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OUR DOMESTIC FIRE PLACES.

EDWARDS.

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OUR DOMESTIC FIRE-PLACES:

A TREATISE ON

THE ECONOMICAL USE OF FUEL

AND

THE PREVENTION OF SMOKE.

WITH

OBSERVATIONS ON THE PATENT LAWS.

By FREDERICK EDWARDS, Jun.

SECOND EDITION.

LONDON:
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PREFACE.

In the opening address of Sir William Armstrong to the British Association for the Advancement of Science, at a late annual gathering of its members, there were some observations relative to the probable duration of our coal fields, which caused considerable sensation in the public mind. The reflection that the process of exhaustion of mineral riches which have contributed so enormously to the development of manufacturing skill in our country during the present century, and which enhance so greatly the comfort of our dwellings, is proceeding at such a rate that the position of England among the nations of the earth may, at no very distant future, be affected to an extent that it would now be painful to contemplate, must have been met by all with a strong hope that further investigation would prove the error of Sir William's deductions, or that progress in scientific discovery would render us less dependent on coal as a means of evolving heat.

It was stated in the address that a great waste of coal exists in all its applications, and so universally is such waste recognised with reference to its use in domestic fireplaces that it hardly becomes necessary to do more than allude to the fact. It will, indeed, be easy to show that an ordinary coal fire is misused in every way, and that a small portion only of the heat generated from it is made

available for warming an apartment. There is the imperfect combustion, resulting in the production of much smoke and ashes, both in great part pure carbon; the escape of the heated products through the register, which are turned to no account whatever; the free escape of the heat radiated at the top of a fire, which is often as considerable as that in front, and which must be considered apart from the heated air and gases; and lastly, there is the singular fact that, in the vast majority of grates now in use, the parts to contain the fire are of the material which is best calculated to abstract heat, and to conduct it where it is wholly useless. Though more than sixty years have elapsed since Count Rumford, in his admirable essays, demonstrated the absurdity of putting a good conducting medium, such as iron, behind a fire, instead of a bad conductor, such as common bricks or fire-lump; and though every person in the country with some knowledge of science is aware of the material best suited to the purpose, there can be no doubt that builders have to so great an extent ignored such considerations, in their anxiety to make a profit out of their transactions, that economy in first cost, and not efficiency, has been very generally their chief object of consideration.

And not merely is there the extraordinary amount of waste indicated by the several causes alluded to, but it must be said that a considerable amount of discomfort and inconvenience attends the use of a coal fire. A room comfortably and equably warmed is seldom to be met with. Our fires require constant attention, and while we have made extraordinary progress in the perfection of our modes of lighting, most of our appliances for generating warmth hold, by marked contrast, a most disadvantageous position.

It must be a source of sincere regret to every reflecting mind that our mineral treasure—coal, which holds so

peculiar a position, when compared with the vegetable and animal products of the earth, which are renewed in their season or generation, and with our metals, which, while serving the purposes of mankind, are not dissipated, should be so abused in its applications, and when it is considered that this mineral was formed on the surface of the earth, in periods vastly remote, for the benefit of the human race, and that the want of it is productive of an immense amount of discomfort and misery to large numbers of our fellow-beings, the urgent need of a general understanding of the efficient and economical use of coal will be forcibly seen.

I have thought this an opportune time for endeavouring to call public attention to the subject, and will, as shortly and clearly as I can, explain the principal suggestions which have been made during this century for improvement in the use of a coal fire, and endeavour to deduce from these and other considerations the principles that should govern us in the construction of our fire grates. My occupation has brought the subject before me for many years, and if some might thereby consider that it would be difficult for me to be the most impartial witness, I trust and believe that no one who may carefully peruse this treatise will be able to do otherwise than consider me to have laboured to the best of my ability to discover and make known the truth.

In the course of certain investigations which I have thought it desirable to pursue relative to a considerable number of suggested improvements that have never been brought before the notice of the public, I have seen much of the evil results of our present patent laws, which has confirmed a belief I had long previously entertained that those laws have been productive of far more evil than good in the branches of manufacture in which I have been

engaged, and that their entire abrogation would have a most beneficial influence. I have therefore added a short chapter on a subject which indirectly concerns the object of this little treatise, and which perhaps will be a little interesting to some of those who watch the progress of a very important matter, which there appears every probability will, before long, engage a considerable share of public attention.

March, 1864.

NOTE TO SECOND EDITION.

In the present edition the two first chapters and the observations on the patent laws are a reprint of the former, with one or two slight additions and some verbal alterations. The chapter entitled "General deductions and recommendations" has been considerably amplified. The author has been urged by some of his readers to publish his treatise in an abridged form, that it may become useful to a larger circle. He can willingly say that if his efforts are considered to demand encouragement, he will, at as early a period as possible, complete the short series of treatises he has projected, and will feel much satisfaction in employing whatever means may be at his disposal for spreading extensively information of a practically useful character upon such matters relating to domestic comfort and economy as have fallen particularly within his observation.

Of the printed letters alluded to in page 45 a few copies are in the hands of the publisher, and may be obtained at a small charge. They will not be reprinted.

Great Marlborough Street,
December 27th, 1864.

CHAPTER I.

ON COUNT RUMFORD'S IMPROVEMENTS IN CHIMNEY FIRE-PLACES, AND ON VARIOUS IMPROVED GRATES WHICH HAVE BEEN INTRODUCED DURING THE PRESENT CENTURY.

It is a remarkable fact that exceedingly little progress has been made on the most primitive methods of warming apartments by open fires, and that the elementary principles explained by Count Rumford at the close of the last century are very far from being generally understood and applied.

The most obvious cause of the little advance in a subject which so closely concerns the comfort of us all, is that since the death of Count Rumford, no one has appeared who, with equal attainments, has been equally interested to pursue the subject to the extent that is necessary for the purpose of understanding, in the first place, what improvements would be generally acceptable, and, next, how those improvements could be made most extensively known and understood. It is also partly to be attributed to the fact that the trade in grates has been conducted, either in the vast emporiums of Thames Street, which have supplied the builders chiefly with the most inexpensive productions in metal, or by the ironmongers of the country, who, in making the trade a branch of their business, have not, as

it appears, been led to give the subject the amount of attention which is necessary for the purpose of instituting improvements.

It is true there has always been a few houses which have given exclusive attention to the manufacture and erection of fire grates and kitchen ranges, but I can only mention one* that has rendered direct service to the public; and, so difficult is it for some persons to move in any channel but that to which they have long been accustomed, that it is still by no means an uncommon thing for grates, even of an expensive description, to be made with the parts surrounding the fire of the materials which have long been condemned as unfit for the purpose.

I will now proceed to describe the chief of Count Rumford's recommendations, and the principal inventions or suggestions which have appeared since his time. Occasion will occur for reference to two or three suggestions of note which were made at previous periods while my subject is in course of elucidation.

No one who ever studied the art of generating heat, and its application for the purposes of warming and cooking, has attained one-half the Count's reputation, the reason of which will be readily understood by any one acquainted with his writings. A cool indefatigable spirit of philosophical research, a mind capable of investigating the most abstruse questions of science, a genial loving nature, an intense desire of doing good to his fellow-beings, and an unflagging patience in endeavouring to extend knowledge upon what were then considered humble subjects, stamp him, not one of the most brilliant, but certainly one of the worthiest of England's sons. His name is still familiar to thousands, and is worthily perpetuated in the Rumford

* That of the late Mr. William Pierce.

medals of the Society of Arts, and, though his essays are now known to few, they may again receive some attention in connection with the vast social questions which in our days of rapid progress are presenting themselves for solution. The Count carried economy in generating heat for cooking to an extent that appears incredible, and it is by no means impossible that his admirable roaster, constructed for the use of the poor, may yet become a favourite among the working classes of the country.

Many of my readers must be acquainted with fire places as they were constructed some sixty years since, and which Count Rumford did much to improve. The old chimney openings still abound in Bloomsbury and elsewhere. They were large, usually about 4 feet wide, and 4 feet high, with a grate of such a form as that in Fig. 1, composed entirely of metal. The whole of the upper part was left open to the chimney. To understand how impossible it was for a fire to be lighted in such a grate without annoyance from smoke, one must consider that smoke is carried up a chimney by the heated column of air which rises from a fire, without the aid of which it could have no power to ascend at all. Both air and smoke must continue to ascend until the heat has been parted with, and, the simple precautions necessary are, that they should not be driven back by gusts of air, and that they should not be too quickly reduced in temperature. These precautions, however, were not thought of before the time of Count Rumford. On lighting a fire in an old-fashioned grate, the heated air from the fire, passing up through a large body of cold air in thin films, quickly lost its acquired temperature, and the general disturbance of the atmosphere, caused by the rush of cold air from all sides of the fire-place and from above, forced the smoke back, and rendered it impossible for a fire to be lighted at all without the

opening of windows, and the admittance of a mass of dense cold air to force the lighter air of the room up the chimney, and thus to establish an upward current irrespective of that which should have arisen on the mere ignition of the fuel.

The Count's simple and effective suggestions are shown in Figs. 2, 3, 4, and 5. The fire-place was to be reduced both in width and height by pieces of marble or stone. It was to be further contracted by the brickwork, shown in section, Fig. 3. The grate was made to project as much as possible, and the sides were splayed, so that much of the heat acquired by them might be radiated into the room. These sides and the back the Count insisted should be of fire-stone or common bricks, and upon no account of metal. The brickwork behind the fire-place was to terminate abruptly, as shown in Fig. 5, the object being to check the rush of cold air upon the fire from the chimney. The brickwork behind the mantel-piece was to be added to, so that it might commence at the lower edge of the marble, and it was to be rounded, as shown in Fig. 5. The opening into the chimney just above this was to be of the width of the grate behind, and 4 or 4½ inches in breadth. These simple additions to a fire-place caused an immense improvement. They proved an almost infallible cure for a smoky chimney. The contracted form allowed the heated air from the fire to carry off the smoke in a gentle current, undisturbed by cold gusts, and at least double the amount of heat was obtained from the consumption of a stated quantity of coal. Fire-places were altered or formed on the Count's principles throughout the country, and I have no doubt, that if his very simple suggestions had been generally followed, the amount of fire-side comfort now existing would be vastly greater than it is. Complaint was made by some that the new fire-places gave too much heat, but, how to

obviate this objection the Count, with all his urbanity, did not think it necessary to explain.

It will now be useful to compare Count Rumford's improvements with the description of grates which has been most largely manufactured since his time. I should state that chimney-pieces were henceforth made of smaller dimensions, the saving in first cost probably hastening the improvement considerably. Fig. 6 is a sketch of the most ordinary description of grates supplied by Thames Street emporiums to the builders of London and the home counties. This is not the best specimen which I could have chosen, but it is a faithful type of the kind of grate which has been manufactured to the extent of hundreds of thousands for the use of the masses, during the last thirty or forty years. In fact, of the entire number of inhabited houses in many counties, there can be but a small proportion in which such grates are not to be found. These grates are composed entirely of metal, Count Rumford's recommendations to use fire-stone or common bricks for the back and sides being disregarded. The sides are not splayed so as to radiate heat into the room, but so as to send rays to and from each other. The upper part of the grate is so open that a return of smoke on lighting a fire is by no means an improbable contingency. To show somewhat fully the amount of error committed in the construction of these grates, I will now give Count Rumford's own explanation of the advantages of brickwork over iron at the back and sides of a fire :—

"In regard to the materials which it will be most advantageous to employ in the construction of fire-places, so much light has, I flatter myself, already been thrown on the subject we are investigating, and the principles adopted have been established on such clear and obvious facts, that no great difficulty will attend the determination of that point. As the object in view is to bring radiant heat into

the room, it is clear that that material is best for the construction of a fire-place which reflects the most or which absorbs the least of it; for that heat which is absorbed cannot be reflected. Now as bodies which absorb radiant heat are necessarily heated in consequence of that absorption, to discover which of the various materials that can be employed for constructing fire-places are best adapted for that purpose, we have only to find out, by an experiment very easy to be made, what bodies acquire least heat when exposed to the direct rays of a clear fire;—for those which are least heated evidently absorb the least, and consequently reflect the most radiant heat. And hence it appears that iron, and, in general, metals of all kinds, which are well known to grow very hot when exposed to the rays projected by burning fuel, are to be reckoned among the very worst materials that it is possible to employ in the construction of fire-places.

"The best materials I have hitherto been able to discover are fire-stone and common bricks and mortar. Both these materials are, fortunately, very cheap; and as to their comparative merits, I hardly know to which of them the preference ought to be given.

"I am well aware how much the opinion I have here ventured to give, respecting the unfitness of iron and other metals to be employed in the construction of open fire-places, differs from the opinion generally received upon that subject; and I even know that the very reason which, according to my ideas of the matter, renders them totally unfit for the purpose, is commonly assigned for making use of them, namely, that they soon grow very hot. But I would beg leave to ask what advantage is derived from heating them?

"I have shown the disadvantages of it, namely, that the quantity of radiant heat thrown into the room is diminished: and it is easy to show that almost the whole of that absorbed by the metal is ultimately carried up the chimney by the air, which, coming into contact with this hot metal, is heated and rarefied by it, and forcing its way upwards, goes off with the smoke; and as no current of air ever sets from any part of the opening of a fire-place into the room, it is impossible to conceive how the heat existing in the metal composing any part of the apparatus of the fire-place, and situated within its cavity, can come or be brought into the room.

"This difficulty may be in part removed by supposing, what

indeed seems to be true in a certain degree, that the heated metal sends off in rays the heat it acquires from the fire, even when it is not heated red hot; but still, as it never can be admitted that the heat, absorbed by the metal and afterwards thrown off by it in rays, is increased by this operation, nothing can be gained by it: and as much must necessarily be lost in consequence of the great quantity of heat communicated by the hot metal to the air in contact with it, which, as has already been shown, always makes its way up the chimney, and flies off into the atmosphere, the loss of heat attending the use of it is too evident to require being further insisted on.

"There is, however, in chimney fire-places destined for burning coals one essential part, the grate, or rather the front bars and bottom of it, which cannot well be made of anything else but iron; but the back and sides of a grate should always be made of fire-bricks, laid in mortar made of clay and brickdust, and there is certainly no necessity whatever for the immense quantity of iron which surrounds grates as they are now commonly constructed and fitted up, and which not only renders them very expensive, but injures very essentially the fire place.

"Those who have not seen the experiment made can have no idea how much better, clearer, and brighter a coal fire, or a wood fire, burns in a grate, the sides and back of which are brick or fire-stone, than in one whose sides and back are of iron. The metal being a conductor of heat, the heat of that part of the fuel that happens to touch it is carried off by it, and the fuel being cooled, the fire goes out, or burns very dull; but when the fire burns against bricks, the surface of the bricks very soon grows red hot, which not only causes the fire to burn clear and bright, but increases very much the quantity of radiant heat sent off into the room."—*Count Rumford's Essays*, fourth edition, 1798. Vol. I., pages 326 to 338.

"Those who are fond of the glitter of polished steel and have no objection to the expense of it, or to the labour that is required to keep it bright, may surround their fire-places in front with a border of it, for there it will do no harm, and may use grates and fenders of the most exquisite workmanship; but if they wish to have a pleasant, cheerful and economical fire, the casings of their

fire-places must be placed obliquely, and they must not be constructed of metal; and if the sides and back of the grate be constructed of fire bricks instead of iron, the fire will burn still brighter, and will send off considerably more radiant heat into the room."—Vol. III, page 392.

The following extracts from excellent authorities will confirm the above observations :—

"When iron is used in large quantity around an open fire, it robs so much heat from it, and communicates so large a quantity, by conduction to the current of air passing up the chimney, that it rarely burns brilliantly. Every portion of metal that may in any way be dispensed with, proves advantageous in an open fire."—*Dr. Reid's Illustrations on the Theory and Practice of Ventilation*, 1844, *page* 231.

"In regard to fire-grates in general, from the preceding experiments, and from the information which has been collected, the Commission is prepared to recommend—

"6. That fire-brick linings to grates should be in general use." One of twelve recommendations contained in the "Report of the General Board of Health by the Commissioners appointed to inquire into the Warming and Ventilation of Dwellings." Ordered by the House of Commons to be printed, 25th August, 1857.

It is deeply to be regretted that metal was not long since abandoned in the construction of the back and sides of a fire-place, or rather that it was ever introduced for the purpose. Within the last few years, however, a great improvement has taken place, and the middle and upper classes are now very commonly supplied with grates composed partly of iron and partly of fire-brick. Not so, however, the working classes. If any of my readers will take the trouble to visit the oldest and most extensive establishments in Thames Street, they will see that a vast majority of the grates still supplied to builders by these establishments, and those adapted for the humblest dwellings, without exception, are still made entirely of

metal. This is particularly to be lamented, as, while the rich can change their grates, or burn coal regardless of anything but their own comfort, the most numerous classes have to bear their life-long the evil results of a want of knowledge in so simple a matter. Many will be surprised that a practice so extensively known to be erroneous should have been so long persisted in, and expect that there is some difference of opinion among practical men as to the value of fire-brick at the back of a grate. But this is not so. I ascribe the neglect of the subject in some measure to want of knowledge, partly to the fact that in following an erroneous course for a considerable time a momentum is acquired which only the efforts of a considerable number of persons, long continued, can check and entirely turn aside, and partly to the practice of builders never to go beyond what is expected from them in providing for the comforts of a dwelling. A grate composed entirely of metal is to be purchased for so small a sum, and can be put into a fire-place at so trifling an expense for fixing, that a builder has no inducement on the score of economy to build up his fire-places with fire-bricks. It would be very honourable on the part of the respectable houses to which I have alluded, if they were to discontinue entirely to manufacture grates exclusively of metal, and thus set an example that would be extensively followed by others. A very effectual remedy would be for District Surveyors to have power to condemn such grates whenever they find them in new houses, a remedy which I have no doubt that many would be thankful to see exercised.

I will now describe, shortly, the best description of grates used for burning fuel according to the usual method, and will in the next chapter examine those which have fuel supplied from below, and which are usually called smoke-consuming grates.

In Figs. 8 and 10 are sketches of two tolerably well constructed grates of the present period, in which Count Rumford's principles are but little departed from. In one the fire-brick is shewn at the back and sides of the fire only, with metal above. In the other the fire-brick extends from the ground to the register plate in the chimney. This register plate by which the opening into the chimney is graduated has been generally adopted, in lieu of the Count's contraction to four inches in breadth shewn in Fig. 5.

In Fig. 11 is a sketch of a grate known as Sylvester's Patent, which was much used about twenty years ago. Each bar of the grate on which the fire rests extends considerably into the room, and thus heat is gained by conduction and radiation. The fire is raised very little above the level of the floor. In fixing the grate, hollow chambers are left behind, with openings into them from the lower part of the room, and outlets in the upper part of the grate, so that air entering below may return to the room somewhat warmed above.

In Fig. 16 is a sketch of a most excellent grate, known as King's Patent, which has never been much introduced to the notice of the public. The aperture for the escape of smoke is behind, and is graduated by a door balanced by chains and weights, which can be moved up or down by a touch with a poker. It is interesting to observe how completely the fire is placed under control by the movement of this door, which instantaneously increases or diminishes the combustion of fuel.

In Fig. 14 is a sketch of a grate which has received a much larger amount of public favour than either of the two former, and is known as Stephen's Patent. In principle it is the same as King's Patent, the smoke passing through an aperture at back; but the means for regulating

the draught are far from being as perfect. The part between the front of the grate and the door behind is filled up by a recessed metal arch. The ash pan with steel bars is chiefly for convenience and ornament. Both in this and King's Patent the effect of air passing over the fire to the chimney is to make the fire present a very bright appearance. Neither of them can be pronounced very economical, but for their clean and comfortable appearance, the ease with which they burn coal dust, and the bright fire they produce, they certainly deserve to be held in high estimation. It is scarcely possible for a chimney to smoke with either of these grates. A considerable number of grates are now made on Mr. Stephen's principle, which are very imperfect in consequence of the space over the fire bars not being sufficiently contracted, and the door behind not being sufficiently recessed. No one could judge of a true Stephen's grate by such as these. The best grate on the construction is one for which a patent is held by Messrs. George Wright and Co., and which is called the Bivalve principle. This consists in suspending the recessed arch, *a*, Fig. 16, on a hinge at bottom, in addition to the door, *b*, so that the opening into the chimney can be considerably enlarged at any time, by pushing the arched plate backwards.

In Fig. 18 is a sketch of a grate with a chamber behind, into which air from an external source is admitted, and which air, becoming warmed by contact with the heated parts of the grate behind, enters the room at apertures in front. An advantage is gained by this plan, but by no means so great as is generally expected, and frequently it is wholly lost in consequence of the channel to admit the air into the chamber from outside being much too small. It should have an area of from twenty-four to forty square inches. It may appear surprising that so plausible a

method of adding to the efficiency of a fire should not have been more frequently adopted. This has not been from want of attention by manufacturers and others, for though the principle was introduced one hundred and fifty years ago by the Cardinal de Polignac, whose suggestions are fully detailed in elementary treatises,* which should be in the hands of all those who believe themselves able to effect improvements in the construction of fire-places, the number of patents which has been applied for and granted for adopting the principle is something remarkable. The expense and trouble attending alterations must have been, however, the chief impediment to its more extended adoption in many existing buildings.

Fig. 19 shows a sketch of a useful little grate composed of fire lump with the bars of metal, manufactured by the late Mr. William Pierce, of Jermyn Street.

There have also been several grates introduced for reducing the formation of smoke by a special supply of air given amidst or over the burning fuel. I am quite unable to see that any of them are as effectual for the object designed as the King's and Stephen's patent grates just described. In these a strong action of the air on the upper surface of the burning fuel is caused by the form of the grate itself, an advantage which some patentees have endeavoured to gain by elaborate contrivances. Fig. 20 is a sketch of one of them patented in 1853 by Mr. John Lee Stevens. There is nothing to remark beyond the double metal casing behind the fire with the hollow chamber. When a fire is burning, air passing up this

* Mr. Charles Tomlinson's "Rudimentary Treatise on Warming and Ventilation," and Mr. Walter Bernan's admirable little volumes on the "History and Art of Warming and Ventilating Rooms and Buildings, with Notices of the Progress of Personal and Fire-side Comfort."

chamber becomes warmed, and being prevented by a guard of metal from rising to the chimney it acts upon the surface of the fire and promotes combustion. I have never heard of the grate being an article of commerce, and have introduced it merely for the object of explaining a particular mode by which it has been sought to improve grates. I will now proceed to discuss the advantages and disadvantages of more effectual methods of preventing the formation of smoke.

CHAPTER II.

ON GRATES THAT PREVENT THE FORMATION OF SMOKE, COMMONLY CALLED SMOKE-CONSUMING GRATES.

WITHIN the last ten years a considerable amount of attention has been called to a new method of supplying fuel in open grates, by which smoke is said to be consumed. The term smoke-consuming has been objected to by Mr. Chas. Wye Williams, in his book on furnaces,* because most appliances are for the purpose of preventing the formation of smoke, not of consuming it, after it has once been evolved. The same may be said of an open fire, which, if it can be used without producing smoke, may be aptly compared to a lamp, which produces no smoke, but which we should not think of terming smoke-consuming. I will, therefore, use the terms smokeless fire and smokeless fire grate, which are short and less objectionable.

Coal has not been much used for domestic fire-places in England for more than about two hundred years. The prejudice against it at previous periods was so strong that early in the fourteenth century its use was entirely prohibited in the city of London, at which time it was much

* "On the Combustion of Coal and the Prevention of Smoke Chemically and Practically considered." This work relates entirely to furnaces.

in demand for the use of brewers, smiths, and others. Mr. Tomlinson relates* that most severe penalties having failed to prevent the use of coal, an act was passed making it a capital offence, and that in the reign of Edward the First a man was tried, convicted and executed, for burning coal within the precincts of the city. Even in our own day a few hours can transport us to a capital where coal is scarcely used, and where the sky has the transparent clearness of the country.

The presence of smoke in the London atmosphere is a gigantic evil. It is proof of an enormous amount of waste. It is the result of a fire in a low state of efficiency, and, having been unnecessarily discharged from us, it returns as a reproach to our improvidence and thoughtlessness to blacken our houses, to discolour our ceilings, paper-hangings, carpets and curtains, and cause us no inconsiderable amount of personal inconvenience. The annoyances can indeed only be fully appreciated by those who have resided much in the country or abroad.

It will be useful to form some estimate of the amount of waste that occurs in London alone in the combustion of coal. During the year 1862 no less than 81,638,338 tons of coal were raised in the United Kingdom. Of these nearly five millions were brought into and consumed in the London district. If we assume that four millions of tons were consumed in the fire-places of London and its suburbs, that waste in fuel amounts on an average to twenty-five per cent., and that the average value of coal delivered at the purchasers' residence is twenty shillings per ton, there is a waste of property to the extent of £1,000,000. sterling per annum. This estimate of waste will probably be considered absurdly low, and there can

* "Rudimentary Treatise," page 63.

hardly be a doubt that it is so. I believe we deprive ourselves of comfort to the extent of £1,000,000. sterling, in addition to this actual waste; and when we consider other sources of loss from deterioration of property, &c., in our begriming atmosphere, it will be seen that smoke is altogether a very expensive evil.

The principle essentially involved in nearly all grates that are said to burn without smoke is, that the ordinary method of putting coal on the top of a fire, and allowing the smoke produced from it to pass into the chimney, should be avoided, and that the fresh fuel should be supplied to the fire from below, or, if supplied at top, that the channel for the exit of the products of combustion should be below the fire. Two opposite modes are here indicated for effecting the same object. In the first, coal is introduced to the fire from below, and the products of combustion escape to the chimney as in an ordinary grate. In the second, coal is thrown on the top of the fire, but the products of combustion are carried through and below the fire before they enter the chimney. Both profess to reduce or prevent the formation of smoke by causing a more perfect combustion of the coal.

The various plans which have been proposed may be conveniently divided as follows:—

1. *For the prevention of smoke by a rotating grate, the coal thrown on the top of the fire being made to pass below.*

2. *The use of a chamber contiguous to the fire, from which fuel can be introduced below or behind the burning fuel, when required.*

3. *The use of a contrivance, not forming part of the grate itself, to introduce coal at any time below the fire.*

4. *The use of a double fire. The fresh coal being introduced into the lower division is supposed to get its smoke consumed in the upper one*

5. *For the prevention of smoke by a downward current for the products of combustion.*

6. *The use of a chamber to contain coal for a day's supply, a fire being made on the top of the fuel, which burns gradually away as it is exposed to the action of the air.*

For the first no less than eleven plans have been proposed, for the second six, for the third five, for the fourth two, for the fifth fourteen, and for the sixth ten; in all forty-eight. A list of them is given in a note in the Appendix; but those which have gained public notice, or which appear to possess merit, I will now shortly describe.

1. *Rotatory Grates.*

The first of these was invented by the American, Dr. Franklin, for particulars of which I am indebted to Mr. Bernan.* Fig. 22 shows a sketch of the doctor's fire cage, as it was termed, which was circular, having a solid iron back, fire bars in front, and grate bars above and below. Two of the fire bars were moveable, and a fire was made in the common way, by removing the upper bar and introducing the wood and coal. When the fire had to be replenished, coal was introduced at the same opening, the bar was replaced, the cage, hanging on joints, was turned over by a touch with the poker, so that the back of the cage might face the room. Another touch of the poker would, however, turn the cage round on another joint, so that the bars might again face the room, but with the fresh fuel at bottom instead of at top. The bottom and top being reversible, the operation could be repeated as often as necessary.

Fig. 24 is a sketch of a similar contrivance, patented in 1818, by Mr. Jeremiah Spencer. The upright sides, *a*, *a*,

* Vol. II., pp. 181, 195.

were fixed firmly to the ground, and supported on joints the metal cage to contain the fuel. The cage had bars in front and behind, with spikes, as shown, to prevent the coal falling. After fresh fuel had been thrown on at the top, the cover was firmly fastened, and the cage was turned over by a handle. What was the back of the cage thus became the front, and the bottom the top. This could be repeated as often as necessary, the parts being reversible.

It will be seen that in these grates no attempt was made to prevent smoke until the fire was required to be replenished. It was necessary to fill the cage at each charge, otherwise the process of turning over would have thrown the whole into a state of confusion. It must also have been necessary to give somewhat particular attention to the fire, because, if allowed to burn very low, it was useless to charge it according to the prescribed method. If a quantity of coal were thrown on a small body of ignited fuel, of which the chief element of vitality, hydrogen, had been nearly all consumed, the act of reversal would only facilitate the total extinguishing of the fire. Several similar contrivances have since appeared, some with internal divisions to allow of reversal, without the whole cage being filled with fuel; but the objections arising from the free entrance of air on all sides, the absence of fire brick, and the necessity for attention, are so serious, and it is so certain that a much greater amount of efficiency can be obtained by simpler means, that I do not see how such a contrivance as a rotatory grate can be regarded otherwise than as a curiosity. There have been ten patentees of such grates, but I never heard of the contrivance being in use.

2. *Grates provided with a chamber contiguous to the fire, from which fuel can be introduced below the burning coal, when required.*

This principle has been honored by six patentees, but I can only find that one has had any success. This is Mr. William Young, who patented a grate in 1856, shown in Fig. 25. The chamber, A, in front of the grate, is open above, but closed in front at each end and below, and contains a screw, Fig. 27, placed longitudinally, which is moved by a poker working in a suitable contrivance at C, with which the screw is placed in connection. The coal when thrown into the chamber falls between the folds of the screw, a turn of which by the poker causes some to enter the fire. This grate allows very little air to enter below the fire. It burns steadily, gives much heat, and must be considered, I think, altogether more successful than the rotating grates. An objection to it is the unsightly appearance, and I am told it is expensive.

Of the remaining patents, I have copies of the specifications in my possession, and have examined them with much care. In two cases no drawings are furnished, and they did not proceed, in fact, to the Great Seal. The others are so radically bad that no good result could arise from my describing them. It is more useful to explain a few successful or fairly successful contrivances than to point out the errors of imperfect ones.

3. *A contrivance, not forming part of the grate itself, for introducing coal below the fire.*

Letters patent were granted in 1816 to Messrs. Dowson and Hawkins for a feeding shovel, which, from the description, was such an article as that shown in Fig. 28. A is a

box, supposed to be six or eight inches square and two inches deep, capable of holding one or two pounds of coal The handle is fixed, and within it, is a moveable rod attached to a piston within the box. The lid, *e*, is opened to introduce the fuel. To charge the fire, the box was filled, the lid closed, and the shovel pushed in between the lowest fire bars of the grate, the front edge of the box serving as a wedge to raise the fuel. The coal was then forced through the lid by the piston, and the shovel, being gradually withdrawn, the whole or the greater portion of the contents were left below the burning fuel as required. In addition to this, an indefatigable patentee, Mr. John Juckes, has endeavoured on four occasions to construct a grate with a mechanical contrivance for introducing coal below the fire, but he does not appear ever to have been successful.

