minutes, and he gave the inspectors similar instructions. He believed the people of Liverpool would welcome some measure for compulsory notification, and he thought the medical profession would also, did they know of the amount of evidence collected during late years. It might have been that the matter was prematurely brought forward, or that evidence was lacking to show the absolute necessity of it previously; but to his knowledge hundreds had suffered, and hundreds of persons had lost their lives owing to the want of some system of prompt notification. It seemed at one time to be looked upon almost as a point of honour to throw every difficulty in the way of the Medical Officer of Health in this respect; he hoped this feeling was rapidly disappearing. Immense structural alterations had taken place at Liverpool, and it was gratifying to find that the cases were dwindling down from thousands to hundreds, owing to the great sanitary operations carried out in the city.

SECTION II.

ENGINEERING AND ARCHITECTURE.

ADDRESS

By Prof. T. Hayter Lewis, F.S.A., F.R.I.B.A.

PRESIDENT OF THE SECTION.

In availing myself of the privilege of addressing the members of the Congress in this active and stirring town, which is spreading itself out in every direction, I have thought it well to bring before them a subject of great interest, but which has not been hitherto much discussed, viz., the extension of our great cities and the erection of new ones; and to suggest such a course as would ensure that such requirements as are now considered to be necessary for their healthful occupation may be provided for at the outset.

In ancient times the creation of a new city almost implied the foundation of a new colony.

In mediæval times towns have risen round monasteries or churches of Bishops,* as Mr. Freeman shews was the case at Wells, Lichfield, and Sherborne; or round a castle, as at Windsor and the Yorkshire Richmond.

But, within our own times, numerous towns, such as Fleetwood, Crewe and Southport, have suddenly sprung into being; whilst, from each of our large cities, extensive suburbs are being pushed out, forming, in fact, new towns.

Of the conditions to be noted in selecting a site for a new city, we have descriptions by writers of all ages, from Vitruvius in the first century to Dr. Parkes in his well-known work of our own time. But this is a subject too large for a short address, and it is of the extensions only that I wish now to speak. They have, almost invariably, been carried out by speculators without any general definite guiding plan, with little or no forethought

* Freeman's "Exeter." p.

for future extension, and with slight provision for supplying the inevitable future wants of the inhabitants. Thus, in course of time, spaces have to be cleared out for churches, schools, institutes, baths, and such like edifices as are now required for a large population, and clearances have to be made to allow for its free breathing. The extension of the cities take place in different directions and from different motives.

The well-to-do citizens leave their smoky town and confined houses to form new suburbs, where they may breathe freely in their open gardens.

The artizans cluster together at first for cheapness and for nearness to their work. Then comes overcrowding and then sanitary acts, and then suddenly the neighbouring fields are invaded, and acres of ground are covered with new small houses, put up as a speculation in the cheapest way, with just so much breathing space as the Local Bye-Laws (if there be any) will allow.

Now if this be the time of activity in building new towns and extending old ones, it is also pre-eminently the time of activity and power in corporate bodies. From Town Councils to Vestries—from Trade Guilds to Trade Unions—from companies formed for their own benefit and companies formed (all honour be to them) for the benefit of their fellow citizens—an active part is being taken in public work.

New and extensive powers are being acquired and exercised by Corporations for the sewage, the supply of water* and of gas, for providing open spaces, regulating the width of streets, and even the height of rooms and size of windows. Your own Bye-Laws are sufficient evidence of this.

Now I simply wish to extend these powers. I wish that when it may appear evident to a Corporation that any district will require before long a large accession of houses for a population which is clearly increasing to an overflow, such Corporation shall have the powers (and I think that public opinion will require it to exercise them) to acquire control over the requisite land—to formulate a general plan, giving the width and direction of the streets—to provide spaces for such public buildings as are certain to be required in a well regulated community, and for such open spaces as are required for its healthy enjoyment.

My scheme is not a very grand one in any respect; I simply want to provide at first for those requirements which must eventually be provided for, and which can only be fulfilled at a great cost, and even then imperfectly, if not so provided at first.

* Bolton Corporation Waterworks, 1881, and Bolton Corporation Act, 1872, 1877, & 1882—pp. 8, 26.

I do not even suggest that the Corporation should build, but that it should give general guiding directions, leaving the working out to private persons, or to such companies as have of late done so much good in building dwellings of various classes, from the highest to the lowest.

To show that such powers as I have indicated might well be called into being on behalf of even a high-class district, I might have brought before you the earnest attempt made, some thirty-five years ago,* by the late Professor Cockerell, R.A., to obtain a public control over the proposed buildings at Hampstead, a suburb now covered with houses.

As I was reminded by my friend, Mr. Rogers Field, the Professor drew out a design by which the whole of that suburb might have been built over on one definite plan, utilizing the various hills and valleys, so as to take every advantage of its picturesque beauties. Public opinion was not ripe for such a course then, and this grand opportunity was lost.

But I found that this example would be too large a one to handle here, and I have, therefore, taken as my text a smaller district near London, actually built over within my memory. I shall point out, first, its defective arrangement, and secondly, the way in which, by a little foresight, the defects might have been avoided.

The houses in this district are of various classes. Some of them are good private dwellings, with forecourts and trees. Many others are tenanted by a superior class of artizans; whilst other portions of the district realise the description given by Mr. Walter Besant, as being composed "of small houses almost all of one pattern—with no green thing to be seen—where no one plants trees. No flowers are in the windows—nothing to gladden the eye."†

And portions even realise the darker picture drawn by Mr. Froude, who describes the dwellers in such a district as having "no sight of green fields, no knowledge of flowers, and with no entertainment but the music hall."‡

The sketch of this, the worst part, may be fitly illustrated by a notice put up at the private bar of one of its chief public-houses, that, "Ladies cannot be admitted unless properly attired, nor without hats or bonnets."

The district is still growing rapidly under the auspices of the speculator, who is building acre upon acre of houses with just so much care and attention as will allow him to obtain

* *Vide* "Builders' Journal," Vol. XI. (1853).
† "All sorts and conditions of men."
‡ "Oceana," 1886. p. 9.

the highest rent at the least cost. That the case may be better understood, I have enlarged a plan of the district from the Ordnance Map; but not one half of it was built over at the time this map was made, so I have completed it by filling in the new streets from numerous personal visits to the spot, and have drawn it as plan No. 1. It is bounded on the west and south sides by a railway, whose course is marked partly by a dead wall and partly by a line of old sleepers, placed upright, whose outline is somewhat relieved by their tops being cut to a point, and whose sombre tint has also some little relief by the marks left by the rusty iron bolts and by the painted tops being tarred black. By the side of this dismal fence runs the main road, about 30 ft. broad, not wide enough for a footway on each side; its one narrow path next the houses being crowded with foot passengers, and the road itself made narrower by costermongers' carts and stalls.

On the north-west side the boundary is a really good road nearly 60 ft. wide.

At the north-west angle (A) where these two roads meet there is a railway station, receiving and discharging thousands of passengers every day, and at (B), to the south is another station.

To the east (E) are spaces as yet unbuilt upon.

Now my plan will shew the extremely haphazard way in which this district has been filled up. The builders have acquired one field after another and followed its irregular forms, or those of the country cross roads or ditches, in laying out their new streets, and the result is about as bad a plan as it is possible to imagine—not in the slightest degree picturesque, simply puzzling and exasperating.

One of the chief features in the district, the railway station (B), is altogether ignored, as it opens now merely on to the narrow road, with no street opposite any part of it; and as you will see, a large number of the streets have dead ends to them, completely closing them against through ventilation, and very many more are not thoroughfares. You will see clearly the reason of this in one case, viz., near the station (A).

The builder who took the ground near to it, built the streets up to the extremity of his odd-shaped fields, which I have indicated by the street hatched on the plan, and used every inch of his ground, not leaving a vacant space for any opening eastward. So when the builder of (C D) came, he could not get any of his streets to open on to the station, and was obliged to run new streets with their dead ends as I have shewn, there being for the whole length of (C D), which is more than a quarter of a mile long, not a single opening to the west.

The further and important result has been, that the whole of the district eastward has been shut off from the main station (A), to which the slightest foresight would have given it an easy access. I have been fairly well used to explore strange towns here and on the continent, and rather pride myself in being able to find my way, but I candidly confess that I have very seldom paid a visit to this district without being sorely puzzled as to my readiest means of getting out of it.

The houses which face the main roads are mostly good private houses or shops, and many of these are three stories high. The rest are, as a rule, private houses, but only two stories high, thus giving an admirable example of Horace Walpole's sneer at London, as being "a gigantic mass of littleness."

Standing on one of our bridges and looking at the magnificent and unequalled range of spires and towers crowned by the dome of St. Paul's, one feels astonished at his insolence. Go to our suburbs and one feels its application.

Now what I want is, I repeat, to shew how, by a very little forethought, a corporate body could so arrange the site of such a suburb or town as to have the same number of people at the same cost and on the same space of ground as is now covered, making such provision as would make it healthy and cheerful, and provide, at the outset, for such public buildings as must, we know, be eventually required.

The necessity for some such provision has been repeatedly recognized, and you will find in the Appendix to the report of the Poor Law Commissioners, 1842*, signed by the well-known name of Edwin Chadwick, a suggested plan by Capt. Vetch, R.E., for laying out the suburbs of Birmingham.

He says, "one of the greatest evils arising from towns extending at caprice without reference to any general plan, is the vast expense that subsequently arises when necessity demands communications to be made through crowded masses of streets. Such events are of frequent occurrence."

He further shows the proposed extension laid out in a network very much on the same principle as I shall have to shew to you.

Sir Christopher Wren's great plan for rebuilding London will come at once to your memories.

The subject was brought prominently into notice by Lord Salisbury's well-known paper in the *National Review* (1883), but little has been done except perhaps in Glasgow, in which a large district of houses was laid waste in order that it might be rebuilt in a better manner.

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* Report from Poor Law Commissioners, 1842. Appendix, p. 384.

That, however, rather emphasizes my suggestion of preventing any such necessity by making suitable provision from the first, and allowing corporations to do just what many of our great landowners, as the Bedfords, Westminsters, and others in London have done on their own estates. And in suggesting as I am now about to do, the manner of doing this I have, as I before stated, no Utopian schemes in view.

I simply take the conditions of life as I find them, and shall not suggest any provision for streets or buildings, public or private, which are not founded upon some actually existing, and which I can cite as my authorities. To bring the case before you as clearly as I can, I have drawn out a map No. 2 (p. 216) of the district, with the streets, &c., rearranged as I would suggest them to have been laid out from the first.

You will see that it is drawn on the strictest utilitarian principles; that I have resisted all attempts at crescents or other curved lines, which would produce, no doubt, a much more pleasing effect than I have done, and that there is not one single frontage which is not straight.

All that I have done has been to ensure a ready access from any one part to another, and to provide that each street shall have its ending in a wide well-ventilated thoroughfare.

I don't propose it as the best plan that could be framed. Doubtless many here will suggest a better one.

Each district, too, will probably have some local peculiarity or object of interest, suggesting a varied plan, such, *e.g.*, as the great Church of St. Paul, the Exchange, the Tower, the river, which formed the keynotes to Wren's design, and as the prominent hills furnished the leading lines in Prof. Cockerell's: or it might be some old ruin, something to make one think and to conjure up memories of bygone times, sermons or histories in stone, and so be religiously preserved.

But unhappily my district has no hill, no view, no river, and we have to think only of stations and tramcars.

The north-west boundary road is of sufficient width, but you will see from No. 1 (p. 216) that at present there is, with the exception only of the street (C D), which leads to a footbridge, no direct communication from it anywhere to anywhere, and that the boundary road (A B), next to the railway, is very much too narrow for its great traffic, whilst its dirty wall and fence, and absence of footway, make it about as dreary as well as inconvenient a road as I know.

But it is the direct route to the country beyond, and I would not alter its course, but make it broader, and thus get a good footpath on each side of it.

Having now taken the two boundary roads as following the existing lines, we have to determine the direction of the main intermediate streets, the first consideration being of course the probable direct lines of traffic.

The chief are indicated vaguely by the series of streets (F, F, G), in No. 1 plan, which follow the lines of an old causeway, winding about in a way which is utterly confusing to a stranger, and leading *away* from the station (B).

This is somewhat beyond a half-mile radius from the main station (A), and nearly the same as from this square to the Heywood Recreation Ground; and I would follow this line, in its general direction, by a wide avenue (F F) in No. 2 plan, leading directly to the station (B), which is absolutely ignored in the present streets.

The form of the main boundary would vary, of course, in each locality according to the general course of traffic, inequalities of the ground, and other such causes.

In the present case I have given it the form shewn, as affording a pleasing contrast to the ordinary straight lines of the streets.

I then form another avenue (C D) on No. 2 plan, taking much the same lines as that on No. 1, and then intersect the whole by the avenues (H, H, H, I); each of these avenues being planted with trees, as at Southport, and as our new streets and some of our old ones are being planted in London: and I do insist that such wide well-planted main thoroughfares are of the greatest importance as regards the health of a town.

They would secure a thoroughly good ventilation through the heart of it, and would give it a cheerful aspect; and I am not sure as to which of these two provisions is of the most vital importance. We recognise the aid to health which a cheerful aspect in a hospital ward affords us: surely the same aid will be given towards *maintaining* health, if the same rule be applied to our streets, no matter in what station in life their inhabitants may be.

You may say that there is the dead wall by the railway, and you cannot make that cheerful. Well, I ask you to remember what has been done with the great ugly railway embankments which cross the beautiful park at Preston, and which have been rendered so sightly by a little care that I doubt, even if we had the choice, we should like to see them removed. I want my wall to be treated somewhat thus, although more simply, and not until houses are built in face of it.

Then I shall be told that the trees will not be allowed to grow—that the roughs will not let them. Now I will not go so far as my son, who had a curacy in one of the roughest districts of London, and who says that he liked the roughs—he could always manage them. Now I *don't* like the roughs,

and I do not think that I could manage them; but my district is not much infested with roughs; and we have planted trees in even some of the worst parts of London, and the trees are none the worse for it.

You will say, looking at my own plan, No. 2, that it is made to look prettier than No. 1 by the trees, &c.* Of course it is, and I so intended it; but I will venture to say that the contrast between the two plans is not nearly so great as the contrast would be between the two districts themselves.

No doubt nearly every large town has now a park (and there are few prettier than your own), but we have to *go* to it. It is, and must be, away from most of the houses, and I do insist upon the fact that the cheerfulness of the home (no matter on what scale and of what class), with its surroundings, is the great thing to be studied; and I see nothing to be said against bringing close to every street, by such arrangements as I have shewn, the cheerfulness of bright foliage and open air.

I now ask you to bear with me whilst I enter, in some detail, as to the public works and buildings for which provision should be made. I assume that, as a matter of course, the sewers, water, and gas, will be provided in the usual way, so I need not detain you as to these.

In the first place I would set aside a strip of land (E) outside the whole for the park, which I take for granted would ultimately be required, no matter what the rank of the adjoining houses may be. Its distance from the furthest point would be about that suggested by Mr. Besant, viz., half to three-quarters of a mile. The size which I suggest is about the same as that of the Hesketh Park at Southport, which is in one of the best parts of the town, and much smaller than the one here. The position of this open space would provide well, also, for the future extension of the town, and would afford the advantages obtained in the same way as, *e.g.*, at Hastings, where the pretty St. Andrew's Gardens, starting from the old town, pass round at the back of the houses, and are continued to St. Leonards, making an admirable belt of free open air and foliage.

Neither in this case, nor in that of public buildings, do I propose the work to be undertaken at the first, but only so to arrange, *at* the first, that the sites shall be so reserved as to be available when required. As to these I need do no more than mention offices for the local authorities, and the library, reading-room, science and art schools, and other buildings required for the particular locality.

* The trees, &c., have not been reproduced in the lithograph.

In the arrangement of these public buildings it would be difficult to take a better example than that of Southport, whose Lord Street and Albert Road form one of the prettiest vistas that I know—(I trust that Birkdale will pardon me for classing it with its neighbour)—and I use the word "prettiest" advisedly, as I could not, of course, compare it with such grand thoroughfares, each unrivalled in its way, as the High Street of Oxford, or Princes Street at Edinburgh.

At Southport the chief public buildings are located behind a group of trees, and I know of few more pleasing views than that of the spires and turrets of Christ Church, the Presbyterian Church, and the municipal and other buildings, towering above the foliage, whilst between the trees the buildings themselves are picturesquely seen. I suggest that a similar arrangement be made here for such buildings, and others mentioned hereafter, in a central position, such as (L) and (K).

Outside the park I should place the infirmary and convalescent home, a position in which they would have free light and air. If any one suggests that such a position would be too public and lessen the enjoyment of the park, I would refer him to your own infirmary and children's hospital (the latter the gift, I believe, of your townsman, Dr. Chadwick, and his family), and ask him whether, as a simple matter of landscape effect, to say nothing of the value of such an outlook to the patients, he would wish this picturesque building, designed by one of your able townsmen, Mr. Knill Freeman, to be removed. Or again, think of the charming way, and without the slightest feeling of sadness, in which the promenade at Southport ends with such a building, whilst at two such different places as Manchester and Hastings, the infirmary forms one of their most prominent buildings. Next to your noble town hall and the old churches, the most important building is, I think, the market. I do not of course propose any such grand building as yours for my district. It might be open at the sides, but covered as at Preston and Blackpool, or be enclosed as here and at Southport, or St. John's at Blackpool. I know that many towns of importance (I may, I think, name Norwich and Cambridge amongst them) have still little more than open and uncovered market places, healthy looking and pretty, with fruit, and flowers, and vegetables, on a fine day; but we often have quite other days in our country, and the attempts at covering up and protecting the stalls then, turns the market place into a wretched collection of tumble-down huts—I had almost said as bad as Fleetwood. If the quarter be chiefly for artizans, public washhouses will be indispensable; and in any case, no matter what the class of inhabitants may be, I look upon public

baths also as a provision which can scarcely be valued too highly. For these baths and washhouses I have suggested no definite site, as this would depend so very much on the kind of inhabitants.

Nor have I marked out definitely sites for churches, chapels, or schools. All these are provided for in the district as it exists, and sites would undoubtedly be claimed for and provided, whatever the general plan might be.

I come now to some other details, as to which I may not possibly have your assent.

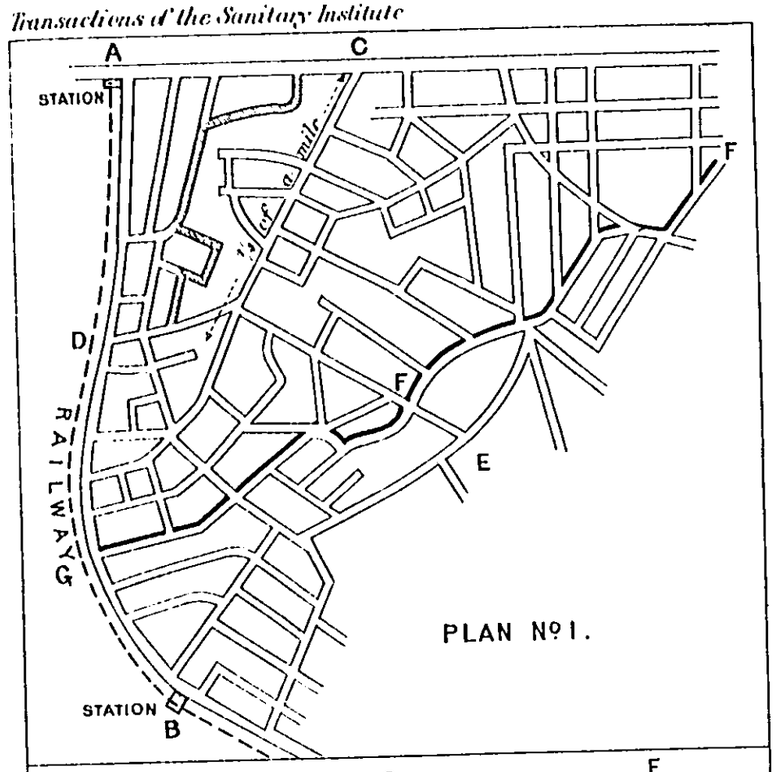
First, as to drinking fountains. That such small ones as are now commonly seen should be provided, you will doubtless quite approve. There are many excellent examples in most of the towns in these parts, each combining a drinking fountain with a public lamp, and being really an ornament to the streets. But I want something more than these, as much for the sake of health as for ornaments to the town.

You know well enough that all the water in use for your houses is stored in cisterns; and although in past times these cisterns were looked upon as being worthy to be seen, and so were ornamented in a way which is now the envy and admiration of workmen and artists alike, they are now rough ugly things, stored away out of sight in any convenient closet or loft which will hold them, and for all that their owners know of them may be considered as the property of the spiders.

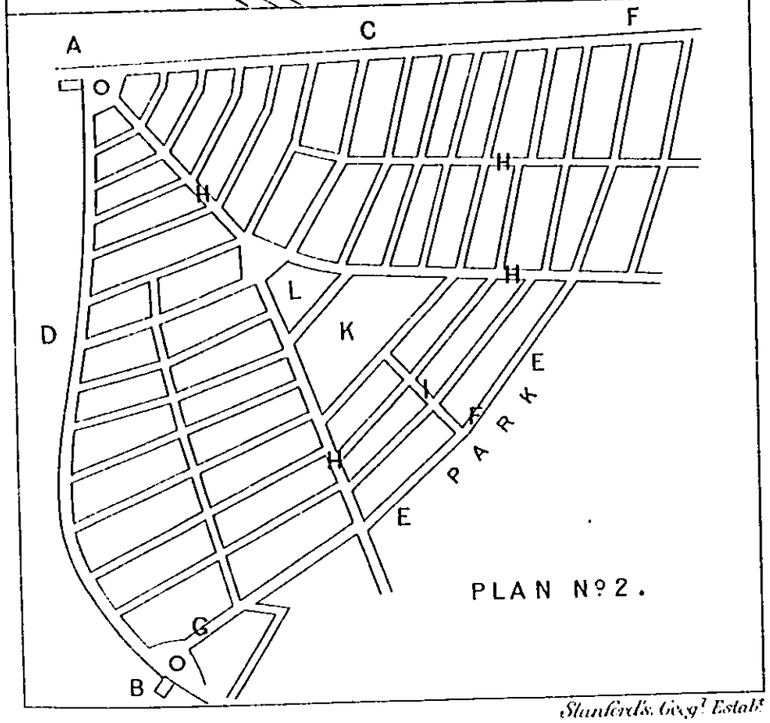
You depend upon your plumber to clean them out once a year. Perhaps he does; perhaps he doesn't. You are none the wiser. But imagine what often happens in the houses of a poorer class. I need not go into details, but I say that a good supply of water, pure for drinking, is an element of health which ought to be provided, and that you can't provide it in a better way than by fountains. These, in what are now called the dark ages, formed some of the chief ornaments of a town, and I see no reason why they should not do so now.

I don't want to bring in such vast bodies of water as were brought through miles of aqueducts into Rome, or such lavish displays as you have seen, *e.g.*, in Paris, or even such things as our fountains in Trafalgar Square. Nearly all these send their waters into the drains.

