for an injunction to restrain the further operation of any furnace, steam boiler, or boilers which are being operated in such a manner as to create a nuisance as above defined; and said Court may, after hearing the parties, enjoin the further operation of such furnace, boiler, or boilers.

"Section 126.—Whoever commits such nuisance as is defined in Section 122, or suffers the same to be committed on any premises owned or occupied by him, or in any way participates in committing the same, shall be punished by a fine of not more than 100 dollars for each week during any part of which such nuisance exists.

"Section 127.—The provisions of the five preceding sections shall not be operative in a city unless they shall be, or the corresponding provisions of earlier laws have been, accepted by a majority vote of the City Council of the city, nor operative in a town unless they shall be accepted by a majority of the voters of the town voting thereon at an annual town meeting."

WÜRTEMBERG.

There are no special laws in Würtemberg for the regulation, restriction, or prevention of the emission of smoke. General regulations are, however, contained in paragraph 52, II., of the Law respecting edifices ("Bauordnung") of the 6th October 1872, which provides that—

"Flues ('Feuerungs-Einrichtungen') and connecting structures must be fire-proof, and provided with special fire-proof walls ('Feuerwaenden') and with a suitable chimney or funnel, by means of which the inhabitants of the neighbourhood may be secured from annoyance from smoke and soot."

Paragraph 48 of the Official Regulations of the 23rd November 1882 (concerning the construction of flues) provides that—

"If the inhabitants of the neighbourhood suffer annoyance from smoke on account of the insufficient height of the chimney-stack, the authorities may prescribe an addition being made thereto on production of proof of such annoyance from smoke.

"Business premises may be required to use smoke-consuming appliances should circumstances justify such a request being made."

As to steam boilers, paragraph 20 of the Official Regulations of the 4th April 1857 provides that—

"Steam boilers must be so constructed that, in heating, the smoke shall be as far as possible consumed."

The authorities granting licences to construct steam boilers are to be guided by paragraphs 18 and 24 of the Imperial Law of Industries ("Reichsgewerbeordnung") as to the issue of Regulations for smoke-consuming appliances.

The following clause is usually inserted in a licence to construct steam boilers:—

"The owner of a steam boiler is required to see that

the fuel is as far as possible entirely consumed, and to endeavour to prevent smoke and soot by using fuel of proper quality and in proper measure, by suitable flues and by careful stoking, and he must further undertake to have such structural and other alterations made as may be from time to time required to attain the object in view."

CHAPTER V

SMOKE ABATEMENT

Smoke Abatement in London—Coal Smoke Abatement Society—Smoke Abatement in Sheffield—Procedure under the Acts—Smoke Abatement in other Towns—Difficulties Involved—Smoke Abatement Associations.

Smoke Abatement in London.—It was the poet Shelley who described the capital of the Nether World as—

> "A city much like London—
> A populous and a smoky city,"

and Prof. C. Roberts recently estimated that the canopy daily overshadowing London contained fifty tons of solid carbon, and two hundred and fifty tons of carbonic oxide gas, acids, and hydrocarbons. The city authorities, however, resolutely refused to move in the matter, turning a deaf ear to all appeals. The nuisance was increasing at an alarming rate, and the polluted, poisoned atmosphere was beyond description.

To remedy this state of affairs the "Coal Smoke Abatement Society" was formed in 1898 to further the aims of those who desired a "Cleaner London."

The sphere of action of this society was mainly limited to the Metropolitan area, and its objects were:—

(*a*) To aid in enforcing, through the Local Sanitary Authorities, the existing law dealing with smoke nuisance which is contained in the Public Health (London) Act, 1891, and the Public Health Act, 1875. For this purpose it employs Inspectors to make observations of smoke nuisances which it reports to the proper authorities.

The number of such reports to the end of the year 1903 was 5894.

(*b*) To promote and encourage all voluntary efforts to abolish smoke from the flues of dwelling-houses, and to inquire into the best means of effecting this object.

(*c*) To obtain evidence of the methods of dealing with smoke nuisances at home and abroad.

(*d*) To publish information on questions relating to smoke nuisances, and the methods by which it may be abated, and for that purpose to encourage the organisation of exhibitions, and stimulate invention by the offer of prizes.

(*e*) To bring about the amendment of the present law where it is not efficient.

The address of the President, Sir W. B. Richmond, in 1901, ably outlines the aims and objects of the society.

In the Report issued by the society for the year 1903, it was stated that 2000 observations of smoke pollution had been reported, which led to the detection of 1460 cases of nuisance, and upon these observations 1278 complaints were forwarded to the various Local Authorities within the Metropolitan area. Following these complaints 40 summonses were issued under the Acts, involving the offending firms in penalties and costs to the amount of £104, 15s. In five cases prohibition or abatement orders were obtained, and in most of the others convictions were only escaped by the defendants obtaining adjournments, on an undertaking to abate the nuisance forthwith by installing effective smoke-preventing appliances. In many other cases no summons was issued in consequence of the offenders abating the nuisance on receipt of the preliminary statutory notice.

As an example of the kind of work which still lay before the society, it was mentioned that no less than 572 complaints had been addressed to West Ham Corporation without its having instituted a prosecution in a single

case, and in two of the cases the nuisance was so scandalous that the adjoining borough of Poplar, being specially affected by them, issued summonses on the report of its own officers, and secured the conviction of both offenders. Fortunately, the law provides machinery for dealing with these derelictions of public duty, which it was hoped would prove to be within the power of the society to set in motion.

With regard to the law as it stands, a valuable decision was obtained in the case of the St. James's Club. This club having been repeatedly reported, a summons was issued against it by order of the City of Westminster. The defendants pleaded they were a private dwelling-house within the meaning of the Act, and therefore not liable under the section. On this defence the magistrate decided in the defendants' favour, but consented to state a case for appeal. The appeal was duly lodged and heard in the High Court, with the result that the magistrate was overruled, and the club held to be liable. Seeing how frequently clubs are offenders in the matter, this decision was of considerable importance.

In relation to the subject of fogs, the following extract from the Report is of great interest. It had been the attitude of the society all along that although fogs cannot be prevented, it is possible to prevent their being black. It would now seem that that attitude has been too modest. According to Captain Carpenter's *Report to the Meteorological Council on the London Fog Inquiry,* not only are the worst London fogs made what they are by smoke, but many of lesser intensity consist of smoke and almost nothing else. In his summary of observation, he says: "It was soon found that light fogs largely attributable to smoke were permanent, or at least of daily occurrence in some parts of London in the winter. From the summit of St. Paul's Cathedral, or of Westminster Tower, for instance, the average limit of visibility between December 20th and March 17th, in twenty-five ascents, made as a rule

between 2 P.M. and 3 P.M., was only half a mile, and the maximum limit of vision 1½ miles. It was not till March 3rd that one of these elevated points was dimly visible from the other. The obscurity was most certainly due chiefly to smoke, for out of the twenty-five days on which ascents were made only nine can be legitimately classed as days of fog." With regard to certain observations at Kew, he says: "It stands somewhat low in the list of frequency, partly owing to its comparative freedom from general smoky surroundings" (the society's successful action in securing this comparative freedom will be remembered), "and partly also to no observation being taken at night. Notwithstanding its comparative immunity from smoke, the damage done to the shrubs during a smoky fog is enormous."

Dealing with the atmospheric conditions conducive to fog, he explains that there is a certain meteorological state which "collects the smoke and causes that peculiar darkness called 'high fog,' which sometimes ends in rain, but more often causes a dark smoky fog to settle here and there over our city." The causes of fog he classifies as three, and explains that "any of these fogs may become permeated by smoke, and the fog particles becoming coated with oily hydrocarbons, are then impervious to the evaporating power of the sun's heat, and may drift long distances, but they slowly settle on ground, houses, and clothes, and are inhaled by all living creatures and plants. . . . On December 20th, when a fog had just cleared off before a rising wind, it was noticed from the top of Westminster Tower that the smoke lay flat over the houses like a dirty counterpane."

Finally, he concludes that smoke is the cause of all dense fogs, and sums up as follows:—

"From the experience gained on the study of the fogs during the past winter, I am convinced that but for the mixture of smoke particles, no fogs in London would attain the density T. (thick), and probably only two or

three in the winter would reach a density (M.) moderate. Fog certainly hinders river traffic, but it hinders railway traffic less and street traffic hardly at all. But a thick fog, black or yellow, with unburnt products of combustion, means an arrest of all traffic, danger to health and life, and a destructive agent to all property, whether buildings, goods, or vegetation. Our river from Deptford to a few miles below Gravesend teems with the greatest shipping trade of London, and it is this very portion which is practically under a continuous fog brought about by hundreds of great chimneys belching forth smoke. It is not, perhaps, for me to argue here why the great factories are allowed to vitiate the atmosphere to this degree when smokeless coal and smoke-consuming furnaces are readily available; but one silently wonders that the pockets of the factory owners should be considered to the detriment of a shipping interest which is world-wide."

In face of this able official report it can no longer be pretended that the typical London fog is not preventable.

Smoke Abatement in Sheffield.—There are upwards of 2000 factory chimneys in Sheffield; 1300 serve various kinds of metallurgical and other furnaces, the remaining 700 serve steam boilers only, or boilers and furnaces, so that at the very least there will be 3000 furnaces and boilers making smoke, very many of them day and night; for many of the chimneys serve six and more boilers and furnaces each. It is impossible to imagine the state of the atmosphere some years ago, for the chimneys were allowed to belch forth dense volumes of black smoke for as long as they liked. Sir W. C. Leng, the editor of the *Sheffield Daily Telegraph*, who had successfully championed many a cause, turned his attention to the smoke question, and suggested practical steps to be taken to abate it. Sir J. E. Bingham joined him in the crusade. The result was the formation of the Sheffield Smoke Abatement Association. An Inspector was ap-

pointed who made many observations; the worst offenders were prosecuted, penalties were imposed, and Magistrates' Orders made to abate the nuisances. This action on the part of the Association caused quite a consternation in the city, not only amongst the smoke makers, but amongst the members of the Local Authority. But it continued its work, which was greatly appreciated by the public; in fact, public opinion was so aroused on the question that it awakened the Local Authority to a sense of their duty which resulted in the appointment of a second Smoke Inspector in 1890, making two for the whole city, and in 1894 a third was appointed. The Inspectors appointed were practical engineers who had had long experience amongst various kinds of boilers and furnaces.

Procedure.—In 1890 the new Inspector very quickly found it to be general for the chimneys to emit black smoke for from twelve minutes to as much as thirty minutes in the hour, and abatement notices were served for emissions lasting over fifteen minutes, which was then considered a little too much in the hour.

A number of observations were made on the worst offenders. The works were visited to ascertain what the chimneys served, whether boilers or furnaces, or both, the construction, the kind of appliances attached, and the system of working; suggestions were made for improvement, and very exhaustive and practical tests were conducted, by which the amount of smoke necessary for the actual and economical working of the said furnaces under various conditions was proved conclusively. These visits to the works very quickly resulted in the diminution of the emission of black smoke, for after the tests the firemen were told very plainly what the consequences would be if they made unnecessary black smoke, and, believing the Local Authority to be in earnest, they worked the furnaces with more care.

The recorded average of minutes of black smoke per hour per chimney previous to 1890 was ten minutes, but

very few observations were made compared with the observations made after 1890. The total number of observations made in 1890 was 6013. The total number of minutes during which black smoke was emitted was 42,091, and the average duration of black smoke was seven minutes in the hour. The Local Authority proceeded under the Public Health Act, 1875, but on the information obtained by the tests it was deemed advisable to pass a resolution of the Council fixing the working limits; anything beyond these was considered a nuisance against which legal proceedings would be taken to procure an abatement.

Limits.—A single boiler is allowed two minutes of black smoke in the hour; two boilers, three minutes in the hour; three boilers, four minutes in the hour; and four boilers and over, six minutes in the hour. Also if a chimney serves one boiler, and one or more metallurgical furnaces, six minutes of black smoke are allowed in the hour. If a chimney exceeds the limit allowed, the works are visited, and all the particulars relating to the cause are obtained, and the chimney is reported to the Health Committee, who order a statutory notice of abatement to be served. This notice is as follows:—

CITY OF SHEFFIELD.

Public Health Act, 38 & 39 Vict., Chap. 55.

Health Department, Town Hall, Sheffield.

To _____ Sheffield, in the said city, the occupiers of the premises hereunder described.

TAKE NOTICE: That under the provisions of the Public Health Act, 1875, the Lord Mayor, Aldermen, and citizens of the city of Sheffield, acting by the Council as the Sanitary Authority of the said city, being satisfied of the existence of a nuisance at —— arising from a certain chimney (not being the chimney of a private dwelling-house) sending forth black smoke in such

quantity as to be a nuisance, do hereby require you within —— from the service of this Notice to abate the same, and for that purpose to —— (the end of the sentence always being) "*and take such other measures as are necessary to abate the said nuisance.*" If you make default by not complying with the requisitions of this Notice, or if the said nuisance, though abated, is likely to recur, a summons will be issued requiring your attendance to answer a complaint which will be made to a Court of Summary Jurisdiction for enforcing the abatement of the nuisance, and prohibiting a recurrence thereof, and for recovering the costs and penalties that may be incurred thereby.

Dated this —— 190—.

Inspector of Nuisances for the City of Sheffield.

Inspector's office hours, 9 to 10, and 5 to 6.

Life of Notice.—Six months is the life of the Statutory Smoke Abatement Notice, and during that period proceedings may be taken against the users of a chimney on whom a notice has been served if the nuisance is not abated.

It is a very frequent occurrence for a nuisance to be abated forthwith after the serving of a notice, to continue to be abated for the whole of the six months, and then to be renewed, often in a more intense form than before the notice was served. The explanation is, the fireman knows the notice expires after six months, and that before proceedings can be taken another notice must be served, so he can be careless in stoking and yet run no risk of trouble. It would prove a great advantage all round if the life of the notice was extended to twelve months or even two years.

When the time specified in the notice for doing the necessary work has expired, further observations are made, and if the nuisance is not abated, about three observations are taken, the last one by two Inspectors, for cor-

roboration in court. After the observation, the two Inspectors visit the works to obtain all particulars of what has or has not been done since the notice was served.

The case is reported to the Health Committee with all the relative facts for and against, and an instruction by resolution is given to the Town Clerk to take proceedings.

A statement is prepared for the Town Clerk, containing all the facts in connection with the said nuisance, and invariably a chart showing in columns the amount of smoke made on different days during three or more years prior to the service of the notice in question. This chart shows at a glance, by the majority of observations being below the limit line, that there is no necessity to exceed the limit allowed. An Assistant Solicitor in the Town Clerk's Department opens the case very briefly. The Inspector is called to swear to the observations made, and also to testify that the nuisance is not necessary. The defending solicitor frequently calls into question the colour of the smoke. When the Inspector swears it was black, the solicitor asks, "What is black smoke?" To this the Inspector usually answers, "Smoke the colour of coal, and opaque two feet from the top of the chimney." Even this answer often leaves doubts in the minds of the magistrates as to whether it was dense brown or some other colour which is outside the Act. As already explained, the word *black* ought to be deleted, whereupon prosecutions would result in more satisfactory results.

There being, in most cases, practically no defence, small fines are imposed in some instances, and Magistrates' Orders made to abate.

Life of Order.—There is no life limit fixed by the Public Health Act, 1875, for a Magistrate's Order. It is reasonable to proceed against the user of a chimney for disobedience to an order any time during three years

from the date of the said order. Very often for two years after the making of an order there is no nuisance, then a recurrence takes place worse than before. In such cases, the Inspector proceeds as in the case of disobeying a notice, and proceedings are taken. If the defendant cannot prove, to the satisfaction of the Bench, that he has done everything practicable to comply with the abatement order, the court has no option but to impose a daily penalty during default, which may be one shilling or one pound, under the Public Health Act, 1875, or five pounds per day under the Sheffield Corporation Act of 1900. If the order is again disobeyed, further proceedings may be taken, with like penalties. Between 6000 and 7000 observations for one hour each are made yearly. In 1890 the average duration of black smoke in the hour was 7 minutes; in 1892 it was reduced to 2.8 minutes per chimney per hour; later it fell to 2.2 minutes, which average has been maintained, with very slight variation, up to 1903.

This is a greater reduction of the nuisance than the figures at first sight would indicate, when it is remembered that Sheffield is one of the busiest, if not the busiest workshop in the world, and that the driving-power required for presses, armour-plate, and other mills, amounting to many thousand horse-power, is very intermittent.

Penalties from ten shillings to sixty shillings were imposed on a few offenders. In the great majority of cases no fines were imposed, but only an order made to abate, which the defendants were often willing to consent to, expecting the matter to end there. The quickest way to abate nuisances, and to prevent their recurrence, is to impose heavy penalties.

Bookkeeping.—The pocket-book for entering the observations in the street should be of convenient size, and each folio numbered for easy reference, especially in court.

Copy of entry of observation:—

April 22, 1904

Messrs. A. B. & Co.

X Street

2 h. 15 m. — 3 h. 15 m.

Forge Chimney

h.	m.		h.	m.	
2	15	—	2	20	5 minutes
2	33	—	2	36	3 ,,
2	51	—	2	55	4 ,,
3	8	—	3	10	2 ,,
					14 ,,

Total duration of black smoke emitted in the hour, 14 minutes.

Smoke Inspector's Record Book. — The whole of the observations are entered into the Record Book, thus: Date of observation; hour of observation; owner or occupier; situation of premises; duration in minutes of black smoke at each firing and total in the hour; date of notice to alter; number of chimney; and remarks. Each folio is numbered, and the minutes and chimneys on each totalled and carried forward to the end of the month for the Monthly Report.

Index Book.—Each page of the Index Book is numbered. A number is given to each chimney. On the numbered page the name and address of the owner of the chimney are entered, and all the observations made on a chimney are recorded thereon, viz., the number of the page in the Record Book, and the total number of minutes during which smoke was emitted during the observation. This makes reference to any observations in the Record Book very simple and easy.

Smoke Abatement in other Towns.—A number of other towns have fixed time-limits for observing chimneys,

varying from half-an-hour to five hours. They have also decided on the maximum duration of black smoke in minutes per hour allowed during the time fixed for taking observations. This varies from one minute to fifteen minutes in the hour.

Difficulties Involved in Smoke Abatement.—Opposition to smoke abatement comes from all quarters, even from the most unexpected. It is quite natural to expect it from those who are directly or indirectly interested financially. A large proportion of the opposition encountered by inspectors in the discharge of their duty comes, however, from the working class itself, and is prompted apparently by sympathy with the firemen and others responsible. In many cases warnings are conveyed to the offenders of the inspector's visit, and in other ways he is hampered and impeded in his work.

Smoke Abatement Associations.—It is impossible to approximate the amount of excellent work done by these associations, and the benefit of a purer atmosphere obtained through their efforts. They have abated nuisances, awakened Authorities, pressed them to move in the matter, and proved themselves public philanthropists, and for this they very much deserve the public thanks.

CHAPTER VI

SMOKE FROM BOILERS, FURNACES, AND KILNS

Causes of Boiler Smoke—Science and Art of Stoking—Annealing Furnaces—Hardening Furnaces—Sheet-mill Furnaces—Special Armour-plate Hardening Furnaces—Reheating Furnaces—Open Kilns—Temporary Kilns—Permanent Kilns—Coke Ovens.

It is beyond the scope of the present work to deal in detail with the various types of boilers in use. The subject is a wide and highly technical one, upon which some standard work should be consulted by those who desire to obtain further information. That under normal conditions of firing, dense smoke is entirely preventable, is a fact upon which practically all authorities are now agreed. Hence the first step to be taken to prevent the emission of such smoke from boilers is to discover the causes to which it is due, and, if possible, remove them.

Causes of Boiler Smoke.—A fruitful cause of smoky boilers is deficiency in boiler power. A plant which suffices for the original installation will fail to supply any increased demands that may be made upon it afterwards, and if such a plant be forced beyond its capacity, smoke will often result. Faulty construction is another cause of smokiness; the boilers may be badly set, the flues too small, or the chimney too short. This means a poor natural draught, and this is responsible for smoke. The boiler ought to be properly set, the flues large, the chimney tall, and provision be made that the fireman can see the top of the chimney from the boiler front, so that if smoke is made he can quickly take steps to

prevent its continuance. If dirty small coal or coal dust is used there is often a difficulty in burning it, and to prevent smoke with this class of fuel is very hard. Good fuel is not only the best for preventing smoke, but the best from every other point of view.

Science and Art of Stoking.—Until a few years ago strength and the ability to use a shovel were considered the only qualifications necessary for a stoker. They are still essential, but not in themselves sufficient; for efficient stoking requires a considerable amount of skill. Stoking consists of so feeding the fires with coal that no combustible matter shall escape into the atmosphere, which is no easy task even when working under the best conditions. It is also necessary to keep the boiler well supplied with water to prevent very serious consequences, and to generate the amount of steam required, which is often more than can be comfortably done. The work of a stoker also entails looking after one and often more engines, and in many instances, doing various kinds of repairs, so that it is more important than some people imagine, as it requires strength, intelligence, and good judgment, for an error of judgment may result in the loss of many lives.

Number of Boilers.—No other work of any kind ought to be added to stoking. It takes the stoker away from the boilers, which is dangerous, for there is a great liability of his staying away too long. Four Lancashire boilers of ordinary size are too many for one fireman to fire as they ought to be fired. It is very general for one man to have charge of three boilers, which are sufficient if worked up to anything like their capacity. Many have two and a half when there is an installation of five or ten boilers, and many are responsible for the working of two boilers only, which is by far the best arrangement not only for the man but for the master, since a man who has too many boilers to fire cannot do his work in the skilful way it deserves, and the difference between

skilled and unskilled stoking will easily account for 20 per cent. of the coal bill.

Firing.—When lighting up a boiler it is necessary to exercise very great care to prevent excessive smoke. Some smoke must be made even with the greatest of care until there is sufficient heat in the fire-box to consume the gases. Heavy firing under normal conditions is too general. Putting on three times more coal at one firing than ought to be put on is popular because it means less work lasting longer, and to prevent smoke under such a system, and with an absence of air, is impossible. To fire one side of the furnace lightly, and allow a little time before the other side is fired for the incandescent fuel to burn the gases, is an excellent system; or to put the fuel in the front of the furnace to coke and then push it back will produce good results.

Air Admission.—Boiler-makers put grids or circular openings in the furnace doors to admit air, but these are often shut, sometimes purposely, and sometimes rendered useless because they have become clogged with dirt; and frequently the men in charge will express surprise when informed they were put on to let in air. Sometimes, however, they will explain that they close them because "air does harm to the boiler," a belief far more widespread than warranted. The admission of air to the furnace after a fresh charge of coal is absolutely necessary.

Quantity.—The class of coal, amount put on the fire, atmospheric conditions, &c., determine the quantity of air necessary, and to find out how long a time it should be admitted after a fresh charge, it is necessary to find out whether all the combustible gases have been consumed, so that nothing but incombustible gases are emitted from the chimney. The length of time of air admission necessary to do this will fix the *quantity* of air required for a given quantity of coal.

Hot versus *Cold Air.*—Either hot or cold air will, if admitted at the right time and place, ignite the gases. There are many advocates for either, and each claims the one to be better than the other. Cold air may for a moment reduce the temperature of the furnace, but combustion takes place quickly and the temperature is increased. There is also a great deal of unnecessary alarm about the damage it is said to do to boilers, if the life of a boiler which has been subjected to this treatment is to be taken into account. It is difficult, moreover, to heat the air to a temperature anything approaching ignition point before admitting it to the furnace.

Where the Air should be Admitted.—If the air be admitted through the door by grids, or through the dead-plate by a valve, there is the possibility of a proper degree of admixture with the gases and of combustion taking place wholly in the furnace. If admitted only between the grate-bars, air ceases to enter the furnace when the bars become dirty and covered with clinker. If let in at the bridge, the air meets the gases when entering the tubes after leaving the furnace, and great difficulty is experienced in consuming the smoke when once made, though it is an easy matter by a plentiful supply of air at the place in question to thin the smoke, and thus send it out of the chimney in a less dense form than it would otherwise be. It is impossible, without considering the conditions of working, to say which place of admission is the best, for if the furnace gets a sufficient supply at the proper time, smoke will in any case be prevented.

Stokers.—There are various classes of stoker, from the experienced and intelligent workman who takes a pride in his work, and is a very profitable servant, as anxious as any one else to prevent a nuisance, to those of whom it may be fairly said that they have had little or none of the necessary experience. It is a frequent occurrence for masters and managers to put utterly inexperienced youths

or labourers to work at stoking, and many of them do admirably considering the difficulties of the work, while others get through their work in a slovenly fashion, and are constantly getting their employers into trouble. Experienced stokers receive as much as 28s. per week; they are special men, and are often worth even more to their employers; 24s. per week is considered a very good wage for the work they have to do, but the great majority get little over 20s., and even less. If employers would pay higher wages, they would unquestionably create a better class of stoker; the extra money would be a good investment, the return being a smaller coal bill and fewer repairs. Prejudice on the part of the workman is answerable for a good deal. Even when the employer provides the most modern plant, and attaches to the boilers an admirable appliance which has been proved most efficient, the workman frequently manifests great antipathy to it, and will prophesy failure, taking care in innumerable cases to justify his opinion. He can, if he desires, make a second-rate appliance do exceedingly well, or he can make the best machine on the market a complete failure. When an employer has provided everything essential for the prevention of smoke, if smoke is made, it is unjust to proceed against the employer, and further encourage carelessness in stoking. Proceedings ought to be taken against the stoker, and when carelessness is proved a heavy fine should be imposed, and even imprisonment. Such a penalty would help considerably in the direction of smoke prevention.

Annealing Furnaces.—This class of furnace is used to temper steel and other metals. The temperature of the furnace varies according to the requirements of the articles to be annealed. They are heated to the desired temperature, and then allowed to cool slowly. In some furnaces where a low temperature is required, and very light material is exposed to the flame, black smoke is essential

as an envelope for the articles to prevent decarburisation and burning, and some smoke must unavoidably be emitted from the chimney because the temperature of the furnace is never sufficiently high to produce complete combustion.

In the large furnaces which are used for heavy work the temperature is higher, and with care in stoking there will be less smoke emitted.

When wire, &c., is put into metal boxes for annealing and placed in the furnace, there is less liability of burning, and no need to exclude all air from the furnace by shutting a blank door directly after firing, and emitting black smoke. If fired lightly and a little air let into the furnace, the annealing is perfectly satisfactory, and very little smoke is emitted.

Some owners of annealing furnaces have discontinued the use of coal, and are working their furnaces with gas. It is quite suitable for the process, being economical and producing no smoke, but very great care must be taken to prevent the burning of the steel, especially in furnaces used for very light work. Even in these, however, the heat can be regulated so accurately as to meet all the requirements.

Hardening Furnaces.—These furnaces are very similar to annealing furnaces. They are of various sizes, and are worked at various temperatures for hardening saws, files, springs, and other descriptions of steelware. When the articles are heated to the necessary temperature, they are cooled quickly by being plunged into oil.

A hardener of thirty years' experience declares that black smoke is necessary, for if air is admitted into the furnace it spoils the steel. The class of hardeners represented by this man nevertheless often allow air to enter the furnace. When the door of the furnace is partly burnt away less smoke is made, and the steel is not spoilt. If their attention is, however, called to the fact, they at once stop the air admission, and there is a recurrence of

an unnecessary nuisance, simply in deference to a silly superstition which prevails among them.

Other hardeners who have had equal experience in working all sorts of furnaces admit that they ought to be fired lightly, and a little air admitted after firing, whereupon there will be very little smoke, while the air will not, in the slightest degree, interfere with the process of hardening. Many furnaces are worked on this system with the most satisfactory results.

Sheet-mill Furnaces.—When these furnaces are used for what is called "finishing"—that is, for reheating very thin sheet-steel for pens, watches, &c.—a lot of smoke is produced, as the temperature of the furnace must be low, or burning will result. In processes like this smoke is unavoidable, and to stop it would impede the trade, unless means are adopted whereby it is consumed after leaving the furnaces.

Special Armour-plate Hardening Furnaces.—The hardening of armour-plates is a special process; the furnaces are very large, and capable of holding plates weighing from twenty to forty tons or more. They are fired heavily, while air, if admitted, would, it is claimed, injure the plates. The chimneys, of which there are often a group, are about 30 feet high, and when several furnaces are fired simultaneously, the dense volumes of smoke emitted for long periods fill the whole district, and penetrate the streets and houses, even when the doors and windows are shut, making the whole neighbourhood unfit for human habitation. If the process demands the making of the smoke, and it is impracticable to consume it after it has done its work in the furnace, chimneys ought not to be allowed to emit it at a height of 30 feet, but should be compelled to discharge it from heights of not less than 150 or 200 feet. Similarly the smoke which is unavoidable in annealing, hardening, and sheet-mill furnaces ought to be emitted at a higher altitude than 25 or even 30 feet.

Reheating or Muffle Furnaces. — There are many kinds of furnaces which come under this head, and are named after the kind of work they do, as plate-furnaces, gun, ingot, billet, ball, fire, rod, spring, and air furnaces, and others used for special processes.

In general this class of furnaces is worked at a much higher temperature than the furnaces previously described, which make it much easier to prevent smoke. A few of the large furnaces, and a few of the smaller types used for reheating ingots, plates, &c., to be pressed or rolled, are now worked with gas, with greater heat, better regulation, more economy, and no black smoke.

Working of Furnaces.—It is very rarely that, when constructing furnaces, smoke prevention is taken into consideration. They are built specially for the work they have to do. Smoke prevention ought to receive consideration in construction, but the working of furnaces is more directly responsible for the making or prevention of smoke than their construction. A furnaceman is responsible for the furnace, and for maintaining the temperature required for rolling and forging. When a furnace is re-charged with cold steel, the temperature is reduced considerably below the ordinary working temperature. This is often an advantage when charging high carbon steel, for if the ingots were put into a very hot furnace, "cracking" would result. When the furnace has been charged, a boy engaged in general work in the mill is usually told off by the furnaceman to fire up. He puts about four times more coal on than he ought, shuts the door, which is a blank one, and the result is from ten to fifteen minutes of black smoke. The next firing in all probability is put on by another boy or man (who works in the mill, as these odd hands are expected to do the firing of all the furnaces amongst them), with similar results. The furnaceman occasionally fires the furnace, but nearly always it is done by the mill hands. There is no fireman whose special duty it is to fire the furnace

or furnaces, subject to the supervision of the furnaceman, hence the boys and men who have to do the firing in addition to their own work are compelled to put on heavy fires to secure time for their ordinary work. This not only creates a smoke nuisance, but entails a great waste of fuel.

When a fresh charge is made in the furnace, there ought to be light and frequent firing, and a little air admitted into the furnace at each firing. The necessary heat is thus quickly generated, heats are got out quicker, less coal is consumed, and very little smoke made.

A firm of steel manufacturers who had a number of reheating furnaces decided to experiment on the lines suggested. An experienced fireman was put in charge of four furnaces to fire. They were fired lightly and often, the heats were ready for getting out in less time than under the old system, much less coal was burnt, and, with the exception of a little smoke when the temperature of the furnaces was low, just after charging, there was no smoke made that any reasonable exception could be taken to. After a month's experiment the firm was so satisfied with the results that instructions were given to work all the furnaces on the new system. Other manufacturers might safely follow this example, admit a little air into their furnaces to cause complete combustion, and yet not have the slightest fear of injury being done either to the steel or to the furnace.

It is quite patent that the greater proportion of smoke made by all kinds of furnaces is unnecessary; it is a preventable nuisance, and ought to be stopped. To prevent it a new departure will have to be made, such as the employment of experienced firemen to take charge of two or more furnaces, according to size, and to be held responsible for the heat of the furnace and for the prevention of smoke.

In 1897 Dr. Harvey Littlejohn, Medical Officer of Health for the city of Sheffield, published a Report on the

Causes and Prevention of Smoke. He asked Professor Ripper, the Principal of the Technical College, Sheffield, to give his views on the smoke question, and they were published in the Report. Professor Ripper said that the question of smoke from the various metallurgical furnaces was a difficult question, but there were encouraging signs that the present form of furnace was likely to give way to a superior type, at least in some departments of such work. The new form of Siemens gas furnace has already been successfully applied on a large scale in England, Belgium, France, Spain, and Italy. There are several at work in the Sheffield district, and the results obtained have fully realised expectations. It can be readily used for producing either a reducing, oxidising, or neutral flame, as required, together with complete absence of smoke.

