comparison with a good Abbotsford grate with solid clay bottom, back and sides, the figures would have appeared seriously the other way.

In a room of exactly half the cubic area of the one referred to by Dr. Siemens we have an Abbotsford grate a little over ⅓rd cubic foot capacity, the actual measurement of the fire space being 5½ inches deep, 8 inches back to front, 14 inches wide. This is lighted at 7 o'clock every morning and at 10 o'clock the grate is filled (not piled high). This fire burns until 10 or 11 o'clock every night untouched, practically smokeless, making the room pleasantly warm all over in the severest weather, and without making a *handful of cinders in a month*. One ordinary boxful of coals lasts two days. We have five, sometimes six, fires going daily at an average cost for coal for the winter season of five shillings weekly, or less than twopence per day per fire. That Dr. Siemens is correct so far as the old style of fire-grate is concerned, I know to my cost, but taking any good grate with clay sides and back and a solid clay bottom, his fire at its best will not compare either for cleanliness, economy, or comfort.

Gas fires are wanted where absolutely no attention and dust can be permitted. Allowing either of these as possible, no substitute I know will approach a well-constructed open fire with a solid clay bottom and fire-box.

With regard to the waste heat, it is no greater than absolutely necessary to take away the products of combustion, as, with our grates, it is utilised for warming the upper rooms. At this moment, with five good fires, there is visible from the tops of our chimneys nothing except a clear transparent current of warm air; any one at a cursory glance would say there were no fires in the house.

It must be borne in mind when I refer to cost that we cook entirely by gas, and the price of good coal here is 14*s.* 2*d.* per ton, coke being about half this price. What is required in a gas fire is a perfectly clean source of radiant heat, without trouble, and quickly available: these conditions are not in any way fulfilled by Dr. Siemens' arrangement. With the exception of two or three minutes expended in lighting, all he has attained can be found in a more perfect form in many of the fire-grates which have been in common use for the last ten years. Amongst our many attempts at gas fires one, although not absolutely the same as Dr. Siemens', was practically so, and was condemned because it required as much trouble as our present fires, and was much slower in lighting. It would be both interesting and instructive if Dr. Siemens would test an Abbotsford grate under the same conditions as his coke gas fire, and supplement his report with one from the individual who has to do the cleaning up and dusting, a department which it is more than probable he ignores.

Another important matter is that I believe the cost of making and fixing Dr. Siemens' grate would be not less than that of a good modern fire-grate.

THOS. FLETCHER

Warrington

THROUGH your courtesy I am enabled to reply to the objections raised by three correspondents against my proposed gas-coke grate, before they have actually appeared in your columns.

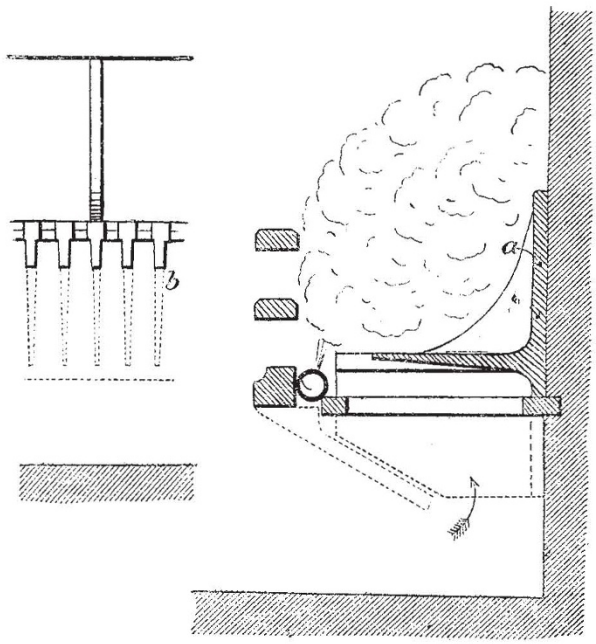
Mr. D. A. Stevenson considers that the use of coke is objectionable on account of the gases evolved in its combustion, and especially the carbonic oxide gas, which would poison the atmosphere. In reply I have to say that in burning coke with a supply of hot air, and in contact in front of the grate with the atmosphere, its entire combustion is insured, resulting in carbonic acid, which is a necessary constituent of our atmosphere. In obtaining the same amount of heat through the perfect combustion of gas, products of combustion at least equally objectionable from a sanitary point of view will be evolved.

The gas-asbestos grate which he describes appears to be judiciously contrived, but its power of heating the room depends entirely upon the combustion of gas unaided by hot air or solid fuel. Now 1000 cubic feet of gas weigh about 34 lbs., and the heat developed in the combustion cannot exceed $34 \times 22{,}000 = 748{,}000$ units of heat.

The heat units produced in burning a pound of coke may be taken at 13,400 (assuming it to contain about 8 per cent. of incombustible admixture, the heat equivalent of pure carbon being 14,500 units), and it requires $\frac{748{,}000}{13{,}400} = 56$ lbs., or just half a hundredweight of this coke, to produce the heating effect of 1000 cubic feet of gas.