4. *Smoke prevented by a double fire.*

This plan was suggested a few years since by Dr. Bachhoffner, who provided a grate with two distinct sets of bars and two gratings. Within the upper bars he proposed that a fire should be made of anthracite coal or coke, and that bituminous fuel should be used in the lower. The smoke rising from the lower fire, the Doctor asserted, would become consumed in the upper. The Doctor also suggested that both fires might burn bituminous fuel; that fresh fuel should be supplied to the lower fire only, and transferred to the upper when in an active state of combustion. I do not see how Dr. Bachhoffner would ensure the passing away of the products of combustion through the upper fire. Unless the coal in this were so carefully arranged that many apertures of escape were left, some smoke would certainly pass into the room. But the proposition, independently of this, does not seem very inviting, for few

persons would care to burn two kinds of coal in one room, or to have a double fire to attend to. Dr. Bachhoffner has also a plan for burning a fire in the lower compartment only. He has a mechanical arrangement for transferring the burning fuel from the lower compartment to the upper, for the purpose of charging the lower one with fresh fuel, and for returning the burning fuel to the lower grate. This arrangement might be interesting to an amateur mechanician, but after having examined carefully the specification and accompanying drawings, it appears to me that it would be totally inapplicable for ordinary use. I can express no opinion as to its efficiency.

5. *The prevention of smoke by a downward current for the products of combustion.*

The first smokeless grate of which we have any record was on this principle. It was constructed in 1680, and exhibited at St. Germains, near Paris. The sketch, Fig. 30, is taken from Mr. Bernan's work already quoted. The vase *a* to contain the coal was open at top, and the fuel rested on an open grating. Below was a metal chamber, with an exit pipe leading to the chimney. When a fire was required, the vase was filled with fuel, a lighted lamp was applied to the pipe, which, becoming very hot, caused a current of air to descend the vase into the chamber below, and up the pipe to the chimney. Dry wood was placed over the coal and lighted paper on the top of all. The downward current, it is said, caused both wood and coal to ignite readily. If all the products of combustion were effectually carried off by the downward current, the contrivance was decidedly effectual, as the fuel supplied at top would undergo a more gradual and perfect combustion than when burnt in the usual way, and a smokeless fire would be the result.

Fig. 31 is a sketch, and Fig. 32 a transverse section of a grate patented in 1856, by Mr. John Marsh, in which the same principle is involved. When a fire is first lighted in this grate the door is thrown back in the position shown by the dotted lines, to allow the products of combustion to pass freely away; but as soon as the chimney becomes warm and a good current is established, this door is pulled forward, and the only escape to the chimney is through openings behind the fire at *b b*. If, therefore, a good fire is kept up, and there is a body of ignited fuel resting against these openings, the coal thrown on will undergo a more gradual and sure combustion than when smoke is allowed to pass freely above. But what assurance is there that all the products of combustion would pass through the openings to the chimney? If the openings were covered with ignited fuel, and the chimney had a weak draught, some of the products would inevitably enter the room. If the door *a* were slightly opened, the principle of preventing smoke would be at an end, and if there were not sufficient ignited fuel to cover both the openings, the fresh fuel would burn in all respects as in an ordinary grate. If the grate were nearly closed in front and used as a furnace, it might succeed in all cases, but with the gentle current necessary in a domestic fire, success appears to me to be impossible.

Count Rumford recommended the principle for a lime-kiln, and it is mentioned in the specification of a patent granted in 1815 to Jean Frédéric, Marquis de Chabannes; but in the first case the fire-place or furnace was closed, and the escape of deleterious products would have been injurious to no one; in the second case the principle was applied to calorifere stoves.

I will now describe another inventor's mode of "consuming smoke," by a downward current, which appears,

perhaps, on a slight inspection, to present a greater probability of success. This is Mr. Taylor's plan, for which letters patent were obtained in 1858 and 1859. The first patent I need not allude to, as it contains merely the embryo of ideas much matured in the second. Mr. Taylor gives sketches of three distinct modes of applying his principle, which are shown in Figs. 33, 34 and 35. Fig. 33 is a sketch, and Fig. 34 a longitudinal section of the grate exhibiting one mode. The fire is lighted in the ordinary way, when the door *a* is thrown open to allow the products of cumbustion to pass direct up the chimney. This door, it is intended, should be soon afterwards closed, when the only access to the chimney is by the circuit flue *b b*. The products of combustion are now supposed to be carried off from the fire in two distinct currents. A portion, it is stated, descends between the bars of the grate into the flue underneath, as shown by the arrows, and passes up the flue *b* on the left into the chimney; the remainder rises in the usual manner, and is then carried down the right hand flue and along the horizontal flue, below the fire bars, into the ascending flue. It must be particularly observed that the space below the fire bars is closed in front, and that it is in passing through this heated chamber that, according to Mr. Taylor's assertion, "the smoke is entirely, or in great part, consumed." At each side of the grate are hollow fire bricks, through which fresh air is allowed to pass, whenever possible, to enter the room warmed at the openings round the grate *e e*. These hollow bricks must be left out of consideration in forming an opinion of the smoke-preventing qualities of the grate, with which question they have nothing whatever to do. Mr. Taylor's grate has now been tested quite sufficiently to allow of a positive opinion being formed as to its capabilities. It has the appearance of being a somewhat inge-

nious contrivance; and if it can be allowed that it would work perfectly, that the products of combustion would securely pass off by the circuit flue, and that the smoke would become consumed in the chamber under the fire, there can then be no doubt that the grate possesses considerable merit, and that Mr. Taylor has by no means received the amount of recompense which is his due. How far there is a possibility of any such success, I will endeavour now to show. There are three distinct questions which require consideration:—1. What is the relative amount of air descending between the bars of the grate compared with that which rises from the fire? 2. What conditions are necessary for the success of the descending flue to carry off the products of combustion? 3. What possibility is there of the smoke being consumed in passing under the fire bars? The first question might be considered as answered by Mr. Taylor himself in his specification, who was evidently aware that all or nearly all the products of combustion would rise immediately from the fire, and who only incidentally alludes to a downward current between the grate bars. It will be well, however, to show that this downward current must be left altogether out of consideration.

We have seen that the fire is lighted in the ordinary way, when the door into the chimney being opened the heated products pass direct up the chimney. As soon as the air is sufficiently rarefied the door is closed. A current of air now begins to move up the left-hand flue, giving motion to the air in the horizontal flue under the grate and in the descending flue on the right. Air from the room and warm air from the fire now descend this flue, and carry off the products of combustion. Every one knows that warm air naturally rises, and it is by virtue of this very power that in this case it is made to descend.

It is in consequence of the powerful current created in the chimney by the rarefied state of the air therein, that air rushes upwards from the left hand flue, followed successfully by air from the other flues and from the grate, the simple condition necessary for the carrying downwards of the heated air and products of combustion being that the urging force of the current in this direction should be greater than the ascensional force of the air from the fire. We will now suppose that a good fire is burning, and that the grate bars are covered with hot fuel. Air rushes to the fire between the front bars; part is decomposed, part is considerably expanded, and the tendency of all the gaseous elements is to rise. Now the simple condition necessary to reserve this tendency and carry any of the products of combustion downwards is identically the same which we have seen to be necessary for the purpose of carrying the smoke down the descending flue, viz., a current of air flowing in that direction, and pushing the air it encounters before it. But how can this occur when a fire is burning? If the grate bars are covered with burning fuel, air rushes to support combustion, and expands. It has now no descending power, and cannot descend except by a current of colder air from the room flowing down between the bars and compelling it. But such currents of air, if possible or permitted, would be subversive of the whole grate, for, with them, the fire would give little heat and possess little vitality.

It is possible that if a portion of the grate bars in front became uncovered a little air from the room might descend, but this would be altogether a chance circumstance, and in the ordinary course, so far from there being any tendency for air to descend between the bars, there can be no doubt that exactly the reverse takes place, and that a portion of the air which passes down the right hand flue

enters the fire below to assist in supporting combustion. I think, therefore, we may safely disregard the idea of there being any downward current amidst the burning fuel.

There is now the question of the flues. Mr. Taylor has two modes of arranging them, in addition to the one already described. In one plan, shown in Fig. 35, he forms a third flue behind the grate for the ascent of the products of combustion, and the flues *b b* at each side of the grate are both descending flues. The heated products are supposed in this to divide above the grate, and to pass off by the separate channels to the chamber under the fire bars, and then to unite in the one ascending flue to the chimney. The other plan is exactly the reverse of this, the heated products being carried down a single flue behind the grate and are then supposed to divide and to pass by two ascending flues to the chimney. The first of these two suggestions is a very unfortunate one, as it affords indubitable evidence of the whole scheme having been devised by one who had had the aid of little or no practical experience in devising his theories. No person who makes it his business to understand the working of flues, could ever have proposed to carry off the products of combustion from a register grate by opposite descending currents of air. This is a matter, however, of trifling moment, for if Mr. Taylor ever tried the mode he can never have repeated it, and if he, in the course of experience since acquired, has been able to establish effectual methods for making his grates answer the expectations he raised, no one can wish to remark his early deficiencies. Of the two other methods the descending flue behind is much the best. In this, the products of combustion are carried off as they should be in the same direction as that from which the air enters, but it must be remarked that after passing from the descending flue into the space below the fire bars they would scarcely

ever be known to separate, as Mr. Taylor would lead us to suppose, but they would pass at once to that flue in which the ascending current happened to be strongest, which current would become thereby accelerated. An imperfect amount of theory might lead some persons to suppose that two small ascending flues would carry off securely the amount of air passing down a single larger descending flue, and, so they might, if the grate were converted into a furnace and the current of air were greatly accelerated; but, in ordinary fire places, if it is true that Mr. Taylor has had a fair amount of success, it can only have been by a descending flue behind the grate, and the use, practically, of a single ascending flue of not less dimensions.

It will now be easy for the writer to show that a descending flue, when carried out in this comparatively effectual manner, can only be applicable in a limited number of cases. An ascending current of air in a chimney is due, as is well known, to a difference of temperature between the air of the room and that situated externally. The lighter air passes to the chimney, and rises or is forced up by the pressure of colder air from the room, or even from the chimney itself. This tendency of the warmest air to rise we call the current or draught. The longer the chimney, the greater the velocity with which warm air ascends, or the better the draught. It is necessary in ordinary fire places, as was shown by Count Rumford, that there should be a sufficient amount of contraction to give consistence and power to the ascending body of warm air from the fire. I have shown that the heated products can only be carried in an opposite direction by the pressure of air from the room forcing them downwards in the endeavour to pass to the more rarefied air in the chimney, and I must now state that, under the best circumstances, with a long chimney, and the bars of the grate covered over, there

would seldom be sufficient difference of temperature between the air in the room and that in the chimney to ensure a downward current in the flue behind, if no fire were burning, and it follows that this current must in nearly all cases be established after a fire has been lighted. Mr. Taylor provides for this by the door, which when thrown back allows the air in the chimney to become very rarefied by the free ascent of the products of combustion; but, it must be remarked that when the door is closed, there must be a few critical moments, for, if all the products of combustion are not at once carried downwards, there will inevitably be a return of smoke to the room. It seems very strange that Mr. Taylor has not provided a sliding curtain or blower, to be drawn down in front of the grate at the critical period of closing the door in the chimney. A simple contrivance of this kind would instantaneously increase the current, but none such has been mentioned in the specification, and it has not been introduced in such of Mr. Taylor's grates as I have seen.

The circumstances which affect the draught of a chimney are so various that I could not attempt to discuss them except at considerable length, but it so happens that conclusions, which would be formed from a somewhat elaborate investigation, are also such as are to be readily appreciated by a very moderate amount of observation and common sense. There is one class of chimneys in which the draught is never strong, and to which it would be utterly absurd to apply a grate with such a source of obstruction as a descending flue. This comprises all short chimneys, and some others.

There is another class in which an ordinary grate would act very well, but which, with a descending flue, would be uncertain. With a good fire burning, and a strong pressure of air from the room, the products would be carried off

securely; at other times sulphureous vapour or smoke might enter the room. This comprises mostly chimneys of medium length, and there is a third class in which the draught is so strong that it requires checking at all times, and in which the current of air would, without difficulty, overcome the obstruction of the descending flue. This comprises most chimneys in the lower stories of buildings, and in which only could Mr. Taylor's grates be considered to have a fair chance of success.

I come now to the last question, which should be dismissed with few words. How is it possible for smoke to be "consumed" in passing at a short distance below the bottom bars of the grate? Where and how does Mr. Taylor make oxygen combine with the hydrogen and carbon of the smoke so as to decompose the smoke. The space under the bars is simply a chamber which is by no means highly heated. There is no flame there whatever; for, irrespective of the fact that under ordinary circumstances there could be no downward current between the bars, we must consider that coal in a full state of ignition, as coal generally is at the bottom of a grate, has lost most of its hydrogen, and is therefore flameless. As far as I can understand from Mr. Taylor's specification, he expects that the smoke by passing near to the hot fuel would be consumed, but this of itself is preposterous. There is one view which would appear a little plausible, but which would generally be utterly subversive of the whole contrivance for domestic use, and that is, that a portion of the air passing from the descending flue enters the fire below, and carries with it a portion of the smoke and other products of combustion. There is, I fear, every reason to believe that air does enter the fire in this way. Whether any and what proportion of the smoke might be consumed by this means I need not enter into. It is quite sufficient

to state that anything approaching to such a circulation of products from the fire round the flue and into the fire again would render the grate unbearable, and that relief would have to be gained by throwing back the door in the chimney, and allowing the grate to work as an ordinary one. If, however, the smoke is all carried off up the ascending flue, from under the fire, without entering the fire, what is the value of the whole contrivance, when as an inevitable consequence no smoke is consumed?

I must remark that there appears to have been a particular want of foresight in the construction of the door in the chimney, which should have had a handle projecting in front of the grate, so that a person might readily open and close the door, and there should have been some means of indicating its position. As it is, a person would have to put his hand up the chimney to close the door, once a day, or more, if care were taken to use the grate according to Mr. Taylor's method; not, probably, a pleasant operation to a porter or a housemaid; and, when it is considered that smoke rises from Mr. Taylor's grate, when charged with fresh fuel, exactly the same as from an ordinary one, and that no person could therefore know by ordinary observation whether the smoke was being consumed or not, the necessity for some such means of indication will be readily admitted.

I am truly sorry to have to form conclusions so adverse respecting the most prominent points in Mr. Taylor's grate, for I am aware he has been to a considerable amount of trouble in maturing his plans and bringing them into public notice; but I do not think that I have been more candid in examining his scheme than I shall be found to be in criticising one in which I might be considered to be particularly interested, and if it is a disagreeable thing for me to take a course which Mr. Taylor may dislike, he

must remember that, if my conclusions are sound, there must be many persons who have suffered considerably by using expensive contrivances which cannot have answered the express object for which they were designed. Mr. Taylor has by no means withdrawn his schemes; on the contrary, only a few months ago he read a paper at a meeting of the Institute of British Architects, in which he strongly recommended their adoption. He therefore fully invites criticism, and if he is able to prove my conclusions to be unsound it will not be difficult for him to counteract whatever adverse effect my remarks may have, and to obtain increased honor and emolument as the result of any endeavour on his part to make known the truth.

The matter is one not to be decided by observations of an insufficient nature on the part of those who have faith in the scheme; but, what is required is very distinct proof with reference to the following two very simple questions, viz., 1. Under what circumstances can Mr. Taylor guarantee the secure passing away of the products of combustion if his descending flues are used? And, 2. What evidence can he furnish that when fresh fuel has been applied to the fire and a quantity of smoke is seen to rise, that an observation of the chimney top establishes the fact of the smoke having been consumed after passing from the fire? If Mr. Taylor will apply to every person who has used his grates, and publish their letters, with such observations of his own as may be necessary for the purpose of eliciting the truth, he will do more than anything he has yet done to advance his grates in public estimation, supposing them really to possess the merit he claims for them.

In the various plans before mentioned there is no departure from the ordinary habit of supplying coal to a fire at intervals during the day. Of their relative merit it

is not difficult to form an opinion. In the rotating grates the advantage of reversing the position of a fire is counteracted by the entrance of too much air, the absence of fire brick, and the unstable nature of the whole contrivance. In Mr. Young's grate, where coal is wound into the fire, there would be little or no smoke after the fire became fairly ignited; the fire would possess more vitality than in an ordinary grate, but there is the disadvantage of a cumbrous appearance. The feeding shovel of Dowson and Hawkins would certainly be inapplicable for general purposes, but it possesses the advantage that coal could be introduced by it below the fire of an ordinary grate, and though it would doubtless give some trouble, many might be glad to avail themselves of so inexpensive a contrivance. The double fire system of Dr. Bachhoffner I need surely say nothing more about, and the principle of the downward current as applied differently by Mr. Marsh and Mr. Taylor I have shown not to be generally applicable. I have now, however, to examine a description of grates which differ essentially from the preceding, and which are charged with sufficient fuel in the morning for a day's consumption.

6. *On grates in which a chamber is provided to contain coal for a day's supply, and in which a fire is made on the top of the fuel, which becomes fully ignited on being exposed to the action of the air.*

This class of grates has had the advantage of being somewhat extensively tested. The first of the description was patented in 1815 by Mr. John Cutler, whose method is shown in Figs. 36 and 37. A chamber was provided below the fire bars, closed on all sides but open above and below, in which was a moveable bottom made to rise or fall, by means of chains and wheels worked by a handle. The bottom was lowered in the morning, the chamber was

filled with fuel, a fire was made on the top, and both bottom and fuel were raised by the chains at different periods of the day.

The objection to Mr. Cutler's grate arose from its being complex, expensive, and from the fact that air was allowed to enter the coal chamber freely, which caused the whole body of fuel to become fully ignited if slightly disturbed by a poker.

A similar grate was patented in 1846, by Mr. George Tillett, who had a mode of supplying the chamber with fuel after the first supply was consumed. Mr. Tillett provided that when the bottom was raised as high as the top of the coal chamber, the ignited fuel and the front fire bars might be pushed backwards into a recess behind the grate; the bottom was then lowered, the chamber was recharged, and the ignited fuel was drawn forward on the top of the fresh supply. Mr. Tillett proposed also to raise the bottom of the chamber by springs, which plan would have been of some value if nothing more had been required than to lift a gradually diminishing weight. The friction in raising a body of ignited fuel within a fixed chamber is so considerable and varying as to render such a plan valueless.

Eight years later Dr. Arnott took up the matter, and introduced the grate which has been generally known by his name. This is shown in Figs. 38 and 39. The principle of supplying fuel is the same as in Mr. Cutler's grate, but the application of it is much more perfect. The Doctor provides a chamber, with a moveable bottom, for raising the fuel, but he excludes air from entering the chamber below with as much care as possible, and provides the simple and effective instrument, the lever, for lifting the fuel. The dotted lines in the sketch represent a metal hood to contract the upper part of the fire-place, with a

damper to regulate the draught, worked by a handle in front of the grate.

Dr. Arnott's mode has been carried out, with some slight differences between them, by two manufacturing firms. Figs. 38 and 39 represent the grate which has been made to his particular instructions by Messrs. Bailey, and Figs. 44 and 45, the grate which was introduced by the firm of which the writer is a member. In the last mode there is no open space visible between the coal chamber and the hearth-stone; the bars are less elevated than in the former, and a sliding curtain or blower is provided above for the purpose of contracting the open space whenever it might be desirable to make a good fire with rapidity. The regulating valve to control the draught in the chimney is shown in Figs. 50 and 51, with the handle and index to indicate its position. It will be seen that an ash pit is required to receive the dust falling down round the edges of the lifting bottom of the coal chamber, and that an opening is provided into this ash-pit, by a hole through the hearth-stone in front of the grate, which hole is usually covered over. As a preliminary to a discussion of the advantages of the principle of burning coal, advocated by Mr. Cutler, Dr. Arnott, and others, I have given particular details of the grate which I have been concerned in manufacturing; but, as these would be interesting to comparatively few persons, I have placed them with the Figs. 44 to 51 at the end of the treatise, and I will now only state that the grate is of simple construction, that it is calculated to work properly for many years, provided that the various parts are put together with ordinary care and intelligence; that it is set by a careful bricklayer, according to the instructions given, and, that the ashes are removed from the pit two or three times a week. The neglect of the latter point would cause an inconvenience, which could, however, soon be remedied.

Shortly after the appearance of Dr. Arnott's grate, a patent was granted to Mr. William Jeakes for his plan shown in Figs. 40 and 41. This consisted of a chamber to contain coal for a day's supply; but instead of raising the fuel to be exposed to the action of the air through the front bars, the reverse method was adopted of lowering a part of the grate, including the fire bars, to the fresh fuel. I see no particular objection to this system if the grate is made with care, and is not very costly.

Two years later Mr. H. E. Hoole introduced a plan for lifting the bottom of the chamber by means of chains and weights in a similar manner to Cutler's method already described, and in the following year the same gentleman obtained a patent for the arrangement shown in Figs. 42 and 43. In this the moveable bottom is raised or lowered by means of a screw and wheel placed immediately beneath it. The wheel has a number of holes similar to the capstan of a ship, into which the poker can be introduced for the purpose of giving the wheel a turn, and raising thereby the screw, and with it the bottom plate and fuel.

It appears there has been no lack of "Inventions" to consume or prevent smoke in open fire-places, the total number being no less than forty-eight. I have shortly described all those which appear to me to possess merit. Of the remainder some are absolutely worthless; some cannot be properly understood in consequence of the applicants for protection by patent having failed to furnish sketches; and, in others, the mechanical arrangements are so manifestly bad that it would be an absurd thing on my part to do anything more than indicate them by name. I have furnished a list of all of them in the Appendix, with the numbers of the specifications, for the benefit of anyone who may be sufficiently interested to go to the library of

the Patent Office, in Southampton Buildings, to further investigate the matter.

I have now to consider a question which is perhaps the most important that arises in the course of this discussion, viz., What is the true value of the principle of burning a body of fuel from the top downwards? Is it merely a means by which the smoke arising from a fire on replenishing it may be prevented, or does it possess such other advantages as can satisfactorily prove that our general mode of using coal is wholly wrong, and must in time become wholly abandoned. It is upon the settlement of this, I think, that it almost wholly depends, as to whether or not we are likely to see our way practically to an end of the smoke nuisance. To examine the matter with any clearness it is necessary first to state the nature of combustion, and to form a careful estimate of a fire burnt in the common way.

For our ordinary means of producing heat and light, we are indebted to a chemical combination between the oxygen of the air and the gaseous elements, carbon and hydrogen, which almost entirely compose the substances, wood, paper, oils, tallow and coal, and which same elements exist in a different form in the gas with which our streets are lighted. To the hydrogen in the above substances, it may be stated, we are chiefly indebted for flame, and to the carbon for heat. If a piece of paper is ignited the flame produced is yellow, having a base of a pale blue; the blue flame is the hydrogen; the yellow flame is caused by the particles of carbon which rise and become intensely heated in the hydrogen flame. The resultants are carbonic acid formed by a union of oxygen and carbon, vapour, and an impalpable refuse. If the combustion of the other substances be observed, the flame will generally be seen to present the same appearance; but, there is this to be

noticed with respect to bituminous coal, that its hydrogen may occasionally be seen by its blue colour, to be combining with oxygen, without the presence of carbon. In coke there is no hydrogen, and the particles of carbon combine with the oxygen without producing flame. Bituminous fuel of the quality most generally used contains from eighty to ninety per cent. of carbon, from five to six per cent. of hydrogen, and a more varying quantity of mineral refuse. When ignited by contact with flame, the immediate results are the liberation of much vapour, which, with minute particles of carbon, passes off as smoke, and the combination of much hydrogen and some carbon with oxygen visible in flame. For some time, the carbon of the coal is but little acted upon, and there is therefore but little heat, the quantity of flame produced being of small radiant power, though capable of acting strongly on any substance with which it is brought in contact: but, as soon as much of the hydrogen has been driven off, and the flame has become thereby much reduced, the oxygen acts powerfully on the body of the coal itself, which begins to assume an intensely red appearance, and to radiate much heat.

The relative value of the carbon and hydrogen of coal may now be easily seen. Hydrogen having a greater affinity for oxygen than carbon, is the cause of bituminous fuel being more easily ignited than coke, which possesses no hydrogen, but it is therefore a great hindrance to our obtaining heat, for while there is much of it to combine with the oxygen, the carbon of the coal is almost untouched.

It is to hydrogen that we are indebted for flame, which is produced in greatest abundance when we have little heat, but in a small quantity it serves to enliven a coal fire that is in a full state of ignition. Hydrogen is never entirely driven away till coal is burnt to a cinder.

It is to the combination of carbon and oxygen, without flame, that we are almost entirely indebted for radiant heat.

Hydrogen, therefore, is partly of service and partly an impediment. It enables coal to ignite quickly, and it enlivens our fires, but it prevents our obtaining much heat till most of it has been driven away.

These remarks will show the absurdity of our depending on flame alone as a means of generating warmth, and that such contrivances as gas stoves can never be very efficient, except at enormous cost.

In a period varying from an hour to an hour and a half after a fire has been lighted, it attains usually its maximum of efficiency. Smoke ceases, there is little flame, and the body of coal presents a bright red appearance of great radiant power. If now a machine were constructed by which small particles of coal could be made to descend at intervals on the fire, we should find that it would burn with remarkable regularity, give some flame and very little smoke. Such a contrivance has been used for furnaces, but there would be great objections to introducing it to a fire place. There would be the expense of the apparatus, the necessity for the coal to be broken very fine, and the difficulty of regulating the rapidity of motion, so that the supply might be readily adapted to the necessities of our varying climate. If the machinery were not very perfect, it would perhaps persist in working when it was required to stop, like the celebrated new organ in the village church, which, not allowing the service to proceed, was carried bodily away out of earshot to the centre of an adjoining field. A fire could be supplied with regularity, however, and in small charges, without the aid of a contrivance of that kind; but, only by an amount of personal attention that would counterbalance the unquestionable advantages that would ensue.

We find, with an ordinary amount of attention, that a fire varies considerably. It continues in its best state but a very short time, seldom as long as half-an-hour. A diminution of the sensation of heat, or a deadened appearance of the fire, gives warning that it should be stirred and replenished. As soon as a quantity of fresh fuel is thrown on, the sensation of heat is still more lessened; a quantity of smoke instantaneously rises; the hydrogen, with carbon, is again visible in large proportion in the flame; the flame and smoke become gradually lessened; the coal becomes fully ignited, and the fire again attains its maximum of intensity. This course, the same as that ensuing on the lighting of the fire, but modified somewhat by the fuel already in a state of ignition, is repeated from eight to twelve times a day. As often as this is there usually the change from a dull smoky fire to a bright smokeless one, and the reverse, and with the change in the fire there is the oscillation of the sensation of heat to a person situated within a few feet of it. At one time the room is so comfortable that he can sit at an occupation, or move to any part without inconvenience or with pleasure; at another he can scarcely feel comfortable close to the fire. An ordinary fire requires stirring about twice as often as it is replenished, and it appears to me, therefore, that the total number of times each day, when it requires attention during the five coldest months of the year, must be from twenty to thirty. With the two sources of inconvenience indicated, arising from the necessity for much attention and the constant variation of the sensation of heat, there are three distinct sources of waste; one arising from the particles of pure carbon being carried off from the fire by the heated air and vapour, and which are deposited in the chimney as soot, and on the surface of our buildings and elsewhere; another arising from the coal being never consumed to any degree

of perfection, whereby much carbon passes away as refuse in the dust and ashes; and a third source arising from the constant change in the amount of heat evolved. A fire that is variable is of necessity wasteful. If a person feels cold he endeavours by pokings to make the fire burn as briskly as possible, and his object of rapidly obtaining heat is only gained by allowing currents of air to stream through the fire and up the chimney; a most wasteful proceeding, as the heat given by the burning fuel to these currents of air is not utilized.

Let us now turn to the question of igniting a body of coal at the top, and compare the results with these. In Mr. Cutler's or Dr. Arnott's grate, the chamber being filled with fuel, paper and wood are placed above, and a panful of cinders or coal on the top of all. These, together with the upper surface of coal in the chamber, become quickly ignited, and the result is smoke and flame, the same as from a common grate. As soon as much of the hydrogen has been liberated, the oxygen of the air combines actively with the carbon, producing a bright red fire and much heat. So far, the action of both fires has been alike, but from this time there is a great difference, and for the rest of the day the fire lighted at top can be used entirely without smoke.

Smoke is chiefly vapour and carbon, carried off by currents of warm air from the surface of coal directly heat is applied to it; but when a body of coal is ignited at top, and the lower layers are kept from being exposed to the action of the air, there can be no ascending current to remove anything from the layers of coal below. The first layer is acted upon by proximity with the ignited fuel; some of its hydrogen, with a little carbon, burns, but very slowly, and the coal gradually assumes the condition of that which is most fitted to enter actively into combination

with the oxygen. The effect of this layer of coal upon the layers below is to prepare them also, but by a slower process, for entering into active combustion. Much vapour passes away invisibly, and the burning of some hydrogen extends a little below the topmost layer, but to an amount that is not merely harmless, but of most essential service. When the bottom of the chamber is lifted, and the topmost layer of coal is exposed through the front bars, this coal burns actively, provided that a poker is thrust in at two or three places to give free admission to air. The next layer is now topmost in the chamber, and is prepared for combustion like the former, and so successively with those below. Now, smoke is prevented entirely by this method of exposing the coal to a gradual preparation for the process of active combustion, and by the absence of any current of air to act on the surface of the coal till it is in a fit state for ignition.

It must be remarked that a little care is necessary in stirring this fire. If the poker is thrust downward and used as a lever some coal may be raised by it from the chamber, and therefore produce a little smoke. This should be avoided. The fire should be stoked by two or three thrusts through the front bars.

In cold weather, when the fire is required to burn actively, fuel from the chamber is raised once in two or three hours, but when a little heat only is necessary, it is a common thing for the fire to be left burning slowly for a very considerable time. The very little air that finds its way among the topmost pieces of coal just suffices to evolve a little flame, which action proceeds so slowly that the fire possesses a vitality which is truly remarkable. Instead of becoming extinguished from neglect like an ordinary fire, it gradually assumes a dead appearance, and flame appears to vanish. Combustion still proceeds, but

so slowly and steadily as to be often imperceptible. It can be quickened, however, into a most active state, in an incredibly short space of time. If more fuel is raised, and two or three thrusts are given to it by a poker, the effect is instantaneous. Jets of flame spring up, and a good fire is made with a rapidity incomparable in a common grate. The effect can be still further accelerated by opening the valve in the chimney and drawing down the blower. So extraordinary is this vitality compared with that of an ordinary grate, that it is a common thing for such a fire to be made in a bedroom or dressing-room, and to be quickened into activity seven or eight hours afterwards. I have known of one to burn for twenty-four hours without being touched, and have heard of cases of thirty-six, and even of forty-eight hours, these remarkable instances being due probably to the description of coal and the state of the atmosphere. A gentleman well acquainted with the subject calls this "putting the fire to slumber," a very apt expression indeed, not only indicative of its vitality, but of the renewed energy with which it appears to wake up after some repose.