It is hardly likely that manufacturers will be induced to demolish their existing furnaces and substitute the new Siemens furnace, at a large initial cost, with the sole object of preventing smoke, but a more powerful inducement will undoubtedly lead to such a change in the near future, if the economy effected by the new furnace is anything like what it is stated to be. One Siemens furnace usually replaces two ordinary coal-fired furnaces, and the saving effected with one such furnace, heating twenty tons of iron piles per twelve hours, is said to amount weekly to a reduction in waste of iron equal to £30, and saving in coal per week £15, the total saving per year of forty weeks amounting to £1800.

The approximate cost of such a furnace is £600, so that with such inducements to improve upon the present type of furnace there is a reasonable prospect that a reduction in the amount of smoke made from this source may be hoped for in the near future.

If such inducements will not suffice to make manufacturers take practical steps for the abolition of smoke from metallurgical furnaces, the law might be put in

motion. The time has now arrived when action ought to be taken against unnecessary furnace smoke, although there will doubtless be a very strong and fierce opposition to this, as there was in the case of boiler smoke years ago.

The same policy could be pursued as has been, and is now being pursued with such satisfactory results with regard to boiler smoke, viz., to find out how much smoke is absolutely necessary for the working of a particular class of furnace, and to proceed against those responsible for the smoke made in excess of this.

Open Kilns.—There are still a large number of open brick kilns in use surrounded by dwelling-houses. They are neither costly nor complex in construction; each consists of a brick building varying from 20 feet long by 15 feet wide and 12 feet high, open at the top, and provided with about twenty firing holes about a foot from the bottom. When the kiln is charged with bricks a layer of coal dust is put on the top, and the fires, which are open ones, are lit at the bottom. The smoke works its way between the wet bricks at the bottom of the kiln until it forces itself out at the top, and volumes of dense black smoke are sent off continuously for three or four hours, until sufficient heat has been generated in the kiln to consume it. This cannot be prevented, and is repeated every time the kiln is relit with a fresh charge of bricks.

Temporary Kilns.—There are a number of kilns put up to work for periods of one to three years. A field is purchased for building purposes, and millions of common bricks are required for inside work. A kiln is therefore erected, the clay from the excavations is made into bricks and burnt in the kiln, and so a nuisance is created. Invariably such kilns are in close proximity to dwelling-houses, the inhabitants of which complain, but are told that they possess no remedy.

Permanent Kilns.—If these kilns are required to be permanent, the Local Authorities seldom interfere. In one case a desire to do something was evinced as a result of

public pressure. A brick company had worked out their clay with open kilns in a moderately populated district, and had been a nuisance for twenty years. They then purchased land in the centre of a densely populated district, put up a big open kiln, and commenced brick making and burning. The people in the district were so indignant at this infliction that they sent a petition to the Local Authority, with threats if action was not taken to end the nuisance. The Local Authority asked the company to replace the open kiln with a modern smokeless kiln, to which the company replied that the clay was of such a peculiar nature that it would take them four or five years to work up the clay to make sufficient room for a continuous kiln, and even if they put one down at a great cost they would not have sufficient trade to keep it going. The nuisance went on year after year, the Local Authority took no further action, and the people were almost smothered with smoke.

An improved barrel up-and-down draught continuous kiln, the patent of Sercombe & Co., Leicester, has been devised to prevent smoke. In the single system there are from three to seven chambers, and in the double system there are from seven to sixteen chambers. The draught is a continuous one, from or to the top, and through all the chambers, produced by a tall chimney taking off the fumes of combustion and securing a uniform heat. The fires are accessible, under control, are lightly fed with coal dust, and perfect combustion is the result.

This class of kiln is becoming very popular, and the makers claim to save 80 per cent. of coal compared with that used in kilns of other patterns, such as round kilns, Scotch kilns, and clamps or open kilns.

In these continuous kilns the burning, the drawing, and the filling go on at the same time, which makes the kiln far superior in every way to the old-fashioned types which have to be lit up before and let out after every

burning, causing a quantity of smoke for hours after lighting up. This kind of kiln has practically solved the smoke question, so far as the burning of bricks and other material are concerned.

There are now hundreds of kilns working of the class named, which are not only practically smokeless, but turn out more and better work in a given time. This is a positive proof that the emission of volumes of smoke for hours together in the burning of bricks, &c., is quite unnecessary. During the last few years in Sheffield, through pressure being put upon the owners of kilns, the old kilns have in a number of instances been abolished, and the modern kiln substituted, with remarkable results, especially from a smoke abatement point of view.

Coke Ovens.—Damage has been known to occur to crops by smoke and fumes from coke ovens At Barnsley an action was heard in which a farmer sued the Carlton Main Colliery Company for damage done to his crops by the smoke and fumes from coke ovens. It was claimed on behalf of the Colliery Company that whilst it was quite possible that the colliery had to some extent contributed to the damage, no nuisance had been committed, as they were carrying out the ordinary trade of the district, and that, moreover, what damage had been committed was not entirely attributable to them, as the railway was much nearer the field than the colliery. A verdict for the plaintiff for £8, 4s., with costs, was, however, recorded.

The Public Health Act, 1875, Section 91, covers not only kilns and coke ovens, but every kind of furnace and fireplace, except domestic. It does not permit the creation of a smoke nuisance if it can be practically prevented, and it gives power to Local Authorities and private individuals to take action, and procure magistrates' orders demanding the abolition of kilns, ovens, or anything else (that are a nuisance), and the adoption of improved kilns,

&c., which create no nuisance, and are superior to the old ones in every way.

If administrative authorities, who are invariably too tolerant to smoke makers, would point out how profitable it would be to abolish the old coal-wasting kilns, and put in the improved smokeless kilns, it would in all probability lead to action. If prospective profits will not induce them to abolish the nuisance, it becomes the duty of the authorities to carry out the law, and compel them to adopt the most improved and scientific system available, so as to prevent unnecessary annoyance.

CHAPTER VII

PRIVATE DWELLING-HOUSE SMOKE

Exemption of Private Dwelling-houses—Domestic Grates—Tests on Grates.

Exemption of Private Dwelling-houses.—In a previous chapter, Section 91 and Sub-section 7 of the Public Health Act of 1875 is cited, which gives power to proceed against any chimney "not being the chimney of a private dwelling-house." Chimneys which serve fireplaces of any kind connected with a private dwelling-house are outside the Act, and there is no legal power to interfere with them. The exemption of this class of chimney is a very serious matter, for in London there are millions of such chimneys—in Sheffield nearly a hundred thousand—and in every city and town tens of thousands, which are at liberty to send out as much smoke as they like, and create an almost incredible nuisance. There never has been any reasonable excuse for this class of chimney being outside the Act, for Section 91 and other sections provide plenty of protection, which prevents any interference with trade, heating, cooking, or anything else in connection with even a private dwelling-house.

Result of the Exemption.—Antiquated cheap smoke-making grates are put in, the brickwork is bad, chimneys small, in some cases hardly large enough to allow the smoke to go up, for frequently it comes down into the room, which necessitates the opening of doors and windows to let it out. This is not an isolated case occurring only in the poorest class of houses, but often in the better class house. The nuisance might be easily obviated if the

builders knew that they were compelled to efficiently construct and put in the best kind of stove. The kitchen chimney is the chief sinner in this respect. If possible it is worse constructed than the rest. It serves as a fireplace where all the cooking, &c., is done, takes the most coal, and makes most smoke. It is usually below the level of the others. There are frequently complaints made by tenants respecting this chimney, and occasionally the owners will effect the necessary alterations to abate the nuisance, when they are reasonable men, or if it happens they are unacquainted with the exemption clause. But the majority of owners know there is no power to make them do what should be done, so they refuse to do anything, and the nuisance, which is practically preventable, continues. Just the same difficulty is encountered with the private green-house chimney through this clause. Owners claim that there is no power to interfere with them, and they please themselves, burn either coke, coal, smudge, or refuse, and create as much smoke as they choose. There are innumerable chimneys in connection with private dwelling-houses which cause great nuisances to the people in the neighbourhood, although they could be abated with very little expense.

Domestic Grates.—Two series of smoke tests have been made by the Coal Smoke Abatement Society on domestic grates.

The results of these tests were published in the *Lancet*.[1] A preliminary investigation into the subject of open sitting-room fire-grates was undertaken at the instance of the Coal Smoke Abatement Society by Dr. H. A. Des Vœux, and the late Mr. Bryan Donkin, the well-known engineer, one of the greatest authorities on the subject.

On the subject of domestic grates there had been no experts, and although there existed an abundance of specifications and drawings of improved grates and appliances connected therewith, no large manufacturer

[1] May 10, 1902, and February 20, 1904.

of grates had thought it worth his while to study the question of a smokeless grate, no demand on the part of the public having apparently arisen for a type of grate which diminishes the emission of smoke. The Society therefore stepped into the breach, and authorised a sub-committee to institute a series of tests on a few domestic grates.

Before describing these, it is well to explain that smokelessness can be attained by the use of smokeless fuels, such as anthracite coal, coke, gas, or oil.

Any one who is interested in the question can co-operate by using at least one of these fuels, and may rest satisfied that he is contributing his part to remove one of the greatest evils from which London, and indeed all coal-burning cities, suffer.

Fortunately, too, each of these fuels in its different degree is within reach of everybody, although as it appears that the great majority of householders are at present unwilling to accept anything but open grates, burning bituminous coal, the Society has confined its tests to grates claiming to be more or less smokeless under such conditions. In order to secure the most comprehensive results, the Society advertised in the daily press, calling the attention of manufacturers to the tests which they proposed to make. To the advertisements a large number of replies were received, describing various grates, the majority of which, however, did not fall within the specified limits, viz., an open grate burning bituminous coal. A certain number, therefore, had to be selected, the specifications of which showed them to be such as the Society was seeking, and the manufacturers of these selected grates were invited to send samples to be tested. Six only responded to the invitation, and consented to the results of the tests made by the Society being published.

In the meanwhile, Lord Esher, Secretary to the Commissioners of His Majesty's Office of Works and Public

Buildings, had expressed a strong interest in what the Society was undertaking, and he offered to place at its disposal a room in which the tests could be properly instituted, as also the services of two skilled employees to conduct them.

The assistance of the Government at such a moment was invaluable, as it ensured the tests being conducted in such a manner that each grade could be judged absolutely upon its merits. It was especially unfortunate, in view of the exceptional opportunities afforded by the Government, that more manufacturers did not compete. Since so few came forward with suitable grates, the results cannot be regarded as comprehensive. All that can be claimed is that certain preliminary results of the highest importance have been obtained, and that it has been shown to be capable of proof that there is a great difference in effectiveness and economy between the various types of so-called smokeless grates, and that it is possible to produce them so as to reduce smoke pollution from domestic chimneys to a great extent while still using ordinary coal and an open grate.

The following is a general description of the circumstances in which the tests were made:—"A sitting-room on a ground floor in central London was selected, 21 feet 6 inches by 14 feet 6 inches by 10 feet 6 inches. Its two glass windows were always kept shut, but a small glass ventilator in one window was continually open, as was also a door leading to a narrow hall. The street door was, whenever possible, kept shut. The chimney measured 69 feet from hearth to pot, with a 9-inch pot on a flue 14 inches by 9 inches. No high buildings were situated near. The tests were made in the months of June, July, and August 1901. The meteorological observations for the days of the tests were noted. Each grate was placed in position by the maker's fixer with the intention of testing it for three days of eight hours each. The manufacturers' directions were

given either verbally or in print to the man whose duty it was to attend to and to stoke the fire, and to note the temperature of the room. The following orders of the sub-committee were observed. The amount of wood used in lighting, and the amount of coal put on each time throughout the day were ascertained by weight, the number of times the fire was stoked was noted, and the coke (or partially burnt coal) and ashes or waste at the end of each day's test were also duly weighed. Directions were given to keep the fire up to the top bar of the grate. Records of the temperatures were taken every half-hour, one by a thermometer 6 feet from the fire, and 2 feet above the floor level, in order to give approximately the radiant heat; another at the far end of the room away from the window and the door, and 5 feet off the ground; and a third in the hall outside the room. The amount of smoke emitted was recorded by means of a smoke intensity scale or 'smoke-shade,' as indicating the proportion of unburnt carbon, on a time smoke chart (Bryan Donkin). It was estimated by a skilled man sitting in a window on the third floor of the opposite house at an angle of about 30° from the top chimney and about 35 feet away. He was watching during the whole working day continuously without going away for meals. Every precaution was taken to avoid error, and each grate was tested in exactly the same way. The coal was ordinary household bituminous smoky coal of rather poor soft quality, and was all taken from one truck, the name of the colliery being unknown."

"The following are the possible sources of error—the summer weather, the variation in outside conditions of atmosphere—although, as will be seen upon reference to the meteorological reports (not given here), the weather differed little throughout—and, finally, the fact that orders were given to keep a bright fire up to the level of the top bar, whereas in an ordinary room the fire is often allowed to become extinguished or to fall low, when it

has to be relighted or carefully stoked. With all of the grates the densest smoke was noticed immediately after stoking. It would have been better to have made tests during winter."

Six grates were tested, each for three days, in addition to the one which had been in use in the room previously, which, being rather old-fashioned, was taken as a standard, and noted as No. 1.

Grate No. 1.—The following is a description of this grate. Fire-brick back with iron sides, three horizontal bars in front. The bottom of the grid was formed of horizontal iron bars with alternate air spaces, and was about four inches above the hearth level.

The daily consumption of coal was 28,[1] 30½, and 32 pounds respectively; the amount of incompletely burnt coal left, three pounds, one and a half pounds, and three pounds; and the amount of ashes three and a half, one and a half, and three and a half pounds. The average daily differences in temperature between the outside thermometer and the radiant heat thermometer were 18.6°, 24.0°, and 26.24° F. The average time taken in raising the temperature from the morning scale to its average height was two hours, one and a half hours, and one hour respectively. The average number of times it was stoked (per day) for the three days was nine or ten times.

Grate No. 1*a*.—This was No. 1 grate with Lee's regulator added. This regulator is described as "a blower fitted with a damper. . . . It controls the supply of air to the grates and provides the proper velocity up the chimney." "The blower is joined to the regulator or damper at its lower edge by a hinge and is worked by means of a quadrant rachet." The result of adding the regulator was as follows. The daily consumption of coal

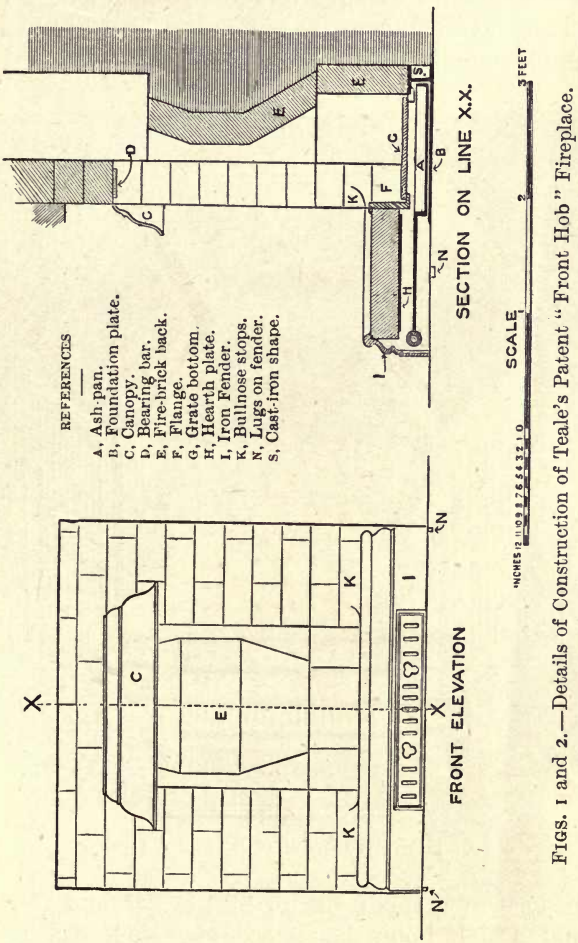
[1] The 28 pounds represent the coal consumed between the hours of 10 A.M. and 5 P.M.; the other two amounts that consumed between the hours of 9 A.M. and 5 P.M.

was 44, 33½, and 29 pounds respectively; the amount of incompletely burnt coal was two pounds per day; and the amount of ashes two pounds per day. It was stoked between ten and eleven times each day. The average differences in range of temperature were 29.29°, 22.06°, and 20.29° F.; the time taken to raise the temperature of the room to its mean temperature was one and a half hours, one hour, and one hour respectively. [*N.B.*—This is the only appliance of which the testing exhibited somewhat contradictory results on each of the three days, and it is possible that some source of error was introduced which escaped notice. It gave the greatest heat with the greatest consumption of coal on the first day. This cannot be accounted for by the only known source of error—namely, that the chimney was not swept before its use. It was swept after, and there was not much soot found.] The chimney smoked badly throughout independently of the amount of coal burnt.

Grate No. 2.—Teale's Patent "Front Hob" Fireplace (Figs. 1 and 2). This grate is constructed almost entirely of fire-brick with a hot-air chamber below the fire which burns in a hollow or well. It is manufactured by the Teale Fireplace Company, and is described by them as being of their standard pattern and the smallest size they make, viz., 13 inches. The bricks are salt-glaze. It has a canopy, a fire-brick back and sides, and a cast-iron bottom or grid. It burnt 28, 28, and 23 pounds of coal on the respective days, and left two, two and a half, and two pounds of partially consumed coal, and two, two, and one and a half pounds of ashes. Its heat production for the three days was 20.17°, 20.88°, and 18.47° F. respectively. One hour each day was occupied in producing this average heat, and the grate was stoked between five and six times each day.

Grate No. 3.—Helyear's Patent "Tropic" Grate. This grate has no register and is entirely closed on the top.

It possesses a canopy, a cast-iron back, and hexagonal projecting cast-iron sides consisting of flues down which the heated gases pass on their way to the chimney. The



FIGS. 1 and 2.—Details of Construction of Teale's Patent "Front Hob" Fireplace.

lower portions of the back and sides are covered by a lining of cast-iron perforated plates or cheeks. The front consists of three horizontal iron bars and the bottom or

grid of horizontal iron bars (Fig. 3). It burnt 23, 23, and 22 pounds of coal in the three days respectively, left one pound of coke each day, and one pound of ashes on the first day and three-quarters of a pound on each of the next two days. It was, therefore, well constructed for the proper combustion of coal, but the amount of its

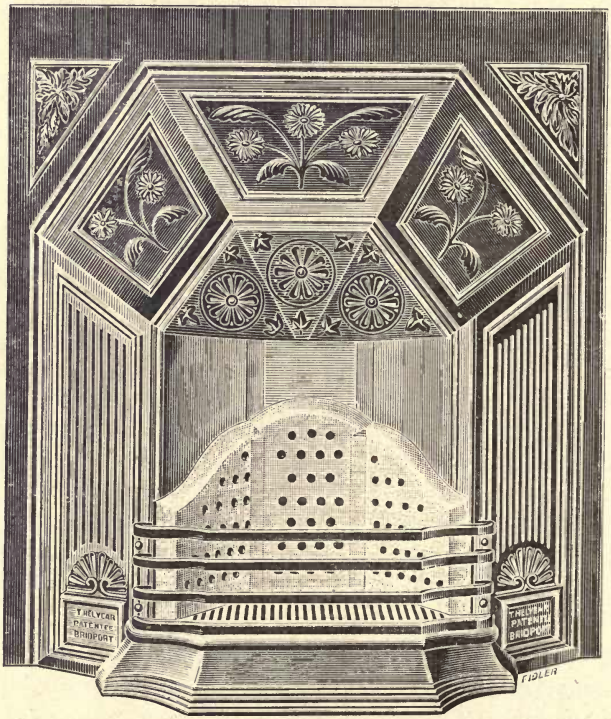


FIG. 3.—Helyear's Patent "Tropic" Grate.

radiant heat[1] was small, viz., 17.88°, 15.82°, and 16.71° F., one and a half hours being occupied each day to produce it. It only required stoking four times daily.

[1] The average radiant heat stated in the text is the daily average difference between the readings of the thermometer in the hall and those of the thermometer in front of the fire.

Grate No. 4.—The Florence Gate (Figs. 4 and 5.)—This grate is made by the London Warming and Venti-

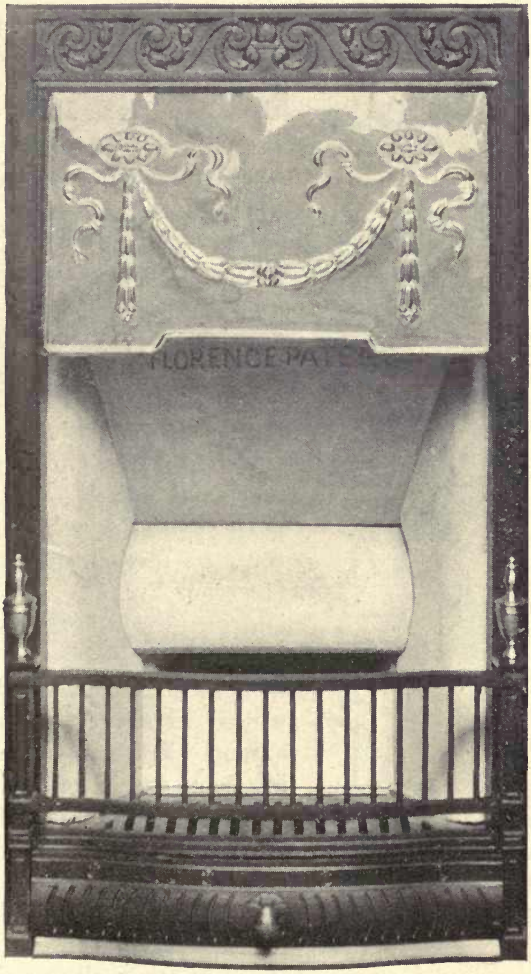


FIG. 4.—The Florence Patent Grate.

lating Company, Limited, and is described as fitted with improved "Jackson" back, Florence's patent automatic

shaking fire-bars, and combination canopy regulator. Its size is 21 by 28 inches. The back and sides are of fire-brick. It has a fire-chamber of 18 inches and a front of vertical iron bars. In each jamb at the hearth level there is a fresh-air inlet, and there is a heated air outlet over the centre of the fire-place, 6 feet above the floor level. The "Jackson" back and combination canopy regulator consists of a sliding door, capable of easy manipulation from the front, which in its two positions allows of careful regulation or adjustment of the two slotted openings, the one at the back of the fire-grate and the other at the top (*vide* section showing side elevation, Fig. 5). The smoke is drawn through the fire to a point where the heat is practically incandescent, and is consumed to a very appreciable extent. The automatic shaking bars consist of a number of separate bars, preferably serrated or vandyked on their sides and upper surfaces. These are mounted loosely on a square shaft, so that the bars can rock to a limited extent on the shaft, or can be rocked by operating the shaft by a handle. The bars are made abnormally deep in the body to heat

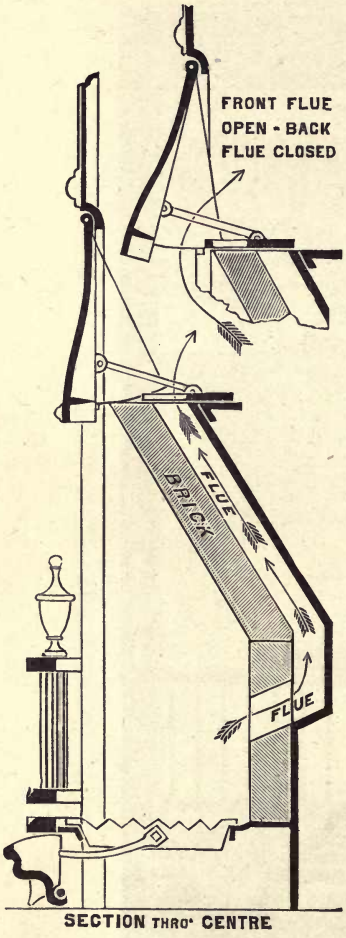


FIG. 5.—The Florence Patent Grate.

the ascending air-currents. As the weight of the coal varies on the different bars, the bars will rock and clear the fire of ashes and dust, so allowing a continuous current of air at a high temperature to pass through the fuel, which causes it to burn brightly even in small quantities. This grate consumed for the three days respectively 20, 19, and 18 pounds of coal, and left one and a half, one and a quarter, and one and a quarter pounds of coke, and

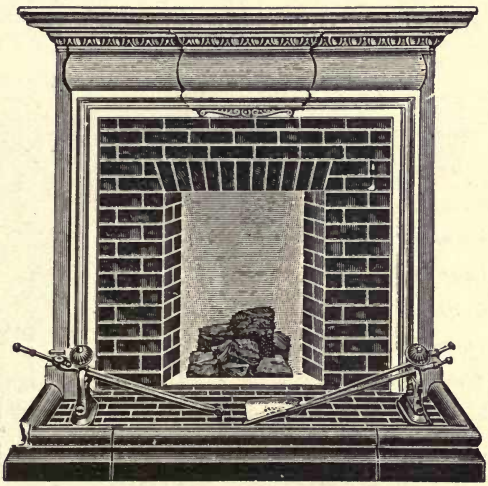


FIG. 6.—The Well Fire (Bowes' Patent).

only three-quarters of a pound of ashes each day. The tests on the first two days lasting only for seven hours each, $2\frac{6}{7}$ pounds and $2\frac{5}{7}$ pounds respectively of coal must be added for these days, making the figures $22\frac{6}{7}$ pounds and $21\frac{5}{7}$ pounds. The average radiant heat was 24.80°, 25.27°, and 24.47° F. One and a half hours, one hour, and one and a half hours were required respectively to raise the temperature to this average, and the grate needed stoking four times daily.

Grate No. 5.—The Well Fire (Bowes' patent) consists

of a fire-basket, which is composed of fireclay and a metal grating supporting the fire, under which is a fireclay well (*vide* Figs. 6, 7, and 8). This fire burnt in the three days 28, 30, and 26 pounds of coal respectively, and yielded two, two and a half, and one and a quarter pounds of coke and one and a half pound of ashes on each of the

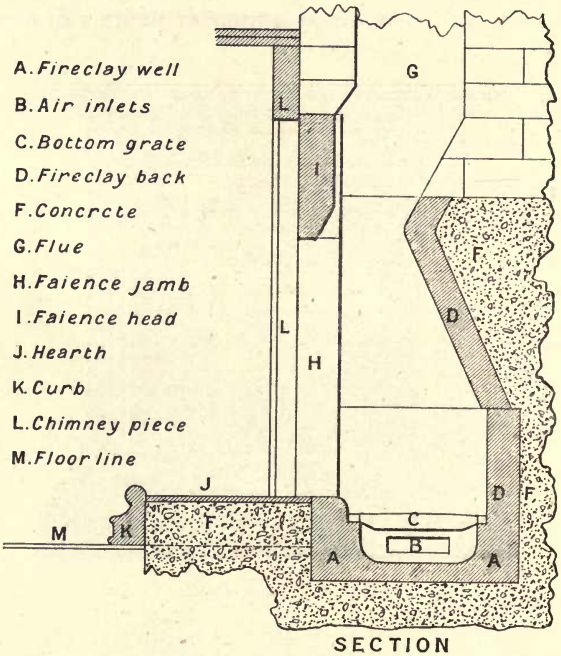


FIG. 7.—The Well Fire (Bowes' Patent).

first two days, and one pound on the third day. Its average radiant heat produced each day in one hour was 20.24°, 20.65°, and 20.76° F. It was stoked five times a day.

Grate No. 6.—This was Messrs. Smith & Wellstood's grate, of which the following is a description. The front was of cast-iron, and the back and sides were of fire-brick. There were ten vertical iron bars in front. The bottom

of the grate consisted of a solid iron-plate portion at each end, enclosing a rectangular grid of iron fire-bars with intervening air spaces. The bottom of the grate was four inches from the hearth level. The size was 38 inches by 38 inches. The fire-chamber was 18 inches in width. This grate used in eight hours for each day respectively 27, 28, and 28 pounds of coal; it left one and a half pounds of partially consumed coal daily, and one pound, one and a quarter pounds, and one and a quarter pounds

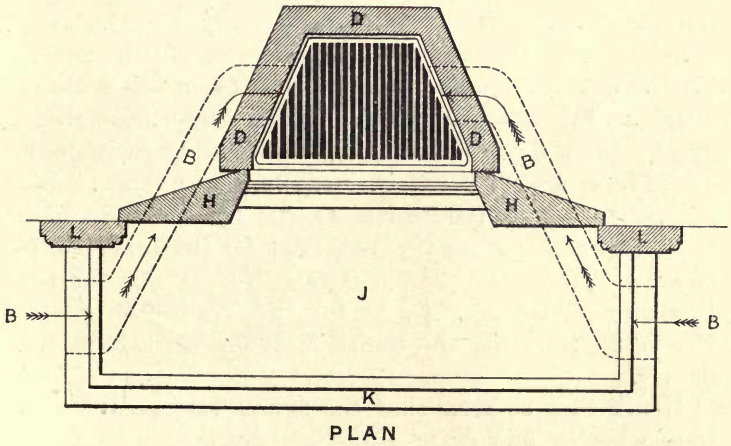


FIG. 8.—The Well Fire (Bowes' Patent).

of ashes, showing a good combustion. The average radiant heat was almost the same on each day, 20.37°, 20.94°, and 18.65° F. It took one and a half hours, one hour, and one hour to obtain this increase, and the grate was stoked between five and six times each day. It gave out a good heat, but, as will be seen by the smoke chart, smoked badly.

Having now described in full the different grates, and their consumption of coal and heat production, a more detailed account must be given of their emission of smoke.

The following is the method adopted for calculating the comparative amount of smoke at the top of the chimney emitted by the different grates, all burning coal of the same quality and heating the same room.

If a Bryan Donkin smoke-chart be examined (Fig. 9), it will be found to be divided by vertical lines into eight large sections, each of the latter being subdivided by more vertical lines into twelve smaller sections. Each of the eight sections is then divided by horizontal lines into five sections. The five sections represent the smoke-shade ranging from 0 (no smoke) to 5 (very black). The eight sections represent hours and each of the twelve subdivisions represents five minutes. From this scale or chart an average has been struck of the smoke-shade for the three days of the smoke evolved by each grate. The smoke figures thus obtained were as follows:—For the ordinary grate (Grate No. 1), $\frac{6}{10}$; for the same with Lee's regulator (Grate No. 1*a*), $1\frac{1}{10}$; for the Teale (Grate No. 2), $\frac{6}{10}$; for the Tropic (Grate No. 3), $\frac{6}{10}$; for the Florence (Grate No. 4), $\frac{1}{4}$; for the Well Fire (Grate No. 5), $1\frac{1}{10}$; and for the Smith & Wellstood (Grate No. 6), $1\frac{6}{10}$.

It will thus be seen that the figures vary greatly, and that whereas one grate emits an average of $1\frac{6}{10}$ for three days, out of a possible smoke-shade of 5 for three days, there were degrees in gradation from this figure down to $\frac{1}{4}$ out of a possible 5, showing that, at any rate under some circumstances, the amount of smoke can be diminished largely by the use of various appliances.

Table I. (p. 145) is a condensed record of the tests.

In the winter of 1902–3, an exhibition of grates was held at the Crystal Palace.