Taking gas coke at 18*s.* per ton (which is an excessive price), the 56 lbs. of coke represent a cost of 5·4*d.*, as compared with 3*s.* 6*d.* for the 1000 cubic feet of gas producing the same amount of heat. This great difference of cost at once shows the advantage of making coke do as much of the work as possible. Without it a gas grate will consume 50 to 70 cubic feet of gas per hour, whereas my experiments prove that an average consumption of 8 cubic feet suffices to heat a large room when combined with a moderate consumption of coke, and with the use of the heating arrangement, to which I attach great importance. Another important consideration in favour of the joint use of coke and gas is that the existing gas companies produce both these constituents very much in the proportion in which they would be required, and could therefore provide the means of supplying an enormous number of coke-gas grates, whereas their plant and mains would be quite inadequate to supply a demand upon them for an extended application of purely gas stoves.

Mr. Cosmo Innes describes a gas grate of his construction, having the closed grate and single gas pipe behind the lower front bar which I advocate; he proposes to fill the grate with common coal, using the gas only as a means of kindling the fire. My objections to his proposal are that in using coal he must continue to make smoke, which we are desirous to prevent, and that the hot back to his fire means rapid distillation of the fuel up the chimney in the form of hydrocarbons and carbonic oxide. The gas arrangement as shown by him will be efficacious, no doubt, as a means of kindling a bright and cheerful fire, but he



would do better in that case to use a few logs of wood instead of coals. A bright but short-lived fire may thus be raised quickly at a cheap rate in a dining-room or in a parlour.

Mr. Thomas Fletcher admits that my grate has the advantage of economy over a common coal grate, but thinks the Abbotsford grate the best of all. This grate is according to him practically smokeless, and produces only a handful of cinders in a month, although common coal is used. Now I have no desire to detract from the merits of the Abbotsford grate, but I fail to see why it should be smokeless, considering that raw coal is used; and the extremely small production of ashes or cinder seems to imply that Mr. Fletcher uses an extremely pure and probably a smokeless coal, very different from the fuel we are usually supplied with in London.

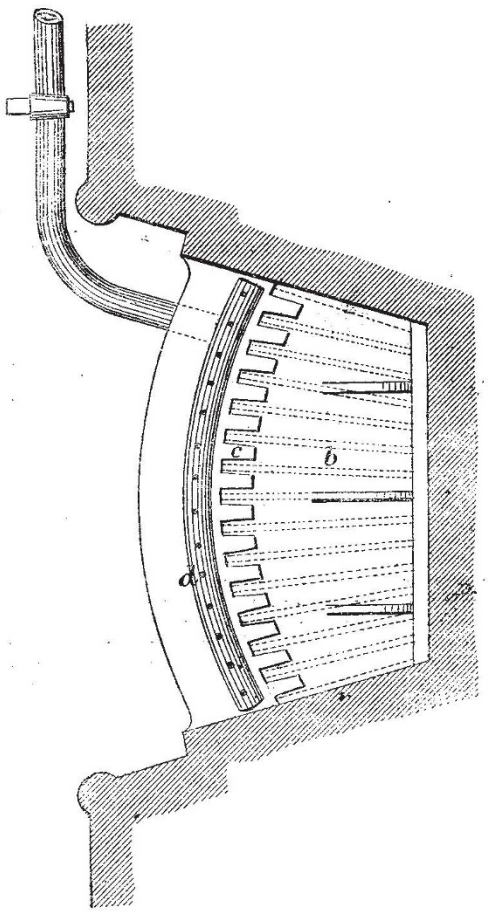
He also objects to the cost of my arrangement, and his opinion in this respect, coming from a practical grate-builder, is entitled to every consideration. In first describing my plan I did not go into the question of cost of application; but having been since asked by grate-builders to advise them regarding the cheapest form of my grate and the easiest mode of applying it to existing fire-places, I have devised a form of application which leaves little to be desired, I think, as regards first cost.

The arrangement is shown by the accompanying sketch, and consists of two parts which are simply added to the existing

grate, viz.:—(1) the gas-pipe (*d*) with holes of about $\frac{1}{16}$ inch diameter, 1·5 inch apart along the upper side inclining inward, and (2) an angular plate (*a*) of either cast or wrought iron, with projecting ribs (*b*) extending from front to back on its underside, either cast with or riveted to the same, presenting a considerable area, and serving the double purpose of supporting the additional part on the existing grate, and of providing the heating-surface produced by the copper plate and frill-work in my first arrangement. In using iron instead of copper it is necessary however to increase the thickness of these plates and ribs in the inverse ratio of the conductivity of the two metals, or as regards the back plate, from $\frac{1}{4}$ inch to $\frac{5}{8}$ inch.

