COMMODITIES AND INDUSTRIES

PATENT FUELS

J. Arthur Greene
and
F. Mollwo Perkin.

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"PATENT," SMOKELESS AND SEMI-SMOKELESS FUELS

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Frontispiece

VARIOUS TYPES OF SOLID PATENT FUEL SUITABLE FOR DOMESTIC AND INDUSTRIAL PURPOSES

PITMAN'S COMMON COMMODITIES AND INDUSTRIES

"PATENT," SMOKELESS AND SEMI-SMOKELESS FUELS

BY

J. ARTHUR GREENE

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EDITOR "A TREATISE ON BRITISH MINERAL OIL," ETC.

AND

F. MOLLWO PERKIN

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PREFACE

In the first portion of this little book I have endeavoured to show in simple language how so-called "Patent," "Smokeless," and "Semi-smokeless" fuels are made, and why this form of fuel should be used in preference to raw coal. This section is intended to appeal to the public at large, who, for the greater part not being versed in highly technical subjects, have never, so far as I am aware, had the question explained to them in language which they can readily understand, and thus, having never understood, have made no demand for the better and more economical article.

The second section has been written to assist the more interested and scientific reader to whom the technical details of the problem appeal.

At a banquet held in Berlin, just before the war, the ex-Kaiser said: "There are two people to whom the prosperity of the German Empire is most largely due—myself, as a commercial advocate, and the late Sir William Perkin, as a scientist who, failing to find support in his own country, brought to us his secrets and discoveries in the manufacture of aniline dyes—and to this industry, under our control, is mainly due the present commercial prosperity of our Empire."

When war broke out, one of our principal industries—the textile trade—representing a capital investment of over £200,000,000 sterling, was absolutely dependent upon Germany for 80 per cent of necessary dye-stuffs produced as the result of Sir William Perkin's researches. Now aniline dyes are, as everyone presumably knows, one of the many products resulting from the scientific treatment of raw coal. And so, when the publishers of this series of books asked me to undertake this work—the scientific treatment of coal and the manufacture of "patent" fuel—I discussed the suggestion with Dr. Mollwo Perkin, who at once volunteered to collaborate with me—an offer which I most gratefully accepted. Dr. Perkin for the past fifteen years has been urging fuel reform, but with little more success in this country than was extended to his distinguished father.

In America, and in Canada, in China, Japan, India, Germany, and other parts of the world, coal treatment plants are now being erected, and in certain parts of some of these countries the burning of raw coal is an offence against the law.

And, when in the first paragraph of this Preface, I use the word "better," I refer not only to its calorific-, thermal- or heat-giving properties, but also to its value in the preservation of health by the prevention, combating and cure of disease.

In my introduction to *A Treatise on British Mineral Oil* (Messrs. Chas. Griffin & Co.), and which contains a résumé of the researches which have made possible the writing of this little book, I said "It (the book) does not claim to be the last word upon the subject of retortable material and its commercial treatment, but it is the latest. It is claimed that in brief form it brings the subject up to date from several points of view, and goes some way towards the solution of a number of difficult problems. It has been a labour of love by several very busy men, who, from motives both of patriotism and the keen interest of the scientist, have done their best to develop a new industry, with the hope of advancing the knowledge of the day and helping those who come after."

Since that time—now nearly four years ago—much has been done, great progress has been made, and although we are yet still very far from being a smokeless country or self-supporting in our production of light and heavy oils, a certain and definite move in that direction has been made.

Thanks, largely, to the efforts of the organization to which reference is made on pages 50 and 52, more than 5,000 householders in the London area abandoned raw coal last autumn in favour of patent or semi-smokeless fuel.

It is improbable that I shall ever witness the realization of the ideals which I have for so long endeavoured to forward and achieve, but, again in the hope that it may advance the knowledge of the day and be of help to those who come after, the preparation of this small volume has been undertaken.

J. ARTHUR GREENE.

12 St. James's Square,
London,
1*st August*, 1922.

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PART I

CHAPTER I

" PATENT " AND SMOKELESS FUELS

VERY few of us seem to realize that coal is the life-blood of Great Britain. It is primarily upon the widespread and immensely valuable deposits of coal, affording the provision of cheap heat and power, that the wealth of our nation has been built. The fact that we, as a nation, have in the past made the *least* instead of the *most* of this great asset constitutes a grave reflection upon the colliery owner, the politician, and the masters of industry, as well as the public at large. The time has now arrived when we must either mend our ways in this respect or become bankrupt and rank as a back number amongst other and more progressive nations.

The remedy lies in the scientific utilization of raw coal and the manufacture of " Patent," Smokeless, and Semi-smokeless Fuels—with which is inseparably associated the production of light and heavy oils, gas, electric energy, and by-products. But prejudice is hard to kill ; insular prejudice is most difficult of all to overcome.

History. Coal was first worked under licence in Great Britain in 852 under a permit granted by the Abbot of Peterborough, although there is ample evidence to show that the Romans during their occupation actually discovered and operated the outcrops of some of our coal seams.

By 1799 an output of 10,000,000 tons per annum had been achieved, and on 16th December of that year—123 years ago—John Frederick Chabannes, of Welbeck Street, London, was granted a patent for the manufacture of patent fuel, " that is to say, coals consisting of great and small mixed together such as are usually bought in the pool in the River Thames for consumption in the cities of London and Westminster, and their environs." " The composition is to consist of small coals so separated as above mentioned from the large coal and a small quantity of earth, clay, cow-dung, tar, pitch, broken glass, sulphur, sawdust, oil-cakes, tan, or wood " to be mixed together and " moulded into bricks or balls." (*See* Appendix.)

Our present output of coal (1922) is approximately 260,000,000 tons per year, and the output of Patent Fuel 2,000,000 tons per year, 1,875,000 tons of which is exported !

Coal was first brought into use in London about 1300, and owing to the high price of wood it rapidly came into general use. The smoke given off, on account of its imperfect combustion, became the subject of agitation in the time of Edward I, and again during the reign of Queen Elizabeth, when Proclamations were issued prohibiting the use of coal in London when Parliament was in Session.

In 1306 a Royal Proclamation was issued prohibiting artificers from using coal in their furnaces upon the pains of punishment of " great fines and ransoms for the first offence," and upon the second offence " the destruction of their furnaces." It is recorded that one offender was tried, condemned, and executed for burning coal in London.

John Evelyn, writing of London smoke in 1670, says: "That hellish and dismal cloud of 'sea-coal' which is not only perpetually imminent over her head but so universally mixed with the otherwise wholesome and excellent air that her inhabitants breathe nothing but an impure and thick mist accompanied with a fuliginous and filthy vapour, which render them obnoxious—corrupting the lungs, and disordering the entire habits of the bodies; so that Catarrhs, Phthisicks, Coughs, and Consumption, rage more in this City than in the whole earth besides."

The illustrations on the two following pages are mid-day views of London taken in summer and winter, and give some idea of "the hellish cloud of smoke" referred to by Evelyn.

In 1648, Londoners petitioned Parliament to prohibit the importation of coal from Newcastle on account of the damage caused by smoke. In the reign of Charles II a Bill was prepared with the object of mitigating the nuisance, but it never became law.

Coal was first worked in Westphalia about 1300, yet, although Germany now has a coal output almost as large as our own, her output of patent fuel exceeds 25,000,000 tons per annum, all of which is consumed in that country. It should, however, be pointed out that of these 25,000,000 tons of patent fuel, a very large proportion is manufactured from lignite, of which considerable quantities exist in that country.

The quantity of coal consumed per annum in the United Kingdom is about 175,000,000 tons, of which London alone consumes 16,000,000 tons. It is estimated that one-third of the coal consumed in the United Kingdom is wasted owing to want of sensible and scientific systems of carbonization. The present consumption of 40,000,000 tons of coal per annum in the United Kingdom for domestic purposes implies the loss, on a very moderate showing, of 400,000,000 gallons of oil!

In the British Isles the annual production of coal smoke by the burning of raw coal is equivalent to 3,000,000 tons of sulphuric acid, most of which is showered down in rain. In soot alone approximately 2 per cent of the total quantity of coal consumed is wasted.

In the City of London 650 tons of soot fall to the square mile per annum, or in the administrative County of London 76,050 tons per annum. This includes 6,000 tons of ammonia, 8,000 tons of sulphate, and 3,000 tons of chlorine, combined as chlorides. The money lost due to smoke and fog in London—resulting from the consumption of raw coal—is estimated at £5,470,000 per annum. An equivalent waste occurs in our provincial towns and cities.

About 25 per cent of the total output of our collieries is small coal—now wasted. (*See* p. 25.)

In 1875 a Public Health Act came into force, providing "that any chimney not being the chimney of a private dwelling house which sends forth black smoke in such quantity as to be a nuisance" should be punishable under the ordinary provisions applicable to any other offence coming under the heading of "nuisances."

In 1735 coke was made and used commercially by Darby, although Dudley made coke experimentally in 1619.

Coal gas was first discovered by Murdock in 1792. Murdock was a Scotsman employed in the Midlands. On leaving work it was necessary, in order to get home, for him to walk across what was then known as the Birmingham Moors, and in the winter evenings it was so dark that it was necessary for him to find means of lighting his way. He evolved a process for the

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" WINTER "

Showing " The Hellish Cloud of Smoke "—a view over London.

extraction of gas from coal, and the gas produced he carried in a bag (a pig's bladder) which he attached to his shoulders.

In 1798 (Beckman's *History of Inventions*) reference is made to " the burning of coals in order to procure from this rock oils, used particularly for leather manufacture, which is much practised in England."

In 1847 the attention of James Young, of Kelly, was drawn to a stream of oil flowing from the top of a coal working at Alfreton, in Derbyshire. From this he succeeded in extracting on a commercial scale paraffin wax, lubricating oil, and burning oil. The supply of the raw material soon became exhausted, and Young attempted to imitate the natural process by which he believed the oil to have been produced, i.e. by the action of gentle heat on coal, and in 1850 he was granted a patent for " obtaining paraffin oil, or an oil containing paraffine, and paraffine from bituminous coals by slow distillation." This processs was extensively carried out in the United States under licence from Young, until the discovery and working of free oil made the industry unprofitable. The commencement of the world's mineral oil industry may be dated from the granting of the British patent to Young, although, as a matter of fact, mineral oil had been produced in America from shale in the year 1840.

Gas making on a commercial basis was introduced in 1802.

In 1815, John Taylor was granted a patent for the process described as producing " inflammable air or olefiant gas applicable to the purpose of giving light " from vegetable or animal oil, fat, bitumen, or resin. This oil gas, compressed by a method patented by Gordan and Heard in 1819, was supplied by a company having the title of " The London Portable Gas Company."

" SUMMER "—THE SAME VIEW

It was contained in vessels having a capacity of 2 cubic feet, which were delivered to the premises of consumers and returned when empty to be refilled.

Last year we imported oil to the value of £54,549,861; the world's present annual production of oil is 700,000,000 barrels of 40 gallons each.

The foregoing facts and figures disclose such an appalling condition of wanton waste that one immediately wonders: "Why on earth has there not been some sort of legislation to stop it?" The answer is simple: "Because the public, not understanding, has made no demand for it to be stopped."

The passage of time has not tended to decrease "the curse," but on the contrary, the conditions existing to-day are more pernicious than ever; although at last the evil effects of coal smoke upon the human body are being recognized by members of the medical profession. The sun, in fact, is being accepted as the world's antiseptic, and there is no question that a smokeless atmosphere would do more to rid us of our diseases than any other conceivable means of prevention. In this connection the use of soft coal as a fuel in New York was prohibited in 1905 for the specific purpose of combating pulmonary tuberculosis. During the following fourteen years—i.e. 1905 to 1919—the death rate in that city from that particular disease was reduced by 50 per cent without any new factor being introduced for the suppression of tuberculosis. In a recent address upon this subject to the members of the London Society, Dr. Saleeby, in the course of his remarks said—

"It is infamous that, possessing such a treasure as Westminster Abbey, which reduces New York to beggary by comparison, we should eat it away as we do by the sulphuric acid derived from the stupid destruction of one of the most valuable ingredients of our coal. But my concern is with public health. The evidence for sunlight derived from my North American visits, in Canada no less than in the United States, led me to define certain of the commonest and most deadly diseases of our own cities as " diseases of darkness." Of these the worst is tuberculosis. It was evident to all, skilled or unskilled in observing tuberculosis, that the disease can be cured, even in extreme and otherwise desperate cases, after all else has failed, by exposure to sunlight. The evidence I found in the cliniques of Dr. Rollier at Leysin, in Switzerland, may be regarded as irrelevant in that it refers to an altitude of nearly 5,000 feet—to which it would be hardly feasible to elevate the city on the Thames. But at Alton, and Hayling Island, in Hampshire, I found Sir Henry Gauvain curing tuberculosis with sunlight, just like Rollier in the Alps. This is a splendid result of the beneficence of a former Lord Mayor of London, Sir William Treloar, whose " Cripples' Hospital " has thus become the most wonderful demonstration of the value of sunlight in this country. Similarly, at Queen Mary's Hospital, Carshalton, Dr. Gordon Pugh is curing tuberculosis by sunlight. The lesson it teaches is that the diseases of darkness would go the way of leprosy and the plague into the limbo of medical history if we applied to the tasks of creation and prevention the same primal and celestial agent which, in such hospitals, fulfils the old words, " And they that dwell in the valley of the shadow of death, upon them hath the light shined." We must have more light. Not for tuberculosis only, nor anaemia only, but for a host of disorders of growth and defects of physique. The restoration of sunlight to our malurbanized millions, now blackened, bleached and blighted in smoke and slums, is the next great task of hygiene in our country."

CHAPTER II

ECONOMY OF PATENT FUELS

The principal purposes for which raw coal is at present consumed in this country are as follows—

(1) Steam Generators (Power Purposes) .	60,000,000	tons per annum.
(2) Domestic	35,000,000	,, ,, ,,
(3) Steam Generators (Low Pressure Purposes)	30,000,000	,, ,, ,,
(4) Coke Ovens (High Temp. Carbn.) .	20,000,000	,, ,, ,,
(5) Gas Works ,, ,, ,, .	18,000,000	,, ,, ,,
(6) Railways	15,000,000	,, ,, ,,
(7) Other Purposes	9,500,000	,, ,, ,,

The public at large has not, and cannot be expected to have, the wide physical and chemical knowledge necessary for the understanding of this subject, i.e. the scientific treatment and utilization of coal. When once the public—the householder—understands the problem and realizes that although he be only an actual consumer of from 5 to 10 tons of coal per annum, he can personally save 20 per cent to 50 per cent of his coal bill—he will understand, and having understood, he will demand legislation. The agitation for Government action has, in fact, been proceeding for many years, but unfortunately it has been mainly urged by highly technical men—eminent scientists who thoroughly knowing their subject, put forward their case in " therms," " calories," and other technical terms which, however simple to the technical expert, are beyond the comprehension of the average person. A few months ago one of our most eminent politicians was holding forth at his dinner table upon this topic. Subsequently, one of his guests asked her hostess the meaning of " therms," and was informed that " therms " were " those little white wiggly things that get into flour when it has been kept too long in the bin."

It will therefore be my first effort to explain in simple language how, and by what means, the home fuel bill, both in Great Britain and elsewhere, can be *immediately* reduced, for it is useless to urge reform unless the householder is able to obtain delivery of a more efficient substitute for coal, and with equal facility; but that substitute must be available *at a price which is less* than ordinary raw coal, *entirely regardless of the fact that it is more efficient.* When once the public realizes that a scientifically prepared coal can be obtained through the ordinary channels—a fuel *more efficient* than raw coal and at a *less cost*—then, and then only, will the householder take a serious interest in, and realize the advantages of patent and smokeless fuels as compared with raw coal.

I would like here to refer to the provisions of the patent granted to Chabannes in 1799, which I have already quoted, and which provided for the manufacture of patent fuel from a " composition " consisting of small coal mixed with a quantity of " earth, clay, cow-dung, tar, pitch, broken glass, sulphur, sawdust, oil-cakes, tan, or wood." In the manufacture of " patent fuel " to-day, the coal or other ingredients to be compressed are ground up, and to this ground up material is added as binder a certain percentage of pitch. This plastic mass is then passed between heavy moulded rollers and compressed. Thus, supposing all the ingredients mentioned in the foregoing specification were mixed up in equal proportion with a binder and compressed into briquettes, it would be absolutely impossible—except, probably, to an expert—to distinguish at sight and before ignition, the difference between briquettes made of this composition and briquettes made of a proper and scientific mixture of small coals.

In an article contributed by me to the *Mining Journal*

(16th July, 1921) I stated, in reference to a particular fuel—

"Of course, there is 'patent fuel' *and* 'patent fuel,' the quality of which depends entirely on the technical knowledge or honesty of the manufacturer. A really good 'patent fuel' can be made of a mixture of the best anthracite and certain ascertained and specially selected coal, with the addition of a very small percentage of pitch or other binder. The composition is compressed into blocks or egg-shaped briquettes. The latter form is manufactured in five sizes; i.e. 1-oz., 2-oz., 3-oz., 5-oz., and 7-oz., ; all give highly satisfactory results in the open grate, kitcheners, slow-combustion stoves, and for general industrial purposes, but the form of grate, draught, and other conditions give one size, and, of course, quality, an advantage over the other.