I have alluded to two advantages resulting from lighting a body of fuel at the top, viz., the prevention of smoke from a period soon after lighting, and the vitality of the fire. Another, and not less important one, is the regularity with which the fire burns, with a small amount of attention. This is due to the fact, that the liberation of much of the hydrogen from fresh fuel, which was the cause of little heat from a common fire, has been already gradually effected in the coal chamber, and that when the coal is raised, it is just in a fit state to combine powerfully with oxygen, and to give much heat. It is only necessary to raise the coal at certain intervals, and to thrust it occasionally with the poker, for the fire to be kept burning

most equably during an entire day. The effect of this is a diffusion of heat and an amount of personal comfort that could not be obtained from a common fire, except by an extraordinary amount of attention.

The preparation which the coal undergoes in the chamber is called by some persons "coking." This expression is objectionable, as it would lead one to suppose that the fire is flameless. It is correct in the same sense as if said of a body of coal thrown on the top of a fire, which, as it parts with its hydrogen, approaches the nature of coke, gives less smoke and flame and much heat; but it cannot be said in a more extended sense. There is just as much hydrogen liberated in the chamber below as is necessary to allow of the carbon entering into active combination with the oxygen, when exposed to the action of the air, and no more. At any time during the day it is quite possible to obtain as much flame as from an ordinary fire well ignited, to which no fresh fuel has recently been applied. This is so true that it is even one cause of the remarkable vitality of the fire, and of its burning up with such rapidity, after several hours of repose, as readily to ignite the extinguished cinders above. This is a point of no little importance, and I shall be able shortly to afford some conclusive evidence of the fact.

The number of times the downward burning fire requires attention may be stated generally at half of that required by an ordinary fire. With respect to the ashes there is not so much difference as might be expected. Much falls down in front in lifting and stoking the coal. This is usually free from dust and should be thrown up again, as it can be very readily re-ignited. If the fire is allowed to expire a few cinders remain in the chamber, and a quantity of very fine dust, which is the mineral refuse of the coal. The cinders can be readily separated and used again.

In observing the comparison of the working of a common fire and the smokeless one, we must leave out of consideration the regulating valve or damper and the sliding blower, which have been mentioned in connection with the latter. These are adjuncts that can be readily applied to a common grate. We must also consider that a common fire could easily be arranged so as not to require such constant attention as that usually necessary. This would be effected simply by shutting off or reducing the amount of air allowed to pass into the fire from below the bars on which the coal rests. With this alteration a common fire might be considered to require supplying with fuel once in two or three hours, and we shall now therefore see that the essential advantages which appear to result from burning a body of fuel from the top appear to be—

1. That there is no smoke after the coal has become well ignited.

2. That, consequently, scarcely any soot is deposited in the chimney.

3. That by the liberation of much hydrogen in the coal chamber, the coal when raised is in a ready state to enter into active combination with oxygen, and that, consequently, a fire may be kept burning with a regularity that it is impossible to attain in an ordinary grate, except by a most unusual amount of attention

4. That from the same cause heat is more equably diffused in a room.

5. That the fire has a remarkable amount of vitality, and can be left alone for from five to eight hours, consuming during this time very little coal.

6. That the absolute refuse is an impalpable dust.

These appear to be the substantial advantages of the smokeless fire. I will now examine, as shortly as I can,

what are the advantages and disadvantages, as deduced from the experience of a large number of persons who have used the grate for some years. After Dr. Arnott read his paper on the subject of his improvement on Mr. Cutler's grate, at a meeting of the Society of Arts in 1854, a considerable amount of attention was called to the new principle throughout the country. The *Times* had a special article upon it. Mr. Charles Tomlinson discussed it in the *Quarterly Review*. The subject was taken up so generally by the metropolitan and provincial press that there can scarcely, in fact, have been many persons of education who did not hear of the new grate. With such a commencement there was great promise of a revolution in the construction of our fire-places. A variety of causes have prevented this taking effect, which it is unnecessary to discuss. However, the number of grates supplied by one house (that with which I am connected) from May, 1854, when the first was sent to the present Archdeacon of Dorset, to the 31st of December, 1863, has been 2,161

The number of existing grates to which the principle has been adapted	114
The number of kitchen grates supplied or erected on the same construction	242
Total	2,517

It is not easy to ascertain the number of establishments in which these two thousand five hundred and seventeen smokeless fires have been used, as a considerable number of the grates have been supplied to wholesale houses, and others who have acted merely as agents for the purchasers; but I should estimate them at about eleven hundred, giving on an average somewhat more than two fires to each. I have thought it advisable, for the purpose of this

treatise, to address a circular to the different parties who have used the grate, to ascertain their opinion of its merits and demerits; partly for the purpose of establishing upon other than theoretical grounds the true value of the principle; partly for the purpose of examining all the objections that could possibly be adduced; and, partly for the purpose of advising any with respect to any objection that might have been encountered, and that could be obviated. The number of circulars addressed was about six hundred and fifty. I have done my best to obtain a candid opinion. No person has been excepted but for a substantial reason. Wholesale houses dealing in grates, exporters, builders and ironmongers, were necessarily excepted, as they could not be expected to give a sound opinion upon a subject of which they had had little or no practical experience. Personal or written application was made to no one, nor was the application addressed a second time. The number of replies received was one hundred and fifty-six. To enable an opinion to be formed of the value of the testimony, I have, with the permission of the writers, had their letters printed in the form of a pamphlet, and have placed against each name the number of grates supplied, and the length of time they have been used, for the benefit of anyone who may be sufficiently interested in the matter to give it a particular investigation. Nearly all these letters proceed from persons of education in the middle and upper classes of society, who may not only be considered capable of forming a sound opinion, but who, from having used the grate for periods varying from two to nine years, must have had abundant opportunities of comparing its mode of working with others; so that the opinions expressed cannot be considered to have been hastily formed. These letters, of which I now give a short analysis, may be conveniently divided as follows:—

Favourable and mentioning no objections	83
Favourable and mentioning certain objections ...	30
Neutral	21
Unfavourable	22
Total	156

It appears that rather more than half the total number of replies are unquestionably favourable, and some, indeed, afford the strongest possible testimony. In the second division the objections mentioned are considered slight by the writers, so that if these are added to the former, more than two-thirds of the replies must be considered favourable. Of the third division nearly half report that their grates have not been properly used, and the rest mention advantages and disadvantages which may be considered, for convenience, to counterbalance each other. Of the fourth division some advantage is occasionally mentioned, but the general tone is unquestionably unfavourable. I do not wish to draw any strong conclusion from the preponderance of favourable replies; for it might be considered that those who thought well of the grate would be more interested to reply than those who thought badly of it, and that a more extended expression of opinion might present different results. I have much reason for believing that the replies received do represent faithfully in their proportions the opinions of all. This is not, however, of much moment, as it will be most satisfactory to any one to judge of the value of the evidence by an examination of the letters themselves.

As, however, these will be read by few, I cannot resist the temptation to insert two of them as specimens of those of a favourable nature; one from Mr. Thomas Burgoyne, a gentleman extensively known and respected, and one

from the gifted President of the Royal Geographical and Geological Societies, Sir Roderick E. Murchison.

160, Oxford Street, London,
Oct. 9th, 1863.

Gentlemen,—In reply to your letter I have to state my entire satisfaction that the Smoke Consuming Grates you have put up for me gradually in the last seven or eight years (now, I think, sixteen in number), are in every way a great success, and an undoubted improvement on the old-fashioned grates which are not made on the smoke consuming principle.

The public unfortunately, however, appear to me to be absurdly incredulous and deaf to all new ideas on the subject, at which they will no doubt some years hence be as much surprised as they now are that our ancestors refused to believe that railways could take passengers at more than eighteen miles an hour, or that the streets could be lighted with gas. How anyone can act so opposite to his own interest as to put up any new grates except on the smoke consuming principle is to me astonishing, but for the general inaptitude of mankind for adopting any improvement, however great, which they do not understand.

I remain, Gentlemen,
Your obedient Servant,
THOMAS BURGOYNE.

Messrs. Edwards & Son, Great Marlborough Street.

16, Belgrave Square,
Feb. 25th, 1864.

Gentlemen,—I regret that a letter addressed to me on the 22nd September has remaind unanswered through misplacement.

You ask me to state my opinion of the efficacy of your Smoke Consuming Grates made on Dr. Arnott's principle, and I willingly declare that I have used two of these grates during two winters, the one in my entrance lobby, and the other in my own room, and have found them successful in every respect, the fire being maintained in each for seventeen or eighteen hours without replenishment of fuel.

I am,
Your obedient Servant,
RODERICK E. MURCHISON.

There can be no doubt that anyone, after perusing the hundred and thirteen letters of a favourable nature, would be thoroughly convinced that the principle instituted by Mr. Cutler, and advocated by Dr. Arnott, is of such value that it ought to become generally adopted. It is equally certain that no one after reading the unfavourable replies *alone* would care to have the grate in his house; and I think that any person who takes a sincere interest in matters connected with the well-being of society, on perusing the whole body of letters, would wish that the matter might undergo sufficient investigation to enable it to become clearly understood. This is the task I am now endeavouring to accomplish, with what amount of success it will be for others to determine. The following is a statement of the advantages and disadvantages mentioned in the letters:—

ADVANTAGES.

NO.	
1.	79 state that the grate is economical in use.
2.	54 that it is generally approved of.
3.	25 that it gives increased heat compared with an ordinary fire.
4.	31 that the fire has great vitality.
5.	31 that the grate is a cure for a smoky chimney.
6.	24 that the smoke is consumed.
7.	20 that the fire requires little attention.
8.	11 that the fire is easily regulated.
9.	10 that the grate is cleanly in use.
10.	8 that there is little or no chimney sweeping.
11.	7 that the heat is generally diffused.
12.	6 that the grate is valuable for sick rooms.
13.	5 that draughts are prevented.
14.	3 that the grate produces a bright clear fire.
15.	2 that the fire can be left with safety.
16.	4 recommend lighting common fires at top.

DISADVANTAGES.

NO.	
1.	13 state that the grate produces much dust.
2.	10 that the lifting apparatus is imperfect.
3.	7 that the grate is not economical in use.
4.	6 that it is difficult to make servants use the grate properly.
5.	5 that the smoke is not completely consumed.
6.	5 that the heat is not pleasant, or that the atmosphere becomes sulphureous.
7.	5 that the coal consumes in the chamber.
8.	5 that the supply is not sufficient for a day's consumption.
9.	4 that the best coals are necessary.
10.	3 that it is difficult to keep a small fire.
11.	3 that the grate has a sombre appearance.
12.	2 that the heat is too great.
13.	2 that no provision is made for refilling the chamber after the first supply of coal has been consumed.
14.	2 that the grate is not a perfect cure for a smoky chimney.
15.	2 that the coal cakes in the chamber.
16.	1 that the fire is difficult to extinguish.
17.	1 that the cinders falling in front are disagreeable.
18.	1 that the noise in lifting is disagreeable.
19.	1 that there is no flame.
20.	1 generally condemns.

It appears from the above figures that the advantage which has been most noticed in the smokeless grate is economy of consumption, which is due to the more perfect combustion of the coal, to the preparation the coal undergoes in the chamber, enabling the fire to burn with regularity, and to the fact of air being excluded from entering the fire below as in an ordinary grate. Then follow in succession other prominent points, viz., increased heat, the vitality of the fire, the prevention of smoke, the little attention necessary, the ease with which the fire is regulated, and the lessening of chimney sweeping.

These numbers, it must be observed, would be larger if

the fifty-four who have expressed a general approval had entered into details. Of the remaining points considered advantageous, the grate being a cure for a smoky chimney, does not apply for the purpose of this discussion, as the same result might have been effected by other means. The question of cleanliness must depend on the description of grate the smokeless one is compared with; that the heat is well diffused is owing to the regularity with which the fire burns, and that draughts of cold air are prevented, is owing to the very contracted form of the fire-place, and to the regulating damper, which allow a less quantity of air than usual to ascend the chimney, which advantage could, however, be obtained in an ordinary grate. The value of the grate for sick rooms must be unquestionable if the advantages mentioned are considered proved. That sparks are unlikely to result is evident, and the question of the fire being bright or dull is entirely one of management.

Of the disadvantages mentioned some are capable of removal; others must be considered to belong essentially to the grate. I will examine them in the order in which they stand in the table.

1. The dust in the Arnott grate is certainly the most prominent disadvantage, and has been most frequently mentioned. When the bottom of the coal chamber is lifted, or when the fire is stirred cinders fall down occasionally on the hearth in front. These should be thrown again on the fire, or they might be received into a pan, such as that shown in Fig. 52. This pan is in two parts. The lower part might be let into the hearth with the cover on a level with the stone or marble. This cover consists of a number of bars cast in one piece, with openings between to allow dust or fine cinders to fall through; the larger cinders being retained above can be thrown on the fire.

There is also the question of dust in the coal chamber. The refuse mineral matter separated from the coal falls partly on the lifting bottom of the chamber, and partly round the edges of the bottom into the ash pit below. This mineral matter is a dust so fine as to be almost impalpable, and if a housemaid disturbed it instead of removing it gently with a shovel, it would fly about and settle on any articles near the fire-place. The inconvenience of dust depends, however, chiefly on the description of coal that is used. That which is obtained from the Northumberland, Durham and Scotch coal fields leaves generally exceedingly little refuse, but from the Derbyshire and Somersetshire coal there is much.

2. With respect to imperfection in the lifting apparatus, this may result from imperfect fixing. The parts are very simple and few, and I trust the particulars I have given, in the description which accompanies the Figs. 44 to 51, will enable persons in the country, who may have been inconvenienced by this, to have their grates examined and rectified.

3. That the grate is not economical must, I think, have been mentioned from want of sufficient observation, as, irrespective of theory, which leads to a different conclusion, economy is the advantage most frequently mentioned by others.

4. Difficulty with servants is sometimes experienced, but as the grate saves them trouble, and is exceedingly simple, they can only require to become more familiar with it.

5. With respect to smoke not being completely "consumed," I have shown that it is necessarily produced for a short time after the fire is lighted, and that only positive misuse can cause it to be produced at a later period.

6. That any of the products of combustion should come

from the grate into an apartment, can only be due to causes that would make the fire-place smoke if an ordinary grate were used. The remedy is, to see that the doors and windows are not fitted too closely, that the top of the chimney is protected from wind, and that, at the same time, there is a free passage.

7. The burning of coal in the chamber can proceed to a very small extent except from careless usage. The precautions necessary are merely to have the parts of the grate fitted with common care, and to beware of stirring up coal in the chamber in using the poker. The burning away of some hydrogen in the chamber, so far from being objectionable, I have shown to be of essential service. The top stratum of the coal must necessarily be in a partial state of ignition.

8. The objection to insufficient supply can be obviated with a little care. A grate should be of sufficient size to warm a room for twelve hours in cold weather, supposing the chamber is exactly filled; and, in very cold weather, the chamber can be filled higher by heaping coal to the height of the second fire bar, or above. In a case of emergency, coal is of course put on the top of the fire.

9. This objection is not a serious one. Bad coal is always the least economical. Any description of coal is suited to the grate, except anthracite, and such as produces a great deal of dust. In some parts of the country none other can be readily obtained, but I think over four-fifths of the United Kingdom there is no difficulty in obtaining coal of good heating power.

10. Those who have made this objection, will, I hope, after perusing this treatise, be able to overcome this difficulty. I have never known a grate that could be kept so perfectly under control as the one now discussed.

11. A sombre appearance of the grate may certainly be

overcome. The fire may appear sombre or cheerful at pleasure.

12. Those who complain of too much heat have perhaps had too large a grate.

13. This objection is more serious. It happens occasionally that a fire is required to burn continuously, and for this, no provision has been generally made in the grates I have been concerned in manufacturing. For a sick chamber the point is one of some importance, and if the grate has not been provided with an arrangement for introducing a second supply into the chamber, coal is usually put on the top after the first supply is exhausted. The reason why grates have not been usually supplied with such an apparatus is, that in the vast majority of cases a fire is required for the day only, and I have never been able to devise or get devised a scheme by which a single person could introduce a second supply with facility. I firmly believe that if grates had been generally constructed with such an addition, the trouble connected with recharging the chamber entirely, or in part, would have diminished greatly the good opinion that has been formed of them.

14. The grate is certainly not an infallible cure for a smoky chimney, nor is any contrivance whatsoever. The contracted form and the small supply of air it requires, render it one of the best grates that can be used for such a purpose.

15. The caking of the coal should be prevented by a few thrusts with the poker. Many persons using the grate neglect to procure a suitable poker, or to have their own altered. A common poker, with a blunt end, is objectionable, and should have a rather sharp point, as shown in Fig. 53. This can easily be put by a blacksmith. So slight a matter as the neglect to have the poker

altered has frequently caused some disappointment in using the grate.

16. The fire should not be extinguished but be allowed slowly to die out, and this can be facilitated by lowering the bottom of the coal chamber. The difficulty to extinguish is certainly not a disadvantage, though it has been mentioned as such. It is to this we owe the remarkable vitality of the fire, and the fact that a room in which one burns, is not cooled so much during night as when an ordinary fire is used.

17. The question of cinders falling in front of the grate has been referred to in disadvantage number one.

18. Noise in lifting the coal must result from the parts of the grate not having been properly put together, so that the lever cannot work with facility. It is frequently necessary, with coal that cakes much, to give it two or three thrusts with the poker before using the lever.

19. That the fire gives no flame is a total mistake, and the supposition can only have arisen from a neglect of the precaution which is necessary, even in a common grate, to make a fire burn cheerfully. There is of course not the quantity of flame attending the burning of black coal when thrown on a fire.

Of the disadvantages above enumerated and examined, those which appear to be of a permanent nature are the falling of cinders in front of the grate, the fine dust which requires care in removing, and the objectio to certain descriptions of coal. To these must be added the increased expense of the grate, and the fact that it is somewhat less simple to erect and to use than an ordinary one.

It therefore appears, by the evidence adduced from the letters, that the most prominent advantages of the grate are the economy in consumption ; the regularity in burning ; the little attention necessary ; the great vitality ; the

tendency to diffuse heat; and the prevention of smoke and of soot; and, that the disadvantages are the cinders and dust, and objections to certain coal; to which must be added the increased expense and somewhat less simplicity. The advantages are exactly those which have been deduced theoretically. That the disadvantages can be in a great measure or entirely overcome will be shown in the next chapter.

There is one point in connection with the evidence given in these letters which requires particular notice. I mentioned that I should be able to adduce striking proof that the coal in the chamber does not become coked. Now, if it were so, it would be a matter of observation with some that a cheerful fire could not be had after the coal had been burning for several hours; but, so true is it that the coal in the chamber simply undergoes that change to which all coal is subject before it can be made to give much heat, that in only one instance of the hundred and fifty-six replies it is stated that the fire burns with a variation of its appearance, and, in this, the context proves beyond question that the writer did not consider the most trifling management to be necessary in using the grate. This is a matter of much moment, showing very conclusively the true nature of the change which the coal undergoes.

The investigation I have given this portion of my subject has by no means been for the purpose of recommending the grates which I have been concerned in manufacturing, but solely for the purpose of proving beyond question the value of the new principle, and the necessity of changing our mode of burning coal. Five distinct grates adopted by the respective firms of Cutler, Bailey, Edwards, Hoole and Jeakes, are shown in Figs. 36 to 51, and have been already described. The differences between the last four are so slight that a person could safely choose which-

ever might please him best on inspection. I shall have, however, in the next chapter to propose other modes by which, as it appears to me, the principle can receive a more general application. The chief impediments which have existed to the grates becoming extensively used, have been their cost, and the necessity for care in setting, which impediments, it will be shown in the next chapter, can be in some measure removed.

I should mention that the principle of filling a common grate with coal, and lighting a fire at the top, has been known for many years, and that, even as a partial application of a reversal of the common method of using a fire, it is very serviceable. Public attention was first called to this by a paragraph which appeared in the *Builder* a few months after the appearance of Dr. Arnott's grate, and which immediately went the round of the papers. The method is alluded to in four letters reporting on the Arnott grate; the writer of one, Mr. William Giles, of Taunton, stating that all his grates which are not Arnott's, are used on this principle. Persons desirous to try the mode should have a thin plate of iron, or a piece of thick brown paper, cut out of the size of the bottom grate and laid upon it. A quantity of coal should then be thrown on, and a fire made above with paper, wood, and some cinders or coal. It will ignite as readily as a common fire, and, if left untouched, will burn for three or four hours without attention. When stirred the whole burns briskly, and coal must subsequently be thrown on the top.

A patent was taken in 1857, by Mr. Goodchild, an architect, of Guildford, for a grate, in which this principle could be somewhat extended. Mr. Goodchild proposed that a closed pan should be fitted under the bottom grate to shut off the supply of air below when necessary, and that a metal guard should cover the fire bars in front, and

be made to slide down and expose the coal gradually to the action of the air. This suggestion shown in Figs. 54 and 55 is good; but it seems extraordinary that Mr. Goodchild did not mature his ideas, and propose such a modification of the ordinary grate as would allow of the supply of coal being ample for a day's consumption.

Whatever may be the value placed on the evidence which has already been adduced in favour of an entire change in the construction of our grates, this part of the subject is by no means exhausted. On the contrary, I have yet to allude to very important testimony, furnished by some of the first scientific men of our time, who were appointed to investigate questions relative to the warming and ventilation of dwellings, and who gave a considerable amount of attention to the subject of smokeless grates. In May, 1856, Professor Wheatstone, Mr. William Fairbairn, Mr. James Glashier and Dr. Lyon Playfair, with Mr. J. F. Campbell, as Secretary, were appointed a Commission by the Board of Health, "to inquire into the best practical method of warming and ventilating dwelling-houses, and to endeavour to ascertain such principles and establish such rules as lead to a better and more efficient system in the consumption of fuel and the maintenance of the air of apartments in a genial and healthy condition." A report of a very interesting nature, though far from exhaustive of the subject, was drawn up and ordered by the House of Commons to be printed. It was signed by the three first-named gentlemen only, the appointment of Dr. Lyon Playfair, as Professor of Chemistry to the Edinburgh University having precluded him from assisting in the labours of the Commission. An extensive series of experiments was conducted at the Wellington Barracks, where five grates were erected in rooms, measuring each thirty-three feet by twenty feet, and twelve feet high. Three of

the grates were for consuming or preventing smoke, made by the firms of Bailey, Edwards and Jeakes, and two to burn coal in the ordinary manner, one being Mr. John Lee Stevens' grate; the other a grate which at that time was commonly used by the Ordnance Department. To enter somewhat fully into the consideration of the report, would require a special chapter devoted to it of considerable length, and that allusion should be made to many matters that would be somewhat irrelevant to my immediate object. I will, therefore mention only the general conclusions arrived at by the Commission, and add a few observations thereto.

"In regard to fire-grates in general, from the preceding experiments, and from the information which has been collected, the Commission is prepared to recommend—

1. The use of reflecting surfaces to direct an increased amount of radiated heat into the room.

2. That the chimney flue should be of small dimensions, and not more than nine inches in diameter at the widest part, to diminish the quantity of air escaping up the chimney, and reduce its tendency to smoke.

3. That chimney flues should not be situated in the outer walls of dwelling-houses to become chilled by contact with the comparatively low temperature of the external air.

4. That the chimney-flue should be provided with a closing apparatus.

5. That the aperture for the smoke should be placed at the back of the fire, to increase the intensity of combustion, and promote the radiation of heat.

6. That fire brick linings to grates should be in general use.

7. That sunk ash-pits and concealed ash-pans be employed to prevent dust, &c., being diffused into the room.

8. That the fire should not be on a level with the floor. This is made evident by the experiments with Leslie's grate.

9. That as a rule, the fire-grate is best situated, which may be seen from the greatest number of points in the room.

10. That a good frontage of fire surface should be exposed. This does not necessitate any corresponding increase in the depth of the grate from back to front.

11. That those stoves be used that prevent the formation of smoke; the formation of smoke being a proof of imperfect combustion, and a representation of so much fuel wasted.

12. The Commission strongly recommend that the fire grate should be studied in its construction, with the view to its affecting a better and more equable distribution of heat, and not as a contrivance for the ventilation of rooms. The Commission is decidedly of opinion, that so long as the fire-grate is studied, with a view to this twofold application, it will not succeed well in the performance of either."

The Commissioners having found in the course of their enquiries that it has become a common habit among manufacturers to use the term "stove" for a fire-grate, adopted the term themselves. This is unfortunate, for what advantage can arise from such a confusion of terms? A stove is a sort of box made circular or square, and composed of iron or other material, which contains the fire within it, and corresponds to the German *stufa* and French *poêle*. A fire-grate is quite a different thing. These terms are not confused in the minds of most persons, and why the old intelligible distinction should have been departed from by manufacturers, I am quite at a loss to conceive. There is even the term "stove-grate," which is intelligible if applied to an article that partakes partly of the nature of a stove, and partly of that of a fire-grate, but which, like the word stove, is now very commonly applied to any description of fire-grate.

Of the various recommendations of the Commissioners the first is good, but the expense of putting reflecting surfaces to a grate renders it only of partial application. The second should be applied with precaution. It has happened more than once that a luckless builder or archi-

tect has constructed circular chimneys 6, 8, or 9 inches in diameter; but, in consequence of not having considered that it was necessary to provide grates for such chimneys of very contracted form, he has obtained disgrace as the result of his temerity. It may be doubted whether the circular form is by any means the best adapted for a fire-grate, and such a diameter as nine inches would, in many instances, be almost useless. I propose at a future time to enter more fully into this matter.

The third recommendation is good but not feasible, and would certainly never have been made if the Commissioners had had an architect in their body. Chimneys in external walls are generally found to be very objectionable; but if built double on the exposed sides, they would be nearly as good as chimneys situated in party walls. The fourth recommendation is good. The fifth, which expresses approval of such forms of grate as King and Stephen's patents, is excellent, but should, by no means, be generally applied. The sixth can hardly be too strongly insisted upon. The seventh is good. The eighth and ninth are excellent, and of importance, as many persons entertain the opinion that a fire cannot be placed near enough to the floor. The best height for the fire bars is such as will allow the downward rays of the fire in front to fall on the carpet, and not to pass through the bottom plate of the fender. The tenth recommendation is good. The eleventh recommends the use of smokeless grates. The twelfth is, I think, equally excellent.

The Commissioners also recommend in page 91 of their report that a supply of air should be given to all rooms near to the fire to support combustion and prevent draughts. This was adopted with respect to the fire-place in the Wellington Barracks, which contained the grate erected by my firm, and the result was a better

diffusion of heat. Some will, perhaps, be inclined to doubt the wisdom of this recommendation, in the belief that our ventilation would become more imperfect than at present. This, however, is a mistake, for effectual ventilation is not much promoted by streams of cold air setting in constantly towards the fire. The question of the most simple and efficacious mode of ventilation for ordinary dwellings, I shall probably discuss at a future period.

There is another matter referred to in the Commissioners' report which is so important that it should not be left unnoticed, and that is the immense advantage which results from the use of double windows, or duplicate panes of glass. It was proved by experiments that by the use of two sashes, separated five inches, the air in contact with the glass facing the apartment was raised nearly ten degrees in severe weather. A very excellent and inexpensive plan is to put two panes of glass in the same sash, separated by an interval of from half an inch to an inch. This can even be done to existing windows at a very small cost, but the panes could seldom be separated more than half an inch. The advantage is considerably less than when double sashes are used; but in cold situations, and especially to windows much exposed to currents of cold air, the plan may be adopted with great benefit.

CHAPTER III.

GENERAL DEDUCTIONS AND RECOMMENDATIONS.

The facts adduced, and considerations presented, in the previous chapters, will render it now, it may be hoped, an easy matter to determine what are the leading principles that should guide us in the construction of our fire grates. I am not anxious to suggest any elaborate contrivance by which a certain economy would be gained, but, at a cost that would render such an advantage somewhat dubious. I would wish to explain the principles that are of general application; that may enhance the comfort of the labourer in his cottage, of the studious man in his library, and of the lady in her drawing room; that should be understood wherever a coal fire is used, and that would long since have been established, but for the general inattention of those persons who are usually depended upon for supplying the public to do anything more than meet what is called "the public demand." If I cannot show that a high amount of efficiency can accompany the greatest simplicity, my labour must be of little service. The somewhat fortuitous circumstance that many of our domestic arrangements have not received the amount of attention they have deserved, has led me to endeavour to do for our fire-places, and other matters connected with the comfort

of our dwellings, something analagous to that which was done by Count Rumford, with so much ability and generosity, for similar subjects in his time; and, while I am far from being so presumptuous as to suppose that the suggestions contained in these pages are exhaustive of the subject discussed, I think it will appear that these suggestions, interfering as little as they do with existing notions, are such as can meet with very general acceptation.

Two of our best instructors, Count Rumford and Dr. Arnott, have expressed opinions against open fires altogether, regarding their use as resulting from an insular prejudice. To such a prejudice, if it be one, I must myself own. I can yield to no man in my attachment to the English fire, and feel assured it will but echo the wish of my readers to state, that long may it be before it is banished from our homes, from any cause whatsoever.

The fire grate, it must be readily admitted, can never be the most perfect contrivance for warming our apartments. The heat from it diminishes so rapidly with the increase of distance, that it is impossible it can ever give that equality of temperature which can be gained by the use of hot water pipes, or by hot air supplied to a room at various points. But, though an open fire possesses a striking disadvantage, when compared with other methods for warming rooms, it possesses advantages which are peculiar to itself. It can be stimulated in a few minutes to give additional heat. If a person becomes cold by absence from a warm room, he receives much satisfaction from restoring a comfortable condition of body by proximity to a fire. And there is, finally, the question of cheerfulness, a point not to be disregarded in a country where so large a portion of the winter is associated with gloomy skies, fogs or easterly winds. Without entering

into a comparison of the advantages of an open grate, with those attending other methods, it may be safely stated that for public offices, factories, houses of business, and the offices of professional men, the balance of advantages is certainly not in favour of the open fire, or of close stoves, if we leave out of consideration the question of first cost. But, for domestic purposes, should it ever even happen that heated air can be supplied to our houses as we have gas and water, it is as hard to believe that such a revolution would be more likely to supersede our fires, as that our carburetted hydrogen gas will supersede every other mode of lighting.