There are fountains even now in most of our towns—a very elegant one at Southport, for example, but, again, with all the water running to waste; whereas in some of the most picturesque mediæval examples it came out in small useful jets, as I would have them here; and I feel no doubt that, by a skilful arrangement of gas jets, the effects of frost might be prevented, and a great boon thus conferred in winter, on rich and poor alike;



PLAN Nº 1.



PLAN Nº 2.

Stanford's Geog.l Estab.t

whilst, by a skilful design, they could be some of the most pleasing ornaments to the town that could be conceived. And, as part of the water must go to waste, send it to feed a small stream in the park, like the one here or at Hastings, and get the refreshing sight and sound, sung of by Longfellow:

"Of the brooklet gushing
From its fountain near;
Down the valley rushing,
Fresh and wondrous clear."

Years back it would have issued in the words of the same poet:

"To fly
To the sea's immensity;
To wash from it the slime
Of its muddy banks."

But we can provide against that now.

Another accessory I must mention is that of seats placed at intervals between the trees. I shall, no doubt, have the same objection made to them as to the trees, and my answer would be the same.

Then to complete my plan I would have a small open space (O) opposite to each railway station. Now we have to see, before entering into the question of the kind of houses to be provided, how much the plans which I have suggested have trespassed upon the space now occupied.

I have laid out my main roads in very much the same general direction as the present ones, though in less circuitous lines; but I have made them 60 ft. wide instead of 40, and have set apart spaces for public buildings, &c. The smaller streets I have made 40 ft. wide, the width required by the Model Bye-laws being 36. The space which I have assigned to the park need not be taken into our calculation, as it is altogether outside that now built on; and I think you will readily see that the great waste of space necessitated by the irregular plan of the district as now actually existing, would allow to a very great extent, if not altogether, for the extra space which the suggested rearrangement would require.

As to the general arrangements of the streets and houses, I will call your attention to some methods, unusual to us, with which one meets abroad. I omit any notice of the large many-storied houses which are familiar to you on the Continent, and I shall take, as examples, one of the northern towns in Europe, Hamburg, and one of the southern ones, Naples. Several years since, I was commissioned to make a detailed report on the former town, for one of the principal Insurance

Offices (the Union) of London, and I was thus led to see more of it than, perhaps, most of the people who visit it. The arrangement is peculiar. The main streets are wide, and give to a casual passer-by scarcely any indication of their affording access to any other streets.

But a nearer inspection shews numerous doorways, so low and narrow that they appear to lead only into cellars, and through which you have, often, to descend by steps, and these lead into the streets behind, locally named Hofs, which we should call alleys, and which are of course completely closed against ventilation from the main street. They vary from 20 ft. to as little as 5 ft. in width, the houses in the wider streets overhanging on each side and being densely populated.

They usually abut on canals, and when these are dry the result in hot weather may be imagined.

This arrangement, intended, no doubt, to bring different classes of the people together, reminds one of the Wynds of Edinburgh, but with all their evils intensified, and a worse result could scarcely be imagined. Very many of these have been demolished, but a large number still remain.

I take you down now to the sunny south at Naples, where the same attempt has been made.

It is not in my province now to describe the ordinary houses there, of the horrors of which Sig. Gallenga and Mrs. Oliphant have given most vivid descriptions, but only the particular class to which I have alluded, and which may be seen, to perfection, in the drive through Portici.

The streets throughout are wide, and lined for the greater part of their length with frames of macaroni hung out to dry, and many here will, no doubt, well remember both the sight and the smell. The houses on each side are several stories high, the first floors *(piani nobili)* having wide balconies, and altogether having a cheerful look and being tenanted by well-to-do and often wealthy people, whose apartments are entered from an internal court approached from the street by a lofty carriage gateway, through which one has lovely glimpses of beautiful gardens sloping down to the Bay of Naples. But the lower stories throughout, close on the ground, are tenanted by humbler classes, their rooms entered from the street.

Here again we meet with an attempt to combine the classes, and thus prevent one neighbourhood being given up to the poor and another to the rich.

But again this fails. The lower rooms have no windows or other openings at the back, and derive the whole of their light and air from the street. The state of the inner rooms (usually parted off by a curtain as sleeping apartments) in the heat of

an Italian summer may be imagined; and these rooms are not inadequately described by Mrs. Oliphant as "dark caverns with one vast door, giving all the light that can penetrate."* Were it not that the people live almost entirely in the open air they must be decimated. The same arrangement will be found in most other Italian towns, but in them there is, usually, some opening, however small, at the back.

Something of the same kind would appear to be adopted, judging from the plan only, in a flourishing town in our own country, viz., Great Yarmouth, the arrangement of which is very peculiar, and unlike that of any other English town with which I am acquainted. I have a drawing of this, enlarged from one which was kindly drawn for me by Mr. Arthur Hewitt, an architect in the town, who has supplemented the Ordnance map by many important details. The main streets are wide and well ventilated, and lined with good houses (mostly shops) several stories high; and running between these streets at intervals of about forty-five feet are long narrow alleys, termed Rows, out of which lead houses of an inferior class.

Looking at the plan only, this would seem to be no better than Hamburg; but in reality they are *vastly* better. The entrances are open for their whole height to a wide street at each end, or to the spacious quay, the alleys are cleanly kept and well paved, the houses in them are low, so as to intercept the light and air very slightly, and each has a small court attached to it; and the whole arrangement, so far as I can ascertain, is not prejudicial to health.

Nevertheless, the narrowness of the streets does, no doubt, to some extent, clash with the golden rule which Dr. Richardson put very strongly in his well-known lecture at Croydon (1879): "Make the sun your fellow-workman," which is much the same as the Italian proverb, "Where the sun does not enter the doctor does."

Now, in remodelling our district, what system shall we adopt as to the houses? The first question is as to their number of stories. This subject is a serious one, for hundreds of acres near our towns are now being covered with two-storied dwellings, clustered close together in populous neighbourhoods, or semi-detached when more in the suburbs. As to this, I do not wish to lengthen my paper by going into any argument, but I must briefly allude to some of the leading facts. The governing idea in respect of the self-contained houses of two stories is, of course, that of privacy, or, in the better class of houses, the absence of stairs; but, in many of our new London squares, one

* "Francis of Assise," 1885. p. 2.

large open space garden, or yard (according to the class of house), is common to all; and the separate houses are being largely superseded by the dwellings in flats. At the first sight the two-storied houses would appear to have the recommendation of ensuring a less dense population than in the many-storied ones; but I wish to consider the subject on the basis of the same number of inhabitants in each case, the area gained by the extra stories being appropriated to open spaces in the way of yards or gardens, so that no question as to the bearing of the density of the population upon their health will arise here.

In considering the relative merits of the different styles of houses, the first fact which presents itself is, that with those of two stories only, the whole of their inhabitants must live and sleep either immediately over the ground or directly under the roofs.

I need scarcely say that the nearer to the earth the ground-floor is the cheaper it is to build, as less height of wall is required; and the consequence is that the floor is raised a few inches only above the street level, and the occupant has only that space between him and the earth. The rest of the inhabitants must live and sleep directly under the roof—not a very pleasant experience even in well-built houses, whether through the heat of summer or cold of winter; and very many here, doubtless, know what is the case where the house is run up cheaply merely to sell. In point of economy of building, and of course of rent, it must be borne in mind that, though the thickness of the lower walls must be somewhat greater in a high house than a low one, one roof will cover, and one foundation hold up, four or more stories, as well as they will cover and hold up two.

As to the general feelings with respect to the subject, I recall and agree with the words of my predecessor, Professor Roger Smith, in his address at Glasgow in 1883,* that the system of flats is opposed to the general feeling; and I agree with him, also, when he says that they are not so unpopular now, and have many advantages.

Of course the height of houses, whether in flats or separate, varies very much, buildings of five, six, or seven stories, being common enough—my own house has six; but I propose, in the comparative plans which I shew, to limit our consideration to four stories, which is the limit suggested by Professor Robinson, in his address at Newcastle, 1882.† My plan shews, first the actual space at present occupied by two blocks, each of fifty-

* "Transactions of the Sanitary Institute, Vol. V., 1883—4."
† "Transactions of the Sanitary Institute, Vol. IV., 1882—3."

eight two-storied houses, and their open areas of streets and yards; and, secondly the space which would be occupied and the area gained, if the same number of inhabitants lodged in half the number of houses, but four stories in height.

The contrast as to open space is rather striking, and with increased height the size of that space will of course increase.

I leave this matter for your serious consideration.

One thing more. In his well-known address in 1879, Dr. Richardson spoke of his ideal cities as competing with each other in the beautiful as well as the useful, and I have spoken all the way through of doing what we have to do in the streets, the buildings, the fountains, in such a manner as to give a cheerful aspect to the scene, and afford some scope, however slight, to the feeling of beauty which is inherent in mankind, whether for colour or form, for a flower or a building, and not to offend the eye by the mean and the ugly.

*Years back, in the prime of his life, Mr. Ruskin pointed out most forcibly "that it is chiefly by private and not by public effort that a city is adorned, and that it did not matter how many beautiful public buildings it may possess, if they are not supported by and in harmony with the private houses (and, I may add, of the factories) of the town:" and if it be held that all we have to do is to provide houses which shall be fairly comfortable whether for rich or poor, and that rows of such houses will answer all the purpose if built with windows large enough and numerous enough, and that nothing else in them need be studied to please the eye and cheer the heart, then I say that our town lacks one great feature which might conduce to the pleasure of its inhabitants, and in neglecting which, we have neglected one means, however slight, towards that healthful mental state which helps the bodily so well.

Lord Basing, F.R.S. (London), observed that in his opinion they might fairly congratulate themselves upon the auspicious manner in which that Section had been opened. The Address they had just heard read held up a lofty ideal, but certainly not a too lofty one, of

* Lectures at Edinburgh, 1854.

Note.—I desire to express my grateful thanks to Mr. Knill Freeman, of this town; Mr. Whyte, of the office of Public Works at Glasgow; Mr. Darbishire, architect to the Peabody trust; Mr. Boutcher, of the Artizans' Dwellings Co.; Mr. Arthur Hewitt, of Gt. Yarmouth; and Herr August Herz, of Hamburg; for kind and valuable information bearing upon this subject; and also to Prof. Corfield, for kindly looking through the rough draft of this lecture.

what our towns and cities might become. The tendency to look to the Municipality or to the Government to provide ornament as well as to be a restraining force, must always be jealously guarded against. He agreed very much with Mr. Ruskin, when he said that after all most of the splendid towns and cities they knew of had been beautified at least in the greater degree by private munificence. Nevertheless it was their duty to see that due regard should be paid to health conditions in towns, and anyone who desired to form an opinion as to the mode in which the necessary improvements might be carried out would do well to study the paper they had just heard, so that he might be ready to judge by its light as to the appropriateness and effectiveness of what he knew and saw to be going on in his own neighbourhood. He had great pleasure in moving a vote of thanks to Professor Hayter Lewis for his Address.

Mr. R. H. Freeman, F.R.I.B.A. (Bolton), seconded the motion, and said he thought he might be allowed to refer for a moment to one point brought out in the Address. That was that something more than mere utility was wanted in their buildings, and also in the arrangement of their streets. He thought that the Corporation of Bolton had recognised this fact, and that their public buildings had not been dealt with entirely from a purely utilitarian point of view. They had caused to be erected structures of which the inhabitants were proud, and which they could look on with satisfaction. He had much pleasure in seconding the vote of thanks to Professor Lewis.

The resolution was carried.

On "Sanitary Apparatus for Convenience in Factories," by J. J. Bradshaw, F.R.I.B.A.

It is perhaps well to say that this paper is prepared rather as a statement of the actual facts of general practice than otherwise. A few suggestions arising out of the subject are made in such places as they naturally occur; but the object of the writer has not been to introduce new schemes so much as to leave these to be brought forward during the subsequent discussion by anyone wishing to introduce the same.

This subject is one which will not be found generally attractive, yet it is of great importance to the health of workers in manufactories, and has such special reference to the work of a Sanitary Association, that I have felt little hesitation in

accepting the invitation of the Secretaries to introduce it in as brief a manner as possible to the notice of the Congress.

The term "factory" is locally applied only to "cotton spinning mills," but this is of little importance, as the provisions required are similar to those of other manufacturing establishments, but becoming more important, and also more difficult of application, from the fact that the rooms in which the actual process of spinning is carried on must be maintained at an average temperature of about 80°.

The question of Ventilation naturally suggests itself for first consideration, as—unlike the accidents from machinery which cannot be hidden, as they are direct in their consequences—"the evils which follow constant employment in overcrowded and ill-ventilated work-rooms are insidious in their inception, rarely complained of openly by the sufferers, and do not in their effects appeal so readily to the sympathy of employers as do the injuries to the person caused by machinery."*

The subject of this paper being restricted to factories, and therefore presumably to buildings specially intended for their purposes, excludes from its consideration the numerous cases of occupations on the small scale of those carried on in dwelling-houses, or rooms attached to tailors' or drapers' shops.

In many of the engineering and other ironworks the trade is carried out practically on the ground floor, and only enclosed with a view to protection from weather; and the cubical air space is so large and frequently changed that the ventilation is sufficiently secured without artificial aid; and in cases where special need arises, fans or other means of inducing currents are generally applied. The same remarks may be made as to the bleaching, paper-making, and other trades of this locality, but attention may perhaps be best given to the cotton-spinning trade as being the leading one of the district.

In the various processes of the spinning trade, ventilation is subject to very special conditions, as the nature of the material manipulated renders it very susceptible to variations of atmosphere, and necessitates a regular temperature, improved by a slight amount of moisture, which, in some of the processes of preparing the yarn for the weaver, must be maintained at not less than 60° during the earlier, and from 80° to 90° during the latter processes.

The case is further complicated by the difficulty of dealing with the fine dust and fluff without injury to the delicate fibre of the material; the amount of dust being much greater in all the processes of preparing coarse yarns, such as are spun from

* H. M. Inspector of Factories Reports, 1885, p. 15.

American cotton in the Oldham district, than in the finer counts spun from Egyptian cotton in the Bolton trade; the amount of dust being perhaps in proportion to the greater weight of the material used in the one case over the other, though the finer counts are more delicate and easily damaged.

By the factory regulation of non-textile work-rooms, 250 cubic feet of air space are required for each person employed during ordinary hours, and 400 cubic feet where overtime is worked; in soldiers' barracks 600 cubic feet are required; and in hospitals for ordinary cases 1,800 cubic feet, and in those for infectious diseases 2,400 feet are generally allowed; but it must be noted that in all these cases provision should be made for frequent changing of the air of the rooms.*

As regards cubical space the operative in a cotton-spinning concern is very favourably situated, the worker, even in the most crowded part of the card room, having never, in a modern mill, less than 4,500 cubic feet, and in a spinning room from 9,000 to 11,000 cubic feet of space. In weaving sheds, which are more crowded, Messrs. Bridge and Osborn, in their Report of 1st October, 1883, on "Heavy Sizing in Cotton weaving," give, as the result of their observation, a cubical space to each worker of 1,800 to 2,400 cubic feet. The same Report, however, contains an observation which applies to all these cases: "The fact, however, is that to maintain a wholesome atmosphere, an allowance of 3,000 cubic feet, or on the lowest computation of 2,000 feet, should be supplied to each person during every hour. This, in the case of weaving sheds, would imply that the air was changed once in every three-quarters of an hour, or 12 or 13 times during the working day. It may reasonably be doubted whether during that period it is changed effectively so often as once. Assuredly the slender currents of fresh air which may penetrate through crevices in woodwork, through broken window frames, or through casually opened doors, would not suffice for this."

It is thus evident that overcrowding is not one of the evils of this trade. The questions of the maintenance of an even temperature and of the change of atmosphere in all cases, and the removal of dust in most of the processes, are however more difficult to deal with. The last-named point arises in the first process—that of opening, in a room of ordinary temperature, the bales of raw material which have been closely pressed for shipment and which, when opened, are found to have a considerable quantity of dust in them, besides the occasional adulteration of sand or other worthless matter.

* H. M. Inspector of Factories, 1883, p. 33. Order, April, 1883.

The heavier portions of this drop to the floor and are cleared away as required: the lighter portions, however, during the opening and following process of mixing the contents of the various bales, float about in the atmosphere, often making it thick with dust, from which the more careful workers protect themselves to some extent by a homely respirator extemporised from a piece of the cotton itself. There are, however, generally speaking, in each mill only a small number of persons engaged for a short time once or twice a week in these processes, which are necessarily carried on in the large area needed for the storage of bales of the raw material, and the amount of material used being much larger in coarse than in fine spinning mills.

Fans or other modes of creating currents to carry off the lighter particles of dust might be with great advantage more generally employed.

The process of scutching, in a temperature about 60° or 64°, is continuous, and carried on in a separate room. The heavier portions of dust are carried by fans in each machine into a specially formed chamber, and though these to some extent ventilate the room, there is still the constant presence of fine dust which affects the workers in it prejudicially. Inlet Tobin tubes and extracting fans might be with advantage more generally adopted, but the current must be so regulated as not to affect what is technically known as "the lap" or roll of a loosely-compacted sheet of cotton.

Carding, in a room of similar temperature, is the next process: this is also dusty, and in many cases, even in fine counts, is either carried on in a separate room or that portion of the room is screened off from the rest by glazed partitions. Many efforts have been made to clear off the dust in this process, but none has yet been so successful as to secure general adoption; the difficulties in the way of a perfect process being very great. The heavier particles of dust are to a large extent collected in the carding engine itself, and the lighter particles can scarcely be removed without also carrying away the lighter portions of the fibre. The thickest cloud of dust is, however, caused by cleaning and grinding the machines, each of which requires, for one purpose or the other, attention during the day from the "stripper and grinder," as these workmen are called.

In some instances a series of tubes, with an inverted hopper over each machine, and the whole connected to a main trunk, fitted with a fan to draw up the air and dust by suction, have been tried, and in other cases powerful fans have been placed at various points in the room, but nothing has yet been found so satisfactory as to secure general adoption, and which is at once sufficiently powerful to clear the dust and still so gentle

as not to injure the lap or the film of cotton proceeding from the machine in a long loose coil of delicate fibres to the tall can in which it is placed for removal. The other portions of the card room, when other machinery is placed in same room, are much freer from dust, and are occupied by various frames, which in succession make the cotton into a more closely-compacted and finer thread, the delicacy of which will perhaps be best understood by the general audience when the fact is stated that screens are regularly put up to protect them from draft and dust and the breaking of the threads, or as it is graphically termed "the falling of the ends," caused by the opening of a door from a staircase or any room which communicates with the external atmosphere.

From the frames the cotton is taken to the spinning-rooms: these are the most free from dust, and have to be maintained at a temperature of from 80° to 90°, and in which the thread becomes increasingly sensitive from its fineness and the rapidity of the motion of the machinery; this renders it specially susceptible to any current of air, and also to any dryness of the atmosphere, such as is caused by east wind or dry frost, and also to the presence of dirt of any kind floating about.

The delicacy of the thread and fibres after leaving the carding machines, and the needed heat of the mule-spinning rooms, the absence of all which will affect the required colour or cleanliness of the yarns, especially those of finer counts, and the ever-increasing necessity to lessen expenses in production, render the question of ventilation difficult; besides which many think it needless from the great cubical space for each worker. This last fact undoubtedly lessens the inconvenience, but there can be no question, I think, but that the health of the cotton operative would be of a more robust character, and there would be less lung and throat disease, if the atmosphere was regularly changed.

At present the need only appears to be felt when there is such a wave of heat generated by summer sun and the rapid movement of the machinery that it becomes unbearable to the workers, and this is then dealt with by the usual method of opening the swing casements provided in a portion of the windows near the ceiling; in all other seasons every cranny and aperture where cold air can enter is carefully stopped up, and if inlets for air are provided during the construction of the building, they are after a short experience invariably blocked up. I may however, remind you that any one who takes the trouble to examine the ventilators of a public building or private residence in a year or two after the novelty of their introduction has worn off, finds such to be generally the case.

The effort to apply ventilation in these cases, which appears to be the most nearly correct in principle and which has had some success in a few cases, though not a complete one, is an arrangement of steam pipes in a small trough of water over which a current of air from the external atmosphere is deflected, and enters on one side of the room and is drawn across by strong fans on the opposite side, discharging either into flues or into the open air. This plan is not yet generally adopted. If a strong wind is blowing on the inlet side, it will give much too strong a current, and if the external atmosphere be smoky, as in a manufacturing town is usually the case, it would also carry with it a large amount of soot, which would materially damage the yarn for sale.

The arrangement also requires more attention in such a variable climate as ours than would ordinarily be given to it, and is not sufficiently automatic; but it is, as before stated, perhaps the most nearly correct in principle of any yet tried.

It is evident that the problem is both difficult and interesting to secure at once, by a practical working scheme, in all weathers a nearly uniform temperature, which shall in some rooms be about 60° and in others 80° or 90°, as needed, by the introduction and extraction of currents of warm and slightly moistened air, delivered at such levels and so imperceptibly as not to damage such delicate threads, and yet be so powerful as to change the atmosphere and carry away the dust. And there is the further and most important consideration that this has to be done without, either in first outlay or maintenance, materially raising the cost of production.

In ring or throstle-spinning and in doubling rooms the operatives are more numerous, and the heat is often raised in summer to a high degree by the action of the machinery; but there is not the same necessity felt to avoid draughts of air, and the window casements are more freely opened, and in some instances extracting fans are used. In other respects the need of ventilation is the same, and as little attended to as usual.

The various processes of preparing the yarn when made, for the use of the weaver or other manufacturer, and known as reeling, winding, and warping, are carried on usually in separate buildings at the normal temperature in summer and at a temperature of about 60° in winter; the threads are less exposed and, the machines not moving so rapidly, dust is less troublesome. Ventilation is usually unprovided for except by window casements, which are opened in summer but kept carefully closed at other times. These processes are frequently carried on in connection with weaving where to be used at once, and

in separate establishments, or in connection with spinning mills when intended for export.

One special process, known as "Gassing," however, calls for separate notice. In these machines fine threads of yarn are passed rapidly through small jets of lighted gas for the purpose of singeing it, and thus burning off the almost microscopic fluff and leaving the threads, two or more of which are also twisted together, perfectly smooth and hard on the surface, as well as slightly glossy. It will be seen at once that the constant working over the numerous gas jets is trying to the eyes, throat, and lungs, and also renders the atmosphere very impure.

Many efforts have been made, with varying success, to improve these rooms. In some cases, where placed on the ground floor, flues or channels for supplying fresh air by inlets at floor level have been tried; but the inconvenience from the draught to the feet and petticoats of the workers have caused them to be invariably stopped up. The least objection is found when placed in an upper story with other machinery beneath; the greater elevation from the ground, together with the slight movement of the atmosphere caused by the motion of the machinery beneath, appear to imperceptibly penetrate through the floor and help to supply a current which feeds the powerful extracting fans generally used.

The process of weaving into cloth the yarn made in the spinning mill is generally carried on in one-story buildings, lit from the top by skylights facing the north: the temperature in summer is the normal one, and in winter is usually about 60° for ordinary weaving, and where heavy sizing is used varying from an average of 60° in some sheds to 70° in others; and the percentage of saturation by steam in these works also varies from 77° to 88°, and from 3·3 grains to 7 grains of moisture per cubic foot of space.*

An escape for air is usually provided near the ridge of each roof, but this is generally blocked up the first winter and rarely re-opened.