"The material is practically smokeless, and yields about 14,000 British thermal units per lb. In comparison with coal, it lasts more than twice as long and gives off much greater heat. The war taught the public the meaning of 'proof' in spirits and 'gravity' in beer, but very little in regard to 'calories' in coal. Colliery waste—in fact, all the pit heaps and the blast furnace slag heaps in this country—could be ground up, mixed together, and converted into 'patent fuel.' But the product, whilst being of the same size, shape, and appearance of good 'patent fuel,' could not be made to burn, and this would go far to kill the development of the 'patent fuel' industry."

From this it will be apparent that the "blending" and "reconstruction" of coal is now a highly developed art—just as is the blending of fuel, oils, and spirits, with the object of arriving at certain specific conditions in relation to calorific power, flash point, viscosity, etc.—and one which is obviously impossible of achievement by anyone not having the necessary technical ability and training.

A story is told of a man who one day went to see his doctor and complained of suffering from giddiness, loss of appetite, inability to sleep, and various other ailments. The doctor asked him a few simple questions—told him to put out his tongue—made up a bottle of medicine, handed it to the patient and said : " 7s. 6d., please." The patient in astonishment said : " What ! 7s. 6d. ? " and the doctor said : "Yes; do you think it's too much ?" " I should think I do," replied the patient. " Very well," said the doctor, " give me ' tuppence ' and help yourself." I hope that the moral of this little story is quite apparent to my readers. It is just as impossible for the average company promoter, solicitor, or mining engineer scientifically to " blend," treat, or reconstruct coal for the manufacture of patent fuel as it is for the same class of individual to possess the qualifications of a medical man in the dispensation of medicines.

From time to time prospectuses have been issued in connection with the flotation of public companies formed for the manufacture of patent fuel or briquettes, the scientific treatment of coal, the production of oil from coal, and for various coal treatment purposes. Such propositions have been backed up in many cases by the reports of scientific experts couched in such ambiguous language that the public were readily lead to believe that their subscriptions would not only lead to the solution of the problem, but at the same time untold wealth would accrue to them as a consequence of the investment of their capital.

CHAPTER III

COLLIERY WASTE AND THE SCIENTIFIC TREATMENT OF COAL

THE raw material in sight divides itself into severa classes, chiefly—

1. Anthracite.
2. Steam coal.
3. Non-caking coal with a high yield of oil, giving a residue of low value as household and steam-raising fuel, but of considerable value for producer gas and other purposes.
4. Caking and non-caking coal with a smaller yield of oil than (3) but affording a residue of great value for domestic and industrial fuel ; and
5. Material of a variety intermediate between (3) and (4).

As a result of tests carried out by various processes, it has been established that a yield of between 15 and 18 gallons of crude oil per ton can be obtained from material existing in the British Isles. This crude oil can be refined to give at least 8 per cent of spirit and 40 to 50 per cent of fuel oil.

The residues obtained from caking material (4) provide a clean, smokeless fuel, and of high calorific value.

The residues obtained from non-caking material (3), high in ash, can be utilized in a producer for the production of power gas and sulphate of ammonia. The quantity of gas must depend on the relative proportions of carbon and ash in the residue, and, consequently, no generalization as to the yield of gas is possible. The residues obtained from non-caking coal low in ash can be utilized in the manufacture of briquettes.

The most popular form of patent fuel for domestic purposes is of the egg-shaped or " ovoid " variety. The word " ovoid " or " ovoidal " comes from the Latin *ovum*, " an egg," and the Greek *eidos*, " like," and refers

FIG. 1 SOLID—1½ OZ.

FIG. 2 SOLID—2½ OZ.

to something of egg-shaped form, in just the same way that *ovolo*, " a convex moulding," is derived from the same Latin word. This explanation is necessary in that it is desirable to point out that the use of the name " Ovoid " in regard to patent fuel must be taken as a generic term and not attributed to the manufactured article of any particular firm or company. From this it is obvious that the material compressed into ovoid form may be anything from pure anthracite—or for that matter, pure gold—to the heterogeneous mixture

SCUTTLE FILLED WITH "DOMESTIC" SIZE FUEL

referred to in the patent specification of Chabannes. As a matter of fact, the use of the name "ovoid" in connection with the fuel so-called is a technical misnomer; its correct geometrical shape and description being "Parabolic." (The illustration on page 15 clearly shows the actual sizes of the two principal types of fuel manufactured for various domestic purposes in this country.)

Anthracite. Anthracite is of an extremely hard nature, has a brilliant black lustre, and does not soil the fingers when handled. Ordinarily, it is difficult to ignite, but when once alight burns with a great heat and gives off practically no smoke or flame. It contains a very high percentage of carbon. The average chemical composition of anthracite is—

Carbon	from	90 to 95 per cent.
Hydrogen	,,	3 to 4·5 ,,
Oxygen and nitrogen	,,	2 to 5·5 ,,
Ash		1·7 ,,

This is really in its raw state the only natural smokeless or semi-smokeless fuel obtained.

However coal is got in the pits, a large percentage of good coal is involuntarily crushed to " smalls " or dust, and this, owing to its brittle nature, is greater in the case of anthracite than in softer coals. These smalls—or " duff "—contain the same heating value, and therefore the same economical value as the actual large lumps of coal of which they are the " waste."

Broken up into the same sized pieces as ordinary " household " coal, anthracite will not burn in the ordinary grate and, therefore, until quite recently, and in order to obtain the heat and economies of anthracite, houses, hospitals, clubs, offices, and other similar buildings utilizing the ordinary open grate with bars, without bars, or in any other shape or form, have been compelled to spend large sums of money on purchasing so-called " anthracite " or " slow-combustion " stoves of one type or another. As a result of researches and experiments carried out in connection with my duties as a member of His Majesty's Petroleum Research Department, discoveries of a most interesting character were made. It is no breach of faith for me to state that a careful survey has been made not only of collieries actually operated in this country, but of unworked and neglected seams of coal and of the waste heaps of both working and derelict collieries which have for long been shut down.

For many years before the war I had taken an active interest in the development of the oil shale industry, and, in fact, on the outbreak of hostilities, I was engaged in the Transvaal arranging for the construction of a plant for the establishment of the industry in South Africa. Early in 1917, the late Sir Boverton Redwood, Bt., sent for me. He informed me that, in view of the unrestricted "U" boat campaign which had been declared by the Germans, he, as Advisor on Petroleum to His Majesty's Government, had been called upon to report at the earliest possible moment what quantity and what quality of light and heavy oils he could produce from materials indigenous to these islands; in what time; by what methods, and at what cost. He impressed upon me the great national urgency and importance of the matter, and invited me to work with him as one of the newly-appointed Petroleum Research Department, of which he had consented to become Director. I gladly fell in with his suggestion.

Up to that time nothing in the nature of a systematic investigation into the possibilities of producing oil and spirit from materials within our own shores had ever been either thought of or attempted. True, samples of coal, oil shale, and other bituminous minerals had been tested, but these tests for the most part had either been carried out in the interests of some person desiring to find capital for the erection of a particular process, or by some other person desirous of forming a company to work oil shale. Nothing in the nature of a thorough independent and comprehensive survey had ever been attempted.

A yard was taken in London in which a low temperature carbonization plant was erected under the supervision of the very able engineering staff attached to the Department, and, in the meantime, search was commenced for retortable material.

It is not permitted to me in this volume to give at any length the result of the work of that Department, but suffice it to say that within a year of the commencement of operations it was conservatively estimated that, without seriously interfering with the ordinary mining of coal, between 6,000,000 and 7,000,000 gallons of petroleum, 100,000,000 gallons of fuel oil, and a considerable quantity of intermediate oils could be produced per annum by distillation. Subsequent and more thorough investigations revealed the fact that the raw material to be utilized for the production of the greater portion of this oil comprised what is known as colliery waste, i.e. "Jacks," "Batts," "Rums," "Inferior," and "Bastard Cannels," "Rattlers," "Rattle-Jacks," "Gees," "Splints," and so forth. Further investigations proved that the production of oil could be enormously increased by the raising of material specially for the purpose.

Coals of all classes and from all parts of the British Isles were tested, and very complete records made.

It was no part of the work of the Department to deal with the solid residues—or low temperature coke—left after the retorting of the coal, so this was used both under the boilers and for heating the rooms at the testing station. The retorts worked continuously day and night under the observation of the engineering and technical staff, and thus—during the long watches of the nights—the importance and value of these solid residues gradually won favour with the technical experts.

Many very poor coals gave surprisingly good solid residues, and ultimately, at the request of Sir Boverton Redwood, samples of residues of all coals treated were carefully put aside for further investigation.

This low temperature coke possessed all the advantages so often put forward by those who urge fuel reform. It radiated a greater heat than raw coal, was perfectly smokeless, cleaner, and in every respect more economical—in fact, at the then price of oil, the liquid product obtained from the material treated would have enabled the sale of the solid residues at half the normal price of coal, and even then allowed a substantial profit on the cost of production. The one objection to the fuel was its friability and lightness, in other words, a cart capable of conveying 2 tons of raw coal would hold less than 1 ton of this smokeless fuel, which, in the necessary handling into the cellar, was found to break up into very small pieces, and create a large accumulation of dust.

It was one of Sir Boverton Redwood's dearest wishes that the work achieved by his department as a war-time measure should result in the establishment of a permanent industry, and he realized that that desire could only be brought about by the conversion of the retorted residues into solid fuel for domestic and industrial use, thus enabling the industry to be developed on a sound and profitable basis.

To this end, a great deal of experimental work was done unofficially, and, under my supervision, a small briquetting machine was brought into use. Residues from one material were blended with residues from another, or with raw bituminous coal and other substances, but ultimately it was found that with the knowledge, facilities and plant then in our possession, the only satisfactory method of treatment was to crush the coke, mix with anthracite duff, and briquette with a pitch binder. Efforts were made to find an efficient and economical substitute for pitch—a combustible binder which would not increase the ash content of the finished product—but without success. Briquettes so made proved highly satisfactory, the only imperfection being the slight smoke created in the process of ignition, due to the 7 to 8 per cent of pitch used. Still, the fuel was a great improvement in every respect upon raw coal and afforded a practical solution of the problem.

An effort was subsequently made by private enterprise to establish an industry in London by retorting bituminous coal to be brought from the North and Midlands and briquetting in admixture with anthracite duff brought from South Wales. For various reasons, this project, however, fell through, but it is one which undoubtedly will be revived and become a *fait accompli* in the not far distant future.

In the meantime, in August, 1921, a synthetic fuel, which very nearly approaches the ideal, was put on the market. Tests were made upon this fuel (brought forward under the registered trade name of "Anti-Waste" fuel) and gave unexpectedly good results.

The tests were conducted in a room of 18 ft. by 14 ft., having an ordinary fire-grate with horizontal bars, the grate area being 108 sq. in. The temperature readings were recorded by a thermometer suspended at 8 ft. from the fire.

"Anti Waste" Fuel

The fuel was lighted at 10 a m. on Tuesday, 10th Jan., when the initial temperature of the room, as shown by the thermometer, was 47·8° F. The fire was lighted in the usual way with sticks and paper and the 14 lb. of the fuel added. The subsequent readings are shown on the accompanying

House Coal

During the test it will be noticed that the temperature of the room rose more rapidly for the first hour, but remained at 58·5° F. for the next half-hour, after which it rose to 65°, with a slight fluctuation and dropped to 60° at 2.5 p.m. At this point the fire was poked to prevent it going out, "ANTI WASTE" FUEL—*Contd.*

chart. On 11th Jan. a similar test was carried out on 14 lb. of best household coal (Derby Brights) in the same room, when the initial temperature, as shown by the thermometer, was 49·5° F. The subsequent temperatures are also plotted on the accompanying chart. It will be noticed that in the case of "Anti-waste" fuel about three-quarters of an hour elapsed before any appreciable change in the temperature of the room took place, i.e. until about 10·45, but after this period this temperature rose rapidly to 64° F., at which it remained fairly constant for about seven hours and then receded until the fire died out at 8.10 p.m.

The fire was not touched in any way throughout this period. The weight of the ash remaining, which consisted of a small quantity of powder with a few pieces of unburnt fuel, was 1·65 lb.

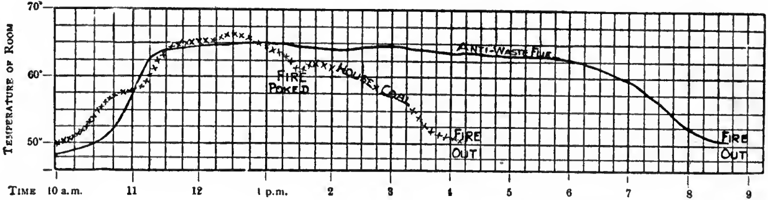
HOUSE COAL—*Contd.*

which increased the temperature a further 2° for a period of about 15 minutes. After this, it gradually receded until the fire died out at 4.15 p.m. The weight of the ash remaining, which consisted of some partly unburnt coal and clinkers, was 1·8 lb. The result of this trial shows the following advantages of the "Anti-waste" fuel over ordinary household coal: (1) it is practically smokeless after it has been lighted for half-an-hour; (2) its length of life is at least twice that of coal; (3) it maintains a practically even temperature without poking or attention. In fact, it should not be poked, as it burns throughout without attention, and throws out more radiant heat than coal. In an ordinary grate the heat efficiency is at least 50 per cent greater than ordinary coal.

The "chart," shown on page 23 and which was made on the occasion of these tests, clearly shows that, irrespective of the greater radiant heat obtained, in comparison with best raw coal, the patent fuel lasted more than twice as long!

It must be remembered that during the war the price of fuel oil and petrol was "what it would fetch." By the autumn of 1920 it was approximately £15 per ton. It has now fallen to about £3 per ton, and this has necessarily retarded the erection of low-temperature carbonization plants, and *ipso facto*, the manufacture of "patent" fuel both in Great Britain and elsewhere.

In these circumstances attention was diverted from



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	Anti-Waste Fuel.	House Coal.
Fire started	10 a.m.	10 a.m.
Weight of Fuel added	14 lbs.	14 lbs.
Initial Temperature of Room	47·8° F.	49·5° F.
Average Temperature maintained	61·4° F.	59·3° F.
Length of Time Fire lasted	10 hrs. 10 mins.	6 hrs. 15 mins.
Weight of Ash remaining	1·65 lbs.	1·8 lbs.

CHART OF TEST CARRIED OUT BETWEEN "ANTI-WASTE" FUEL AND RAW COAL

From which it will be noticed that the "patent" fuel affords twice the life of raw coal.

the extraction of oil as a primary product to the manufacture of solid fuel as a first consideration, leaving the distillate as a by-product.

It was in the course of my researches that I became responsible for the idea—and coined the phrases—of "Coal Blending" and "Reconstructed Coal." In discussing an article contributed by me to the *Press*, I had stated: "The war taught the public the meaning of proof in spirits and gravity in beer, but left it very little wiser in regard to the understanding of calories in coal." As the outcome of discussing spirits, beer, coal, and oils, the idea of "blending" and "reconstructing" coal was evolved. The blending of tea, oils, whisky, tobacco, and so forth is in each case an art in itself, and it must be perfectly obvious that the "blending of coal" involves an equal amount of specialized technical knowledge in order to achieve the desired result. While claiming to myself the coining of the phrases referred to, I do not lay claim to the sole credit for the solution of the problem, so far as it has been solved. Early in 1918 I resigned my position with H.M. Petroleum Research Department in order to organize—at the request of the Institution of Petroleum Technologists—a Committee known as "The Committee on the Production of Oil from Cannel Coal and Allied Minerals," which was appointed with the following terms of reference—

"To obtain evidence in respect of the quantity of cannel coal and allied minerals available in Great Britain as a source of motor spirit, fuel oil, and other products, and to formulate a scheme for the utilization of such supplies."

To this Committee I became Honorary Secretary and Technical Advisor on Minerals and Supplies. Realizing the great importance of producing oil from indigenous sources, Sir Boverton Redwood obtained for his

Department the whole-hearted support and co-operation of the most eminent geologists, engineers, chemists, and other technical men from all quarters of the world, and to the Committee which I organized, and of which I had control, was extended by these gentlemen the benefit of their advice and knowledge so readily placed at the disposal of the State. It is largely as a result of their collaboration that the successful system of " blending " and " reconstruction " of coal as we have it to-day has been evolved.

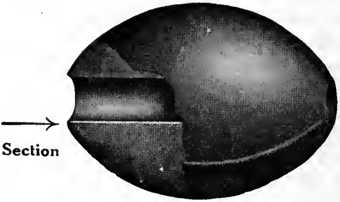
Some slight indication of the waste now going on at various collieries in this country can be vaguely appreciated from the following particulars relating to material existing on so-called " waste heaps " at six collieries within a few miles of each other in the Midlands—

	Estimated quantity of good material put on to heap per day.	Ascertained yield of crude oil per ton of material.	Quality of solid fuel remaining after retorting.
	Tons.	*Gallons.*	
A	150	48	Good.
B	200	54	Good.
C	540	37	Very good.
D	210	55	Fair.
E	240	21	Excellent.
F	120	27	Good in closed stoves.