In considering what may be done towards the perfecting of our fire-places, we may first observe, that we require artificial warmth during seven or eight months in the year, sufficient to raise the thermometer from five to fifteen degrees. Our fires should be able to ignite readily, to attain a maximum state of intensity within a short time, that the damp and cold air may be rapidly changed, and then to burn with regularity, with cheerfulness, but with the smallest possible amount of attention, for several hours, and they require to have appliances so that a great accession of heat may be developed on days when the temperature is low. In the vast majority of cases, a fire is required for a full day and no longer. Persons employed in manufactures, trades and professions, require a fire for a period varying from eight to fourteen hours. The exceptional cases, when a fire is required to burn continuously, as for many ailing persons, or for a short period only, as in bed rooms, dressing rooms, the sitting rooms of persons in lodgings, employed elsewhere during the day, are few in comparison. To consider, therefore, how an open fire can be best arranged, so as to burn with much economy of consumption and the smallest possible amount

of attention, during a period varying from eight to sixteen hours, we will examine—

1. What is the best form for the grate?
2. Of what materials should it be composed?
3. What should be the general arrangements of the fire receptacle?
4. What provision should be made for checking the escape of the heated air?
5. How should air be supplied to the fire?
6. How are the heated products escaping into the chimney to be utilized?
7. How should coal be supplied to the fire?

1. *What is the best form for the grate.*

We shall be assisted on this point by referring to the Figs. 10, 14, 16, 44, 62 and 64. Figs. 14 and 16 should be considered together, for, though they are admirable grates, they are not, for reasons which will be pointed out, as well adapted for very general use as the other forms. Figs. 10, 41 and 64 are very usual forms for a grate. The first is the simplest. The back portion, when formed of fire brick, radiates considerable heat, but there is little heat reflected. Heated air and products rise from the fire without hindrance, and pass at once to the chimney, so that the metal front of the grate simply radiates the little heat it acquires by conduction. If, now, we compare this with Fig. 44, we shall see that the latter is provided with a sloping surface between the fire bricks and the metal front, the whole of which above the lowest fire bar would, of necessity, receive much heat from the fire, and radiate, or reflect it, according to the nature of the material, into the room. The square form of Figs. 64 and 70 presents, evidently, a much larger amount of surface to radiate or reflect heat, and, on the question of utility, it may, there-

fore, be considered preferable to the arched form. As a matter of taste, the arched form of Fig. 44 is the most popular, but, those whose taste may be justly supposed to be the most disciplined, generally prefer the square form.

Figs. 14 and 16 present a very large amount of surface exposed to the room, a great portion of which attains a considerable temperature. But, the advantage of an extra amount of radiating or reflecting surface is counterbalanced by the increased intensity with which a fire burns. It has been pointed out that the very contracted space behind, by which the smoke can escape, causes the air which passes over the fire to become highly heated, and that the current to the chimney is, consequently, so strong as effectually to remove the products of combustion at the opening to the chimney. This strong current causes the fire to burn with considerable intensity; an advantage in a large room which is heated with difficulty. In a small room the heat from such a grate is generally overpowering.

In very small fire-places it is impossible to use reflecting surfaces, and for such places, a simple form, as Fig. 62, may be considered serviceable. The question of the form of the interior part of the grate will be alluded to further on.

2. *Of what materials should a grate be composed?*

So much has been said already of the necessity for avoiding metal as much as possible in the interior portions of a grate, that but little need be added on this subject. It would be well if no person would tolerate the use of metal in immediate contact with any fire, if it could possibly be dispensed with. The regulator in the chimney, and the bars in front, are, in fact, the only interior portions of a grate that need be of metal. Such a grate as

Fig. 8, with the back and the sides of the fire chamber in fire-brick, and the remainder in iron, is very much better than a grate made exclusively of iron; but, it would be still better if the grate were made on the more rational principle of Fig. 10, which has the fire-brick continued to the register door in the chimney. Our manufacturers appear to retain the use of so much iron where it is useless, and indeed injurious, in the belief that metal is more susceptible of ornamentation than fire-brick, and they are reasonably desirous that their grates should be as pleasing to the eye as they can make them. Their course is much to be regretted. There is so great a difference in the use of fire-brick and metal for the whole of the back parts of a grate, that it is not possible to believe a person can appreciate such difference, who, upon any consideration, would consent to have metal. Fire-brick and terra-cotta are both as susceptible of as much ornamentation as can reasonably be desired at the back of a fire-place, and, if the public will but pronounce emphatically against metal, they will find that manufacturers will rapidly meet their views.

The materials which have been usually adopted for the exterior parts of a grate have been black iron, polished iron and burnished steel. Glazed tiles have, of late years, been extensively introduced. Black iron becomes heated chiefly by conduction, and radiates much when its surface is fully exposed to the room, but it gives trouble to clean, and is cheerless. Polished iron and burnished steel reflect the heat thrown upon them, and harmonize well with marble mantel pieces, but they require systematic attention, if they are kept in good order. Glazed tiles are now made in great variety, and of great beauty, in porcelain, encaustic and majolica. They absorb less heat than polished iron or steel, reflect heat as well or better, and

give less trouble in cleaning. As, therefore, tiles may be as usefully employed as metals; as they are of great beauty, and are inexpensive; as they entail much less trouble in cleaning than metals, and never require any other restoring process than the use of a damp cloth, they may become, judiciously, very generally employed. Grates are now frequently introduced into bed chambers and elsewhere, constructed almost entirely of ornamental tiles and fire-brick, and with no more ironwork than is found absolutely necessary. A specimen of such a grate is shown in Fig. 64. Ornamental tiles are often used to cover the hearth, the iron bottom-plate of a fender being dispensed with. It is much to be desired that the use of tiles in a fire-place should become very largely extended, for few persons have an idea how cheerfully, elegantly, cheaply and usefully their fire-places can be arranged with the aid of a few tiles, some fire-bricks and a little ironwork, instead of the usual cheerless black grate.

It would give me much satisfaction if anything I could say would call attention to the helpless condition of the poorer classes on the subject of their fire-places. The contrivances which are provided for their use are of the most objectionable character, and answer one requirement only, viz. cheapness. A "working man" would be much better off if he pulled out his metal grate, and, with the aid of some fire bars, constructed his fire-place with simple bricks and mortar. I hope to do what little may be in my power by publishing a small treatise for a trifling sum, in which the labourer's cottage will be taken into special consideration, with respect to his fire-place, his convenience for cooking, the prevention of his chimneys from smoking, and the ventilation of his rooms. Much, however, may be done if all those who are convinced that a fire-place built up of fire-bricks, or even of common bricks,

is far preferable to the common metal grate, will discountenance on all occasions the unnecessary use of metal where it proves to be so injurious. And, we may hope, that as the lower classes get to understand the subject themselves, they will not be content that they should have to make extravagance of consumption to compensate for a bad article, or that they should be deprived of the amount of comfort they would possess if more reasonable attention were paid to their requirements.

3. *What should be the general arrangement of the fire receptacle.*

It has been, I hope, amply shown that, for the sake of economy and comfort, iron should be dispensed with, to as great an extent as possible, in the interior portion of a grate. Fig. 57 is a sketch of a chamber in fire-brick, which it is proposed to substitute for the metal bars or grating commonly used. Fire-brick below a fire is as serviceable as behind, or nearly so. It adds to the cheerfulness of the fire; the great heat of the brick promotes a more perfect combustion, and, therefore, causes the residue left to be exceedingly small. The few holes shown in the brick receptacle are for the purpose of allowing a little air to enter the fire on certain occasions. Fig. 58 is a similar chamber, but of angular form instead of oval or elliptical. Fig. 57 appears to be at sight a very suitable form, but practically Fig. 58 is found to be preferable. In the angular chamber the body of coal is rather more considerable than in the other, and, therefore, burns longer without attention. The portion of the chamber on which the coal rests is made dish-shaped; a form similar to one recommended by Count Rumford, and found very serviceable, as it enables the coal to become more perfectly consumed than when burnt on a flat surface. Figs. 60 and 61 repre-

sent fire-bricks, intended to surmount Figs. 57 and 58. Both lower and upper portions are supposed to form the back of the grates Figs. 62 and 64. The angle of the sides of Figs. 58 and 61 may be of forty-five degrees with the back line, or of one hundred and thirty-five degrees with the front line of the chamber, for most fire-places. In very small fire-places, however, the angle should differ, and be of one hundred and twenty-five degrees with the front line, or of fifty-five degrees with the back line. The object of giving increased room, comparatively, to very small grates, is to retain a compact body of coal that the fire may not become extinguished too readily.

The fire bars of a grate must continue to be made of metal, but heavy bars, which deprive the room of heat, are very objectionable. If bars are made straight they will be stronger than when made of any other shape, and may, in consequence, be lighter. In fact, the best protection we can have for the coal is a light sort of lattice-work of iron wire, made sufficiently strong to resist the action of the poker and of the fire, but shielding as little of the burning fuel as possible from the room, and just sufficiently close to prevent coal falling through on the hearth. The width of the bars may be conveniently stated at twelve inches as suitable for a room containing a thousand cubic feet of air, and fourteen inches for two thousand cubic feet, sixteen inches for three thousand, and so on; two inches of fire bars being added for every additional thousand cubic feet of air. Special circumstances may render a modification of this rule necessary. If a room, for instance, becomes exceptionally cold in consequence of its having a considerable amount of window surface, it will be well to provide two inches more of fire bars in width than what would be given by the above calculation. The breadth of a fire within the bars should be from seven to eight inches, if good Wallsend coal is used. A greater breadth would be

wasteful, and with less the body of coal would not have sufficient consistence to burn cheerfully and possess much vitality. In many parts of the country, coal is used of a very different quality to the Wallsend, such as the Derbyshire coal, which is generally put on a fire in large lumps and is allowed to burn slowly for a long time. Such coal leaves a large residue of ash, and it does not possess great heating power. In some of the midland counties, none other can be readily obtained, and its use becomes therefore a matter of necessity; but, notwithstanding the objections to the coal, many persons like it in consequence of the considerable amount of flame which is evolved in the burning of the hydrogen gas, which that coal contains in great abundance. A breadth of nine inches in the fire receptacle is not too much for the Derbyshire coal.

4. *What provision should be made for checking the escape of the heated air?*

This question relates to the register door, regulating valve, or damper, as it is variously termed, which should control the upward current from a fire, and it exposes a very gross defect in our grates as they are at present generally constructed. When a fire is lighted in an ordinary grate, it is usually necessary to give free ingress to the chimney for the products of combustion, and the register door is therefore opened to its full extent; but, after a short time, when the chimney has become warmed and an upward current firmly established, the opening to the chimney should be reduced, that the heated air and products from the fire may not pass away with unnecessary rapidity. No reasonable means of regulation are, however, provided. It is true there is very frequently a rack to graduate the opening of the door; but, as the rack is in a position where it gets blackened by the smoke from the fire, no one can think of making daily use of it, so that

the heated air from the fire escapes almost, or entirely unchecked. A grate should be not only provided with a well-fitted door to graduate or close the opening into the chimney, but this door should have a handle in front of the grate, made of a non-conducting material, such as ebony, which a person could use with clean hands. The door should open as shown in Fig. 63, and be of the same width as the fire. The breadth, or measure across, may be from four and a half to eight inches, according to the size of the fire. Such a door would at all times give sufficiently free access to the chimney, and would operate, when required, as an effectual check to the draught.

The importance of such a check to the upward current in a chimney cannot be too strongly insisted upon. If the quantity of air ascending a chimney is reduced by one-half, so much less warm air from the room, or air warmed by contact with or close proximity to the fire, is withdrawn; the fire burns more steadily, and, what is exceedingly important, the lessening of the quantity of air which can pass away by the chimney reduces the quantity of air that can find access to the room, and, consequently, diminishes draughts of cold air.

Such a regulator of the chimney current as that just described should not be provided to such grates as Stephen's and King's, Figs. 14 and 16. In Mr. Stephen's grate, the door behind is moved backwards and forwards on a hinge at bottom, for the purpose of increasing or diminishing the current. In Mr. King's grate, the sliding door, moved up or down by a poker, is of considerable efficacy; but if it were attempted to check the chimney draught still further by such a contrivance as that recommended for ordinary grates, there would be frequent peril of the escape of a portion of the products of combustion into the room.

5. *How should air be supplied to the fire?*

This question is no less important than the preceding. We have not only been in the habit of giving very free ingress to the chimney, but we have allowed too free access for air to the fire. If more air is allowed to penetrate a body of burning fuel than is necessary to support active combustion, the surplus quantity has a very injurious effect. It becomes instantly highly heated, and ascends with rapidity to the chimney. Streams of air thus pass incessantly through the fire, the vital power of which becomes lost in a very short time. A fire, therefore, requires very constant attention, and is burnt to great waste. In fact, a grate, as often constructed and used, is as much a contrivance for warming the largest possible quantity of air to be discharged up the chimney, as a contrivance for radiating heat into an apartment. When air is excluded from entering a fire from below, the fire burns immediately much more steadily, and will go twice or thrice as long without attention. Free access for air can be given by a stir with a poker without unnecessary waste, or a little air can be admitted in very cold weather by means of an ash pan with a regulator, shown in Fig. 56, which could be applied with great advantage to most ordinary grates.

To new grates, the brick chamber, Fig 57 or 58, can be used, in which a few holes are provided which should taper from above, so as to ensure dust from the fire falling through. An ash-pan, Fig. 59, is made to fit the space below the brick chamber; and, by means of the small regulator in front, a little air might be allowed to enter the fire below on any occasion when it might be desired to make the fire burn very actively. The scooped shape of the fire-brick chamber, where it receives the coal, is of considerable moment, as it enables a small current of air to act below

with considerable intensity. Few persons can form an idea what an amount of difference is effected in the economical and efficient use of a fire by such simple contrivances as the exclusion of an unnecessary amount of warm air from passing up the chimney; the exclusion of an unnecessary amount of air from entering the fire, and the use of a fire-brick receptacle for the fuel instead of an iron grate.

A very simple mode of excluding air from entering the bottom of a fire is to have a plate of sheet iron cut of the size of the grate bars, and to lay it upon them. Such an article could be prepared for a trifling sum by any iron-monger, if a paper pattern of the exact shape and size were given to him. The ash-pan, with regulator, Fig. 56, is still better, and could be made and carefully fitted to very many ordinary grates by a tolerably good mechanic.

In some of the best constructed grates which have been introduced of late years, the inconvenience of admitting too much air to the fire has been partly remedied, though not apparently with the express intention of the projectors. In Stephen's grate, Fig. 14, the supply of air below the fire is checked by the ash-pan, which is intended for ornament. In Sylvester's grate, Fig. 11, the supply of air is still more checked by the radiating bars. In the smokeless grates several of the advantages gained are due chiefly to the absence of any current of air from below, and the same observation applies to the common fire lighted at top proposed by the *Builder*.

Somewhat in connection with this subject is that of the expediency of giving a special supply of air to the fire by means of a channel communicating with an outside wall This question must not be confused with that of excluding, in part or entirely, the free entrance of air below a fire. The two systems are not in opposition, but are perfectly reconcileable. If the special supply of air is

sufficient, it is calculated to insure in the first place that there shall be sufficient pressure of air near to the fire to maintain the passing upwards of the smoke and gases from the fire ; and next, it prevents constant draughts of cold air from doors and windows, which rush in the direction of the fire-place, thereby greatly adding to the comfort of an apartment, and promoting economy in fuel. Fig. 65 shows openings at the bottom of the grate on each side, at *b b*, at which the special supply of air is supposed to enter the room.

6. *How are the heated products escaping into the chimney to be utilized?*

The few attempts that have been hitherto made, to effect this desirable object to some degree, have had simply in view the construction of a grate, with a warm air chamber behind, as shown in Fig. 18. Air is supplied to the grate from an external source, and, on becoming warmed by contact with the heated parts of the grate at back, enters the room by apertures or valves, as shown in the figure. It might appear to many that a considerable accession of heating power would be gained by the adoption of this principle ; but, it is found that if a grate is carefully constructed with fire brick, so as to produce a good clear fire, and to radiate heat directly into a room, that the chamber behind performs its office so badly that any amount of warm air entering the room is imperceptible to common observation. Those who strongly advocate the system are driven, therefore, to the exclusion of fire brick and its substitution by metal. They subtract from the efficiency of a grate fire in front that they may add on behind. They, in fact, convert a grate in some measure into a stove. Raised metal hearths are also used in conjunction with the air chamber ; but, there is, unfortunately, one invariable result

from these expensive appliances, viz., that the amount of heat obtained is by no means equal to what had been expected. To use a common French expression, *le jeu ne vaut pas la chandelle.* As it is the object of this chapter to give exclusive attention to those schemes which are likely to enhance the efficiency of our fire-places at small cost, I may, I trust, be excused from dwelling longer on this matter. But, it must be observed, that though the trouble and expense incurred in forming a chamber at the back of a grate, may not be found to be repayed by the benefit received from it; a different opinion will probably be formed if the idea be extended, and if, when a house is constructed, a double flue be formed above the fire-place for the purpose of giving a supply of warm air to upper rooms. It has been amply proved that when a grate is well constructed, no considerable quantity of air can be heated by contact with the back parts of a grate; but, if the heated products on ascending a chimney are allowed to part with their heat to a current of air in an adjoining flue, a considerable advantage may be gained, and it is probable that a room over that in which a fire is burning would have its temperature raised by several degrees. A section of a chimney, with a warm air flue, *e*, *e*, *e*, and a ventilating flue, *f*, is shown in Fig. 67. It is much to be hoped that the discredit of sending so vast a quantity of heated air from our fires to be entirely wasted, when we have great facility for turning it to account, will not much longer continue.

There is a simple mode by which much of the heat radiated from the top surface of a fire can be arrested and given to the room, which demands consideration. In Figs. 60 to 64 is shown an inclined slab of fire-brick, *a*, which would of necessity receive a considerable amount of heat from the fire burning below, and radiate it in a useful direction. This slab cannot be very usefully or readily

adopted except to grates of the square form like those shown on the last three Plates.

Of the few preceding recommendations, those which, to my mind, should be generally applied in the construction of grates whether for rich or poor, and which would enhance in a remarkable degree the amount of comfort derived from artificial warmth, are as follows :—

Recommendation 1. That the back and sides of a grate within the bars should be entirely of fire brick, and upon no account of metal.

Recommendation 2. That the metal bottom bars of a grate should be dispensed with, and a fire brick receptacle substituted, which should have a few tapering holes to allow dust to fall through below, and be of a scooped form, as shown in the Figs. 57 and 58.

Recommendation 3. That an ash-pan, as Fig. 59, should be used to every grate, which would receive the dust falling through the holes of the brick receptacle, and exclude air from entering below the fire. A small regulator could be provided to the pan so that a little air might be allowed to enter on a very cold day.

Recommendation 4. That a properly constructed regulating valve or register door should be applied to the grate that the upward current of warm air in the chimney may be effectually checked. The regulator should have a handle in front as already described, and be of the medium width of the fire, or thereabouts, that the passing away of products of combustion may not be impeded.

Recommendation 5. That grates should be used of a square form, as shown in Figs. 62, 64, &c., and that an inclined slab of fire-brick, *a*, should be applied for the purpose of radiating into the room a portion of the heat developed at the top of the fire.

Recommendation 6. That fire bars should be straight

and no stronger than is really necessary to protect the coal. The bars may be made lighter of wrought iron than of cast-iron.

The above recommendations are so simple that many will, perhaps, be disposed to doubt whether or not their adoption would be followed by very appreciable results. If, however, they will, for a few moments, consider what an enormous quantity of air generally passes away in an open fire-place, amounting frequently, in a single hour, to no less than the whole cubical contents of a room, and, that this air is not, let it be clearly understood, vitiated air, but, chiefly pure air below the chimney opening, which is constantly supplied from doors and windows, and which becomes expanded by proximity to the fire, and passes upwards warm and unbreathed; they will understand what a great change must be effected directly the quantity of this moderately heated air passing away is reduced by one-half or two-thirds, and the supply of cold air from doors and windows is lessened to the same degree. If they will also consider what a constant amount of attention an ordinary fire requires, and what a change would, in all probability, be effected, if air were prevented from passing through a body of burning coal in continued streams, and were only allowed to attack the coal in front and above, they will understand that the above suggestions, simple as they are, may be followed by very substantial benefit. It would, doubtless, confer honor on myself, if, instead of considering all suggestions which have been made for improvements in a fire-grate, and endeavouring to give recognized principles their full application, I were able to discover laws in nature, hitherto unsuspected, that would command for any propositions I might make a very unusual amount of attention. But, I am obliged to be content with more modest aims; and, if the recommen-

dations contained herein are simple, they have the advantage of being easily understood, and they can be applied at no considerable expense.

There are other suggestions than those alluded to, which are also calculated to add to the comfort of apartments in winter, but which are of less general application. They are comprised in the following recommendations:—

Recommendation 7. To give a special supply of air near to a fire. If the special supply is in sufficient quantity to support combustion, and to replace that which passes by the chimney opening, draughts of cold air will be prevented to such an extent that the air in a room will have an equable temperature that will add greatly to the geniality of wholesome warmth. The tube to form a passage for the air should have an area of not less than twenty-eight cubic inches for a room containing a thousand cubic feet of air, and four inches more for every additional thousand cubic feet. The apertures in the grate, by which the air can pass to the room, should be of the same area, and should have a means for partly or wholly closing them.

Recommendation 8. To use double windows, or to double glaze the sashes, leaving as much space as convenient between the two panes of glass. This recommendation is of great importance in many bleak situations, especially if the surface of glass is considerable. The cooling influence of the external atmosphere, and the passage of warmth from the room, are so greatly arrested by the interposition of an extra pane, and a closed space filled with air, that the most beneficial results are found to follow so simple an expedient. When we remember the rapid ratio at which the power of heat diminishes with the increase of distance, and the great difficulty there always is in warming rooms comfortably which contain much

window surface, we must see that improvement of the window sashes is, by comparison, of the greatest importance. A room that is warmed with great difficulty can never be comfortably warmed, but, if the source of obstruction be greatly reduced, economy and comfort will both be considerably promoted.

Recommendation 9. To double glaze skylights, or to use double sashes. When a room is lighted from above by a large skylight, the cooling influence of the external air is often so considerable that no opposing influence from below suffices to make the place comfortable, but, if a ceiling of glazed sashes is formed below the skylight, the place is warmed with facility, and light penetrates more softly and agreeably.

There will no doubt be some, who, on considering the preceding observations, will be inclined to suspect that by improving our fire-places, and more effectually warming our rooms, we shall be exposed to evils of a different nature to those we now encounter; that we may possibly begin some day to suffer from too much heat, and render our apartments close and unwholesome. They may say, that if the quantity of air passing up a chimney be greatly reduced, and, if that which does pass be derived chiefly from a special source, our ventilation will be much less perfect than at present. With reference to the amount of heat, this surely is a matter entirely under our control. If our grates are properly constructed, and are of proportionate dimensions to our apartments, we shall be able, without difficulty, to maintain a tolerably uniform temperature, whatever may be the state of the external atmosphere; and, if the improvements we can effect tend to diffuse heat more agreeably, and to economize coal, there is no reason why their adoption should give anything but satisfaction. It is a mistake to suppose that health is

promoted by habituating ourselves either to a low or to an unequal temperature, for, on the contrary, those who most enjoy a cold season, are those who can have indoors the temperature which is most genial to their feelings, and who maintain, by suitable clothing and exercise, a regularity of circulation on passing into the cold air.

As to the second point, if we do render our rooms more unwholesome than at present, this can only arise from continued neglect of a subject of great moment; and, it will be well if we are forced to seek for a truly rational system of ventilation by so desirable an impetus as the more effectual warming of our rooms. Questions of warming and of ventilation can be, and should be, considered entirely apart. It is one thing that the air of our rooms should be as genial as we can make it, and, it is quite another that that air should become entirely changed at certain intervals.

The twelfth recommendation of the Board of Health Commission on Warming and Ventilation, is so valuable that it may be quoted again.

"The Commission strongly recommend that the fire-grate should be studied in its construction, with the view to its effecting a better and more agreeable distribution of heat, and not as a contrivance for the ventilation of rooms. The Commission is decidedly of opinion, that so long as the fire-grate is studied, with a view to this two-fold application, it will not succeed well in the performance of either."

Genial warmth and pure air are as necessary for our comfort as wholesome food, reasonable exercise and cleanliness of body; but we shall be most likely to avoid perplexity, and to attain to a tolerably clear understanding of each matter, if we follow the sensible recommendation of the Commission, and are careful not to confuse questions that are in themselves entirely distinct.

7. *How should coal be supplied to the fire?*

There is yet another question to be considered, which has been discussed already with much minuteness in the preceding chapter. Are we to continue to supply our grates with coal on the old method, or is there conclusive evidence, not only that a reversal of that method and the principle of burning a body of coal from the top downwards are attended with certain advantages, but that those advantages are such that it becomes chiefly a question of our having simple and inexpensive contrivances for people to use, for the new method to receive rapid and very extensive approval. It appeared in the last chapter that the advantages which result theoretically, and have been extensively considered to result practically from the new principle are: economy in consumption; great vitality of the fire; greater diffusion of heat; more regular burning; less attention necessary; little or no smoke, and little or no soot; and that the disadvantages requiring removal are: the dust, the expense, and the want of sufficient simplicity both in erection and use when compared with an ordinary grate. I have already gone so much into detail respecting this grate that it is needless to reproduce arguments, but I will proceed merely to enquire whether or not there is any mode by which the public may become familiar with, and therefore profit by, the new principle, so that it may gain gradually in public estimation, if it really does possess the preponderance of advantages, which have been deduced in these pages, over our ordinary method of using a fire; and I will also enquire to what an extent it may appear possible for the objections mentioned to be overcome, that the advantages may preponderate to a still greater degree.

Allusion has been made in a preceding page to the practice recommended by the *Builder*, of placing a body of coal

in a grate and making a fire on the top of it. Now, every one should test, and, if he should be satisfied with his experience of the test, he should recommend that very simple and undoubtedly useful expedient. A person has only to get a plate of sheet iron cut of the size of the bottom bars of his grate, and lay it upon the bars. For a single experiment he can even dispense with the plate, or use a piece of thick paper. He should nearly fill his fire chamber with coal, put wood and paper above, and a small quantity of coal on the top of all. The fire can then be lighted, and should be left for a long time; and it will burn with great steadiness, give considerable heat, and require no attention. It can be stimulated into a little extra activity at any moment by a slight disturbance of the upper surface of coal, or the whole can at any time be excited to burn with activity by stirring with a poker. Now, it must not be supposed that to use a fire in the manner described is merely a question of economising fuel by a certain amount. The practice involves a domestic convenience of decidedly greater moment, and its benefit can be appreciated both by those who can daily make a choice of luxuries and by those who have to learn by hard experience to place a considerable value on every pound of coal. In towns, during a great portion of the fire-burning season, we require no very considerable amount of heat, so that if a fire can be lighted that will burn nearly half the day without attention this will be preferable to an ordinary fire which must have attention every hour. Again, it is a practice with very many to use a fire in their bedchambers. Most persons doing so care only to dispel the cold and damp air, and to have the cheerfulness of a fire on retiring to rest. The very fire for such a position is surely the one that will burn for a long time without attention, until it gradually expires. So useful an expe-

dient places within the reach of everyone the opportunity to test to some little extent the principle of a downward burning fire, and a means of applying it very frequently to their own benefit with scarcely any trouble or expense.

Now, if a person experimenting with such a fire become convinced that it possesses a decided utility, he will readily perceive that any appliances by which the system can be perfected will, with much probability, render the fire much better adapted for general use than one which demands very constant attention. He will observe that if a greater depth of coal can be provided; if air can be carefully excluded below the burning portion of the coal; if the unburnt coal can be exposed gradually in front by some simple contrivance, and if the burning portion can be readily excited at any time to burn with an extra amount of activity, that the most essential requisites are obtained for effecting a revolution in our mode of using a fire. Having thus pointed out how, by the useful suggestion of the *Builder*, every person may to his own benefit, and by a nominal expense become accustomed to the new method of using a coal fire, I will enquire what are evidently the simplest modes of extending the system that it may be readily used for an entire day. Fig. 68 represents a grate in which an extra depth of coal is gained by adding one or two fire bars to the grate, and which is provided with hooks at *a*, *a*, *a*, and a loose cover, Fig. 69, to cover a greater or less portion of the body of coal by being suspended on the hooks. A sliding blower, *b*, is provided to stimulate the ignition of the coal. This arrangement is evidently a very simple one, and may be very effectual if carried out with reasonable care. The cover should be of cast iron, that it may not become warped by the heat; it should lay as closely against the fire bars as possible; at each side and below the fire bars the cover should lay accurately against

the grate; the hooks of the grate should project outwards and upwards at a certain angle, so as to provide an easy means for receiving the cover, and that the cover may find its proper place by the pressure of its own weight; and, lastly, the cover must be provided with two ebony knobs or handles, that it may be removed or replaced without uncomfortably warming a person's hands. Now, there can be no doubt that such an article as the cover to be removed by the hands is rather a crude arrangement, but it must be remembered that the simplest possible contrivance is of necessity the cheapest, and that there can be no hope whatever for the most numerous classes to profit by improvements, unless they are attended by simplicity and small expense. Even for the bedchambers of the more prosperous, where the metal cover would often not be used, and, when used, would probably only be detached and replaced once in a day, such a simple expedient would be found satisfactory, provided, of course, that the grate is made with sufficient care to enable the cover to be easily detached and replaced in two or three seconds.

A preferable, but a more expensive method, applicable for very general use in drawing rooms, dining rooms, and libraries, is shown in Figs. 70 and 72. The metal cover is there shown fitted in grooves between the fire bars and the outer part of the grate, and is suspended by chains which pass up the grooves over pulleys, with balance weights, as shown by the dotted lines. This arrangement, like the last, is evidently a very simple one, and, if the details are carried out with sufficient care; if the door will always move easily, and at the same time exclude the free action of air on the coal within, it may be pronounced all that can be desired. Assuming that the objection of want of sufficient simplicity in Dr. Arnott's arrangement is disposed of by the above propositions, we can ask whether

there is anything objectionable in the appearance of grates constructed as shown by Figs. 79 and 72. The cover or blind to shield the coal can be as ornamental as anyone can wish; the fire bars can be substituted by ornamental lattice-work of the required depth, and a polished steel ash pan, such as is used to an ordinary grate, can improve the appearance of the hearth and receive any fine dust falling in front. And, as the exterior portion of the grate is not affected by the arrangement, it may be of the form, material and design that anyone may desire. An increased depth of fire bars, if arranged so as not to offend a correct taste, will hardly appear an objection to anyone in these days of crinoline.