The practice of steaming the sheds—now prevalent in some districts and special branches of the trade, so that the weaving can be more easily done in heavy sized goods—has attracted so much attention, and has been so fully discussed elsewhere, that I need not now bring it under your notice.

The question of flooring is one of importance, especially in the mule-spinning rooms, where, from the heat averaging 80° at least, and the active movements required in piecing-up the broken threads, the workers have their feet bare. In these

* Heavy Sizing Report, 1st Oct., 1883, p. 4.

rooms boarding is generally used, and is much the best; in some cases tiling has been adopted, and also concrete floors faced with cement. To both the last named there are serious objections, as the cold surface causes both rheumatism in the lower limbs and the disease of flat foot, affecting the muscles of the instep: the want of the slight elasticity found in a boarded floor makes the labour much more exhausting, and increases the loss of time from sickness. The passage, for general traffic and skips or boxes of materials, alongside the spinning rooms, is often laid with flags, and in these cases the workers sometimes complain that the change from the warm boards to the colder surface of the stone flag, whilst the feet are bare, strikes a rheumatic chill up the legs. The passages are much better laid with hard wood in narrow widths, laid with the length of the wood at right angles to the line of traffic, so as to diminish any risk of splinters entering the foot. In the cooler rooms and on the ground floors the workers are generally shod, and no inconvenience is felt from the floor being flagged or tiled; more particularly as special precautions are taken to keep them perfectly free from damp, which would affect the carding engines and other machinery.

In weaving sheds there has long been an idea that the flags should be bedded on sand laid on clay or earth; in this respect following the idea of the old hand-loom weaver, who generally preferred his floor, where practicable, to be of well-trodden clay. The conditions of power-loom weaving are, however, so different, that the same rule does not apply, and there is said to be much less sickness where the flagging has been placed on a good deep layer of dry ballast; and this should always be done.

In many of the American mills the main passages in the rooms are washed once a week, and the other portions of the floor at frequent intervals; this is done at the request of the Insurance Companies to prevent any accumulation of fluff or dust on the floors, which is also regularly removed from all pipes, &c. The result is to make the rooms much sweeter and the floors much cleaner, more sightly and healthy; and the adoption of such a rule in English mills would be a great improvement.

Whilst speaking of American mills it may also be named here that in "the American mills wardrobes, with separate compartments, are provided for the clothes of the workpeople, who are allowed 15 minutes 'fixing time' before the machinery is stopped. The American mill hands are very well dressed outside."*

* J. B. Gass, Godwin Bursary Report, 1885, p. 19.

It is supposed that an eye is kept on the work during this time, but there will be a liability to some loss both in quantity and quality of work from this practice, which will be however of such immense value in other ways as to be well worth consideration for partial adoption here.

The water closets, or other arrangement for disposal of excreta, naturally claim the next place in the matters to be brought before you.

In many manufactories where the workshops are mainly on the ground floor, and only males employed, the system of the common privy placed in blocks of five or six, with a cesspool to same, is still used; and with the object of deterring loiterers, they are kept as plain as possible, and uncomfortable rather than otherwise. These are however being gradually superseded by those built of salt or other glazed bricks, and fitted with water-closets similar in construction to such as are afterwards referred to.

Where the works are carried on in buildings of several stories, closets are generally provided on each floor, and arranged in tiers in a projecting block forming an external pier.

The old provision for these was similar to that said to be, until the last few years, universal in French and other foreign hotels, viz.: an upright pipe of iron or socketted earthenware secured to the wall, and having obtuse-angled branches with hoppers and seats; the excreta falling by gravitation and the occasional assistance of a bucket of water to the foot of the upright pipe, and thence by a short elbow making its way into a cesspool. I am glad to say that I do not, personally, know of a single instance of this system remaining in use in this district.

Various causes retarded the use of water-closets in factories, as there is not only the question of the expense of water, but of repairs where there is the slightest possibility of a closet being thrown out of order by use or carelessness.

I believe earthenware hopper closets, fitted with lead or earthenware traps, and fixed in wooden framing, were next introduced, and these, in many cases, were prepared to discharge from the cistern by self-acting levers, moved by the weight of the body on the seat. Objections were felt to these on account of their liability to be thrown out of order, the quantity of water consumed, and the waste of the material used in the manufacture, and which there were no means of checking or detecting.

Trough closets, let off at certain hours by an attendant, as manufactured by some of the Scotch firms and others, were introduced to meet these objections, and came into extensive use.

Being made of iron they however soon became very foul and offensive, and this led to the manufacture of them in earthenware, and various slight improvements have been adopted.

The closets of this class are generally re-charged by a self-acting ball tap, and these are soon out of order; in addition to which, if a piece of paper or any other matter lodged on the seat of the outlet valve, a leakage took place, which led to a waste of water: from these causes the ball taps have been in many cases taken out, and ordinary taps substituted, by which the attendant charges the trough at his periodical visit.

The latest closets are of earthenware, in the various forms made, and discharged by automatic syphon flushing apparatus. In some cases where the water supply is obtained at the cost of pumping only, improved forms of hopper closet, with trap combined, and discharged by the weight of the body on the seat, are again being introduced.

The question of the form of aperture in the closet seat may seem trivial, but is really of some importance where, as in factories, the closets are to be used by a number of persons, any one of whom, if uncleanly in habit, or suffering from infectious diseases, may cause, in the first case annoyance and inconvenience, and in the latter case serious dangers to others, who may thus innocently be subject to grievous penalties.

The ordinary shape is adapted to the form of closet, but is generally too short. Where trough closets are used opportunity is afforded to make the aperture a longer oblong, with rounded front, instead of the ordinary slightly oval form. By this means the back of the closet seat is less liable to be fouled by an uncleanly person, and the front is less likely to be infected in the case of its being used by a person suffering from venereal or other similar disease.

It may be noted here that, as in all cases closets are rarely inspected, it is desirable to make them give as little harbourage for dirt in corners and elsewhere as possible; that they should, for the same reason, be well lighted, and the lower portion of the walls either faced with glazed bricks or painted with an enamel or varnish paint, so as to be easily cleaned. Where the building is lofty the upper parts of walls are best lime-washed.

Where practicable a small ante, lighted and ventilated on each side, between the main workroom and the closet is exceedingly desirable, and though in many cases the processes of workmanship lead to a jealous exclusion of currents of cold air, the ante is valuable in such cases also. The upper part of door to such ante may be glazed in all cases, and so assist in preventing it being a harbour for loiterers, into the difficulties of dealing with whom I do not propose to enter.

It is often most convenient, especially in towns, to supply the closets with water purchased by meter from the local authorities, and the desire to reduce this expense leads generally to very defective flushing; and as the discharges, when under the care of an attendant or by automatic action, generally take place consecutively, if not simultaneously, there are large masses of solid matter thrown into the drains at one time, and the slight flush not being able to carry them far forward, the public sewers in the neighbourhood of large works are apt to become elongated cesspools. In such cases the noxious stenches and gases evolved are very perceptible at the manholes in the public streets, and often penetrate dwellings, to the serious injury of the inmates.

I believe we are not free from instances of this kind in our own district any more than other localities, and it would be well if the local authorities, either insisted upon efficient flushing or, in such cases, required the provision of well-ventilated cesspools for the retention of the solid matter, and which should be cleansed, when needed, by them. The factory chimney may often be available to form an active current from such places, and might be made available often for sewage ventilation generally, if in the thick walls of the lower portion flues were carried up from which, when the current had been raised to the temperature of the chimney, vents might be opened to the inside near the top of the stack.

Soil pipes are generally carried up full bore to the highest point as a ventilator and fitted with some form of hood, but the provision of inlet near the base to insure a current through same is not always attended to. Where practicable it is exceedingly beneficial to carry a branch pipe $\frac{1}{2}$ in. or $\frac{3}{4}$ in. bore, from a nozzle specially provided under the closet seat and above the overflow line, the branches being connected to a main, increasing from $\frac{3}{4}$ in. to $1\frac{1}{2}$ in. or 2 in. bore, the end of which terminates in a furnace flue or tall chimney; in this way any offensive smells from the excreta in the hopper or trough is drawn off by a strong current, the closet is also ventilated, and the odour is less likely to penetrate into the workroom.

The requirements of water-supply for drinking purposes vary so greatly, according to the temperature of the rooms and nature of the work, that I can only say generally that it is exceedingly desirable that there should be an efficient supply of good drinking water, and that in all cases there should be ample provision for washing the hands, &c. The fittings for these are best in all cases, and most cleanly looking, of cream-coloured glazed earthenware.

In the majority of cases cotton-workers live near the mill or shed at which they are employed, but in some instances the distances are too great for them to go home for meals, especially for breakfast, for which less time is allowed than for dinner. In all such cases where other provision cannot readily be found, good airy and well warmed rooms should be provided on the works, and fitted with suitable plain strong tables and seats, and kept thoroughly clean; ample provision should be made for washing the hands and face, and every facility given for the cultivation of cleanly and decent habits.

The Government regulations under the Factory and Workshops Act, 1878, and which by an Order of 17th March, 1880, were extended to non-textile factories and workshops, provide as follows:—

"For the purpose of securing the observance of the requirements of this Act as to cleanliness in every factory and workshop, all the inside walls of the rooms of a factory or workshop, and all the ceilings or tops of such rooms (whether such walls, ceilings, or tops be plastered or not), and all the passages and staircases of a factory or workshop, if they have not been painted with oil or varnished once at least within seven years, shall be lime-washed once at least within every fourteen months, to date from the period when last lime-washed; and if they have been so painted and varnished, shall be washed with hot water and soap once at least within every fourteen months, to date from the period when last washed."

It is evident from these that the lime-washing will be the most convenient to do in factories, and such is almost universally the case, and on the whole is carefully carried out. There are, however, instances in which it is very perfunctorily performed, and only the flats of the ceiling and sides of the beams visible from the door of the room are done annually with the hope that these will pass the glance of H. M. Inspector, who, it is needless to say, when the same is detected enforces a due performance of the regulations.

In conclusion, it is perhaps needful to say that it seemed more appropriate to the occasion and place of meeting, as well as probably more useful, to deal with one special class of works rather than to refer slightly to the large number of facts and special trade novelties which the extensive nature of the general area and range of inventions would allow.

I fear that this may have caused the paper to be less interesting and generally attractive than otherwise, but hope that it may, by calling attention to the special field of observation, be nevertheless of some service to the community among which I dwell.

Prof. T. Hayter Lewis, F.S.A. (London), remarked that the paper just read must be extremely interesting in a district such as this, and coming from a gentleman so thoroughly acquainted with the different kinds of works about Bolton. His (the President's) own knowledge of the district was insufficient to allow him to make any detailed observations on the subject. Mr. Bradshaw had gone very fully into details, *e.g.*, the difficulty of getting ventilation without draughts. They found over and over again in their experience, that whenever openings had been made for ventilation, they were stopped up by the persons who used the rooms. How this difficulty was to be got over was not made quite clear in Mr. Bradshaw's paper. Mr. Bradshaw had alluded in his paper to the subject of cleanliness, and made it one of his great points, and upon this they could all thoroughly agree with him. Without cleanliness there could be no cheerful home, and scarcely could there be a healthy one.

Mr. E. C. Robins, F.S.A., F.R.I.B.A. (London), said that in opening the discussion he might inform the section that he had received that morning various papers from the veteran philanthropist, Mr. Edwin Chadwick, who took a great interest in the proceedings of the Congress. Especially applicable to this section was a paper (much too long to be read, but which would doubtless appear in the Transactions), which happened to be on a subject quite in harmony with that which they were now discussing; it was entitled "*Ventilation of air from superior layers in place of inferior layers.*" The suggestions in the paper were not uncommon to many of them, and were simply directed to enforce the condition that the incoming air should be taken from a higher level, rather than from the surface of the ground, which was most usual, in connection with which he gave illustrative instances of an interesting character from various parts of the world. Mr. Robins proceeded to observe that in providing for the ventilation of rooms the inlets for fresh air were as important as the outlets for foul air, and that in their arrangements for bringing in the fresh air architects should be careful to know what were the circumstances affecting the quality of the atmosphere surrounding the building. At the University College laboratories at Dundee the air was brought in from the upper part of the building by a descending shaft, from which fresh air was admitted to the lower part of the building, and was then brought in under pressure. There were many buildings in which the same method had been adopted. But he had a strong objection to the use of long flues for the introduction of air, because they could not be got at for the purpose of cleaning, and had a tendency to accumulate impurities. To bring fresh air from the upper part of a building by tubes, and then to pass it through flues in the walls, was not he thought a desirable thing. His opinion was in favour of letting every room have its air brought directly in through external gratings, communicating with coil cases, within which the heating pipes could be so arranged that the fresh air might be warmed as it passed into the room in winter time. Such a system was certain to act if arrangements were made to extract the foul air by artificial means, and so change the air at least four times in the hour. The sucking out of the foul air necessitates its replacement by purer air, and the introduction of vertical air currents well distributed eliminated draughts.

Mr. A. E. Eccles (Chorley) had been connected with cotton mills for forty years, and had taken some interest in ventilation. His opinion was that the *greatest amount* of ventilation could be obtained when the workers were absent from the mills, either during the night or their meal hours. One of the reasons why workpeople would not have ventilators open was because a sufficient number of them to be efficient was not placed in the mills. Something like the case in that room in which they were at present assembled. There were four windows in that room, but only one was opened; now if all the four windows on one side were opened the velocity of the air would only be one-fourth of what it was with one opened. In his opinion it was high time they had a change in the matter of the ventilation of their public buildings. It was certain they could not get any purer air inside than that which was to be obtained outside public buildings, and they had better have a little soot fall amongst their furniture than have their lungs filled with carbonic acid gas. In his district they had followed the system of ventilating the factory and school when the people were out, and they had derived from it great advantages.

Prof. H. Robinson, M.Inst.C.E. (London), thought it ought not to be taken for granted that dust and dirt could not be removed from air. The very best remedy was to introduce a layer of wool into a Tobin or other tube which conveyed the fresh air from the outside. He did not think it was desirable they should have the dust from the outside brought into the room at all, when by very simple methods they could remove it by screening the matters in suspension from the external air prior to its introduction.

Mr. John Leach (Bolton) did not wish to say much with regard to the ventilation of factories. He wished rather to direct attention to school buildings. The Board of which he was chairman had just completed the erection of a new school in the borough, and they had been rather exercised to know in what way they might best promote the ventilation of that building. After considerable investigation, they had come to the conclusion that the best means was to admit air by Tobin tubes, or some similar apparatus, and then have upright shafts, with an opening into each room supplied with a Bunsen's burner to create a draught, and to remove by that means the foul air from the several parts of the building. In schools containing a thousand children, where the surroundings of many of them were not of the pleasantest, and the children's clothes not of the sweetest, they required an amount of ventilatien and fresh air which he thought was greater than that required in factories. He thought it was highly important that the surroundings of these children should be as

healthy as possible, and he should hail with satisfaction the adoption of some system of ventilation at once simple, inexpensive, and automatic. The Board were recommended to try a great many systems. Some said it was sufficient if they provided for the supply of air, and not for its exit; whilst others provided for its exit, and not for its entrance. In others which were mentioned they required a gas engine and appliances of various kinds, working archimedean screws, and other systems for expelling the foul air. He should, however, be very glad indeed if that section could assist them in arriving at some effective means of ventilating these difficult buildings.

Mr. N. Simmons (Bristol) said the gentleman who read the paper appeared to have some difficulty in keeping out the soot, but he thought this difficulty could be met by cotton filters. He had seen them used in many cases with very great advantage. He had had some experience in the ventilation of schools and other places, and he had invariably found the Sherringham system to be very useful. They could put them at any height they thought fit—generally above the head. By that means they could get a lateral pressure, and could regulate the supply just as they desired by partly opening or closing the aperture on the opposite side. That system was well known, and was described in "Galton's Healthy Dwellings."

Mr. Norbury (Leigh) thought Mr. Bradshaw had very wisely confined his remarks to one particular kind of ventilation—the ventilation of factories and workshops. The paper was an excellent one, and dealt with everything that could be said on the subject. He had had some experience in the ventilation of mills, being an inspector. Mr. Bradshaw anticipated the greatest defect there was about the whole thing when he referred to the privies, and reprobated the old system. Mr. Bradshaw seemed to be very hopeful that the old system was very rare. He himself only wished that hope were well founded, but as a matter of fact it was not well founded. Mr. Bradshaw had probably mainly to do with new mills, and he had no doubt that in the mills Mr. Bradshaw erected proper means were taken to prevent the difficulty to which he would refer. In many of the old mills and weaving sheds he knew that a villainous system of privies connected with sewers existed, and these privies being usually placed in a cool place, and the atmosphere of the mill becoming heated to a very high degree, the air they really got in the mills actually came from the closets, and through what Mr. Bradshaw had well described as an elongated cesspool.

Mr. J. Honeyman, F.R.I.B.A. (Glasgow), said one of the difficulties of ventilation pointed out by Mr. Bradshaw in the case of these mills was the necessity of keeping up the heat of the atmosphere. That considerably complicated the matter, but he thought it pointed to this, that the extraction of air should be from the floor line. If they extracted the air from the upper part of the room they of course got rid of the bad air, but they wasted heat. They might, however, maintain

a very high temperature and effect the necessary removal of air if they extracted from the floor level. As to water closets, he had long had the idea that those for mills, railway stations, and similar places to which large numbers have access, ought to have no seats at all. It was quite an easy matter to make an adaptation of basin which with a movable bar could be quite as easily used the one way as the other. He thought this of considerable importance.

Mr. Rogers Field, M.Inst.C.E. (London), expressed his appreciation of the value of the paper read by Mr. Bradshaw. It was of great importance in dealing with this question of ventilation by artificial means that they should know the relative value of the various appliances for moving air. In the Exhibition which had just been opened they had fortunately a goodly number of ventilating fans and similar appliances, and the members of the Congress might see them working as it were side by side. These appliances would, moreover, be practically tested in London before the awards of the Judges were made, and the results of these tests would doubtless be very valuable to those who, like a previous speaker, were seeking for a settlement of the best means of securing ventilation for schools, &c.

Mr. E. C. Robins, F.S.A. (London), said that where there was no engine or apparatus giving motive power such as would turn a fan, they required some simple automatic method. He had had some personal experience in regard to the use of Tobin's ventilators, by which it was sought to introduce air in such a manner that it should not at once move laterally, but should rise vertically and gradually disperse itself. This was the main merit of Tobin's tubes, of which, by the way, Mr. Tobin was not the original inventor, for as he had shown elsewhere the invention was really about a hundred years old. However, the system was very useful, and he had seen it carried out with great benefit in the ophthalmic ward of St. George's Hospital. In this room there were about eight or ten of these ventilators admitting the air, and though there was no other outlet than the fireplace, and the patients, whose diseases made them especially sensitive to a draught, were sitting round the fire, yet there was a general feeling of comfort, and certainly no draught, the air rising from the ventilators and passing slowly up to the ceiling and down to the floor in circular waves until the extracting fire was reached. Certainly in that room the ventilation was eminently successful, but he knew many others in which it was not. Where this method was adopted, and they had no fireplace, or at least no fire in it, they might adopt the system of having outlet gratings to vertical flues in the walls to carry off the vitiated air, aspirated by a gas-jet at the bottom. He had himself tried the system in wards and in school dormitories. The gas might be so applied as to serve the double purpose of causing the up draught and lighting the room at the same time. If they had not this gas jet burning they might find that a down draught instead of an up draught existed in the so-called extract flues. Where there

was a heating apparatus, they might use coils of pipes both in the inlet and outlet shafts. On this principle he had himself heated and ventilated the North London Collegiate School for Girls. The fresh air was introduced and the bad air extracted by means of coils of hot water pipes in the inlet and outlet flues. In the great hall there were openings in the ceilings, and the vitiated air was conducted to each end of the triangular space in the apex of the roof, whence it was discharged through large vertical air shafts rising some distance above the ridge, at the base of which shafts hot water coils were placed, and kept heated both in winter and in summer by a special boiler. In the great hall there were often seven or eight hundred people who had almost perfect immunity from bad air or draught. A similar arrangement had been adopted by himself at the Society of Arts. In that case there was a shaft three feet square going from the basement to the top of the building, and immediately adjoining the hall. He placed at the top of that shaft a coil of pipes, and he connected the ceiling ventilators by zinc tubes through the roof with this shaft, and thus drew out all the bad air. The fresh air was admitted to the room through five openings fitted with canvas screens, the air from which passed over heating pipes, and was delivered into the hall through horizontal gratings the whole length of one side of the hall. It was very desirable that an investigation should be made as to the value of the different fans in the present exhibition, because he had had to take fans out which were found to be unsuitable, either on account of their noise in working, or failure to withdraw a sufficient volume of air. The shaft on the delivery side of the fan should be as wide and open as possible to give free scope for the expulsion of the air, and the more direct the action the better—every right angular turn in the channels halved the force of the extracting current.

Mr. Tom Nanson (London) thought there was a point in Mr. Bradshaw's very able paper which had quite been lost sight of, that was: that it was not only necessary to introduce fresh air at a certain temperature, but that it should also be introduced with a certain percentage of moisture. He thought that this could be attained by passing it over a trough of steaming water. It would be at once seen that if the air was sent into an air chamber, and then deflected over this trough of steaming water, there could not be brought in with the moistened air those sooty particles which had been complained of. Then they had heard several remarks about fans, but Mr. Bradshaw had clearly shown the necessity of changing the air with the least possible motion, and in his (Mr. Nanson's) opinion, the use of fans would create such a considerable agitation of the air as to render their use impracticable. Why should they not have the air brought in by a series of trunks and comparatively small ventilators? They would only have to increase the number in exact ratio with the size of the room they wanted to ventilate. He had not the same objection to the trunk and chamber system that Mr. Robins had. It had been said, and he was sure that Mr. Rogers Field would agree with him on this point, that it was possible to keep a drain as clean as a drinking jug, if they only took pains with it; and the keeping of those trunks clean was simply a matter of detail in construction. By a system of doors they could be cleaned out weekly, though he did not think it would be necessary to clean them out more than monthly. As to the filtration theory, he thought the cotton filter was practically out of the question. In a cotton factory they would have to clean these cotton filters twice a day, or they would get clogged up. And with regard to the removal of the foul air, he thought it should be attained by the ordinary fixed induced-current ventilators.

Mr. T. Connolly said that he thought one point appeared to be very often lost sight of: the tubes were frequently too large and wide and too few, so that they got a strong current from each inlet, producing a very disagreeable draught. In his opinion they ought to be very long and very narrow, not more than an inch in depth. They believed in having the walls and floors cemented, and in this case there was no danger whatever of getting in any impurity through the soil. The air being pumped into the chamber room was therefore under pressure, so that there was no chance of air from the outside permeating into the room. With regard to cotton filtering, had it not been found by persons of practical experience that where utilised it interfered very materially with the current?