In addition to the crude oil, between 2 and 6 gallons of spirit (petrol) per ton of material distilled is obtained. The residues contain from 6 per cent to 15 per cent of volatile matter.

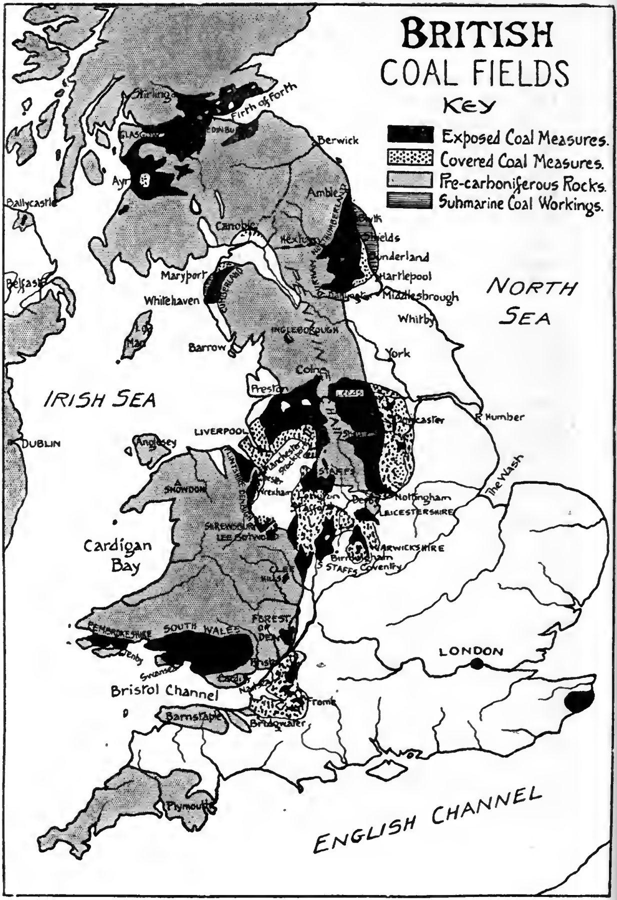
Perforated Egg-shaped Fuel. A well-known Continental firm has evolved an ingenious system of perforating this type of fuel, as shown on page 26.

This perforated fuel, it is found, gives even more satisfactory results than the solid product. Owing to the system of perforation, not only is the surface area of combustion considerably increased, but the circulation of the gaseous elements is facilitated, thus affording a better admission and intimate mixture of the air with the combustion gases. This form of fuel ignites more readily than is the case with the solid fuel, and reaches its maximum incandescence in a shorter space of time. A brighter flame and greater heat is produced, in addition to which the small amount of smoke which is present



with the ordinary solid ovoid is almost completely consumed, owing to the additional air space, thus providing the nearest approach to a solid smokeless fuel that has yet been attained in reconstructed coal. At the present moment this fuel is being manufactured in conjunction with a coal tar pitch binder, but if this substance were replaced with a petroleum pitch binder, to which I will refer later, the long-looked-for and ideal smokeless fuel of high calorific value would result. Up to the present time, so far as I am aware, no experiments have been made with this process upon British coals, but a licence to operate the patent in this country has been acquired by a group of enterprising British capitalists, and there is every probability that in the near

VIEW OF TYPICAL COLLIERY "WASTE" HEAP



BRITISH
COAL FIELDS
KEY
Exposed Coal Measures.
Covered Coal Measures.
Pre-carboniferous Rocks.
Submarine Coal Workings.
Firth of Forth
Berwick
Amble
Ayr
Ballycastle
Shields
Sunderland
Hartlepool
Maryport
Whitehaven
Middlesbrough
NORTH
SEA
Whitby
INGLEBOROUGH
Barrow
York
Preston
IRISH SEA
Humber
LIVERPOOL
DUBLIN
Anglesey
The Wash
SNOWDON
Nottingham
LEICESTERSHIRE
Cardigan
Bay
WARWICKSHIRE
Coventry
S. STAFFS
SOUTH WALES
LONDON
Bristol Channel
Barnstaple
Frome
Plymouth
ENGLISH CHANNEL

future the perforated ovoid will make its appearance in the British market.

The almost universal dissatisfaction with the quality of ordinary house coal and anthracite which is being distributed at the present time has largely contributed to the increased demand for patent fuel, and this, in its turn, has resulted in the production of a superior quality of fuel unknown in this country until quite recently. But it has given satisfaction and the demand is rapidly increasing, with the result that still greater attention is being given to improving the article in one respect or another. In fact the manufacture of high-class patent fuel in this country is progressing at such a pace that what may be genuinely referred to as the most excellent fuel on the market to-day may, in a few months' time, be relegated to a second—or even third-rate qualification.

CHAPTER IV

EVILS OF COAL SMOKE

With regard to the behaviour of coal briquettes in the fire, it is to be remarked that well-prepared briquettes made with pitch as binding material should burn readily with little flame, without crumbling, and without giving off much smoke. Its behaviour depends especially upon the degree of fineness of the pitch, upon the way in which the briquettes are made, and upon the shape and size of the briquettes and their arrangement in the fire, and the grate or other apparatus in which they are burnt.

The average Londoner is credited with being a most conservative person, yet—and this must be accepted as a tribute to the excellence of the fuel referred to—in the past six months no less than 5,000 householders in London forsook raw coal in favour of this patent fuel This is, indeed, a praiseworthy achievement, in view of the fact that patent fuel made from bituminous slack, with a large percentage of pitch, had previously been sold in London during the coal shortage, and had brought anything of the nature of patent fuel into extremely bad repute.

It cannot be held that the "Ideal" fuel has yet been produced—it has not—because of the pitch binder used, which necessarily creates a small amount of smoke during the first 20 or 30 minutes after lighting; but "Rome was not built in a day," and the fuel having all the advantages claimed for it, and giving off 80 per cent less smoke than raw coal, is a very great step in the right direction.

It is exceedingly unfortunate that the fuel (to which reference is made on p. 21) should not have made its

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A VIEW TAKEN AT SHEFFIELD ON SUNDAY, 11 A.M.

appearance until a month or so after the presentation of Lord Newton's Report (Final Report to the Ministry of Health and Committee on Smoke and Obnoxious Vapours Abatement), from which the following extracts are given—

" It is useless to expect, in the present state of our knowledge, that any law can be practically applied to the fire-places of common houses, which, in a large town like London, contribute very materially to the pollution of the atmosphere.

" Two members of the Committee have visited the principal industrial towns of the Rhine Province and Westphalia, as well as other German cities, with a view to ascertaining comparative conditions in regard to air pollution obtaining in Germany and in this country. . . . The report shows clearly that the comparative cleanness of the atmosphere in German towns is due not so much to the action of the Government as to the intelligent co-operation of all parties in the interest both of the most economical and effective use of fuel, and of the general amenity of life. . . . Small houses are heated by stoves, which are generally fired with coke or briquettes, and are therefore smokeless. . . . The evidence shows clearly that a large percentage of the smoke in the atmosphere of towns comes from chimneys of dwelling-houses. . . . The burning of raw coal is a dirty, wasteful, and unscientific practice, and on grounds of economy, as well as of public health, it should be restricted as much as possible, but, after full consideration, we do not consider it practicable at present to propose legislation dealing with smoke from private dwelling houses. . . . It is clear that the smoke problem, particularly with regard to smoke from domestic sources, *will finally be solved when, and if, a solid smokeless fuel can be produced economically on a*

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THE SAME—" THE DAY'S WORK BEGUN "— MONDAY, 8 A.M.

commercial scale. It might then be both practicable and desirable to legislate against the burning of raw coal."

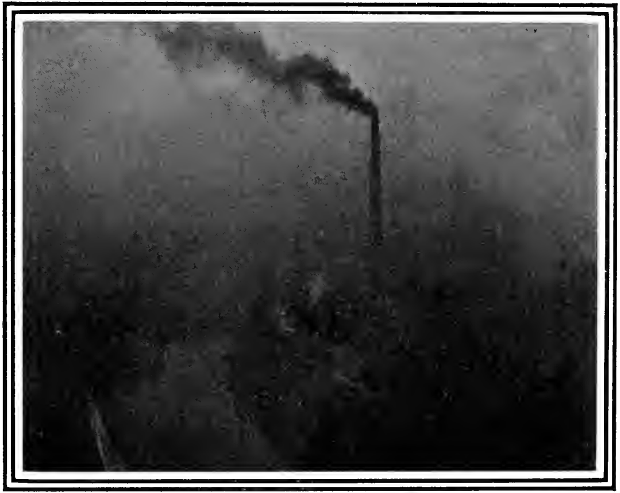
Included in the Report is a copy of the Interim Report issued by the Committee, in which occurs the following paragraph—

" Anthracite. This fuel requires for efficient burning a special type of stove, and, if used, special arrangements for ventilation are necessary."

Addressing a recent meeting of the London Society, Lord Newton said—

" As probably some of you know, I was Chairman of the Departmental Committee which has been considering this question for something like two years, and issued a report a short time ago. The great trouble we experienced was that we could hardly ever find any person who would take the smallest interest in our proceedings.

" We sat in London and heard evidence from a large number of very eminent people, who gave impressive evidence as to waste and dirt, and also destruction of buildings, the effect of smoke upon health and vegetation, and the expenses incurred in rectifying the ravages made by the emission of coal smoke. We received evidence from many persons as to the almost intolerable existence they were obliged to live in, owing to the pollution of the air in their neighbourhood ; others gave us statistics as to the pollution per acre. Only the other day the Coal Smoke Abatement Society waited upon Sir Alfred Mond, the Minister of Health, and represented that legislation should be initiated by the Government in accordance with the recommendations of the Committee. Although smoke and dirt affect almost everybody in this country, nobody takes any interest in the matter. The dirty condition of this country is really caused by the indiscriminate and wasteful use of raw coal for all purposes.



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THE SAME—THE CHIMNEYS AT FULL BLAST—NOON

In one respect, cheap coal has been a curse to the country, for in the past it has been so cheap that there was no particular reason to economize in its use. But the idea of coal going up into the sky in the form of smoke is more painful now that it is more expensive. Another thing we do not realize is that we have already laws to deal with Coal Smoke, but the authorities fail to enforce them. I think it is discreditable in a civilized community that we should calmly acquiesce in this state of affairs. Many millions of people in this country do not know what real sunshine is, because they do not see it, unless they leave their homes. Millions of housewives spend a large portion of their lives fighting the dirt which comes from coal smoke. Millions of people have never seen the real colour of the trunks of trees, and one can quite understand the question of the child : 'Mummy, are all the sheep born black ?' During the coal strike of last year, we were all amazed by the change in London's atmosphere, but I do not think there is much hope of any permanent improvement in our condition unless the Government recognizes that coal smoke is a national, and not a local, nuisance. Legislation, however, is not everything. In the course of the inquiry of which I am speaking, I induced the Department, with some difficulty, to allow myself and another member of the Committee, to go to Germany and investigate the conditions there. To my surprise, we found that German towns, which we all believed to be lower down on the list of legislators on this subject than we are in this country, were much cleaner. Our visit was confined to a small portion of country in the Rhine district, but in the industrial towns the results made me feel ashamed of being an Englishman. Our visit to towns like Cologne and Dusseldorf, which we might fairly compare with Manchester and Sheffield,

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THE SAME—" THE END OF A PERFECT DAY "—4.45 P.M.

made us realize what can be done under an intelligent system. An application of common sense and the determination not to tolerate a nuisance are all that are required."

The " Ideal " fuel should be smokeless. By the introduction of a specially prepared petroleum pitch instead of ordinary coal-tar pitch, the " Ideal " fuel—smokeless—could be produced, but this substance is not at present produced in this country ; other chemical substances, such as boran silicate, might be used, but these are non-combustible binders, which reduce heat and increase ash.[1] On the other hand, the manufactured fuel could be passed through the retort and thus drive out the pitch content, as practised in America ; but this process would increase the cost of manufacture. Nevertheless, it is instructive to note some of the proved advantages of this form of compressed anthracite fuel in comparison with ordinary raw coal.

Advantages of Compressed Anthracite Fuel in comparison with Ordinary Raw Coal

1. The fuel burns equally well in any form of grate, slow combustion stove, or kitchener. (Note the importance of this in conjunction with the Interim Report of Lord Newton's Committee in reference to " Anthracite." (*See* p. 34.)

2. It lasts at least twice as long and gives out more than twice the heat. (*See* Diagram on page 39.)

3. It is much more economical and hygienic.

4. There is no shale or dangerous non-combustible matter to fly out or cause personal injury or fire.

5. There is no clinker, as is so often the case with raw anthracite.

[1] For other substances useful as binding material *see* Appendix.

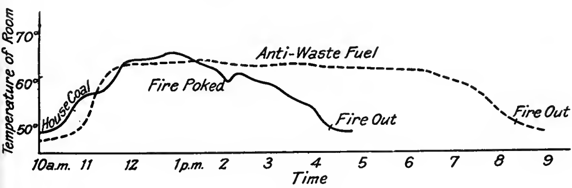
6. There are no small fragments to tread into the carpets.

7. No big pieces to break up, and only a small percentage of slack.

8. Lights much more readily than ordinary anthracite, with the use only of paper and sticks, and without ordinary coal.

9. It is practically smokeless.

10. Maintains an even temperature in the room, as compared with the fluctuating heat of raw coal.



11. A fire made up in the morning will last throughout the day. In fact, once made up, the fire should last about eight hours.

12. If hot water is obtained from the kitchen range, a small quantity put on the fire at night will give hot water in the morning.

13. There are no cinders and no waste.

14. It occupies less space than ordinary coal, and being water-proof, can, without damage, be stored in the open ; this is an important factor in that distribution charges being heavy, consumers may purchase this in larger quantities than they would ordinarily purchase coal.

It is significant that of a particular class users of this fuel comprise members of the medical profession, who appreciate it from the fact that at whatever hour of the night they may come in or have to go out, they have the luxury of a fire always in their home. The hardships of the servant problem are also modified when it is realized that, in the use of this fuel instead of raw coal, the fire, if made up before retiring for the night, will be found burning merrily at breakfast-time next morning without being touched.

In considering the adoption of any new form of fuel into the home, one of the first points which will occur to the good housekeeper will be—more particularly in these days of the shortage of domestic help—" What will the servants think about it ? " and this point is, indeed, one of no small importance. Experience has shown that both indoor and outdoor servants infinitely prefer to use patent fuel instead of raw coal for many reasons, more particularly in houses where coal has to be carried from outside or from the basement to the upper rooms. To the ordinary domestic servant, the carrying of scuttles of coal from room to room is heavy and laborious, and if, as is the case, by using another form of coal which will enable but one bucket full to be carried where three buckets full of ordinary coal are required, this one fact alone immediately obtains favour and preference for patent fuel over raw coal.

In addition to this, the percentage of slack—usually left to accumulate in the cellar or for use in the kitchen—is much less than that remaining with raw coal ; owing to the long " life " of this fuel in the grate, the heat is retained in the iron and brick work, thus resulting in the fire burning up much more readily when re-lighting in the morning ; there are no big lumps to break up in the cellar, nor in cleaning out the grate is there any troublesome shale, clinker, or other waste material to be dealt with.

Block Fuel. Although not in any very great demand in the South of England, a very extensive business has been developed in the Northern Counties in the manufacture of patent block fuel. (*See* Frontispiece.) This fuel, for the greater part, is made in blocks weighing about 2 lb. each, and in the process of manufacture bituminous slack with ordinary coal-tar pitch binder is used. The manufacturers of this form of block fuel make no extravagant claims as to its value and virtues. It pretends to be nothing more and nothing less than what it actually is, but it serves a useful purpose and finds a ready sale. It is necessarily a smoky fuel, high in ash, not particularly clean in use, and difficult to ignite. In the industrial districts of the North, this fuel may be seen on sale at almost any small grocer or greengrocer's shop, and is bought, as a rule, at prices varying from ½d. to 2d. a block. By those who find it necessary to get to work in the early hours of the morning, the general practice is, before going to bed, to put one of these blocks on the fire and surround it with wood, cinders, or other waste material, in which manner it will ignite and burn for many hours, keeping the room comfortably warmed. In the morning, the block is broken with a poker. The pitch having been driven off, the remaining fuel breaks into a cheery blaze, thus enabling the householder to boil his kettle and make his breakfast before turning out to work. In many of these houses, by the use of this form of fuel, the kitchen fire is maintained and not allowed to go out from one week-end to another. Owing to its smoky nature, this form of fuel cannot be advocated for use in our large cities, but it can be made very cheaply, its manufacture utilizes small coal which otherwise would be a drug on the market, and its more general adoption in country places can be advocated. The time will undoubtedly come when all this small coal will be carbonized, either before briquetting or the briquettes carbonized after manufacture, as is now done in the United States of America, but in the meantime the block fuel now manufactured is a serviceable, economical, and useful commodity for the purposes indicated. It is obvious, however, that this fuel cannot economically bear the heavy rail and transport charges existing to-day, and in this respect small coals produced in the Forest of Dean, from the Kent coal fields, North Wales, and the Midlands have been found to afford very excellent results for the manufacture of this class of briquette, and as the percentage of smalls raised in these districts is abnormally large, the establishment of suitable plant should not only be operated on a remunerative basis, but enable the economical distribution of the finished product in the immediate districts.