We can now inquire whether or not the objection to dust and cinders which has often been complained of in Dr. Arnott's grate is less considerable or is practically removed in the new methods proposed. In Dr. Arnott's grate, the falling of coal in front is caused by the action of lifting the body of the coal in the chamber, and by the poker in stirring the fire; but, if the coal is not raised, the grate is only exposed to the same contingency in respect to falling coal as an ordinary grate. The objection to the dust collecting in the chamber, it is proposed to overcome by the following means:—It has been explained that in consequence of the non-conducting or comparatively impervious nature of fire brick to heat, that a fire burns more brightly, and therefore more effectually, within it than when surrounded by a chamber of metal. If, therefore, a fire brick receptacle, as Fig. 57 or 58, be used instead of a metal grating or solid plate, the coal will become more perfectly consumed, and the quantity of cinder remaining after a day's use, will, without doubt, be less than in any other grate; and if a small pan, *g*, Figs. 68 and 70, be used to receive any dust that may fall through the tapered aper-

tures of the brick chamber, such dust may be removed every morning without causing inconvenience. To such grates as Figs. 70 and 72, it is proposed to form an ash-pit in front, as shown at *f*, in Fig. 71, that the cover, *a*, may be pushed down below the level of the hearth. This ash-pit may have a pan to fit it, by which the dust can be removed, and if an ornamental radiating cover be used, as shown in Fig. 72, it is impossible that the most fastidious could complain of an objection from dust.

Another objection that has been mentioned to the Arnott grate is the increased expense when compared with an ordinary grate. The full remedy for this is entirely in the hands of the public. When a demand is small, prices are high from causes wholly beyond the control of any manufacturer. The two conditions for insuring low price are extensive demand and competition. If a manufacturer has to create a demand by an extensive system of advertising, the public must pay the expenses; but, if the public determine to have smokeless grates, they will be certain to succeed in getting them cheap. Irrespective of such considerations, the Figs. 68, 70 and 72, present very simple elements of cost; but, no one must suppose that such grates can or should ever be as inexpensive as those whose intrinsic value is exactly what they will fetch in the furnace pan. Those who are intent upon constructing their fire-places at the smallest possible cost, should use fire bars of metal, and common bricks cemented together with fire-clay.

We can now shortly compare the two methods above proposed with those described in the last chapter, for exposing gradually the front portion of a body of coal. In Mr. Cutler's, Dr. Arnott's, and Mr. Hoole's grates, the body of coal, with the bottom of the coal chamber, is lifted gradually by means of a lever or other contrivance; but, in

each, sufficient force must be used to overcome the friction caused by the caking of the coal, and its adhesion to the coal chamber, and an ash-pit is required below the fire, and lower than the hearth, to receive the dust which may fall through. In Mr. Jeakes's grate, the coal is stationary, but a considerable portion of the grate, including the fire-bars, has to be lowered so as to expose fresh fuel. Mr. Goodchild's plan is but a crude form of those which I have proposed. If we leave out of consideration the cheap form of Fig. 68, it will therefore appear, that, assuming the blind of Fig. 70 to answer its purpose effectually, the movement of this by a light poker is an easier method than either the lifting of the coal or the lowering of part of the grate with the fire bars, and is therefore preferable.

There is a point of some importance in the construction of smokeless grates, which should be particularly noted. The chamber to receive the coal must not be too small between the bars and the brick behind. It is found that if the dimensions in this direction are the same as in an ordinary grate, that there is hardly sufficient consistence to the body of coal, and that therefore it does not burn as cheerfully as it should. If the breadth, as it has been termed, of the fire chamber is from eight to nine inches, and if the sides slope according to the directions given for ordinary grates, the capacity of the coal chamber will be found satisfactory.

A qualification of both the grates suggested is, that they can be used at pleasure to burn coal either on the ordinary or the new method. If used as smokeless grates, the ordinary fire instruments are unnecessary. A light poker, Fig. 73, usually termed a pokerette, with a sharp end, can be used for stoking the fire, and a similar article, with a turned end, Fig. 74, to move the blind. They are the only ones necessary in the fire-place. Anyone, however, wishing

to amuse himself occasionally with a little extra blaze can harmlessly have a small pair of hand tongs with which to put two or three pieces of coal at any time on the top of the fire. A coal hammer, Fig. 75, with a handle thirty or thirty-six inches long, would sometimes be of service in the coal cellar.

Those who have used Dr. Arnott's grate have been generally recommended to have their chimneys swept once in two or three years, by way of precaution; but there can be no doubt that, if the grate is not misused, this may be disregarded. The following extract from a letter by Mr. Charles Booth, of the *Standard* newspaper, of Montrose—a gentleman who has taken much interest in the amokeless grates, and to whom I have been indebted for many practical suggestions—will be read with satisfaction:—

"As to the consumption of smoke, your prospectus did not lead us to expect that it would be entire, yet, practically, we have found it so; for, since the date above-mentioned (1857), when the use of the grates commenced, we have never had the chimneys swept, nor had any occasion to think such an operation required. No doubt, a film of soot may at times collect about the throat of the chimney, owing, I think, to want of attention in kindling the fire; but it is evidently either burnt or blown away before it becomes more than a mere film, for there has never been any sensible augmentation of it. Once the fire is fully kindled, no smoke can escape—it is inevitably burnt."

As much as is necessary has now probably been urged in these pages in favour of the smokeless fire. If the facts and arguments adduced, and the proof just offered that the objections to the grates can be practically overcome, have the same effect on the minds of others as they have on my own, there can be no doubt whatever that a reversal of our method of using coal is chiefly dependent on the

subject becoming better understood. The coal-box, the hearth brush, our heavy fire bars, the sweeps and their progenitor, may therefore, at no very distant period, all belong to the past. Our fire irons may even be as curious to our descendants a hundred years hence as those of mediæval manufacture are to ourselves; and it must soon be considered extraordinary that our crude method of using a fire should have held its way so long undisturbed. Let the truth, however, of all that has been advanced be as convincing as it may, it will be a very considerable time before there is a great diminution of the smoke nuisance. The number of houses in the city and metropolitan parishes is about 300,000 and the number of fire-places probably 3,000,000; and we are increasing to such an extent that London and its suburbs will, perhaps, fifty years hence, cover an area twice as large as at present. The difficulty of getting rid of smoke will therefore, perhaps, be regarded by some as so gigantic as to be practically impossible, and it is certain that our only hope exists in the thoroughly practical nature of whatever propositions may be made for mitigating the evil.

If it should become extensively understood that smokeless fires are altogether more convenient and economical than those which are not smokeless, and if the Press render the service they are accustomed to do with respect to subjects which are considered to be of public moment, those concerned in the erection of new houses will be obliged, for their own interest's sake, to provide such contrivances as the public will alone consent to use. Should such a state of things come about, there will be a clear way open for an end to the smoke nuisance. The time may come that the evil will not be extended. Every year will greatly diminish the number of old grates in present buildings, and it is perhaps not impossible that,

at the end of fifty years, there will be comparatively few constantly used in London for burning coal on the present method.

If smokeless fires or well-constructed grates become generally used, an entire change in the construction of our chimneys will be not only possible but highly desirable; and we may then have our chimneys ornamented at top, instead of disfigured. This subject, in connection with the ventilation of dwelling-houses, and the utilization of the heated products from our fires, I hope to discuss at a future period, unless it should be treated by another, in a manner deemed satisfactory, in the meantime.

Allusion has not been made in this treatise to the use of coal for cooking purposes, which, perhaps, will cause some surprise. This is not because I undervalue the importance, for, on the contrary, I believe that the consumption of fuel, both in Leamington kitcheners and the old-fashioned kitchen ranges, is truly disgraceful; but, I am unable to suggest considerable improvements without depriving the cook of the sight of a fire, which would not be probably a small undertaking. If, however, this treatise succeed in calling public attention to the general subject of our fire-places, it will give me much pleasure, a few months hence, to afford such information upon a kindred matter as my observations may allow.

CHAPTER IV.

ON THE PATENT LAWS.

In the winter of 1863-64, the author of the preceding treatise, feeling desirous of exploring any source of new information which might be open to him, and which could have any reference to the subject he intended to discuss, paid a number of visits to the library of the Patent Office, in Southampton Buildings, for the purpose of ascertaining what suggestions for improvement had been patented which had never come into public notice, and of making some examination into the merits or demerits of those suggestions. Great was his astonishment to find that for one patent or application for protection by patent, of which he had heard, there were not less than ten which were new to him. He felt interested to ascertain the nature of the specifications, and began by examining those which appeared most particularly to refer to the subject he was considering; and, with these, his labours would have ended, for he found the pursuit to be very far from inviting or satisfactory.

Further consideration, however, induced the author to continue his investigation, not for the prosecution of his original purpose, but that he might bear some unpretentious part in assisting forward a movement, the reali-

zation of the objects of which, he believes, will be followed by much public benefit. The writer has, perhaps, just reason to consider himself qualified to express an opinion respecting the patent laws, and particularly with regard to the branches of manufacture in which he has been engaged; for, though he went into the enquiry with a strong bias, though his earliest associations in connection with patents displayed to him the fact of protection being often granted for the manufacture of articles of most inadequate utility; though he had known numerous instances of the public and others being sufferers by patents, and not one single instance, within his own observation, of an intelligent and industrious patentee reaping the reward of his labours, and though he had therefore given an immediate assent to the views expressed by several influential authorities, he will state, for the information of some who appear to consider that a man cannot express an opinion against the patent laws except from a strong motive of self-interest; that he never applied for protection by patent; that he never had the slightest interest in any patent; that he never infringed one or felt a desire to do so, and that he was never engaged in any way with respect to disputed rights in a patent.

It was without much surprise that the opinion which the writer was obliged to form of the merit of the schemes he examined, was soon verified by a discovery of the fact, that the patentees had found it unprofitable, in most cases, to pursue those schemes, and that the instance of a patentee paying the amount of fees necessary for an extension of the protection granted to him for the extreme period allowed by law was exceedingly rare.

The total number of patents granted for "inventions" connected with fire-places, stoves, &c., down to the period

when the Patent Laws Amendment Act came into operation in 1852, is 169. The number of cases of patents, or of provisional protection only, from that period to December 31st, 1863, is 348. The following is a short analysis:

					TOTAL.
Number of patents relating to fire-places, stoves, &c., to October, 1852					169
	Received Provisional Protection only.	Obtained Protection for 3 years only.	Obtained Protection for 3 years and a subsequent period of 4 years.	Obtained Protection for a total period of 14 years.	
1852 ...	7	6	4	2	19
1853 ...	8	13	6	1	28
1854 ...	8	20	4	0	32
1855 ...	7	14	3	1	25
1856 ...	15	23	7	2	47
1857 ...	18	11	2	1	32
1858 ...	10	12	5	0	27
1859 ...	7	11	2	0	20
1860 ...	11	10	4	0	25
1861 ...	12	11	4	0	27
1862 ...	13	22	0	0	35
1863 ...	18	13	0	0	31
	134	166	41	7	517

From the year 1857 conclusive results are not shown, as it can only be known at the expiration of seven years from the date of a patent, whether or not the patentee is willing to pay the sum of £100. to extend his protection for a further period of seven years, and at the expiration of three years from the date of the patent, whether or not, he is willing to pay for the shorter period of four years. From the year 1852, to the end of 1857, the results are conclusive. Of the total number of one hundred and eighty-three cases allotted to the first six years, it appears that sixty-three, or about one-third, received

provisional protection only, in consequence of the applicants being unprovided with the necessary fees, or having found that there was little or no probability of their schemes becoming remunerative. It appears that eighty-seven, or nearly one-half, obtained powers for three years, and at the close of that period did not think it worth their while, or were unable, to pay the sum of fifty pounds to have those powers extended for a further period of four years; that twenty-six obtained protection for seven years, and that seven only obtained protection for the full period of fourteen years.

These figures are calculated probably to cause much astonishment to those who, like the author, have not been very familiar with all the results of our present system of patents; but, what is still more surprising, is the nature of the evidence, presented by a close examination of the specifications furnished by the patentees. Many of them refer to furnaces and other matters not immediately connected with the subject of open fire-places and stoves, and upon which, therefore, the writer will not presume to speak; but, of those which he examined, amounting to about three hundred, he can but express his belief that though it must appear surprising that so few should have appeared to gain any profit by their patents, it is equally surprising that most of those few should have held their patents for a period of seven or fourteen years. The amount of ignorance which a great proportion of the specifications display is truly remarkable. There cannot be the least doubt that scarcely any of the patentees were ever familiar with the very few useful books which have been published on the subject of grates, and it is equally certain that nearly all must have lost their money without gaining a corresponding benefit in any shape or form. A more unprofitable labour the author never undertook than

an examination of the three hundred specifications alluded to, and it really appears as if the fact of a man taking a patent for an improvement in grates affords *primâ facie* proof that he understands but little on the subject in which he should be proficient. Patentees of all ranks, from the French nobleman to the butler, have appeared. The names of the well-known London dealers in grates seldom or never occur. A Sheffield manufacturer appears now and then, but generally soon to vanish from the stage. Some of the suggestions are so exceedingly simple or ludicrous that one might suppose the applicants for protection, to read the solemn legal phraseology, alluding to their "inventions" with a similar gratification to that of M. Jourdain, when he discovered that he had been talking prose all his life. It will be interesting, however, to know something of the nature of the seven patents, for which protection has been obtained for the full period of fourteen years. Two of these refer to slight improvements on the grate known as "Stephen's patent," shown in Fig. 16. This grate, and also "King's patent," on the same plate, never were patented, though they have always been formally termed patent grates. Mr. Stephen died a few years ago, and though he had had no patent himself, one slight alteration to his grate, which is not for one moment to be compared with the whole original contrivance in point of merit, was patented by a Scotch ironmonger, and another by a wholesale manufacturer of Sheffield. A third large contributor to the funds of the patent office introduced an ash-pan somewhat similar to that used in Stephen's grate, but he had a sliding plate to close the apertures between the open bars, so that the dust below might be effectually hidden. A fourth case is that of a firm of ironmongers in Ireland, who patented some improvements in kitchen ranges. A fifth case relates to furnaces. A sixth is the grate by Mr. Young, shown in

Fig. 25; and the last is a patent for making kitchen ranges, with the ovens lined with fire tiles. The author prefers to make no comment on these cases.

Many of the foregoing facts show somewhat remarkably the true nature of the improvement which has resulted from the Patent Law Amendment Act of 1852. Before that time patentees could only obtain protection for the full period of fourteen years, for which they had to pay the sum of three hundred and fifty pounds for England, Scotland and Ireland, and there can, unfortunately, be no doubt that the vast majority of those who obtained a patent for improvements in grates or stoves simply lost their money. The patent laws now in force are less severe, and a patentee can therefore escape the penalty following on his want of information or judgment by the loss of a much smaller sum. It may be supposed by some that a patent could be worked profitably for the first period of three years, and for the further period of four years, which might henceforth be unprofitable, in consequence of further or different improvements being effected by others. Such a case is certainly not impossible, but with reference to the majority of successful patents it cannot be said to apply. Three years in the early life of a patent are next to nothing. In the very striking case of the sewing machines discussed a few months ago in the public journals, Mr. Judkins' patent right was sold for fifty pounds nearly seven years after it had been first obtained. In fact, the difficulties and expense attending the extensive promulgation of improvements are generally such that the fact of a person obtaining letters patent for three years after having received six months provisional protection, affords no other proof than that he has faith in his scheme, and has the means wherewith to pay the necessary fees. Nearly all the patents for seven or fourteen years contained in the previous table

have been in the hands of persons to whom they might be considered to be most immediately productive of advantage; but, it would be an error to suppose that therefore those patents must be of considerable value. That deficiency in judgment or knowledge, which leads a man to place a higher value on any production of his own than a calm observer, leads him also to imagine that unless he is protected in carrying out his ideas, many will endeavour to profit by them, and to deprive him of what he regards his due reward. Not only are there these considerations to account for the fact of many persons obtaining an extension for their patent rights, but there is the very cogent one that a patent is often made the means of extending, by indirect means, the estimation in which a dealer or manufacturer is held by the class of persons who purchase his goods. It is easy to a country ironmonger, for instance, to increase his reputation by means of a patent. He introduces an improvement of some sort to his customers, and he is inevitably asked if he has taken a patent. The triumphant Yes is much more agreeable and remunerative to him than the unsatisfactory No, for his reputation of being a successful man in business, and a practical man, is quite as useful to him as anything that can result more directly from his patent. If, therefore, these circumstances are taken into consideration, it will be seen that the number of patents of intrinsic merit, few as they are shown to be from the statistics of the Patent Office, must be few indeed.

If the injurious effects of patents did not extend beyond the patentees themselves, the subject would not deserve perhaps much consideration; but there are others who are affected to an extent which none can at present adequately conceive. With reference to certain manufactures, some discussion has already taken place, but in less pretentious

branches the evils are less known, but are perhaps of no less importance. There are the subjects which have been discussed or alluded to in the preceding pages, the application of heat for warming and cooking purposes, the ventilation of dwelling houses, and the prevention of smoke. A general understanding on these subjects can only be attained by a clear comprehension of a few of the simplest and most appreciable of nature's laws; laws, which, when clearly grasped, admit of as little variation in their reasonable application as the formation of letters to a type-founder; laws which in these days should surely be at the free service of mankind; but there is this never-ceasing crop of deluded patentees, applying, or failing to apply those laws after their own fashion, doing little or no good to themselves, obstructing others, obtaining patents for things which might lead one to suppose that the progress of civilization proceeds about as gradually as the precession of the equinoxes, or the gyration of the earth on its axis; but, answering one useful purpose, and that only, viz., by displaying in the yearly accumulations of the Patent Office unanswerable proof that our course hitherto has been very far from having a reasonable amount of success; that it has been injurious alike to patentees and the public at large, and that we should endeavour to proceed strongly in a more promising direction.

The operation of the present system of patents with reference to fire-grates is exemplified in the table at page 95, and in another table given in the Appendix. Though, as will be seen, several hundred patents have at different times been granted or applied for, the substantial improvements which have been effected were never the subjects of patents at all. Count Rumford, who did far more for our fire-places than anyone else, never had a patent. Mr. Stephen's admirable grate was never the subject of a patent, although a slight

improvement in the arrangement of one portion is now the subject of a successful patent, in the hands of a manufacturer who had nothing to do with the original contrivance. Mr. King's grate was never patented. Mr. Cutler had a patent, but he became involved in a law suit and lost a considerable sum of money. Dr. Arnott never had a patent; but soon after he had made public his improvements on Mr. Cutler's grate, several enterprising manufacturers, believing that smoke-consuming grates were going to supersede those to which they had previously been accustomed, rushed to the Patent Office with some method different to Dr. Arnott's for solving the very simple problem of how to lift the bottom of the box which is filled with coal. The table in the Appendix shows that the same thing has been patented several times over, the patentees sometimes almost treading on each other's heels at the Patent Office. And if, as there is but too much reason to believe, the same thing has occurred in all other branches of manufacture, it will be evident that the evils attending the present system are such as require somewhat urgent attention.

There can be no doubt that, the more the question of patents is examined, with reference at least to many branches of manufacture, the more their simply obstructive nature is brought to light. The author would not even have ventured to make such slight allusions as he has in the preceding pages to certain subjects which call for improvement, but for the hope that a growing distaste of the public to patents, and the proof that is here furnished that patentees must almost invariably lose their money, will deter any from pursuing the thread of his investigations with any other than a truly legitimate object. In fact, should anyone appear to extend our ideas considerably on the subject of warming, and recommend an

entire change in the construction of our houses; that they should have double walls and double windows; that a certain number of houses should be supplied with heat from hot-air channels below—a patent would, in all probability, not be of the slightest service to him, and would simply cause him to throw his money away. His scheme would, perhaps, require some years to elaborate; and, supposing even that it were truly practical, his patent would possibly expire before he found investors ready to assist him. For such a person to receive due recompense, he would simply have to offer his services in the same way as the engineer or architec t.

The public hear much of patents in the law courts, but there is, perhaps, not one in five hundred that is seriously contested, the truly successful patents being so few; and, of these, how many become eventually more unfortunate still than the luckless ones with which no person thinks of interfering!

Many, doubtless, suppose that the "inventor" is protected by patent laws, and that, if without capital himself, he is, by the help of those laws, enabled to gain the position he deserves, and which he could not otherwise acquire. The "inventor" here understood certainly does appear at the patent courts; but his usual appearance and prospects are not those which some delight to imagine. He appears as a man of fair intelligence, possessing some ingenuity as a contriver, with a golden dream always before him, not very practical, losing his own money and that of others too, and missing the fair competence he might have earned by a steady application of his abilities to more ordinary pursuits, if there had been no delusive patent laws.

It has been stated that it is impossible for the full amount of inconvenience and injury resulting to the public and others from the patent laws to be fully appre-

ciated. Evil arises, to some extent, from the fact of persons being induced occasionally to pay considerably for inventions of much pretension and little merit, which are trumpeted forth with much clamor, but chiefly from the incubus that impedes improvement in many branches of manufacture, and which discourages the industrious investigator, for fear he should fall foul of some patent he had perhaps never heard of or imagined.

An evil of another nature will be best illustrated by a certain circumstance. It has been mentioned in a previous chapter that a most excellent and inexpensive contrivance is the use of double panes of glass in a window sash, separated by as much space as convenient, especially in bleak situations, where it is sometimes impossible to obtain anything approaching to an equable temperature in an apartment. The air between the two panes, acting as a non-conducting medium, greatly increases personal comfort and effects economy in fuel. Protection by patent was actually applied for a few years ago by a patent agent for this very simple contrivance, and as this agent gave the name of no other person as "inventor," it may be assumed that he was the "inventor" himself. For some reason or another, not possibly for the public benefit, this "invention" did not obtain patent rights, and it was therefore freely at the service of the public; but, if this fortuitous circumstance had not taken place, no person could have had the benefit of this useful suggestion without employing this patent agent, and paying him whatever sum he chose to demand for his labours. To suppose him to have been, in any sense, the originator of the suggestion is preposterous. It has been applied by others, who had no conception of there being a person who had claimed sole legal right to apply the idea; and all that can be recognized is, that this patent agent was the first who thought he might benefit by applying for a patent.

A question has been discussed occasionally in one of the Houses of Parliament relating to improvements required at the Patent Offices. If anyone should have occasion to spend a few hours, or days, in the long passage, lighted all day by gas, which is termed a library, in the perusal of specifications sufficient to disgust Dryasdust himself, he may well ask, with tightened brows or revolting stomach, "Where are our inventors?" and entertain rather more than a suspicion of what is the true nature of the improvement the Patent Offices require.*

It will indeed be an admirable thing when, for the present imperfect and obstructive system, there is substituted one that will leave the application of nature's simple laws freely at the service of all; that will exhibit, in a respectable measure, the state of industrial art in our country; and that, by bringing the suggestor and his improvements before the notice of the public without unnecessary hindrance, will do whatever a truly practical scheme can do to stimulate improvements and a disposition on the part of observers to comprehend them.

Should there become established a museum of industrial art worthy of our country and time, there are three distinct objects which, to the mind of the author, require to be kept in view. There is the exhibition of inventions or improvements of recognized utility, which should be exhibited without cost to the producers; the exhibition of new contrivances which have a status to acquire, and with respect to which it could not be expected that any expense could be borne by the State; and, lastly, the exhibition of

* The atmosphere of the long passage is such that the writer, though possessing an excellent constitution, which has never been debilitated by disease, is unable to remain in it for two hours without sensible discomfort. The long passage has been recently made of twice its former length, by the removal of division doors, and it is now ready apparently to receive specifications for several years to come.

manufactures of good quality but of the most simple utility, for the benefit chiefly of the working classes. The first object is at present provided for, to some trifling extent, by the Patent Museum at South Kensington; the second by the small annual exhibition of the Society of Arts; for the third there is practically no provision whatever. There was a small Economic Museum formed at Paris in 1855, within the grounds of the Palais de l'Industrie, of objects selected from among those then exhibited; and in the year following a similar museum was formed at Brussels. In London, also, Mr. Thomas Twining made a useful collection, which he exhibited a few years since at the Polytechnic Institution, and which he afterwards transferred to a building provided at his expense at Twickenham, where, as the author believes, it is still exhibited, free of charge, to anyone who may present himself for admission.

Should the present Government have it in their intention to promote any such schemes as those alluded to, the author will venture to express a hope that those schemes may not be allowed to become an instrument in the hands of resolute men intent chiefly on their own advancement; but that worthy hands may be found, such as those which have so successfully laboured in the Post Office for so many years, which will attend to a conscientious fulfilment of duties towards the public and others, and leave their own advancement to take care of itself.

There are matters to which the author has not alluded, and which can be more properly dealt with by others. How a Wheatstone or a Babbage should be recompensed, he will not pretend to say; but he entertains the fullest confidence that it would be far—nay, infinitely—better that such men should be rewarded by the State than that the present system of patents should be any longer continued.

Should the foregoing observations induce anyone to give the subject of patents a more general investigation than other occupations have permitted to the writer, he will find that an examination of the three thousand yearly applications for protection furnishes corresponding results to those mentioned as ensuing from one subject alone; and the more he pursues his investigations, the more he will probably discover that, of those few inventions or improvements which are most ostensibly valued by the projectors, a great majority would be adequately recompensed by an award of an honorary nature, and the results which an advantageous publicity would bring to them. He will have against him the little army of patent agents, and perhaps many possible or would-be patentees; but, on his side, the silent though expressive support of the vast majority of past patentees, a rapidly increasing amount of public opinion, and the conviction that he is assisting in the formation of what may eventually become one of the most useful institutions of the country!

NOTE

REFERRED TO IN PAGE 17.

A LIST OF CONTRIVANCES FOR "CONSUMING SMOKE," OR FOR PREVENTING ITS FORMATION, IN OPEN FIRE-PLACES.

I.—Rotating Grates.

Date.	No. of Specification.		
——.	——.	Dr. Franklin's contrivance, shown in Fig. 22.	
1818.	4316.	Spencer, Jeremiah. Rotating grate, shown in Fig. 24.	*Patent expired.*
1825.	5257.	Jacomb, Charles. Rotating grate, with divisions.	*Patent expired.*
1854.	613.	Woodford, James. Rotating grate, with divisions.	*Patent void.*
1854.	1221.	Geychin, George Kennedy. Description only furnished.	*Not patented.*
1854.	1617.	Bainbridge, John. Description only furnished.	*Not patented.*
1855.	646.	Young, William. Rotating grate, with divisions.	*Patent void.*
1856.	2077.	Juckes, John. Description only furnished.	*Not patented.*
1856.	469.	Young, William. Rotating grate, with a hopper to supply coal.	*Not patented.*
1861.	479.	Dray, William.	*Patent void.*
1862.	1418.	Clark, William. Description only furnished.	*Not patented.*

II.—Grates provided with a Chamber, to contain Fuel, contiguous to the Fire.

1816.	3975.	Deakin, Thomas. Chamber at back of grate, from which the fuel is drawn forward.	*Patent expired.*
1825.	5190.	Atkins and Marriott. Chamber at back of grate, from which the fuel is drawn forward.	*Patent expired.*
1854.	1323.	Rawe, John, the younger. Chamber at side of grate, from which the fuel is raised into the fire below by means of a piston.	*Patent void.*

Date.	No. of Specification.		
1857.	2193.	Young, William. Chamber at back of grate.	*Not patented.*
1856.	663.	Leighton, John. Chamber at back and sides of fire, for the purpose of preparing coal for combustion. Description only furnished.	*Not patented.*
1856.	2202.	Young, William. Chamber in front of grate; screw to raise coal into fire, as shown in Figs. 25, 26 and 27.	*Patent in force.*

III.—Other Contrivances for introducing Coal below the Fire.

1816.	4001.	Dowson and Hawkins. Shovel, as shown in Figs. 28 and 29.	*Patent expired.*
1858.	595.	Juckes, John. A short description only furnished.	*Not patented.*
1859.	360.	Juckes, John. A short description only furnished.	*Not patented.*
1860.	2783.	Juckes, John. This is an ingenious contrivance, by which, the bars and bottom grate being each made to move on an axis, coal can be raised into the fire. As to its adaptability for general use, Mr. Juckes has by this time probably had such experience as to enable him to furnish testimony.	*Patent void.*
1862.	2867.	Nicholl, John Richard. Double metal back to grate made to form a chamber, when necessary, to receive coal for combustion, from which chamber the fire is supplied. Description only furnished.	*Not patented.*

IV.—System of a Double Fire.

1654.	2812.	Bachhoffner, Geroge Henry.	*Patent void.*
1858.	1599.	Bartlett, Thomas.	*Patent void.*

V.—Smoke Consumed or Prevented by a Downward Current for the Products of Combustion.

——.	——.	Stove exhibited at St. Germains, Seine et Oise, France.	
1791.	1798.	Collins, Benjamin Charles. Description only given, which it is impossible to understand.	*Patent expired.*
1854.	297.	Olding Henry. A similar plan to Mr. Marsh's, shown in Figs. 31 and 32.	*Patent void.*
1855.	670.	Williamson, Alexander William. A similar plan to the last.	*Patent void.*

Date.	No. of Specification.		
1856.	106.	Owen, William. Smoke carried down the back and side of the grate and under the fire to an ascending flue.	*Patent void.*
1856.	924.	Marsh, John. Mode shown in Figs. 31 and 32.	*Patent void.*
1856.	2848.	Cornwall, Frederick. Description only furnished.	*Not patented.*
1856.	2902.	Leslie, John. Description only furnished.	*Patent void.*
1857.	2477.	Fortescue, John. Description only furnished.	*Not patented.*
1858.	985.	Taylor, John. A mode similar to Mr. Owen's, but matured in a subsequent patent.	*Patent in force.*
1859.	683.	Cook, William. Description only furnished.	*Not patented.*
1859.	1662.	Taylor, John. Method shown in Figs. 33, 34 and 35.	*Patent in force.*
1862.	984.	Welch, Edward.	*Patent in force.*
1863.	850.	Pôtel, Jerome Jean. An ingenious contrivance, but adapted to stoves and furnaces, not to open grates.	*Patent in force.*

VI.—Grates provided with a Chamber to contain Coal for a Day's Supply.

1815.	3873.	Cutler, John. Method shown in Figs. 36 and 37.	*Patent expired.*
1846.	11035.	Tillett, George. Method described at page 30.	*Patent expired.*
1854.	——.	Arnott, Dr. Neill. Method shown in Figs. 38 and 39, also in Figs. 44 and 45.	
1854.	1168.	Jeakes, John William. Method shown in Figs. 40 and 41.	*Patent void.*
1856.	106.	Owen, William. A singularly complicated system of lifting.	*Patent void.*
1856.	173.	Hoole, Henry Elliott. A method of lifting the coal by chains and weights, similar to Mr. Cutler's.	*Patent void.*
1856.	355.	Stephen, Thomas. Apparently a slight modification of Dr. Arnott's method.	*Patent void.*
1857.	1272.	Hoole, Henry Elliott. Method shown in Figs. 42 and 43.	*Patent void.*
1857.	2331.	Goodchild, Thomas. Method shown in Figs. 54 and 55.	*Patent void.*
1859.	549.	Maxwell, Adams, Law and Inglis. A method of lifting the coal by means of a bar and lever in the upper part of the grate. Description only furnished.	*Not patented.*

Of the above list, the eight patents mentioned as having expired were granted previous to the Patent Laws Amendment Act coming into operation in 1852; the fourteen mentioned as not patented obtained only provisional protection, in consequence of a failure on the part of the applicants to furnish drawings of their contrivances, or to pay the necessary fees; of the seventeen patents which have become void, fourteen secured protection for three years only, and three for seven years; of the five patents still in force, two have secured protection to the end of seven years from the date of the patent, and one for fourteen years.