The jury met and selected certain stoves as appearing most likely to satisfy the conditions imposed, and the grates so selected were fixed in position by the exhibitors, who each gave written directions as to the manner in which the grates were to be treated, but who, by arrange-

ment, were not present during the trial. The tests of

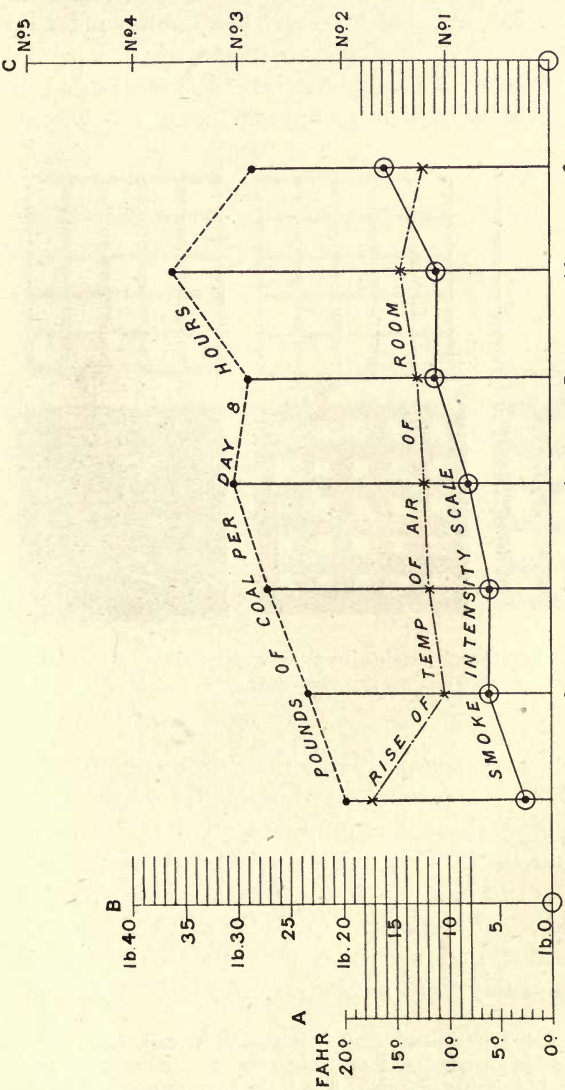


FIG. 9.—Plotted results of tests on six domestic open fire grates used successively to heat the same room. A, temperature in degrees Fahrenheit; the middle line (Rise of Temperature, &c.) is plotted from this column. B, weight of coal consumed; the upper line (Pounds of Coal, &c.) is plotted from this column. C, smoke intensity scale; the lower line of the same name is plotted from this column. A, B, and C correspond respectively to columns 8, 2, and 9 of Table I.

each grate were continued for a period of three days.

The actual tests were carried out by an assistant acting under the direction of the jury. He was supplied with scales for weighing the coal used and thermometers for indicating the temperature of the air in the apartment and also of that in the hall outside. He was instructed to light the fires at 9 A.M. in accordance with the written

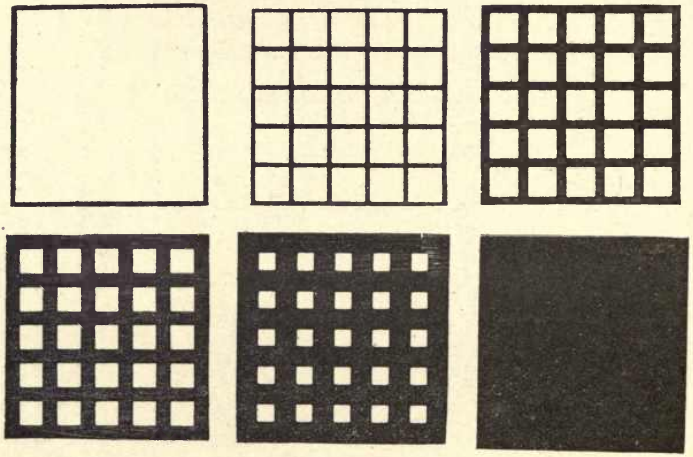


FIG. 10.—Diagrams of smoke-scale 0 to 5 (see also charts). 0, no smoke; 1, light grey; 2, darker grey; 3, very dark grey; 4, black; 5, very black.[1]

directions of each competitor, and to urge the fire until the thermometer, suspended in the middle of the room from the ceiling, showed a temperature of 20° F. above that of the air in the hall outside, and so to regulate the fire as to keep the heat up to that point during the day. The coal and wood used were carefully weighed and the amount recorded, and the time of each stoking noted. At 5 P.M. each day the fire was drawn, and, when cold,

[1] Copies of the Ringelmann Smoke Scales, reprinted from Bryan Donkin's "Heat Efficiency of Steam Boilers," are obtainable from C. Griffin & Co., Ltd., price 3d. each. These tints are those given by the sketches when seen at a distance of about 50 or 60 feet in a good light.

TABLE I.—*Summary of Tests on Six Domestic Open Fire Grates, with the Quantity of Coal Burnt, the Temperature of the Room, and the Smoke Observations made, during the Summer of* 1901, *all used (one after the other) for Heating the same Room and Burning the same Smoky Coal. Mean Results of Three Days' Tests on each Grate for Eight Hours each Day.*

Name and Number of Grate.	Amount of dry coal burnt (plus half the weight of wood for lighting) in eight hours in pounds.	Amount of unburnt residue left in the grate at the end of the day in pounds.	Number of stokings per day of eight hours.	Mean temperatures of the air in degrees Fahrenheit.				Degree of smoke by smoke scale or average intensity by observation. Mean three days.
				In the hall.	At the end of the room.	In front of the fire.	The mean of columns 6 and 7 less column 5; or rise of temperature.	
Florence—No. 4	19.00 Coal + 0.75 Wood	2.0 = 10.1%	4.0	67.8	77.1	92.6	17.0	$\frac{1}{4}$
					Mean 84.8			
"Tropic" Helyear—No. 3	22.60 Coal + 0.75 Wood	1.7 = 7.2%	4.0	74.8	78.4	91.6	10.2	$\frac{6}{10}$
					Mean 85.0			
Teale—No. 2	26.30 Coal + 0.75 Wood	4.0 = 14.8%	5.7	72.2	76.2	92.0	11.9	$\frac{6}{10}$
					Mean 84.1			
No. 1, old; name unknown; no blower	30.10 Coal + 0.75 Wood	5.0 = 16.2%	9.3	66.1	Not taken.		...	$\frac{8}{10}$
Well Fire—No. 5	28.0 Coal + 1.0 Wood	3.3 = 11.4%	5.0	71.0	76.0	91.6	12.8	$1\frac{1}{10}$
					Mean 83.8			
No. 1A (old), with blower; same grate as No. 1	35.50 Coal + 0.75 Wood	4.0 = 11.0%	10.6	70.8	75.6	94.7	14.3	$1\frac{1}{10}$
					Mean 85.1			
Smith & Wellstood—No. 6	27.60 Coal + 0.75 Wood	2.7 = 9.5%	5.6	72.3	76.9	92.3	12.3	$1\frac{6}{10}$
					Mean 84.6			

The temperatures of the room, &c., were taken every half hour. These tests are placed approximately in order of merit. See also Plotted results. The experiments were carried out by Dr. H. A. Des Vœux and the late Mr. Bryan Donkin, M.I.C.E., M.I.M.E., &c., with two assistants (Messrs. R. Hawkins and J. W. Smith).

TABLE II.—*Tests on Six Domestic Open Grates in London. Details of Smoke Observations. See Smoke Scales 0 to 5. Observations every Five Minutes during Eight Hours = 96 per day. Twenty-three Days' Tests, Seven to Eight Hours, Burning the same Coal and Heating the same Room. Maximum Smoke at Lighting Up and after each Stoking. Warm Summer Weather, June, July, and August* 1901.

Number of Grate.	Name of maker, &c.	Date of test and number of hours. Date.	Hours.	Number of smoke chart.	Smoke Results, Nos. 0 to 5 Smoke Scale. Mean for the whole day.	Lighting up only.	Maximum during the whole day.	Minimum during the day.	Other notes on smoke.	Mean for the three days of each grate (Column 6).
No. 1 (without blower)	Existing grate in room, name unknown	1901. June 27th	7	1	1 (barely)	2 for 15 minutes	2	½ for 30 to 40 minutes	Never 0	$\frac{6}{10}$
	,,	,, 28th	8	2	$\frac{6}{10}$	1½ for about half-an-hour	2 for 2 minutes	¼ for some hours	,,	
	,,	July 1st	8	3	$\frac{5}{10}$ (barely)	2 to 2½ for one hour	2½ for a few minutes	0 to ¼	Zero at end of the day only	
No. 1*a* (with blower)	,,	,, 3rd	8	4	1 (fully) (1.1)	1¼ to 2¼ for one hour.	2¼ six times for a few minutes each	¼ for one and a half hours	Never zero	$1\frac{1}{10}$
	,,	,, 4th	8	5	1¼	1½ to 3 for one hour	2 and 3 seven times for a few minutes each	½ for one and a half hours	,,	
	,,	,, 5th	8	6	1 (fully) (1.1)	2 to 3 for half-an-hour	3; 1½ nine times for some minutes	½ (about) for one hour	,,	
No. 2	Teale "Front Hob"	,, 10th	8	7	¾	1½ to 2½ for half-an-hour	2½; two to four times for a few minutes	0 to ½ for three hours (about)	Zero or no smoke for one hour	$\frac{6}{10}$
	,,	,, 11th	8	8	½	1 to 2 for half-an-hour	2; 1 to 1½ five times for one and a half hours	0 to ¼ for four and a half hours (about)	Zero for two hours	
	,,	,, 12th	8	9	½ (fully)	2 to 2½ for three-quarters of an hour	2½	0 to ¼ for five and a half hours	Zero for three and a half hours	

No. 3	Helyear "Tropic"	,, 17th	8	10	$\frac{7}{10}$	1¼ for three hours	1	0 for one and a half hours	Zero to ½ for four hours	$\frac{6}{10}$ (barely)
	,,	,, 18th	8	11	½	1¼ for one hour	1¼	0 to ¼ for four hours (about)	0 for two hours	
	,,	,, 19th	8	12	½ (barely)	1½ for half-an-hour	1½	0 to ¼ for four hours	0 for one hour	
No. 4	Florence	,, 23rd	7	13	⅓ (fully)	¼ to ½ for one hour	1	0 to ¼ for three and a half hours	0 for two hours	¼ (minimum of all grates)
	,,	,, 24th	7	14	$\frac{2}{10}$ (barely)	,,	1½ for three minutes	0 to ¼ for five hours (about)	0 for three and a half hours	
	,,	,, 25th	8	15	¼ (barely)	¼ for one hour	1 for 20 minutes	0	0 for five hours	
No. 5	Well Fire	,, 31st	8	17	1¼ (fully)	2 for half-an-hour	2	¼ for half-an-hour	Never zero	$1\frac{1}{10}$ (fully)
	,,	August 1st	8	18	1 (barely)	2 and 2¼ for half-an-hour	2¼	Zero at end of the day for half-an-hour	¼ for one hour	
	,,	,, 2nd	8	19	1 ,,	2½ for half-an-hour	2½	¼ for one hour	0 for one hour	
No. 6	Smith and Wellstood	,, 8th	7½	21	1¾ (barely)	2½ to 3 for three-quarters of an hour	3; five times 2 to 3	¼ for three-quarters of an hour	Never quite zero	$\frac{6}{10}$ fully (maximum of all grates)
	,,	,, 9th	8	22	$1\frac{6}{10}$	2½ to 3½ for one hour	3½	1 for two hours	,,	
	,,	,, 10th	8	23	$1\frac{6}{10}$	2½ to 3¼ for three-quarters of an hour	3¼	⅞ for one hour	,,	

the unburnt cinders were weighed and the amount deducted from that of the coal put during the day on the fire. Throughout each day another assistant in an upper room of a house on the opposite side of the street at an angle of about 30° from the top chimney and about 35 feet away, commanding a clear view of the chimney which carried the smoke of the stove under investigation, was directed to observe the intensity of the smoke. The amount of smoke emitted was carefully recorded on a chart every five minutes by means of a series of the smoke tints (Fig. 10) used by the late Mr. Bryan Donkin. There was no communication between the two assistants, and members of the jury visited the respective rooms from time to time to satisfy themselves that the tests were being carefully carried on and the results correctly noted.

On the completion of the tests, which together occupied some weeks (one week being devoted to the setting, testing, and removal of each grate), the results of the observations were carefully tabulated. The amount of smoke emitted from the chimney was averaged. The amount of coal consumption in each case was also carefully averaged.

A certificate was awarded by the Coal Smoke Abatement Society to the successful competitors indicated in the order of merit.

The owners of the "Well Fire Grate" (Bowes' patent) say, "that in their opinion the results of the tests made by the Coal Smoke Abatement Society, and published in the *Lancet* (which we have republished), were quite impossible if the 'Well Fire' had received fair treatment, because the fireplace will burn the greater part of the day in a clear incandescent state, quite free from smoke, which must give off less smoke than a fireplace that requires replenishing several times during the day. This result is obtained by the introduction of the fire-brick regenerative hot-air chamber, which provides a continuous supply

TABLE III.—*Summary of Tests on Four Domestic Open Fire Grates, with the Quantity of Coal Burnt, the Temperature of the Room, and the Smoke Observations made, during the Months of February and March* 1903, *all used (one after the other) for Heating the same Room and Burning the same Smoky Coal. Mean Results of Three Days' Tests on each Grate for Eight Hours each Day.*

Name and Number of Grate.	Amount of dry coal burnt (minus cinders, plus half the weight of wood for lighting) in eight hours in pounds.	Amount of the ashes left in the grate at end of the day in pounds.	Average number of stokings per day of eight hours.	Mean temperatures of the air in degrees Fahrenheit. (*a*) In the hall.	(*b*) In the room.	(*c*) Difference between (*a*) and (*b*).	(*d*) In another part of the room.	Degree of smoke by smoke scale or average intensity by observation. Mean three days.
Tropican—No. 2 (Chavasse and Kerr)	26.66 Coal − 3.41 Cinders 23.25 + 0.312 Wood	1.06 = *4.5%	5.33	54.37	71.68	17.31	71.66	2/10
Landers'—No. 3	32.00 Coal − 3.50 Cinders 28.50 + 0.375 Wood	1.41 = *4.9%	6.33	52.13	68.07	15.94	67.87	1/2 (fully)
Bratt, Colbran, & Co.—No. 1	36.33 Coal − 1.80 Cinders 34.53 + 0.437 Wood	1.06 = *2.13%	6.0	46.64	63.33	16.69	63.37	8/10
Francombe's—No. 4 . .	34.66 Coal − 2.43 Cinders 32.23 + 0.375 Wood	1.10 = *3.37%	5.6	49.09	64.05	14.96	63.35	I 3/10

* Percentage amount of ashes to total amount of coal - cinders + half wood.

of superheated air for combustion purposes, and also keeps up its heating capacity with economy."

Results of two tests subsequent to the tests made by the Coal Smoke Abatement Society:—

No. 1 Test.

Results of a test carried out in a large public institution by an independent expert appointed by the management committee.

No. 1 is an ordinary heavy cast-iron grate.

No. 2 is a special grate with a fire-brick bottom.

No. 3 is an ordinary slow combustion grate.

Nos. 4 and 5 are two of the best known and most perfect types of modern patent grates.

No. 6 is Bowes' Patent Well Fire.

	Coal Consumed.		Pounds of coal consumed per degree of increased temperature per hour.
	Total.	Per Hour.	
No. 1. Ordinary grate .	196 lbs.	3.266 lbs.	.0933
No. 2. Special grate .	126 lbs.	2.100 lbs.	.0715
No. 3. Slow combustion grate . .	209 lbs.	3.483 lbs.	.0844
No. 4. Patent grate . .	151 lbs.	2.516 lbs.	.0596
No. 5. Patent grate . .	207 lbs.	3.450 lbs.	.0890
No. 6. Well Fire . .	112 lbs.	1.833 lbs.	.0484

The test extended over a period of sixty hours, during which time the temperature was taken every hour.

The six rooms were identical in size and position.

No. 2 Test.

A test made with a 14-inch Raby "Well Fire" in a room measuring 15 feet by 15 feet by 9 feet 6 inches gave the following results:—

The fire burned for 50 consecutive hours.

The total consumption of coal was 74 lbs.

The average temperature outside was 47°, and inside 70°.

The temperature was raised from 53° to 76° in 1½ hours.

The fire burned for 23 hours without attention or feeding.

The residue after 50 hours' burning and consumption of 74 lbs. of coal was: Cinders, 3½ lbs.; fine ash, 3½ lbs.

Thomas Helyear also points out in connection with the report of the Coal Smoke Abatement Society, published in the *Lancet*, May 10, 1902 (see p. 129), "That the 'Tropic Grate' was tested during the three days of highest shade temperature, viz., 88°, 86°, and 90°. Therefore it was much more difficult for the grate to raise the temperature, say 10°, than for the other grates tested which worked or were tested during days in which the shade temperature was much less.

"This point was not noticed by the Society; also the 'Tropic Grate' does not heat by *radiant heat* as much as by *diffusive heat*.

"It is easy to raise the temperature of a room 30° in *winter*, say from 40° to 70°, but to raise the temperature 30° in *summer* with the thermometer at 86° in the shade would be very difficult.

"Stoking is not required so much with the 'Tropic Grate,' as all the heat is utilised, and thereby smoke is lessened."

CHAPTER VIII

CHIMNEYS AND THEIR CONSTRUCTION

Height of Chimneys—Perforated Radial Brick Chimneys—Size of Chimneys for Steam Boilers.

A CHIMNEY is the passage by which the smoke and fumes made in the furnace escape into the atmosphere, and is practically an absolutely essential part of the furnace. Without it the furnace would be useless, as it is the chimney which creates the draught, and so facilitates efficient combustion.

Height of Chimneys.—The draught depends largely on the height of a chimney; if it is low there is but little draught, and there is very imperfect combustion; hence the fires burn sluggishly and yield little heat. But if the chimney is high the draught is keen, great heat is generated, and the result is complete combustion. With a low chimney, and an insufficiency of natural draught, it is absolutely essential to employ *forced or induced draught* to procure the necessary heat. The chimney being the principal part of the furnace, Section 91 of the Public Health Act, 1875, provides what height it shall be to produce the draught required, or the alternative provision of an artificial draught, so as to consume, as far as practicable, the combustible used in the furnace.

There are a few Authorities who have a special Local Act which determines the minimum height of chimneys for both furnaces and fireplaces, but the great majority have no such Act, neither do they enforce Section 91 of the Public Health Act. To fix a uniform minimum

height for chimneys in a flat district would be perfectly satisfactory, but in a hilly district it would be quite wrong. The wiser course is to consider each case, the furnace, the district, and the surrounding buildings, before determining what the height ought to be. A very fair percentage of boiler chimneys are of reasonable height, ranging from 80 to 200 feet and more, but there are a great number which are much too low, and ought to be raised to the requisite height.

In Sheffield and other places a few metallurgical furnaces are served by chimneys of reasonable height, from 80 to 150 feet. One chimney will serve from three to twelve furnaces. Many furnaces are served by the boiler chimneys, and in each case the results, both from an economical and from a smoke abatement point of view, are all that can be desired. But 90 per cent., if not more, of these furnaces are served by a low chimney, from 20 to 30 feet high, each furnace having generally a separate chimney. It is claimed that low chimneys are necessary, and that if they were higher the draught would be too keen, and would spoil the steel. This is about the only reason which is put forward in favour of low furnace chimneys, although such furnaces are, in many cases, actually being worked by high chimneys, the draught being regulated by the damper to suit the exact requirements of the furnace, while the work done is equal, if not superior, to that effected in furnaces served by low chimneys. The real reason for putting up low chimneys instead of high ones is their lower cost. But although the initial cost is less, the working and waste of fuel amount in a few years to a great deal more than the difference in cost of a low and a high chimney, so that if manufacturers would serve their own interests in this particular they would serve those of the public at the same time.

A certain works in Sheffield is situated in a street where there is a great amount of vehicular and pedestrian

traffic. The works possesses thirty small reheating furnaces, served by as many chimneys not more than 20 feet high. For small furnaces they do a great amount of work, being frequently very much forced, and fired by boys who consider the work as an *extra*, as they are paid for the amount of work done on the machines. The firing is thus very heavy, and is very carelessly done. It is a common occurrence for the whole of the chimneys to be sending forth volumes of black smoke at the same time, and, being emitted at such a low level, the surrounding streets and houses are literally filled with smoke. To remedy this state of affairs a chimney 180 feet, at least, ought to be erected, with a main flue to which the flues of the thirty small reheating furnaces could be connected, and a damper provided for each furnace to regulate the draught. If this were done, the output of the furnaces would be increased by the generation of more heat through increased draught, and the combustion in the furnace would be more complete; hence very little smoke would be emitted, and there would be a saving of fuel.

Perforated Radial Brick Chimneys.—This method of building chimneys was originated by Alphons Custodis in Germany some thirty years ago, since which time the company has built over four thousand chimneys in all parts of the world.

The great popularity of this class of chimney in the United States, its adoption by the Government and by many representative industries, is very practical proof of the reliability of the work of construction, and the benefits derived from tall chimneys.

In the various industries the chimneys are used for greatly different purposes; their height ranges from 30 feet to 365 feet. The latter, the tallest chimney in America, at the works of the Oxford Copper Company, Constable Hook, N.J., is one of the most conspicuous objects in New York Harbour.

For chemical works, metal refiners, furnaces, &c., where the gases are of such nature or temperature as to disintegrate the brick, it is necessary to protect the walls of chimneys with refractory or acid-proof linings, and sometimes to band the chimneys externally with iron hooks to guard against effects of explosions.

Round chimneys are more effective for draught purposes than square or octagonal forms, and better withstand the violence of storms.

Common bricks are not adapted for laying circles, as

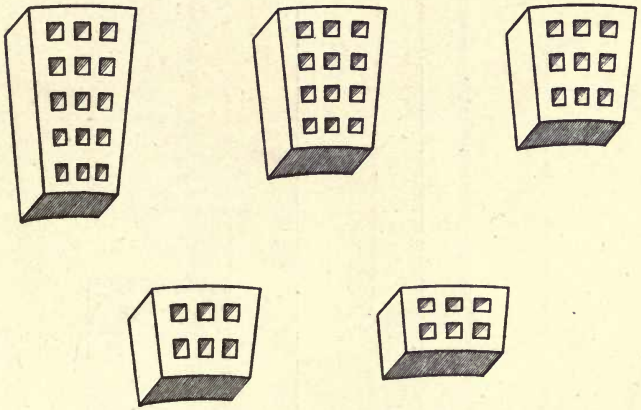


FIG. 11.—Perforated Radial Bricks.

they require constant clipping to make them fit, and excessive use of mortar to fill voids. Common bricks also vary greatly in quality, no consideration being given in their manufacture to the use to which they will be applied; hence the advantage of specially prepared material over ordinary materials.

The sectional elevation (Figs. 12 and 13) show that the chimneys are greater in internal diameter at the bottom than at the top. While the capacity is determined by the top diameter, a greater area is provided at the point of entrance, where the gases are the hottest and occupy the most space.

With this design the average internal area is greater than if the chimney was of uniform diameter throughout;

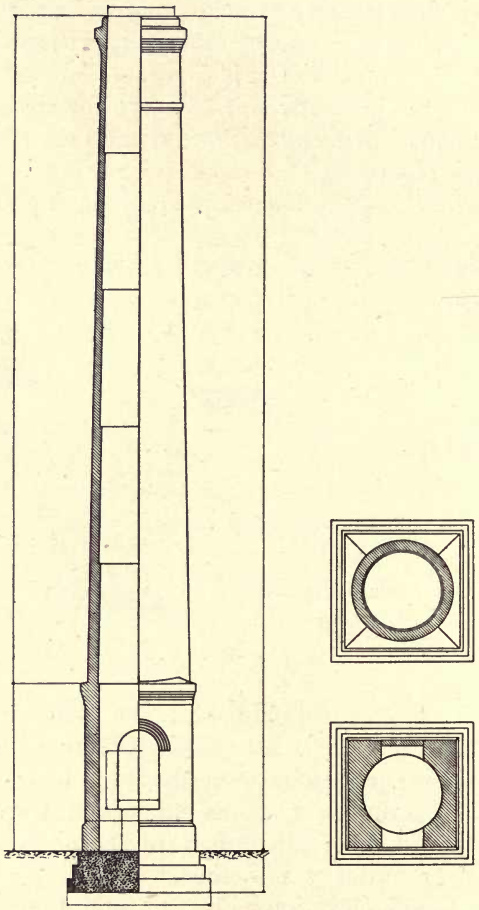


FIG. 12.—Elevation and Section of Chimney with Square Base, with Arched Opening in Base for Connecting Over-ground Flue.

consequently there is a considerable reduction in frictional resistance along the sides of the chimney opposing the flow of gases.

The blocks used in this system are formed to suit the circular and radial lines of each section of the chimney,

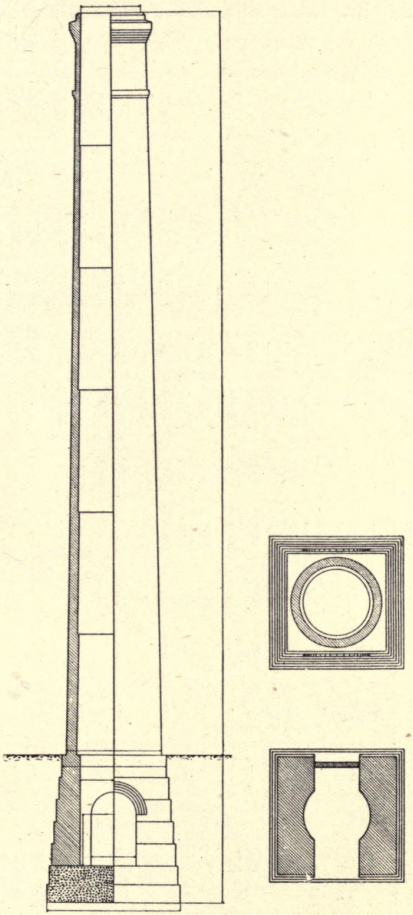


FIG. 13.—Elevation and Section of Chimney with Arched Opening in Foundation for Connecting Under-ground Flue.

so that they can be laid with thin, even mortar-joints, and regular, smooth surfaces. The blocks are much larger

KENT'S TABLE OF SIZE OF CHIMNEYS FOR STEAM BOILERS.

Formula: $H.P. = 3.33 (A - 0.6 \sqrt{A}) \sqrt{H}$. (Assuming 1 H.P. = 5 lbs. of coal burned per hour.)

Diameter. Inches.	Area A Sq. Feet.	Effective Area, $E = A - 06. \sqrt{A}$ Sq. Feet.	Height of Chimney. Commercial Horse-power of Boiler.													Equivalent Square Chimney. Side of Square, $\sqrt{E} + 4$ in.
			50 ft.	60 ft.	70 ft.	80 ft.	90 ft.	100 ft.	110 ft.	125 ft.	150 ft.	175 ft.	200 ft.	225 ft.	250 ft.	300 ft.	
18	1.77	.97	23	25	27	29	...	...	...	...	...	...	...	...	...	...	16
21	2.41	1.47	35	38	41	44	...	...	...	...	...	...	...	...	...	...	19
24	3.14	2.08	49	54	58	62	66	...	...	...	...	...	...	...	...	...	22
27	3.98	2.78	65	72	78	83	88	...	...	...	...	...	...	...	...	...	24
30	4.91	3.58	84	92	100	107	113	119	...	...	...	...	...	...	...	...	27
33	5.94	4.48	...	115	125	133	141	149	156	...	...	...	...	...	...	...	30
36	7.07	5.47	...	141	152	163	173	182	191	204	...	...	...	...	...	...	32
39	8.30	6.57	...	...	183	196	208	219	229	245	...	...	...	...	...	...	35
42	9.62	7.76	...	...	216	231	245	258	271	289	316	...	...	...	...	...	38
48	12.57	10.44	...	...	...	311	330	348	365	389	426	...	...	...	...	...	43
54	15.90	13.51	...	...	...	...	427	449	472	503	551	595	...	...	...	...	48
60	19.64	16.98	...	...	...	...	536	565	593	632	692	748	...	...	...	...	54
66	23.76	20.83	...	...	...	...	...	694	728	776	849	918	981	...	...	...	59
72	28.27	25.08	...	...	...	...	...	835	876	934	1023	1105	1181	1253	...	...	64
78	33.18	29.73	...	...	...	...	...	...	1038	1107	1212	1310	1400	1485	1565	...	70
84	33.48	34.76	...	...	...	...	...	...	1214	1294	1418	1531	1637	1736	1830	2005	75
90	44.18	40.19	...	...	...	...	...	...	...	1496	1639	1770	1893	2008	2116	2318	80
96	50.27	49.01	...	...	...	...	...	...	...	1712	1876	2027	2167	2298	2423	2654	86
102	56.75	52.23	...	...	...	...	...	...	...	1944	2130	2300	2459	2609	2750	3012	91
108	63.62	58.83	...	...	...	...	...	...	...	2090	2399	2592	2771	2939	3098	3393	96
114	70.88	65.83	...	...	...	...	...	...	...	...	2685	2900	3100	3288	3466	3797	101
120	78.54	73.22	...	...	...	...	...	...	...	...	2986	3226	3448	3657	3855	4223	107
132	95.03	89.18	...	...	...	...	...	...	...	...	3637	3929	4200	4455	4696	5144	117
144	113.10	106.72	...	...	...	...	...	...	...	...	4352	4701	5026	5331	5618	6155	128

For pounds of coal burned per hour for any given size of chimney, multiply the figures in the table by 5.

than common brick, and on this account the number of mortar-joints is reduced one-half.

In addition to being so shaped, the blocks are moulded with vertical holes or perforations (Fig. 11) to permit of more thorough burning in manufacture, thus increasing their density and strength while reducing the weight. Perforations also serve to form a dead air space in the walls of the chimney, preventing the rapid heating and cooling of the wall, and causing maximum draught by conserving the heat.

In laying the blocks the mortar is worked into the perforations about one half-inch, effectively locking the blocks together, and making the wall of the tightest possible construction.

The table on p. 158 gives the data of the principal dimensions to be observed in furnace construction.

CHAPTER IX

SMOKE PREVENTERS AND FUEL SAVERS

Mechanical Appliances—Testing Smoke-preventing Appliances—Ellis and Eaves System of Induced Draught—Tests on Boilers—Jones Underfeed Mechanical Stoker—"Koker" Stoker (Meldrum's Patent)—Sprinkler Stoker—Bennis Patent Self-cleaning Furnace—Underfeed Stoker.

DURING the last fifteen years, in Sheffield and other places, manufacturers have tried quite a number of so-called smoke preventers and fuel savers, and they have abandoned them owing to unsatisfactory results. In some instances the appliance was responsible, in others the men in charge of the appliances, and in many cases the manufacturers were badly advised as to the kind of apparatus to attach to boilers or furnaces. Their experience has been a costly one, for many have spent thousands of pounds in first trying one patent and then another, as they were most anxious, regardless of expense, to prevent the smoke nuisance. The result has been that they are now prejudiced against smoke preventers, so that even an efficient machine, which has been proved to be both a smoke preventer and a fuel saver, has little chance of being adopted. It is quite natural for manufacturers to feel strongly in this matter, but it is unfair, because a few worthless appliances have been thrust on the market, to condemn all.

Mechanical Appliances.—Mechanical genius has not been dormant with regard to smoke preventers. There are numerous appliances in the market, and almost every conceivable kind of arrangement, simple and complex. Some, if not very carefully handled, are smoke

makers and fuel wasters, while others are practically perfect as smoke preventers, and effect great economy. They may be classified as follows: 1. Induced draughts; 2. Forced draughts; 3. Mechanical stokers, underfeed stokers and sprinklers, and cokers; 4. Patent bars, hollow and movable, &c.; 5. Furnace-door arrangements; and 6. Bridge arrangements.

In the great majority of cases the conditions of working are such that it is absolutely necessary to have some kind of mechanical arrangement to always prevent smoke, and manufacturers would act wisely by calling in an expert to advise them as to which appliance is the most suitable for them. It is not surprising that so many of the appliances are taken off and condemned as unsatisfactory, considering the rough and unreasonable treatment they so frequently receive. Amongst a certain class of engineers and firemen there is an antipathy to any kind of appliance, and these men are, in no small degree, responsible for the unfavourable reputation such appliances obtain, but which many of them do not deserve.

Testing Smoke-preventing Appliances. — The tests which some appliances are subjected to are not fair tests, and it is impossible by these means to find out whether a given appliance is an efficient smoke preventer or not. To do this effectively it is necessary that the tests should be made by persons whose only object would be to ascertain scientifically the worth or otherwise of the appliances.

Many tests have been made at various periods in the past by patentees, municipalities, and Smoke Abatement Associations. But nearly all these tests have been confined to appliances for preventing smoke and saving fuel from boilers. Boilers have had a great deal of attention from the expert, and much has been accomplished by mechanical and other means. The prevention of smoke from metallurgical furnaces equally demands investigation. In the meanwhile great care is necessary in the

selection of an efficient appliance. There are smoke preventers and fuel savers which embody the results of exceptional experience, and after years of work have proved themselves preventers of smoke and economisers. It is impossible to notice all the excellent appliances now on the market which give satisfaction, but a few excellent representatives of each class will be described.

The Ellis and Eaves System of Induced Draught.—In 1830 engineers recognised the value of mechanical over natural draught where the height of the chimney was restricted, as in steam vessels.