Difficulty of Branding. From the foregoing facts it will be realized that the composition of these egg-shaped briquettes may be almost anything, and so long as the product is black, it is difficult to tell the difference between a good fuel and a bad one until they come into use.

A simple form of identifying one from another would be to brand them with the maker's name or mark, but this has been found impossible, as any indent made in the moulds causes the material to adhere.

Thus, briquetting plants are operating in the Midlands, in Scotland, in Lancashire, and other places, using mixtures of "batty" coal and bituminous slack, the product being mostly used for local boiler work, but should this inferior quality reach the London market, and be supplied to the London householders, it will go far to kill the popularity of the genuine article.

CHAPTER V

HEAT AND RADIATION

Some remarks on the theory underlying the proper heating of rooms and buildings may not be amiss, as the general public seem to be singularly uninformed on the elementary facts. It is important to know, when we talk of "blending" and "reconstructing" coal, what results are to be aimed at, and the correct methods to adopt in order to achieve these results in the light of our knowledge concerning heat and combustion, radiation, convection, etc. Some recent writers on the subject of "Coal Blending" and "Coal Reconstruction" appear to think that the problem is a similar one to that of blending tea, tobacco, or whisky, only more simple, and that all one has to do is to select a mixture of anthracite and bituminous or semi-bituminous materials, as suits one's fancy, or such materials which may be conveniently to hand, to produce a satisfactory briquette. Such attempts are doomed to failure, and unfortunately too many of such briquettes have been put on the market, to the detriment of the proper and scientifically manufactured article.

There are two primary systems of heating, viz.—

(1) By convection.

(2) By radiation.

(1) Under this system we may include closed stoves in the centre of the room, anthracite stoves, closed gas stoves, electric stoves, steam or hot-water radiators (so-called), and sundry oil-burning stoves. In all these cases, when convection is the principle adopted, the room is heated by the medium of the air which, coming

in contact with the stove or radiator, is warmed and circulates around the room. It should be mentioned that in certain types of anthracite stoves some heat by radiation is also obtained through the mica doors, and this also applies to the lamp type of electric radiator, but, nevertheless, the amount of radiant heat received is very small compared with that which is conveyed by convection.

This system of heating dwelling-houses and other buildings is largely in favour in America, and the indoor temperatures maintained are much higher than those which we are accustomed to in this country. The reason for this is that air is a bad conductor of heat, and in order to secure a feeling of comfortable warmth it has to be heated to a temperature considerably higher than that required by the body.

There has been much controversy from time to time as to the merits or otherwise of this system of heating, but from a purely hygienic standpoint, there can be little doubt that this overheating of the air of a room has a deleterious effect on the respiratory organs and directly contributes to colds and other complaints, added to which it is an established fact that the air of a room which is in constant circulation in this manner picks up and retains in suspension dust and other impurities.

(2) The simplest and most hygienic form of heating is by radiation, or, to go back to primeval days, the camp fire of prehistoric man. We all of us have to admit that, in spite of civilization and the "appliances" which it has evolved, no other form of heating provides the genial comfort of the open fire, and, given the right form of fuel to comply with the altered conditions due to civilization, no other system of heating can yet compare with it, either on hygienic or economic grounds.

Heat radiation is the transmission of heat by aether waves in contrast to its transformation by air currents—" convection." Most readers to-day are probably aware that there are many known forces which are transmissible *via* the aether, viz., light, heat, electricity, X-rays, etc., and in all probability these are merely degrees of the same thing. At any rate, we know that the speed of transmission is in each case approximately the same, i.e. 182,000 miles per second, but, although the speed of transmission is fixed, the " wave length " is capable of infinite variation.

Thus we have the electrical wave lengths used in wireless telegraphy, which may vary from 10,000 to 20,000 metres, while the wave length of sunlight is so short that it cannot be intelligently expressed in the ordinary terms of measurement. Between these come the wave lengths of heat transmission which may vary from a source of intense heat (short wave lengths) to those of the darker colours of the spectrum. It follows, therefore, that various fuels have different wave lengths, and, as far as our present knowledge goes, these are directly proportional to the temperatures of ignition of these various fuels.

Every housewife knows that if brilliant sunlight is allowed to impinge on a coal fire it will put it out—notwithstanding the disclaimers which have been made by certain non-technical people on the subject.

Why is this? It is *because the high frequency wave lengths of sunlight will not synchronize with the comparatively low frequency wave length of the coal fire, and a condition of " jamming " is established in which the longer wave is finally vanquished.*

In electrical aether transmissions, i.e. wireless telegraphy, this principle is well understood, so much so that definite rules are now laid down regarding the wave lengths to be used by sending stations in order to avoid interference with each other.

From the foregoing it will be clear that, if we are to obtain the maximum heat *radiation* from a composite fuel, *the ingredients must be selected with due regard to their respective wave lengths of ignition, in other words, their suitability to synchronize with each other.*

It is not suggested, of course, that the calorific (heat) value of a composite fuel, as determined under different conditions in the laboratory, is affected by these considerations, but rather that the power of such fuels to radiate or transmit their heat to objects through space depends entirely on their composition with regard to wave lengths, and this is what we have to study in order to get the best results from an open fire.

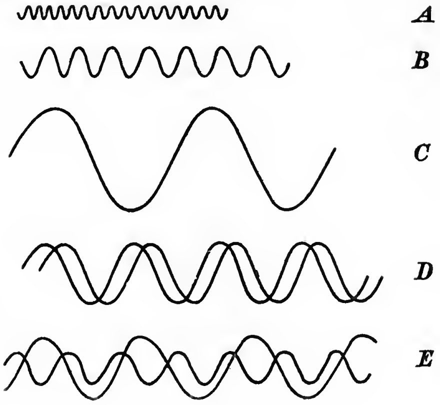
As an illustration of this we may give the results of a simple test recently made on two classes of briquettes or composite fuels.

" A " consisted of a mixture of 50 per cent of anthracite duff, 40 per cent dry steam coal, and 10 per cent of pitch as a binder. The calorific value on analysis gave 13,250 B.T.U.'s (heat units).

" B " consisted of a mixture of 60 per cent anthracite duff, 30 per cent bituminous slack, and 10 per cent pitch. Calorific value on analysis, 13,800 B.T.U.'s : 10 lb. of each of these fuels were in turn lighted in an ordinary open fire-grate, and the heat radiated in each case was recorded by a thermometer placed against an upright blackboard at 5 ft. from the fire.

In the case of " A " the mean temperature recorded was 68.3 F., while in the case of " B " the mean temperature was 62.9 F. It will be observed that, although " B " showed a *higher* calorific value than " A," on analysis the radiant heat given out was considerably less.

The following illustration shows (diagrammatically) what is meant by varying wave lengths. They are, of course, not to any scale, as the wave length of sunlight, for instance, is so short that it could not be proportionately illustrated.



HEAT WAVE LENGTHS

A. Sunlight Wave.
B. Heat Wave.
C. Wireless Transmission Wave.
D. Synchronous Wave.
E. Waves out of synchrony.

It will be seen, therefore, that, in order to get the maximum radiation from a composite fuel, the ingredients must be carefully and scientifically selected.

But there is another factor which also has a bearing on the ignition temperature and "wave length" of a fuel and its radiation properties, i.e. the composition and quantity of its ash content. It has been found that some fuels, notably anthracite, which contain a large percentage of limestone impurity, actually give a higher radiation index than others having a much lower ash content, although their calorific value, as determined by analysis, would be lower. This apparent paradox is explained by the fact that the limestone supplies additional oxygen in a nascent state to the fuel, which increases its ignition temperature

From this it would appear that there may be considerable possibilities of improving the burning qualities of some fuels by a small addition of calcium carbonate material, though, of course, the ash content would necessarily be increased. This is a question which is being closely investigated.

The advantage of the open fire, or radiation system of heating is, therefore, that it heats the object in a room without unduly heating the air, added to which it conveys that friendly feeling which is absent from the closed stove or steam radiator. For the average size dwelling-house, it is still the best system of heating, but it has its limitations. For instance, in churches, large halls, and other public buildings as constructed to-day, the convection system of heating is obviously necessary and, in fact, the only one which can be economically employed.

CHAPTER VI

HINTS ON HOW TO USE PATENT FUEL

THIS little work would not be considered complete unless reference were made to such manufactured fuels as are now available, and also hints given as to the best methods of utilizing such fuels. Amongst the leading manufacturers of fuel in this country—fuel which has given praiseworthy and satisfactory results for the various purposes for which it is manufactured—may be mentioned the following concerns—

The Bute Patent Fuel Co., Cardiff.
The Cambrian Patent Fuel Co., Ltd., Swansea.
The Cossell Coal Company, Nottingham.
The Eclipse Fuel Company, Highbridge.
Messrs. Evans & Rogers, Llanelly.
Low Temperature Carbonization Co., London.
Manor-Powis Coal Company, Scotland.
Naden Coal Company, Leicester.
Neath Abbey Patent Fuel Co., Ltd., Neath Abbey.
Northern Briquetting Co., Ltd., Upholland (Lancs).
Powell-Duffryn, Cardiff.
Reliance Fuel Co., Ltd., Llanelly.
South Wales Fuel Co., Ltd., Swansea.

All these firms have produced fuels which have given varying results, but it must be pointed out that in almost every case a different mixture is used and a different method of manufacture adopted, in addition to which the products of the foregoing concerns vary greatly, both in shape, size, and weight (*see* Frontispiece), from which it is quite obvious that discretion and guidance is necessary to the consumer in selecting the product which is likely to give him satisfaction.

It is, however, now recognized that only those concerns equipped to efficiently wash and dry the coal before conversion into this class of fuel can possibly meet the requirements of the market in the future. The prospective consumer, therefore, is faced with the problem as to which of the products of the foregoing or any other manufacturing concerns is the one which is most likely to be suitable for his requirements—that is for burning in the open grate, kitchen range, slow combustion (or anthracite) stove, or for boiler, greenhouse, or central heating work. The first essential, therefore, in order to obtain satisfaction and value for money, is to start by purchasing the right kind of fuel, and it will be readily understood that, as every parent considers his own child the most perfect and wonderful in the world, each manufacturer considers his product more suitable for general purposes than that of his competitors. In order to assist the development of the industry on sound lines, this difficulty was anticipated some time ago, with the result that an organization known as the Patent Fuel Marketing Co., Ltd., of 16 and 17 Pall Mall, London, was established. This concern is unique in that, operating as it does under sound and eminent technical advice, it is not interested in or " tied " to any particular manufacturing concern, its sole object is, as indicated by its title, a Patent Fuel Marketing Company, and its aim in life is eloquently expressed in the following extract from one of the leading technical journals—

" For reasons of their own, many of the coal owners do not want to see the scientific treatment of coal—which resolves itself into the manufacture of ' patent fuel '—developed in this country, and for that reason would supply a very inferior, or even quite useless article, in order to kill the sale of the genuine one. This

OLD-FASHIONED BAR GRATE LAID READY FOR LIGHTING has, in fact, already been done to such an extent that, in the interests and for the protection of both the manufacturer and the consumer, 'The Patent Fuel Marketing Co., Ltd.,' has been formed. The company will market only the product of approved manufacturers, thus assuring to the consumer full value for his money and at the same time act as a protection against dishonest vendors."[1]

From this it will be apparent that it is entirely in the interest of this company to advise consumers to use a fuel which will give them satisfaction, and to this end a special department has been set apart for the purpose of giving free advice to householders and others who contemplate using this more modern and economical form of heating in preference to the old-fashioned and extravagant use of raw coal. Communications should mention the purpose for which the fuel is required, that is, whether it is wanted to be burned in the open grate, closed stove, kitchen range, boilers, greenhouses, central heating, or other purposes, and as advice to use a fuel which would not answer the purpose would only be to defeat the ends for which it has been established, the public at large can rely on receiving sound and unbiased guidance in reply to any communication addressed to this firm.

The foregoing is the first and most important advice that can be given in connection with the use of patent, smokeless, and semi-smokeless fuels, and the following hints in addition thereto should be carefully read and followed—

1. Never mix the fuel with ordinary raw coal. Light the fire in the usual way with sticks and paper or any good fire-lighter (*see* reference, p. 63). (Many people think that the proper way to establish a patent fuel fire is to light up with coal and then put on the fuel ;

[1] *See* Appendix : "Distribution of Patent Fuels."

MODERN "WELL" GRATE LAID READY FOR LIGHTING this is entirely wrong.) *No coal in any circumstances should be used.*

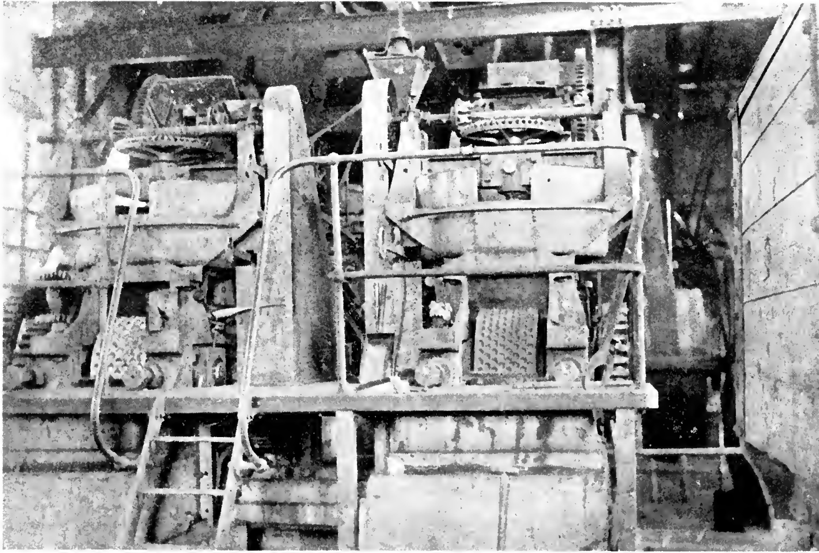
The illustration on page 51 shows an old-fashioned bar grate laid ready for lighting ; while that on page 53 shows a modern well grate similarly prepared.

2. In an ordinary open well or bar grate, the sticks should be laid as usual and a small pile of the fuel added to cover them to a depth of 3 or 4 in. (*see* illustrations on pages 51 and 53. Light the fire and allow this small quantity of fuel to first get well ignited, then add a sufficient supply of the fuel to well fill up the grate and form a compact heap. If this is done, a fire will be obtained which will last from 9 to 10 hours without attention, and the fire should not be poked or disturbed in any way during this period, except to occasionally gently remove the powdered residue from the bottom of the bars—perhaps once or twice—in order to permit free air passage.

A mistake a great many people make in using patent fuel is to light the fire and add small quantities of the fuel from time to time, as with ordinary coal, the idea being that economy is effected by this method, but this is not so. With patent fuel it is far more economical to put a good supply of the fuel in the grate to begin with, as above stated.

3. In re-lighting the fire, the ash should first be very gently removed, as it usually consists of a very fine powder, which is liable to fly about the room if not carefully put into the ash-pan—put the ash-pan as near to the grate as possible before putting in the ashes, so as to prevent dust flying about the room.

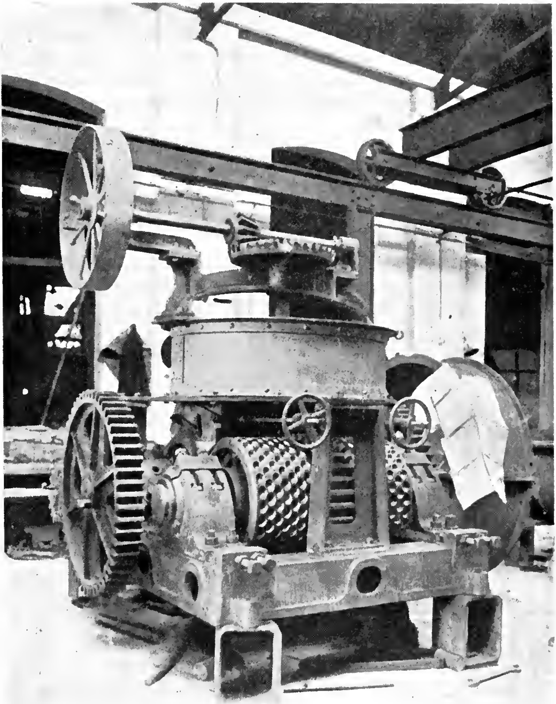
4. Any partly burnt fuel which remains should be put on top of the sticks when re-laying fire. This partly burnt fuel is in the nature of semi-coke, and is therefore easily ignited.



DOMESTIC EGG-SHAPED FUEL PRESS (TYPE A)

5. For central heating boilers and other hot water furnaces, patent fuel gives very satisfactory results ; in fact, it is far superior and more economical than coke for this purpose. It has been found, however, in many cases that the fuel is too hot for these boilers, which are usually constructed to burn under intense draught conditions. In these cases, a mixture of the fuel with coke in about equal proportions gives the best results. This also prevents excessive clinkering, which usually occurs when using coke alone.