I selected from the specifications of the Patent Office all those which appeared to require investigation. There are some few of which no notice has been taken, and in which the means suggested are so inadequate to the end, or are so very absurd, that I could not even include them in the above list. Of the first description, one or two talk of reducing smoke by altering the shape of a fire bar; of the second, a Frenchman suggests the use of superheated steam, and another thinks that an open grate might be constructed with a dead surface of fire-brick on each side of the fire and at back, on which the bituminous fuel should be piled, to be supplied to the fire occasionally when in a fit state for active combustion. It is fair to state, however, that the two last plans were primarily adapted for furnaces, and that the allusions in the specifications to fire-grates may be considered incidental.

Fig. 1. Old fashioned chimney opening and grate, similar to what existed in Count Rumford's time.

Fig. 2. The same opening reduced by pieces of stone or marble *a*, and fire-brick covings *c*.

Fig. 3. Plan of fire-place, showing the sloping covings and back *c*, and the brick-work behind them *b*, to contract the fire-place.

Figs 1. 2. 3.

Fig. 1.

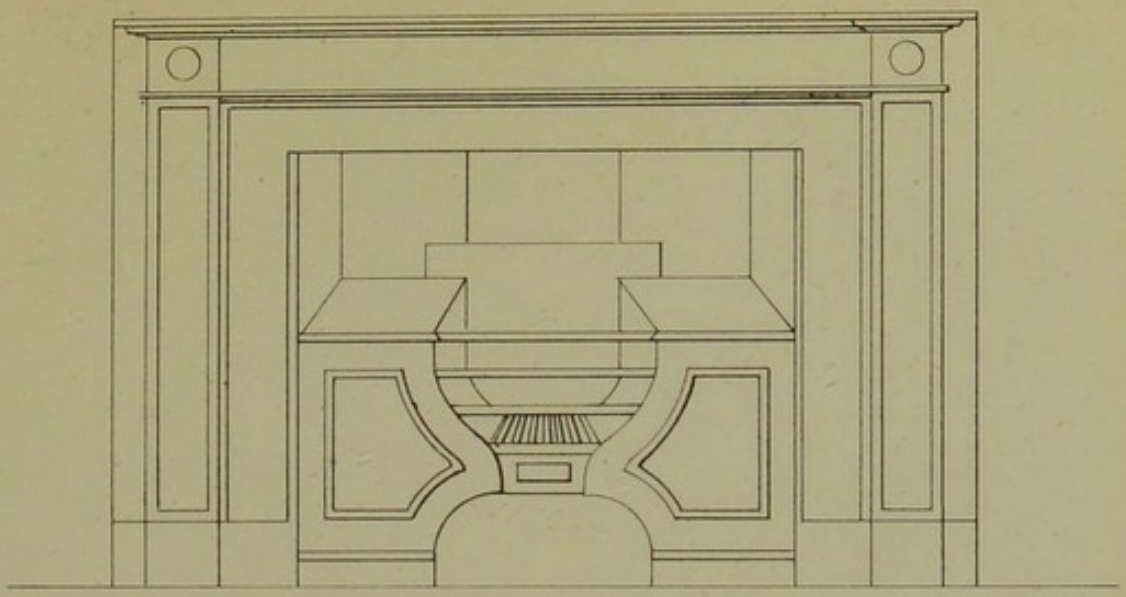


Fig. 2.

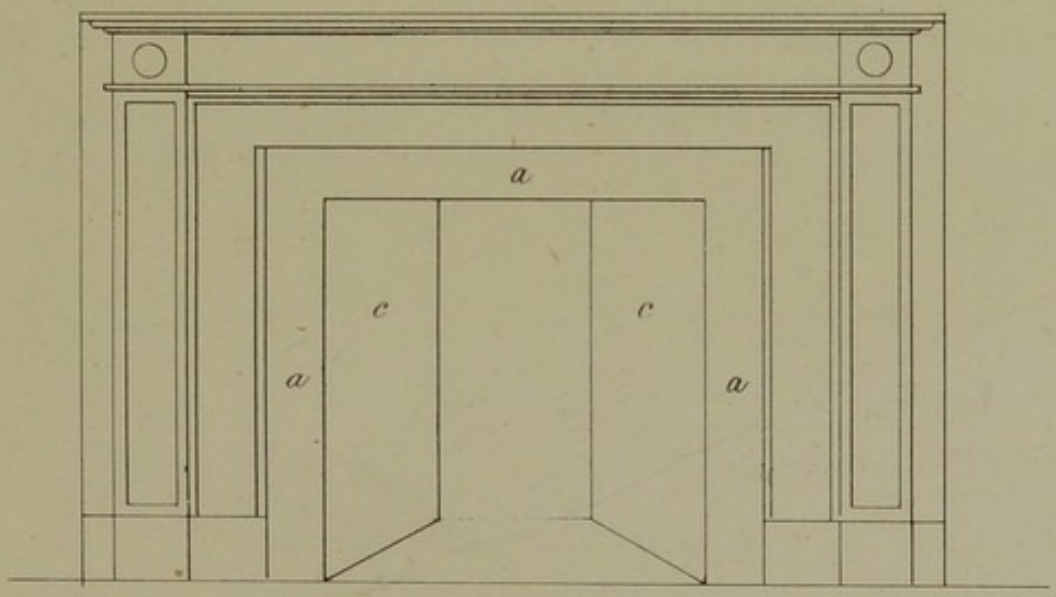


Fig. 3.

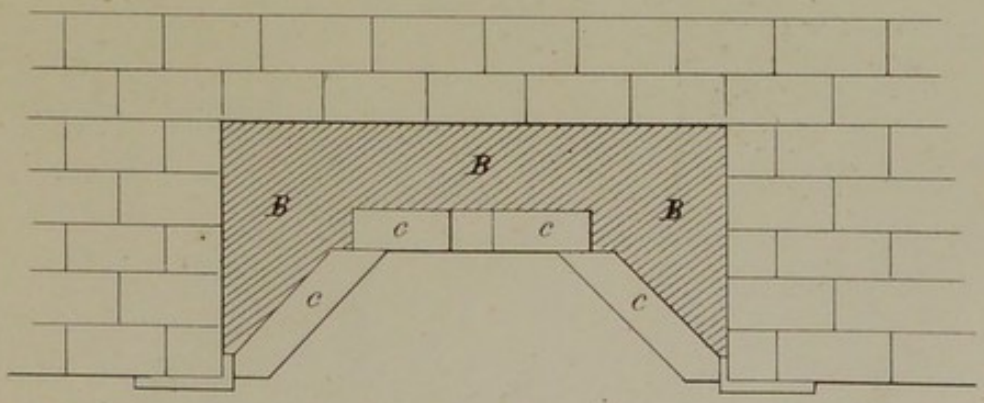


Fig. 4. Transverse section of fire-place before being altered by Count Rumford.

Fig. 5. The same fire-place with the Count's additions; *a*, the breast of chimney, *b*, addition below, *c*, *c*, brick-work to reduce fire-place.

Fig. 6. A Thames Street grate, made entirely of metal.

Fig. 7. Transverse section of Fig. 6.

Figs. 4 to 7.

Fig. 4.

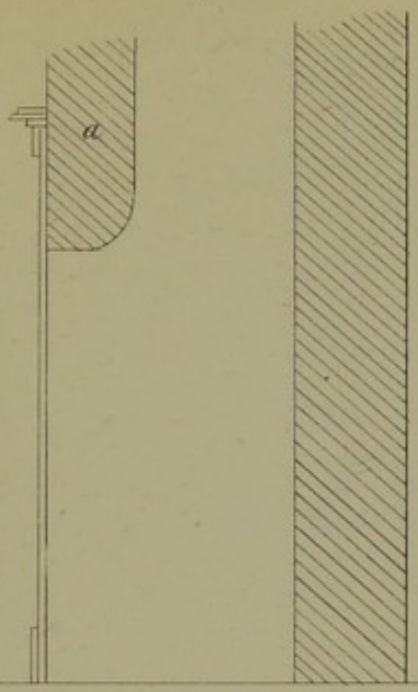


Fig. 5.

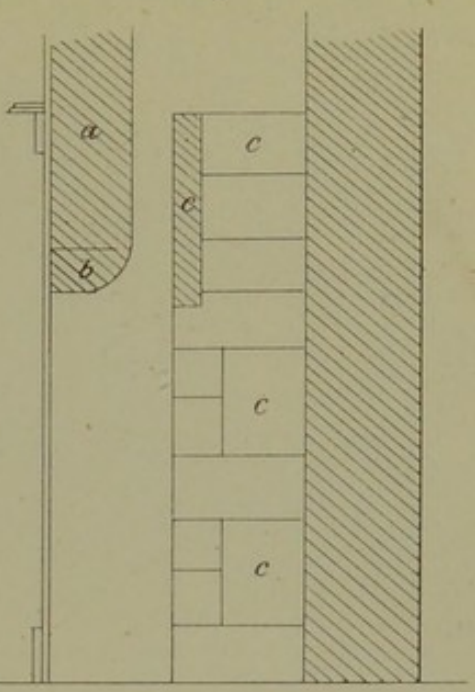


Fig. 6.

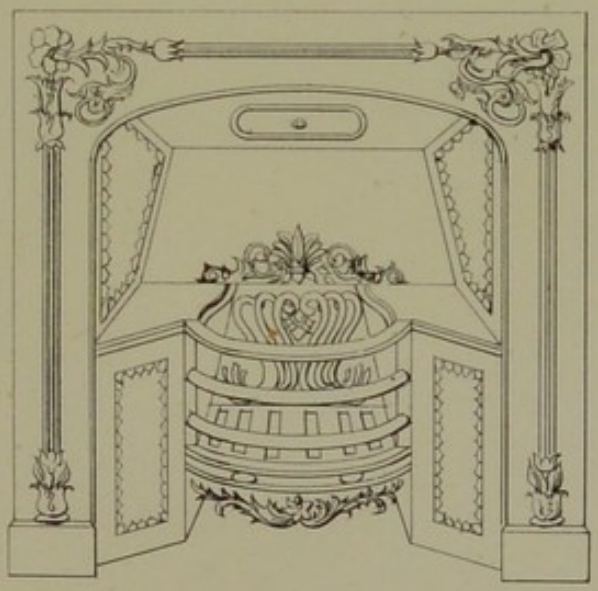


Fig. 7.

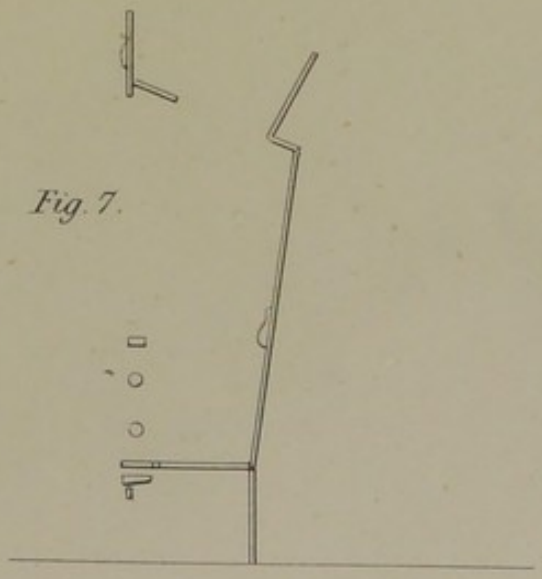


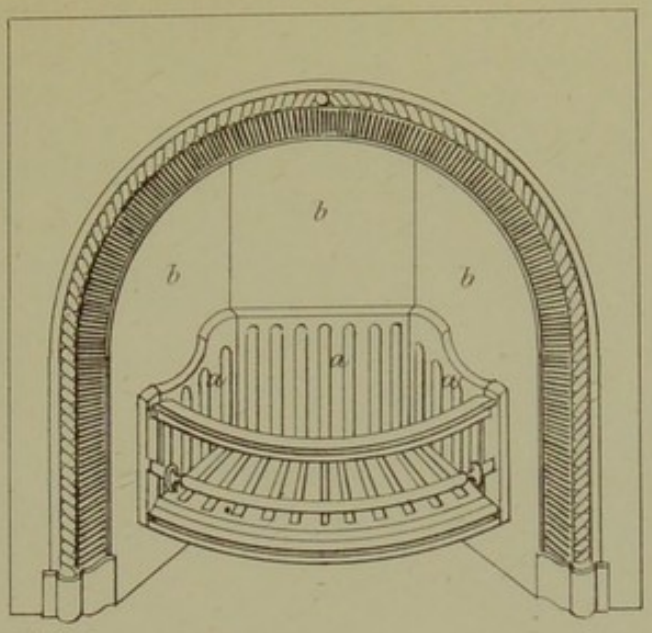
Fig. 8. An ordinary grate of Sheffield manufacture: *a*, *a*, *a*, fire-brick; *b*, *b*, *b*, metal.

Fig. 9. Section of Fig. 8, showing the register door *c*, and a rack *d*, to graduate the opening.

Fig. 10. A grate showing fire-brick, *a*, *a*, *a*, continued to the register in the chimney.

Figs 8. 9. 10.

Fig. 8.



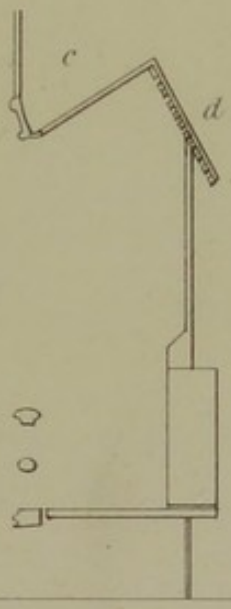
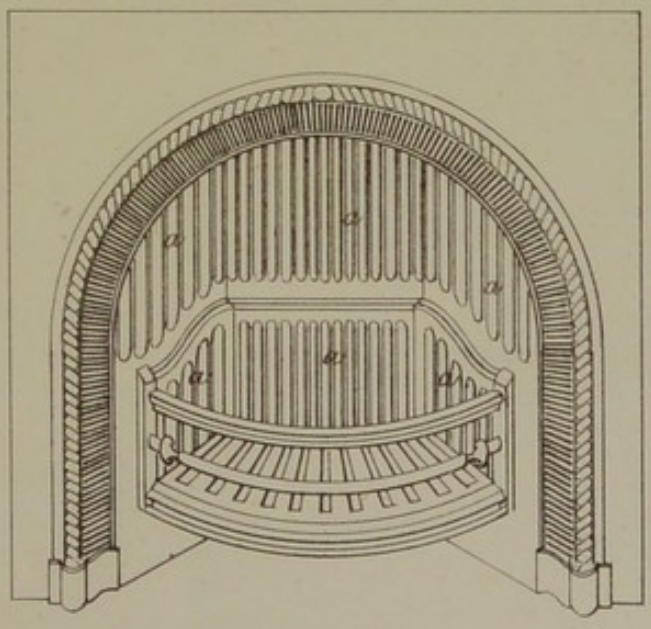


Fig. 9.

Fig. 10.



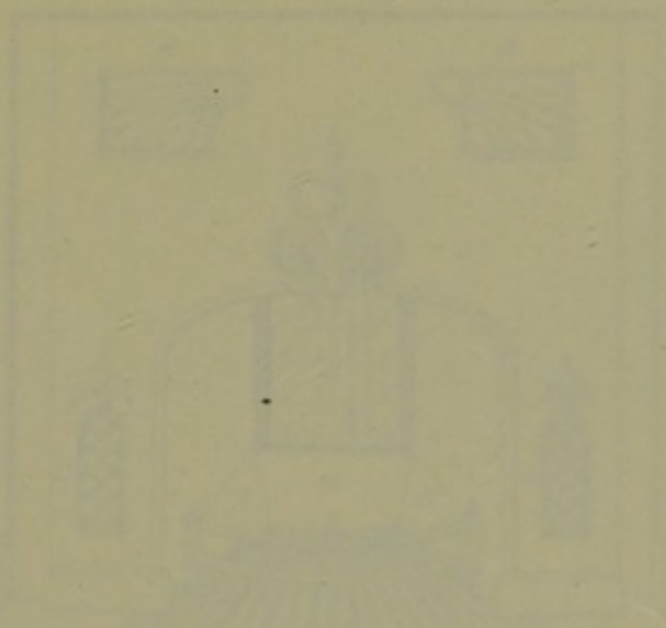


Fig. 11. Sylvester's Patent Grate: *a*, *a*, *a*, radiating bars; *b*, *b*, *b*, Venetian plates between which the smoke passes to the chimney; *c*, *c*, openings for air to enter the warm air chamber from the room; *d*, *d*, openings for the warm air to escape into the room; *g*, *g*, *g*, fire-brick.

Fig. 12. Transverse section showing the chimney *e*, and the ash pit *f*,

Fig. 13. A separate radiating bar of Sylvester's grate.

Figs. 11. 12. 13.

Fig. 11.

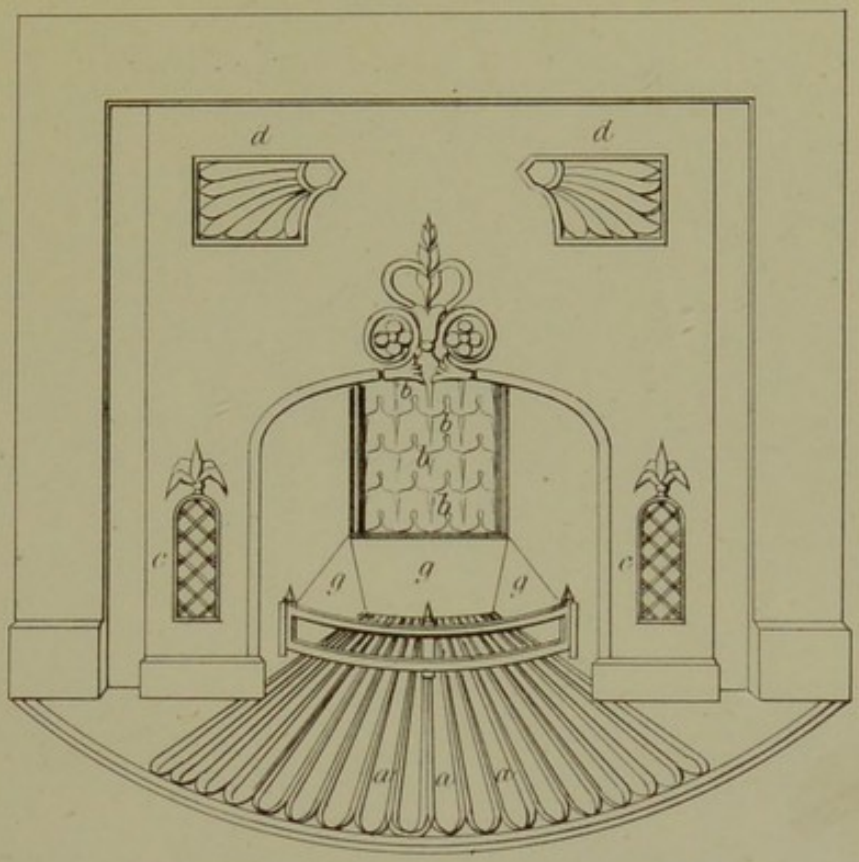


Fig. 12.

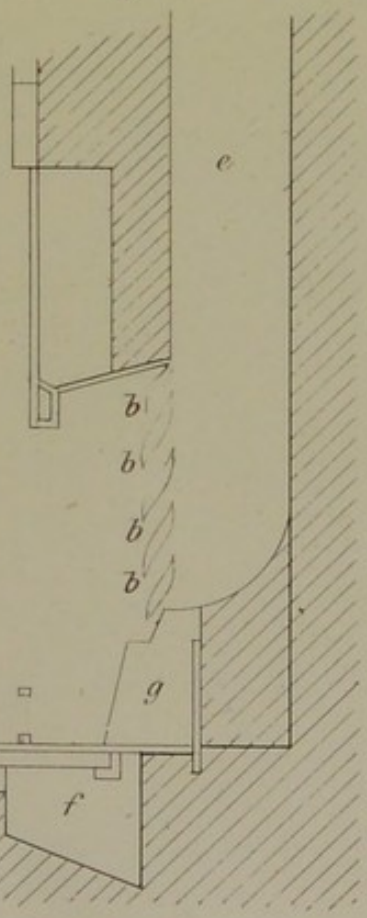


Fig. 13.

Fig. 14. Stephen's grate: *a*, an arched recessed plate over the fire; *b*, the door opening into the chimney by which the smoke escapes; *c*, an ornamental cover to ash-pan; *d*, *d*, *d*, fire-brick.

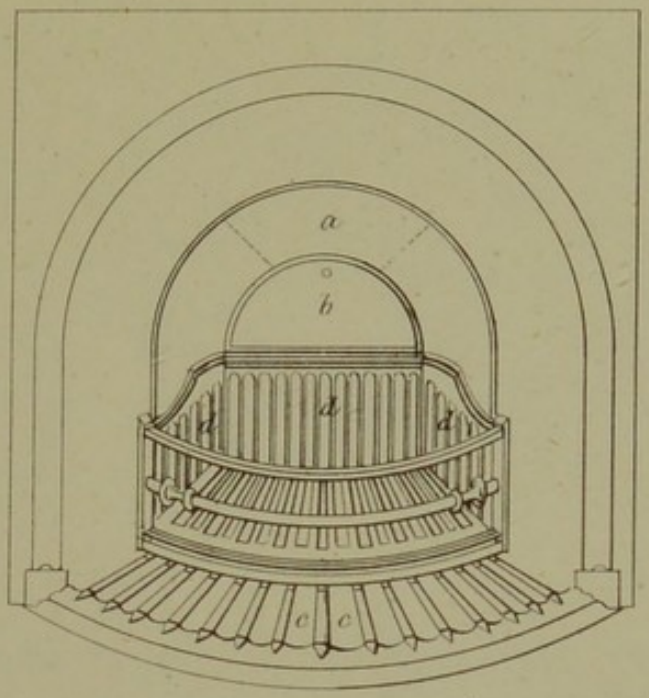
Fig. 15. Transverse section of Stephen's grate, showing the door *b*.

Fig. 16. King's grate: *a*, an inclined plate of metal over the fire to reflect heat; *b*, a door (suspended by chains and weights) by which the smoke escapes, which door is moved up or down by a poker; *c*, *c*, *c*, fire-brick.

Fig. 17. Transverse section of King's grate, showing the door *b*.

Figs. 14. 15. 16. 17.

Fig. 14.



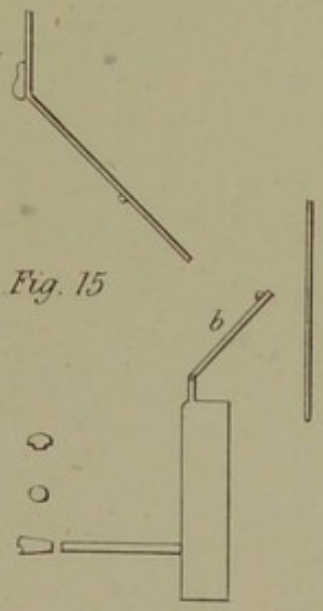


Fig. 15

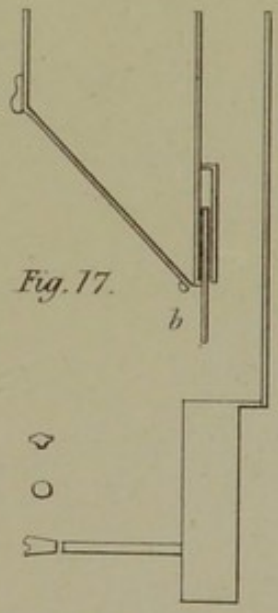


Fig. 17.

Fig. 16.

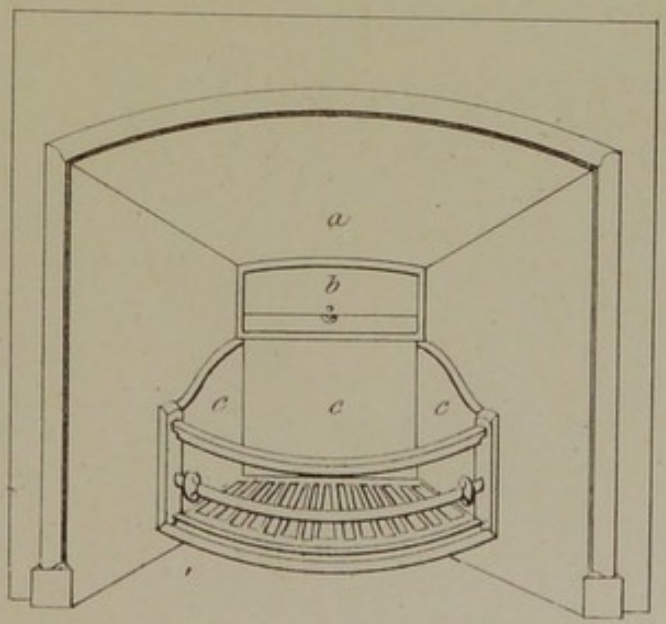


Fig. 18. Sketch of a grate provided with a warm air chamber behind; *a*, *a*, sliding valves by which the air is admitted.

Fig. 19. Fire-brick grate made by Mr. Pierce.

Fig. 20. John Lee Stevens's patent grate.

Fig. 21. Transverse section showing the hollow chamber *b* behind the fire, and the guard *c* to cause the air ascending the chamber to act on the fire.

Figs 18 to 21.

Fig. 18.

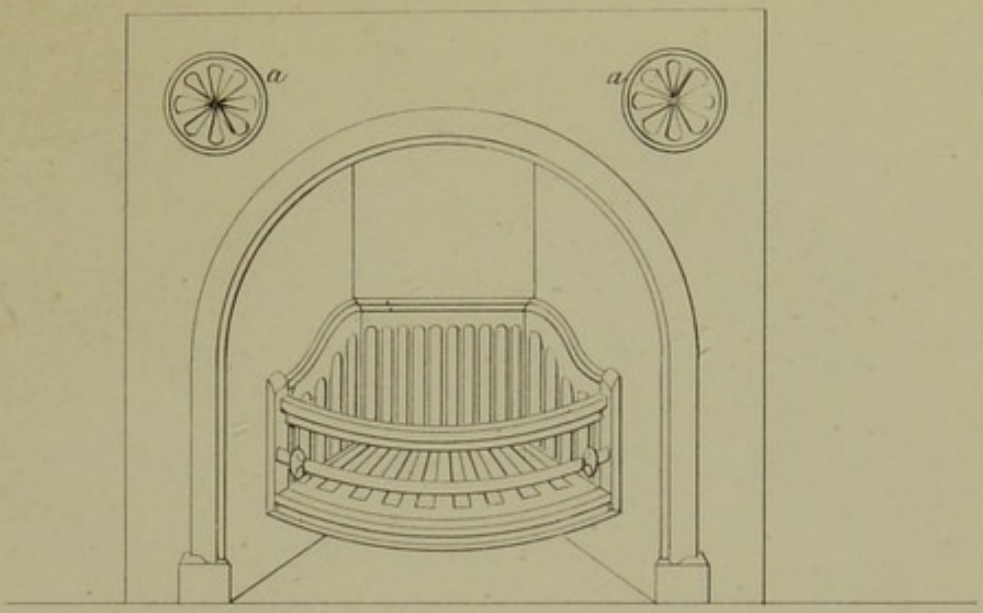
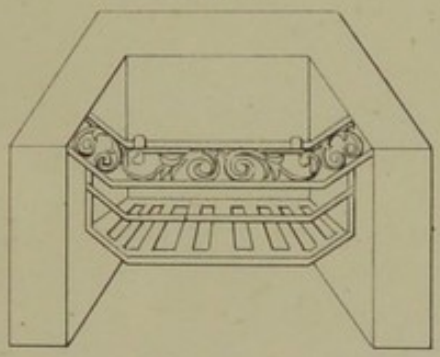


Fig. 19.



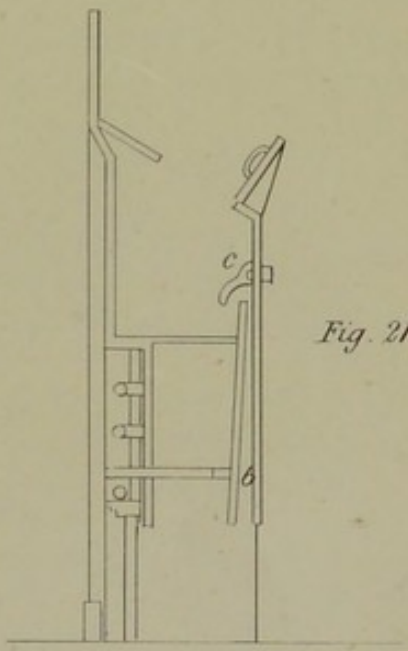


Fig. 21.

Fig. 20.

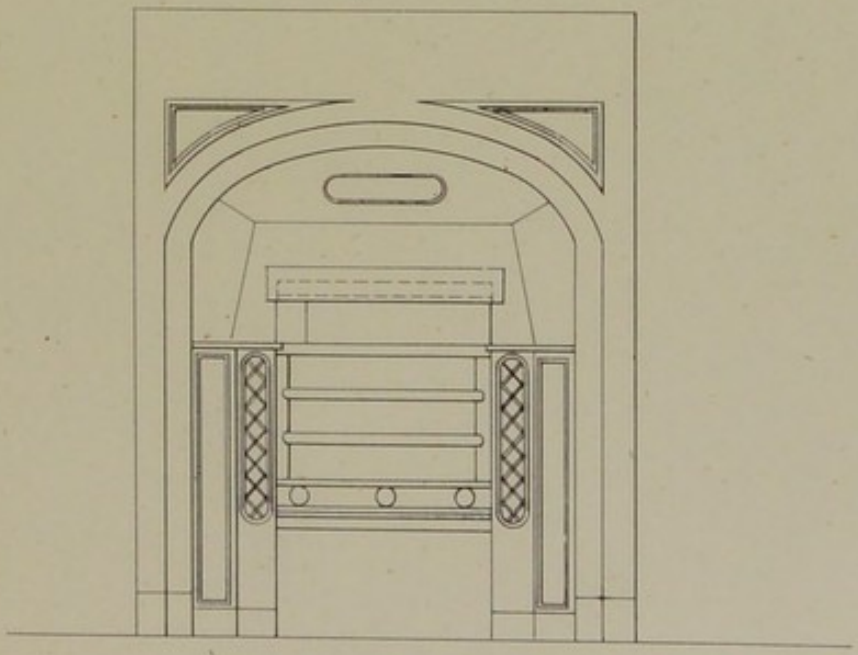


Fig. 22. Dr. Franklin's fire-cage; *a*, *a*, moveable bars; *b*, *b*, joints by which the cage hangs on the support *c*; *d*, a joint on which the cage, including the support, is made to revolve; *e*, a stand to which the whole is attached.