The first real impetus given to the introduction of mechanical draught was in 1884, which was produced by a fan or fans. The Ellis and Eaves system is a combination which embodies all the advantages of an intensified natural draught, together with the undoubted economy to be gained by heating the air of combustion before entering the fires. This is achieved by placing an exhausting fan at the base of the funnel, with an air-heating apparatus between the smoke-box and the fan inlet, through which the waste gases pass on their way to the fan, the air of combustion also passing through this heater on its way to the furnaces. By this arrangement not only is the air heated, but the waste gases are cooled to such an extent, that they can be handled by the fan with perfect safety, even at the very highest rates of combustion in the furnaces.

Mechanical draught has many advantages. 1. If the boilers are well constructed, and are provided with ample room to ensure circulation, their steaming power may, without injury, be increased to 30 per cent. over that obtained by the natural draught for continuous working. 2. Such augmentation is accompanied in normal cases by an increased consumption per indicated horse-power. 3. It enables an inferior fuel to be used. 4. Under certain conditions of weather it would be difficult to maintain steam with natural draught, but with forced draught the

power is ensured. 5. Much thicker fires can be worked than with natural draught, causing the air to travel through incandescent fuel, with more time to give up its oxygen, while the intensity of the draught through the incandescent fuel causes a more intimate mixing of the air

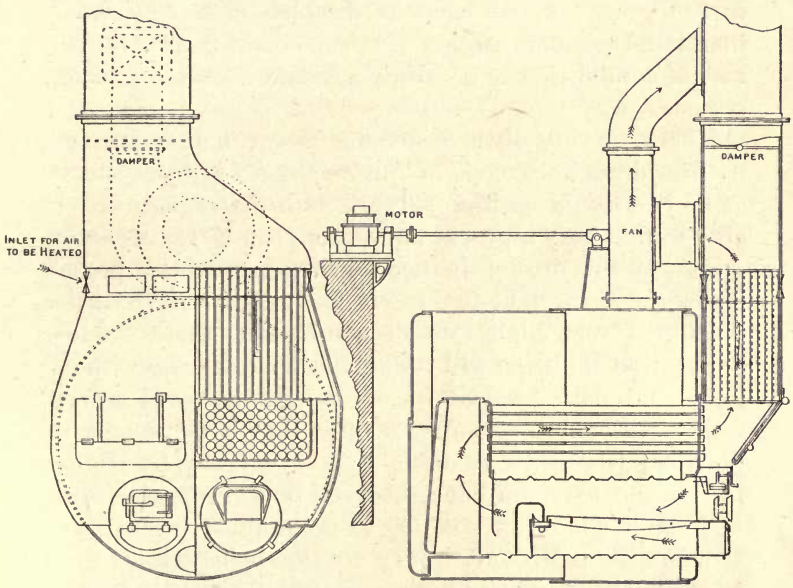


FIG. 14.—The Ellis and Eaves (Patent) System of Induced Draught as applied to Land Boilers, an Electric Motor being used to drive the Fans.

with it than is possible with ordinary chimney draught (Fig. 14).

There is a partial vacuum at all the casings, &c., from the furnaces to the fans, so that there can be no tendency for dust to blow out through any crevices which may exist in the casings. The stokers, instead of being enveloped in an atmosphere of coal dust, have pure air to breathe. A certain amount of air is admitted under the grates direct from the stokehole; this further tends to

draw away all dust, and also causes a constant circulation of air. In the case of a breakdown of boilers, as in electric light works, for instance, it is possible with induced draught to increase the evaporation of those remaining 50 per cent., which means that if in a battery of three boilers burning at a normal rate 30 lbs. per square foot of grate bar, one boiler be disabled, it is possible to maintain the steam supply with two boilers increasing the rate of combustion to 45 lbs. per square foot for a short period.

There is very little difference between induced and natural draught, except in the matter of intensity; and as no one would hesitate to work with the draught available from a very high chimney, there can be no objection raised to the use of induced draught provided proper precautions are taken. It is not wise to advocate a continued very high rate of combustion, as experience proves that no boiler will stand continued forcing without injury, no matter what form of draught is used; still it seems reasonable to suppose (and this is borne out in practice) that with a draught in every way similar, as far as the fires are concerned, to one of nature's own making, it should be possible to maintain a higher rate of combustion without injury to the boilers, than with a form of draught differing essentially from nature's methods.

The gases on leaving the smoke-box pass upwards through the air-heating boxes, and from thence direct to the fan, the fans discharging directly into the funnel, so there is little loss due to tortuous passages, and in actual practice it is found that the vacuum in the smoke-box is the same as at the fan inlet.

The air heater can be of two forms. It may be composed of long horizontal tubes placed in boxes above the boiler, and so arranged that the hot gases enter these boxes directly from the smoke-box and circulate round the tubes on their way to the fan inlet, the air to be

heated being drawn through the tubes on its way to the furnace fronts. Or it may be composed of a number of vertical tubes through which the products of combustion pass, having a combined sectional area rather in excess of the area through the tubes in the boiler. As these tubes are necessarily very much shorter than when placed in a horizontal position, some means had to be adopted to compensate for the want of length. Owing to the low specific heat of air, it is found that by bringing it into very close contact with the surface from which the heat is derived, it is easy to raise its temperature even with comparatively short tubes. At a point about one quarter of the length of the heating tubes from the top a diaphragm plate is placed; the holes in this plate through which the tubes pass do not fit the tubes but are $\frac{1}{2}$ inch larger than their outside diameter. The air can circulate freely through the upper portion of the tubes above the diaphragm plate, but to reach the valves on the furnace fronts it is drawn down in thin annular streams round the heated tubes from which it takes up the heat at once.

As the heated air is drawn from the ends of the heating-boxes there would be a tendency for the air entering the annular spaces at the corner of the box furthest from its exit to take the shortest possible course, namely, move in a diagonal direction across the tubes. This is prevented by placing vertical division plates between the tubes, so that no matter where the air enters it is forced to travel over every portion of the heated tubes before escaping, with the result that it is heated to over 300° F. This arrangement is less expensive than the horizontal air-heating tubes, and also takes up much less space above the boiler.

On leaving the heating-boxes the air is led down passages on both sides of the smoke-boxes, and enters the fire through the regulating valves on the furnace mouthpiece or front. Five valves are provided on the furnace front,

as will be seen on reference to Fig. 16. The two lower valves communicate with the ashpit, and the three upper valves with the furnace above the bars. As the air passes through perforated baffle-plates in the ordinary way, the two upper side-valves are only required when an excess

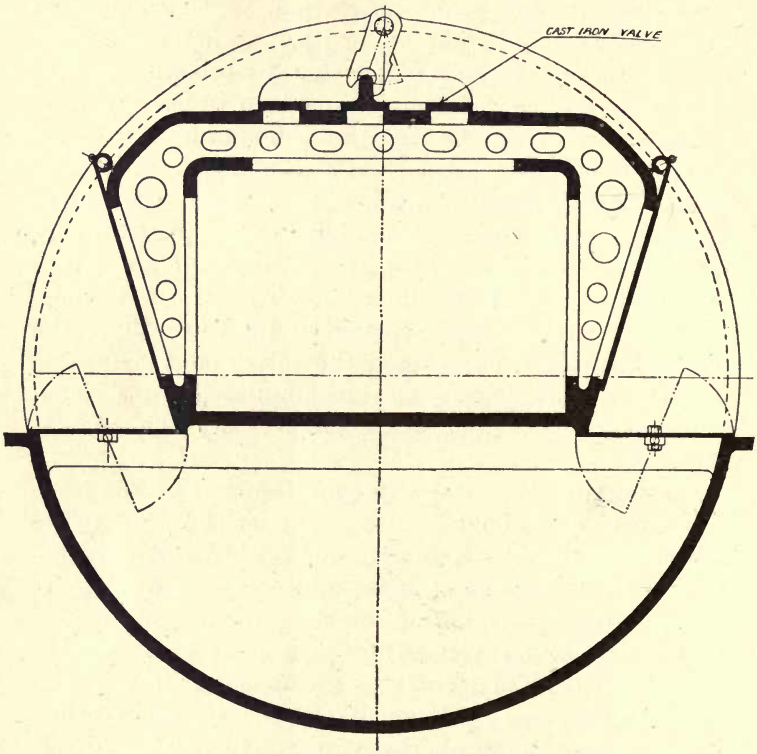


FIG. 15.—Section of Furnace Front.

of hot air is necessary. Under ordinary circumstances plenty of hot air can be admitted above the fires through the valve on top of the furnace fronts (Fig. 15).

A cast-iron ashpit door (Fig. 16) is fitted to the lower portion of the front; this door is perforated with a

number of $1\frac{1}{4}$ inch holes to allow the entrance of a certain proportion of cold air under the bars. In some cases the doors are fitted with a sliding perforated plate at the back to regulate the air admission. A little cold air under the bars in no way affects the economy of the

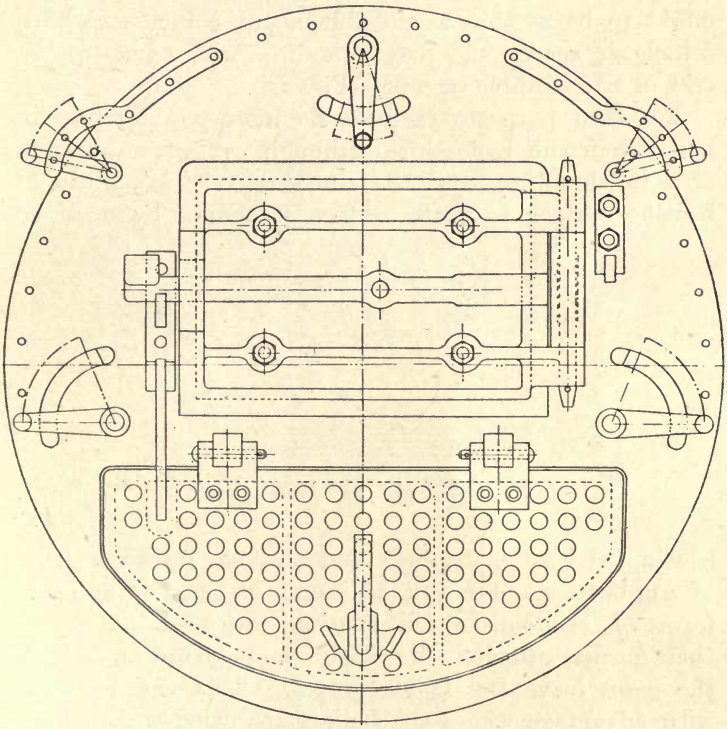


FIG. 16.—Furnace Front.

system, for it has to pass through a mass of incandescent fuel on the bars, which reduces the temperature very slightly. It has an advantage in that it keeps the bars and bearers cool, and this is very essential when burning at a very high rate.

For all rates of combustion ordinary cast-iron bars

may be used, but it has been found advisable in most instances to raise the grates 2 inches higher at the bridge than at the mouth of the furnace, the usual practice being to make the back end of the bars level with the centre line of the furnaces, the dead-plate and door being kept 2 inches lower than the centre. The bars ought to be as thin as possible, about $\frac{5}{8}$ inch full, with $\frac{3}{8}$ inch air spaces, and may sometimes with advantage be cast in sets of three or more (Fig. 17).

For land purposes there is no more popular type of boiler than the Lancashire, although, owing to the large area in the flues, and the comparatively low ratio of heating surface to grate surface, it cannot by itself be

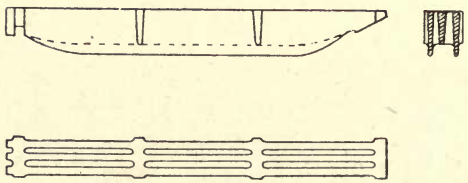
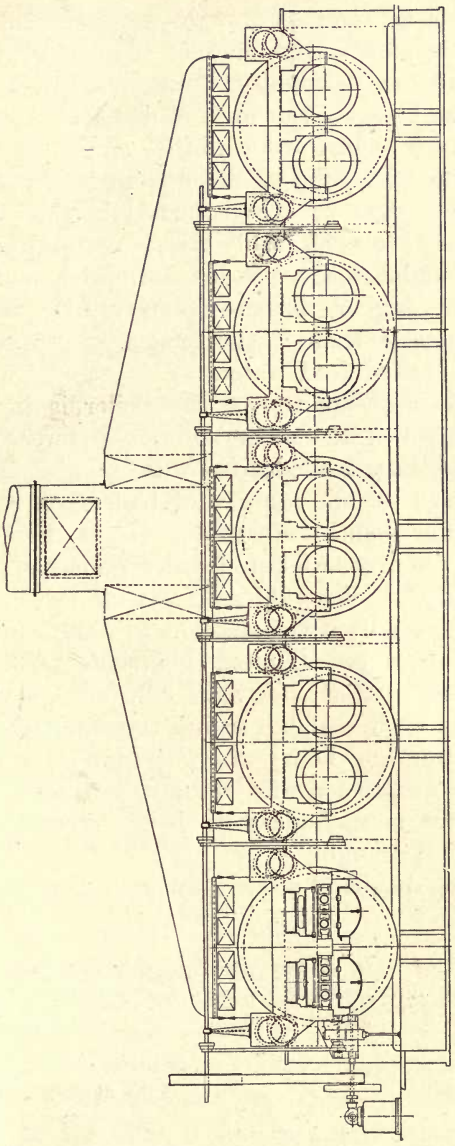


FIG. 17.—Fire Bars.

considered very economical and suitable for high rates of combustion. For this reason it is usual to fit some form of economiser for heating the feed water, by this means utilising the high temperature at which the gases leave the boiler proper. This can be done with advantage where the boilers are fitted with a high chimney of ample capacity.

An economiser, placed between the boiler and the chimney, is an obstruction to the passage of the gases, hence the temperature at the base of the stack is reduced, unless there is sufficient draught to overcome the obstruction. What is gained by heating the feed water is lost through defective draught, and the result is poor combustion and smoky fires.



Front Elevation.

FIG. 18.—Battery of Five Lancashire Type Boilers, fitted with the Ellis and Eaves System of Induced Draught and Mechanical Stokers.

With the hot air induced draught it is different, as an inducing fan is part of the system. The waste heat is arrested as in an economiser, but instead of being returned to the boiler in the form of hot feed water it is returned to the fires in the form of *hot air for combustion*, and by this the advantage of the system is apparent, as for every 100 degrees of heat returned in this way the furnace temperature is probably raised 200 degrees, due to improved combustion, hence less formation of smoke, owing to the higher furnace temperature, and the economy is greater than if the heat were returned in the shape of heated feed water.

The evaporating capacity of the boiler is increased upwards of 50 per cent., and the additional power reduces the cost of new installations fitted with induced draught, as only two-thirds of the number of boilers are required to give the same quantity of steam. Hence there is not only the saving in first cost, but also an economy of 20 per cent. in working, which would soon pay off the first cost of installing, especially if the statement be true (made by Messrs. Davy Brothers, Limited, engineers and boiler-makers, Sheffield), "that they have effected a saving of £250 a year in their coal bill (using the same quality of coal) since fitting one boiler with the induced draught." The firm were so satisfied with the results that in a very short time three more Lancashire boilers were fitted up with the induced draught.

The following details of a test may prove of interest:—

Particulars of Test on a Lancashire Boiler 8 *feet diameter by* 28 *feet long, fitted with Ellis and Eaves Patent System of Induced Draught, March* 5, 1902.

Duration of trial	. 6 hours.
Kind of fuel used . . .	. Rothervale washed nuts of average quality.
Average draught at fan suction .	. 2 inches.
Average observed steam pressure	. 84 lbs. per sq. in.

Average temperature of feed water	142 deg. F.
Average temperature of gases entering air heater	795 deg. F.
Average temperature of gases at fan	667 deg. F.
Average temperature of air entering air heater	100 deg. F.
Average temperature of heated air entering fires	324 deg. F.
Average fan revolutions	362 per minute.
Total coal fired	6,480 lbs.
Total refuse	405 lbs.
Percentage of refuse	6.2 per cent.
Coal fired per hour	1,080 lbs.
Coal consumed per square foot of grate per hour	30 lbs.
Water evap. per hour from temp. of feed water (142 deg. F.) to mean boiler pressure (84 lbs. per sq. inch)	10,180 lbs.
Water evaporation per hour from and at 212 deg. F.	11,291 lbs.
Water evap. per lb. of coal from temp. of feed water to boiler pressure	9.42 lbs.
Water evap. per lb. of coal from and at 212 deg. F.	10.45 lbs.
Water evap. per lb. of combustible from temp. of feed water to boiler pressure	10 lbs.
Water evap. per lb. of combustible from and at 212 deg. F.	11.15 lbs.
Water evap. per sq. foot of heating surface from and at 212 deg. F.	13.28 lbs.
Water evap. per sq. foot of grate surface from and at 212 deg. F.	313.6 lbs.
Total water evaporated in six hours	6108.3 gallons.

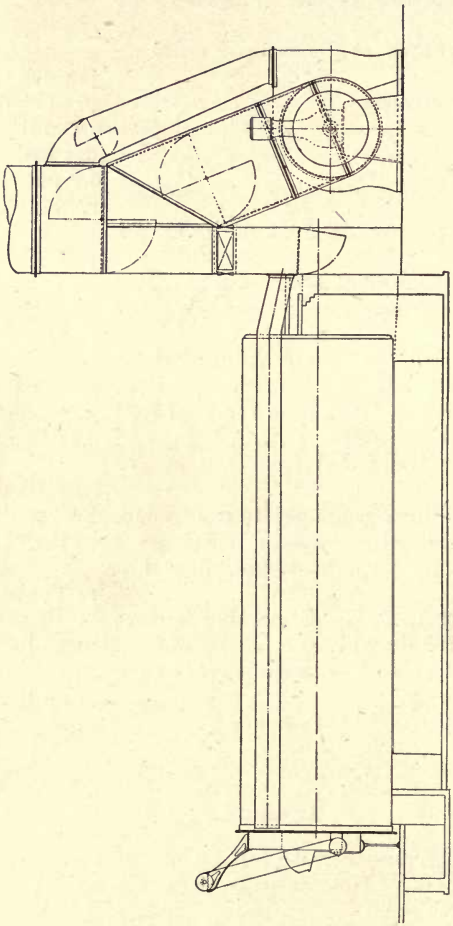
Remarks.

Dampers.—Hot air under grate full open. Hot air over grate sides full open. Hot air over grate top closed. Ashpit door slides closed.

Smoke.—Observations were taken at intervals during the trial, and at no time was smoke visible.

Fires.—The trial started at 9.30 A.M., the fires having been cleaned at 8.30 A.M.

Water.—The tanks for measuring water were placed one on top of the other, the top tank having been previously measured and graduated. This tank was filled, and the water was then allowed to run into the lower tank. The mean tem-



Side Elevation.

FIG. 19.—Battery of Five Lancashire Type Boilers, fitted with the Ellis and Eaves System of Induced Draught and Mechanical Stokers.

perature of the water in the tanks was 62 deg. F. This water was then pumped through one of Green's Patent Economisers, and was there heated by escaping gases from the boiler to a mean temperature of 142 deg. F., at which temperature it was admitted into the boiler.

The Jones Underfeed Mechanical Stoker.—This stoker is manufactured by the Underfeed Stoker Company of America. Fig. 20 shows the stoker complete, ready for installation. It consists of a steam ram with a fuel hopper outside of the furnace proper, and a retort or fuel magazine and auxiliary ram within, tuyere blocks for the admission of air being placed on either side thereof.

Fig. 21 gives a longitudinal cross section of the retort when filled with coal. The ram, as shown, is actuated by steam, and is worked automatically, or by opening the throttle valve as desired. By means of the ram and its auxiliary, fuel is forced underneath the fire, its movement being upward and backward. Green fuel does not reach the fire in any instance, as it is thoroughly coked before rising to the zone of combustion. Air is admitted at low pressure through the openings in the tuyere blocks, as seen in Fig. 22, the air being supplied by a blower operated by a small independent engine, or by connection with a line shaft.

The tuyere openings are at a point above the green fuel in the retort, but below the fire, and thus the air is thoroughly mixed with the gases, which are being liberated from the coking coal below. This combustible mixture of necessity passes upward and through the mass of burning fuel, thereby ensuring complete combustion. There is no waste of gases, so there is no waste of solid fuel, and from a number of tests made during the last five years, it was proved that from one to one and a half per cent. of the saving covers the cost of operation.

A plain view of the fire is obtainable at all times by looking through the fire-doors, or through mica inserted in the doors. The fire has not to be "seen from the rear," as is the case with some inclined grate-stokers, which proves the presence of "blow-holes" in their fires.

There is little to wear out, break or burn, no movable

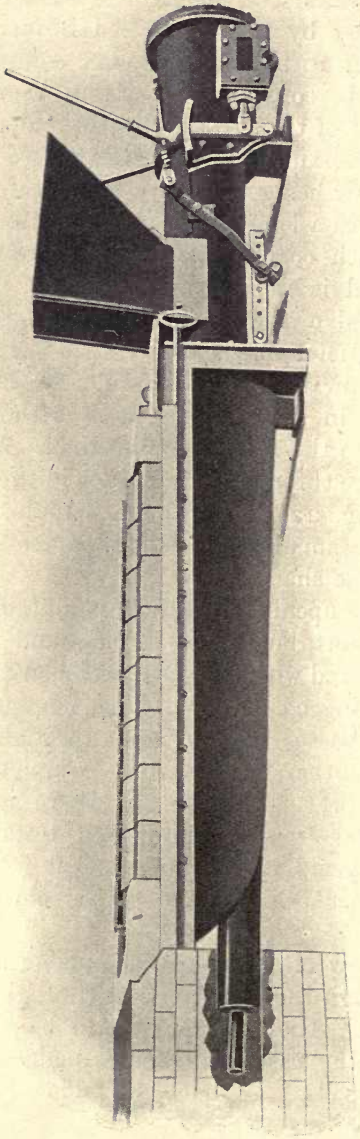


FIG. 20.—Jones Underfeed Stoker ready for use.

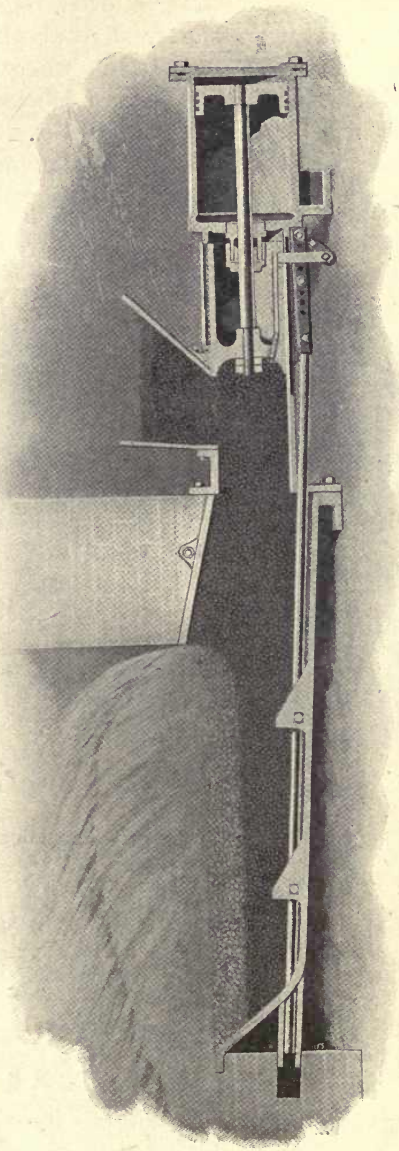


FIG. 21.—Longitudinal Section of Jones Underfeed Stoker in operation.

part exposed to fire. A straight, even, regular thrust of the ram deep down in the fresh coal places the fuel exactly where it is wanted—that is, where it will yield its last degree of heat. The tuyere blocks alone are in contact with the fire, and these (heavy iron castings weighing from twenty to twenty-five pounds each) are protected by the air-blast passing through them. They

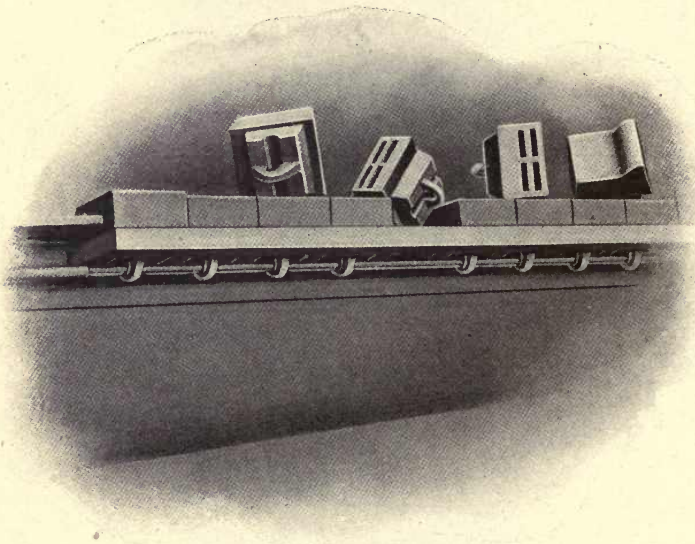


FIG. 22.—Jones Underfeed Stoker—Method of holding Tuyere Blocks in position.

are as durable as grate-bars. When it is necessary to replace one, this can be done while the furnace is in operation. By simply shutting off the air-blast the tuyere block, which is held in position by a rod passing through an eye, can be removed, and a new one inserted without trouble.

The installation is a very simple item, and involves little disarrangement of the existing boiler plant. In a

general way all that is required is the removal of the old grate-bars, the introduction of the fuel retort through an opening in the boiler front, the setting of dead-plates on either side of the retort, and the ordinary steam connections to the ram. All this can be done at a slight cost and with little trouble.

As all the air is supplied by an independent blower, it gives a great increase in boiler capacity, as the amount of coal consumed depends entirely upon the air supplied, and the ability to place the necessary amount of fuel in the furnace at the desired point. By forcing the boilers (although unwise to do so) it is possible to increase the boiler capacity 100 per cent.

Owing to the upward and backward movement of the fuel, the retort is practically self-cleaning. The complete combustion of each atom of combustible matter, secured by the mingling of air with gases at the tuyere blocks, gives the smallest possible amount of ash. The slight residuum is, by the upward movement of new fuel as introduced by the ram, forced outward and upon the dead-plates at either side of the retort, and removed therefrom by a few moments' work at intervals, according to the quality of fuel used and the intensity of fire maintained.

In many plants the saving in labour pays a large percentage on the cost of installation, a saving which alone would make the installation of the stoker a financial gain. In small plants the work of the fireman consists simply in filling the hopper, in the operation of the lever, when necessary to actuate the ram, and at long intervals the removal of the ash. In larger plants, where the automatic stokers are used in connection with the mechanical handling of the fuel and ash, the care of the boiler-room is reduced to a minimum, no skilled labour being required, and it is possible to teach in one day any man of ordinary intelligence to operate the stoker.

Poor grade coal, bituminous, lignite, small slack, or lump coal, not too large for economical hand-firing, are

suitable for the stoker, from which good results, as shown by tests, are obtained. Owing to the fact that 50 per cent. less air is required than in hand-firing, the volume of heated gases passing up the chimney is decreased, and

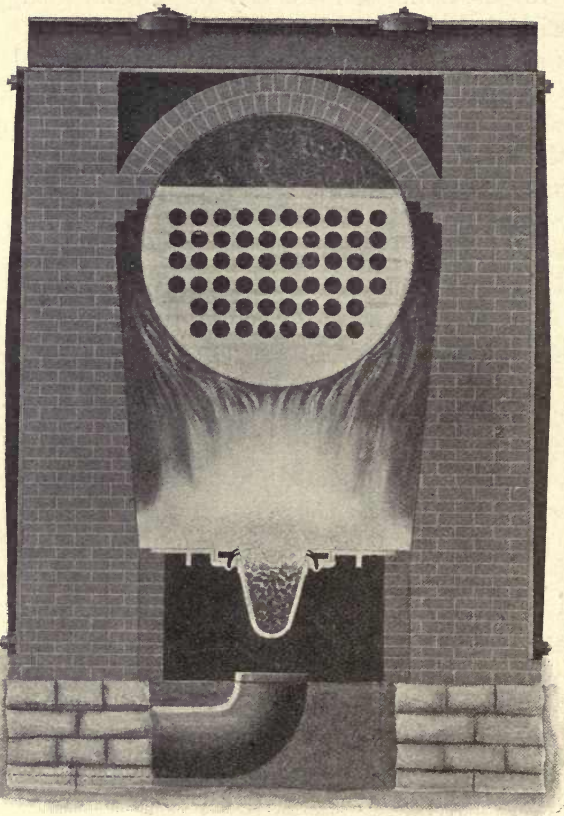


FIG. 23.—Cross Section, Jones Underfeed Stoker, showing Furnace in Application.

the velocity of gases is reduced, allowing more time for the absorption of heat by the boiler surface, and reducing the temperature of the escaping gases. It is difficult to fix a percentage of saving, as the conditions of working

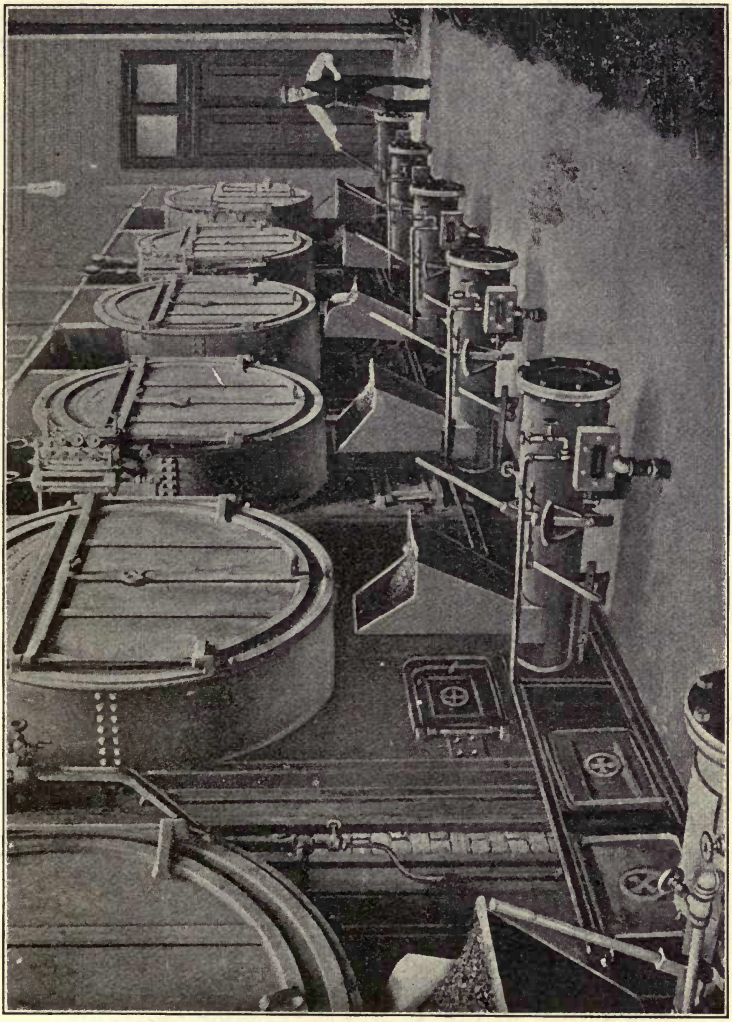


FIG. 24.—Jones Underfeed Stoker applied to a Battery of Boilers.

are so different; the saving is never less than 10 per cent., and sometimes as much as 42 per cent.

By the thorough mixing of the gases with the proper amount of air from the tuyere blocks (which is always under the operator's control), and by passing that combustible mixture through the fire where perfect combustion takes place, smoke is entirely prevented.

The stoker can be adapted to special types of boilers and metallurgical furnaces where intense heat and freedom from smoke are desired.

Figs. 23, 24, and 25 show applications of the Jones Underfeed Stoker, and the details of the retort.