The arrangement will be rendered more perfect by the use of the bent plate fastened to the lower grate bar, which directs the incoming air upon the heating-surfaces.

The front edge of the horizontal plate has vandyked openings (*c*), so as to form a narrow grating, through which the small quan-



tity of ashes that will be produced by combustion of the coke and anthracite in the front part of the grate discharge themselves down the incline towards the back of the hearth, where an open ash-pan may be placed for their reception.

In adapting the arrangement to new grates, the horizontal grating had better be dispensed with, and the casting with its lower ribs extended downwards, so as to find its fixed support between the back of the fireplace and the inclined deflector plate.

Mr. Fletcher speaks of the large amount of ashes that would be produced, but this amount can surely not be as great as in the case of a coal fire, seeing that the consumption of solid fuel is reduced to less than one-half, of which nearly one-half is anthracite, a fuel remarkably free from ashes. Neither do I participate in Mr. Fletcher's fear regarding opposition on the part of housemaids, except it be from an apprehension on their part that, with Othello's and the chimney-sweeps', their "occupation be gone."

The tendency of grate-builders of the present day, and also of your correspondents, appears to be to look for economy to brick-linings, which no doubt have the effect of producing hot radiating surfaces. I maintain however that such radiation is obtained at too great a cost of fuel, and that superior economical results will, on the contrary, be attained by abstracting the heat from the back of the fire, and concentrating it upon the purely carbonaceous material in front of the same.

To illustrate my reasoning I may here refer to an experiment which can easily be made of throwing a shovelful of bituminous coal into a steel-melting furnace; the result is an instantaneous dispersion of the coal, accompanied with a powerful refrigerative action on the furnace. In constructing gas-producers I take advantage of hot walls to turn solid into gaseous fuel, and a fireplace with hot brick bottom and sides is very much in the condition of a good gas-producer, giving out radiant heat no doubt, but combined with rapid distillation of combustible gases into the chimney. This action is made apparent in placing on the fuel towards the back of such a grate when in full glow a piece of wood, which will be seen to dwindle away rapidly without giving rise to flame, the atmosphere immediately over the glowing fuel being essentially a reducing one.

In my grate the heat, on the contrary, is confined to the coke immediately behind the bars, in contact with the heating gas flames and with the air of the room flowing in towards the chimney, whereas the coke at the back of the grate remains comparatively cool and unconsumed throughout the day. The cold furnace-back also means a cold chimney, and it is rather remarkable to observe that in the case of the application at my office, a thermometer held high up into the chimney showed a temperature of only 130° F., while the front of the grate was in a high state of incandescence. These, I maintain, are conditions most favourable to economy combined with entire absence of smoke or deleterious gases. C. WILLIAM SIEMENS

12, Queen Anne's Gate, S.W., November 24

CURIOUS IMPRESSIONS IN CAMBRIAN SANDSTONE NEAR LOCH MAREE

IN course of the short excursion to Loch Maree and its neighbourhood, Mr. Walter Carrutliers, of the *Inverness Courier*, happened, on June 13, to light upon an interesting portion of the Cambrian or Torridon Red Sandstone of the district, forming part of the bed of the burn, near Loch Maree Hotel, on which occur what have been called the Victoria Falls, so named from the fact that the Queen visited them. There an exposed surface of the rock about sixteen feet in length, nearly as much in breadth, and almost perfectly level, is marked by several double grooves quite discernible, and each divided by a very thin raised line. These traverse the whole length of the rock in a perfectly straight line, and on both sides of them are roughnesses which, if we could entertain the idea that the grooving had been caused by some living creatures, might be produced by footprints which have been to a great extent obliterated. The impressions were so striking that they immediately suggested a recollection of the footprints discovered in the sandstones of Morayshire and Tarbatness, though there was no other resemblance than their marked character on the broad, flat rock. Having heard that Mr. William Jolly, H.M. Inspector of Schools, was in the neighbourhood, Mr. Carruthers called his attention to the subject, and indicated where he should find the markings. Mr. Jolly was not slow to examine the spot, and he writes to Mr. Carruthers as follows, as given in the *Inverness Courier* of July 1:—

"I found your curious lines without difficulty, guided by your accurate description of their locality. They are assuredly no 'mare's nest,' but *bonâ fide* ancient impressions of some kind, which should receive the attention of geologists, both on their own account and as existing in the second oldest geological formation in Britain, in which, as yet in Scotland, no evidences whatever of organic life have been discovered.

"The lines or bands in question occur in the chocolate-coloured Torridon sandstone, the Cambrian of Murchison and Geikie, which is so well developed around Loch Maree, and rises into the great dome of the Slioch, or the Spear Head, that guards its waters. The most distinct of the impressions consists of two continuous flat bands side by side, 1¼ to 1⅓ inch broad, and about a quarter of an inch deep, running quite straight across the flat layers of sandstone *in situ*, and perfectly distinct for sixteen feet, disappearing on the west side under the superincumbent rock, and broken only where portions of the sandstone have