Mr. Herbert Fletcher (Bolton) said he had made practical application of cotton filtering, though not in a cotton mill, but in his own house. He kept a window open in the cellar, and fixed in front of it a large frame, over which he threw a calico bag about six feet square, entirely covering the window; the air in passing through the bag left a large portion of its impurities on the inner side of the bag. The bag soon became very dirty, but was ready for use again after washing. His house was within the Borough. The texture of the calico was coarse, but the "nap" was "raised" by some process in the mill. Mr. Fletcher concluded by inviting the members to his colliery, where they might see the boilers hard fired, yet emitting no smoke, and have the opportunity of descending a mine where the subject of ventilation is necessarily the first to which the attention of the management is always directed.

Mr. Leach (Bolton) said that it had been remarked that in a London Hospital the ventilation was produced satisfactorily by means of Tobin's tubes around the room. He wished to ask whether the Tobin's tubes were on two sides of the room only, or otherwise.

Mr. E. C. Robins, F.S.A. (London), said in reply, that the room in question was square, and as far as he could remember there were three tubes on each side — perhaps twelve altogether; he also

remarked that canvas tops to the tubes were of little use unless often examined and cleaned. They were, however, very effectual in keeping out blacks, but the Æolus Water-spray was a better plan for that purpose.

Mr. DARLEY (Leeds) pointed out that Mr. Bradshaw had headed his paper "Sanitary Apparatus for Convenience in Factories." Hospitals and schools had been introduced into the discussion, whereas the subject under deliberation was factories. Mr. Bradshaw wished it to be understood that he was not pushing some speciality in connection with sanitary apparatus for the convenience of factories. No one supposed he was. If, however, there were any special system, he should be very glad to know it, and would like to have it put before the meeting. Ventilation was a problem which the greatest men of the day considered unsolved. There was an important factor which had not been touched upon—except by Mr. Bradshaw—that day, viz., varying climate. A fall in the temperature of ten degrees was not an uncommon thing, but was one which would create a great difficulty in keeping up the temperature of the factory and maintaining a thorough ventilation. One of the principal reasons why people closed the inlets was because they would be warm, and therefore they got one benefit at the sacrifice of another. There was a great difficulty in creating and keeping up the temperature and at the same time giving the quantity of air requisite for ventilation. Turning to the question of factory closets, he would like to know whether there were any closets and drains ventilated by chimney shafts. His experience taught him that they were more the exception than the rule, for the simple reason that a number of chimney shafts were built of insufficient capacity for the duties they had to perform in connection with ordinary steam boilers. If such chimneys were called upon to also ventilate closets, it would be found to reduce the draught in the boilers, and thus create a difficulty in maintaining steam. In conclusion, he trusted they would get from Mr. Bradshaw some definite answer on the subject of the particular system of ventilation he recommended.

Mr. E. SERGEANT (Bolton) said the practical experience of ventilation he had had was in connection with that at the fever hospital in Bolton. They had recognized the great difficulty that existed in regard to ventilation, and were satisfied that in order to have it efficient, it should be as free as possible from any mechanical contrivance that was liable to get out of order. He thought they had succeeded fairly satisfactorily. They had had ventilators introduced whereby the wards might be kept at a proper temperature in winter and made cool in summer without cold air being directly introduced. There was a special sort of catch-pit underneath the ground which caught the air from the outside and then it was passed along troughs running round the wards, and having been heated was introduced under each bed, and by means of shafts conveyed over each of them

at a distance of about six feet from the ground; inside the top of each shaft they had, in a movable drawer, a sort of diaphragm with a covering of worsted which intercepted the dust and any objectionable particles. Thus the air was introduced warm, free from dust, and so as to obviate any draught; these were conditions he thought they ought always to aim at. They had also in their wards an arrangement which he thought was highly essential for removing burnt gas, which they considered very deleterious to the health of people in a hospital. They had a special arrangement which he thought was worth looking at: it was in the shape of a cap over each gas bracket, which was so arranged that the burnt gas was conducted by means of a tube an inch and a half in diameter through the ceiling, and so passed out of the room by means of the ventilators. If the current was not satisfactory they were able to rectify it, and so at all times to take away from the wards the burnt gas which was so prejudicial in living rooms. They were also able to collect the foul air from the wards and withdraw it by means of the current induced by the hot air through the ventilators. In conclusion, the doctor invited those members of the section so disposed to visit the hospital that afternoon, where he could more clearly explain the methods of ventilation.

Mr. J. J. BRADSHAW (Bolton), in replying, said he did not wish to extend the time by entering into the general question of ventilation. He pointed out that in a room 20 ft. by 16 ft. by 12 ft., which contained about 4,000 cubic feet of space, the Tobin tubes were often closed. The rooms in the Bolton Town Hall were ventilated by their means, and the clerks complained strongly of the draught when the wind was in the direction of the tubes. The wind came in with great force, and they were often stopped up with books or something of that sort. This showed the difficulty of ventilation in a small room: but increase the area of that apartment from 4,000 cubic feet to 800,000 cubic feet, and what a difference that would make. Added to this, they had a fibre to manipulate which was as sensitive as a thermometer, and which under given conditions they could not work at all because it would drop off. Under all circumstances the ordinary expedients of filtering the air by folds of cotton wool, or anything of that sort, became totally unapplicable, because the work had to be done on so large a scale, and all the time they had to bear in mind the delicacy of the material upon which they were working. Fresh air, admitted as it frequently was by direct, or slightly indirect, inlets from the atmosphere, meant to the manufacturers increased coal consumption in the winter, because the temperature of the room must be maintained to avoid damage to the material. He was not recommending any special system of ventilation because, to tell the truth, he did not know of anything that answered the purpose absolutely well. He had plans of his own, but he had not brought them before the meeting for the simple reason that he had not given them a successful trial on the scale required for buildings of that class. The varying temperature of the atmosphere, and the necessity of preventing draughts—which was a

thing common to all systems of ventilation on either a small or large scale—were difficulties that seemed too great to overcome in old buildings: he thought he could see his way to achieve it in new buildings, where a special provision could be made. Manufacturers, in erecting a large mill, were generally compelled, from prudential reasons, to regulate every penny of their expenditure: if an expenditure of some hundreds of pounds were proposed, the manufacturer wanted to know what he was to get in return for it, and to see an example of the contrivance in actual operation. They were all willing for some one else to "bell the cat." This was one of the difficulties they had to overcome. He knew of no scheme that could be applied to existing buildings with a guarantee of perfectly satisfactory results. That was a reason why he did not name anything of that kind and bring it before the conference. Mr. Norbury's observations might apply to other buildings, but not to the cotton mills of Leigh. With regard to Mr. Honeyman's remarks, he was sure that that gentleman had never worked in a cotton mill, or he would not have made the proposal he did with regard to closets in cotton mills. After people had been employed five or six hours he thought there ought to be some reasonable provision for comfort, and that at the same time every precaution should be taken to prevent the possibility of annoyance or danger arising from it.

Prof. T. Hayter Lewis, F.S.A., remarked that there was no fear of any one considering Mr. Bradshaw's paper anything but interesting. It had brought about a valuable discussion, and personally he was much indebted to him.

On "Village Water Supply," by Stephen Harding Terry, Assoc.Mem.Inst.C.E.

The excessive drought of the present summer is causing many who have hitherto either never considered the subject of this paper, or who have obstructed the progress of a water scheme, to look upon it as a necessity, and one which must now be dealt with.

Having been brought more or less intimately in contact with many of the difficulties which arise in connection with the supply of water in rural districts, I venture to think that this paper may not be without interest; and I propose to show that the cost, which is the real deterrent in connection with the adoption of a water scheme, is in most cases (if a qualified

engineer is consulted) far less than is generally believed, and that in many instances where a gravitation scheme not involving the cost of a large reservoir or great length of mains is adopted, it is found that a small water rate, not exceeding 2d. or 3d. per week per house, is more than sufficient to pay for the whole cost, if the works have been constructed by means of a loan repayable in equal annual instalments of principal and interest.

I propose to give examples of various methods of supply:—

No. 1. Gravitation.
No. 2. Pumping.
No. 3. Arrangement with Water Company or adjacent authority possessing water.
No. 4. Draw-wells and Hand-pumps.

No. 1.—*Gravitation.*

The village of Tansley, near Matlock, is an instance of the first method of supply.

The population is 678; rateable value, £2,069.

Prior to the completion of these works in 1885, the village was entirely without any proper means of water supply, and was dependent on certain surface-fed springs, which failed in dry weather and were subject to pollution; there are also certain small streams flowing through the village, but these are polluted.

Messrs. Fowler and Sons, of Sheffield, designed the following scheme, which was successfully carried out by Messrs. Thompson, contractors, of Sheffield:—

Two underground reservoirs, of a total capacity of 4,200 gallons, receive water from two springs having an average flow of 36,000 gallons in twenty-four hours. Stoneware pipes bring the water to the reservoirs, which are kept constantly full, the overflow passing into the original channel of the brook. The pipes are cast iron, three inches diameter, and were tested to 600 lbs. per inch; the greatest head is 180 feet. Eighteen stand-pipes with screw-down cocks, and three fire-hydrants are provided. Some houses have the water laid on free of charge, except for the cost of connecting the service-pipes. The work is done by the authority, and repaid by the house owner. The actual cost of the works, giving a constant supply (up to fifty gallons per head, if necessary) to 678 people, has been £700, the annual instalment of which, principal and interest, at 3½ per cent. for thirty years, is £38 1s. 3d., or 4s. 4d. in the pound on the whole rateable value, or about 1s. 2d. per head per annum; or, assuming that there are 114 houses, a water-rate

of 6s. 8d. per annum, or just over 1½d. per house per week, would entirely relieve the general rates of all charge. The capital cost of the works per head of population has been £1 0s. 7½d., a sum which compares favourably with the cost of supply of most large towns.

Below is given a typical estimate of cost of works of supply by gravitation for two villages situate in Gloucester and Wiltshire. It will be noted that 120 houses, with a population of 560, are supplied at a capital expenditure of £1,200, and that the total cost at 4 per cent., repayable in thirty years, amounts to £69 8s. per annum. The revenue at an average of 3d. per week per house, including farm-houses, is £78, showing a balance of £8 to meet expenses of collection.

There are 5¾ miles of main and service pipes; and as the spring is to be depended on both in summer and winter, a large storage reservoir is not required.

	£	s.	d.
3 miles cast iron main 3 in. diameter, at 2s. per yard laid	528	0	0
1 mile of 2 in.	165	0	0
¾ „ 1 in.	63	15	0
1 „ ¾ in.	65	0	0
Draw-off cocks, stand posts, air valves, &c.....	78	5	0
Reservoir, valves, &c.....	100	0	0
Engineer's commission and contingencies, 15 % ...	150	0	0
	1,150	0	0

Or in round figures say £1,200 for the supply of those parts of both villages which are now without drinkable water.

The annual repayment on £1,200 at 4 per cent. for 30 years is £69 8s. 0d.; an equal rate on the whole rateable value £18,303, would require to be 9d. in the £ supposing no special water rate was levied.

Assuming that 120 houses in the two villages are supplied at an average rate, including farm-houses, of 3d. per week, a gross revenue of £78 per annum will be obtained; which will be more than sufficient to pay the entire cost of the loan, and will leave a margin of £8 to meet the expenses of collection.

No. 2.—Pumping.

At present very few villages are supplied from waterworks of their own by pumps worked by steam power, but this system of supply is in many cases the only one possible, and with the production of economical and simple motors, such as those of Davey, of Leeds, is likely to greatly extend.

A village in one of the midland counties is now constructing

waterworks of this character, under the advice of Mr. Herbert Walker, of Nottingham. The population is about 1,000 and the works will cost about £1,200. The reservoir will hold about four days' supply or more, and the pumps will raise in one day enough for four days, so that it will only be necessary to run the engine and pumps twice weekly. In this way the charge for superintendence will be lessened. The capital cost per head of population will be £1 4s.

	£	s.	d.
The annual instalment of principal and interest at 3½ per cent. for 30 years will be.....	65	0	0
Assuming coals and supervision to cost*	35	0	0
	100	0	0

Assuming that 180 cottages at 3d. per week take the water, there will be a revenue of £112 10s., leaving a balance of £12 10s. towards repairs and contingencies.

It is remarkable that in this country windmills are so little used for public water supply in villages. They are largely used in America for supplying water on railways for locomotives and station purposes, and if the reservoir filled by them is large enough to contain a week's supply they give very satisfactory results. Small sizes have been in use some years in this country for supplying private houses and farms, and I have recently seen, near Rickmansworth, a large Halliday windmill, with fan 25 feet in diameter, mounted on a platform 80 feet high, which raises water from a deep well against a total head of 180 feet. It supplies a mansion, farm buildings, and stabling, together with a large horticultural establishment, and I understand it gives complete satisfaction, keeping the reservoir always sufficiently full. I have no means of knowing the volume pumped, as the speed varies continually and no water meter is attached.

The little town of Lechlade, in Gloucestershire, which for the purposes of this paper may be considered as a village, has adopted a windmill pumping scheme; the works are now under construction. Water is obtained from two Norton tube wells, and the reservoir and engine are of the Halliday type. The reservoir is a circular wooden one, and carries the framing of the mill on its top. The pump is of the Ontario type. The first cost of the wind engine and reservoir is slightly in excess of the cost of a small steam engine, pumps and reservoir, on account of the necessity of increasing the size of the reservoir

* Arrangements are being entered into with a farmer in the parish for the use of one of his men as engine-driver twice weekly.

when wind is the power employed, to insure a supply during calm weather.

As an example of a pumping supply in a comparatively rural district, I will instance the Sutton-in-Ashfield, and Hucknall-Huthwaite Works, which were completed recently, Mr. G. Hodgson, of Loughborough, being the engineer. The Works supply a population of 11,000 people in the two towns and adjoining villages: the towns are some miles apart, have separate reservoirs and rising mains, but the same pumping station. The machinery and buildings are of a very substantial character, and the entire cost of the works has been £17,300 or £1 11s. 5d. per head of population. The well yields 1,000,000 gallons daily, but at present only some 300,000 gallons per day are required.

No. 3.—Arrangement with Water Company or adjacent authority possessing water.

As an instance of this I may mention Seend, Wilts. The whole of the lower part of the village—in which there are very few wells, and those polluted—is now supplied by agreement with the Trowbridge Water Company, who charge 1s. per 1000 gallons by meter; the rural Sanitary Authority laying mains up to the limits of supply of Trowbridge Company, the latter meeting them. The rural Sanitary Authority charge water rates for stand-pipes, and the sum thus recovered is almost sufficient to repay principal and interest on the small capital, some £250, together with cost of water.

Another instance of this is Stanks, near Cross Gates, Leeds. The rural Sanitary Authority of Barwick, in Elmet, are now completing works for the supply of this hamlet of 51 houses.

The cost is estimated at £250, or nearly £5 per house supplied; the revenue derived from water rates at 3d. per house will be more than sufficient to repay the loan in thirty years.

Hucknall-Huthwaite and Sutton-in-Ashfield, the example quoted in the heading No. 2, is an instance of arrangement with adjacent authority. The Sutton pumping station was first completed, and, the water having been found abundant, it was decided to supply Hucknall from the same source. There are throughout the country numerous instances in which an arrangement of this kind would be made to advantage, but frequently the opportunity is lost through local antagonistic feeling between the parties concerned.

No. 4.—Draw-wells and Hand-pumps.

Several villages in Suffolk and Essex have within the last few years been supplied with water by means of public wells

constructed under the Public Health Act and Public Health (Water) Act, and the cost has been defrayed by means of loans; and as the cost of any well so constructed seldom exceeds £100, and loans for a period of thirty years are sanctioned, the incidence in the rates is very small; notwithstanding this, these applications are generally met with great opposition on the part of some ratepayers living beyond the reach of the well so constructed.

In public wells, wherever possible, the well should be covered in, and the supply obtained by a pump. Where the depth of water precludes the use of a suction-pump, and a deep-well pump, on account of expense, is deemed unadvisable, some form of well-engine should be provided, with two buckets, by which the empty bucket descending partially balances the full one ascending; and in all cases of public wells a draw-bucket should be provided attached to the chain, so that the private buckets of those fetching water need never be dipped in the public well. It might be supposed that this precaution is sufficiently obvious, but it is frequently neglected. Children, or even their elders, stand buckets down in filth, and even use buckets which have recently contained filth, and then send them down a public well.

To prevent this, all that is necessary is to provide a public bucket attached to the chain, and to protect the mouth of the well, so that no water or filth near the top can pass down through the cover or sides. All wells should be lined with brick in cement for a considerable distance down; in fact, until some impervious strata is reached, to prevent the entrance of impure surface waters.

The village of Littlebury, near Saffron Walden, has signalized the jubilee year by making a boring 120 feet in depth, 116 feet of which were in chalk. The boring is lined to within a few feet of the bottom with four-inch screwed flush-jointed wrought iron pipes. Water rises to within 10 feet of the surface, and is of excellent quality. Fifty gallons per minute for eight hours consecutively pumped from it only lowered the water level a few inches, and it is intended to connect the vertical pipes with horizontal mains at a depth of about 13 feet, and from this source to supply the lower part of the village, the higher part being already supplied from the pump. The cost of the boring and pump has been £135; the work was done by Mr. Ingold, of Bishop Stortford. An unsuccessful boring was first made about 100 yards away from the present one, to a depth of 220 feet.

Many villages and towns also would have been satisfactorily supplied for less money than the present unsatisfactory schemes

have cost, if they had employed engineers instead of those who have had nothing to do with water supply.

Schemes are brought out by land surveyors, architects, and masons, and others who, however able they may be in their own professions and callings, have not had any experience in water supply. Some few years ago a proposal was put before me by which it was intended to pump the whole low-level supply of a district 20 feet higher than was necessary to supply the low level, in order to work an hydraulic ram to raise one-third of the volume an extra height of 80 feet to supply the high-level district!

It may be objected by those who unfortunately oppose the progress of sanitation, that I have not dealt with the question of acquisition of water right or compensation; this question when raised is generally too large to be dealt with satisfactorily in a short paper, but it is not too much to say that only a very short-sighted policy would offer obstructive opposition to the adequate supply of a village with one of the first necessaries of life, and in many cases the volume required is so small as to be of no use to the mill interests, although unfortunately a great point is often made of this where a local authority is treating for a supply.

There are numerous instances in which the mill interests have been greatly benefited by the construction of large storage reservoirs for public supply, as their construction has enabled a given volume of compensation water to be daily delivered to the water course during continued periods of drought, whereas without such reservoirs their water would have reached the sea weeks or even months previously in useless floods.

In conclusion, it is hoped that the figures and instances here given, and the discussion which may arise, will shew that the cost of supplying villages with water is not so great as is generally supposed, and that in many cases, where circumstances are favourable, the whole cost can fall on those who are benefited by it.

Section 64 of the Public Health Act empowers a local authority to compel an owner of a house to supply that house with water at such rates as may be in force in the district (if there is a local Act in force), or should there be no local Act, at a rate not exceeding 2d. per week, or such rate as the Local Government Board may consider reasonable. Section 9 of the Public Health (Water) Act, 1878, provides for the levying of water rates on all houses using water from stand-pipes, if such houses are within 200 feet of such stand-pipes.

The above clauses provide ample means for recovery of the cost of construction of such works as bring the supply into the

houses or to stand-posts, whether such supply is obtained by gravitation from springs or by pumping, and whether such supply be obtained by a rural Sanitary Authority, direct or by agreement with a neighbouring authority, or water company. Nothing in these sections however provides for cases in which the geological formation or altitude of houses to be supplied prevents the supply of water by means of pipes, either to stand-posts or into houses. Section 3 of the Public Health (Water) Act, 1878 (framed upon the evidence given before Mr. Alexander Browne's Committee), was intended to deal with cases in which the supply can only be obtained by draw-wells or hand-pumps; but this section has, it appears to me, not been used to the extent which might have been expected, on account of the opposition generally found in rural districts, based on the objection on the part of a ratepayer well supplied with water in one part of a parish to pay for the sinking of wells or fixing of pumps for the benefit of others, perhaps several miles distant.

It is true that the framers of the Act in question foresaw this difficulty, and apparently intended that sub-section (5) should meet it.

Sub-section (5) is as follows:

"Where the owners of two or more houses have failed to comply with the requirements of the notices served on them under this section, and the authority might under this Act execute the necessary works for providing a water supply for each house, the authority may, if it appears to them desirable, and no greater expense would be incurred thereby, execute works for the joint supply of water to those houses, and apportion the expenses as they deem just."

In Section 3 power is given to cause works to be executed (wells to be made) at a cost not exceeding £8 13s. 4d., or in certain cases £13 for each house. If water were in all cases sufficiently near the surface to enable a separate well for each house to be sunk for this sum, there would be no difficulty in recovering it by means of a rate of 2d. or 3d. per week on the property benefited. But it is precisely in such districts that a sufficiency of wells (though not necessarily pure) already exists.

It is for cases in which the wells have to be 50, 100, or more feet in depth, that the power of charging the cost on the property benefited rather than on the whole parish is desirable. At first sight nothing would appear easier than to deal with the matter as follows under sub-section (5).

Suppose there are 10 houses sufficiently near together to use one well, and that such well be made and provided with a pump, or windlass with bucket, chain, &c., at a total cost of £130.

If each house owner paid £13, or 3d. per week (Section 3), a water supply for these 10 houses would be provided at the cost of those benefiting from it, without increase of rates, or those receiving no advantage from it and dwelling perhaps miles from it. For reasons which I do not propose to discuss, sub-section (5) is not so read, the result being that works are seldom carried out under this section, a thing much to be regretted, as I believe that much of the opposition which retards, and in some cases prevents entirely, the adoption of some form of public water supply, would be withdrawn if it were possible to work under this section. I do not venture to suggest any special alteration or modification in the wording of this section, but I have drawn attention to the matter, as I believe it to be one with which the future of village water supply is closely connected.

[*For discussion on this paper see page* 254.]

On "Artesian Wells and Water Supply," by ROBERT SUTCLIFF.

THE usual object of sinking an artesian well is to obtain a water supply from a pure source, uncontaminated by any surface drainage, and it is from that aspect that the subject has especial interest and importance to a body like the Sanitary Institute. Anything that facilitates the obtaining of pure water supplies is a matter of great national importance, and the object of this paper is not only to refer to the various methods of sinking wells, but also to point out the value of information bearing upon the right spots for undertaking such operations. If this be not done, a great waste of money may take place by sinking at a site where technical information could have indicated beforehand the probabilities of failure. Every abortive boring is likely to injure the enterprise of others who contemplate a similar work, although the circumstances that caused the failure may not be present in the cases of those that are so deterred. The first questions then to be considered are: What strata will have to be pierced? What depth will have to be reached, and what supply and water-level will be obtained by the well-sinking operations? These are questions to be answered by geologists, and especially by those geologists who make a study of hydrogeology. To this study

should be added the compilation of data with regard to existing borings, whether successful or the reverse. The opinions of a contractor, when based upon long and varied experience, may be of great value in assisting and supplementing the advice of the geologist; but as the contractor gets paid for work done and not for opinions, it is very desirable that skilled technical advice should be obtained at the outset. Geologists (like other mortals) are not infallible, and of course they base their opinions on evidence and knowledge that they possess. A boring may reveal a different state of things to what had been expected, due to local circumstances with which no one was previously acquainted. For this reason it is very desirable to submit samples from time to time to the advising geologist as the work progresses, should there appear anything obscure or different to what was expected. The geologist is also frequently able to express an opinion as to the character of the water that will be found, and to say whether it is likely to be a good potable water, or brackish, hard, or chalybeate. As all underground water comes more or less remotely from the surface where the waterbearing stratum outcrops, the area of outcrop, the rainfall of the district, and any probable sources of contamination have to be duly considered. All inferences and deductions as to the probable quality of the water should, however, be positively proved by analysis of samples taken directly from the boring, with the usual precautions to ensure that the samples are properly representative of the water to be examined.