The following report of a trial made at the plant of the Collins-Taylor Company, Cleveland, Ohio, is of interest:—

Firing (hand or stoker)	Hand	Stoker
Boiler (type and size)	Int. fired—Two 42-in. furnaces	
Date	11–9–03	12–11–03
Duration (hours)	10	9
Kind of coal (name and class)	Goschen Mine Run	Salinsville Slack
Cost of coal (per ton)	$2.05 (9s. 9d.)	$1.35 (7s. 1d.)
Steam gauge (lbs.)	87.8	90
Feed temp. (degrees F.)	183	170
Total coal (lbs.)	7336	8544
Coal per hour (lbs.)	735.6	949.3
Total refuse (lbs.)	1053	742.5
Refuse (per cent.)	14.31	8.67
Total water (cubic feet)	911	1096
Total water (lbs.)	55097.28	66603.92
Actual evaporation per lb. coal	7.49	7.79
Evaporation F. and A. 212 per lb. coal	7.994	8.425
H.P. developed	170.45	232.00
Cost to evaporate 1000 lbs. water from and at 212 degrees	$0.1282 (6.41d.)	$0.0801 (1.6d.)
Saving in fuel (per cent.)	...	37.5
Factor of evaporation	1.0673	1.0816

Mr. George C. Tewksbury, Boston (Mass.), read a paper at the New York Meeting of the New England Cotton Manufacturers' Association, October 2, 1902, on the Underfeed Stoker, in which he said: "To Evan William Jones, of Portland, Oregon, alone is due the credit of first inventing an underfeed mechanical stoker that has been successful to a degree almost unknown in mechanical stokers, not only of the underfeed type, but of stokers in general."

The principle of underfeed stoking is an excellent one. In the Jones stoker the application is very simple, and

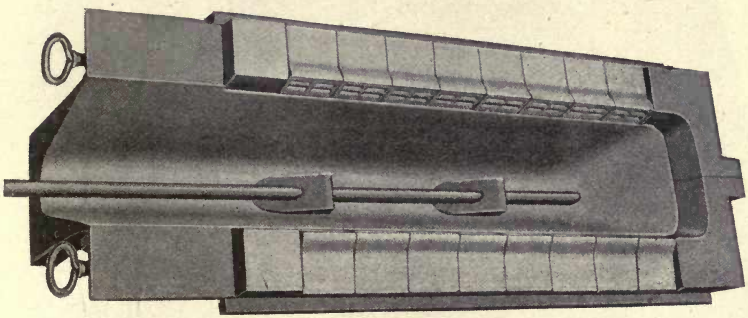


FIG. 25.—Jones Underfeed Stoker, showing the arrangement of the Retort.

the results are most satisfactory, both from a smoke-preventing and an economical point of view.

The "Koker" Stoker, Combined with Meldrum's Patent Forced Draught.—This stoker combines the advantages of the well-known "Meldrum" furnace with those of a first-class mechanical stoker on the coking principle. By it a high rate of combustion is attained, a smokeless chimney secured, and a saving of labour effected. Every part has been carefully designed to minimise wear and tear, and to avoid breakdowns. Duplicate parts are, as far as possible, made to template,

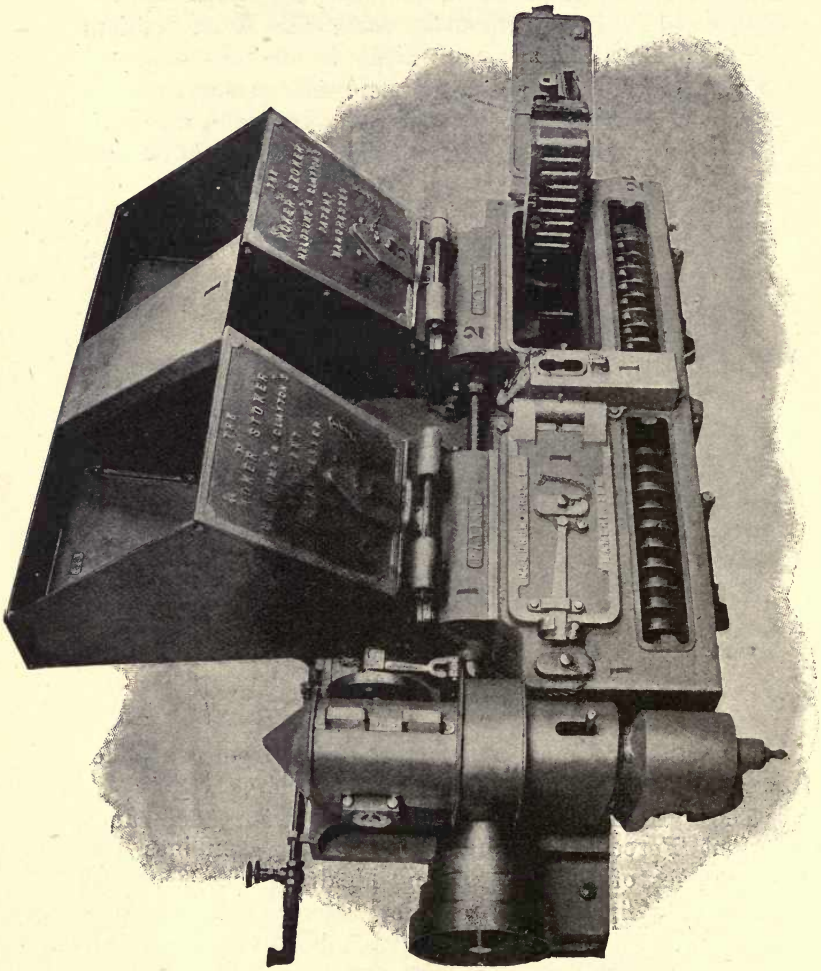


FIG. 26.—The "Koker" Stoker.

to facilitate renewals in case of accident, and the faces of all doors, &c., are planed to secure accuracy of fit.

The ram (shown in Fig. 27) is an entirely new departure; it consists of a sector working on a pivot instead of being flat and sliding backwards and forwards; by this means much less power is absorbed in working. The ram is also provided with an arrangement by which the rate of feed may be regulated at will

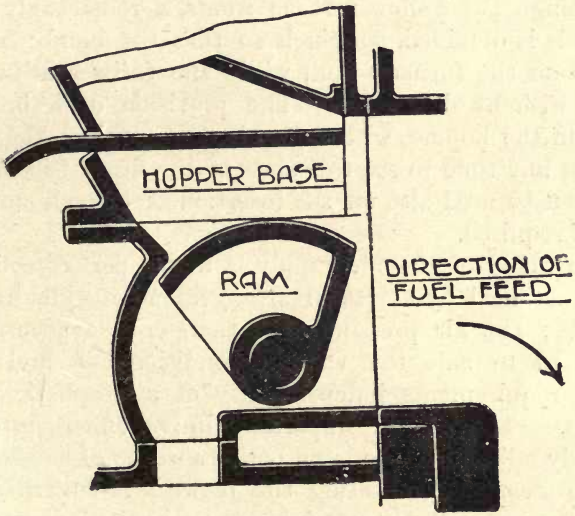


FIG. 27.—Showing the Ram of the "Koker" Stoker.

without stopping the machine. The cams are carefully machine-moulded with hexagon cores, and fitted to a hexagon shaft; they have chilled faces, and are so designed (in conjunction with the bars) that the maximum wearing surface is provided with a consequently greatly increased life of both. The cams and bars have been constantly at work for two years without showing in either case any appreciable wear.

The bars are made with an undulating surface, so that

the reciprocal motion of adjacent bars prevents the clinker from adhering, and assists in keeping the fire "open."

The spacing (or windage) of the bars is made very narrow, so that great loss of fuel is avoided. There is no difficulty in the lubrication of the bar-ends and cams, hence the bars are kept cool, and consequently there is little wear and tear.

The whole of the ashpit being covered, and air forced in through the hollow furnace fronts, a remarkably cool fire-hole is obtained, so much so that the hand may be placed on the furnace front while the furnace is in full work without discomfort. The provision of a bridge-piece in the hopper, with a small door, enables the fireman at any time to see the state of the fires; this sight-hole can be used also for the insertion of a small stoking tool if required.

The whole of the air supply is under perfect control, being obtained by a special arrangement of "Meldrum" blowers; the air pressure may therefore be accurately regulated to suit the varying conditions of fuel and steam requirements independently of atmospheric conditions. This is an important improvement, and if properly adjusted there is an entire absence of smoke.

The steam for actuating the blowers is superheated. By this means all danger of dampness in the boiler tubes is avoided, and the blowers rendered more efficient. The total quantity of steam used by the blowers for the double purpose of forced blast and cooling the bars is very small.

The furnace fronts are hollow, the blast being made to circulate through the spaces provided, with the result that the air is heated and the furnace front kept cool. This assists in maintaining a cool and comfortable stoke-hole.

Furnace fronts, bar-ends, &c., which are exposed to the greatest heat and liable to be burnt, are provided with shields which can readily be renewed at a small cost.

The accompanying illustration (p. 186) shows an actual installation taken while the furnaces were in operation.

The following test was carried out at the Bristol Corporation Electricity Works on Lancashire Boiler (No. 10), 28 feet long, 8 feet diameter; grate area, 34.75 square feet; fitted with the "Koker" stoker and Meldrum's forced draught.

Date of test	September 19, 1899.
Duration of test	6 hours.
Kind of fuel used	Tredegar washed peas.
Total fuel burnt	6,216 lbs.
Fuel burnt per hour	1,036 lbs.
Fuel burnt per square foot of grate, per hour	29.8 lbs.
Average steam pressure	128 lbs.
Temperature of feed water	178° F.
Total water evaporated	57,660 lbs.
Water evaporated per hour	9,610 lbs.
Water evaporated per lb. of coal, actual	9.28 lbs.
Water evaporated per lb. of coal, from and at 212° F.	10.03 lbs.
Total weight of clinker and ash	599 lbs.
Percentage	9.63

Analysis of Flue Gases.

Percentage of CO_2	10.5
Percentage of O	9.0
Percentage of CO	Nil.

The following advantages are claimed for the "Koker" Stokers:—

1. Entirely automatic, requiring no assistance in the way of hand-firing.
2. Easily adjustable, both as to feed of fuel and speed of bars.
3. Increased boiler capacity.
4. Bars have exceptionally narrow spaces, thus obviating waste of fuel.
5. All working parts easily removed and renewed.
6. Little wear and tear, hence small repair bill.

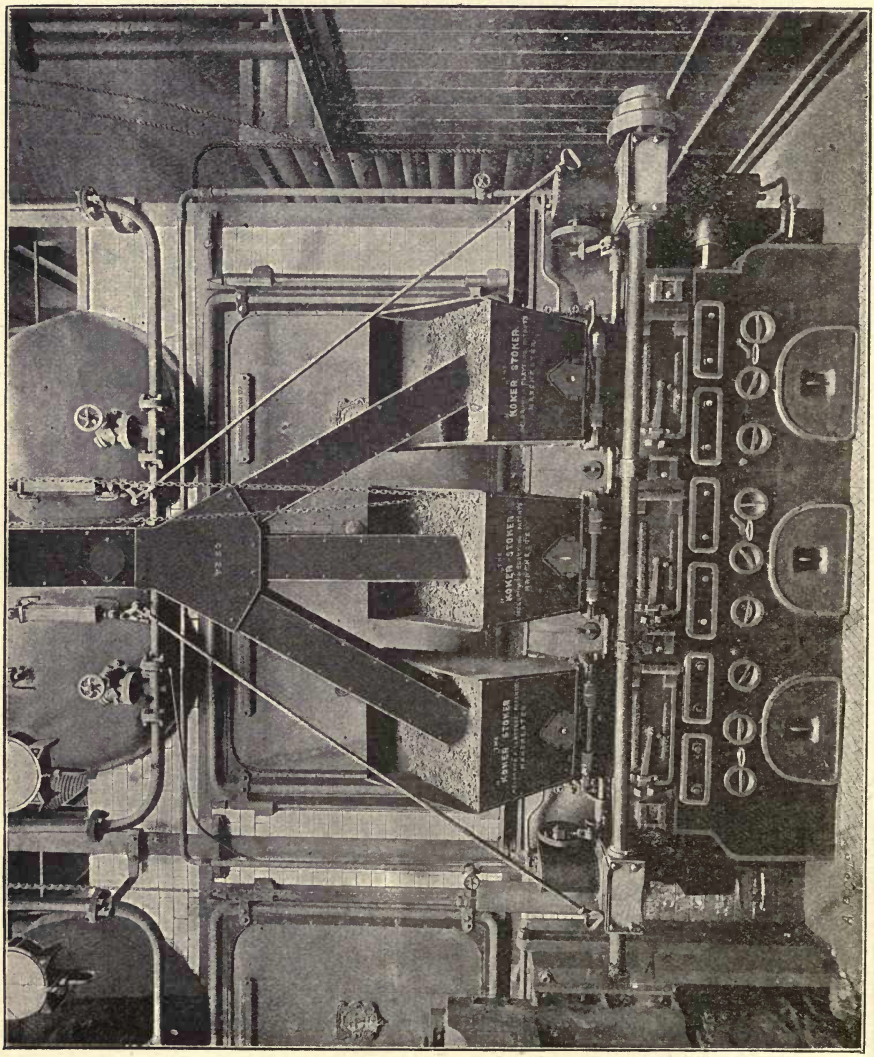


FIG. 28.—The "Koker" Stoker as applied to Babcock & Wilcox Boilers at the Bristol Electricity Station.

7. High econometer reading, in other words, a high percentage of CO_2 in the gases, and consequent economy.

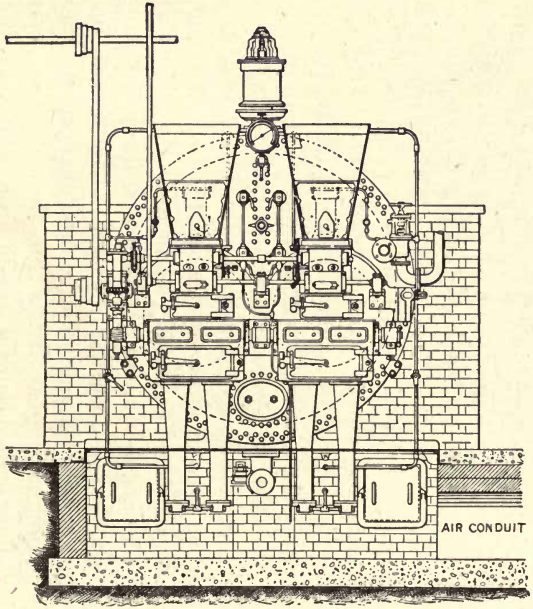
8. Very little interference with the boiler when fixing the apparatus.

9. May be used with forced or natural draught at will.

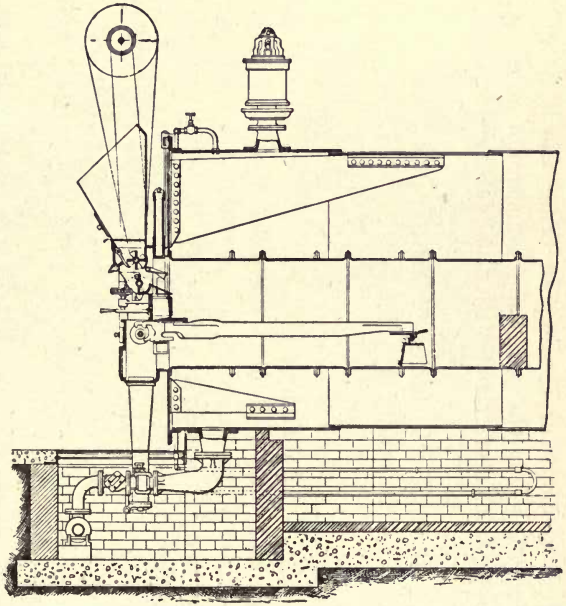
10. A smokeless chimney.

The Sprinkler Stoker made by the same firm (Figs. 29 and 30) is fitted with moving bars to deliver the clinker to the clinker pit, the fuel is sprinkled over the major portion of the incandescent grate, though as an alternative stationary fire-bars are preferred by some, notwithstanding the increased attention required by the fires in consequence of compulsory cleaning out by hand. It is far better to have movable bars as they render valuable assistance in securing economical combustion and maximum evaporation.

The Bennis Patent Pneumatic-Geared Machine Stoker.—In this machine the fuel is thrown or fed by conveyor or elevator into a hopper holding about three cwt., of which there are two to each Lancashire boiler. Under this hopper is placed a cast-iron feeding-box, in the interior of which there is a very simple pusher plate. A certain quantity of fuel falls in front of this plate, and is pushed, by its movement, over a ledge formed by the bottom of the box. The weight of the fuel so pushed over is regulated with the greatest exactitude by means of a cam on the driving-shaft, so that in a very short time the most ordinary fireman would know just how much fuel he was feeding by the position of the cam. The fuel thus pushed over falls on to a flat plate, which is called the shovel-box, from which it is projected into the fire by a shovel, propelled forward, striking the fuel and scattering it in the most perfect and effectual manner. A patent pneumatic gear drives this shovel. This consists of a long coiled spring, made from the very best drawn steel, enclosed in a cylinder and pressing on a



Front Elevation.



Longitudinal Section.

FIGS. 29 and 30.—The Sprinkler Stoker applied to a Lancashire Boiler.

piston. The spring is used merely to propel the shovel forward, and any remaining force is taken up by the air cushion, thus avoiding all shock or jar on the boiler front, and making a noiseless machine.

The cam which draws back the shovel has four varying lifts, the effect of this motion being to scatter the fuel on the fire in four divisions, each about 18 inches long, so that in a 6 feet furnace the fuel is thrown on only a quarter of the fire at once; a most material point where smokelessness is important, giving time for each portion of the fire to become incandescent between each charge.

When using low class or waste fuels, which generally contain a large proportion of clinker and ash, the air spaces in the fire-bars of ordinary furnaces soon become more or less covered and stopped up, and the fire suffers in consequence.

It is manifestly impossible to adjust the supply of air to the fire, to consume the fuel perfectly, unless the clinker and ash are regularly removed.

In the Bennis Patent Self-cleaning Compressed Air Furnace this is effectually accomplished. This consists of tubular fire-bars of the length the fire is intended to be, which all move into the fire together about 2 inches, and are then drawn out one by one by the action of cams placed on a shaft. These cams are made the full width of the bar (about 4 inches or so), so that there is scarcely any wear upon them, and so powerful is the self-cleaning action that in travelling from the front of the fire to the back the coal ascends an incline of more than 3 inches.

The clinker is slowly carried by this action to the back end of the bars, where it drops over into a closed chamber, gives up its heat to the boiler, whence it is drawn out about once every day.

The air spaces between the bars being always free and open, and each tubular bar having its own supply of compressed air, the draught is evenly distributed over the

whole fire-grate, and the boiler continues to do its work even while cleaning out the clinker from the chamber, and the fire being always clean is ready to have sudden

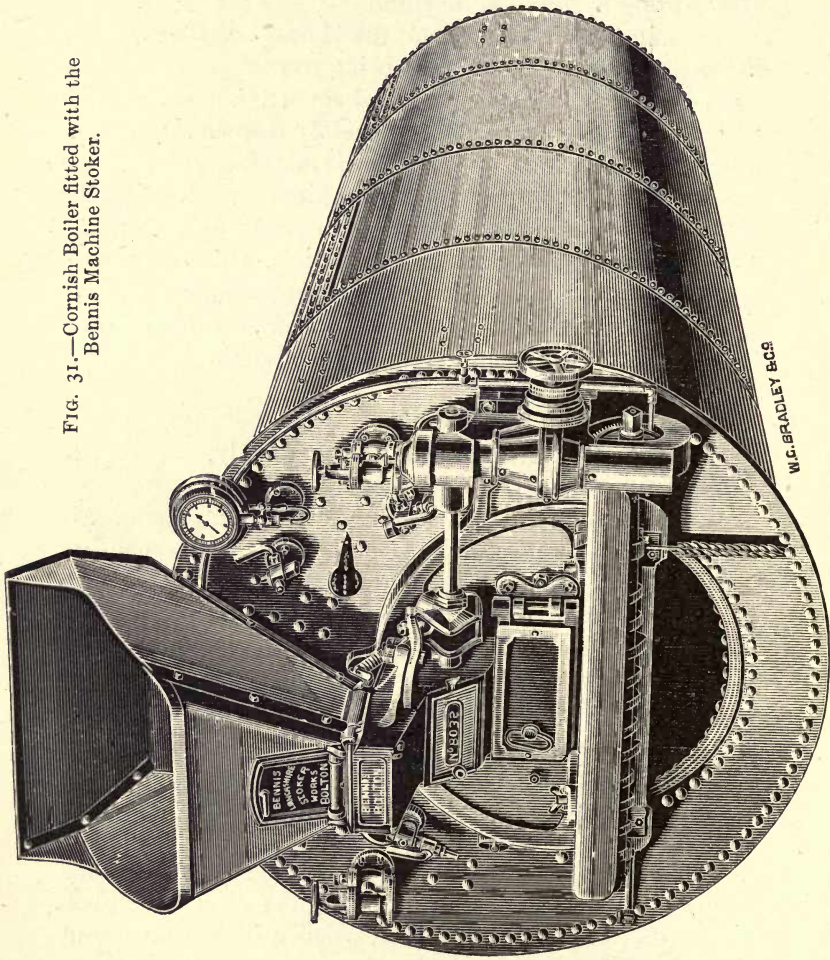


FIG. 31.—Cornish Boiler fitted with the Bennis Machine Stoker.

calls for steam made upon it, and by turning on the blowers full, the rate of combustion can be enormously increased.

The bars are constructed with extremely fine air spaces so that breeze or dust fuel may be burned with advantage.

An automatic device is shown (Fig. 32) for controlling the damper in the flues, the speed or motion of the machine stokers, and the supply of air to the furnace from the steam pressure, maintaining a constant pressure on the boilers suitable for all classes of work, especially where the load is very variable.

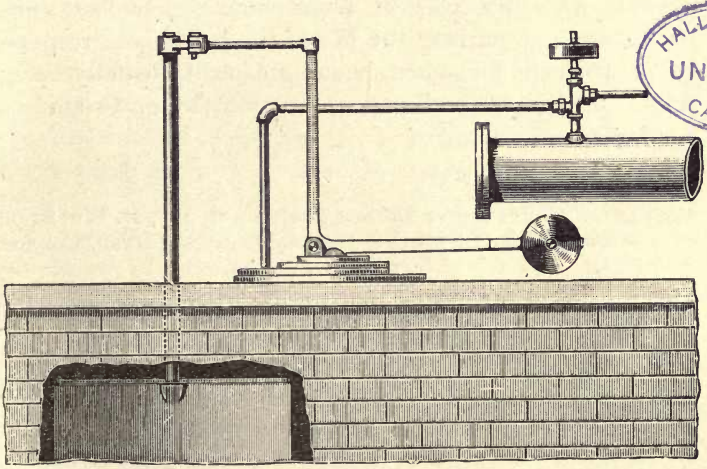


FIG. 32.—Automatic Device for Regulating Damper.

The illustration shows the dead-weight valve on the steam-pipe, which controls a large hydraulic valve working the swivel damper in flue, and from which suitable connections are made to driving for machine stokers and to the blowers for furnaces.

The Bennis Stoker and Compressed Air Furnace is most valuable—

(*a*) Where there is a short supply of steam.

(*b*) Where smoke is a nuisance.

(*c*) Where firemen have oiling and engines to attend to.

(*d*) Where cheaper fuel can be had.
(*e*) Where the load is very irregular.
(*f*) Where economy is an object.

There is no cleaning out of fires; each fire is under separate control; the fire doors open outwards, as in ordinary hand-firing, and are of large size; and the air supply to fire and the coal supply are under immediate and simple control. It is claimed that the furnace will burn low-grade fuels or high-grade fuels with the utmost possible economy, prevent black smoke, give less work to the firemen, prolong the life of the boiler, and respond to sudden calls for steam, burning capacity usually being up to 30 lbs. of fuel per square foot of grate surface per hour.

RESULT OF COMPARATIVE BOILER TESTS MADE AT THE WORKS OF MESSRS. THE BUTTERLEY IRON COMPANY, LIMITED, CODNOR PARK.

Hand Firing versus *the "Bennis" Machine Stoker and Patent Self-cleaning Compressed Air Furnace.*

	Hand.	Bennis.
Date of test	18/1/1902	23/1/1902.
Duration of test	5 hours	5 hours
Type of boiler	Lancashire	Lancashire
Size of boiler	7 ft. 6 in. × 30 ft. 0 in.	7 ft. 6 in. × 30 ft. 0 in.
Total water evaporated	2320 gallons	4540 gallons
Total coal burnt	2 tons 3 cwt.	3 tons 4 cwt.
Water evaporated per hour	464 gallons	908 gallons
Coal burnt per hour	963 lbs.	1434 lbs.
Water evaporated per lb. of coal	4.82 lbs.	6.33 lbs.
Price of coal per ton at pit	2s. 6d.	1s.
Cost of fuel to evaporate 1000 gallons of water	2s. 3¾d.	8½d.
Extra evaporation per hour	...	95.69 per cent.
Extra evaporation per lb. of coal	...	31.48 ,,
Net saving in weight of coal	...	23.94 ,,
Net saving in cost of evaporation	...	69.58 ,,

Underfeed Stoker.—Fig. 33 illustrates an underfeed stoker of English make. The principle of underfeed is exactly the same as that of the underfeed stoker of America, but the mechanism by which the principle is applied is distinctly different. The stoker consists of a hopper or receptacle for the fuel, the base of which communicates by means of a pipe with a horizontal trough or combustion retort within the furnace of the boiler. This trough or retort contains a screw or worm conveyor actuated by a small steam motor placed in front of the hopper. By the rotation of the worm the fuel is advanced from the hopper into the retort, filling it with coal, which overflows upon the terraced grate bars at the sides in a rounded mound. Air for the combustion is introduced below these grates and through tuyere orifices along the inside of the retort at a point near its top. The description will be more perfectly understood by reference to the figure, in which is shown a stoker for internally fired boilers, below which a cut of the feeding worm or conveyor also is shown.

By reference to the figure named it will be seen that it is the hopper into which the coal is introduced either by a shovel or by a mechanical coal conveyor. The hopper communicates by means of a pipe with the retort or combustion chamber of the stoker, B. In the bottom of the retort lies the taper worm, C, which, for explanation, is shown in the cut removed from the stoker. The worm is caused to revolve by the steam motor, D, which communicates its motion by a rack-lever and a ratchet-wheel, the details of which are fully shown in Fig. 34, where the driving-gear has been exposed by removing the protecting shields. Referring again to Fig. 33, E is the bridge wall bracket, F the terraced grates with the apertures for discharging the air horizontally, thus preventing the entrance of ash and unconsumed coal into wind box, G. The air for the combustion of the fuel is led to the stoker by galvanised sheet-iron pipes, which

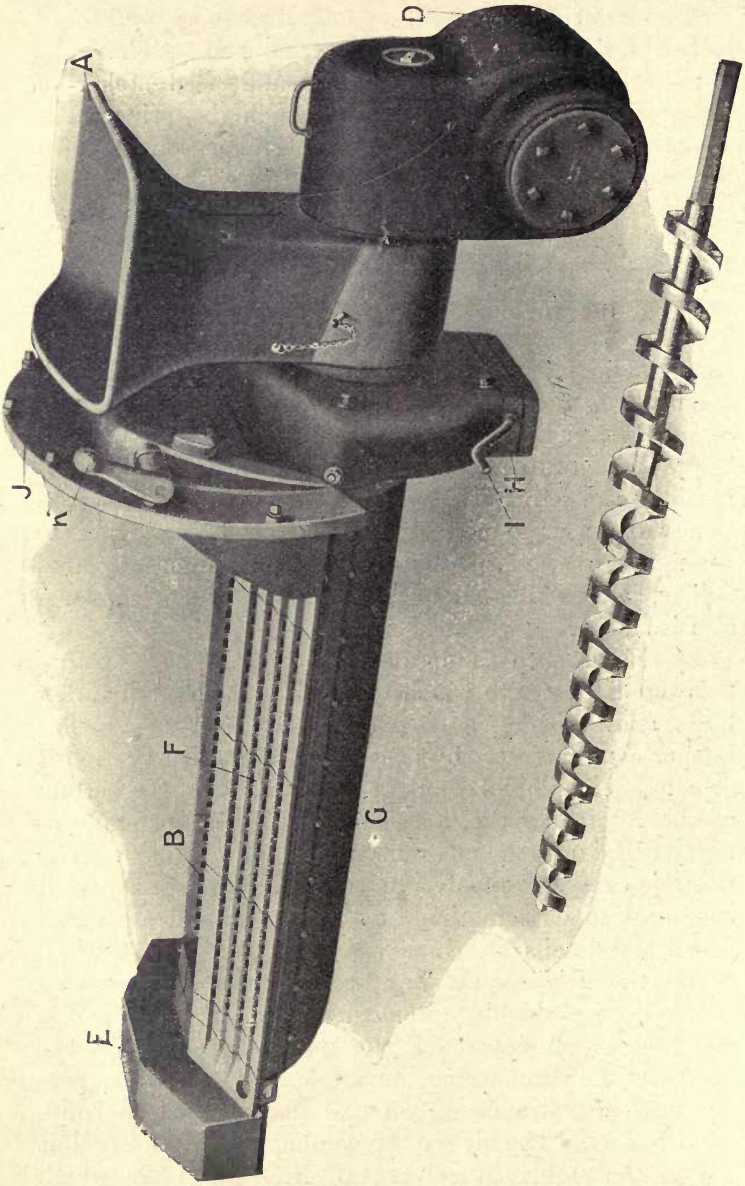


FIG. 33.—The Underfeed Company's Stoker.

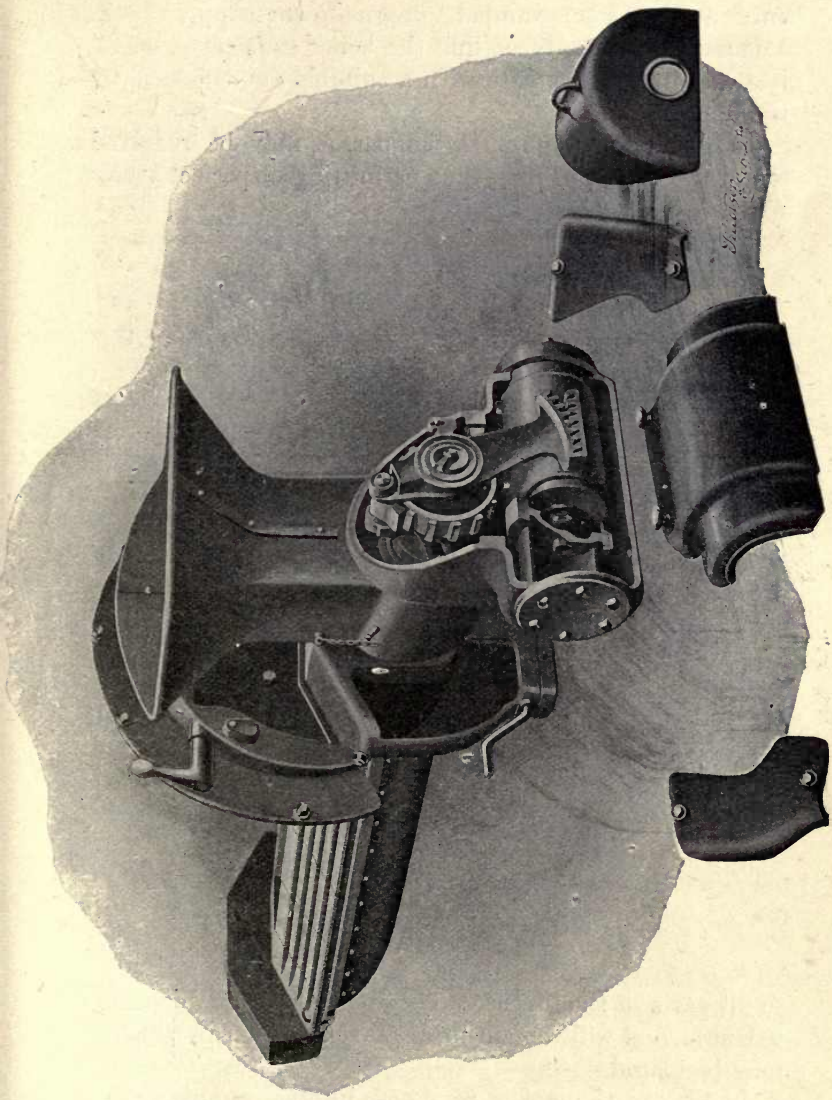


FIG. 34.—Protecting Shields of the Stoker removed to show the details of the Driving Mechanism.

enter at H. I is a damper to regulate the supply of air. The stoker is introduced into the boiler as far as J, which is a cast-iron front plate with a suitable door opened by the handle, K.