Fig. 23. Side view of Fig. 22.

Fig. 24. Spencer's patent rotating grate: *a*, *a*, metal sides fixed to the ground to support the cage; *b*, *b*, joints on which the cage hangs, and is made to move; *c*, handle to turn the cage over.

Fig. 25. Young's Patent Smoke-Consuming Grate: *a*, *a*, chamber to contain coal; *b*, *b*, screw to raise the coal into the fire; *c*, aperture by which a handle or bar is made to work the screw.

Fig. 26. Transverse section of Fig. 25.

Fig. 27. Screw *b*, *b*, used in the chamber of Fig. 25.

Figs. 22 to 27.

Fig. 23.

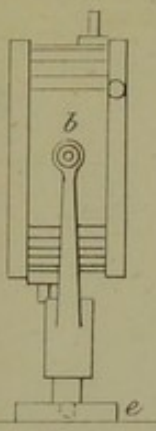


Fig. 22.

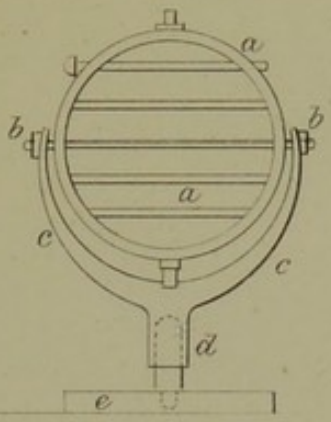


Fig. 24.

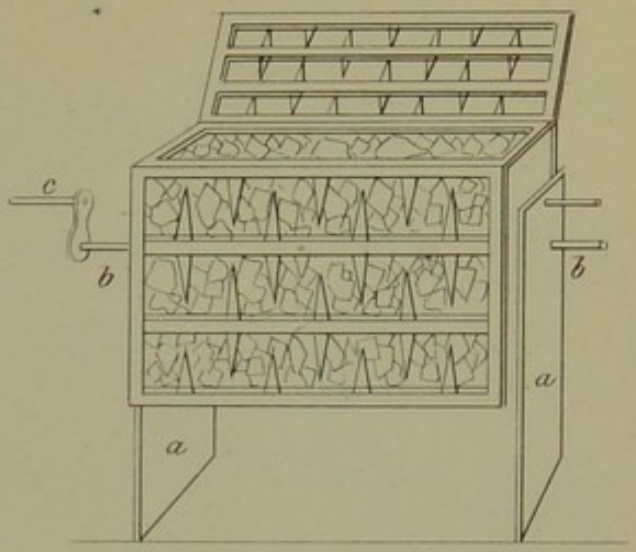


Fig. 25.

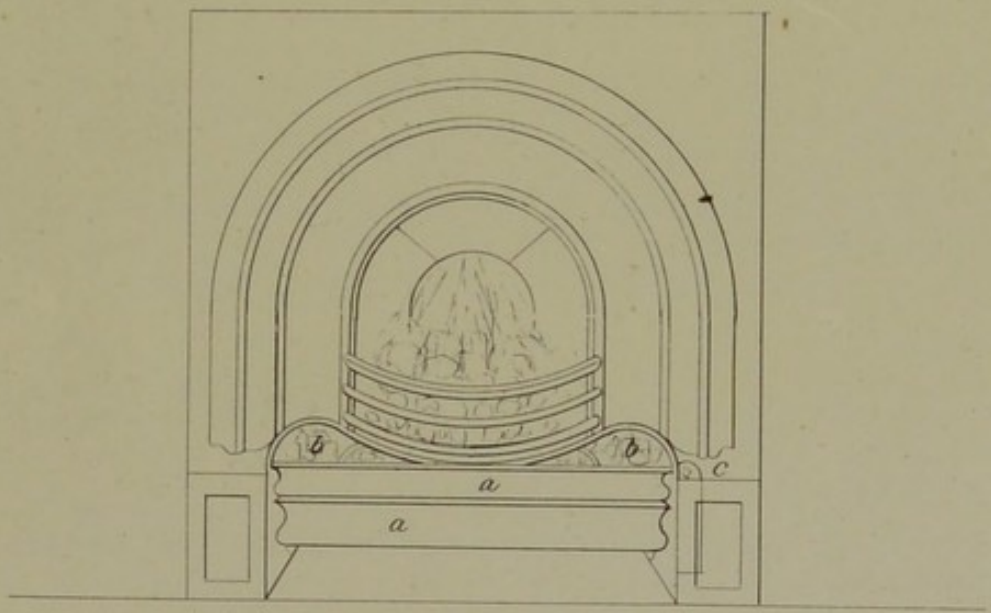


Fig. 26.

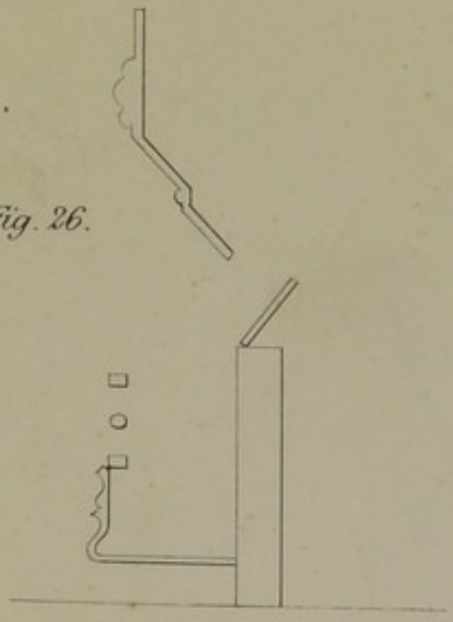


Fig. 27.

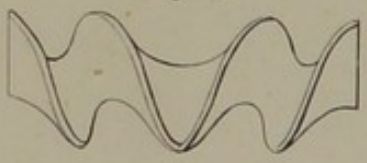


Fig. 28. Dowson and Hawkins's patent feeding shovel for grates: A, the chamber to contain coal; *c*, the handle; *b*, the moveable rod attached to a piston in the chamber; *e*, the lid.

Fig. 29. Section of Fig. 28, showing the piston attached to the moveable rod *b*.

Fig. 30. Transverse section of a smokeless grate, exhibited in 1860 at St. Germains, Seine et Oise: *a*, the vase to contain coal; *b*, a chamber below; *c*, the channel for the exit of the products of combustion.

Fig. 31. Marsh's patent grate for consuming or preventing smoke; *a*, a door opening into the chimney; *b*, *b*, apertures for the escape of the products of combustion when the door *a* is closed.

Fig. 32. Transverse section of Fig. 31. The dotted lines show the position of the door *a* when thrown open.

Figs 28 to 32.

Fig. 29.

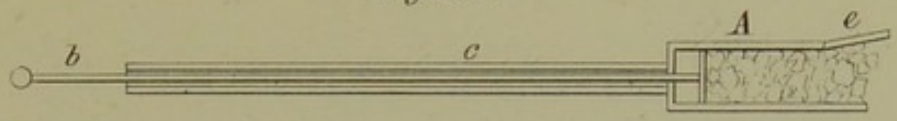


Fig. 28.

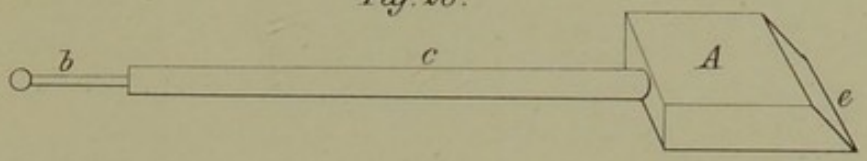


Fig. 31.

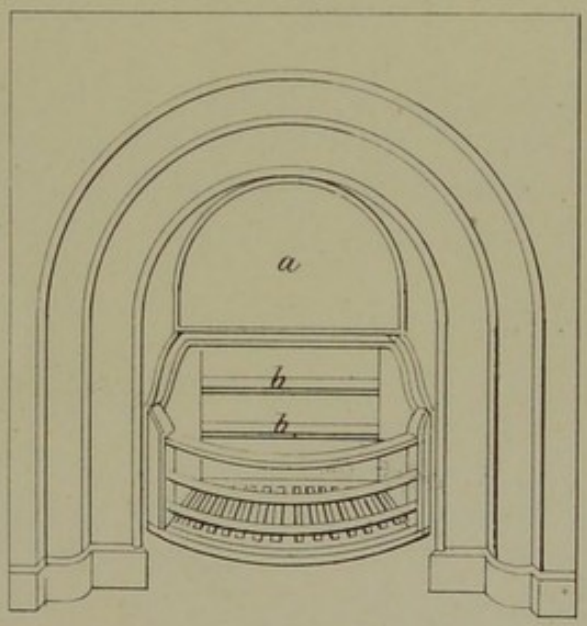


Fig. 32.

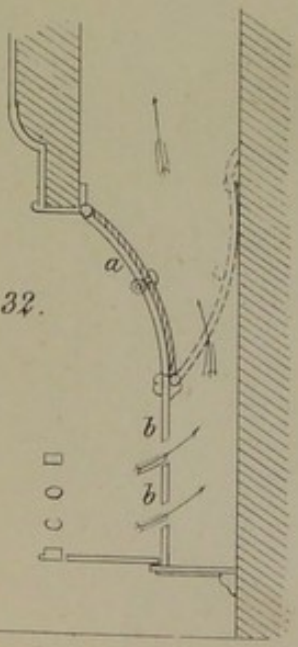


Fig. 30

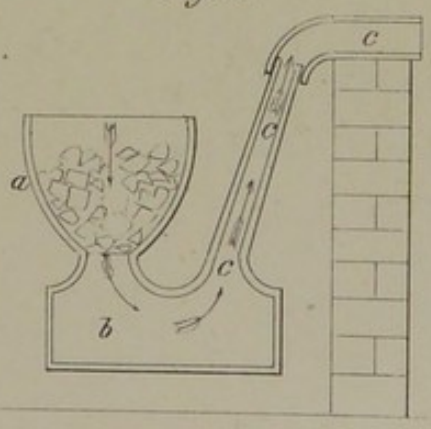


Fig. 33. Taylor's Patent Smoke-Consuming Grate: *e*, *e*, *e*, openings through which warm air passes into the room; *d*, *d*, *d*, hollow fire-bricks.

Fig. 34. Longitudinal section of Fig. 33; *d*, *d*, *d*, the hollow fire-bricks; *a*, the door opening into the chimney, the position of which when thrown back is indicated by the dotted lines; *b*, *b*, *b*, the circuit flue.

Fig. 35. Another method of Mr. Taylor's shown in longitudinal section. The heated products are supposed to divide and pass off in opposite directions by the flues *b*, *b*, into a space below the fire bars, and then to ascend a flue behind the grate.

The figures have been taken from Mr. Taylor's Specification, but have been reduced and simplified.

Figs. 33. 34 & 35.

Fig. 33.

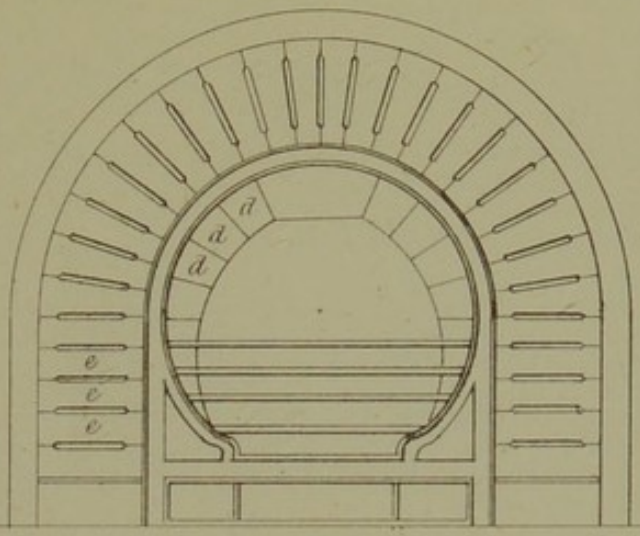


Fig. 34.

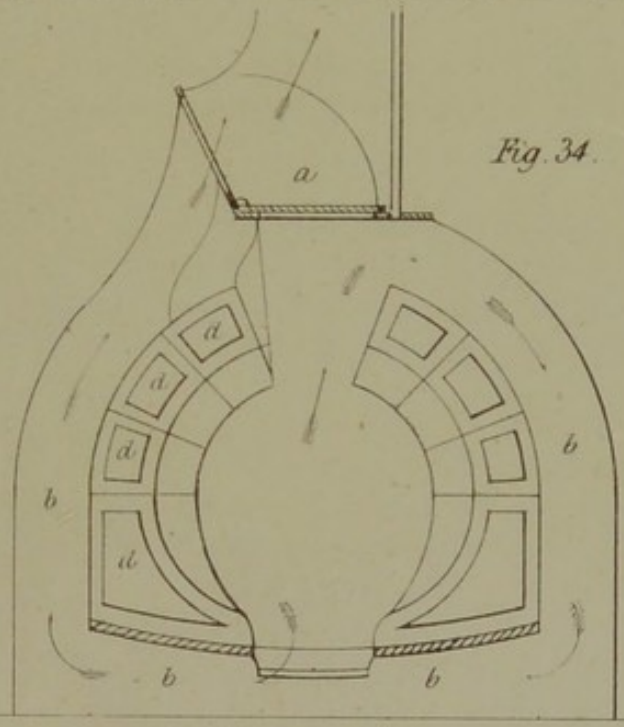


Fig. 35.

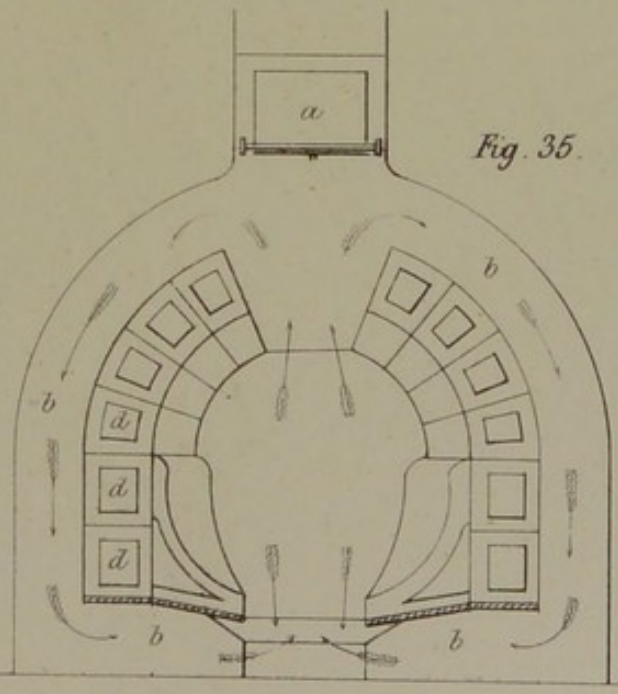


Fig. 36. Cutler's Patent Smoke-Consuming Grate: *a*, *a*, the chamber to contain the coals; *b*, *b*, the moveable bottom; *c*, *c*, the chains attached to the bottom; *d*, the handle for winding the chains on the pole *e*, for the purpose of raising the bottom.

Fig. 37. Horizontal section of Fig. 36: *e*, the pole ou which the chains are wound; *f*, the aperture in front of the grate where the handle is introduced; *g*, a wheel attached to the pole, and placed in connection with a socket wheel turned by the handle *d* in Fig. 36.

Fig. 38. Dr. Arnott's grate: *a*, the coal chamber; *b*, the lifting bottom; *c*, the lifting rack; *d*, a metal hood to contract the opening into the chimney; *e*, a channel for the supply of air from an exterior source. This sketch is taken from Dr. Arnott's work on Warming and Ventilation.

Fig. 39. Transverse section of Fig. 38, showing the regulator *f*, and the handle, *g*, to move it.

Figs. 36 to 39.

Fig. 36.

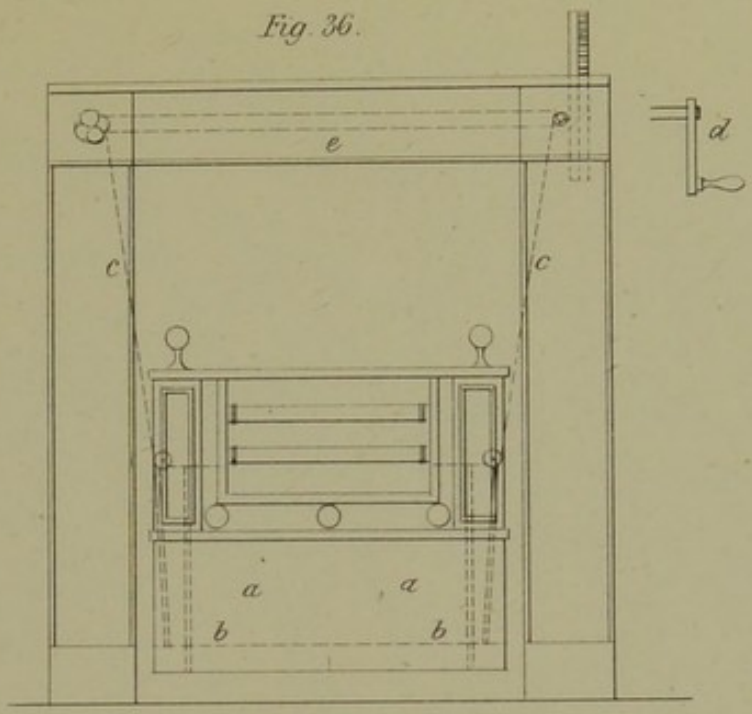


Fig. 37.

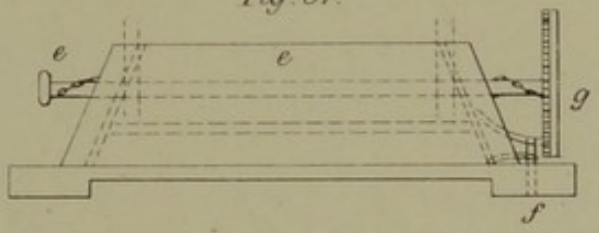


Fig. 38.

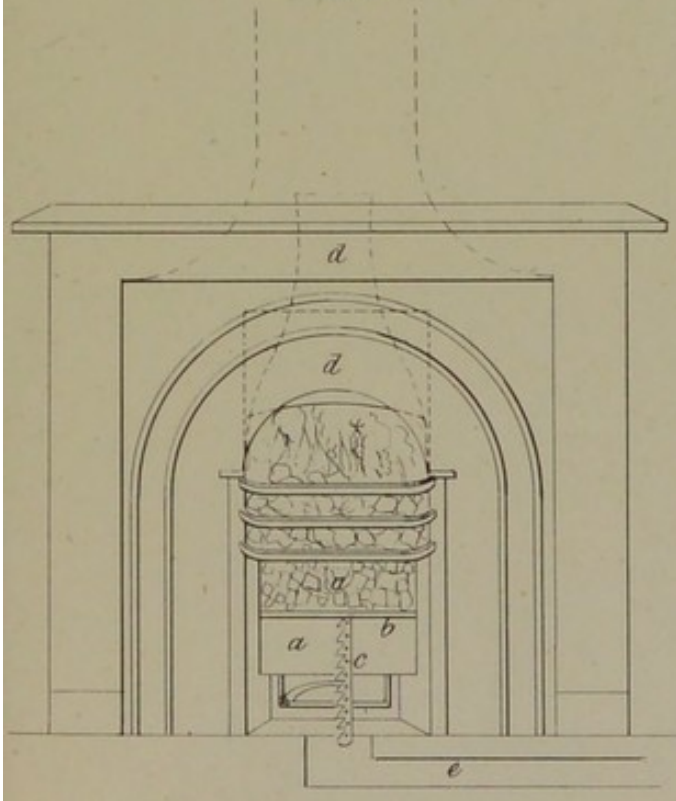


Fig. 39.

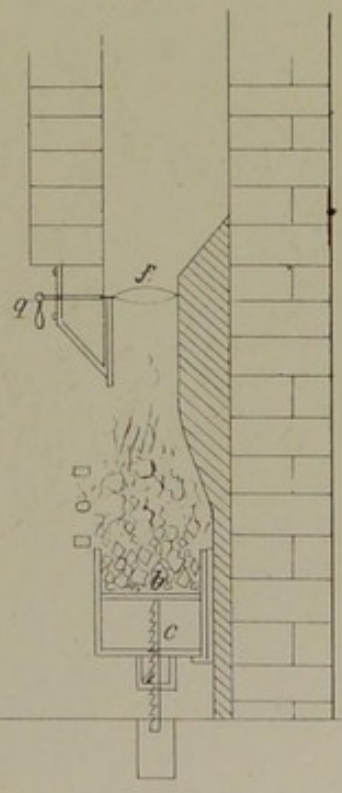


Fig. 40. Jeakes's Patent Smoke-Consuming Grate: *a*, *a*, *a*, *a*, the portion of grate including the bars, which is raised or lowered by the rack *b*.

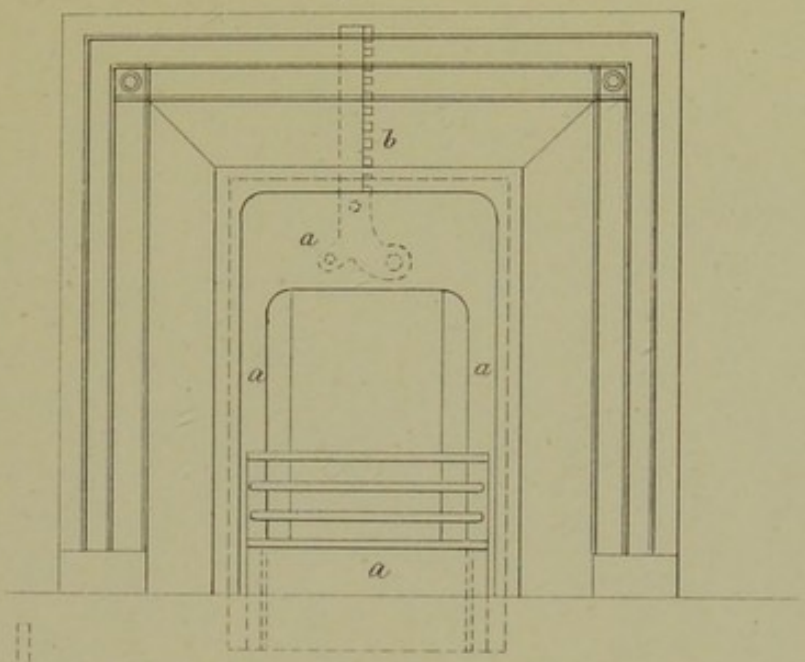
Fig. 41. Transverse section of Fig. 40: *a*, *a*, *a*, the moveable portion of the grate; *b* the rack; *c* a handle attached to a rod and socket wheel for moving the rack; *d* an ash pit, into which the moveable part of the grate is lowered.

Fig. 42. Hoole's Patent Smoke-Consuming Grate: *a* the chamber to contain the coal; *b* the wheel by which the coal is lifted.

Fig. 43. Transverse section of coal chamber in Fig. 42: *b* the wheel to lift the screw *c*, and the bottom of the chamber *d*. The wheel has a number of apertures in its periphery to receive a lever or poker for the purpose of turning it.

Figs. 40 to 43.

Fig. 40.



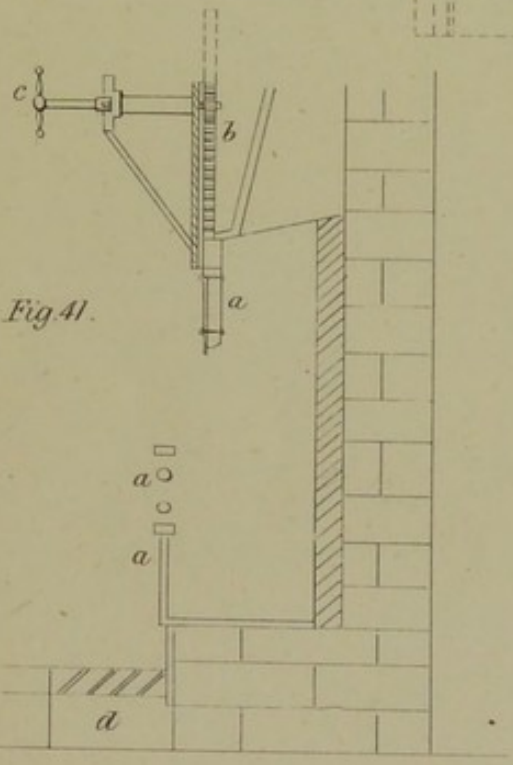


Fig. 41.

Fig. 43.

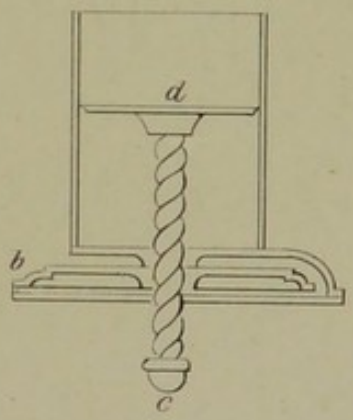
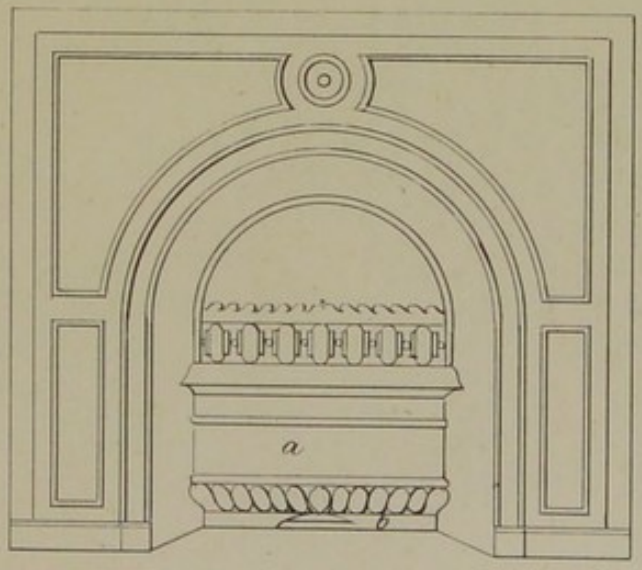


Fig. 42.



Figs. 44 to 51.

Fig. 44.

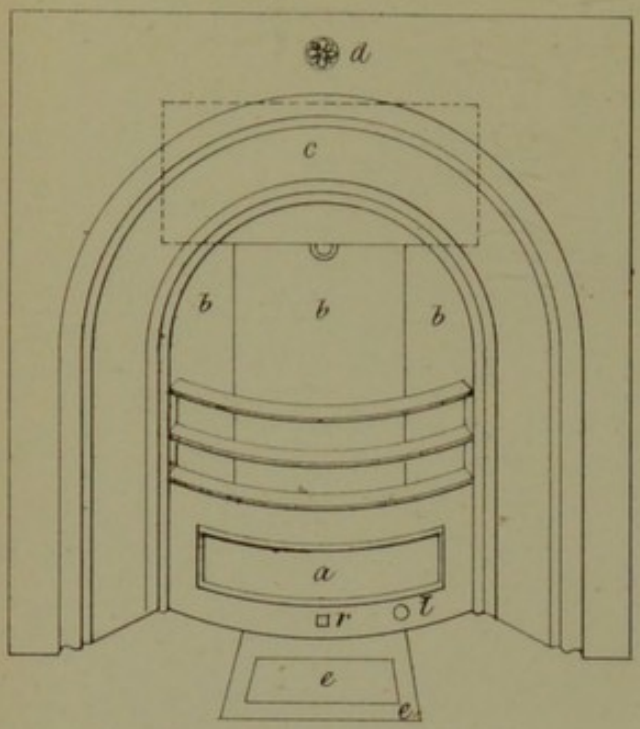


Fig. 45.

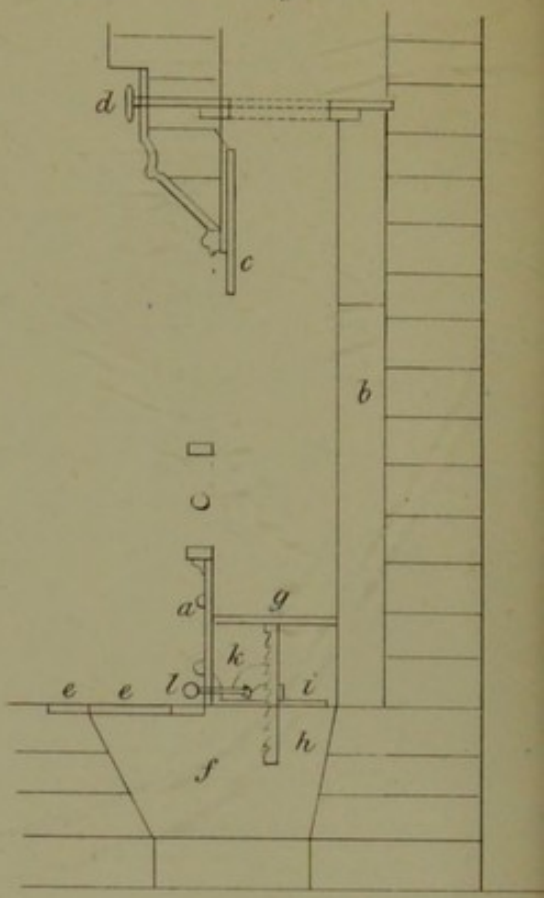


Fig. 46.

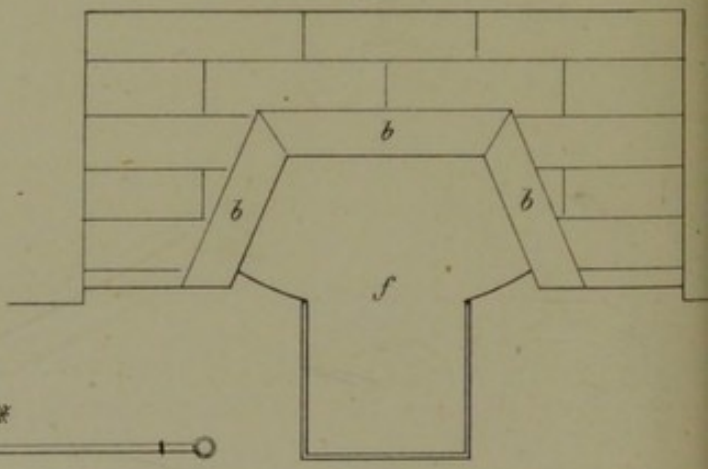


Fig. 48.