This egg-shaped fuel is made by compressing the mixture between heavy rollers (*see* illustration, page **55** and next page), with the result that a small " fin " may be seen protruding around the egg. In transport and loading into cellars, this protrusion often gets broken off, thus forming a small amount of slack. This can be used for banking up the fire at night, particularly in the kitchen range, where it is desired to obtain hot water very early in the morning. Care should be taken, however, not to put too much of this dust on, and a few lumps should be added with it to get the best results. A fire made up in this way—say, at 9 o'clock at night, in the average kitchen range—will produce hot water for baths or other purposes in the very early morning. For ordinary domestic use, this composite fuel gives general satisfaction, both in the old-fashioned grate with either horizontal or vertical bars. In some cases, where the bars are very wide apart—such, for instance, as the grates at Devonshire House, Piccadilly (in which this fuel was used on the occasion of the Prime Minister's reception on 20th January, 1922)—it is advisable to fix a wire grid inside the bars, in order to prevent the fuel from falling through the grate. These grids can be purchased for a few pence from any ironmonger.



DOMESTIC FUEL PRESS (TYPE B)

Amongst the many popular forms of apparatus in which this fuel has been found to give results far superior to that obtained from raw coal or coke, whilst at the same time effecting considerable economy both in money and labour, may be mentioned the following—

Open Grates

"Devon" Fire-place. (Messrs. Candy & Co., Ltd., Newman Street, London.)
"Bewty" Grates. (Inter-Oven Stove Co., Ltd., Charing Cross Road, London.)
"Nautilus." (Nautilus Fire Co., Oxford Street, London.)

Anthracite (or Slow Combustion) Stoves

Danish Coke-Burning Heating Stoves. (Messrs. Pryke & Palmer, Ltd., Upper Thames Street, London, E.C.)
"Esse" Anthracite Stoves. (Smith & Wellstood, Ltd., Ludgate Circus, London.)
"Perfecta" Stoves. (Inter-Oven Stove Co., Ltd., Charing Cross Road, London.)
Coal Saver Range. (Hot Water Stove Co., Ltd., Guildford.)

Kitchen, Cooking, and Heating Hot Water Ranges, Etc.

"Cookanheat." (National Radiator Co., Ltd., Oxford Street, London.)
"Carron" Ranges. (Messrs. Carron & Co., Berners Street, London.)
"Triplex" Grates. (Triplex Foundry, Ltd., Great Bridge, Staffs.)
"Eagle" Range. (John Wright & Eagle Range, Ltd., Regent Street, London.)
"Foresight" Patent Combination Range. (Samuel Smith, Smethwick.)
"Hydresse" Boiler (Ideal Ranges). (Smith & Wellstood, Ludgate Circus, London.)
"Inter-Oven" Convertible Cooking and Heating Stove. (Inter-Oven Stove Co., Ltd., Charing Cross Road, London.)
"Aquaheat." (Hot Water Stove Co., Ltd., Guildford.)
"Kooksjoie" Range. (London Warming Co., Newman Street, Oxford Street, London.)

Anthracite Stoves, Salamanders and other forms of Slow Combustion Stoves. From a trade circular issued by one of the firms referred to on page 49 is reproduced the following report, made over the name of Dr. W. R. Ormandy, D.Sc., F.I.C., F.C.S.—

"I have analysed the sample of your anthracite 'Ovoid' fuel sent to me for experimental purposes, and have tested the same in a large 'Hygiene' anthracite stove supplied by the London Warming Co., Ltd. I have to report entirely satisfactory results.

"The sample received was, I am informed, taken from bulk, and proved to contain moisture 40·8, volatile 9·15, ash 5·58, and fixed carbon by difference 81·19 on the sample as received. This compares very favourably with ordinary anthracite and is much superior to the anthracite which I am receiving at present. There are, of course, no shale or clinker pieces and the ash is so fine that it very readily passes through the shaking bars or grid of the stove. The binding material showed no tendency to separate and run, and although the 'Hygiene' stove has a very large cooling area in the fuel supply end there were no signs of condensation of tarry or sticky deposits as has been the case with other patent fuels.

"I consider that your anthracite 'Ovoids' are more efficient than the anthracite nuts now on the market. They are undoubtedly much more economical than anthracite nuts at 95s. per ton containing a large amount of shaley products, which will neither burn nor pass through the grid. Now that a suitable fuel for anthracite stoves can be obtained at a reasonable price, I intend to employ more anthracite stoves and to use your products."

Greenhouses and other Horticultural Purposes. For horticultural purposes certain classes of this fuel have been found to give most excellent practical results, and effect a saving nearly almost equivalent to that obtained by its use for domestic purposes. Where tubular boilers are in use it has been found desirable, in some instances, to provide a metal grid so arranged that the bars will rest between the tubes and thus prevent the partly burnt fuel from falling through. The fuel does not "pack" in the fire and ensures the necessary air space to permit of perfect combustion; entire absence of clinker as compared with the use of raw anthracite and other coals obviates damage to the tubes, a source of considerable trouble where huge blocks of clinker have to be withdrawn. Another very important factor, in connection with the use of this patent fuel for horticultural purposes, is that the pitch used as binder water-proofs the fuel so that it may be permitted to be stored in the open air for an indefinite period without deterioration or loss of calorific value. As in the case with steam raising, the fire should not be banked up nor should the material be "pricked" or disturbed in any way, but a free air passage should be maintained by occasionally removing the ash from below. Whilst writing, I have before me a series of letters from some of the largest growers in this country who testify that after having given this fuel exhaustive tests they find that a saving of over 50 per cent has been effected.

In reference to the particular fuel manufactured by one of the firms referred to on page 49, the following extract from the *Horticultural Advertiser* of 26th October, 1921, will be of interest—

"The fuel has a novel appearance, looking like a heap of black eggs, being about the size and shape of a hen egg. From casual inspection we should say that it was composed of small anthracite compressed with some binding material, but this is conjecture, as the makers naturally do not publish details of this description.

"The grower who was using it kindly introduced us to his boiler shed and gave us all the information in his power. The weather being so warm, and his stocks mainly chrysanthemums and carnations, only one boiler was going, and this had not been touched since the early morning. The damper was pushed home as far as possible, so as just to keep the fire in and no more. We gave it a stir up, put on a couple of shovels of fuel, pulled out the damper, and left it for half an hour. On our return the fire had pulled up, hot and bright, and the water was on the move.

"The fuel makes a little smoke for a short time after stoking, and then burns clear and almost smokeless, the 'eggs' being a glowing red mass. There were no unpleasant sulphur fumes, no clinker, and scarcely any soot, so that the labour of stoking is reduced to a minimum. The size and shape make the fuel easy to handle ; there is, of course, no breaking up to doand very little dust.

"Our informant said the price was cheaper than coal, but he would prefer it if 10s. dearer on account of its heating and lasting quality ; the latter being so good that night stoking was rarely required. We only spent a couple of hours on the establishment so that these notes have not the weight of a scientific trial, but it is an easy matter for those readers who are interested to make a trial for themselves."

For Steam Raising. To obtain the best results by the use of this fuel in Lancashire and Galloway boilers the air space between the fire bars should be not less than $\frac{5}{8}$ of an inch, a somewhat better draught being required than in the use of raw coal. Fires should be kept evenly across the furnaces and an average thickness of six to eight inches maintained, the greater thickness being at the back. Until combustion has been properly set up and the fuel passed the softening stage, the slice should be kept away and the fire should at no time be " teased " or poked. Once going, the fire will look after itself but should be fed regularly, whilst the occasional use of the " pricker " in the bars is desirable. If vertical boilers are in use ample air space should be allowed between the bars and care should be taken to see that the smoke stack is adequate. If the draught is poor an exhaust pipe may be run into the stack and a " jimmy " or small steam jet fixed at the base. Ample air space should be provided at the front and the damper plate should not be fixed unless, of course, for retarding. In the Cochran type care should be taken to see that the tubes and smoke boxes are clear of soot. The addition of a steam jet has occasionally been found to have a remarkable good effect. As has already been stated, if used in admixture with broken coke under certain types of boiler, still greater economy is effected.

CHAPTER VII

COMPRESSED FUEL FIRE-LIGHTERS

WITH scientists and engineers diverting their attention to the domestic grate, it is not surprising that efforts have been made to evolve some sort of efficient and economical substitute for sticks and paper.

Fire-wood is expensive, often damp, and sometimes difficult to obtain, and although paper is cheap enough, this antiquated method of fire-lighting leaves much to be desired. From time to time, during recent years, various forms of fire-lighters have been introduced, but most of these for one reason or another have failed to obtain any great degree of popularity in the general household. For the most part, efforts have been confined to an amalgamation of sawdust, wood shavings, or chips, saturated in resin—sometimes in admixture with naphthaline or similar substances—and compressed. By hospitals, hotels, and big institutions where many fires have to be put on daily, these lighters are purchased at about 35s. per 1,000, and are found to be much more convenient than the " paper and sticks " method.

The price, however, is high and, therefore, as a result of various experiments carried out recently, a new fire-lighter—really a patent fuel of sorts—has been evolved, and the construction of plant for its manufacture is now under consideration. The base of this " lighter " is lignite or peat. The material is dried and passed through a mascerating machine, after which it enters a mixer, where it is impregnated with certain chemical compounds—the precise composition of which is regarded as a laboratory secret—after which the mass is forced through a sort of sausage machine, tapering towards the end, and down the centre of which are fixed four or five metal rods, which result in the production of what appears to be a perforated fire-lighter.

At the end of the machine an automatic wire cutter is fixed, thus producing a briquette of uniform size on very much the same principle as an ordinary building brick machine.

These briquettes weigh about 4 oz. each, do not easily break, readily ignite, and one is quite sufficient to ignite any class of fuel in any form of grate. Various tests of this new article have been made, with quite satisfactory results; in an open grate, two of these briquettes, without the addition of any coal or other fuel, were found sufficient to boil a tin kettle containing slightly more than 1½ pints of water. In houses where there is no gas-cooker, and where a fire is only required for preparing a small breakfast, these briquettes will be found extremely useful and economical.

It is estimated by the manufacturers that this fire-lighter fuel can be produced and put on to the market to be retailed at the rate of about 4 for 1d., or, in larger quantities, round about 20s. per 1,000.

If the expectation of those responsible for the production of this commodity are realized, a considerable industry should be established, and much of our long neglected deposits of peat and lignite turned to good account.

CHAPTER VIII

A DESCRIPTION OF A MODERN COAL WASHING, DRYING AND BRIQUETTE-MAKING FACTORY

The basic idea the engineer must have in his mind when he designs a modern Patent Fuel or Briquette Factory is " to reconstitute small coal so that it will be equal in economic value to the large pieces of coal from which it has been chipped."

Small coal produced in the process of mining has a low money value because of its size. Large coal sells at the highest price and small coal sells at the lowest price, because large coal can be transported, handled and burnt with greater efficiency than small coal.

Anthracite nut coal sells to-day at 70s. per ton at the colliery. Anthracite small or " Duff " coal sells at a few shillings per ton. When this small coal is " reconstructed " into the size of a nut, it becomes equal in every respect to the large coal from which it was broken. The following is a description of a modern factory designed by Mr. Herbert Alexander, Consulting Engineer, Westminster, for treating anthracite small coal.

All small coals contain a higher percentage of dirt or ash than lump coals, because the lump coals are more carefully picked and screened. The first operation, therefore, in treating the small coal is to separate the dirt or ash from the coal. This is effected by specially designed coal washing machinery. Advantage is taken of the fact that the specific gravity of shale or fire clay, of which the dirt or ash is composed, is higher than coal, and the machinery is designed so as to " float " away the light coal, and "precipitate" the heavier shales or clays.

The small coal arrives at the factory in ten or twelve ton wagons direct from the colliery. These wagons are provided with end doors, so that the wagon can be tipped up and the whole contents discharged automatically and quickly into a large hopper fixed under the railway. In cases where various qualities of coals have to be treated and blended separate hoppers are provided for each quality.

At the bottom of each hopper an automatic measuring machine is fixed, so that the desired quantity and percentage of each quality from its respective hopper can be delivered. The measuring machines work with great accuracy and are capable of wide adjustment.

The measured coal is delivered from each machine into a tray conveyor which in turn delivers the complete mixture into an endless bucket elevator of the required capacity. This elevator carries the coal to the top of the washery building and discharges into a large screen. The screen separates the coal into various sizes or grades, because it is better to wash coal of a uniform size in the same washing box. The desired number of washing boxes are provided for each grade or size of coal according to the output capacity required. The washing or separating of the coal from the shale or clay is effected by the "pulsation" of the water in each box; this is done by a powerful pump. The pulsated water "floats" the coal over a weir, and permits the heavier clay or shale to precipitate to the bottom of the box. There are various modifications of this system, but the general principle remains the same.

The washed coal is collected into draining hoppers, and the shale, or clay, is conveyed to the dump. In

VIEW OF NEATH ABBEY PATENT FUEL WORKS

some cases it is found that flakes of coal adhere to the shale ; if the percentage is appreciable, this shale is crushed to a fine powder, and then re-washed ; in this way all the coal is recovered.

The second process is that of drying. It is impossible to briquette wet coal unless an excessive amount of " binder " is used. Failure to appreciate this important fact has been the cause of many disappointments in the past, and also accounts for the lack of cohesion in briquettes manufactured from wet coals.

The Alexander Patent Continuous Coal Dryer will dry coals however small in size, even if they contain 60 per cent of water, and will reduce the moisture contents to 2 per cent. Small coal from an efficient washer, after being drained, contains from 12½ to 15 per cent moisture. Before such coals can be converted into good briquettes the moisture must be reduced to 2 per cent with a maximum of 3 per cent.

The washed small coal from the draining hoppers in the washery is conveyed to the top of the Patent Continuous Dryer. An automatic measurer feeds a regular uniform supply into the dryer through sealed valves. The wet coal is then distributed into the top series of trays to a uniform thickness. From this point the coal is slowly wiped off each tray to fall on to the tray below, and so on until the full descent of the dryer has been made. The effect is to create a large number of falling cascades of coal in finely divided quantities.

The principle on which the drying of the coal is effected is by " the saturation of hot air or gases " and not by the usual method of " evaporation of the water." Hot air, or waste chimney gases, are blown into the base of the dryer in sufficient volume to absorb the quantity of water to be extracted from the coal.

Hot air or chimney gas has an affinity for water and it is a well established fact that a given volume of air at various temperatures will absorb a known quantity of water. The higher the temperature the greater the absorbing capacity. Care must be taken not to over saturate the hot air otherwise the moisture is thrown down as dew.

This system of drying by saturation of hot air is very considerably cheaper than that of the evaporation of the water by heated plates on a shed floor, and the process is continuous, so saving labour. Any waste chimney or furnace gases can be utilized, care being taken to control and balance the actual temperature of the gases delivered into the dryer, so as to ensure a uniform supply.

Having now washed and dried the coal, the next process is the manufacture of the briquette. The dried coal is delivered from the dryer by a conveyor into the hopper of a measuring machine. A second hopper on this machine receives the pitch binder after being crushed to the required degree of fineness. The desired percentage of pitch is accurately measured with the coal, and the two materials are then delivered into a special grinding and mixing machine. From this machine the mixture is delivered into a heater or cooker where superheated steam is used for melting the pitch and produces a semi-plastic mixture. On discharge from the heater the material is broken up in a cooler so as to release all steam, also to reduce the temperature of the mixture to that most suitable for moulding and pressing.

If it is desired to produce egg-shaped fuel, usually called " Ovoids " or " Boulets," the prepared mixture is delivered by the cooler into a distributor or feeding pan which passes a regular uniform supply into the space between the two mould rollers (*see* illustration, page 57). The mould rollers are provided with a large number of cups or half moulds, and these index with each other as the rollers revolve, so making a complete mould at the point of contact and compressing the material into a dense hard piece of fuel the size of an egg.

The finished product as delivered from the machine is then passed over suitable screens, so as to remove all tailings and fringe. From this screen the ovoids are delivered into railway wagons for sale, or into storage hoppers as may be desired.

The whole operation covered by the foregoing description is entirely automatic; from the beginning, when the wagon of coal is emptied, to the end when the finished briquette or ovoid is delivered into the railway wagon ready for sale.

The fuel produced contains the minimum percentage of ash or dirt, there is no dross, pyrites, or clinker, nothing but pure coal. The calorific value is equal to the natural lump of coal from which the small was obtained. For storing in the open air for a long period, in any kind of weather, this form of fuel is better than natural coal, because the "binder" preserves it; whereas natural coal decomposes on lengthy exposure to the weather. The fuel is practically smokeless and can be burnt in open grates as well as closed stoves.

When it is desired to briquette other qualities of coal than anthracite, such as steam coal, or house coal, the same process of manufacture as described above is followed, the only difference being that, instead of moulding the fuel in the shape of an egg, it is usual in the case of steam coal to make large blocks varying in weight from 11 lb. to 27 lb. These blocks are used principally on Continental railways, and steamships.

In the case of household coal the blocks are made about 2 lb. weight each.

The modern railway engineer buys coal for its calorific value, not for its colour. He prepares a specification of his requirements, limiting, under a penalty clause, the percentage of ash and moisture. Briquetted fuel exported from this country to, say, Brazil, becomes extremely costly by the time it reaches its destination, and the engineer naturally does not want to pay the cost of transporting and handling fuel which contains excessive percentages of ash and moisture.