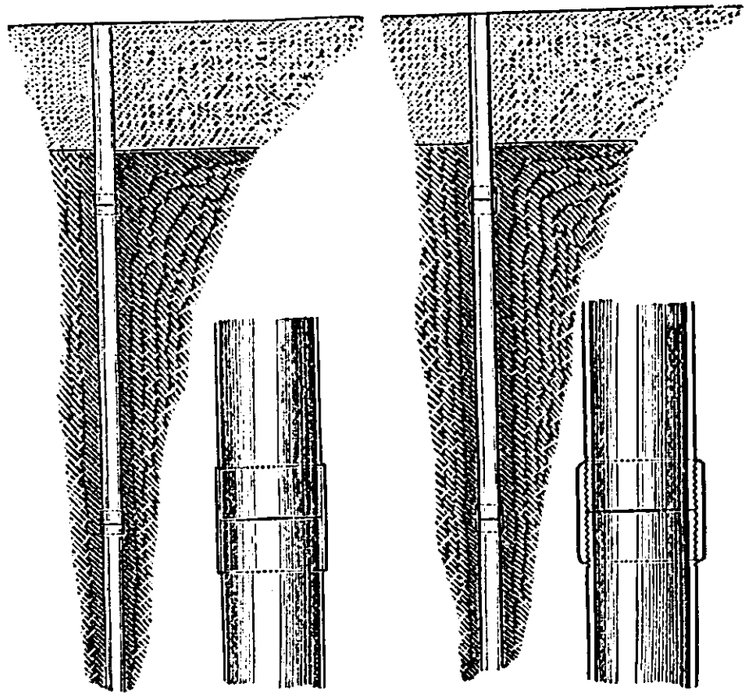
The various methods of constructing wells, so far as they have a bearing on the purity of supply, may next be briefly dealt with. These methods may be roughly divided into four branches: the first and most ancient is digging; next comes boring; after which follows a combination of digging and boring; finally, there is the Tube Well system, which in certain cases dispenses with both digging and boring. To deal with these in the order given, the dug well has first to be considered. As regards cost, the digging of shallow wells under favourable circumstances is very economical, but if a great depth has to be reached and objectionable surface water excluded, the process becomes costly, and from a sanitary point of view extremely unsatisfactory. The crudest form of dug well is lined with loose bricks, not cemented in any way, and through the interstices of the brickwork the water percolates into the well. The danger of contamination in such cases is very great, and is shown very graphically by Mr. T. P. Teale, M.A., and Surgeon to the General Infirmary at Leeds, in a work entitled "Dangers to Health." Such a method of obtaining a water supply requires

no further comment, as it must meet with the condemnation of all sanitarians.

The better class of dug wells are either lined with cemented bricks or iron cylinders, and if they exclude contamination through the sides are very costly, especially if the digging has to be made through a large body of contaminated water. Such wells are also liable to contamination by the introduction of objectionable matter from the top. It will be remembered that the Caterham dug well, which caused an outbreak of typhoid fever in the district that it supplied, was polluted in a particularly disgusting and dangerous way by workmen employed in it, who used the well buckets for an improper purpose.

The well that is made by boring alone may be sanitarily good or the reverse, according to the method in which it is carried out. To deal first with the objectionable method,

FIG: 1. FIG: 2.



which is shown in Fig. 1, the lining tubes are what is called "telescoped," that is, one tier of pipes is dropped within the other without any proper connection between the different sizes

of pipe, and hence every point of junction is a possible source of contamination. The metal in the pipes is also thin, little better than sheet iron, and the joints are what are known as braize and collar, which is frequently not an efficient air-tight joint. Owing to their weakness, such pipes cannot be driven forcibly through the strata, and hence they fit the bore hole more or less loosely, thus allowing surface water to run down the annular space outside them. Such pipes cannot be placed in air-tight connection with the pumps. There are, therefore, four dangers in a well of such construction: contamination may get to the source of the supply outside the pipes, and through the imperfect joints, and at the point of junction between the different tiers of pipes, or actually through the iron, which is so thin that it offers very short resistance to the action of corrosion.

The combination of digging and boring affords a much safer means of obtaining a water supply if the bore pipe be properly constructed, and attached by air-tight connections to the suction of the pumps. Should this precaution not be adopted, the danger of contamination is exactly the same as in the dug well pure and simple.

The bored well that complies with sanitary principles is shown in illustration, Fig. 2.

It will be seen that the tubes are much thicker; the joints are screwed and fitted with great accuracy, so as to be not only water-tight but *air*-tight. A continuous tier of tubes goes from the pure spring to the surface. The outer and larger pipes are simply used as tools for obtaining this result, and only those that serve a useful purpose in excluding objectionable water remain permanently in the ground. The stoutness of the tubes enables them to be driven very tightly into the bore hole. Tubes of this construction are frequently subjected to 100 blows with a 1200 lb. monkey to drive them a single inch without any injury to pipes or screw threads, as the pipes accurately butt in the centre of the socket, and leave no exposed thread. The connection to the pump from the tube is air-tight, so that the spring is effectually sealed from all sources of contamination, and is delivered just as it comes in its natural state from the spring. This last mentioned method is known as the "Artesian Bored Tube Well" system. It is a development of the "Abyssinian" Tube Well system, and became necessary when strata were met with that could not be penetrated without the removal of cores. The "Abyssinian" Tube Well system is so widely known as merely to require passing mention. A pointed tube is driven forcibly into the ground until it meets with the desired water supply. The water is then drawn into

the tubes through the perforated bottom length by a pump in air-tight connection with them. This simple means is available in cases where the soil can be penetrated by mere displacement, or by fracture and displacement, without any removal of cores. As a rapid and economical means of obtaining water supplies free from surface contamination it is the most efficient known. It was awarded the Medal of the Sanitary Institute, and the Gold Medal at the Health Exhibition. At the recent water famine at Swansea it was largely brought into requisition, and by its means water was found at a depth of 40 ft. in less than two hours, which was pronounced by the public analyst to be the purest water in Swansea. The greatest depth that an "Abyssinian" Tube Well has been driven within the knowledge of the author was 157 ft., at Norwich. The largest supply of water obtained from "Abyssinian" Tube Wells is probably at Burton-on-Trent, where the large breweries draw about two million gallons daily from a number of tubes coupled to one receiver, and pumped by steam power. The time at disposal will not permit of a description of the method of pumping from a tube when the water is far below the surface, but it may be mentioned that water is drawn from a depth of from 100 to 200 ft. through tubes 4 in. and upwards in diameter.

[*This discussion applies to the two preceding papers by* Mr. STEPHEN TERRY *and* Mr. ROBERT SUTCLIFF.]

Professor T. HAYTER LEWIS, F.S.A. (London), explained that he had allowed these papers to be read consecutively, because they were so closely allied that it would save time to discuss them together.

Mr. ROGERS FIELD, M.Inst.C.E. (London), observed that he had often been struck in considering the question of water supply, that such little use was made of the windmill. Of course one could well understand that in the case of supplying a town of any considerable size it would not be advisable or economical to use wind power. The question was, however, altogether different in the case of a small village, or even a moderate sized town. The great disadvantage of a windmill was of course its uncertainty; for some time they would get a considerable amount of wind, and then for days or weeks

perhaps they would get none at all. But this was capable of being entirely met in the case of the water supply of small towns, for all they had to do was to construct a reservoir of sufficient size to hold a supply large enough to meet the demand until such time as the windmill could be got to work again, when they had at once a power for raising water which worked practically at a nominal expense. Some time ago he had to look into this question, and was anxious to see what was the necessary size of the reservoir; but he found that there was hardly any reliable information at all on the subject. He had therefore investigated the question to a certain extent for himself. The first point to ascertain was the length of time they might have to wait in this country without the wind blowing with sufficient force to work the pumping engine. In order to gain accurate information on this point he got the records of the velocity of the wind as recorded in the quarterly weather report of the Meteorological Council, and he took five different places of which there was a continuous record, and which he thought would fairly represent the difference found in the climatic conditions of the several parts of the country. Of course anyone who had paid attention to the subject knew that the velocity of the wind and the extent of calms would differ very much in different parts of the country. He took Stonyhurst, Kew, Glasgow, Greenwich, and Aberdeen. At Stonyhurst there was the least amount of wind and the greatest amount of calm, at Aberdeen there was the greatest amount of wind and the fewest calms. Before using these data he had to determine another point, about which there was the greatest possible uncertainty—viz., what is the velocity of wind which will work a windmill effectively; there was hardly anything definite known about this, but as far as he could ascertain the velocity seemed to lay between five and eight miles per hour. Dealing with these data in the best way he could, the result he arrived at was as follows: taking an ordinary case, such as that represented by Stonyhurst or Kew, they might have twenty days, or from that to thirty days, in which the windmill would practically do them no good, and therefore they might want twenty or thirty days' storage capacity. Taking on the other hand a favourable case, such as that represented by Greenwich or Aberdeen, they probably would not require more than a fortnight's storage capacity. Mr. Terry stated that in America storage capacity for a week's supply had given satisfaction, but he did not think that would meet the wants in England. If they only made a reservoir capable of holding a week's supply, they would soon find themselves running short; but if they provided a fortnight's or a month's storage capacity, then it seemed to him that wind power might be used with the greatest possible advantage in country places. There were numbers of places which could be supplied from springs or wells at a low level if the water were elevated by this means. He knew of one or two cases where large mansions were supplied in that way, and when the reservoirs were made sufficiently large the results had been advantageous. He wished also to emphasize the point made by the writer when he called attention to the necessity of having waterworks

properly designed; he knew cases where land agents and others who had no practical knowledge on the subject essayed the task of planning waterworks with the idea that money would thus be saved, whereas it was generally not so. Often a spring was chosen without any sufficient research as to what was the yield of the spring in dry weather, and a large outlay was thus incurred to very little advantage. He could instance the case of a small village where iron pipes had been laid to convey water from a spring which had not been properly investigated, and then directly a drought came they were short of water. Now no engineer would dream of going to work until he had some reliable data as to how much water could be depended upon in dry weather.

Mr. H. Law, M.Inst.C.E. (London), endorsed what had been said by Mr. Field. It was a very important matter that really healthy supplies should be obtained for the villages, but it was also important that they should bear in mind that the villages were often so small that they could not bear a large expenditure; which difficulty however might be overcome, as was pointed out in the paper, by the amalgamation of districts. But this was often a difficult matter from conflicting interests and jealousies, and therefore any practical suggestion which enabled the village to provide for its own wants in some inexpensive manner was well worthy of being considered by the profession. He felt very sure that if proper reservoirs, which could now be very cheaply constructed of concrete, were provided, the windmill pumping would in many cases form an easy and economical solution of this important question.

Mr. Page considered Mr. Terry would have done well to have added some information upon the collection and purification of roof water. In the country districts where dwellings were isolated, rain water formed a very important feature in cheap water supply; and he thought the paper would have been rendered a great deal more valuable had the storage of water from the roofs been mentioned, and some means of purifying it indicated. In travelling in country villages and districts, they must all have seen what a number of dwellings there were without any provision in the way of water supply; it was only the other day that he was investigating a rural district, and he found people actually fetching their water in buckets from a stream nearly a mile distant, of very doubtful purity. He thought some legislation ought to be carried into effect to render it absolutely necessary for owners to provide a water supply to their property. Roof water might be collected and purified cheaply in many cases.

Mr. H. Law, M.Inst.C.E. (London), observed that in the large and important city of Buenos Ayres, in South America, the people depended almost entirely for their water supply upon a large underground tank, which was constructed in the centre of the court of most of their residences, and it was hardly ever known to fail. He knew cases in the neighbourhood of London where water for drinking

purposes was supplied by collecting rain water, which only required filtering to become pleasant for drinking purposes.

Prof. T. Hayter Lewis, F.S.A. (London), knew a district not above fifty or sixty miles from London where no one could drink the water from the wells, and every drop of water was collected from the roofs. The problem of getting the water from the roofs and clearing it of defilement, was a serious one, and the people in this case had to use filters and strainers, and so forth, to get rid of the grosser impurities.

Mr. L. L. Macassey, B.L. (Belfast), referred to the case of a friend of his own in Ireland, who wished to provide his country home with a supply of water under pressure. This gentleman obtained the following particulars of a windmill in actual operation at a railway station, and the details might be interesting to the meeting. The mill worked a set of pumps with a lift of thirty-five feet, and raised on an average some five thousand gallons per day; the cost of erection was about fifty pounds, and the superintendent of the railway stated that he found at the end of the first year's working the saving in coal formerly used in the pumping by steam was about equal to the cost of the mill. The pattern adopted was the American self-reefing mill, with a diameter of thirteen feet. The amount of storage required to keep up the daily supply during calm weather was about fourteen days—but it must be borne in mind that the situation was very favourable for catching the wind. Village authorities, as a rule, objected to engines or windmills, or in fact anything likely to get out of order; what they wanted was a means of supply that would work automatically, and consequently a gravitation system was always to be preferred when it could be obtained at a moderate outlay. He was of opinion that fresh legislation was necessary in the matter of acquiring water by means of a provisional order: at present a local authority could not obtain powers to take waters compulsorily in this way; they could take land and sink wells, but if they desired to acquire stream or surface water they had to obtain an Act of Parliament. In the present state of the law, local authorities who could not afford to go to Parliament had to treat with the riparian owners—and anyone who had ever done this would know what it meant—or else they had to resort to a supply of water from wells. One great objection to well supplies was the liability of pollution. The surface soil became saturated with organic matter, and in many cases portions of this matter were washed down into the well through the pores of the ground in wet weather. A friend of his living in the country had a well some distance from his house, which he prized very highly; mineral oil was used in the house, and the barrel of oil was kept in an out-house some little way from the well; by accident the oil tap was left open, and the oil ran out and soaked into the ground; as a consequence, the well-water became undrinkable, and it remained tainted by the oil for over twelve months. This well was thus dependant for the purity of its water on the condition of the surface; and without doubt, many wells in connection with dwelling houses were in an equally unsatisfactory condition.

Mr. J. Corbett (Manchester) remarked that special consideration was required as to the cheapest means of raising water for village supply. After all, the cheapest and simplest power was that of the housewife's arm and the hand-pump, and if they could apply that power to an improved source of supply they would best meet the village wants, and meet them with the least expenditure. He wished particularly to call attention to a case with which he himself had had to deal. The landowner who was making the improvement stipulated that the work should cost so little that he had to come down to the very simplest of means. A good supply was brought into the village by gravitation, but at such a level as to supply only a few houses. All the houses were situated within about twenty feet of the level of that supply. He therefore carried suction-mains to the eight or ten existing pumps, and then supplied new pumps in the old casings. This, with a small covered reservoir, completed his arrangement. In one case he had a pipe 220 yards long, with a lift of 22 feet. He made that pipe only 1¼ inch diameter, and it was of lead-encased block-tin. It gave a satisfactory supply, thanks to the expedient of placing an air-vessel with the suction-pipe from the supply introduced into the top of it, and the air-vessel placed at the height of the pump-barrel and connected to its suction-valve at the base. This appliance formed a self-priming cistern for the pump valves and bucket, and also formed an equalising or air-vessel for the long suction-pipe; and the practical result was perfectly satisfactory.

Mr. R. Railston-Brown (Bridlington Quay) said that he had been superintending the waterworks for Market Weighton. They found the place supplied from dumb-wells about ten feet deep, and the drainage in a most unsatisfactory condition. When they went there they found no fewer than eighty cases of typhoid, but within three months of starting their first supply from the chalk, from a well and bore seventy-six feet deep, there was not a case of typhoid in the village.

Mr. A. E. Eccles (Chorley) wished to know how it was that whilst the cities and towns were getting rid of *pump* water, they were now recommending it to villages. Pump water was generally hard water, and hard water was injurious, as it contained lime and other mineral matter, which produced stone and other internal accumulations in the body of man. Wherever it was possible, villages should be supplied with soft pure water from a hilly district, like some of our best waterworks are.

Mr. J. J. Bradshaw (Bolton) observed that they frequently found people in villages had good teeth, whilst those in towns had bad ones. There was that objection to town water, that it had often not sufficient lime in it to aid in the formation of bone. The difficulty of separating pure and impure roof-water was in many cases met by Mr. Roberts' Separator.

On "The Fouling of Streams," by Major Lamorock Flower, Sanitary Engineer to the Lee Conservancy Board, &c.

Water!—of Heaven first-born: ever in all ages a sacred emblem, from that remote period when "the earth was without form and void, and darkness was upon the face of the deep, and the Spirit of God moved upon the face of the waters." Alas! in these latter days more abused than is any other element; and fouled streams—from the babbling brook to the broad, once silver highway of nations, and those portions of the "wide, the open sea" (a "stream" within the meaning of the Act of 1876)—amply justify the assertion.

It will be convenient in considering the subject to regard it from three distinct points of view:

1st. The Causes of the Fouling of Streams.
2nd. The Effects thereof.
3rd. Remedial Measures.

I trust my long experience and daily familiarity with the subject may be my excuse, if I appear somewhat didactic in this paper.

First, then—The Causes.

Prominent is inefficient legislation: the permissive character of existing Acts of Parliament which have been framed with the object of abating and preventing river pollution, and the many loopholes which are found in special clauses. Our laws hereon are complicated; they are conflicting, and also are ineffective. Prosecution of offenders is enormously expensive, and the machinery is cumbersome.

The removal of sewage by water-carriage, born of the introduction of the water-closet—which contrivance, some say, was the invention of the devil—lies at the root of much fouling of streams. Sewers are laid by which sewage of towns and villages is discharged direct into streams; or, if into cesspools, these receptacles have overflows which contribute sewage in its worst condition—putrefaction. The fluid part of sewage is the worst part of it.

Then the storm-water outlets, the "back door" to systems of sewerage; there must of necessity be a safety valve of the kind, but this contrivance has too often acted as a "back door," or means of surreptitiously passing large volumes of foul matter

to our streams. For example, given a town of say 10,000 inhabitants which disposes of its water-carried sewage on land, we will say—the land either worked by a sanitary authority, or, it may be, leased to a sewage farmer—what are the conditions? The authority or its tenant is bound to receive and also to dispose of the whole of the sewage of the inhabitants every day of the week, all the year round, rain or shine, heat or cold, presumably on a given area of land; what happens? When all is fair sailing the sewage is properly got rid of, but when storms come or when a hard frost is present, where does the sewage go to? Naturally into the streams again. I am prepared to hear it advanced that sewaged land is not liable to be frozen, and therefore no overflow could take place; but experience teaches me that sewaged land does get frozen, and that sewage does escape over such frozen land into the water-courses. Again, in heavy storms the sewers get overcharged, and volumes of sewage pass to the rivers of our country by the "back door."

Or, the sewage may be disposed of by chemical treatment. What a temptation lies here to save chemicals and let the sewage improperly dealt with pass away. The sewage doctor as well as the chemist, to say nothing of the ratepayers, seem to profit by practically breaking the law. The sewage farmer lets what he does not want of the sewage pass away by the storm outlet. The Local Sanitary Authority saves by starving the chemicals.

Again, unless the sewage be borne to the outfall by gravitation, how excellently good it is to be able to save some few pounds in a year by reducing the pumping expenses; what a feather in the cap of the official in charge to be able to say, "we have saved something," however trivial. "Keep the rates down" has been one of the fruitful causes of fouling of streams—a "penny wise and pound foolish" policy. When will folk learn the value of the wise man's saying, "There is that scattereth and yet increaseth?" and I am sure that many of my hearers can point to the result of following out the principle in their own experience. False economy is another of the causes of fouling of streams.

High farming—the top dressing of lands with manure of all kinds, artificial or otherwise—and the drainage therefrom into water-courses; sewage sludge spread on lands and allowed to drain into a stream also.

Carriage of manure in old and rotten barges is another cause; one of the greatest difficulties I have to overcome in the river Lee is pollution from manure barges. The carriage of manure is specially sanctioned by a clause in the Act of 1868.

Canal boats and house boats on rivers are fruitful causes of pollution; all the refuse from a canal population passes or is cast into the water; and as to house boats, I give a picture from a local newspaper of the condition of affairs at Henley-on-Thames:—"There was a great number of decomposing salad leaves, some rotten fruit, innumerable egg-shells, with part of the yellow of the egg still adhering, several large pieces of bread, the skin of a salmon, a skirt of lamb, stale pieces of fat and meat, some spring onions, innumerable crushed lemons, faded flowers, lobster shells, bruised tomatoes, and a dead roach." The report follows grotesquely, "a bucketful of water taken from the midst of this garbage smelt very unpleasant!"

Inefficient or improper chemical treatment of sewage is another cause. "All is not gold that glitters," we know, and "bright effluents," "pellucid jets of spring water," are often delusive. I always say that the value or otherwise of a chemical process is shown by the effect upon a stream of the effluent which is discharged therefrom.

Privies erected over water-courses are another cause, and similar necessary conveniences placed over ditches also; here the filth accumulates and decomposes, and is washed away into the nearest water-course by heavy storms.

Pollution from manufactory refuse also contributes to the long list of causes of river pollution. How frequently do we read some such notes as the following:—"The river Aire flowing through Leeds contains probably every loathsome and disgusting impurity which exists; it is the open sewer for half a hundred towns and villages; it is the ever ready receptacle for every waste product of mills, tanneries, dye works, chemical works, slaughter-houses, and everything else of which man is in a hurry to rid himself; such a burden does the black bosom of the river Aire bear at Leeds bridge."

Again, we read of the Irwell: "From time immemorial it has been the receptacle for quarry rubbish, surplus excavation, ashes, and refuse of the various manufactories on its banks; and at the present time (1887) the sewage from a population of upwards of a million persons passes, with scarcely an attempt at purification, into its stream." Of the Irwell it is said: "It is the most foully used stream in the world. The staple trade of England is largely indebted to this river for its prosperity, and like many another faithful servant, its well-being has been ignored by those who have derived most advantage from its services."

Refuse cast or allowed to be discharged, of which malting refuse brings about some of the greatest nuisances possible, also fouls streams to a great extent. On the river Avon, one writer

relates that his attention was drawn to a flotilla of floating palliasses or square mattresses, which having been infected, were thrown into the river.

Pail washings, a most disgustingly filthy pollution, to the extent of 30,000 gallons daily, is discharged into a river by the Corporation of an important town situate not 100 miles from this place. Butchers' offal, dead animals, and filth of all kinds are daily heedlessly thrown into our streams as the readiest way of getting quit of them. Sheep washing, again, is a bad pollution.

Some people claim, as an excuse for pollution, "vested interests." Here is an extract from a recent report on pollution from dye and bleach works: "This pollution is of a character which the Local Board finds difficult to cope with, as any interference would inflict such serious injury on these industries that it has always been considered unwise for the Board to interfere beyond making suggestions." This is a specimen of that "masterly inactivity" of which some of us have recently heard.