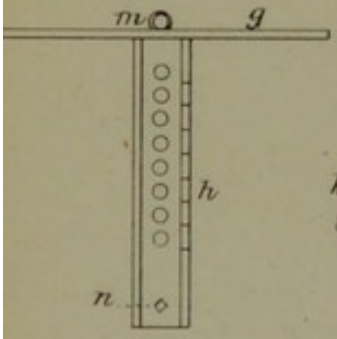


Fig. 47.

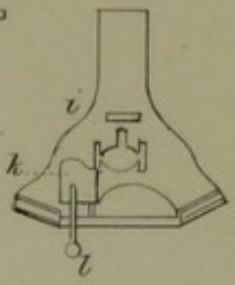


Fig. 50. *

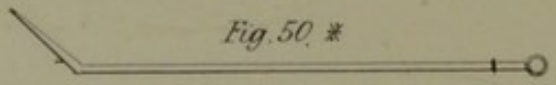


Fig. 49.

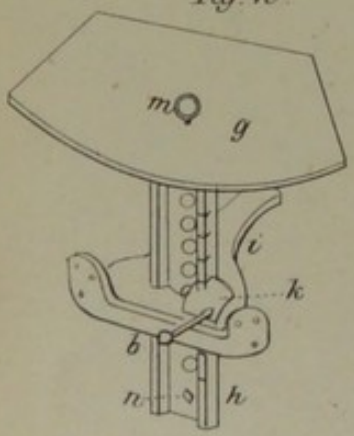


Fig. 51.

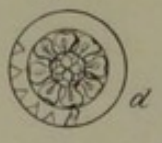


Fig. 50.

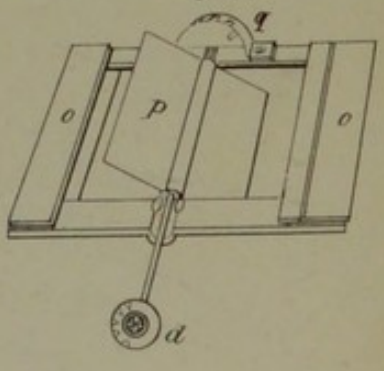


Fig. 44. Grate on Dr. Arnott's principle, as manufactured by the author's firm: *a*, the front of the coal chamber; *b*, *b*, *b*, fire bricks at the back and sides of the grate; *c*, a sliding blower shown by the dotted lines as pushed up out of sight; *d*, handle to check the ascent of heated air in the chimney; *e*, *e*, an iron frame and a cover rebated into the hearth in front of the grate, through which the ashes are removed from below.

Fig. 45. Transverse section of the grate Fig. 44, as fixed in a fire-place; *f*, an ash-pit; *e*, *e*, the frame and cover rebated into the front hearth-stone; *a*, an iron plate, forming a part of the grate below the bars, and the front of the coal chamber; *b*, fire-brick back of grate and coal chamber; *c*, the blower; *d*, the handle to move the regulating valve; *g*, the lifting bottom of the coal chamber; *h*, the rack on which the bottom *g* is fastened; *i*, the frame-work fastened to the grate, by which the rack and lifting bottom are supported.

Fig. 46. Horizontal section or plan of ash-pit, &c.; *f*, ash-pit; *b*, *b*, *b*, fire-brick back and sides of coal chamber and grate.

Fig. 47. An iron frame, *i*, attached to the bottom part of the grate by means of four pins and nuts, and made to carry the plate and rack Fig. 48, as shown in Fig. 49. Attached to the frame is a "catch" or rachet, *k*, which falls into notches of the rack *h*, to maintain it in any required position. The "catch," *k*, is attached to a rod and knob *l*, in front of the grate.

Fig. 48. The rising plate and rack: *m*, is a hook by which the plate can be lifted by the hand; *n*, a screw with a square head inserted after the rack has been introduced into its place in the central aperture of frame Fig. 47. This screw acts as a stop to prevent the rack being lifted beyond a certain point by the lever in raising the coals.

Fig. 49. Shows the Figs. 47 and 48 attached.

Fig. 50. Regulating valve for the chimney attached to the grate at *d*; *o*, is a frame of iron carrying a plate, *p*, turning on a spindle. This plate is capable of being moved backwards or forwards within the limit of about a quarter of an inch. When in its forward position it can be turned freely by the handle, *d*. When pushed backwards it becomes caught between one of the notches in a graduated rack, *q*, and can be thereby fixed in any required position.

Fig. 51 is a brass plate attached to the grate at *d*, having a portion graduated to correspond to the rack, *q*, in Fig. 50, and the words open and shut engraved on its face. The spindle of the valve of Fig. 50 passes through the centre of this plate, and is provided with a handle, and a brass finger to indicate on the brass plate or dial the position of the valve in the chimney.

Fig. 51*. A lever used to lift the bottom of the coal chamber.

In fixing the grate care is required to form the ash-pit of the exact size of the lifting bottom, *g*, with an opening to it through the front hearth a little smaller than the iron frame, *e*. The hearth should then have a rebate cut in it so that the frame may be on a level with the top edge

of the stone. The fire bricks, *b*, should be fixed perfectly upright, and so as to allow of a space of about a sixteenth of an inch between them and the bottom of the chamber, *g*. The frame of the regulating valve, Fig. 50, should be supported by brickwork carried up to it on the top of the fire bricks, *b*.

To raise coal from the chamber, the lever, Fig. 51*, is inserted at the aperture, *r*, at the bottom of the grate. It passes over the front bar of the frame, Fig. 47, on which it rests as a fulcrum, and enters one of the holes in the rack, *h*. If forced downward the rack is lifted, and with it the bottom, *g*, and superincumbent coal. The catch, *k*, falling into a notch of the rack holds it in its new position. The plate, *g*, is not lifted higher than the bottom bar of the grate, being prevented by the screw, *n*, in the rack, *h*.

There is only one method of raising the coal, in which the "catch," *k*, is self-acting; but there are three methods of lowering the bottom of the chamber, and in neither is the catch, *k*, self-acting. 1. When no fire is burning, the plate, *g*, can be raised slightly by the hook, *m*, in the left hand, and if, at the same time, the catch is pulled forward by the small knob, *l*, in front of the grate, the plate can be let down to its lowest position. 2. Another method is to put in the lever, and lift the weight slightly by it. If, then, the knob, *l*, is held forward and the lever is withdrawn, the bottom of the chamber and its contents descend to the lowest position. 3. The third method is the same as the last, but applied so as to lower the coal by successive stages. The lever is inserted and the weight lifted; the "catch" is then pulled forward and the lever raised. If, then, the "catch" is let go and the lever is withdrawn, the rack descends a short distance till held again by the catch. This repeated two or three times suffices to lower the contents of the chamber. The first method is the simplest, and should be used before lighting the fire; the second is usually adopted when a fire is burning that it is considered desirable to extinguish; but as this sometimes causes dust to fly about, the last is preferable.

Care should be taken to remove the ashes from the pit two or three times a week by means of the small shovel provided. If this is neglected, the rack in rising carries up dust with it, the frame, *i*, gets covered and clogged, the catch, *k*, ceases to act, and the consequence is a suspension of the proper working of the apparatus. The remedy is to clean out the ash-pit, to withdraw the screw, *n*, by inserting the hand through the hole of the ash-pit, *e*, to pull up the plate and rack by the hook, *m*, to clear away the dust, and then restore the whole, as at first.

In some grates there is a slight difference in one or two of the parts, the knob, *l*, attached to the catch, *k*, being made to be pressed downward, or to be turned, instead of pulled, forward: and in others there is a small hole made in the hearth instead of the ash-pit described.

The above particulars are given in the hope that they may be useful to some of those who have used the grate, and who have not been familiar with the various parts which are not usually visible.

Fig. 52. An ash pan for a Dr. Arnott's grate, to be let into the hearth.

Fig. 53. A cover for Fig. 52, with openings between the bars.

Fig. 54. Showing the end of a poker sharpened for the smokeless grates.

Fig. 55. Mr. Goodchild's grate: *a*, a metal guard to protect the coal. The fire bars behind are shown by the dotted lines.

Fig. 56. Transverse section of Fig. 55, showing the metal guard *a*, the door into the chimney *b*, and the ash drawer *c*.

(The last two figures are taken from Mr. Goodchild's specification.)

Figs 52 to 56.

Fig. 52.

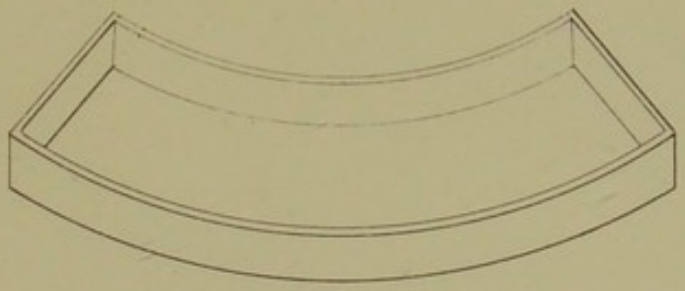
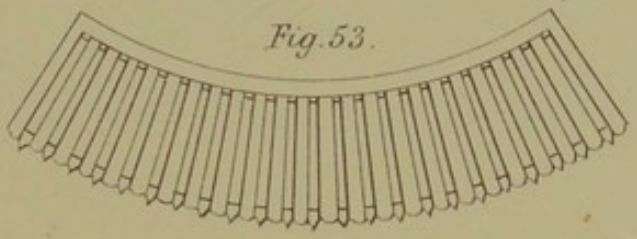


Fig. 53.



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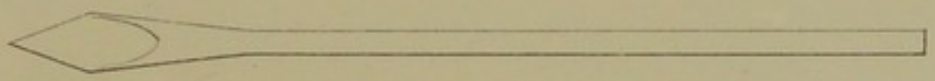


Fig. 56.

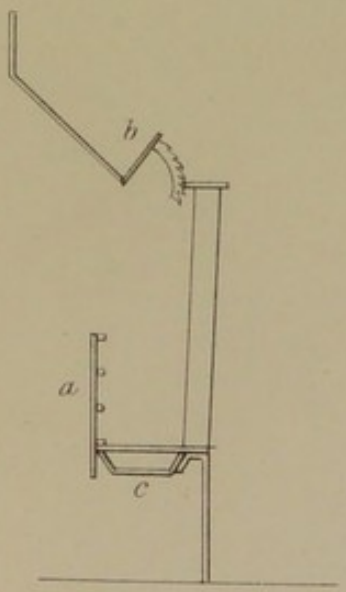


Fig. 55.

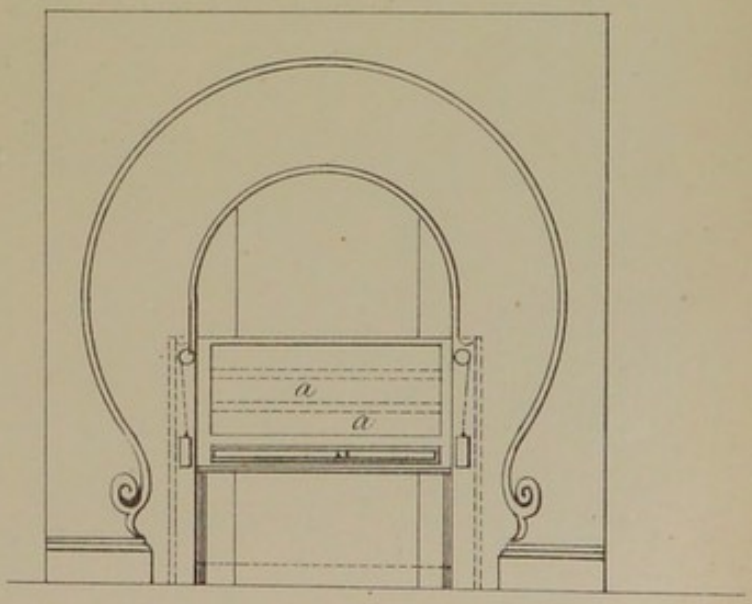


Fig. 56*. Ash-pan, with regulator to admit air, for use with an ordinary grate, as suggested by the author.

Fig. 57. Fire-brick chamber to receive coals, suggested by the author in lieu of the ordinary metal grate.

Fig. 58. A similar fire-brick chamber, but of a different form.

Fig. 59. Ash-pan, with regulator to be used with the fire-brick chambers Figs. 57 and 58.

Fig. 60. Top fire-brick, to be used with the brick chamber Fig. 57: *a*, an inclined slab of fire-brick to radiate heat from the fire.

Fig. 61. Top fire-brick, to be used with the brick chamber Fig. 58: *a*, an inclined slab of fire-brick to radiate heat from the fire.

Fig. 62. A chamber grate, with the brick chamber Fig. 58; the top fire-brick, Fig. 61, with the inclined slab *a*; the ash-pan, Fig. *d*, 59; and a regulator *b*, to check the escape of the heated air.

Fig. 63. Transverse section of Fig. 62, showing the inclined slab *a*, the regulator *b*, *b*, the brick chamber *c*, and the ash-pan *d*.

Fig. 64. A grate similar to Fig. 62, fitted with ornamental tiles with the brick chamber, Fig. 58, and the top fire-brick, Fig. 61.

Figs. 56 to 64.

Fig. 56.

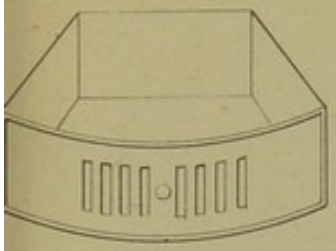
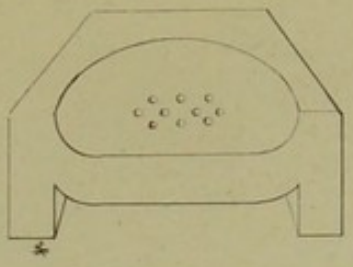


Fig. 57.



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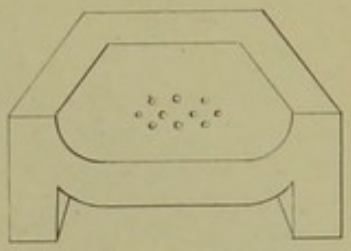
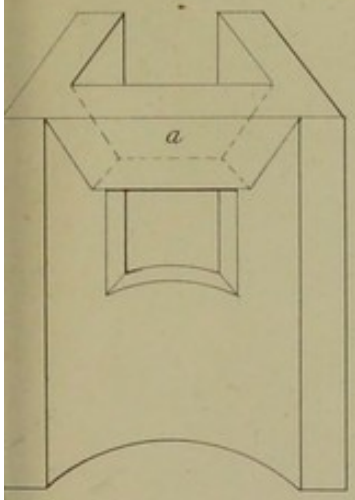


Fig. 59.

Fig. 60.



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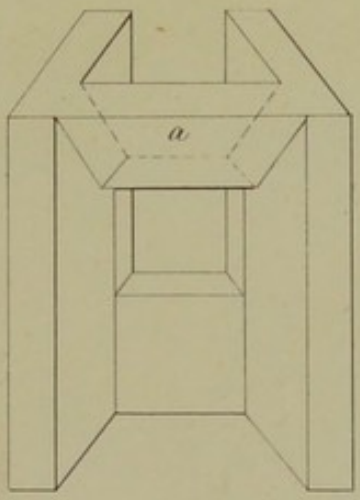

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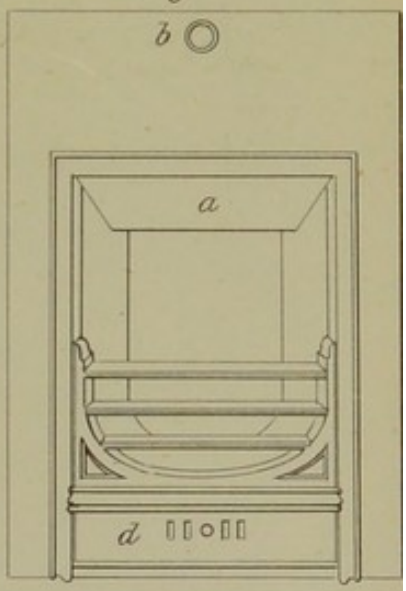


Fig. 63.

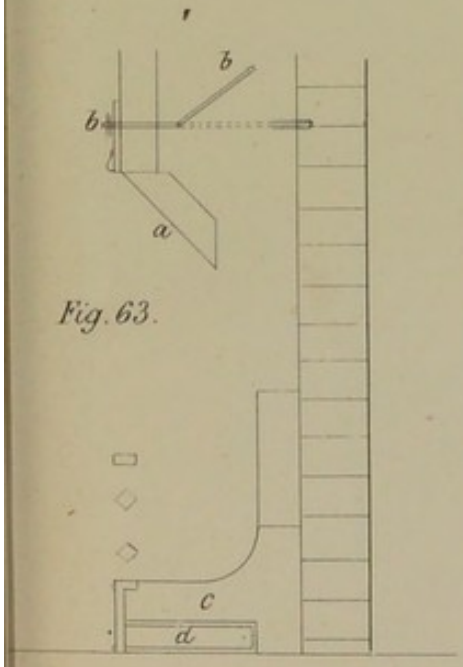


Fig. 64.

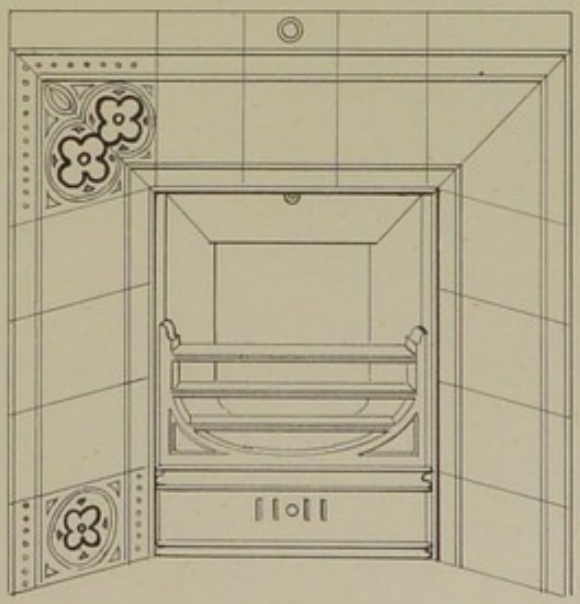


Fig. 65. An improved grate, constructed with Mr. King's door shown by the dotted lines: *a*, regulator to admit air to the fire; *b*, *b*, regulators to admit air from an external source; *c*, ornamental ash-pan; *d*, *d*, *d*, *d*, fire-brick.

Fig. 66. Transverse section, showing a ventilating flue, *f*, above the grate.

Fig. 67. Horizontal section of chimney, showing the warm air chamber, *e*, and a ventilating flue *f*.

Fig. 68. A new smokeless grate adapted for bed chambers; *a*, *a*, *a*, projecting pieces on which the guard or cover, Fig. 69, is hooked; *b*, the inclined slab of fire-brick; *c*, *c*, *c*, fire-brick; *f*, regulating valve in chimney; *g*, ash-pan.

Fig. 69. Guard or cover to protect coal from the action of the air.

Figs. 65 to 69.

Fig. 67.

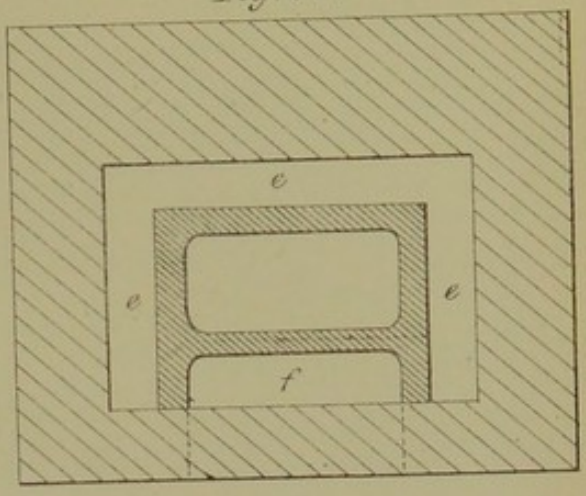
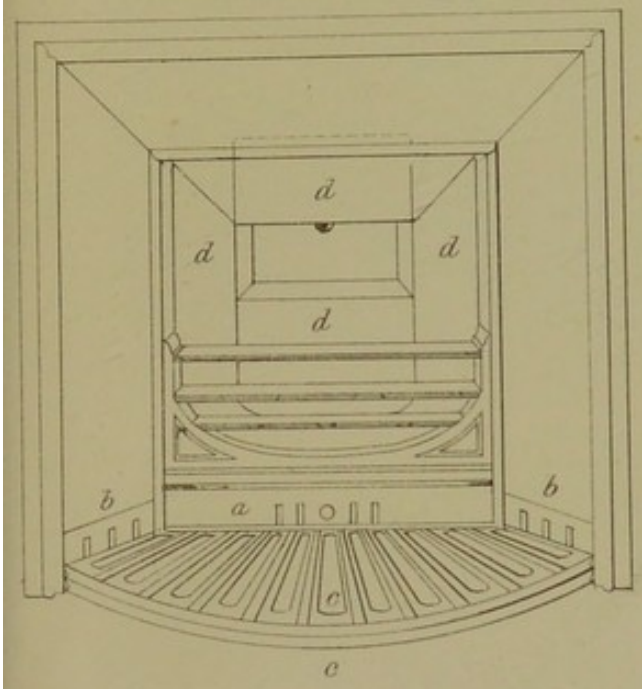


Fig. 65.



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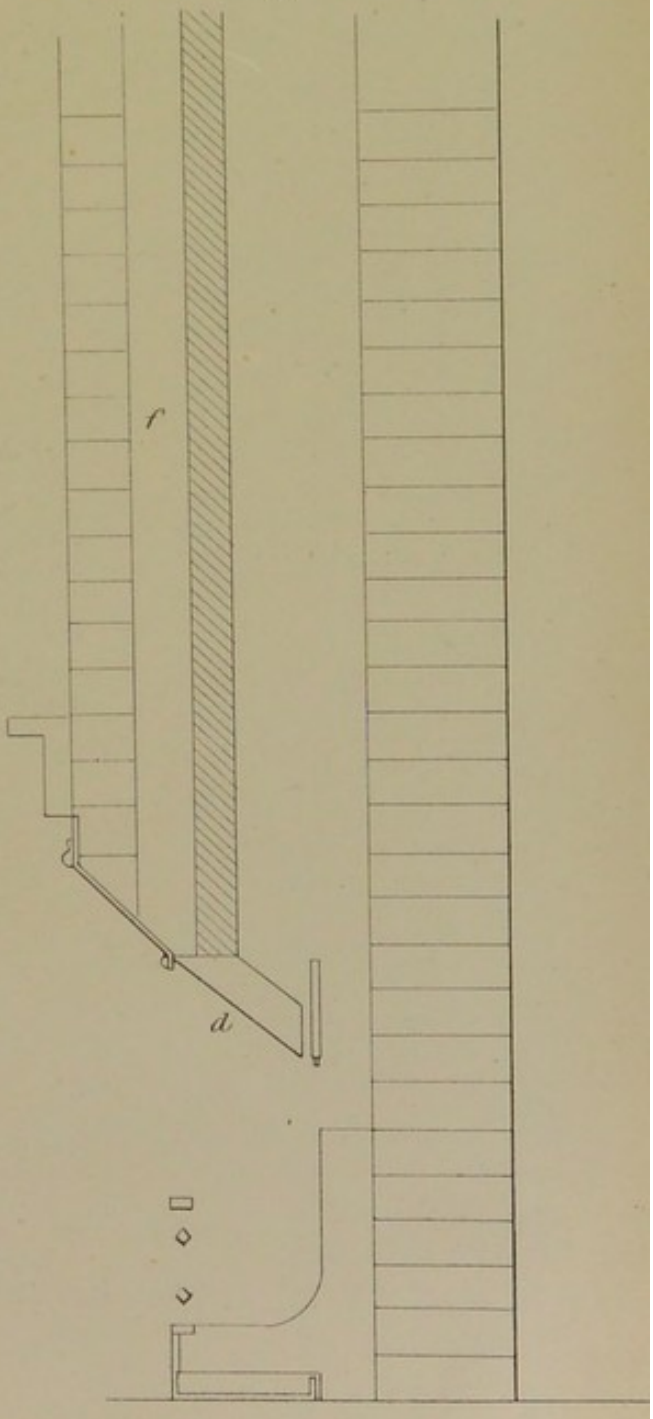


Fig. 68.

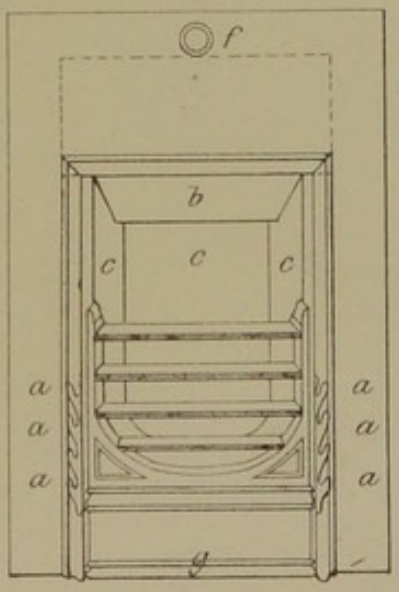


Fig. 69.

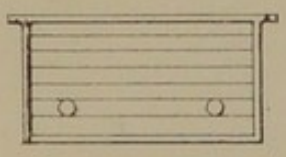


Fig. 70. A new smokeless grate, suggested by the author: *a*, a metal shutter, to be moved up or down by a poker, in front of the coal; *b*, *b*, chains and weights by which the shutter is supported; *c*, *c*, *c*, fire-brick; *d*, regulator to chimney; *e*, sliding blower indicated by dotted lines.

Fig. 71. Transverse section of Fig. 70: *a*, the blind or shutter; *c*, *c*, *c*, fire-brick; *d*, *d*, regulator to chimney; *f*, ash pit in front of the grate; *g*, pan to receive ashes.

Fig. 72. A similar grate to Fig. 70, with ornamental bars and an ash-pan.

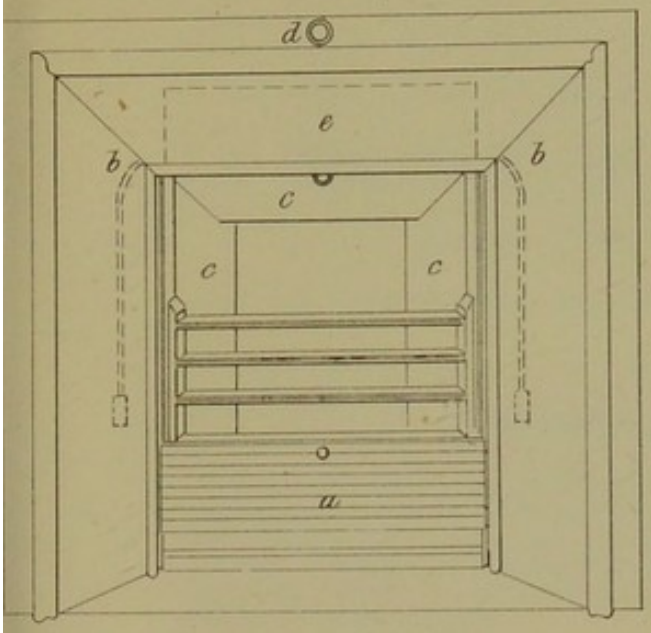
Fig. 73. A pokerette for stoking a smokeless fire.

Fig. 74. A raker, for extending or depressing the blind in Fig. 70, &c.

Fig. 75. A coal hammer.

Figs 70 to 75.

Fig. 70.



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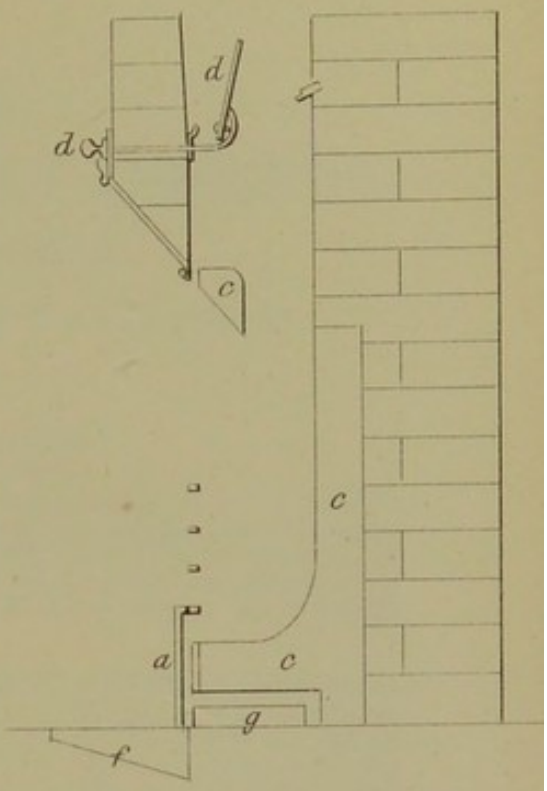

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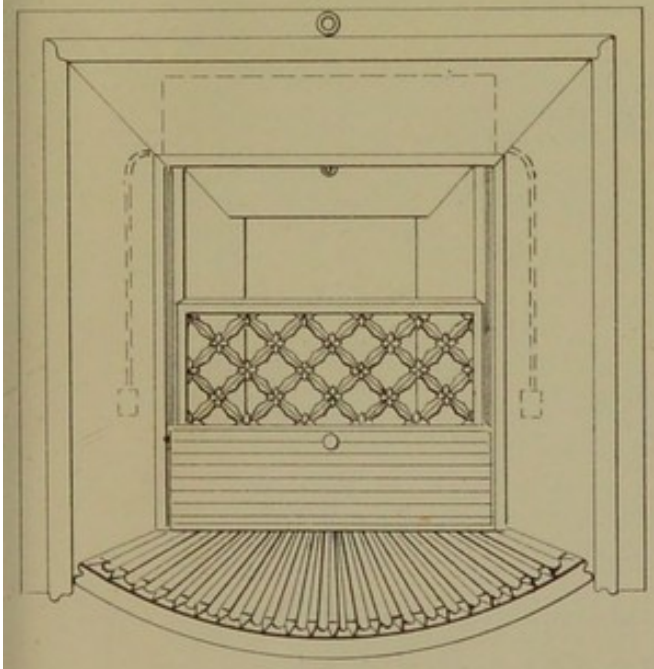

Fig. 74.

Fig. 75.

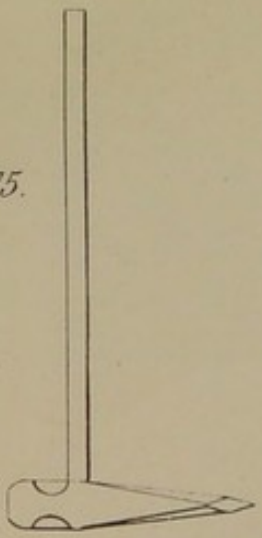

Fig. 73.

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