In cleaning the fire the hopper, A, may be revolved round the conveyor pipe, thus permitting of perfect access

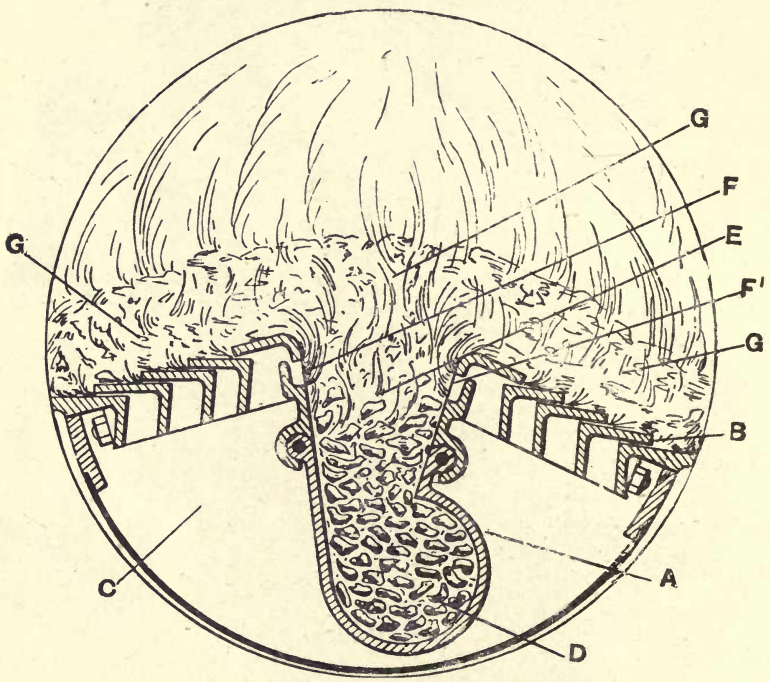


FIG. 35.—Cross-Section of the Underfeed Stoker in the Flue of a Lancashire Boiler.

to all parts of the furnace. The door is perfectly counterbalanced, and will remain in whatever position in which it may be placed.

In Fig. 35 the stoker is shown in cross section, inside the flue of a Lancashire boiler feeding and burning coal. Here A is the retort or fuel magazine, B the terraced

grates, C the wind box, D the green coal which, being gradually pushed up to the burning point, has commenced to ignite at the point E, when it meets the incoming air from the tuyeres F and F'. Here the coal is coked, *i.e.* deprived of its volatile hydrocarbon gases, which, as they can only escape by rising through the glowing coke, are completely consumed without smoke, while the combustion of the fixed carbon in the coal is completed by the air introduced through the apertures in the sides of the terraced grates, B.

The stoker is built to operate in both internally and externally fired boilers, and the two types are designated the "B" and "C" stokers respectively.

The "B" stoker for internally fired boilers, such as the Lancashire, has already been described.

The "C" stoker for water-tube and other externally fired boilers has the same apparatus for underfeeding the coal as the "B" type, but is further provided with mechanism for rocking the terraced grates in such a manner as to not only break up any hard masses of coke or clinker which may be formed during the combustion of the fuel, but also to spread the coal to the right and left over the grates from its place of entrance into the furnace at the retort. Thus it is possible with a single stoker to spread the coal over a furnace as wide as 10 feet. There are ash trays at the sides of the grates along the side walls of the furnace into which the ash and clinker is carried by the movement of the grates. The ash may be removed from these trays without in any way interfering with the body of the fire.

There is secured a combination of underfeeding the coal (the advantages of which have already been fully explained), spreading it at a proper thickness evenly over a very wide furnace, a regular air supply at a very low pressure, and a practically self-cleaning grate.

Mechanical draught is an inseparable part of this stoker system, and according to circumstances it may be

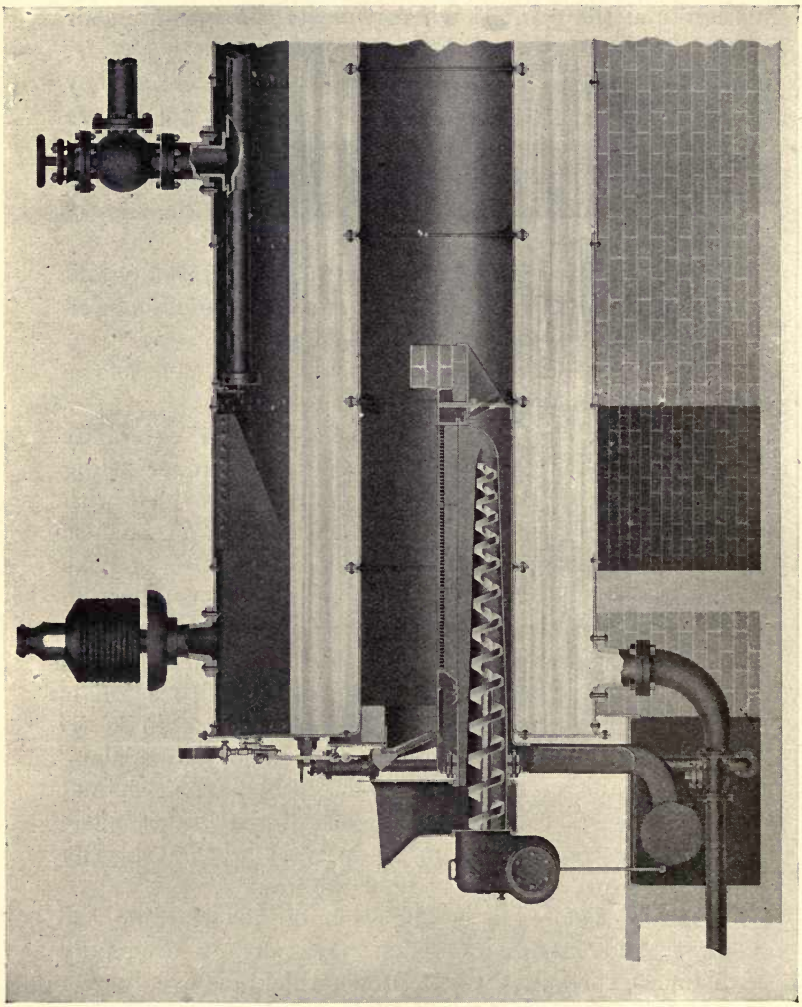


FIG. 36.—Longitudinal Section of the Underfeed Stoker in the Flue of a Lancashire Boiler.

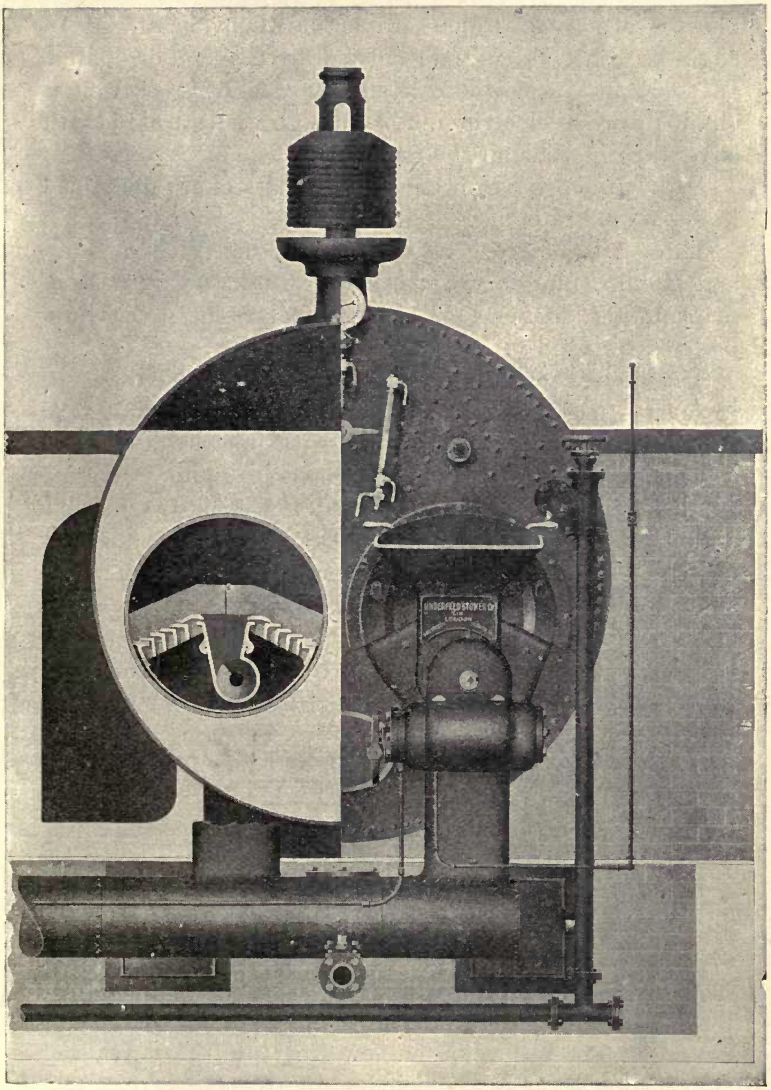


FIG. 37.—The Underfeed Stoker applied to a Lancashire Boiler, one-half in Section. The Air Piping is shown below the Boiler.

either forced or induced. For this purpose special fan-blowers are used, which are actuated by small steam engines, either directly connected to the fan or belted. In some instances where a supply of electric current is obtainable, an electric motor may be substituted with advantage in place of the engine.

Figs. 36 and 37 show the underfeed stoker, as applied to a Lancashire boiler.

These trials were conducted by Messrs. Vickers, Sons, and Maxim, Limited, at their works, for the purpose of determining the economy and capacity of Lancashire boilers, equipped with underfeed stokers.

The boilers were adjacent to each other and identical in every particular, one being fitted with underfeed stokers, and the other hand-fired with forced draught.

The comparative trials were made under different conditions. During the first trial nut coal was burned, and it was then the aim to evaporate the same quantity of water in each boiler in order to compare the consumption of fuel.

In the second trial, slack coal was used, and practically the same quantity was burned in each boiler, for the purpose of making a comparison of the quantity of water evaporated.

In each case the trial lasted eight hours (p. 201).

The following reasons may be adduced to show why the stoker effects the important economies shown in the tests :—

1. Fire doors are not being constantly opened for stoking, with the inevitable inrush of cold air.

2. The boiler is always receiving the radiation of heat from a clear bright fire, and there are no periods of a dull or black surface. The combustion of fuel being complete, the full calorific power of the fuel is realised, there being no loss of efficiency due to escape of smoke and unconsumed gases up the stack. Due to the principle of its feed supply, the combustion of the gases

	First Trial.		Second Trial.	
	No. 9 Hand fired.	No. 10 Stoker fired.	No. 9 Hand fired.	No. 10 Stoker fired.
Dimensions.				
Grate surface . sq. ft.	33.4	27.75	24.7	27.75
Ratio heating to grate surface per cent. . . .	H.S.–17.28 G.S.–1	20.9 1	23.3 1	20.9 1
Pressures.				
Steam gauge . . .	133.6 lbs.	134.5 lbs.	122.9 lbs.	132.3 lbs.
Pitot gauge air supply at stoker	...	.417″ R.H. .408″ L.H.	...	.46″ R.H. .45″ L.H.
Temperatures.				
Flue uptake . . .	909° F.	680° F.	743° F.	683° F.
Feed water	193.1° F.	191.3° F.	194° F.	193.3° F.
Steam	357.1° F.	357.6° F.	351.1° F.	356.6° F.
Fuel.				
Total coal consumed . .	6,244 lbs.	5,235 lbs.	4,637 lbs.	4,664 lbs.
Total refuse . . .	468 lbs.	296 lbs.	279 lbs.	292 lbs.
Per cent. of refuse . .	7.49 %	5.6 %	6 %	6.26 %
Total combustible . .	5,776 lbs.	4,939 lbs.	4,358 lbs.	4,372 lbs.
Fuel per Hour.				
Coal per hour . . .	780.5 lbs.	654 lbs.	579.6 lbs.	583 lbs.
Combustible per hour . .	722 lbs.	617 lbs.	544.7 lbs.	546.5 lbs.
Coal per sq. ft. of grate .	23.36 lbs.	23.57 lbs.	23.4 lbs.	21 lbs.
Flue Gas at end of Boiler.				
CO_2 per cent. of vol. . .	...	...	12.00	15.82
O ,, ,, ,, . .	...	...	6.85	2.75
CO ,, ,, ,, . .	...	...	.00	a trace.
Total Water.				
Total water used . .	36,821 lbs.	36,973 lbs.	27,835 lbs.	35,072 lbs.
Factor of evaporation . .	1.065	1.0682	1.063	1.065
Total from and at 212° F. .	39,214.4	39,494.5	29,588.6	37,351.7
Water per Hour.				
Evaporated into steam .	4,602.62 lbs.	4,621.62 lbs.	3,479.37 lbs.	4,384 lbs.
Evaporated from and at 212° F.	4,901.81 lbs.	4,936.81 lbs.	3,698.5 lbs.	4,688.9 lbs.
Economic Evaporation.				
Apparent per lb. coal . .	5.89 lbs.	7.06 lbs.	6 lbs.	7.51 lbs.
Equivalent per lb. coal from and at 212° F. . . .	6.28 lbs.	7.548 lbs.	6.381 lbs.	8.008 lbs.
Apparent per lb. combustible	6.37 lbs.	7.48 lbs.	6.38 lbs.	8.02 lbs.
Equivalent per lb. combustible from and at 212° F. .	6.788 lbs.	8.00 lbs.	6.79 lbs.	8.54 lbs.
Result.				
Increased evaporation per lb. coal by stoker . .	...	20 %	...	25.3 %

is practically effected when they reach the bridge wall. *i.e.* the coal is burnt with a shorter flame. This enables the boiler to more completely absorb the heat, and permits of a lower temperature of the uptake gases.

3. It burns the coal with a minimum amount of air. When it is considered that about fifteen times its weight in air has to be used to burn a pound of coal, and that of this four-fifths is inert nitrogen which has to be raised to the furnace temperature, the importance of only introducing into the furnace the precise amount of air necessary for the combustion of the coal becomes apparent.

4. The stoker burns cheap, low-grade, slack fuels, with high thermal efficiency, and without creating a smoke nuisance.

CHAPTER X

SMOKE PREVENTERS AND FUEL SAVERS—

Continued.

The "Loidis" Patent Furnace—The Wilson Smokeless Process—The British Smoke Preventer—Simplex Smoke-preventing Appliances—Gregory and Foster's Smoke Consumer—Rushworth and Livsey Self-cleaning Furnace—The Johnson Economiser—Green's Economiser.

The "Loidis" Patent Furnace.—In the "Loidis" furnace, manufactured by the Horsfall Destructor Co., Ltd., a successful attempt has been made to secure the benefits of "forced draught," namely, increased duty from the boilers due to perfect combustion, combined with the prevention of smoke. The forced draught is obtained by means of steam jet blowers of special construction under the grate, while a split bridge of special construction is provided to give the air supply over the grate for the complete combustion of smoke.

The first form of steam jet introduced was doubtless the plain round nozzle. It is generally held that the action of the steam jet is almost entirely due to surface friction between the steam and the air. This being so, the correct thing is to make the steam jet flat, which is the form used in the blowers. The adoption of these improved jets for use in the "Horsfall" destructor and the "Loidis" furnace has resulted in a large saving of the steam used by the jets.

With forced draught, fire-bars having fine and perfectly even spaces are necessary to ensure a regular distribution of the blast.

The bar used with the "Loidis" forced draught is

specially designed with this view, the width of the spaces being varied to suit the fuel to be burnt and the kind of draught to be employed.

The furnace when burning refractory fuels such as anthracite dust, coke breeze, house refuse, tanners' refuse, or "spent bark," has been found most efficient in keeping up a high temperature so essential to perfect combustion;

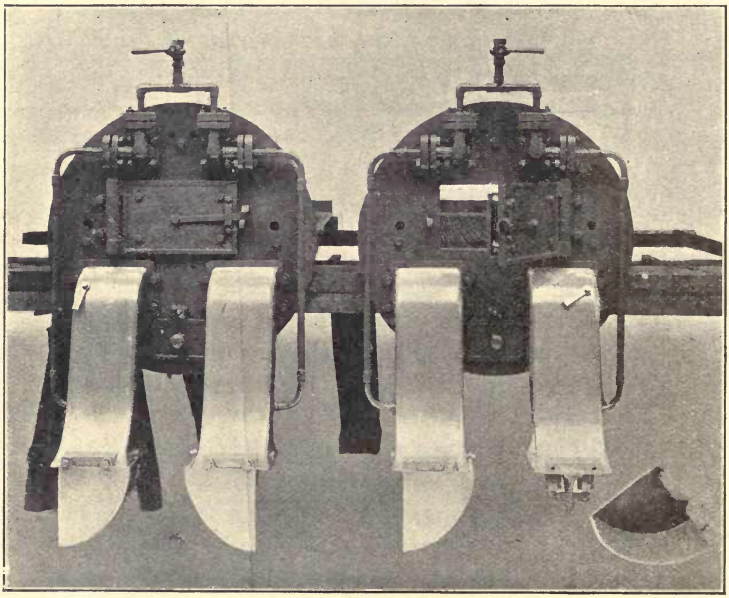


FIG. 38.—The "Loidis" Patent Furnace (Front Elevation).

and it is suitable for all kinds of boilers. The furnace is shown in front elevation in Fig. 38, and in section in Fig. 39.

This furnace comprises a steel front plate in one piece turned to fit the grummet of the boiler front; two patent flat jet blowers to each fire placed outside of the flue and delivering a steady stream of air, thus main-

taining an even pressure under the bars instead of blowing holes in the fire; a split bridge controlled by a door and rod delivering hot air into the heart of the fire, which is a most effective smoke preventer; firing doors of ample size, well fitted and protected by baffle-plates; a hollow baffle, protecting the upper portion of front plate from the heat; a special super-heater for the steam supply to blowers; a closely fitting ashpit door;

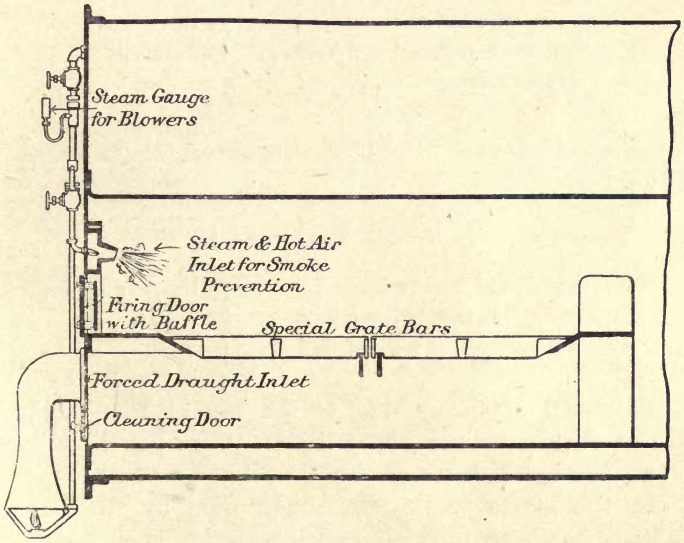


FIG. 39.—Section of "Loidis" Patent Furnace for Lancashire or Cornish Boiler.

grate bars of special design ensuring even distribution of air, and preventing escape of unburnt fuel; massive and durable dead-plates, bearers, and ties; stop-valve and pressure-gauge on steam pipe by which a moderate pressure may be maintained on the jets, ensuring economy and dry steam. Actual trials of this furnace on users' premises have proved the economy effected by it.

The following tests of this furnace are appended:—

Results of Tests.

Natural Draught (ordinary furnaces and grate bars). Date, October 1899.

Mean of Two Trials.

Steam pressure maintained .	75 lbs. per sq. in.
Nett water evaporated per hour .	6090 lbs.
Nett evaporation per lb. of coal .	7.21 lbs.

"Loidis" Forced Draught Furnace. Date, October 1899.

Mean of Two Trials.

Steam pressure maintained .	75 lbs. per sq. in.
Nett water evaporated per hour .	6061 lbs.
Nett evaporation per lb. of coal .	10.04 lbs.

Increased efficiency due to the use of the "Loidis" patent furnace equals 2.83 lbs. of steam per lb. of coal, or 39 per cent.

In the above results the steam used by the patent blowers has been fully allowed for, having been carefully measured at the time, and deducted from the figures given for the evaporation.

The increased efficiency was most marked in the afternoon, after the fires had become dirty, the "Loidis" furnaces maintaining a constant evaporation throughout, whereas the evaporation under natural draught fell off considerably as the trial proceeded owing to the fires becoming clinkered up. Following the usual practice at the colliery, the fires in all cases were only cleaned once a day.

TRIALS—LANCASHIRE BOILER.

1. Natural Draught. Date, March 21, 1901.

Duration of test	Six hours.
Total water evaporated	39,850 lbs.
Equal per hour	6,641.6 lbs.
Total coal used	5,704 lbs.
Equal per hour	956.6 lbs.
Water evaporated per lb. of coal	6.942 lbs.

2. "Loidis" Forced Draught. Date, March 22, 1901.

Duration of test	Six hours.
Total evaporation	35,800 lbs.
Equal per hour	5,966.6 lbs.
Total coal used	3,080 lbs.
Equal per hour	513.3 lbs.
Water evaporated per lb. of coal	11,623 lbs.

Coal consumed in each case, Messrs. Insole's (Cymmer).

The temperature of the feed water was practically constant, at about 240° F., but averaged a few degrees lower in the forced draught trial. The steam used by the steam jets (maximum) four jets at 60 lbs. per hour, equalled 240 lbs. per hour, leaving nett evaporation 5,726.6 lbs. per hour. The nett evaporation per lb. of coal for forced draught equals 11.15 lbs. The nett increase in evaporation per lb. of coal equals 4.21 lbs., or 60 per cent., giving a nett saving in coal for equivalent work of 36 per cent.

The Wilson Smokeless Process.—The mechanism connected with the Wilson process (Fig. 40) is exceedingly simple and free from delicate or intricate working parts to be maintained externally or in the furnace, and therefore is not liable to become disordered or troublesome. The practical operative principle is, that it in no way interferes with the ordinary methods of firing or operating the boiler. It deals only with the gases rising from the

fire-bed of the furnace which otherwise would pass off unignited. With these products is diffused a preparation which is atomised by steam (Fig. 41) and mixed with hot air over the fire, causing increased temperature and ignition of the gases which would otherwise leave the furnace unburnt. The chemical supplies all the

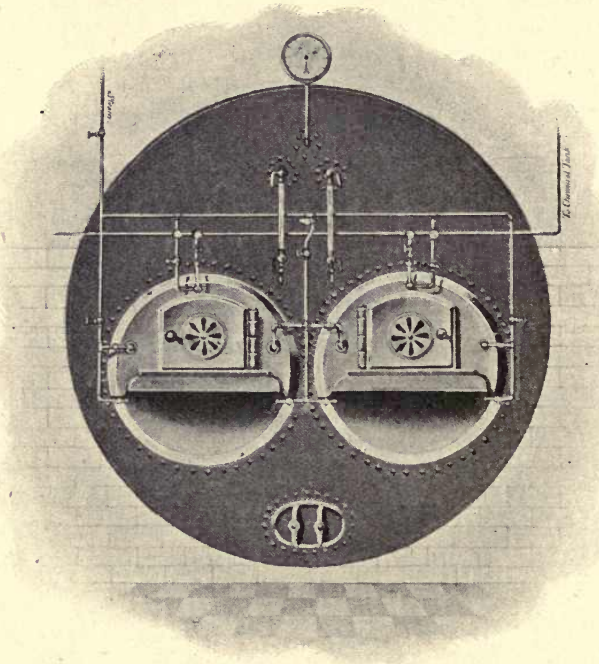


FIG. 40.—The Wilson Smokeless Process as applied to the Lancashire Type of Boiler.

conditions requisite for perfect combustion, and is introduced to inflame the carbon, and accomplish what may be broadly termed *the burning of smoke*. The cost per ton of coal for the chemical is insignificant; and as it is alkaline, and not brought into contact with the metal, it has no deleterious action on the furnace or

plates. On the contrary, it serves to neutralise sulphuric acid formed by the combustion.

The soot deposit is of necessity greatly reduced through the perfect combustion effected by the process; the draught is improved, because of the decreased specific gravity of the gases; and lower grades of coal can be economically burnt with satisfactory results.

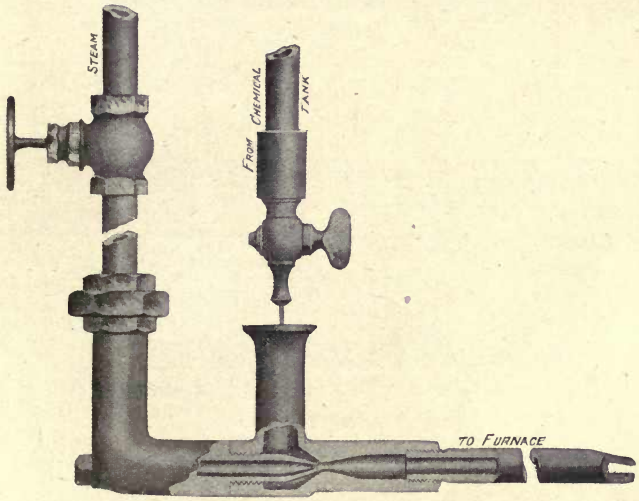


FIG. 41.—The "Atomiser" applied to Boilers in connection with the Wilson Smokeless Process.

By referring to Figs. 40 and 41 it will be seen that the Wilson process as attached to a Lancashire boiler is unobtrusive in appearance, and is operated by a few small valves controlling the chemical supply and air to the furnace.

The internal arrangement is likewise simple, and necessitates no change of or to the grate bars or shape of the furnace.

The work of applying the process to a boiler can usually be done with a stoppage of one day.

The boiler is not subject to delays resulting from any possible disability of the process, and can be worked equally with or without it in operation.

It does not necessitate any changes in the usual practice of the stokers or the customary method of hand-firing.

The following tests of the process were conducted at

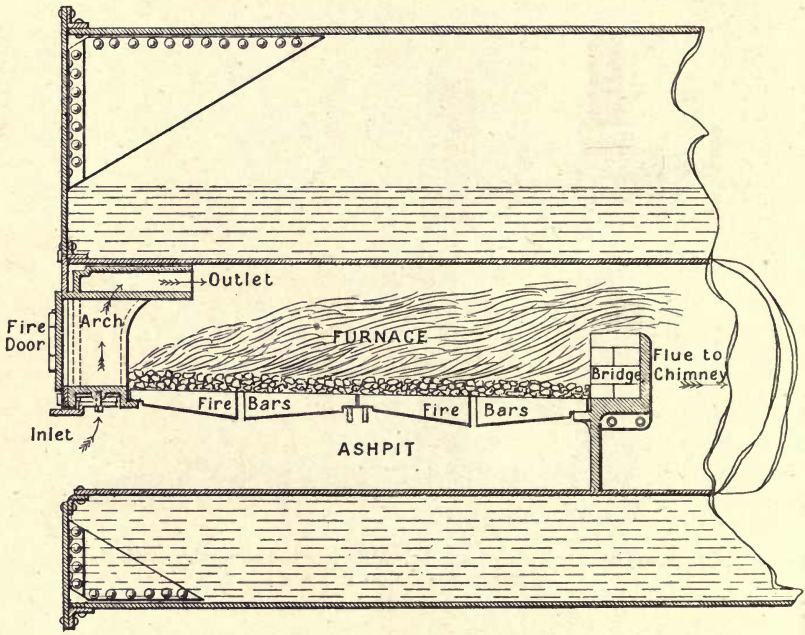


FIG. 42.—The British Smoke Preventer, Longitudinal Section through Furnace.

the New Hall Works, Birmingham, on January 17th and 18th, 1901:—

Two Lancashire boilers, 6 ft. 6 in. by 30 ft.

Coal used, slack and screenings, Aldridge Colliery.

Duration of each test, 9 consecutive hours.

Fires cleaned immediately before tests commenced and once during tests.

Coal taken from same boat-load, all conditions alike. Feed water passing through economiser, average 139° F.

	Without the Wilson Smokeless Process.	With the Wilson Smokeless Process.	
	Pounds.	Pounds.	Gain per cent.
Coal burned	6,272	4,816	23
Ashes	1,226	984	...
Water evaporated	32,032	33,242	...
Evaporation per pound of coal	5.10	6.90	37½
„ „ „ combustible	6.34	8.67	37½
Appearance of chimney top after firing	Black smoke	Perfect combustion No black smoke	

Comparative tests made on two "Belleville" water-tube boilers at the Halles Centrales, Paris, on February 17 and 18, 1903, gave the following results:—

	Without Wilson Process, Feb. 17th.	With Wilson Process, Feb. 18th.
Duration of tests . . hrs.	5½	5½
Period of tests . . .	9.30 A.M. to 3 P.M.	9.30 A.M. to 3 P.M.
Average steam pressure lbs.	181.7	185.36
Average temperature of feed water . . . F.	130	131
Total coal consumed . lbs.	3,821	3,466
Total water evaporated . lbs.	23,180	23,309
Water evaporated per lb. of coal . . . lbs.	6.06	6.73

Gain by process in evaporative duty of boiler, 11 per cent.

The British Smoke Preventer.—Fig. 42 gives a longitudinal section through this furnace, and Fig. 43 shows the furnace front in position, and furnace front removed.

The apparatus is fixed at the front or firing end of the boiler furnace, and stands upon a special dead-plate, which is perforated on either side of the fire-door opening; over these openings are arch-shaped hollow castings,

conforming on their outer skin to the shape of the furnace, and on their inner skin to the fire-door opening. The air admitted into the chambers from the ashpit becomes heated, and is then passed forward through a series of nozzles or tuyeres, and delivered to the gases from the fire at a temperature of over 300° Fahr.

The amount of air admitted can be controlled or

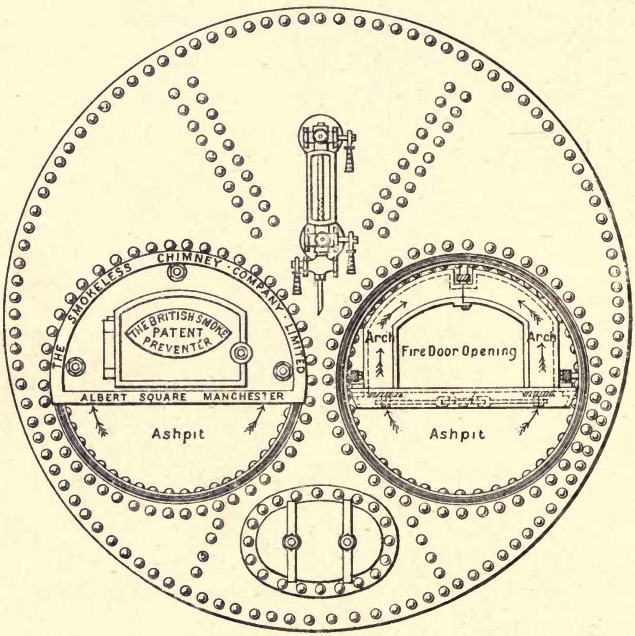


FIG. 43.—British Smoke Preventer, showing furnace front in position with door closed and furnace front removed.

regulated by a small flap valve which fits inside the air admission openings through the dead-plate. The valves are connected on one small rocking shaft under the dead-plate to which a draw-rod worked by a knob on the outside of front is connected. The draw-rod is notched, and its position in the different notches regulates the opening, and consequently the amount of air admitted.

The fire-doors are provided with an effectual baffle-plate on the fireside, and on the outside with an efficient and simple locking catch, which holds the door in position when the ship is rolling, and when the fire-door is open for firing, thus preventing the door from swinging to and fro, which is a source of great annoyance.

The furnace fronts are also provided with ashpit damper and pricker bar-rod. The dampers are made to swing on the pricker bar-rod, and can be either taken off altogether, or lifted by the chain to suit the working, either going easily or full speed. In connection with marine fronts, the ashpit damper shuts tight, as the wings of the ashpit are closed in, and the damper makes a good fit, thus keeping steam from blowing off and consequent waste. In all marine work, the bars are not interfered with, the front and apparatus being made to suit those existing.

This appliance is a very simple one, cheap to instal, and to work. It requires no more attention than closing the fire-door, immediately after firing or raking, its action entirely depending on the ordinary pull, or draught of the chimney.

The Company guarantee the apparatus to effectively prevent the emission of black smoke, and obtain a minimum economy of 5 per cent. If unsuccessful, they will remove the apparatus, without damage to boiler, and at their own expense.