River pollution is a thing of the last half century following the vast expansion of manufactures and dwellers on the banks of streams. Doubtless it is a very cheap and ready way of disposing of refuse, to let it be thrown into or passed to streams—"the natural drainage of the country," to quote an oft-given excuse; and now the chief polluters complain that to compel them to cease from pollution would be to close their works.

It cannot be admitted that anyone has *a right* to turn out noxious filth, with the result that the health, food, profit, and pleasure of all below the polluter on the river are destroyed.

This brings me to the second part of our subject—the effects of fouling of streams.

I extract the following from a poetical description of a river given some years since by an anonymous author in a sporting paper:—

"Behold the babe! springing from the bowels of Mother Earth. See, it lies asleep in its moss-girt cradle-bed, pure as ever was infant. Soon it crawls over the side of its cradle—its moorland nest—a tiny, strengthless thing. The age of progress once begun, there is no turning back, and soon it has grown into the mountain brooklet—the jolly, noisy, splashing, dashing, leaping, tumbling, boisterous 'burn.' Anon, as if wearied out, sleeping quietly, self-intoxicated, in its own sweet gurgling eddies. Then growing and flowing, till the brooklet of yesterday is the river of to-day. Westward looms a growing haze, and towards that the river slowly but surely is going, 'like as the waves make to the pebbled shore.' Swiftly now, as if confronting a foe, it rolls along, facing the future, dark though it be; proudly and defiantly. It has entered the city! where now the bright sun, the verdant pastures, the song of birds? overhead all is gloom, around, an atmosphere of impurity. Oh! how it chafes, how it chokes! Nobly battling for the mastery, it goes on: a sharp struggle, perhaps, and then out beyond the city. Purity once more—the glorious country and the golden sunshine! Alas! step by step, it grows foul and turbid, and the odours are those of death and decay, not life and health. The river is no longer beautiful and pure, but foul and loathsome. It has emerged from the city, '*bearing its stain.*' How sadly, how painfully it flows now; aye, and flows on till it is lost in the loving arms of the ocean's resistless tide. How like, indeed, to man's life—from the cradle to the grave."

What, then, are the effects of the fouling of streams?

In natural sequence let us look at the laws. To foul a stream is to transgress the law. One effect thereof is to try to escape punishment, and in such endeavour to avoid the consequence of evil, experts have amassed fortunes. It has been said, not inaptly, that it is possible to drive a coach and four through most clauses in Acts of Parliament. I think experience has taught us that in river pollution, at all events, there is some excuse for the legend.

Fouling of drinking water is an effect. Time was when the Fleet Ditch, sewer as it is now, was as "the river of wells," a pure infant, and the water supply of much of London. Soon by filth, contributed by dwellers on its banks and by factories, was it reduced to the condition described by Pope, as

> "The king of dykes, than whom no sluice of mud
> With deeper sable blots the silver flood."

"The silver flood"—The Thames: once the silver highway of nations!

Destruction of recreation is an effect of fouling of streams.

The discharge of impure fluid into the Lee below Tottenham Lock in 1885 practically destroyed the boating trade, and so deprived the hard-working toilers of a large district of London of that amusement which tended to keep up their health, their strength, and their places in the national power; for we must not forget that the strength of a nation lies in the health of its people. Fouling of streams is in effect a national evil.

The special clauses to which I have before referred have the effect of legalising pollution. I will quote a few words from Mr. Ruskin last year, on the neglect of our streams by Parliament:—

"I have not myself noticed much that it has done to any

purpose, except virtually abolishing the Act against pollution of rivers; which repentance of theirs virtually signifies that the management of the millenium we have presently to look to is to be put in the hands of the sort of British patriot who is ready to poison the air and the wells for his neighbours 100 miles round, and to sit himself all his life up to his throat in a jakes, so only that he may lick up lucre from the bottom of it."

An article in an evening paper in August of last year states that—

"Local self-government acts in the opposite direction as to abatement of river pollution.

"The high type of it exists at Hertford, which, for example, insists on pouring its 'treated' sewage into the Lee. When the much maligned Conservators try to prevent Hertford from doing this, they are fought in the law courts from point to point with bitter and dogged tenacity. Nor can we blame Hertford; just as Bath and its satellites convert the once pellucid Avon into a turbid torrent of filth:

"The law allows it, and therefore courts have awarded it. If anyone is to be blamed it is not the municipalities but the legislature, whose clumsily drafted enactments give municipalities in such circumstances a legal right to poison pure sweet streams with sewage."

Pollution of a river spoils the pleasure of every one dwelling on its banks. The landscape is ruined; a peaceful contemplation of the country is impossible with the odour of ten thousand sewers in the air: the angler is banished: during the last twenty years the trout streams have been depopulated to the extent of from fifty to one hundred per cent.; and the refining influence of a pellucid stream hurrying onward to the great ocean, fit type of the larger stream of life, is lost in the accumulated filth of cities, towns, and parishes.

The lower manufacturers on the banks of a polluted stream are sufferers by the pollution of those above them.

To them the effects of fouling of streams are injury to health, to enjoyment, and to trade.

We come now in the third place to remedial measures.

New legislation is absolutely requisite. The Act of 1876, brought about by the noble Lord who presides over our Congress, was a step in the right direction, but I am sure his Lordship will admit, and, in fact, did admit in his opening address, that very much more is wanted before we may flatter ourselves that any effectual legalised means exist to prevent river pollution.

"Thou shalt not," must be the motto of any future laws on the subject. A shorter course of procedure in punishing offenders must be brought about. No roundabout way of getting one's ends accomplished, but action, short, sharp, and decisive.

The late Attorney-General, Sir Charles Russell, considered that the failure of the Pollution of Rivers Act of 1876 to do all that was expected of it was, "because the local sanitary authorities, who were generally the chief offenders, were entrusted with the power of enforcing the Act."

In 1885 we read that the German High Court recently gave notice to the municipal authorities of Essen-on-the-Ruhr, that if the town sewage, at that time flowing into the river, was not conveyed elsewhere or pumped in a systematic and satisfactory manner on or before a certain date, not only would a penalty of 1,000 marks a day be inflicted, but should any nuisance dangerous to health be found to exist, the magistrates of the town would be sent to prison.

The effect has already been magical at Essen-on-the-Ruhr, and probably if we could give half the members of the Metropolitan Board six months "hard," an improvement would be found in the neighbourhood of Barking and Erith.

Recently also in Russia a factory polluted a river. The Czar ordered that within a certain specified term, the pollution should be abated on pain of pulling down the factory, and a military force was marched on to the neighbourhood with instructions to carry that order into effect. The result was, proper measures were taken, the nuisance abated, and the factory works on.

We are too permissive in our legislation. Again I say, "Thou shalt not" should be our watchword. Fresh legislation then is one remedial measure.

This matter should be taken up by the government, and an effective public measure introduced to the consideration of both Houses of Parliament.

Perhaps we may find that sanitary matters and prevention of fouling of streams may form an important section in the promised "County Boards" Bill.

In laying-out systems of sewerage, no storm outlet should be permitted which does not discharge on to an area of land or on to an adequate filter; and where neither of these can be obtained, then the sewage overflow should be disinfected.

Storm overflows are sometimes sanctioned by Parliament. One case in point is that of the main drainage of London, which pollutes the river Lee at Old Ford; to lessen the evil of this I suggested certain automatic machinery for the application of efficient chemicals, an idea which found favour with the

Metropolitan Board, and is under their serious consideration with a view to my ideas being adopted.

There are very few places where the remedial measures which I suggest cannot be carried out.

Thus I propose the evils of the "back door" shall be abated.

Then as to disposal of sewage. I am not going to travel over the old well-trodden track and thrash out the sewage question *de novo*.

There are now certain well-known and adopted principles. First of all comes the land. Shakespeare says: "The earth's a thief that feeds and breeds by a composture stolen from general excrement." It is pretty generally admitted that in disposing of our refuse it should be "earth to earth," and the disposal of sewage on land must rank first in all our modes of disposal; but where sewage lands are, care must be taken against the contingencies which I have noted in speaking of the causes of fouling of streams. There must always be an area laid out to receive possible excess of sewage or of storm overflow; and a belt of osiers properly planted is a good remedial measure.

I shall not attempt to follow the myriads of chemical processes which have from time to time been brought into public notice, and shall merely record certain results which have come prominently under my notice.

Where land cannot be obtained in sufficient quantity and of an appropriate character, deposition of the solids of sewage may be effected by chemicals. A much less area of land is required for merely depriving the effluent of those organic matters which no chemical process has yet been able to remove. I speak within reason.

I believe I was the first man who tried, on a large scale, the combined method of chemical and land treatment. This was done at Enfield, and the result was satisfactory in every sense; in fact it is now fully admitted that dealing chemically with sewage, and following this by filtration through land, is the highest form of sewage disposal.

Of course where deposition of the solids precedes irrigation or land filtration, there is the question of sludge to be dealt with. Dehydration by pressing is a valuable auxiliary in disposing of sludge; and if this be followed by the furnace, we get a result which is undeniably of value.

As to burning of sewage sludge, I have for some time carefully watched certain experiments made with a view to see how far coking of coal and incineration of sludge-cake might be combined. This has been effected with great success: the mode by which it has been achieved forms one of our exhibits.

As to carriage of manure, it is surely possible to prevent nuisance by seeing that only sound craft are used for the purpose.

Respecting house-boats and the nuisance therefrom, closets thereon should be abolished, and a scavenger-boat be established, which should each morning remove the refuse, garbage, ashes, &c., &c., from the boats.

As to efficient chemical treatment, it must never be admitted that any one system is equally applicable to all places, nor must mere clarification be mistaken for purification. I can point to cases where fluid, as clean apparently as spring-water, is discharged from the outfall works, which before going a mile becomes putrid; and to other places where an effluent, not good-looking in appearance, is discharged, but which being passed into a foul river actually improves its condition.

Then refuse from manufactories. This might be met by making the manufacturers deal with their own refuse on their own premises, and not pour the said refuse into the public sewers to increase the difficulties at the outfalls, nor into the rivers to foul them direct.

The recovery of waste products may in most cases be remuneratively carried out; and in one case, the refuse of soda manufacture is specially treated by Messrs. John Hanson & Co., of Wakefield, and used for sewage treatment with very great success. This must not be confounded with employing fresh black ash waste in treating sewage.

Although much has been effected in abating river pollution, a very great amount remains to be done; and I submit that, as I said ten years ago, if we want to have our streams free from pollution, we must map out the country in watershed areas, and put each under the charge of an experienced man, backed by a good Board, who should legalise his acts.

In conclusion, I think we must admit that the remedy against a condition of affairs, which is to us a national disgrace, is—mainly, improved legislation; abolish all special clauses or exemptions; and make the fouling of streams a penal offence. We shall then probably cease to hear complaints like the following:—

"The rapacity of property owners, the greed of manufacturers, the 'masterly inactivity' of local authorities, have secured for us the pestilence-laden atmosphere which robs us of our nearest and dearest, and the heavy taxation which wears out the heart and energy of the suffering ratepayer." And may use the words of a writer in *Engineering*, on the struggles of a progressive Board whose motto, like that of Bolton, was "onward, ever onward," which, on the completion of its labours, could

with a clear sanitary conscience say, "we have gained for our district that title to civilization which must be denied to any community, however pretentious, which consents either from ignorance or false economy to welter in its own emanations. Health we have given which is wealth, and more than wealth, and cleanliness which is next to godliness"—a condition to which all may attain.

Mr. H. Law, M.Inst.C.E. (London), said that when the law required that cesspools should be abolished, the sewage from water closets was transferred to and polluted our rivers. The question of river pollution was a large one and did not arise entirely out of the pollution from sewage. Probably there would have been little difficulty in obtaining wise and sufficient legislation on the subject of the prevention of river pollution if it had only been a question of dealing with sewage. But when it came to a question of interfering with manufacturing interests no Government had felt it wise to deal with the subject. He himself took part in the deputation which waited upon the present President of the Local Government Board not very long since for the purpose of urging upon him the importance of legislating upon this subject. He (the President of the Local Government Board) explained to them that in the present depressed state of trade it was no use recommending to the Government that any measures should be proposed which would in any way restrict the present license, if he might use the term, which was accorded to manufacturers. He himself thought that if a commission or some other machinery were appointed which could fully enquire into the subject, it would be found that a great deal of manufacturing pollution which now exists could be avoided, greatly to the advantage of the manufacturers themselves. That, he was sure, could and would be done; but in the present state of want of knowledge as to how pollution could be avoided without restriction of trade processes, he was afraid they must not look for any drastic measure of legislation. As to the sewage, there could be no doubt that its application to the land was the natural way of treating it and, where it could be adopted, the best. He and his brother engineers who had had experience in the various schemes proposed for dealing with the sewage of towns and villages, must have experienced the immense difficulties created by the opposition of land-owners and residents to allowing land to be taken for the purpose of a sewage farm. That was the great difficulty in the way of the system. His opinion was that the best plan was first to apply a proper chemical process, and then follow that up by passing the effluent through the land; but he was also of opinion that the difficulty had been immensely reduced by the introduction of the sludge-pressing system.

Mr. J. J. Bradshaw (Bolton) pointed out a cause of fouling which could not be considered as sewage. In the neighbourhood of Bolton there were very large works situated on the banks of the Irwell and other streams, where the owners regularly disposed of their cinder heap by pitching it into the river every time there was a flood. Sometimes there were as many as twelve men hard at work throwing into the river this refuse and letting the flood carry it away.

Dr. Alfred Carpenter (Croydon) said there could be no doubt it was a wrong thing to send our sewage down to our neighbours; there was a time when we used to send our moral sewage to distant countries, but those distant countries objected, and now we treated it at home with greater success and more judiciously, and he contended that we ought to deal with our own sewage in our own localities. Bolton must deal with its sewage in such a way that it will not become a nuisance to their neighbours, as would be the case if it were emptied into the stream to be carried down possibly to destroy the health of others below them as regards elevation. It was possible to prevent that fouling by taking out that which caused the mischief and utilizing it in a way that it should be an advantage to the people who had produced it; just as it was possible to take the smoke from the atmosphere he saw before him and utilize it, so they could do in regard to sewage. If it were possible to apply the sewage of large towns to the land and to apply it at once, and to his mind there could be no doubt about it, there could be no mistake about the propriety of that course being taken; though there were certain erroneous ideas in the minds of the people which prevented that course from generally being taken. People thought that sewage necessarily stank. Fresh sewage did not stink, and if fresh sewage were applied at once to the land there was no likelihood, or ought to be no likelihood of smell at all. To produce smell in sewage, time was required, because it was the action of living organisms that led to the decomposition of the material. Until those microphites had been at work there was no room for smell, and if sewage were got on the land within a certain time after its production there was an absence of smell. They might use their sewage close to the population which produced it, provided it were properly and scientifically managed, and they might use it in a manner which would be utterly free from objection to the neighbouring inhabitants; the moment they got sewage on land the change which took place was in a direction antagonistic to the production of smell. The action of earth or vegetation produced such a change in arresting actions so that micro-organisms could not be produced, and there was of course an end to all smell; and this fact was illustrated when the cat misbehaved itself in the hall and the servant sprinkled the result of its misbehaviour with earth. Sewage which came fresh from the body was not harmful, or else everybody would be poisoned by their own excreta; those were simply ethereal smells which were dissipated at once and did not rise to mischief; those which did mischief were associated with a certain fermentative process taking place in

changing organic matter which was ceasing to live, and if they stopped that, which the earth or vegetation would do, they had at once a removal of the conditions which gave rise to smells which were injurious to health. He had had under his eyes for the last three-and-thirty years an illustration of the effective manner in which the work could be done. He was speaking as to its scientific aspect, because sewage farming was a purely scientific process, and if it were managed by unscientific people, by unscientific committees of Local Boards, they might depend upon it it would be a scientific as well as a financial failure. If, however, a sewage farm were conducted properly, there would be a sufficient return from the proceeds of that farm to pay all the expenses of management, to pay a certain percentage upon the outlay as far as the farming arrangements were concerned; but there would be nothing to pay interest upon the sum that was required for the purpose of acquiring a site for the farm—that was a burden which must be borne by the locality. The locality provided the sewage, and the locality must provide the means of taking that sewage out of the water; if they left that as a charge upon the locality, they need not pay one single sixpence in annual cost for farming purposes. There were difficulties in obtaining land in a locality like Bolton, but it was not necessary that the land should be in close proximity; they might have areas here and areas there, and if they could command those areas by gravitation they might be actually in the grounds of a gentleman's park, and there was no difficulty in so arranging their sewage that there should be no mischief and no miasm from it that would be injurious. There was no reason why they should have any kind of effluent which could not be admitted to any fresh waters. There were of course difficulties in the way of managing this, the principal of which was the want of scientific knowledge. It was certainly easier to adopt a precipitating process of mixing lime in the water and getting rid of the suspended matter and letting the effluent go, but by that means all its manurial qualities were lost to the country; he thought it was an injury to the country that this should go on. We were now-a-days so considerate of £ s. d. that if it were seen there was a possibility of expense upon the locality, they did not so much look at that side, and at once took up the sentimental aspects; that was the side he was always fighting against, and it always expressed itself in this: that to bring a sewage farm close to a population, was to introduce the elements of disease. There was no reason whatever why it should be anything of the kind; though sentiment has often more to do with the failure to establish a sewage farm than anything else, the very high price which would have to be paid for land for the purpose close to a town was often a serious drawback. Where it was impossible to carry out the course he suggested, then there were ways by which precipitation methods might remove the suspended matter which developed mischief, and also take out some of the albuminoids which were likely to produce disease. The locality which allowed one of the ordinary streams of the district to be fouled by their sewage, whether that sewage contained only, as was the case at Bolton, dissolved material that

came off and was not visible, or whether it was that visible material which was taken out here, and did go in in some places; they were failing in their duty, and were not doing what they ought to do, both as local legislators and as citizens of a county which ought to grow food enough for its people to live upon, without having to depend upon the foreigners for our food supply. Utilization of our sewage by farming would help us to do this.

Mr. Rogers Field, M.Inst.C.E. (London), could not agree with Dr. Carpenter that it was a right thing to take the sewage from towns and discharge it on gentlemen's estates. But putting this point aside he thoroughly agreed with the doctor with regard to the difference between fresh sewage and sewage that was highly putrefied. It was a distinction that was very seldom recognised, but it was one of vital importance. In order to dispose of sewage without giving offence the sewage must always be fresh, and it was there the difficulty lay, as in the case of towns it was almost impossible to get fresh sewage. In the case of many large institutions, such as lunatic asylums, hospitals, workhouses or large mansions, the conditions were more favourable, as the whole of the drainage system had frequently been carried out "*de novo*," so that it was self-cleansing. There was then no decomposition, and they might deal with the sewage on the land without any trouble or difficulty, or any offence at all. The way the matter was frequently treated, however, was to conduct the sewage into cesspools and then take the overflow of the cesspools on to the land. This method was doomed to failure, inasmuch as the cesspool was a mass of decomposition. The very first thing was to do away with the cesspools; but this was not sufficient; they must also go further than that: do away with all sewers, drains, and traps which favoured deposit, so that the entire system should be self-cleansing. Then and not till then the sewage would be fresh, and the disposal be effected without offence. The question naturally arose, How was this to be done in the case of towns? There were of course great difficulties, but they were getting much nearer to it. He was glad to know that in many towns now very great attention had been paid to the subject, and very stringent regulations had been made with respect to house drains, which were generally the great offenders. All defective house drains should be reconstructed; new sewers should be substituted for the old ones, and everything got into a better state, and just in the measure that this was done would they find themselves able to deal more satisfactorily with the sewage. As matters now stood, in towns it was frequently necessary to have some chemical process, as they were dealing with decomposed sewage; but if the sewage were delivered on to the land in a perfectly fresh condition, a chemical process would not be necessary. It could not be too strongly impressed upon Boards of Guardians, or those responsible for large institutions, that there was no reason whatever in the vast majority of cases why sewage could not be dealt with most satisfactorily on land.

Mr. W. Wilkinson (Bury) ventured to say that the question of £ s. d. had a great deal to do with the tardiness which characterised the dealing with sewage in Lancashire. He rose to bring before the notice of the members a suggestion which was made when their Council was discussing the question at a recent meeting. It was that inasmuch as the landowner is the chief person to benefit by the pollution of rivers with the sewage of towns as his land is increased in value sometimes ten, twenty, or thirty times by the building of houses and the turning of sewage into the rivers, the landowner is liable for a share of the expenses in the purification of that sewage. As far as he knew they had no means at present of getting at the landowners and making them pay their proportion of the expense of purification.

Mr. L. L. Macassey, B.L. (Belfast), asked Major Flower what form of legislation he thought should be adopted to remedy the existing grievance. It was a pretty well settled question now that rivers in many parts of the country were polluted beyond endurance. It was a mere matter of money to make things right, but the question now was "What is to be done?" It would be very important if an Institution like theirs could go the length of giving a formal expression of opinion on the subject. If they could get some idea for the skeleton of an Act of Parliament he thought it would be well. The Rivers Pollution Acts had been rather unworkable, because no one at the time they were passed knew very much about the question of how the remedy was to be applied; and the Legislature, feeling the difficulty, left the matter a very open one. Nearly all legal proceedings against parties polluting streams had been taken at common law and not under the statutes. He thought if an expression of opinion came from a body like this, or if the matter was referred to the Council to deal with, it could in course of time be brought under the notice of the Legislature. The Sanitary Institute included amongst its members many gentlemen who, having given special attention to this subject, were able to speak with authority upon it, and no doubt the opinion of the Institute would receive careful attention.

Major Lamorock Flower (Lee Conservancy) said Mr. Law and he were practically on all fours in their opinions. The President of the Local Government Board was a manufacturer, and looked at the question from a manufacturer's point of view, hence the answer given to the deputation to which Mr. Law had referred. Putting ashes into a river could surely be prevented by common law, but putting a small quantity in had really preserved many a stream in Lancashire from being beastly. With regard to Dr. Carpenter, everybody knew his views on the treatment of sewage. There was but one Dr. Carpenter in the world, and he had always said that if the doctor's theories could be carried out, people would have no reason to complain of stinks and annoyances from sewage farms. He agreed with Mr. Field, that it was necessary to deliver sewage fresh on to farms,

but this was impossible under the present conditions upon which they received sewage from towns. It did not come down to the farms fresh, but stinking, through badly constructed sewers. He happened to know one or two cases where sewage from mansions was disposed of without offence, on gentlemen's parks even, and nuisances which used to go into the drinking water of London, were prevented. He thought it was perfectly possible in the case of large institutions to deal with sewage upon land entirely without offence if the sewers were properly constructed.

Mr. W. Wilkinson (Bury) said it was rather hard lines to fall upon land-owners and ask them to pay for the drainage of a town. They needed some legislation on the subject.

Major Lamorock Flower (London) said one of the speakers wished him to give a special opinion as to the proper lines upon which a new "Rivers Pollution Act" should be framed. He would rather not commit himself to any definite expression of opinion on this occasion. They would consider the matter very fully in Council he believed. Many of them belonged to a society which had done a great amount of good, but which had unfortunately not been much backed up. It was the society to secure effective legislation against river pollution. One of its proposed Bills had been kicked out of the House by the agency of manufacturers, who said they could not afford to keep sewage out of streams. If the law were to say to each manufacturer that he must deal with his own refuse on his own premises the manufacturer would benefit, and the rivers would be in such a condition that perhaps they might even catch salmon within a mile or two of a manufacturing town.