The best qualities of Admiralty steam coal contain 8 to 15 per cent of ash. Briquetted fuel made from washed and dried small steam coal can be produced with a guaranteed maximum of 8 per cent ash, and even this small precentage can be reduced when the buyer is willing to include in his specification a primes and penalty clause, whereby the manufacturer receives extra money for each percentage reduction in ash and moisture, and pays a similar penalty for each percentage increase above the agreed maximum.

Another important advantage which the engineer obtains with steam fuel is that he can have the mixture blended to suit the special requirements of particular types of steam boilers.

For example, all railway locomotives are not called upon to perform the same duties, neither are the boilers all the same size. The locomotive used for long distance express trains has a long boiler and a wide heating surface. The fuel for such a boiler should have 18 to 20 per cent of volatile gas in its composition so as to give off a long flame. The locomotive used for hill climbing sections of a railway or for hauling heavy mineral traffic has usually a relatively short boiler and quick steaming is essential. The best quality of fuel for such a boiler is one with the minimum of ash, and with 14 to 16 per cent volatile, because a concentrated heat is required and a short flame.

The same remarks apply to the boilers of steamships as well as locomotives, and that is why briquetted fuel, which can be blended to suit the exact requirements of the engineers, has been found so very economical and advantageous for generating steam on railways and steamships.

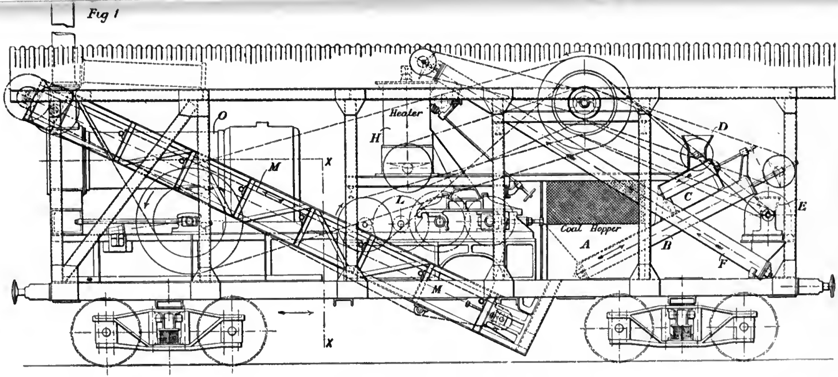
A NOVEL INSTALLATION

It is well known that on all railroads, particularly on long distance railroads, there are places where small coal, cinders from smoke and fire boxes, etc., are dumped, and remain there as waste material, or are used merely as ballast for the permanent way.

In order to utilize this waste material, and by a simple process bring it to a condition of profitable fuel value, a novel plant has been constructed for, and is now in successful operation by, one of the Argentine railways.

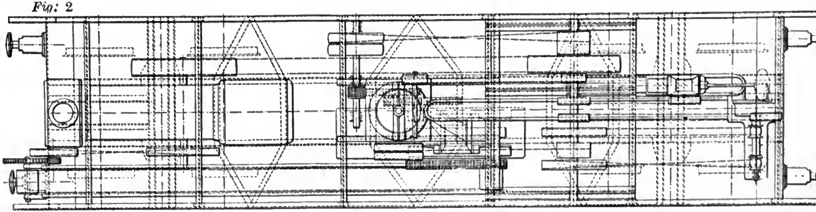
These dumps are usually of too small a character and too long a distance apart to make it a profitable undertaking to erect a central plant, to which the material can be carried and made up into fuel. This plant is a complete fuel manufacturing installation, including its own motive power, and is carried upon a truck of standard railway gauge (*see* illustration opposite). By this means the factory can be readily taken to the material instead of the reverse, make up the waste into fuel, and then proceed to the next dump by simply hitching the truck to an ordinary freight train. The type of fuel this plant turns out is a small " ovoid " or " cushion " shaped article weighing about 5 oz., and it is, owing to its shape and bulk, particularly suitable for

Fig 1



A NOVEL INSTALLATION

Fig: 2



A NOVEL INSTALLATION—ANOTHER SECTION

locomotive purposes. Its lie on the fire presents a maximum air space all round, and thus facilitates complete combustion with a maximum of clinkering.

This type of fuel has been tested against Welsh steam coal in both locomotive and marine boilers, and has been found excellent in steam-raising properties.

The labour required is practically negligible, one man and one lad being sufficient to operate the portable factory, the only other hands required being those necessary to bring material from the dumps into the plant, and to trim the fuel as it is delivered from the plant into a following wagon automatically.

The output of this plant as described is about 3 tons of fuel briquettes per hour.

J. A. G.

PART II

NOTE

In the following pages reference is made to various types of retorts and other coal-treatment processes. There are many other systems and it has been difficult to select those to which particular attention should be called in order to give a general idea of the methods to be adopted in the production of liquid and solid fuel.

In the effort to make the section readable and not too technical much has naturally had to be eliminated and no reflection is intended upon the many systems, processes and plant to which, for want of space, no particular reference is made.

PART II

HIGH AND LOW TEMPERATURE CARBONIZATION OF COAL

ORIGINALLY the carbonization of coal was carried out with only one objective—production of gas. It must be admitted that this is still the main aim.

The gas engineer lays himself out to produce the maximum amount of gas from a ton of coal, and is not particularly interested in the by-products, although, if he had not these by-products, the cost of the gas as supplied to the consumer would be very much greater.

It was not until after 1856, when the first aniline dye was manufactured, that the value of the tar produced in the gas-works was recognized. Tar was a messy substance, which the gas manufacturer did not know what to do with. A portion, certainly, was used for covering fences, railway sleepers, and the like, but the rest was generally run to waste, and great trouble was incurred in drainage systems.

Furthermore, the value of sulphate of ammonia was not realized—farm-yard manure being the only class of fertilizer which was then used.

The consequence was that the gas was not water-scrubbed, nor was it to any extent purified. In fact, one may say that the gas was passed into the mains in the *raw* condition ; choking of the mains, therefore, constantly occurred. Even now, with careful purification, pipes are often choked with naphthalene.

Evolution followed slowly—but the objective was always the same, namely, to produce gas, and as much gas as possible. It got gradually realized, however, that tar was a valuable by-product, and then tar distilleries began to be erected.

Then it was found that sulphate of ammonia was a useful fertilizer, and some of the larger works put in ammonia recovery plants.

It was also found that by scrubbing with water and taking out the ammonia, the illuminating and thermal value of the gas was improved. Furthermore, the gas mains were less corroded.

In the first place, horizontal retorts were always used, and were made of cast iron. Later, fire-clay was substituted for cast iron, and this was more satisfactory, owing to the fact that the temperature of carbonization was being continually increased.

By increasing the temperature larger quantities of gas were being obtained, and also a larger quantity of benzoid compounds were obtained in the tar.

The value of the benzoid compounds became recognized as the synthetic colour and synthetic drug industry increased. Incidentally, it was of enormous importance in respect to the manufacture of explosives: this, however, was hardly recognized until the cataclysm of 1914. All the resources of the gas-works and coke ovens were then called into being, and the chemists were relied upon to save the nation—to save the world !

The products of gas-works and coke ovens, as it was truly said, saved the Allies. The chemist was then recognized to be of paramount importance, but now we are going on in the old rule-of-thumb method.

The chemist and engineer did much to win the war.

Reference has already been made to carbonization of coal in gas retorts for the production of gas, and, as already mentioned, horizontal retorts were employed for a long period. Then, in order to increase the output of gas per unit and save labour, the vertical retorts were introduced. It was later on found that larger quantities of gas could be obtained by passing steam up the retort, either wet or superheated.

The drawback to the vertical retorts in regard to the tar by-products is that a more or less bastard tar is obtained. That is to say it is a mixture of benzenoid, paraffinoid, and olifeinoid compounds. Consequently, it is difficult to separate the benzenoid compounds should these be required for dyes or explosives. On the other hand, larger yields of gas and ammonia are obtained.

But there is another objection, the coke is not so good. The steam reacts or burns with the carbon of the coke and causes a part of the carbon to be consumed, consequently the ash content in the coke is increased.

The actual cause of the difference in the quality is shown by examining the diagram " A Retort of the Glover-West System." Coal is a bad conductor of heat. It enters the top of the retort cold, and is nearly half-way down before the centre core of the coal is heated through. It really amounts to this—that until the coal is heated through, a low temperature carbonization takes place. The bulk of the volatile matter is, therefore, driven off at a low temperature. The flue temperature of the retorts—that is to say, the heat acting upon the outside walls of the retort—is very high, from 1,100° C. to 1,400° C.

In horizontal retorts the gases and tar as produced come in contact with the heated sides and dome of the retort, consequently, the amount of benzene naphthalene, and anthracine compounds is increased. The yield of gas, however, is not so great as with vertical retorts.

Coke ovens, in which hard coke for metallurgical purposes is made, also produce a large quantity of benzenoid compounds.

In some parts of Scotland the blast furnaces are fed with coal in place of coke usually employed, large quantities of tar being produced. It may seem a paradox seeing the great heat employed in a blast furnace, but the tar is mainly of the low temperature type. The reason is practically in the use of the vertical retort; the coal enters cold and the gases and tar are driven off at a comparatively low temperature.

In the public mind there is considerable misunderstanding as to high and low temperature products. It is frequently stated that if low temperature carbonization were introduced, more products for the manufacture of dyes and explosives would be produced. This is not the case. No low temperature process can possibly make the products which are used for the manufacture of dyes and explosives, unless, indeed, future research finds a method of doing this. From low temperature carbonization, motor spirit, fuel oils, paraffin wax (not always), smokeless fuel, and gas of very high calorific value are produced. There is also sulphate of ammonia, but not in such large quantities as obtained in gas practice, or with coke ovens.

If we were to carbonize all our coal, and use none in the raw state, the atmosphere of our cities and towns would be pure and wholesome and not polluted with smoke and soot. Gas would be the prime factor for power and smokeless fuel for heating in the domestic grate. Furthermore, one ton of smokeless fuel radiates out much greater heat than the same quantity of raw coal, and even if it costs a little more is more economical.

The British public like to see a blazing fire—that is, one producing a large amount of flame. They also like to see a bright red glow, but with ordinary coke they in most cases are not able to obtain it. With a smokeless fuel, either briquetted or without briquetting, there is no difficulty in obtaining a bright red heat—no smoke and greater heating properties. The fire has the appearance of what is usually called a frosty fire—that is, a bright glow.

The time will come, and come shortly, when all coal will be carbonized, some at high temperature for the gas-works and coke ovens, but the bulk at low temperature for domestic purposes.

The great difficulty experienced in low temperature carbonization is through-put. That is to say, in a given time to get a large tonnage through without having an enormous plant at a high capital cost and high labour cost.

It is obvious that if a retort is heated, say, to 1,000°C. the heat will penetrate more rapidly through the coal mass than if it is heated to, say, 500° C.; consequently, the time of carbonization must be longer, although not necessarily *pro rata*. It is to get over this difficulty that research has been carried out for many years—that is, a retort which will shorten the time element. Various retorts which have this objective in view will now be described—although not necessarily in historical sequence. It will also not be possible in the scope of this book to describe all that have been devised.

Speaking generally, there are three main systems employed for low temperature carbonization.

1. Heating the coal in a chamber or retort in thin layers. The heat is applied externally and is usually supplied by hot gases produced from an outside combustion chamber, such gases being burnt round the retorts by means of secondary air. Coal being a bad conductor of heat, it must remain in the retort for a considerable time before the heat, due to radiation, convection, and contact with the heated surface of the retort, penetrates, and complete carbonization ensues.

2. The coal is placed in a retort, in which it is mechanically carried forward and at the same time

continuously turned over, thus fresh surfaces are always being exposed to the heat. These retorts are also externally heated.

3. The coal is heated by what is termed " sensible heat "—that is, hot producer gas is passed through the retort, and the " sensible heat " of the gas is given up to the coal. As the gas percolates throughout the mass of the coal, naturally, every particle of the coal becomes equally heated and the rate of carbonization is accelerated.

Del Monte. This retort was one of the first which aroused interest in this country. It consists of a long horizontal tube, which is externally heated by means of gas jets entering into the sides of the fire-brick lining in which the tube is embedded. Within the tube there is an Archemedian screw, which is caused to revolve slowly. The coal or other substance is fed in from a hopper, which has an hermetically sealed valve. The screw carries the coal forward, and by the time it has reached the end of the retort it is carbonized and discharged through a similar valve to that by which it is fed in. The gases and volatile matter produced by the carbonization are drawn off, and the oils condensed and scrubbed in the usual manner employed in gas practice.

The gas produced, after being scrubbed, is rather more than sufficient to heat the retort. As the gas is of high calorific value, the residue can be used to enrich ordinary town gas.

The Del Monte works very well with shales, lignites, Cannels, and the like, but it is not successful with caking coals. Such coals stick on to the blades of the screw and form a plastic mass which causes adherence to the sides of the retort. It is thus practically impossible to get the screw to work, even with great power on the driving gear. The chief drawback to this retort is to obtain an adequate through-put in a given time. There is no doubt the oils produced from this retort are of very good quality and the yield is also good. On the other hand, owing to the grinding action of the screw, there is a very large proportion of breeze in the residual fuel. This latter makes little matter because the breeze can be briquetted or put to other profitable use. The retort, however, has only a limited use, in that it can only be employed for non-caking coals.

Tozer Retort. This retort is on quite a different principle. It is vertical and there are no moving parts. Where moving metallic parts are subjected to even moderately high temperatures, i.e. temperatures above 400° C., there is always a tendency to stress, owing to uneven expansions. This trouble, found in the Del Monte retort, does not occur in the Tozer system.

The retort was originally designed by F. W. Marshall and C. W. Tozer, and was known as the " Tarless Fuel Process." The name meaning that the tar had been extracted from the coal, and that, consequently, a smokeless fuel was the residual product.

The retort is externally heated. It is made of cast iron and is surrounded by fire-brick, and is placed in a combustion chamber which can either be heated by producer gas or by the gas generated by the carbonization of the coal, or by both. More than sufficient gas is produced by the carbonization of the coal to heat the retorts and carry on the process of carbonization.

The retort is 8 ft. high—that is to say, the carbonizing part of the retort is 8 ft., and it has a diameter of 19 in. at the top, and tapers out to 21 in. at the bottom. The retort is provided with an inner and outer annulus. No coal is charged into the inner annulus. The outer annulus is provided with four radiating partitions, which serve to conduct the heat through the coal.

The coal is first passed through a breaker in order to make it uniform in size. It is then weighed, elevated to the top of the retort settings and charged into the retort with shovels.

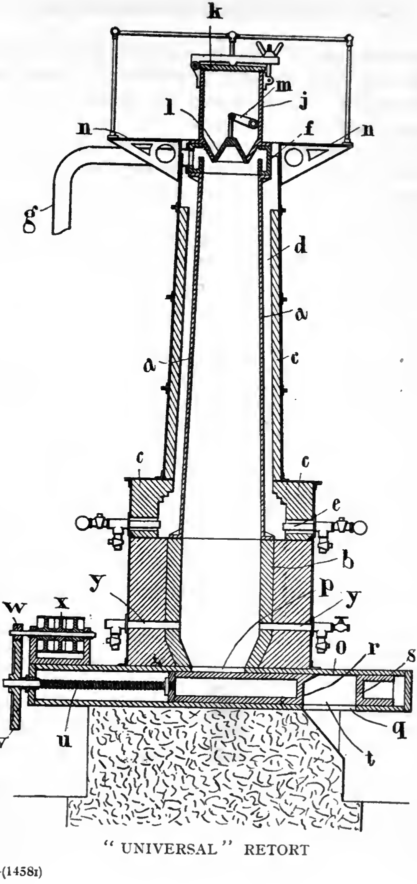
When originally designed it was worked under a considerable vacuum, from 18 to 22 in. The object was to draw off the products of carbonization as rapidly as possible to prevent cracking. This, of course, is theoretically correct. In practice it is rather difficult to keep a high vacuum, as there is a tendency to leakage owing to keeping the lids of the retorts tight. Now the retorts are being worked with a lower vacuum.

This retort gives a most excellent smokeless fuel, and can deal with almost any character of coal or shale.

The "Universal" Retort. This retort, designed by G. F. Bale, can be utilized for complete gasification or for the production of smokeless fuel. It could probably be adapted for the production of hard metallurgical coke.

It is a vertical retort, and was originally designed for carbonization at low or medium temperatures, with the object of producing gas, distillates and coke (smokeless fuel) in varying ratios.

According to this figure, the apparatus consists of a vertical cast iron tube *a*, slightly tapered, placed with its larger end downwards on a firebrick setting *b*. The firebrick setting is so shaped as to constitute an extension of the bore of the tube for a further length equal to about one-third of the length of the tube. From the point where the tube joins the firebrick setting an external firebrick casing *c* is built up around the tube *a* for nearly the whole of its length and is so arranged as to leave an annular space *d* around the tube. Four or more gas burners *e* are arranged to project through the firebrick *c* towards the tube *a* for the purpose of heating it externally. On the top (small end) of the



"UNIVERSAL" RETORT

tube is mounted an annular cast iron trunk *f* forming a collecting chamber with its near side so cut away as to provide an opening into the tube. A pipe *g* is connected with this trunk to convey away the volatile and gaseous products, liquid and semi-solid products collected within the trunk *f* being prevented from falling back within the inner retort shaft.