The "Simplex Smoke-preventing Appliance" (Gregory and Applegarth's Patents).—Figs. 44 and 45 show the front and section of a Lancashire boiler; and Fig. 46 the section of a Babcock boiler fitted with this appliance.

The principle on which this invention is worked is that of a strong induced air current applied in a special manner. The apparatus can be readily understood by referring to the illustrations, which show that it can easily be applied to any boiler without alteration of existing arrangements, being fitted through the furnace front into

the furnace above the fires. Steam is conveyed by a pipe of small diameter from the nearest convenient source to the appliance.

The velocity of the air current can be controlled at

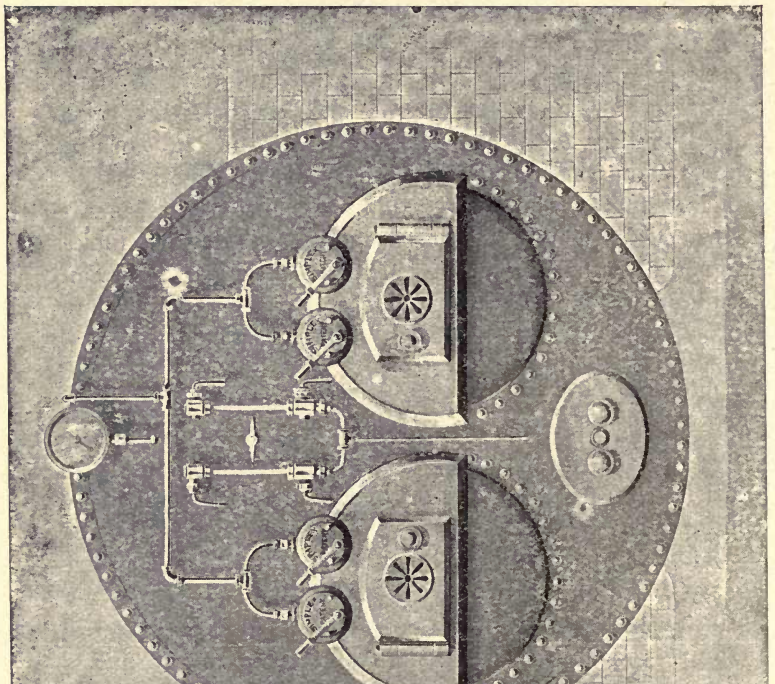


FIG. 44.—Front of Lancashire Boiler fitted with the Simplex Smoke Preventer.

will to suit the nature of the fuel or the rate of combustion required. The admission of the induced current of air to the furnace can at any time be checked or stopped, full control of the fire being thus obtained.

In cases of sluggish draught the apparatus is especially useful, and of great value where boilers are hard pressed, or where high-pressure steam is required to be raised quickly.

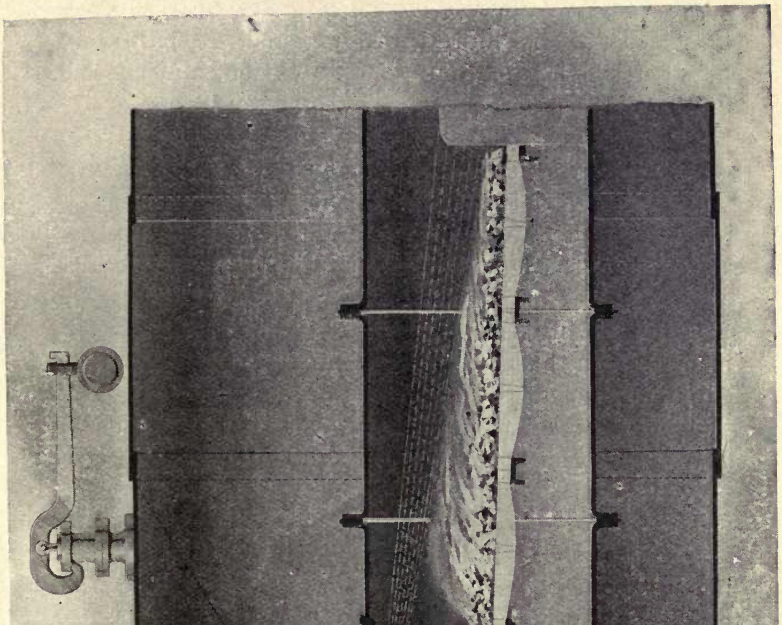


FIG. 45.—Section of Lancashire Boiler fitted with the Simplex Smoke Preventer.

It is quickly fixed; the gases are immediately and effectively diffused; the steaming power of the boiler is increased; there is complete combustion; and smoke is prevented.

Comparative tests, with and without this appliance, will be found on pp. 218, 219.

The boiler was of the Lancashire type, 22 feet long, 6 feet diameter, having two flues, each 2 feet 6 inches diameter, with a total grate area of 27 square feet.

The coal, which was of the ordinary quality of Deshagar coal, fairly lumpy, was weighed. The first trial was for five hours, from 7 A.M. to noon, under natural draught, and *without* the appliance at work.

During this trial, from 7 A.M. to 9 A.M., dense smoke issued from the chimney when the furnaces were fired; but as the trial continued the smoke became less dense each time coal was put into the furnaces; still at no time throughout the trial did the smoke entirely cease.

The following day, the 11th instant, a second trial was made, and on this occasion the Simplex Smoke-preventing Appliance was applied.

The trial commenced at 7 A.M., and was continued for five hours, exactly upon the same basis as the trial of the previous day.

During the trial the smoke emitted from the chimney was practically *nil;* a higher temperature of steam was maintained throughout; the temperature of the economiser was considerably increased; and the coal consumed was 1 cwt. less.

It will be noted that the coal consumed without the smoke-preventing appliance in use was 13 cwts., and with the appliance in use 12 cwts., a saving of 1 cwt. with the appliance in use. This gives a saving of over 7 per cent. on the gross coals used, which at first sight may appear contrary to what one might expect, since live steam is utilised in creating complete combustion; but it must be borne in mind that in creating combustion, units of heat, which otherwise would have been carried away through the chimney with the dense volume of black smoke, are utilised in heating the flues and also the feed water in

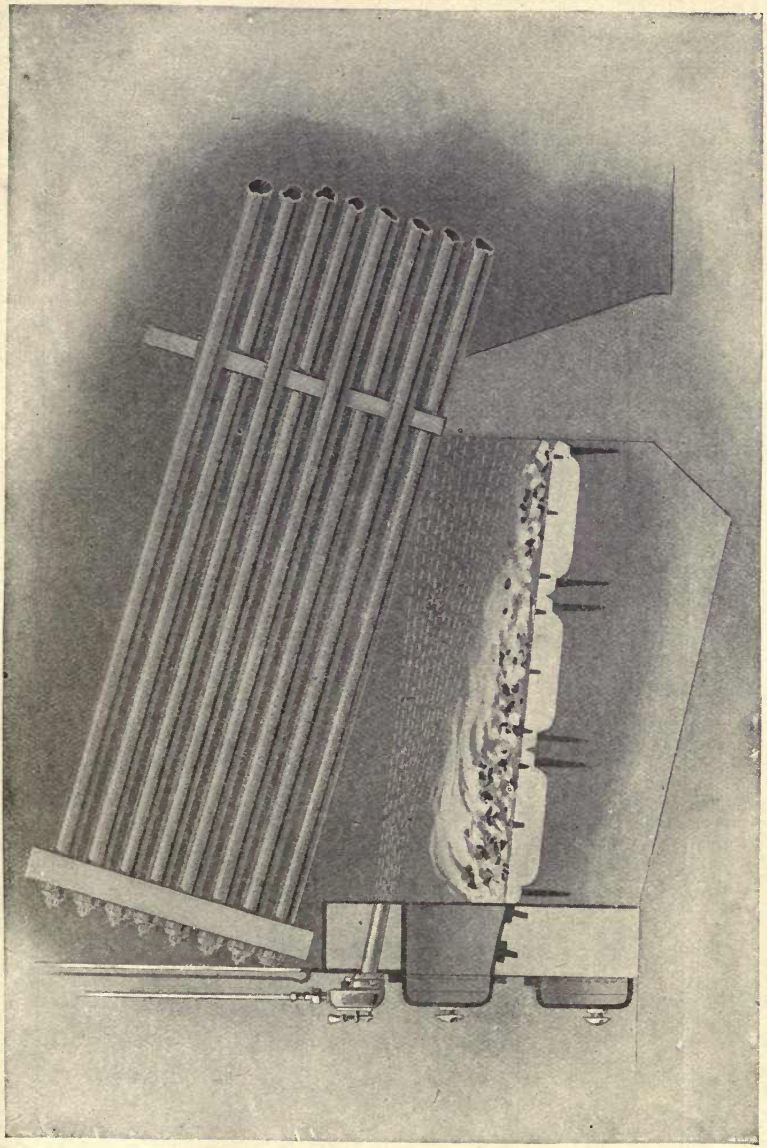


FIG. 46.—Section of a Babcock Boiler fitted with the Simplex Smoke Preventer.

Trial without *the Simplex Smoke Preventing Appliance.*

Time.	Boiler Steam Pressure.	Revolutions of Engines, per Minute.	Temperature of Economiser.	Temperature of Boiler-room.	No. of times the Donkey or Supplementary Feed was put on to Boilers.	Vacuum.	Height of Water in Boilers.	No. of times Furnace Fired.	No. of times Furnace Cleaned.	Total Coal Burnt or Consumed.	Total Clinker and Ashes removed.	Smoke from Chimney.
December 10, 1903	lbs.											
7 to 8 A.M. . .	112 110	55 55	152°	82°	1	26½	5¾ 4¾ 5¾	9	...	Total coal burnt, 13 cwts.	Total dirt removed, 312 lbs.	Smoking more or less all the time.
8 to 9 A.M. . .	110 108 110	55 55	155°	82°	1	26½	5½ 4¾ 5¾	9	...			
9 to 10 A.M. . .	112 110	56 55	180°	84°	. .	26½	5¾ 5¾	9	...			
10 to 11 A.M. . .	111 104 110	55 52 55	190°	84°	...	26½	5¾ 5⅝	9	1			
11 A.M. to noon .	109 111 110 Average 109.77	55 55	200° 212°	85°	...	26½	5⅝ 5½	9	...			

Trial with *the Simplex Smoke Preventing Appliance.*

Time.	Boiler Steam Pressure.	Revolutions of Engines.	Temperature of Economiser.	Temperature of Boiler-room.	No. of times the Donkey or Supplementary Feed was put on to Boiler.	Vacuum.	Height of Water in Boiler.	No. of times Furnaces Fired.	No. of times Furnaces Cleaned.	Total Coal Burnt or Consumed.	Total Clinker and Ashes removed.	No. of times the Appliance put on to Furnaces.	Smoke from Chimney.
Dec. 11, 1903.	lbs.												
7 to 8 A.M.	112 111	56 55	150°	83°	1	$26\frac{3}{4}$	$5\frac{5}{16}$ $4\frac{15}{16}$ $5\frac{5}{16}$	8	...	Total coal consumed, 12 cwts.	Total dirt removed, 243 lbs.	8	Slight smoke seemed to issue each time furnaces were fired, but ceased in 40 to 50 seconds.
8 to 9 A.M.	112 112	56 56	178° 240°	83°	1	$26\frac{3}{4}$	$5\frac{1}{2}$ $4\frac{15}{16}$ $5\frac{5}{16}$	8	...			8	
9 to 10 A.M.	112 113 111	56 55	247°	84°	...	$26\frac{3}{4}$	$5\frac{5}{16}$ $5\frac{5}{16}$	8	...			8	
10 to 11 A.M.	113 106 111	56 $52\frac{1}{2}$ 55	255°	85°	...	$26\frac{3}{4}$	$5\frac{1}{2}$ $5\frac{1}{4}$	8	1			8	
11 A.M. to noon	112 118 114 Average 112.07	56 56	263°	86°	1	$26\frac{3}{4}$	5 $5\frac{3}{16}$ $5\frac{3}{16}$	8	...			8	

the economiser, for while the maximum temperature of the economiser without the appliance in use was 212°, with the appliance in use it was 263°, being a gain of 51°. This increase of temperature in the feed water when being converted into steam more than compensates for the coals used in supplying steam to the appliance. The tests were carried out by Mr. A. L. Whittell, M.I.Mech.E.

Mr. W. T. Carr, Engineer to the Crystal Palace, Sydenham, made some tests with best quality of Hucknall slack, on a boiler fitted with the Simplex Smoke Preventer, the water and coals being carefully measured and weighed in the same manner as when previous tests had been made with other coals. The boiler was one of

	Weight in lbs.				Hours Worked.
	Coals.	Water.	Ashes.	Clinker.	
Wednesday . .	3,360	22,242	209	252	12
Thursday . . .	4,256	27,185	248	293	14
	7,616	49,427	457	545	26

Lbs. of Water Evaporated per lb. of Coal.	Weight in lbs.			Percentage of Refuse to Coal.
	Coals.	Water.	Refuse.	
6.49	7,616	49,427	1,002	13.15

Galloway's 27 feet by 7 feet diameter, and throughout the trial was doing about 100 horse-power work, driving machinery and the dynamos for electric lighting. The average steam pressure maintained was 60 lbs. per square inch. The coals used for raising steam are included in

the return. The Simplex Smoke Preventer was used as per the directions of the makers, and kept on after each firing until the coals were well alight. The smoke was prevented, as claimed by the makers.

Ordinary good quality Welsh coal costs 35s. per ton delivered, while Hucknall slack coal costs 20s. 4d. per

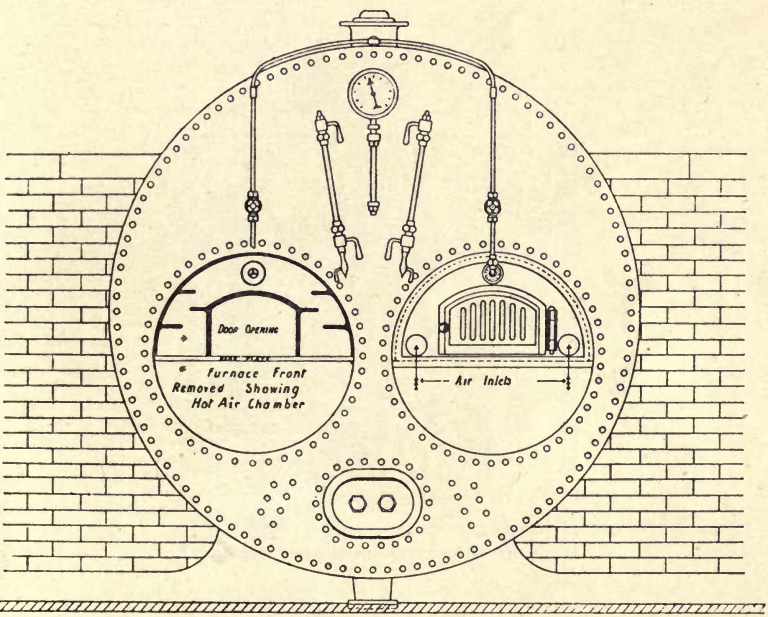


FIG. 47.—Gregory and Foster's Apparatus fitted to a Lancashire Boiler.

ton delivered. Welsh coal evaporates 7.5 lbs. of water per lb. of coal consumed, and Hucknall slack evaporates 6.5 lbs. of water per lb. of coal consumed. To make the comparison exact, one-seventh (3s.) must be added to the cost of slack, increasing its cost to 23s. 4d., to do the work of 1 ton of Welsh coal at 35s. It will thus be seen that by using, say, 1 ton 3 cwts. of slack at a cost of 23s. 4d. (assisted by the Simplex Smoke Preventer), the

same work is done as that obtained from 1 ton of Welsh coal, costing 35s. per ton, thus saving 11s. 8d.

Gregory and Foster's Smoke Consumer and Steam Generator.—On referring to Figs. 47, 48, and 49, it will be seen that in this consumer the air is drawn through openings in the furnace front into an interior chamber which forms a shield to furnace front, keeping it

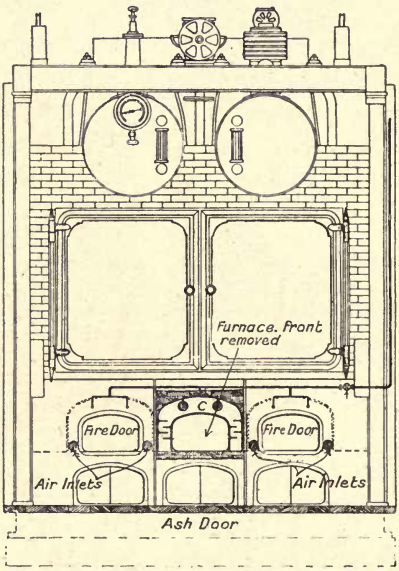


FIG. 48.—Front Elevation of the Gregory and Foster Consumer applied to a Babcock Boiler.

cool, likewise heating the air to a *high temperature* before it enters the furnace.

Two retort pipes are laid from the interior chamber and directed over the fire. Inside these retort pipes is a specially constructed nozzle admitting a $\frac{1}{8}$-inch jet of steam which causes a strong induced current of air to flow. The steam and air mingling together in these retort

pipes form, with the gases formed within the furnace, *carburetted water gas* which is effectually consumed, thus preventing smoke.

This is another very simple appliance, adapted for various types of boilers, will burn inferior fuel, increase steaming power of boiler, prevent smoke, and save fuel.

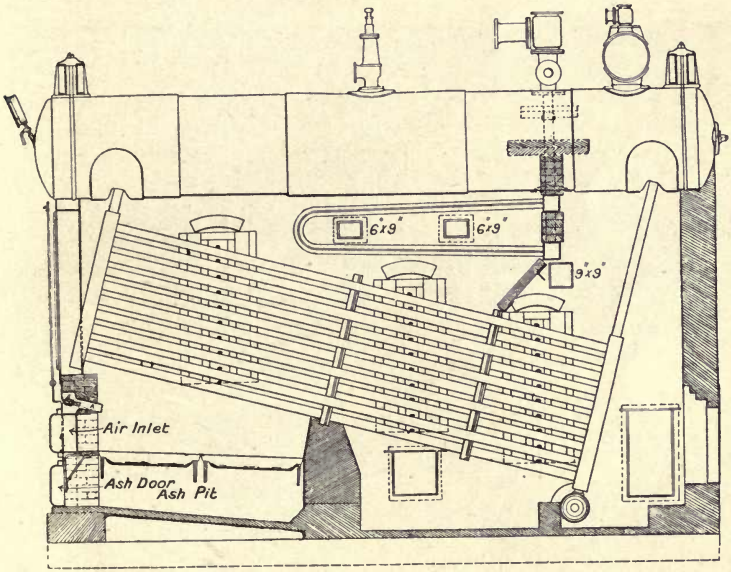


FIG. 49.—Section of Babcock Boiler fitted with a Gregory and Foster Consumer.

Rushworth and Livsey Self-cleaning Furnace.—Fig. 50 will readily explain the working of this furnace. A small shaft is fixed overhead in front of the boilers, the motion is then transmitted by an eccentric to the ratchet wheel below. As the worm wheel revolves the tubes are moved backwards and forwards about once in five minutes. This motion, with the aid of the toothed side-bar shown in drawing, is sufficient to keep the fire free from dirt. The fire-bars which reach the whole length of tube are

held firmly in position with slotted brackets, thus obviating all risk of warping and lifting.

The makers claim for the furnace that 2 horse-power is sufficient to drive the mechanical parts for a battery of eight boilers, increased boiler power, no dense smoke, and a saving of fuel.

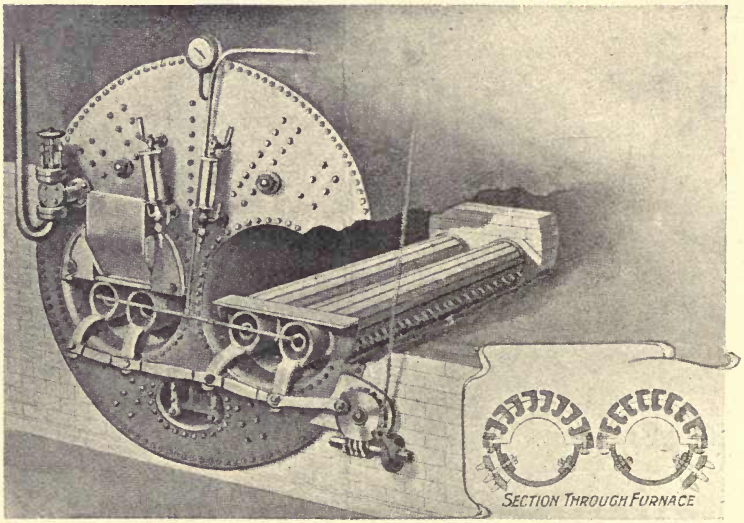


FIG. 50.—Rushworth and Livsey Self-cleaning Furnace.

The Johnson Economiser and Smoke Consumer.—The principle on which this invention (Fig. 51) is based is that of an extra grate without fuel, built behind the first bridge on which the special material by the ordinary flame, hot air, and by ignition of unburnt gases becomes incandescent.

The effect of this grate is to create a regenerative furnace which will destroy the smoke, and give a greater heat in the flues, necessitating less fuel on the usual fire-grate, and effecting economy at the firing end. The

radiation of heat from the grate makes up the loss of temperature which occurs when the furnace is fired, and keeps up a steady head of steam.

The air is supplied through a channel plate in the bottom of the ashpit directly under the incandescent bed, and becomes heated in its passage through without the aid of steam jets, and is entirely controlled by the ordinary draught of the chimney.

The secondary grate is kept clear of dust and particles of fuel by means of the special steam spray which is used for half a minute three or four times a day.

The advantages to be gained by the use of the apparatus are prevention of smoke, increased evaporative capacity of the boiler, and a saving of fuel.

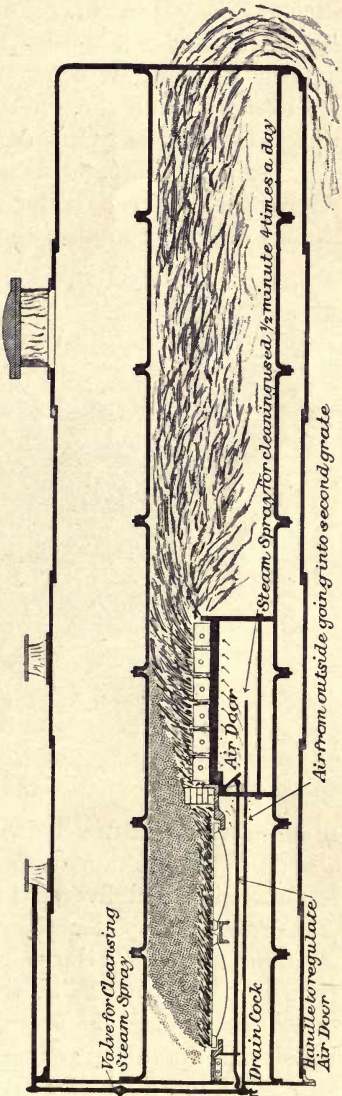


FIG. 51.—Johnson Economiser and Smoke Consumer (Section).

Green's Economiser.—This appliance is used for utilising the waste heat from steam boilers. It is shown in Fig. 52. In the generation of steam the principal source of waste is the escape of heat up the chimney-stack. In boilers working under conditions most favourable to economy the temperature of escaping gases

is much in excess of what is needed to create the necessary chimney draught. This surplus heat ought not to be wasted but utilised for heating the boiler feed water, and to do this an economiser is essential. This can be effected, and the consumption of fuel reduced by the adoption of Green's Economiser, as shown in Fig. 52. It is erected across the main flue in the direct path of the boiler gases. These pass through the economiser chamber to the chimney, and the differ-

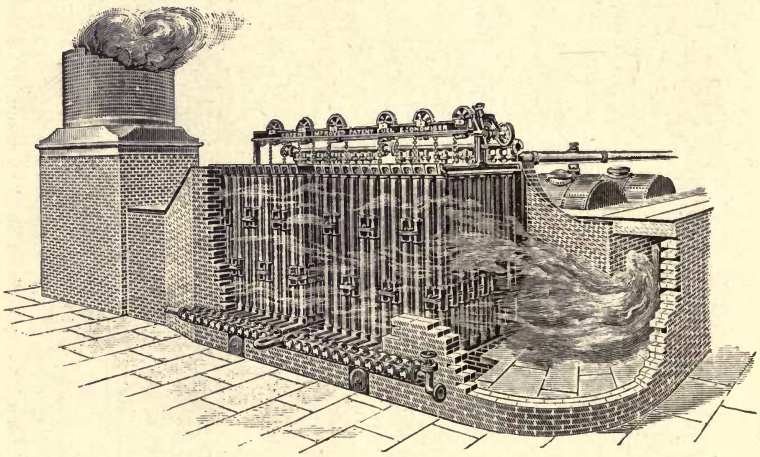


FIG. 52.—Green's Modern Economiser in operation.

ence in temperature between entering and leaving is absorbed by the apparatus, and imparted to the feed water, which is delivered to the boilers at a high temperature. The boiler power is thus augmented, and in addition there is a large reserve of hot water ranging from 200° to 300° Fahr. always available.

An economiser is not only a saver of fuel (a fact which all manufacturers ought to be alive to), but it also adds to the boiler power, which nearly all manufacturers need; moreover, it abates to a great extent

the smoke nuisance, because less coal is burnt, and less forcing of the fires is needed.

Green's Economiser has been before the public over fifty years, and the number that are working in this and other countries is a practical and positive proof of the merits of the apparatus. On behalf of those who are wasting their fuel, unduly forcing their boiler fires, and creating an intolerable smoke nuisance, it is necessary briefly to call their attention to the apparatus in question, its principle, parts, construction, application, and the advantages to be gained personally, and the benefit to the public health by its adoption. Fig. 53 shows the economiser gearing driven from centre.

The economiser consists of a series of cast-iron tubes, 9 ft. in length by $4\frac{9}{16}$ in. in diameter. These are arranged in sections of various widths, across the main flue, between boilers and chimney. The sections are formed by forcing the tubes simultaneously into longitudinal "top" and "bottom" boxes, by means of powerful hydraulic presses. The tube ends and sockets are respectively turned and bored to standard measurements, forming a perfect metal-to-metal joint. When in position the sections are connected by branch pipes running lengthwise, one at the top and the other at the bottom, on opposite sides, the latter being outside the brickwork which encloses the apparatus, and the former secured to the flanges of top boxes.

The waste gases are led to the economiser by the ordinary flue from the boilers to chimney, and the feed water is forced into economiser by a boiler pump or injector, at the lower branch pipe nearest the point of exit of the gases, and emerges from the apparatus through the upper branch pipe, at the opposite end, where the gases enter.

Each tube is encircled by a set of patent triple overlapping scrapers, with chilled cutting edges, the tabs of which rest on a "lifting bar" with "guard" placed above

to keep in position. These travel continuously up and down the tubes at a slow rate of speed, the object being

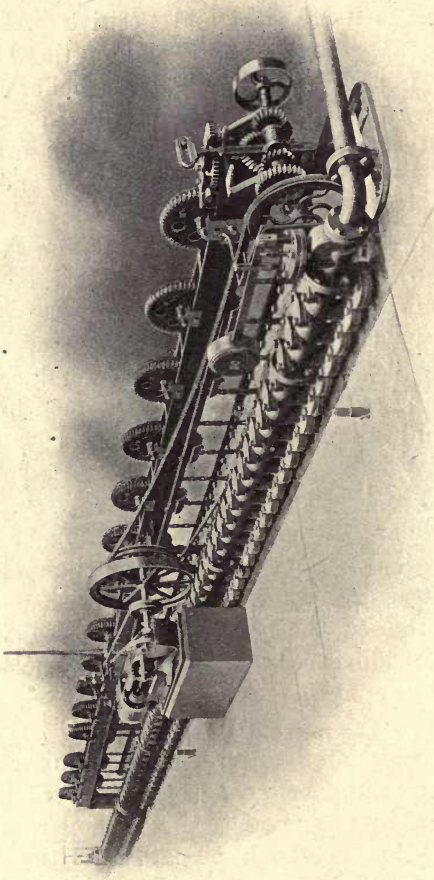


FIG. 53.—Showing Green's Economiser Gearing driven from centre.

to keep the external surface free from soot, which is a non-conductor of heat.

The mechanism for working the scrapers is fixed to the top of economiser, outside the chamber, the motive power

being supplied either by a belt from some convenient shafting or small independent engine or motor attached to the gearing frame. The power required for operating the gearing, however, is very small.

The tubes are made from a combination of the best Scotch pig and hematite, cast vertically in dry sand moulds, and are of equal thickness and free from blow-holes throughout. The patent gear for reversing the scrapers is attached to the end of gearing frame, and is fitted with improved clutch box, lever, and rolling weight. It is simple and effective, and secures prompt reversal at the right moment. This gear is so arranged as to be readily detached if necessary. All parts are accessible without removing the brickwork, and in the rare event of a tube giving way it can be easily replaced by removing the lid above, and proceeding as shown in Fig. 54.

The various types of lids that are fitted in the top boxes of Green's Modern Economiser to suit the working pressure for which the apparatus is constructed, are as follows:—

"*Internal*" *Circular Lid*, with conical joint, but with taper the reverse way of the socket in top box. This lid is inserted from inside, and kept in position by internal pressure, leakage being an impossibility. A further advantage is that being without bolt or crossbar, a larger area and clear passage for the water inside top box is provided. (For pressures from 120 to 200 lbs.)

"*External*" *Lid*, with conical taper joint, secured by bolt and crossbar. (For pressures up to 120 lbs.)

"*Internal*" *Oval Lid.*—The most effective improvement invented for the top boxes of high-pressure economisers. This lid, like the circular type, is drawn into place from the inside, and kept in position by internal pressure. Owing to its shape it can be passed through the oval hole in top box. The circular lids are also inserted or withdrawn through this oval hole, which is a distinct

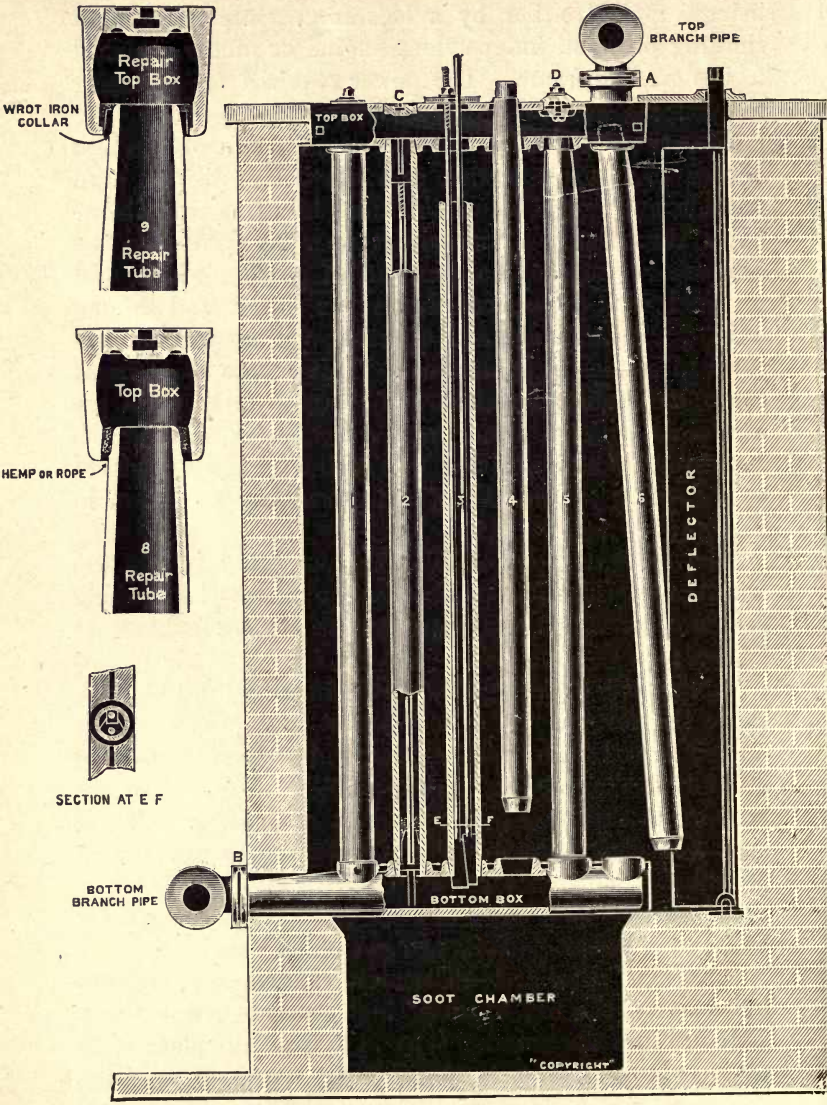


FIG. 54.—Green's Economiser, showing method of withdrawing and replacing a damaged tube.

advantage, and obviates the necessity of removing the top branch pipe, as is the case where the lids are all of the circular type.