On "House Drainage," by Reginald E. Middleton, M.Inst.C.E., M.Inst.M.E.

Public Sewers.

As the necessity for some of the requirements of house drainage depends on the *sewer*, the writer proposes to say a few words on this subject before dealing with house drainage proper.

So far as the drainage of a house is concerned, it is necessary to deal with sewers as they exist, not with a theoretically perfect condition of things. Sewers, as separate pieces of construction, may be, and frequently are, admirable; but as channels for the rapid removal of all that passes into them they are faulty.

Sewers in most of our towns are designed not only for the removal of excreta and vegetable matter, but they have also to receive a large amount of storm water, necessitating the presence of washings from roofs, street sweepings, &c., and they should therefore be constructed to provide a rate of flow in them which should remove much heavier substances than those contained in sewage proper. If this be not done, the more ponderable matter will subside, and even if this subsidence be regular, there will be a considerably reduced rate of flow due to friction; and as the subsidence never is regular, bars will be formed in the sewer which, unless removed by flushing or excavating, will in time close the sewer altogether, or make it nothing better than a cesspool.

The necessities of practice and the configuration of the ground in almost all cases prevent the possibility of sewers, worked by gravity only, being laid to such gradients as will produce a regular rate of flow sufficiently rapid to remove the ponderable matter, or the sewage proper, in a space of time sufficiently short to prevent deposits and fermentation in the sewer; thus, as fermentation must necessarily take place, and as the householder has no power over the cleansing or ventilation of the sewer, it becomes his duty to separate the occupants of his house from the possible and probable effects of any direct connection with a receptacle or channel which contains gases injurious to health, and may contain the germs of serious disease which have passed into it from some other habitation.

If the drainage of all houses were in such a condition as to get rid of all matter liable to decomposition at once, and it were not the fact that, owing to the faulty construction of many house drains, decomposition has already become active before the matter to be removed has ever reached the sewer, if the sewer were self-cleansing and thoroughly ventilated, and the dangerous matter were removed before fermentation set in, if it were not the channel through which must necessarily be passed excreta carrying with them the germs of disease, *there would be no necessity for the careful* separation of the several systems of house drainage from the sewer proper; but as sewers do receive matter already decomposed, as they do not at once remove matter subject to decomposition, and as they are not thoroughly ventilated, it is necessary that each house should be disconnected as effectually as possible from any chance of contamination from this source, and the intercepting trap between the main house drain and the sewer is a necessity.

Much exception is taken to the system at present in force for the ventilation of sewers, and it is proposed by some to put a large ventilating shaft at the head of every sewer; but a very

small amount of calculation will prove clearly that, even if the openings into the street were closed, any such system would be perfectly ineffectual, and that if the street openings remain as they are, any such ventilation would not extend beyond the first or second of these openings. If sewers could be cut off into short lengths with an effectual seal at either end there would be no difficulty about the matter; such an arrangement is easily ventilated; but how to ventilate a large length and area of pipes open in many places, either into the air or to other sewers, the writer knows not. The ventilation of a coal pit will serve to illustrate the difficulty.

Street openings are frequently offensive to the sense of smell because the sewer is foul, but this is not a reason for closing up the openings into the streets, which would have the effect of forcing the gases into the houses by the pressure of the sewage when increased in volume during the day, or by a sudden access of storm water, or by the expansion of the gases themselves, or by a combination of two or more of these forces; but rather for increasing the number of openings, and thus reducing the temperature in the sewer as compared with the outside atmosphere in cold weather, and diluting the gases to the utmost extent possible. It is of course obvious that if fresh air be admitted foul air must be expelled.

If sewers can be efficiently ventilated there should be no delay in doing it. The proposal which seems to the writer to have the most practical value, is that of carrying a pipe from the sewer to a point above the roof of every house, or of certain houses on one side of the street only, or alternately on one side and the other, but so that ventilating pipes shall not be opposite each other on the two sides of the street. The ventilators should not be connected with the house drain or with that part of it which is in the street, as this is liable to be flooded, and the ventilation would then be stopped, but with the highest point in the sewer. To make such a system of ventilation efficient, it would be necessary that a street opening should be placed midway between each pair of ventilating shafts, or if the shafts did not rise to the same elevation above the sewer, they should be so spaced that each should receive an equal amount of air in proportion to its requirements from the street opening, and the latter should be of ample dimensions so that the indraught should not be checked. Taking the difference of temperature between the column of air in the ventilating pipe and that of the atmosphere at the street opening at 5°, or supposing that the expansion of the gases produces a head equal to this difference of temperature, then a 4 in. pipe 40 ft. high might be expected to change the air in a 60 ft. length of 3 ft. sewer.

running one-third full in 14 minutes (see Hood on "Warming and Ventilating Buildings," p. 364), or in other words, in order to change the air in 27 cubic feet capacity of sewer five times per hour, a ventilating pipe 40 ft. high and having a sectional area of 13 in. will be required on the supposition that a difference of temperature equal to 5°, or a difference of head representing the same amount can be secured. Having made these few remarks on the condition and ventilation of sewers, the writer proposes to proceed to the consideration of house drainage proper.

House Drainage.

It is proposed to take certain propositions as axioms granted by all sanitarians, and to enlarge on these. The axioms are taken from a report prepared by a committee appointed by the Civil and Mechanical Engineers' Society.

If no remark be made on any particular axiom it is considered that none is required.

(1.) Every drain, or part of a drain, inside a house, and all soil-pipes, shall be watertight throughout. The writer believes that this requirement can be thoroughly carried out with glazed stoneware pipes, if they be thoroughly bedded in concrete, and no contact with any part of the foundation of the house be permitted. He, however, prefers to use cast iron pipes where a drain passes through a house, and considers that with this material it is to be preferred that the supports should be at considerable intervals, and that access to all the joints should be simple and easy, and that the drain should be in such a position that it will come under constant inspection. Under these conditions leakage can be quickly detected, and injuries from rusting may be reduced to a minimum.

(2.) The main drain of the house shall be ventilated at its upper extremity by means of a continuation of the soil-pipe, or by a special pipe provided for the purpose, such ventilating pipe, whether connected with the soil-pipe or otherwise, having a clear sectional area of at least 10 square in. throughout, and being carried to such a height that its outlet shall be at least 3 ft. above the eaves of the roof, and the same distance above any window or opening in the roof not being a chimney, and not less than 6 ft. distant from any chimney or opening in the roof, whether of the house to which it belongs, or of the next adjoining house measured in any direction. The main soil-pipe shall be similarly ventilated, and if there be more than one soil-pipe, then each such soil-pipe which shall be longer between the basin of the closet and the main drain than 8 ft. shall be

similarly ventilated. The main drain shall be disconnected from the sewer or cesspit by means of a syphon trap of approved construction, provided with means for cleaning the trap, and the portion of the drain between the trap and the sewer or cesspit, and it shall be ventilated by an inlet air-pipe or ventilated disconnecting man-hole; and if there be more than one outlet ventilating pipe connected with the house drain, then each such portion of drain and outlet ventilating pipe shall be provided with a suitable syphon trap and an inlet air-pipe or disconnecting man-hole, as already described; and the area of the inlet air-pipe shall in all cases be at least double that of the outlet ventilating pipe in the clear.

It is contended by some writers that the inlet for fresh air should be at the head of the drain, and the outlet at or near the disconnecting man-hole. The objection to this arrangement is that the soil-pipe will either remain unventilated or a separate system of ventilation will have to be provided for it, thus introducing unnecessary complications. The argument in its favour, that it follows the flow of the drain, does not seem to be at all conclusive, for as no house drain ever runs more than one-third full, unless under most exceptional circumstances, there is not much reason to fear that the air passing up the drain, which is more volatile than the water flowing down it, would have its current arrested by the traversing current of water; on the contrary, it is probable that the effect would be that the current of air would be temporarily accelerated, and especially would this be the case when, as frequently happens, the drain has a diameter of 6 in., while that of the ventilator is 4 in.; also, if the water in the drain were giving off vapour this would rise in the drain and travel in a direction contrary to that of the water; this, therefore, seems to be the natural direction of the current.

Writers have repeatedly stated that the number of ventilating shafts should, if possible, be increased indefinitely, and from some of the statements to this effect it may be inferred that the relative elevation of the several shafts is a matter of no importance, and that rain-water pipes may be used for this purpose. It cannot be too often or too urgently repeated that this is altogether a mistake (see Hood on "Warming and Ventilation of Buildings," p. 360), that under no circumstances should rain-water pipes be used as drain ventilators; they cannot go above the eaves of the roof, and therefore the foul air from them is liable to enter the house; also if more than one upcast shaft be used it will not, unless each shaft be of exactly the same height and heated to exactly the same extent, and affected by the wind in just the same manner, increase the ventilating

efficiency, but will rather diminish it. The writer has frequently come across systems of ventilation which were faulty on this account; but when the system of ventilation is simple, that is to say where there is one upcast shaft for each inlet, where the inlet opening is of ample dimensions, and leads as directly into the drain as possible, with few or no angles or bends, he has found no difficulty, and he is of opinion that cowls of any kind should be avoided, and that a Mica return flap on the inlet opening is unnecessary. Where the work can afford it, a ventilating disconnecting man-hole should be built, as it affords easy access to the drain; but a perfectly satisfactory arrangement can be made without it so long as the drain remains in good order.

The disconnecting trap should be self-cleansing; therefore, it must be of large radius with easy curves in all directions, and there must be no projections or corners in it which will either arrest the flow through it or tend to collect deposit. These requirements condemn all forms of dip trap, and in fact the only trap which will satisfy them is the ordinary syphon trap, if the radii of the curves be sufficiently great, and it be of good form throughout and well glazed. No inspection pipe in the middle of the length of the trap is possible; this would seriously retard the flow and cause deposit. A cascade action is recommended by some, but consideration will, it is thought, show that this action, while it may by the greater head obtained with a small supply of water force an obstructed trap, does not really offer any advantage which does not exist to a greater degree in the ordinary syphon described above. If with the cascade action a greater local head be obtained with a reduced amount of water, it is at the sacrifice of the general gradient of the drain, and therefore of the rate of flow in it. With the cascade action the distance travelled is greater than with the other system for the same fall, and the very fact of the head being obtained proves conclusively that this trap has a retarding effect on the flow, and the conclusion arrived at by the writer is that it is far better to make the best of the gradient procurable, to have a length of drain next to the trap from 1 ft. 6 in. to 2 ft. long, falling at the rate of 1 in 6, than to have a local vertical fall, whether small or great, and that in this manner a far better scouring action and a cleaner trap would be secured than with a cascade action trap.

(3.) No pipe which passes through any part of a house not being a soil-pipe or soil-drain shall be connected directly with the main drain.

(4.) No water-closet shall be situated next to a larder or place where food is stored. No pan-closet or D trap shall be used, and every water-closet shall be trapped, and shall be arranged so as to prevent syphonage.

(5.) The overflows from safes of closets and of baths, and from cisterns, shall be discharged into the open air in an exposed position, and shall not be connected with the soil-drain or rain-water pipes, either directly or indirectly, but shall act as detectors.

(6.) All sinks, baths, lavatories, and urinals shall be trapped with suitable traps, and the discharges from them shall be carried outside the walls of the house, and shall not be connected directly with any soil-drain, nor shall they be introduced under the grating of any trap, but they shall terminate in the open air, and not near any window or other opening.

The writer is aware that many sanitarians prefer to introduce the pipes leading from sinks, &c., under the gratings of the yard gullies, but he thinks that this is a mistake, and that it is far preferable that the discharge should be made fully in the open air, so that there may be as little chance as possible of the collection of any matter in the pipes, than that it should be hidden out of sight and, possibly, choked. If the gratings become foul from this cause, it is better that this should be apparent than that it should be hidden; it is the object of scientific drainage to bring any collections of foul matter to light, not to hide them.

(7.) All water-closets, urinals, and slop sinks shall be provided with suitable flushing cisterns, and the flushing-pipe for any closet shall not have a less internal diameter than $1\frac{1}{4}$ in., and the height of the flushing cistern above any closet, urinal, or slop sink, shall not be less than 4 ft. It shall be impossible to draw water from any cistern used for flushing purposes for any other purpose than that of flushing.

(8.) The cisterns used for general purposes shall be easily accessible, and shall be provided with covers ventilated into the open air outside the house by a rising pipe other than the overflow pipe, and no pipe from them shall be connected in any way with any soil-pipe drain, or with any pipe receiving the discharge from any bath, lavatory, urinal, sink, or flushing cistern.

(9.) No rain-water pipe used to receive the waste from any bath, lavatory, sink, or urinal, shall be placed near a window or other opening, and no rain-water drain shall connect directly with a soil-drain, and no rain-water pipe shall be used as, or connected with, the soil-pipe nor as a ventilating pipe.

Though there are many bad sanitary appliances in the market, the selection of good ones is a simple matter, requiring little more than common sense knowledge, it being obvious that sharp bends and angles and straight vertical sides are undesirable,

that all utensils should retain matter liable to decomposition for as short a time as possible, but should pass it quickly to the drain, which in its turn should pass it quickly to the sewer. Complications both in apparatus and in the drains and ventilating and inspection chambers are most undesirable, and economy without loss of efficiency should be studied. Finally, whatever sanitary work is done it is of the first importance that it should be done well, that the construction should be thoroughly accurate and carried out in a trustworthy manner.

[*For discussion on this paper see page* 286.]

On "The size of House Drains, and the use and misuse of Traps," by JOHN HONEYMAN, F.R.I.B.A.

RECENT investigations seem to prove that certain elements of ordinary atmospheric air—chiefly oxygen—acting upon aerobian microbes, destroy or attenuate their virulence, so that in either case the microbe, as a vehicle of specific disease, is annihilated.* The significance of this fact, in relation to the proper ventilation of sewers and house drains, has, I think, not been generally realized. The earlier advocates of such ventilation—among whom I venture to claim a place—aimed rather at the dilution and rapid removal of sewage emanations than at the destruction of associated microscopic organisms; but they were not without some apprehension of the truth, since demonstrated, that such organisms are practically destroyed by the action of atmospheric oxygen. It is exactly thirty years since I myself published a paper on sewer ventilation, in which I endeavoured to arouse the better class of my fellow citizens by pointing out the fact that while they in the most elevated and least crowded parts of the city had to submit to the frequent recurrence of epidemic disease, the people on the banks of the river (which seemed to them so pestiferous) were almost exempt from anything of the kind. And my explanation was this: I said that "the agents at work in both localities were identical, but they were *differently developed*." In the one case tainted air, undiluted and confined for miles in unventilated sewers, remained pestilential, whereas in the other, "mingling freely with the

* I venture parenthetically to ask, if the protective effect of attenuated virus can only be obtained by inoculation? There seem to be grounds for inferring that it may also be obtained by inspiration or absorption.

atmosphere, it became harmless—as a homœopathic globule in a glass of water." I would be inclined to use very much the same language now—and I regret to say there is almost as much need to use it—but we have made an immense stride when we are able to plant our feet upon ascertained fact instead of reasonable but somewhat vague deduction.

We may indeed say that we have now a new and potent argument in favour of drain ventilation. We advise it not merely for the dilution of noxious gases, and their rapid removal, or for the relief of hydrostatic pressure, or the aeration of sewage, but also for the destruction of disease germs, or at least the attenuation of suspended virus; and it is evident that if we succeed in this we render our aerial drainage, if I may so call it, innocuous, so that even if it accidentally gained admission to our houses it would do no harm. To secure this, however, even partially, it is obvious that we must allow a much larger volume of fresh air to pass through our drains than has hitherto been customary—in short the more nearly we can make them approach in airiness to the condition of open drains the better. These remarks apply to drains of every size, but in this short paper I shall refer to house drains only.

One reason why I do so is that it seems almost a hopeless task to convince those who have control of the common sewers that anything in the shape of ventilation is called for. After nearly forty years of sanitarian effort, argument, entreaty, and painful and costly experiences, it is now almost as necessary as ever that those who connect their drains with common sewers should carefully protect themselves against the risks they run in doing so. In this and many other things, sanitarians have been very much like the "importunate widow," but after so many years' ineffectual reiteration of the same tale, they may almost be pardoned if they begin to despond. In the case of house drains, however, they are able to appeal to individuals, and individuals are more amenable to reason. Now, our house drains are under our own control, we can cut them off entirely from the common sewer and ventilate them as much as we like; and in view of the facts already referred to, this important question presents itself: do we in practice ventilate our house drains sufficiently to secure the best results? I think it is perfectly manifest that we do not, and that it is simply impossible to do so with drains of the size generally used.

Pipes of small diameter are recommended to facilitate rapid flow and scour; but we want rapid flow and scour of aerial as well as of liquid sewage, and we are met by this difficulty, that whereas small pipes are best for the one purpose, large pipes are absolutely necessary for the other. Now while we admit

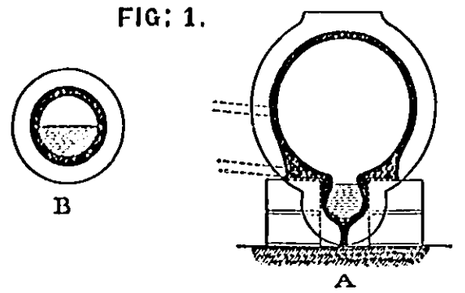
the importance of dealing with the aerial as well as the liquid contents of drains, we have hitherto made no adequate provision for doing so. We have, no doubt, several schemes of drain ventilation which are theoretically good, and which are useful so far as they go; but they stop a very long way short of that thorough flushing of the drains with fresh air which is desirable. In order to bring out clearly the difference between what is usually done and what I think ought to be done, let us suppose that we are dealing with a house of moderate size, having, say, two baths, three water-closets, three basins, and three sinks; a 4 in. pipe would suffice to carry away the sewage from such a house, but in practice a 6 in. pipe would probably be used. Now in many—I fear I must still say in most—cases no attempt would be made to ventilate this drain at all, although soil-pipes connected with it would for the most part be ventilated. In some an outlet shaft would be provided, 2 in. in diameter, in some 3 in., and in a comparatively small number shafts 4 or 4½ in. in diameter. Let us consider the state of matters in such a drain with the outlet shaft of the largest size. If we suppose that the contents of the drain would fill a 4 in. pipe, the 4½ in. shaft would give an area almost equal to that of the remaining empty segment of the 6 in. pipe, so that, roughly, what we have to do is to ventilate a tube, say 5 in. in diameter and 100 ft. long, the greater part of which is horizontal. Even assuming that there are no restricting cowls or gratings at either end, it is manifest that in such a tube there could hardly be any appreciable current without the application of great mechanical force, even if we suppose the tube to be smooth and empty. But the tube we have to deal with is neither. It is rough, and it has for the greater part of its course an exposed surface, greater than that of a 5 in. tube, part of which is in motion in an opposite direction to that which the aerial current would naturally take. In such circumstances it is evident that the current would not only be sluggish but variable, now in one direction, now in another, and often, when opposing forces were well balanced, stagnant. If such be the condition of a drain with a 5 in. air outlet, I need hardly pause to consider the condition of the great majority now in use, which have nothing like so much ventilation.

Of course everything depends on what we call ventilation. If we mean by that term such a change of air in the pipes as is possible under the conditions just described, we may admit that some of our house drains are ventilated; but if we mean by it constant flushing of our drains with fresh air having something like its normal proportion of oxygen, then I fear we must say that none of our house drains are ventilated—with such

restricted sectional area and consequent friction the thing is impossible.

The question then comes to be, can we provide the air space necessary for ventilation without either extending the exposed surface of the sewage or of the contaminated periphery with which the air must come in contact? I venture to think that it is quite possible, and indeed easy, to do so by means of a simple contrivance which I now submit to you (Fig. 1).

FIG. 1.



A. PROPOSED NEW FORM OF DRAIN-PIPE.
B. ORDINARY SIX-INCH DRAIN-PIPE.

The same quantity of liquid is shown in each.

A drain-pipe such as this may be made of any ordinary size, but assuming that one having the upper portion 12 in. in diameter would suffice, let us contrast it with the drain already described. In the first we had a sectional area for the transmission of air of (omitting fractions) 15 in., in the other you have 120 in.; in the first the surface of sewage exposed is 6 in., in the other 2¾ in., assuming that the maximum flow would fill a 4 in. pipe; so that in this new pipe there would be fully a half less exposed surface of sewage, and eight times the amount of air; besides which the flow of sewage would be more rapid being more confined. In such a drain 100 ft. long, open and unobstructed at both ends, the current would not be overpowered by friction, and would hardly be affected by the comparatively trifling area of moving surface; and we by no means advise that it should be open at the two ends only, but at as many points as practicable along its course. Dealing with comparatively pure air we would be at liberty to make intermediate openings without risk—the fresh air would thus have the upper hand and keep it. We can give air as well as water

too much to do, and in fact it is more dangerous to overcharge air than water with impurity.

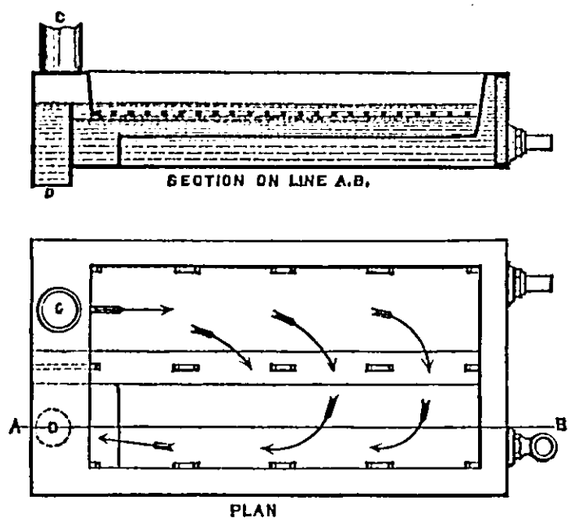
But while I recommend the use of large pipes immediately in connection with the house, that is to say on the inlet side of the manhole and intercepting trap, I must observe, that in most cases it will be advisable to use pipes of small diameter between the intercepting trap and the outfall, especially if that outfall be a common sewer. In that case our object must be to leave no room for air in the pipe—to use pipes large enough to hold the sewage and no more, so that when full or nearly full the air may be expelled from them. I speak of things as they are, not as they ought to be. Our sewers ought to be in a different condition, but while they remain a source of danger the more completely we shut them off from our dwellings the better, and the less we allow their polluted air to remain in contact with the seal of our intercepting trap the better. Where the outfall is good and the branch may be safely ventilated the large pipe of the section shown will be best. In short, the use of the one or the other is indicated by the practicability or otherwise of thorough ventilation.

I must now make one or two remarks on the use of traps in connection with a thoroughly ventilated house-drain. The complete isolation of a house-drain is a fundamental condition. It must not be connected aerially either with a common drain or with the drain of any other house. Having secured that condition by means familiar to you all, and having also secured the thorough flushing of the drain with fresh air and water, it follows that trapping, as a protection against foul air, is unnecessary.