On the top of the trunk *f* is mounted a hopper *j* with a gas tight lid *k* and a bottom valve *l* which is operated by a lever *m* for the purpose of feeding the tube with the material to be treated. A platform *n* may be fixed around the hopper for convenience in charging.

Beneath the firebrick setting at the lower end of the tube is fixed a horizontal cast iron box *o* of rectangular section having a circular hole *p* in its top side of the same diameter as the hole formed by the firebrick setting with which it coincides. At one end of the iron box *o*, and in its bottom side is another hole *q* of about the same area as the first mentioned.

Within the iron box is a hollow iron ram *r* coupled by rods or bolts to an iron block *s* and so arranged that a space *t* exists between the ram and the block. The block follows the ram in its movements to and fro in the iron box or casing.

The ram is operated by a horizontal screw *u* which projects through one end of the iron box and is driven by gear wheels *v*, *w*. The gear wheels are driven by a shaft on which is mounted a fixed pulley *x* with a loose pulley on either side of it. These pulleys are driven by belts from any convenient source of power and are so arranged that normally one belt rotates one loose pulley in one direction while the other belt (which is crossed) rotates the other pulley in the opposite direction. A fork or guide is arranged to move the belts alternately on to the fixed pulley at predetermined times thus giving a clockwise and counterclockwise motion to the gear wheels and therefore a reciprocating motion to the ram *r* within the box or casing.

At each end of the box or casing *o* is fixed conveniently a trigger, the two triggers being coupled by rods and balance weights to the belt forks in such a manner that when the ram has travelled the required distance within the casing it operates one of these triggers which in turn moves the other belt on to the fixed pulley and thus reverses the direction of the ram.

The operation of the apparatus is as follows: A fire is first made at the bottom of the tube *a* and the gas burners *e* are lighted to heat up the tube externally. The material to be treated is then fed in through the hopper until the tube is full, and steam and air are admitted to the lower end of the tube by means of a pipe or pipes *y* as and when required. When the material is deemed to be sufficiently carbonized the ram is set in motion and continues travelling until the space between the ram and block is underneath the hole in the top of the box or casing and the material falls down into this space. At about the same time the ram is reversed in its direction by contact with one of the triggers before mentioned and pushes the material forward to the end of the box where it falls out through the opening *q* in the bottom of the box. The ram is again reversed and the complete operation is repeated as long as desired.

As the material passes down the tube and is ejected by the ram, fresh material may be added through the hopper *j* to keep the tube filled and so make the whole process a continuous one. The volatile products and fixed gases which are driven off from the material during its passage through the hot zone ascend to the top of the tube and are collected by the annular trunk *f* and conducted away by the pipe *g* connected therewith.

This retort works on the principle of the gas producer, only there is also external heating of the retort tube. This latter provision secures a long hot zone of even temperature, thereby accelerating the through-put. By using these two systems together, a wide range of temperatures and zone conditions can be obtained, which enables this retort to deal with almost any class of fuel. Hence the name, " Universal."

One of the chief features of the retort is the ram for discharging the coke or residue. The ram has a reciprocating motion in a horizontal casing beneath the combustion chamber, and discharges the residue at intermittent intervals. By a simple adjustment which alters the rate of travel of the ram, the rate of discharge can be regulated to suit all classes of material. This system has considerable advantages over the usual worm or valve method of discharge, as it allows the material to remain at rest for a period while passing through the hot zone, which has been proved to be of importance in producing a good coke, and there is less liability to jamb or stick, which frequently happens with other systems.

The material to be treated is fed into the hopper and is passed into the retort tube by a lower valve. In the larger units this valve is mechanically operated.

Steam and air are admitted into the combustion chamber by inlets, which are provided. By this means a slow, partial, or, if desired, complete combustion can be obtained. These inlets are at the bottom of the retort, and the hot gases so produced cause the distillation of the coal in the upper regions of the retort. Naturally, the external heating of the retort also assists. When smokeless fuel is desired, it is obviously not desirable to admit too much air and steam, because this, owing to partial decomposition, causes the fuel produced to be of a lower grade. It follows that if a coal contains a certain quantity of ash, that the ash in the final product will be increased if some of the carbon is burnt away. In any case, naturally the extraction of the volatile matter raises the ash content. This, of course, is the case in all carbonization processes—either high or low.

The gases and volatile products are collected by the annular trunk at the top of the retort and conducted to the condensers and other auxiliary apparatus. A portion of the non-condensible scrubbed gas is returned to the retort and consumed at the external heating burners. Thus the retort is entirely self-supporting when once it has been started. By increasing the steam and air admission to the combustion chamber, larger quantities of gas can be produced as required. In fact, with using material of high ash content, which would produce a worthless coke residue, it may be found advisable to completely gasify it in the combustion chamber after the volatile matter has been removed in the upper part of the retort. In this case the residue discharged will be simply ash and clinker. On the other hand, when using a fuel of high volatile and low ash content, it is, as already stated, desirable to reduce the steam and air admission to the lowest limits, thereby producing a smaller amount of gas but a high yield of distillate, with a good smokeless coke residue.

Producer Class of Retort. In all producer processes, the means of heating is "sensible heat." That is, the carbonization is produced by hot gases inert or otherwise. At any rate, they are inert at the top of the retort.

The Mond Producer, as invented by the late Dr. Ludwig Mond, has now been in operation for about 30 years. When it is charged with coal, the oils produced from it—that is to say, when a recovery plant is employed—are of the low temperature type. The reason being that the greatest heat of the producer is at the bottom end, where complete gasification of the fuel takes place. At the top, where the coal enters, it is met by the hot gases, and as it gradually sinks down the retort the volatile matter is driven off. The main portion of the volatile matter is probably driven off at a temperature not exceeding 600° C. The gases usually leave the producer at a temperature in the neighbourhood of 500° C.

In producer practice it is usual to inject about $2\frac{1}{2}$ lb. of steam for 1 lb. of coal gasified. Only about one-third, however, is decomposed in the producer. In consequence, the gas, as it escapes from the producer, contains the other two-thirds of the steam. This, of course, is wasteful because fuel has to be employed to raise the steam. At the present prices of fuel, this is a serious consideration. On the other hand, a large amount of the loss is made up by the high yield of sulphate of ammonia, about 65 to 75 per cent of the nitrogen in the coal being recovered.

The Power Gas Corporation (the owners of the Mond and Lymn retorts) realizing this waste, and also the importance of obtaining large quantities of low temperature oils, have modified the Mond Producer so that a heat treatment is given to every particle of coal which enters the producer for a very much longer time. At the same time the temperature of the gas leaving the producer has been reduced to about 300° C.

It follows, therefore, that no cracking of the volatile matter can take place as, owing to the large volume of gas passing up the retort, the volatile matter, as it is driven off, is immediately carried away.

Another important point is that the amount of steam used has been reduced to about 1 lb. per lb. of coal gasified. The yield of sulphate of ammonia is practically the same as by the older process.

The saturated air blast no longer requires to be heated. The oils produced are of a better quality. The following is a typical analysis of the oil—

Start to 170° C.	1·5 per cent.
170–230° C.	7·8 ,,
230–270° C.	12·6 ,,
270–300° C.	7·0 ,,
300–350° C.	13·7 ,,
Above 350° C.	17·3 ,,
Residue	37·5 ,,

The following are the claims made by the inventors—

1. The gas producer works at lower temperature, hence pipe lines are smaller and maintenance costs less.

2. The capital outlay and ground space required are much less, owing to the elimination of air and steam superheaters.

3. The plant is so arranged that the quantity of either ammonia or tar can be altered by simple manipulation, as may be required to meet existing market conditions.

4. The regular gasification capacity is considerably higher than the formal normal rating.

5. Much larger overload can be carried for considerably longer periods during the working day, thus making the plant far more suitable for working under the peak load type of conditions met with in many power stations.

6. The thermal efficiency is much higher than with the former by-product producers.

Maclaurin Retort. This retort is also of the producer type. It resembles an elongated producer. The height of the retort is about 40 ft., and the width at the combustion zone about 8 ft.

The release of volatile matter, with the production of oils and formation of coke, is done entirely by the hot gases formed in the lower part of the producer—the combustion zone.

The coal is charged in at the top of the retort, as in the case of the "Universal" Retort and the Reswick-Rambush Producer.

The chief novelty in the retort is the method of trapping the oils to prevent them from trickling back into the retort should they get condensed before passing into the condensers. A form of collar is fitted round the upper end of the retort. This may practically be called a gutter, into which the condensed oil trickles and is then carried off by a side pipe.

The inventor states that the coal is in the retort for 20 hours before carbonization is complete. This gives the impression that it would require a very large installation in order to obtain an adequate through-put, and although the retort *per se* is not very expensive, it would naturally require a large number of units. This would mean the covering of a large space and increase the number of connections. It would therefore ultimately become an expensive process.

The temperature at which the smokeless fuel is produced is stated to be about 700° C., and only contains about 4 per cent of volatile matter. In this respect it differs from most low temperature cokes, which contain from 9 to 11 per cent of volatile matter. It is said, however, that this fuel ignites as readily as other low temperature fuels.

Another claim is that by increasing the temperature in the combustion zone hard metallurgical coke can be obtained. This, of course, is feasible—but the temperature can only be increased by a larger consumption of the carbon, seeing that no external heat is applied, heated producer gas from external sources not being employed.

One peculiar claim is that—

" During carbonization any stony matter in the coal tends to drop out, and a large quantity of the adhering mineral matter scales off and is concentrated in the breeze. It is therefore quite easily possible to obtain a clean coke containing no higher percentage of ash than the original coal: the bulk of the ash being separable as stones or collecting in the breeze."

This seems rather like a fairy tale. Why should this happen in this particular process and not in others? Also, how is the stony matter to be satisfactorily separated from the coke?

If there is much mineral matter in the coal to be treated, the only correct and logical way to remove it is to wash the coal before it is retorted.

It is claimed as an advantage that large quantities of phenolic bodies are obtained in the oil up to 50 per cent. In all low temperature oil there is a considerable quantity of phenols. But the lower the amount the better is the oil obtained. The distillates are also said to be very low in light oils—surely this is not an advantage!

" L.M.N. " or Neilsen Process. This retort is the invention of Mr. Harold Neilsen and is one in which " sensible heat " alone is used. That is to say there is no external heating.

The process consists essentially of the combination of an ordinary producer with a low temperature carbonizing retort, in which partial distillation of the raw coal is effected by the sensible heat of the producer gas. The hot gas from the producer passes down through the retort, in which it comes into actual and intimate contact with the raw coal. It distils off and carries with it the lighter hydrocarbons, and the solid residue emerges cool and of a much greater calorific value than when it entered. The ammonia, tar and oil can be extracted by the ordinary known methods, and the gas, even then, owing to its higher calorific value is much more effective for heating or power purposes than if it had been used directly from the producer. The partially-coked coal in the retort, moreover, makes excellent fuel for the producer, so that by suitably proportioning the plant, an extremely efficient combination is secured, taking in raw coal and turning out a cool and comparatively rich gas, from which the saleable constituents may be separated before use.

The retort is a long cylindrical tube which is placed at an incline. It is slowly rotated and the material to be carbonized is fed in at the top end, and discharged at the lower end. The hot producer gas enters at the lower end and passes out at the upper end through a "cyclone" dust extractor and then through a cyclone heavy tar extractor. It then passes forward to the condensing and scrubbing plant.

The retort has a slight taper—the upper end where the material is fed in being slightly smaller in diameter than at the discharge end. Consequently, as the retort rotates the coal works its way down to the discharge end. The length of time which the coal remains in the retort can be regulated by accelerating or retarding the speed of rotation.

A retort capable of producing 100 tons of smokeless fuel has a length of from 90 to 100 ft. At the take-off end it has an internal diameter of 7 ft. and at the discharge end an internal diameter of 9 ft.

The producer is placed in close juxtaposition to the retort, in order to prevent, as far as possible, heat losses.

The producer gas enters the retort at a temperature of from 500° to 600° C. and meets the already carbonized coal where a little more of the volatile matter is driven off, probably in the form of gas. It then meets partially carbonized coal and then less carbonized coal until it passes through the incoming raw coal. This causes a certain amount of pre-heating and drives off the moisture. After passing the entering coal it passes, as already stated, through the cyclones into the cooling and condensing system. The temperature of the gas at the exit is about 180° C.

It will be noted that near its larger end the retort is surrounded by an annular belt, 14 ft. in diameter. This is for the purpose of discharging the carbonized material which passes out through hand or mechanically operated sliding doors. The retort is caused to rotate by gearing. The final drive takes place through a spurring surrounding the retort near the centre of the latter. As is already mentioned, the weight of the retort is carried by supporting rollers. Near each end of the retort and also at the centre of its length is a runner band which runs on the rollers just mentioned. Endwise motion is prevented by thrust rollers working against the side of the running band.

At the end of the retort at which the coal enters is a fixed cylindrical portion 3 ft. 6 in. diameter, carrying both the coal-feeding mechanism and the gas outlet branch. This portion enters the retort proper through a specially designed gland where gas tightness is assured by means of cast iron rings working on metallic surfaces only. The successful solving of the problem of keeping a very large diameter stuffing box tight under high temperatures is intimately connected with the successful working of a rotary retort.

Fusion Retort. This is a retort within a retort, that is to say it consists of an outer and inner tube which revolves. It is claimed that a portion of the sensible heat liberated by the carbonization of the coal in the outer tube heats the coal in the inner tube, and if this is so the material to be carbonized is heated by the sensible heat liberated from the material in the outer tube, which is heated externally. It may therefore—provided this is correct—be termed something in between sensible heat carbonization and external heat carbonization. (*See* Appendix for illustration.)

The cylinders are connected together to one gland and are rotated. The inner cylinder into which the material to be carbonized is charged has a loose "star" breaker or cutter. That is an iron shaft with star cutters which rolls round with the motion of the retort and is said to break up the material and thus constantly expose fresh surfaces to the action of the heat.

If we take it that one ton of coal heated to 600° C. gives off 3,500 cu. ft. of gas, the sensible heat would be valuable in pre-heating the fuel.

We come now to other kinds of retorts which are entirely externally heated. Some of them have moving parts in the carbonizing zone, and others rely upon gravity for the discharge of the fuel. A few of the processes will now be described.

Coalite Process. The original coalite process was invented by the late Mr. Thos. Parker about 20 years ago. This was the first serious attempt to manufacture smokeless fuel, that is low temperature fuel, on a commercial basis.

Enormous sums of money have been spent on this enterprise. The initial mistake was the erection of a very large plant before the process had been sufficiently tried out. This plant, in which the retorts were made of iron, had to be scrapped.

Fire-brick retorts were then employed. With these, difficulties were met in the discharging of the carbonized material. Low-temperature carbonization is generally supposed to be a carbonization which takes place at temperatures between 480° and 600° C. which is about the temperature at which most coals expand to their maximum. To get over this difficulty the carbonizing temperature was considerably raised. That is to say it could hardly be called low-temperature carbonization. As the retort was then constructed it was found impossible to prevent leakage of the gases produced by the carbonization leaking into the flues. The temperature was raised still further by the burning of those gases, so that the so-called low temperature carbonization was carried out at a temperature more nearly approaching 900° than 600°, that is to say the average temperature employed on horizontal gas retorts at the gas works, and as the rich gases charged with vaporized oil could not be kept from coming into contact with the incandescent coke, cracking took place.

Difficulties also occurred in discharging. The coke on discharging burst into flame. This, of course, got rid of the volatile matter left in the coke—a small quantity of which is essential. It is this small quantity of volatile matter which makes the fuel burn more readily than gas or coke-oven coke. This plant had therefore to be scrapped.

Further plants were erected and scrapped. The same mistake was made throughout of putting too large units before the retort had been tried out.

The present construction of the retort is on entirely new lines—the recovery and condensing plant has not been to any extent modified.

The retort is built throughout of silica brick and is rectangular in form, 7 ft. 6 in. by 8 ft. 6 in. by 12 in. wide. The interior of the retort is, however, divided into three distinct chambers by means of two perforated cast-iron plates suspended on pivots from either side of distance pieces which in turn are carried on a rotating shaft. The arrangement is such that with the distance pieces in the horizontal position the plates form the central chamber, their respective positions being maintained by lugs on their inner sides engaging with each other. When the shaft receives a partial rotation (a door is provided in the top of the retort for the insertion of a lever for this purpose), the distance pieces are brought to a more or less vertical position, and the plates collapse.

The chamber is supposed to form four distinct functions.

1. It enables the pull of the exhausters to apply throughout the full length and breadth of the charge with equal effect to all parts.

2. It causes the gas to travel towards the central chamber and so attract the conductive heat from the walls in the same direction.

3. It prevents the gases coming into contact with the incandescent coke as far as possible, thus reducing cracking and preventing the gases carrying off undue heat.