Especial care is exercised in the construction of the top and bottom boxes. They are, like the vertical tubes, made from the best combination of metals to withstand various pressures. For the higher pressures they are specially strengthened throughout, and are sound castings. The tube joints and lid holes are all bored conical to accurate gauge by patent machinery, and the surface, edges, and flanges are planed and finished perfect.

Easy access to any part of the apparatus inside the flue is provided, facilitating inspection, cleaning, or repairs, when necessary.

The details of the disposition and application of the tubes can readily be understood on reference to Figs. 55 and 56.

The following tests of Green's Economiser have been carried out:—

TEST No. I.

Daubhill Brickworks, Bolton.

One Lancashire boiler, 30 ft. × 8 ft.; working pressure, 100 lbs.; square feet of grate area, 38; heating surface, 966 sq. ft. One economiser, 96 pipes; heating surface, 960 sq. ft. Total area of heating surface in plant, 1926 sq. ft.

Particulars.		Economiser working Oct. 17, 1899.	Economiser not working Oct. 18, 1899.
1. Duration of test	hours	5	5
2. Total quantity of coal burnt	lbs.	2,850	3,584
3. Ashes and refuse	,,	299.2	379.9
4. Percentage to coal burnt	per cent.	10.5	10.6
5. Weight of coal consumed per hour per square foot of grate area	lbs.	15	18.8
6. Weight of pure coal consumed per hour per square foot of grate area	,,	13.4	16.8
7. Weight of water evaporated	,,	25,000	24,370.5
8. Lbs. of water evaporated per lb. of coal	,,	8.7	6.79
9. Lbs. of water evaporated per lb. of pure coal	,,	9.7	7.6
10. Average boiler pressure (above atmosphere)	,,	92.4	88.6
11. Average temperature of feed water entering economiser	deg. Fahr.	62.1	...
12. Average temperature of feed water entering boilers	,,	259.5	52
13. Number of deg. feed water was heated by economiser	,,	197.4	...
14. Average temperature of flue gases entering economiser	,,	656	...
15. Average temperature of flue gases entering chimney	,,	410.5	...
16. Number of deg. flue gases were cooled by economiser	,,	245.5	...
17. Horse-power based on evaporation of 24 lbs. per H.P.		208.4	203.08
18. Coal burnt per H.P. per hour		2.73	3.5
19. Pure coal burnt per H.P. per hour		2.44	3.15
20. Equivalent evaporation from and at 212°.		11.15	8.81
21. Percentage gained by using economiser		21	..

TEST No. II.

SPRING VALE WORKS, MIDDLETON.

Two Lancashire boilers, 30 ft. × 8 ft. 6 in.; working pressure, 100 lbs.; square feet of grate area, 82; heating surface, 2080 sq. ft. One economiser, 216 pipes; heating surface, 2160 sq. ft. Total area of heating surface in plant, 4240 sq. ft.

PARTICULARS.	Economiser WORKING Oct. 26, 1899.	Economiser NOT WORKING Oct. 27, 1899.
1. Duration of test . . . . hours	8	8
2. Total quantity of coal burnt . . lbs.	10,442	11,660
3. Ashes and refuse . . . . ,,	976	962
4. Percentage to coal burnt . . . per cent.	9.34	8.25
5. Weight of coal consumed per hour per square foot of grate area . lbs.	15.9	17.76
6. Weight of pure coal consumed per hour per square foot of grate area ,,	14.4	16.3
7. Weight of water evaporated . . ,,	88,100	75,200
8. Lbs. of water evaporated per lb. of coal . . . . . ,,	8.4	6.4
9. Lbs. of water evaporated per lb. of pure coal . . . . . ,,	9.3	7
10. Average boiler pressure (above atmosphere) . . . . ,,	90.2	87.3
11. Average temperature of feed water entering economiser . . deg. Fahr.	59.6	...
12. Average temperature of feed water entering boilers . . . . ,,	301	66.1
13. Number of deg. feed water was heated by economiser . . . ,,	241.4	...
14. Average temperature of flue gases entering economiser . . . ,,	656.25	...
15. Average temperature of flue gases entering chimney . . . ,,	410	...
16. Number of deg. flue gases were cooled by economiser . . . ,,	246.25	...
17. Horse-power based on evaporation of 24 lbs. per H.P.	458.75	391.66
18. Coal burnt per H.P. per hour . . .	2.84	3.72
19. Pure coal burnt per H.P. per hour . . .	2.56	3.41
20. Equivalent evaporation from and at 212°. .	10.60	8.05
21. Percentage gained by using economiser . .	24.7	...

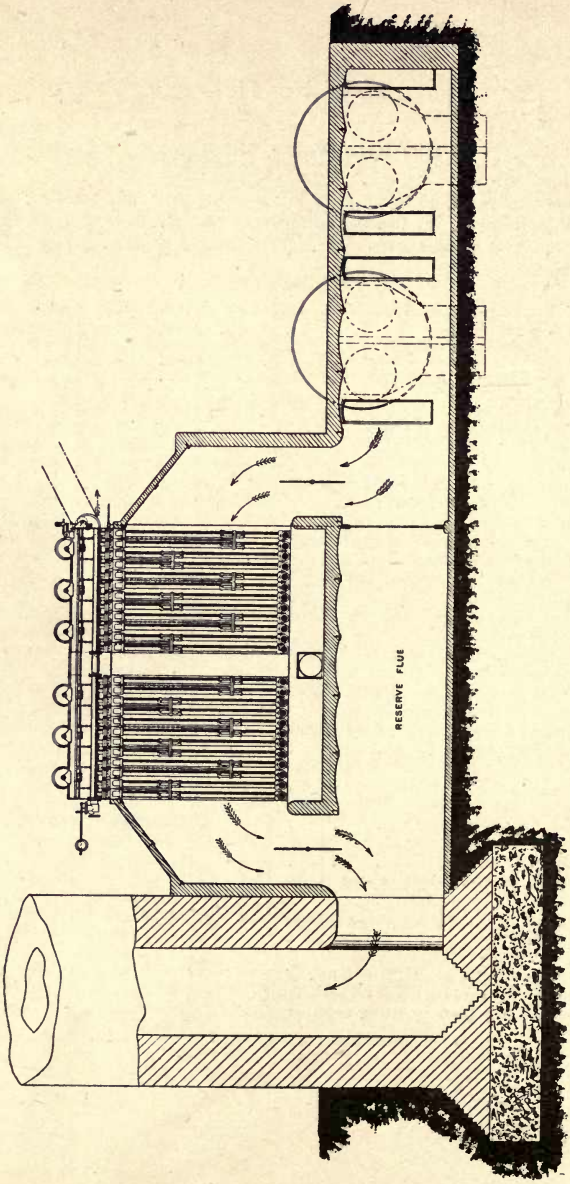


FIG. 55.—Green's Modern Economiser of 192 Tubes in two groups placed on top of main flue.

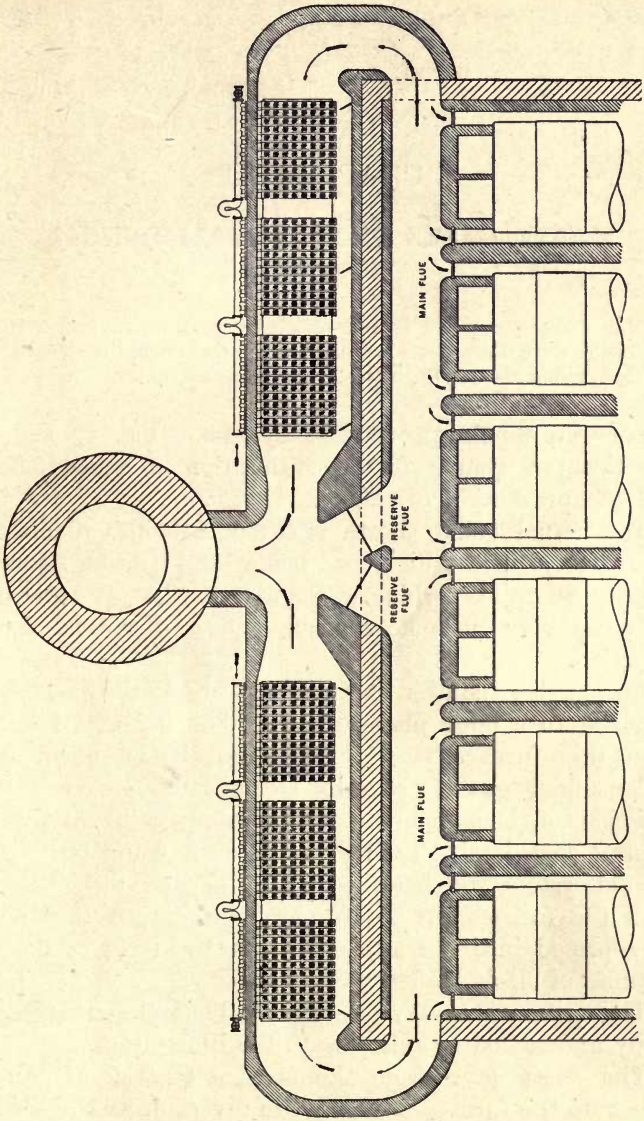


FIG. 56.—Green's Modern Economiser of 576 Tubes in six groups of 96 Tubes each.

CHAPTER XI

WASTE GASES FROM METALLURGICAL FURNACES

Cochran Smoke-prevention System—High Temperature Furnaces—Low Temperature Furnaces—Gaseous Fuels—Gas Producers—Types of Gas Producers—Gas Engines—Domestic Gas Stoves.

Cochran Smoke-prevention System.—Fig. 57 shows the Cochran system for the utilisation of waste gases and the prevention of smoke.

The actual boiler shown is 6 feet 6 inches diameter by 14 feet 6 inches high, and has a total heating surface of 500 square feet, which works at 100 lbs. pressure; it takes up very little floor space, and is of special construction.

For twelve months at Cochran's works it has been attached to a large plate-furnace. The gases and heat from this furnace pass through the boiler, burn the unconsumed gases, generate steam, and prevent the emission of black smoke, which, needless to say, has been a considerable saving to the firm compared with the old system, which was to allow the gases to go direct from the furnace up the furnace chimney, from which they passed into the atmosphere in the form of dense volumes of black smoke.

The system is a very practical and simple one, and is easily understood by referring to the illustration.

The waste gases from the furnace, instead of going direct up the furnace chimney, are diverted, passing over an incandescent fire which ignites the unburnt gases, the heat passing through the boiler, generating steam, then

passing into the chimney, and escaping from the chimney in the form of a thin vapour, containing very little, if any, combustible matter.

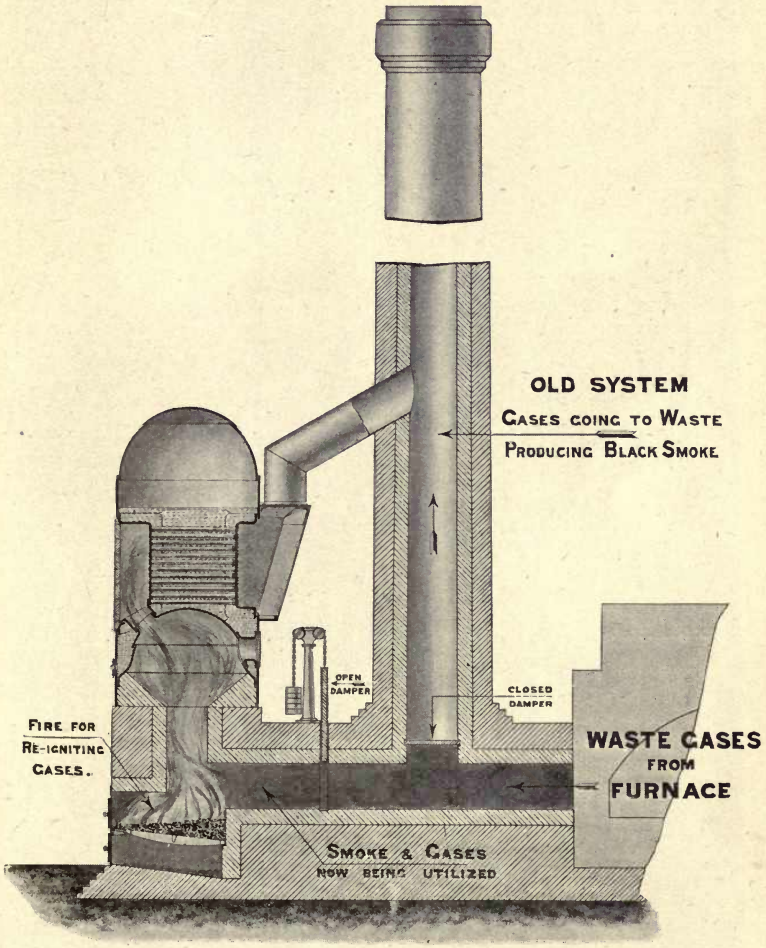


FIG. 57.—Cochran System for the Utilisation of Waste Gases and Prevention of Smoke.

Fig. 58 shows the large plate-furnace attached to the Cochran boiler; and Fig. 59 shows another view of

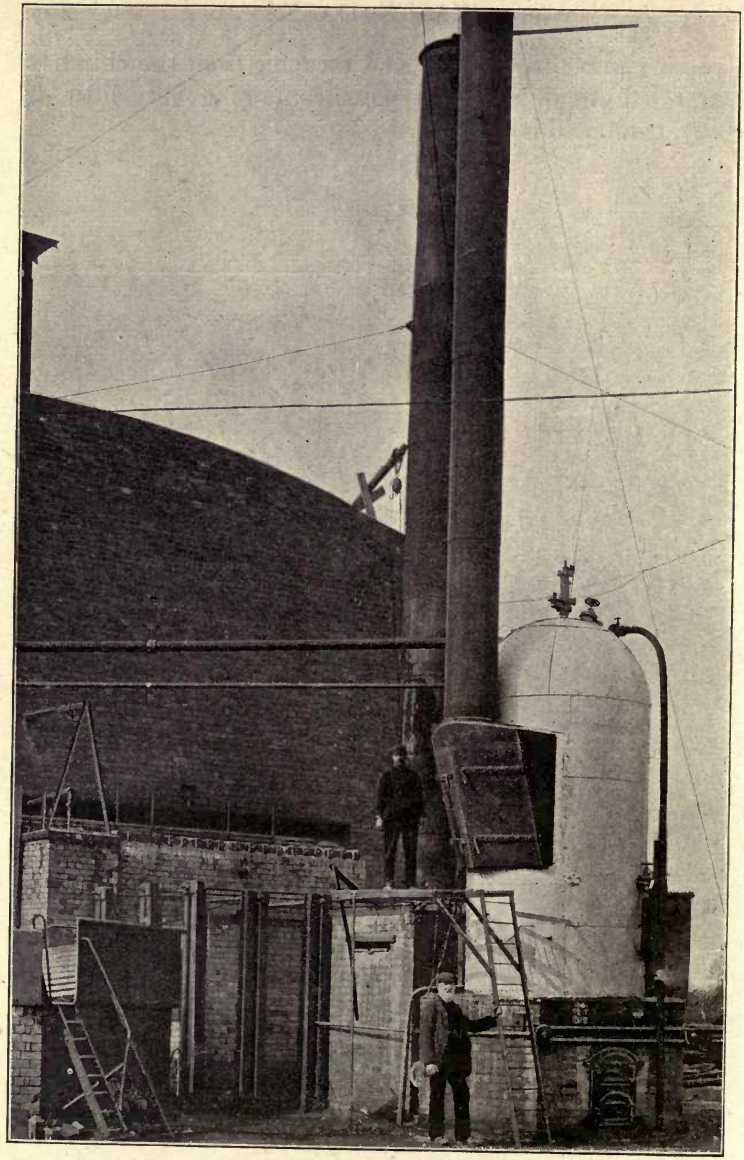


FIG. 58.—Boiler fitted with Cochran System, utilising the Waste Gases from a Reheating Furnace.

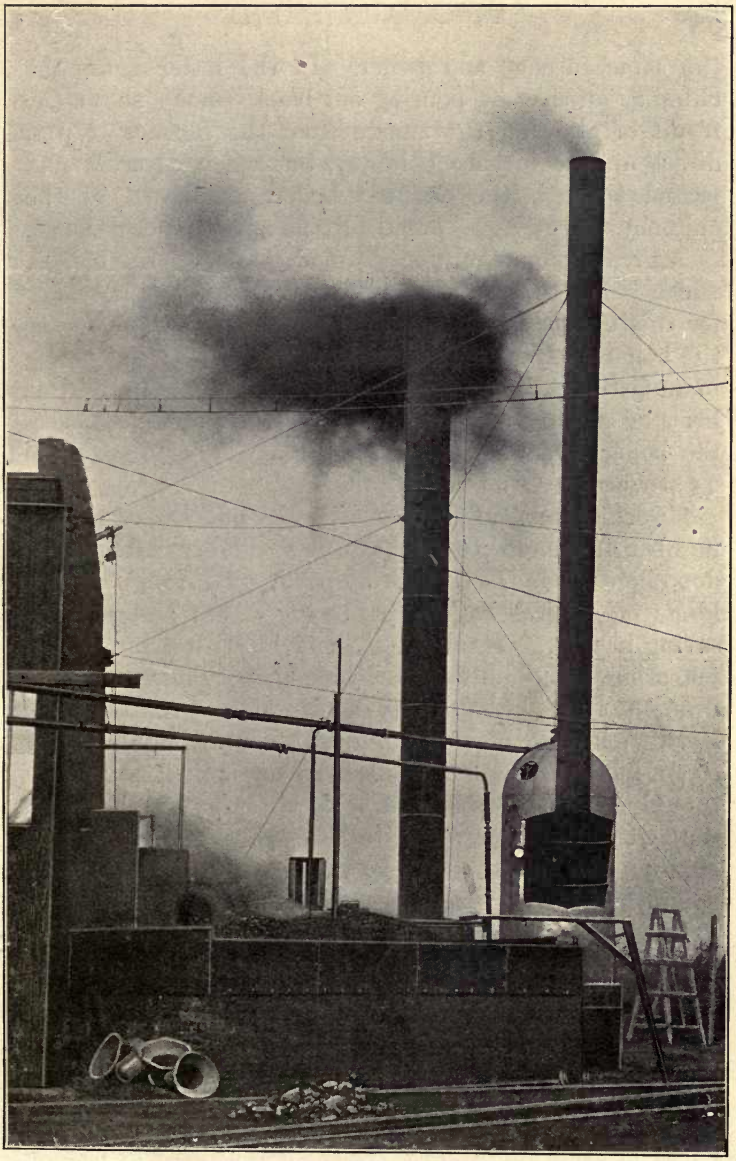


FIG. 59.—Cochran System—Left-hand Chimney when not used, and Right-hand Chimney when system is in operation.

the same furnace and boiler. In the latter figure the chimney on the left, pouring out black smoke, shows the result of allowing the smoke from the furnace to pass direct up the furnace chimney, but when diverted and passed through the Cochran boiler, as shown by the chimney on the right, practically no smoke is occasioned.

A great amount of unconsumed gas leaves the boilers, which is loss to the manufacturer. There is no necessity for this if proper and practical preventers are applied to the boilers. Heat must pass from the boilers, and many manufacturers, being alive to this fact, are utilising this heat by passing it through an economiser, which heats the boiler feed water, and effects a saving of from 15 to 25 per cent.

High Temperature Furnaces.—For many years a large number of manufacturers have used the heat after it has done its work in the furnace by passing it through various kinds of vertical boilers, producing steam and a great saving in fuel. One firm in Sheffield, with a number of reheating and puddling furnaces, using the waste heat from the furnaces, were able in this way to generate more steam than they required to drive their rolling-mills and steam-hammers. The result was an annual saving of thousands of pounds in coal. No attempt had, however, until recently, been made to use the gases which pass off from the furnaces in question in the form of dense volumes of black smoke at a low level.

The furnace temperature is sufficient to produce complete combustion of the gases (if the construction is not defective) when an efficient appliance is attached and the furnaces are carefully stoked; otherwise the unburnt gases pass from the furnaces with a great waste of fuel and the creation of a serious smoke nuisance.

The Cochran system, if applied to this class of furnaces, answers admirably. The heat is utilised in passing from the furnaces, and the unburnt gases are likewise consumed.

Low Temperature Furnaces.—There are very many furnaces worked at a low temperature, such as hardening furnaces, annealing furnaces, and furnaces for special processes. In these processes the temperature required is not sufficient to consume the gases in the furnace; in fact, the methods employed require that unconsumed gases or smoke should be present to act as an envelope for the steel. The smoke or gases must, therefore, after they have served their purpose in the furnaces, pass away, and be either utilised or wasted.

In this class of furnaces unburnt gases must unavoidably be discharged; to consume them in the furnaces would render the special processes impossible. But there is now no need to waste the gases, for it is practicable to pass them over an incandescent fire, generate heat, and so raise steam, without in the slightest degree interfering with the processes in the furnaces. A great economy of fuel and the abolition of the furnace smoke nuisance is thus effected.

The question of practically and economically disposing of the gases from all kinds of metallurgical furnaces is an all-important one for the future. It is the duty of manufacturers to consider the amount of money they are losing by these gases being wasted, and to adopt any practical system which utilises them. By so doing they will not only be benefited themselves, but will benefit the general public by reducing the smoke nuisance.

Gaseous Fuel.—Many advocates of the utilisation of gaseous fuel, with more partisanship than consideration for practical possibilities, contend that, in order to put an end to the smoke nuisance, the use of gaseous fuel ought to be made compulsory. The extended use of gas would certainly abate the smoke nuisance, but it is not practicable to use gas under all circumstances. In many instances the cost would be prohibitive, while for reheating or the working of metals the use of solid fuel is essential. Gas would make special processes impossible by spoiling

the steel. In support of this statement it may be mentioned that over twenty years ago a wealthy firm of steel manufacturers who had a number of coal-fired reheating furnaces, and did a big business at home and abroad in a special class of steel, decided to reconstruct their furnaces and work them by gas, believing that this course would be a saving to them and would end the smoke nuisance. The gas-producing plant was put down, the furnaces rebuilt, and were apparently working satisfactorily ; there was no nuisance, the output was greater, and the firm was being congratulated both for their public spirit and also for their prospective personal profits. In a very short time, however, the steel worked in the gas-fired furnaces was returned, both by home and foreign customers, who pointed out that it was no longer of the same class that they had had before, and that it had not the temper, texture, nor toughness, and was entirely unsuitable for their purposes. These customers had not been informed of the change in the working of the steel, so there was no prejudice on their part in the matter. The return of the steel resulted in exhaustive tests being made, which corroborated the statements of the customers, and the firm was compelled to revert to the old coal-fired furnaces.

The use of gas has nevertheless played no small part toward smoke abatement, and wherever its use is practicable it ought in the future to be adopted. There are a number of special processes for the generation of gas to be used either as a fuel or for power purposes. To describe in detail these special processes is unnecessary, for they are well known, having been in use for many years, and have given excellent results, both from a smoke abatement and from an economical point of view.

The systems mostly in vogue are :—

Siemens and Wilson Gas Producers.—These gas producers are amongst the oldest and the best, and, as a proof of the latter statement, they have had a remarkable reception, and very many are now in use. The gas may

be used directly in its original state as a fuel for various kinds of metallurgical furnaces and boilers, the essential consideration being the proper amount of air supplied to ensure complete combustion. It can also be used, after all the tarry matter has been taken from it, for driving gas engines.

Douson Producer Gas.—In this gas there is no tarry matter, it being produced from coke, charcoal, or anthracite coal. It is therefore chiefly used for driving gas engines.

It is also used in a great number of cases for heating purposes, such as metallurgical furnaces, bakeries, laundries, boilers, &c., but in boilers its substitution for solid fuel has not been found economical, although it is smokeless.

Mond Gas.—In this process gas suitable for either fuel or motive power is produced from bituminous slack, and not from coke or anthracite coal, which would increase the cost of production. The cost of production is further reduced by the recovery of the by-products, the sale of which, it is alleged, covers the cost of the fuel used, which makes the process a very cheap one, as there is only the cost of labour and interest on the first cost of the plant. As far back as 1901 a scheme was on foot to produce Mond gas in large quantities in a central station in Staffordshire, and to distribute it through pipes for use in the surrounding districts in metallurgical furnaces and for the driving of gas-engines. Very little has been heard of this scheme since, but it is hoped the claims put forward for it are capable of realisation, as it would be an admirable step toward smoke abatement.

Coke oven gas, when purified, can be burned under retorts, and also beneath boilers in order to raise steam.

Water gas, which is produced by sending steam through incandescent coke, can be used as a gaseous fuel.

Waste Gases from Blast and other Furnaces.—The combustible gases discharged from the tops of blast fur-

naces may be used to fire the boilers or in other ways, and the gas given off in the process of refuse destruction may also be burned under retorts or cells by the admixture of air.

Residues.—In Sheffield until recently it was the invariable custom of all the firms who had their own gas producers to shut them down about every three months to clean out the culverts, &c. There would be in the culverts or flues through which the gas went from the producers to the melting or other kinds of furnaces from 3 to 6 inches thick of tarry matter. It was loosened with the pick-axe and taken out. Whether the process was too costly, or from some other reason, it has been abandoned by some of the firms, who now at the week end fire the gas deposits. This is in all probability a cheaper way of getting rid of residue, but it creates a serious smoke nuisance, for the gas-producer chimney pours out for over two hours without cessation dense black smoke, which deluges the whole district. Whatever the advantages to the manufacturer by this change may be, it is a decided disadvantage and a gross injustice to those who are compelled to live near such chimneys, and ought not to be allowed.

If it is found necessary to get rid of the deposits more frequently than in the past, when no smoke nuisance was committed, it might be easily arranged to clean out the culverts instead of burning them out at shorter intervals.

Gas Engines.—During the last twenty-five years gas engines have become very popular, and there are thousands now in use of different kinds, which have taken the place of the steam engine, thus dispensing with the steam boiler, and the invariable accompanying smoke nuisance. To run a small gas engine of from one to twenty horse-power by illuminating gas continuously costs more than to run a steam engine of the same power; but for manufacturers who do not require continual power, but only use it at intervals, the gas engine

is far preferable, there being no boiler explosion risks, no standing expense when power is not required, and many other advantages which make even the small engine cheaper than a steam engine when only used intermittently.

There are many large gas engines used for all sorts of purposes, and they have been found more economical than the steam engine. The economical results are obtained by putting down a plant for generating a cheap gas from coke or coal. A large number of firms have recently substituted gas engines for steam, and one firm in particular, which recently put in three new Lancashire boilers, fitted up with a modern appliance, but which, through the negligence of their firemen, have been on two occasions fined for making smoke, have given an order for gas engines of over 400 horse-power, and for a gas-producing plant, for they find it will be more economical in working than steam, and will put an end to the smoke nuisance.

There is no doubt much controversy as to which of the two methods is the cheaper, steam or gas, but there is no question that the latter effectually solves the smoke nuisance problem.

Domestic Gas Stoves.—These are more popular to-day than ever, and millions are in use for cooking and for heating rooms. To their use belongs in no small degree the credit for the reduction of the smoke nuisance, which had been created by the millions of open fires in public and private houses before they were replaced by gas stoves. Their advantages are so well known that it is unnecessary to dwell on the subject.

CHAPTER XII

SUMMARY AND CONCLUSIONS

In the preceding pages the aim has been to carefully consider the smoke question in all its aspects from a practical point of view, as it has to be faced daily by the engineer and the fireman, and to point out what has been done in the direction of smoke abatement, what remains to be done in order to bring about the practical solution of the question, and put an end to the wholesale injury to property and health which the present state of affairs occasions.

At the beginning of the nineteenth century public feeling was so aroused at the wholesale havoc caused by smoke that it demanded that Parliament should take action, with the result that Commissions were appointed to consider the question in all its bearings, and report upon it. This was a work of many years, for Parliaments and Commissions move very slowly. In 1875 the Public Health Act was passed, and the sections in this Act relating to the smoke nuisance are exceedingly good, being of a very practical character, and giving power to Local Authorities or private individuals to proceed against, and procure penalties from, those creating a smoke nuisance, which is unnecessary for the carrying on of a particular trade or process. The Act exempts all smoke from private dwelling-house chimneys whether preventable or not. To have included this class of chimney would not have been in the slightest degree an injustice to any one, and if the exemption clause were deleted a great deal less smoke would be made. The omission of

the word "black" would also be a great boon to the public, and power would have been given to proceed against all unnecessary smoke. After the Act was passed, there seemed very little disposition on the part of the authorities to avail themselves of it, or to proceed against offenders. The Local Government Board, Local Authorities, magistrates, manufacturers, the Sanitary Institute, and others, whom it might have been supposed would be most enthusiastic on the subject, were, as a matter of fact, most apathetic, and it was not until the Coal Smoke Abatement Association of London and kindred associations in the provinces made their appearance, and evinced very definite determination to fight the smoke fiend, and force the authorities to do their duty, that any real improvement was effected. These associations have done excellent work, preventing to a large extent the pollution of the atmosphere by unnecessary smoke, awakening, and forcing the hands of the Local Authorities. Though they have accomplished much, much still remains to be done, for there are still a large number of Authorities who resolutely refuse to take any steps on behalf of smoke abatement.

Throughout the country much has been done to prevent smoke from boiler furnaces, and so successfully, that it is now admitted by all experts that there is no necessity for boilers under normal conditions to make even dense smoke, and all are still agreed that when such smoke is emitted from boiler furnaces the offenders should be mulcted in heavy penalties. In many manufacturing districts 80 per cent. less smoke is now made from boilers than was the case a few years ago, yet there are districts where the boilers continue to emit dense volumes of black smoke without the slightest restriction.

Very little, or practically nothing, has been done to stop the unnecessary volumes of dense black smoke which are day and night poured out at a very low level from an enormous array of metallurgical furnace chimneys. There

has not been the same pressure put upon the owners of these furnaces as upon owners of boilers. The fight against furnace smoke will be a very fierce one, but no fear need be entertained as to the result.

The old-fashioned brick-burning and other kilns, which made smoke for hours without cessation, have given place in many instances to a better kiln for burning purposes —one, too, which is practically smokeless. There are still many of the old type working, and some Authorities do not seem disposed to compel the owners to put in the smokeless forms; but, on the other hand, some Authorities have very wisely fixed by bye-law the minimum height of chimneys used for various purposes.

There is no cause for complaint of a scarcity of smoke-preventing and coal-saving appliances. Indeed, if anything, there are too many, and smoke makers are puzzled as to which to adopt. There is now in the market almost every conceivable kind of apparatus to suit all conditions of working. They comprise induced draught and forced draught mechanical stokers of the underfeed type, and of the Koking and Sprinkling types, door arrangements, patent bar arrangements, bridge arrangements, waste fuel economisers, and other forms. Very many of the appliances named have been in use for years, and the results have been very satisfactory both from a smoke-preventing and from an economical point of view.

Gas and electricity for power, heating, and other purposes are more popular to-day than ever. Probably the latter will supersede the former in many ways, but undoubtedly both are, in the future, destined to do much in the direction of smoke abatement, and the reason they have not as yet been more generally adopted by manufacturers is that the latter have not realised fully the many advantages there are to be derived by their use.

The general attitude of the public toward the smoke question is not very encouraging to those who are doing

all in their power on behalf of smoke abatement. It is an attitude of indifference, drift, or non-interference even on the part of those who are specially elected and appointed to deal with this matter.

Dr. Russell Wallace, in his recent book, "Man's Place in the Universe," says: "The huge and ever-increasing cities, the vast manufacturing towns belching forth smoke and poisonous gases, with the crowded dwellings where millions are forced to live under the most terrible insanitary conditions, are witnesses to a criminal apathy, an incredible recklessness and inhumanity. Yet this is the one great and primary essential of a people's health and well-being, to which everything should for the time be subordinate. This is the gospel that should be preached in season and out of season till the nation listens and is convinced. Let this be our claim. Pure air and pure water for every inhabitant of the British Isles. Remember we claim to be a people of high civilisation, of advanced science, of great humanity, and of enormous wealth."

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THE END

Printed by BALLANTYNE, HANSON & Co.
Edinburgh & London

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