4. At the end when carbonization is complete, the collapsing of the chamber by releasing the pressure on the sides of the charge allows the retort to discharge itself freely.

A hopper designed to hold 15 cwt. of slack is mounted above the retort and sealed by a revolving door. The retort is carried above a water-jacketed cooling chamber, from which it also is sealed by a revolving door. The burner flues are placed horizontally one above another between the retorts, the main burner being in the top position, the spent gases pass downwards at the end of each horizontal passage into the similar flue below, where they receive a boosting charge of gas from a supplementary burner, and so on in each succeeding flue until they reach the bottom of the retort when they enter the recuperators which are placed on either side of the battery passing upwards and downwards through these recuperators, counterflow to the primary air supply, to which they give up a large amount of their heat. The spent gases finally pass down between the water jackets of the cooling chamber to the main flue, which they enter at a temperature of about 80° C.

The retort is intermittent in action and the time of carbonization varies from 6 to 8 hours, depending upon the class of coal carbonized.

The feed hopper in which the coal is pre-warmed by radiant heat from the previous charge is opened into the retort by means of a revolving door. The coal spreads itself on each side of the central chamber to a thickness of about $3\frac{1}{2}$ in. At the end of the period of carbonization a revolving door at the bottom of the retort is opened, when the "Coalite" falls into an air-tight chamber. The plates are then restored to their original position in the retort—then a further charge is added.

The cooling chamber is water-jacketed. The jacket is exposed on one side to the hot "coalite," and on the other to the heat of the spent flue gases. It therefore becomes a heat economizer. The steam thus raised can be utilized in a producer or in the distillation plant.

In *The Iron and Coal Trades Review* of 28th October, 1921, the following particulars are given. A mixture of 70 per cent non-coking coal and 30 per cent coking slack was employed. After washing it gave the analysis as shown on page 100.

ANALYSIS

	Coking per cent.	Non-coking per cent.
Volatile matter	34·0	36·4
Fixed carbon	61·1	58·5
Ash	4·9	5·1

The carbonizing period was between 7 and 8 hours. 17·9 gall. of oil were produced.

ANALYSIS OF COALITE

Volatile matter	10%
Ash	6·4%
Fixed carbon	83·6%

The analysis, of course, is practically the same as that obtained by any other system. It is given, however, because the "coalite" is the oldest process in this country in which it has been endeavoured to work on a commercial scale.

The one point which arises in one's mind is how long will the collapsible plates stand the sliding action of first the coal as it is charged in and the hot coalite as it is discharged. The idea is extremely ingenious, but will it operate satisfactorily with a swelling coal which practically becomes semi-fluid at one period of carbonization.

There is another point to be considered. Since each retort is only designed to take 15 cwt. and only three charges can be put through in 24 hours, to carbonize any large quantity huge installations would be required with a consequent very high capital outlay.

Process of W. Everard Davies. This process may be termed unique. Mr. Davies does not only rely upon heat for the purpose of obtaining oils by the carbonization of coals, shales, etc., he brings to his aid electrical discharge.

The gases as they are evolved either within the retort or as they leave it are acted upon by high tension electricity, and he claims that this renders the molecules of the various compounds more sensitive and consequently to be in a state of greater chemical activity. The electrical disturbance is caused by placing electrodes of different potential along the path of travel of the gases " with a view of obtaining increased yields of desirable by-products."

A short quotation from the patent will suffice to give an idea as to the claims of the inventor. Whether it is feasible on a commercial scale or theoretically correct is another matter, upon which we will not comment. Those interested in carbonization will have their own opinions. To the general public it is interesting as showing the wide range of ideas covered in endeavouring to solve the process of carbonization.

The following quotation is taken from Patent No. 131,105—

" The aim of the invention consists in obtaining a field containing a variety of constituents with control over both their chemical and physical conditions, within sufficient limits to enable like control and determination over the issuing by-products isolated therefrom so as to render the method successful commercially."

This rather involved description probably means that by taking off the products of carbonization at differing zones a more or less fractional separation of the oils is obtained.

The patent then goes on to explain that the conditions can be so regulated that hydrocarbons of the aromatic series, such as benzol, toluol, etc., or aliphatic hydrocarbons together with phenols, bases, ammonia, cyanogen compounds, organic sulphur compounds, cyanamides and gases of various composition can be obtained at will. One can, however, hardly imagine anyone wishing to obtain sulphur or cyanogen compounds, The object in most retorts which have internal mechanical movements is to cause fresh surfaces of the coal to be exposed so that the heat may act as rapidly as possible. The great difficulty to be overcome is that moving pieces at high or moderately high temperatures are very apt to become distorted. Also when caking coals are being dealt with it frequently happens that blocking takes place owing to the swelling and adhesion of the coal to the moving parts. Great ingenuity has been displayed by the designers of retorts which have these internal movements. It will not, however, be possible in the scope of this book to describe them all. It is simply desired to give a general idea on the principles adopted. The Del Monte Retort has already been referred to. There are obvious disadvantages to internal movements in heated retorts. There is always a tendency for the bearings to seize, and there is another trouble—that of distortion which would be caused by uneven heating.

The Beilby Retort. This retort is the invention of Sir George Beilby. Its essential feature is that the coal is exposed to the action of the heat in very thin layers in trays which are carried by a rotating frame. The trays rotate in a horizontal plane and are provided with a feeding hopper. After a period of rotation they are automatically tipped and discharged and resume their normal position. They are then again recharged and passed through a similar process.

The apparatus is so arranged that the trays are pivoted on the rotating frame so that at a given point in the rotation they tip and then discharge the carbonized material. The horizontal position is then resumed in order to receive a fresh charge from the charging hopper. The edge of the hopper is so arranged that the thickness of the coal distributed on the trays can be determined.

The whole arrangement is naturally contained within a gas-tight casing which is provided with an outlet for the gaseous products of carbonization and is externally heated.

Patent Specification No. 124,039, explains the working of the retort. It should, however, be mentioned that carbonization can be accelerated by the introduction of hot gases or steam over the surface of the material in the trays. This is theoretically sound and also works out in practice.

Enclosed within a chamber of brick, or the like, is a gastight casing containing a rotating frame on which the trays carrying the material to be carbonized are mounted.

A vertical shaft supported by a bearing projects upwardly into the casing through a suitable gland. This gland also extends through the bottom of the chamber so that it is not reached by the high temperature gases.

The frame is fitted on the upper end of the shaft and consists of inner and outer circular rings connected by radial spokes, which may be conveniently constructed of iron or the like.

Between the rings are fitted the trays by means of rods pivoted to the rings; these rods thus form an axis about which the trays can swing, and being placed to one side of the centre line of each tray, the tray tends to assume a vertical position. This is prevented by means of rollers carried by the trays and bearing on the under side of a circular rail. As shown this rail, however, is interrupted at one point of its circumference allowing the trays successively to assume the vertical position to discharge their contents. They are returned to the horizontal position by the rollers encountering an upturned portion of the rail and remain in this horizontal position during the greater part of the revolution of the frame. The weight of the frame is supported by rollers running on a rail as well as by the shaft.

The material to be carbonized is placed on a hopper provided with a chute of the elongated shape shown so that the whole radial length of each tray is covered. The plane of the lower edge of the chute is parallel to the direction of motion of the trays and is placed close to them but with a small clearance which may be modified to suit the type of material which is being carbonized. There is no room between the tray and the chute for the material to form into a heap, and the material to be deposited immediately beneath the chute automatically prevents any more descending until the tray has moved to bring a fresh vacant space underneath the chute. By this means a uniform thin layer, without heaps, is spread over each tray.

Richards-Pringle Retort. This is a horizontal retort with an endless band running longitudinally, that is to say, it is practically the same as a feed stoking plant. The size of the carbonizing area is 30 ft. long by 3 ft. wide. There are ten troughs each 3¼ in. across the top and narrowing to 2½ in. at the bottom.

The conveying plant moves at a speed of about 1 ft. in 5 minutes which means that the charge goes through in from 2½ to 3 hours.

The internal feeding device is so arranged that each trough is charged as another one is discharged at the other end. The novelty about the troughs is that as they pass over the discharging end they open out and thus prevent any sticking of the material which has been carbonized, even supposing it to be a very sticky product.

Each retort will carbonize between 12 and 15 tons of coal per day. Being automatic and continuous little labour is required and on the experimental plant two men were employed by day and two by night, but the same number of men could easily look after several units.

The primary object of the Richards-Pringle process is the conversion of slack coal, not otherwise suitable for first-class coking processes, into a high quality smokeless domestic fuel, and it will also deal satisfactorily with other carbonaceous matter, such as cannels, lignite, etc.

The principle is correct provided that a steel can be obtained which will stand the strain of continually working at moderately high temperatures—up to 600°C.—and this is the difficulty which has been met with in all internal mechanical movements.

High Temperature Carbonization. In gas works procedure and in coke-oven practice high temperatures are always employed. In the first case because gas is the desideratum and in the second because hard metallurgical coke is required. Gas coke is also hard but is not suitable for metallurgical purposes as it usually contains a larger amount of breeze and is generally smaller than metallurgical coke. The latter coke is also baked for a longer period—that is to say it is subjected to high temperature heat for a longer period.

Coke produced by low temperature carbonization —often termed "semi-coke"—differs from high temperature coke in two respects—

(1) It contains more volatile matter—8 to 10 per cent as against 1 to 3 per cent in high temperature coke.

(2) It is not so hard and consequently does not stand transport so well.

All three forms of coke are smokeless when burnt. It is, however, not easy to ignite high temperature coke in the ordinary grate and it is apt to burn dead. Low temperature coke on the other hand ignites quite readily, burns with a bright red glow, and throws out much more radiant heat than coal.

In producing low temperature coke—" smokeless fuel "—a yield of approximately 70 per cent is obtained from every ton of coal carbonized. As, however, the heat value is greater, even taking this loss into account and neglecting the by-products, it is a commercial proposition to carbonize the coal. The consumer can afford to pay more for smokeless fuel than for coal and then find he is better served. Then there is the great advantage—freedom from smoke. The chimney sweep will have to turn his hand to some other calling. The house will not require to be decorated so frequently. The atmosphere will be purer. One has only to remember how much brighter the atmosphere of London and other large cities was during the coal strike of 1921 to realize what a difference the employment of smokeless fuel would cause. Further, the outside of public and private buildings and statues would maintain their pristine appearance for a very much longer period. One point must, however, be noted. Even with smokeless fuel one cannot eliminate the sulphur. The carbon in smoke blackens the buildings. The sulphur, owing to formation of sulphuric acid by the oxidation of the sulphur dioxide given off, eats into the stone-work and brick-work and causes disintegration. It is probable however, that sulphur and carbon when acting together have a more injurious effect than either singly. The carbon will prevent the sulphur (sulphuric acid) being readily washed out by the rain and may possibly have a catalytic action in the formation of the sulphuric acid.

As just stated it would be a sound commercial proposition to carbonize all the coal—even if smokeless fuel were the only product : but it is not. Valuable oils, motor spirit and gas of high calorific value are the by-products. There should be sufficient to pay the cost of the carbonizing process, thus the fuel should not be sold much above the price of the raw coal. But there is another point of national importance—the country would be self-supporting in oil. We should no longer be dependent upon outside sources for our oil. The tendency is for all ships, warships and mercantile, to burn oil fuel in place of coal.

FUEL FROM HOUSEHOLD WASTE

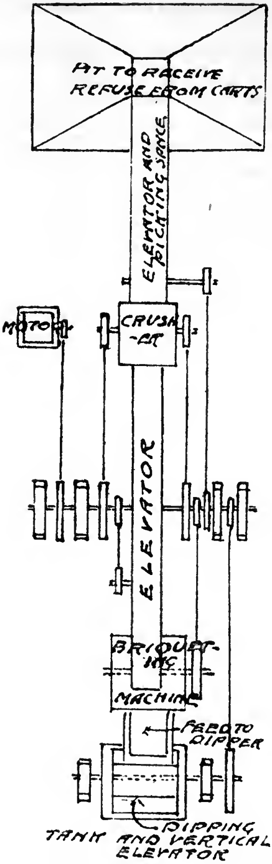
"Commercial Products" process—

A method for the manufacture of an artificial fuel from household refuse is in operation at Southall, Middlesex. The whole of the refuse collected from houses (such as ashes, cinders, paper, straw, and vegetable matter) is dealt with and turned into fuel, thus conserving the coal supply.

A brief description of the process is as follows—

On arrival at the refuse disposal works the tins are removed and the refuse is tipped into a crusher and reduced to a powder. It is then lifted by an elevator and made into small blocks by means of a briquetting machine. No binding material is added at this stage.

From the briquetting machine the blocks are discharged to a vertical dipper which carries the briquettes into and through a bath of oil tar which easily and quickly permeates the whole of each briquette. The blocks are taken to storage and can be used as fuel when and where required. If fuel of greater calorific



COMMERCIAL PRODUCTS PLANT (*see* p. 107) value be required, the briquettes, instead of being dipped, are placed in a cylinder and impregnated under pressure.

It may be pointed out that oil tar is used because of its high disinfecting, calorific, and binding qualities, as it contains 20 per cent of carbolic and 20 per cent of pitch in a finely divided state, and being obtained from oil (used at gas works for enriching gas) its heating value is high. It is claimed that by this process the treating of the refuse is sanitary and can be carried on anywhere without creating a nuisance.

The owners claim that, besides being a means of providing a valuable fuel out of material now wasted, the briquettes can be used for domestic and steam-raising purposes and thus save the whole of the present cost of disposal.

The illustration on page 108 shows the lay-out of plant which will deal with 20 tons of refuse a day.

F. M. P.

BINDERS used where coal-tar pitch is not obtainable—

Tar, asphaltum, petroleum refuse, crude oil, silicate of soda, sugar cane refuse, molasses, sago, rice, maize, Millers' offal. Plaster clay and lime or cement can be used under certain conditions. Wood pulp has also been successfully used in local plant.

APPENDIX

LXII. *Specification of the Patent granted to* John Frederick Chabannes, *of Welbeck Street, in the Parifh of Saint Mary-le-bone, in the County of Middlefex, Efq. for a Machine for feparating Coals, and a Compofition for making fmall Coals into Cakes or Bricks to be ufed for Fuel.*

Dated December 16, 1799.

WITH A PLATE.

To all to whom thefe prefents fhall come, &c. Now know ye, that in compliance with the faid provifo, I the faid John Frederick Chabannes do hereby declare, that the nature of my faid invention, and the manner in which the fame is to be performed, and the effects thereof, are to be produced, is particularly defcribed and afcertained as follows; that is to fay, coals confifting of great and fmall mixed together fuch as are ufually bought in the pool in the river Thames for confumption in the cities of London and Weftminfter and their environs, are to be difcharged or thrown upon grates or gratings of the defcription hereinafter contained, which grates or gratings are to be fixed either horizontally or on an inclined plane; and, by means of fuch difcharge, and throwing of the faid coals, the fmall coals will be feparated from the large. The grates or gratings are to be conftructed either of wood or metal, and are to be of any length or breadth fuited to the place where they are fixed, and to have bars at a diftance from each other not lefs than a quarter of an inch, nor more than an inch and an half. The form of thefe grates or gratings is particularly defcribed in the

the plates or figures delineated in the margin hereof. (See Plate XIX.) The compoſition is to conſiſt of the ſmall coals ſo ſeparated as abovementioned from the large coals, and a ſmall quantity of earth, clay, cow-dung, tar, pitch, broken glaſs, ſulphur, ſaw-duſt, oil-cakes, tan, or wood, or of any other combuſtible ingredient, to be mixed together and ground with a wheel in water in a wooden veſſel. The compoſition, together with the water, is then to be conveyed by pipes or any other conductor into pits or holes of any dimenſions, made for that purpoſe, to be lined with tiles or bricks cemented together with water, except in the centre where a drain or watercourſe is to be cut below the pit or hole, and ſuch drain or watercourſe is to be covered over with uncemented tiles, by which means the water will paſs off into the drain or watercourſe, and leave the compoſition in the pit or hole. The compoſition is then to be moulded into brick-cakes or balls, and put on a frame to dry; and when dry is fit for uſe as fuel. In witneſs whereof, &c.

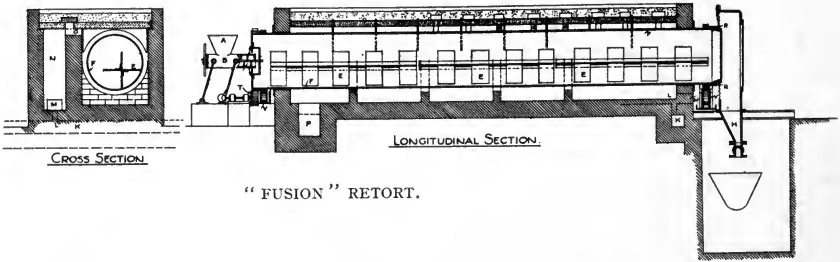
Reference to the Plate.

A. Plan of the grate or grating.

B. Veſſel in which the coals are raiſed from the barge, and from whence they are thrown on the grate or grating to ſeparate them.

C. The profile of the grate or grating with the coals running on it.

D. is the ſtage where the ſmall coal is received.



"FUSION" RETORT.

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