We are practically safe, and the fewer traps we have either outside or inside the better. We do not require to trap soil-pipes, rain-water pipes, or gullies; and by leaving them trapless we only the better insure the purity of the air in the drain. The truth is that by a multiplicity of traps we create a multiplicity of obstructions and deposits, and to that extent interfere with the rapid cleansing and efficient ventilation of the drain. The only excuse for using traps inside at sinks, baths, and the like, is to protect the inmates from cold draughts. For this purpose some obstruction is no doubt necessary, but it need not take the form of a syphon trap. If it does it is most desirable that every trap of the kind should be accessible and cleansable from the vessel with which it is connected. Scullery sinks should be provided with a grease box, which would also serve as a trap; but it ought to be inside, easily got at, and regularly cleaned by the servant who works at the sink. By appliances at present in use it is impossible to catch the

grease in close proximity to the sink, especially where much hot water is used, but I think the difficulty may be got over by a contrivance which I shall now describe (Fig. 2).

FIG. 2.



C. Pipe from Sink. D. Pipe to Drain.

This consists of a shallow box encased with cold water, and covered with a movable grating resting about half-an-inch or more, according to circumstances, below the level to which the waste water will rise. The casing or jacket is really an expansion of the cold water supply to the sink, and the water in it would therefore be frequently replaced. The contents of the sink entering this box would at once spread over the cold bottom and impinge against the cold sides and raised central division. Much of the grease would rise through the grating and congeal above it, and thence be easily removed, but a good deal would no doubt adhere to the bottom and sides of the box. A depression is made at the end of the box to catch sand or other solids; the size would be in proportion to the amount of work to be done in the sink. It is evident that such a box would be quite easily cleaned, and that the cleaning of it could not be neglected without interfering with the use of the sink; moreover, as it would not be enclosed in any way it would not be out of sight and therefore out of mind.

I shall conclude with a word or two about the trapping of water-closets. The ordinary wash-out closets have necessarily traps which prevent the inconvenient or otherwise objectionable

ingress of external air, but I have no doubt that a good valve closet without any trap is hygienically a greatly superior apparatus. The external air is effectually excluded in this case by the water held in the basin; but it would be *sufficiently* excluded by the valve itself if we assume that the air in the house drain is innocuous; there is therefore no use of a trap in addition to the valve, and without that obstruction the contents of the closet are at once discharged into the drain and carried clear of the house in a few seconds. In this way you not only with certainty get quit of excrementitious matter, but also of water which has been in contact with it; whereas in trapped closets you may get rid of the former but not of the latter, and in many varieties you get rid of neither. It is about twelve years since I first ventured to use trapless closets, and I have recently had an opportunity of comparing some of these, which have been in use for more than ten years, with trapped closets of about the same age, with the following result: in no case was I able to detect the slightest smell from a trapless closet, however long I held the valve open, and in every case where the closet was trapped a most offensive smell was perceptible, if the valve were kept open for a few seconds. All my experience indeed points to this: that our best chance of safety lies in so contriving our house-drains and plumber-work that there shall not be one single receptacle where stagnation is possible throughout our entire system, and that the pure air of heaven shall constantly permeate every nook and cranny of it.

Besides plenty of air and a good scour, and periodical flushing, one thing more is desirable, if not essential, if the contents of our house-drains are to be harmless, and that is that they should be regularly cleaned. I may not enter upon this subject now, but venture to say that I see no difficulty whatever in having this cleaning done periodically at less expense, and with very much less trouble to the occupants of the house, than a somewhat analogous operation to which we are quite accustomed—the sweeping of chimneys. There is indeed no reason why we should not have drain-sweeps as well as chimney-sweeps.

[*This discussion applies to the two preceding papers by* Mr. R. E. Middleton *and* Mr. John Honeyman.]

Mr. Daniel Emptage (Margate) opened the discussion, and remarked that he agreed with Mr. Middleton that the best way to ventilate a sewer was by carrying a pipe from it to the top of every house, though he thought the pipe should be taken as close to the

seal of the disconnecting trap as possible. He also considered that the disconnecting trap should be self-cleansing; but he could not agree with Mr. Middleton that a plain syphon trap was as good as a cascade action. His experience taught him that with the former it was difficult for paper, &c., to pass through unless before a heavy flush of water. He had experimented with them, side by side, with equal quantities of water, and under equal conditions, and found that while the cascade action forced water at once through the trap, in the other the water frequently slipped underneath the paper without carrying it through. With regard to the waste from sinks discharging over instead of under a grating, he might say that he had tried them both ways, and his experience showed him that it was best for the waste to be so fixed that it would deliver the discharge straight on to the seal of the trap, but that the outlet of the waste should be so fixed and tapered off that bad smells from the surface trap could not readily pass up it. The advantage of this arrangement was that there was no accumulation of filth upon the grating. Speaking with respect to Mr. Honeyman's paper, he pointed out that that gentleman said, the only excuse for traps inside under a sink was to keep out a cold draught. To his mind there was a much more important reason, viz., to keep out impure air. They all knew that waste-pipes became quickly more or less fouled, and to have air constantly passing through such channels, was, to say the least, very undesirable. He was sorry to hear the author so strongly advocate those, so-called, trapless closets. He had hoped that, by sanitarians at least, this system had been condemned. If they could ensure such apparatus always being fixed under the conditions insisted upon by the gentleman who introduced them, viz., complete trapping and ventilation of the drain and soil-pipe, and a good flush, they might be tolerably wholesome, but this they could not do. If the closets were made, they would be fixed, either ignorantly or wilfully, regardless of conditions. He had recently removed one which was fixed to an untrapped drain in connection with a cesspool; and upon one occasion he was shown over some large houses at the West End of London in which this system was carried out (the builder being a strong advocate of the arrangement). In connection with the first closet which he attempted to flush there was a defective flushing apparatus, as no water came into the basin, which he found dry and in an unclean state.

Mr. Rogers Field, M.Inst.C.E. (London), expressed his general concurrence with Mr. Middleton's excellent paper. Regarding the ventilation of sewers by pipes carried up the house, he quite agreed with Mr. Middleten, assuming his meaning to be that if pipes were adopted they should not close the openings in the streets, as was often done, which was a great mistake. He also agreed with what the author of the paper said about the use of cast-iron pipes in house drainage. One of the best methods of using these was the one adopted in the United States, where the cast-iron pipes were invariably made to pass under the house and hang along the side of the

wall. This was an admirable plan, as the pipe was always visible, and any defect could at once be detected. He did not quite understand Mr. Middleton when he said, "if there be more than one outlet ventilating pipe connected with the house-drain, then each such portion of drain and outlet ventilating pipe shall be provided with a suitable syphon trap and an inlet air-pipe or disconnecting man-hole." There were cases no doubt in which this might be desirable, but the great thing to be aimed at should be simplicity. To have a multiplicity of traps and pipes would be a mistake. Again, it was perfectly impossible to lay down hard and fast rules: the matter should be left for consideration in each individual case by competent men. As to the question of cascade action with disconnecting traps there were differences of opinion, and he had himself tried a long series of experiments on the subject. The conclusion he arrived at was, that a certain amount of cascade action was desirable, as they could not clear away the paper without it, but that too much was objectionable, as it caused the sewage to splash against the opposite side of the trap. They must judge cases by the peculiar circumstances that arose. Mr. Middleton said that the height of the flushing cistern above any closet, urinal, or slop-sink, should not be less than four feet. This was quite right if they could get it, but there were many cases where they could not, and he consequently did not consider a hard and fast rule desirable in this instance. There were, moreover, many flushing cisterns that would flush the closet effectually at less than four feet. Mr. Middleton remarked that "though there are many bad sanitary appliances in the market, the selection of good ones is a simple matter, requiring little more than common sense knowledge." He could not agree with this, for his experience, which was considerable, taught him that the question of whether appliances of this character are good or bad could only be told by actual test. As one of the Judges of the Exhibition of the Institute since the commencement, he had had much experience in testing closets; but notwithstanding this, he never drew a conclusion as to any new form of closet without practically trying it. Anyone who formed an opinion from merely looking at a closet might find himself very much deceived. Turning his attention to Mr. Honeyman's paper, Mr. Field said the author appeared to start with the idea that they could not get sufficient ventilation in drains to make them satisfactory as they were ordinarily laid. If the author meant by this drains inefficiently laid, as was unfortunately too often the case, Mr. Field quite agreed with the idea; but on the other hand, he was sure they would never find any difficulty in getting a cylindrical six-inch drain thoroughly ventilated, so as to have no smell at all emanating from it if only it were well laid and made perfectly water-tight. This being so he could not see the necessity for the very complicated arrangement Mr. Honeyman proposed, or that there was any corresponding benefit to be derived from it. The author proceeded to say that "having secured that condition by means familiar to you all, and having also secured the thorough flushing of the drain with fresh air, it follows that trapping as a protection against foul air is unnecessary." He

agreed with Mr. Honeyman that a multiplicity of traps was objectionable and should be avoided as far as possible; but could not coincide with him that trapping should be done away with altogether. On the subject of grease traps as ordinarily understood, his experience was, that that contrivance was nothing but an unmitigated nuisance. Each discharge which took place from the sink passed through the grease trap and carried some of the filthy matter from it along the drain, thus causing everything in connection with it to smell abominably. The operation of cleaning a grease trap would never be forgotten by anyone who had assisted at it. The contrivance was, moreover, generally quite unnecessary, its supposed necessity arising from defects in the drains. He had removed grease traps from many large institutions and mansions, and had always found things work satisfactorily without them, as long as the drainage generally was in thorough good order. The next question he had to refer to was trapless closets. He had used them himself many years ago, and they were still working satisfactorily, so that he could not altogether condemn them; at the same time he should certainly not recommend them for general use, as their satisfactory action depended on several conditions which would not be attended to in general practice; in fact, he did not now use them himself except in very special cases. In his last paragraph Mr. Honeyman made a good suggestion about the cleaning of house drains. He did not think there was any reason why they should not be cleaned periodically, just as chimneys were swept, and an arrangement might be made for the workmen who came to clean the drains also to clean the cisterns and look over the whole of the sanitary appliances.

Mr. J. Corbett (Manchester) also remarked upon the ventilation of drains, and intimated that by considerable observation he had come to the conclusion that whatever course they might lay out on paper for the current to pass, it would certainly at times go the opposite way. If they depended upon heat, they must at the same time be prepared for cold, which of course reversed the current arranged by heat. He thought this was a matter sanitary engineers were apt to overlook. He believed a perfectly satisfactory arrangement could be made by a syphon trap without an access manhole, so long as the drain remained in good order; but it seemed to him they ought always to provide for the drain getting into bad order. It should be the custom never to bury any traps without access, either by a direct manhole or at least by tools down an eye. He could quite corroborate Mr. Field's remarks as to the difficulty of selecting sanitary apparatus. He must say that every sanitary exhibition he went to had a depressing effect upon him, because it was usually an insanitary exhibition: and, without excepting even the latest one now open at Bolton, he did think that a great work still remained for the Sanitary Institute in the matter of sanitary exhibitions. So far, at nearly every exhibition he had been to—he thought he had been to nearly all—there was a preponderance of things that ought to be in a chamber of horrors. He suggested that in future a select committee

of the association should be appointed to supervise the exhibits, and be armed with power to let no apparatus be admitted into the exhibition that did not meet with their approval. This done, they would have the great result that, instead of being sneered at as having a small shop show, they would have the thanks of the public, who would then be led to think that the Sanitary Institute could do something for them, and was not merely a tool in the hands of shopkeepers and manufacturers.

Mr. E. C. Robins, F.R.I.B.A. (London), said he wished it to be particularly understood that the papers just read started from two different points of view: one was a repetition of what had been done in sanitary science for the benefit of householders up to the present time, and the other was an original paper which aimed at the introduction of something novel. The author of the latter deserved more commendation than he had received; but at the same time he knew Mr. Field did not discredit original work, and would be happy to see and recognise success when it came. Mr. Honeyman's paper showed a great amount of ingenuity, and if worked out a deal of good might come from the suggestions.

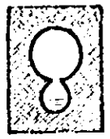
Mr. W. Wilkinson (Bury) drew attention to the paragraph in Mr. Middleton's paper in which he said: "The main soil pipe shall be similarly ventilated, and if there be more than one soil pipe, then each such soil pipe which shall be longer between the basin of the closet and the main drain than eight feet shall be similarly ventilated." He should maintain, in a case of that kind, that every soil pipe should be ventilated irrespective of the length of it, whether it be eight feet or eighty feet. He contended from his experience that traps were a necessity, and also maintained that Mr. Honeyman had himself demonstrated the necessity of traps in his observation that, besides plenty of air and a good scour, one thing more was desirable, if not essential, if the contents of their house drains were to be harmless: and this was that they should be regularly cleaned. That to his mind gave the deathblow to the "no trap" theory, because if there was a necessity for drains to be cleaned, so also was there a necessity for traps to prevent foul air from entering the house. His experience had also been that to allow a slopstone pipe, even if only a yard long, to act as a fresh-air inlet for a house, was certainly a suicidal policy; because if they had such a pipe only a yard long, through which continually passed greasy water, it was impossible to use that pipe even for a week without it being offensive.

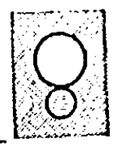
Mr. R. E. Middleton, M.Inst.C.E. (London), in replying, said he should not think of having the openings in the street closed, as to do so was most objectionable. Four-inch pipes were no doubt very small for sewer ventilators, but he considered that this form of ventilation was the only one practicable for the purpose. He did not say it was the best, and he should be glad to hear of something better. With regard to using different systems of ventilation in the same set of house drains, if two ventilating pipes were put in the same drain

with one inlet ventilator, he found they counteracted each other, and were equal only to one system where one inlet pipe and one outlet pipe were used, and the inlet pipe would, under these conditions, frequently become the outlet one. In his opinion if more than one outlet ventilating pipe were used it was necessary to have a separate inlet pipe for each, and that each system of ventilation should be separate and distinct. In making the remarks he had done it was of course open to every sanitarian to make objection, and if these objections led to the whole question being sufficiently ventilated, some system which would be generally accepted might be advantageously drawn up. With regard to what he said as to the selection of sanitary appliances, he could quite understand his remarks being misunderstood. He did not mean to say that those things should not be tested carefully, for they should be, but it was easy to find a moderately safe appliance by the simple rules of common sense. If they were able to test them of course it was all the better.

Mr. Harry R. Newton (Weybridge) said: I fear, Mr. Chairman, the time at disposal will only suffice to enable me to make a few remarks, though I had wished to have spoken *in extenso* on this particular question connected with sewering; viz., that air should in all possible ways be excluded from fouled waters: for which purpose I hold that every drain and sewer throughout the kingdom, instead of being nearly empty, and therefore full of air, as they now are (except at storm periods), should be always charged with liquid, always full, always slowly overflowing; in fact, that an absolutely enclosed and arrested rivulet should be created, running over and away in every locality at a higher level than ordinary; so that, besides storing reserved force for the most powerful removal of the contents of any drain, by the usual drain outlet, at any moment desired or required, other beneficial opportunities would arise to take advantage of and to suit any circumstances by which the contents of any drain, or sewer, must in all ways then be under entire control; instead of, as now, the contents of such drains and sewers being left to the chapter of accidents, and remaining without control, restraint or check to the unpleasant, destructive and deleterious properties that fouled waters contain. With reference to animal and vegetable refuse, solid or liquid, the actions of three of the elements on them are definite and distinct in all ways. 1st. *Earth*, by absolutely enclosing organic refuse from the external air, can compel all organism to resume its original condition, its elementary innocuous condition. 2nd. *Water* is, under any circumstances, but a temporary holder of organic refuse, and if then kept from air, retains organic refuse in its then condition without power, *per se*, to reduce that organic refuse to a wholesome condition; but refuse water, in direct connection with air, has enormous powers of making the organic refuse of contagion infinitely more baneful than when in its initiatory state, producing an unhealthiness hitherto next to impossible to get rid of, accumulating as refuse does day by day. 3rd. *Air* has no action on refuse, but what is primarily intensely bad for the health of human nature; for air

attacks vigorously everything with moisture in it; so that everything created by nature may ultimately be evaporated, diffused and given up to it, for its own atmospheric purposes, to be subsequently returned according to the natural and unfathomable laws that control the universe. This natural process of distribution, or action of atmospherical conditions, it is the absolute duty of humanity not to aid or inconsiderately feed with any impurities whatsoever, but where it can and as it can, stamp such unhealthy actions out. Hence, if water is used for getting rid of animal impurities—and which I see no avoidance of for reasons I have given elsewhere—it should *only* and *solely* be used under the following condition, viz.: to be held up at pleasure, and overflow so as to obtain increased power for removal, and to obtain at the same time the actually most favourable conditions and powers for the deodorization, the sterilizing and the destruction of all impurities within its grasp. With the short time at my command, the house drain less requires explanation as to how it can hold liquid and exclude air; but for sewer requirements I can best convey what I desire to do to the meeting, if our friend Mr. Honeyman, who read a paper here this morning, will kindly allow me to explain my views by a reference to the model he has favoured us with and brought here to explain his system for the better ventilation of drains: a condition I am taking the opposite view on. Mr. Honeyman's model shows a quasi sub-drain; that is, a drain with a smaller drain in it at the bottom, not joined in the middle, as the two divisions have a free communication with each other by a horizontal and longitudinal opening throughout: the object being, I understand, to contract a circular space for sewage at the bottom, and provide a permanent air circular reservoir at the top for ventilation. My view is, that it would be better that the semi-division between this dual form of drain should be entirely closed up, so that the two parts be without any connection one with the other; that the lower (the sewage) drain should be always full and running over and away, as before described by me; and that the upper one should be of the size for a man to pass through it easily, and otherwise should be only used for surface and storm waters: the lower drain would then, equally with the house drain, be in precisely the condition required for the artificial correction or sterilizing of all fouled liquids entering therein, and so that, by absence of emission of any deleterious vapour, a source of nuisance and ill-health to humanity may be removed. Though I should like to say a great deal more as to the considerations foreshadowed and as to many details, still I have, Mr. Chairman, in essence, expressed the views I have formed on the sewage question, holding firmly to the definite standpoint, that liquids must





[Note by the Editor.—It is presumed that, in Mr. Newton's case, the pipes would be kept full by the syphon being above instead of below the general level of the pipes. It is to be hoped that both Mr. Honeyman and Mr. Newton will hereafter prepare further details, showing the application of their respective principles to an ordinary London residence of the first class.]

be kept absolutely from all contact with air, so long as they retain, in the smallest degree, any foulness or constituents for fermentation; which fermentation can only arise from the conjuncture of the two elements—Air and Water. On these grounds I maintain that any ventilation whatsoever of fouled liquids or of refuse waters is a fatal error of the most profound character.

Mr. J. Honeyman, F.R.I.B.A. (Glasgow), said he must admit having spoken rather rashly with regard to the absence of traps altogether. Protection from smell was quite as good a reason for using traps as protection from cold draughts. He would not like it to be supposed that he advised the omission of all traps between waste pipes, &c., and the house, although he said that as a protection against air from the house drain they would be unnecessary. He was sorry he could not agree with Mr. Field regarding the necessity of more air in the drain; he thought it could be shown to be physically impossible to ventilate a drain only six inches in diameter sufficiently without mechanical force. Mr. Field said he got a six-inch pipe perfectly without smell; but even if he did he must be aware that a smell was not necessarily a test of the purity or harmlessness of the air. This was a point often forgotten. He would like it borne in mind that his remarks with regard to the doing away of traps were based upon the idea that the house drains were entirely disconnected from the common sewer, and that they were formed and ventilated and kept clean as he had suggested.

On "Health, Comfort, and Economy in Cottage Construction,"
By J. Corbett, Sanitary Engineer.

In studying this question, and the cognate ones of improving city slums and providing block-dwellings in populous districts, I have inspected the slums of our largest cities, and also their improved dwellings: visited and lectured in many manufacturing towns, and collected plans and useful information from many sources.

The liberal offer made by Mr. William Westgarth, through the Society of Arts, for essays on the best means for providing dwellings for the poorer classes of Central London, induced me to prepare an essay and plans for block-dwellings, to which was awarded in 1885 the premium of £100.

Many of the special features of these plans for block-dwellings are equally applicable to ordinary cottage or small house construction, and so I have embodied them with some modifica-

tions in the following paper, in order to bring them under the notice of cottage builders in this populous manufacturing district.

The recent tendency to return to Old English examples for middle class household furniture, and also for structure and arrangement, may with advantage be extended to cottage dwellings. By judicious modification and adaptation to modern ideas of comfort, many old features of cottage construction may be re-introduced, displacing the shabby imitations of classical architecture which are now the usual features of cheap building.

Before entering into structural details it will be well to consider what are the chief requirements of health and comfort, and what the chief hindrances to attaining health and comfort in cottages or cheap houses.

Health requires ample light, airiness, cleanliness, warmth and dryness in every room.

Comfort requires avoidance of draughts; avoidance of hollow floors or walls forming warrens for mice and other vermin; of weak plaster easily pierced by vermin; of weak floors, creaking and yielding underfoot; of fragile ironmongery, shelving, and other fittings.

Economy requires that the cheapest efficient materials, and the smallest quantity of materials compatible with efficiency, shall be used throughout the structure.

In order to put my suggestions into some definite order, I will endeavour to follow the several trades through the construction of an ideal group of cottages, beginning with the excavators' and bricklayers' work.

The less excavating the better, as a rule, for cottages without cellars. Surface soil should be removed because of its vegetable consistency, and it is generally saleable.

"Made ground" or filled up stuff is often a perilous foundation either for health or stability. A great sanitary authority is reported to have stated some years ago that midden refuse tips were not fit for building upon until *two years* after their formation: and this fatally misleading advice has been repeated again and again by careless writers. Common experience proves that such refuse tips remain foul and give out injurious emanations for scores of years, probably for centuries, after their first formation. In my opinion the only structure for a house floor on such a site compatible with health, comfort, and economy is that of raising the house floor two steps above the surface level, and covering the site with half-brick arching and a coat of pitch; thus providing for free ventilation between the foul ground and the floor, and preventing any direct emanations

from the ground into the house. The bricks used for these arches and their foundation walls may be of inferior quality and rough shape.

The outer walls need not be more than one brick (nine inches) in thickness. The great majority of middle-class houses in Lancashire have walls only this thickness, and it must always be remembered that to insist on a needless thickness of walls is to insist on a needless burden of rent caused by their extra cost.

The outer facing-bricks must be of hard, impervious quality, and this for many reasons.—They will thereby prevent rain from soaking through to the rooms.—They will avoid liability of the bricks to bursting by frost and thaw.—They will retain their warm colour, not becoming either mossy or soot-stained.—But most important of all, they will keep the house warm by avoiding taking in moisture and gradually evaporating it out again, a process similar to that of a porous water carafe, by which the inside temperature is made many degrees lower than the external air.

Where the bricks are not sufficiently impervious, they may be protected externally by a couple of coats of boiled linseed oil, laid on hot while the walls are dry in summer time. Mineral oil or melted wax will also answer the purpose.

Stone walls may be similarly benefited by two coats of Portland cement wash, of the consistency of cream: and this may be slightly tinted where so required.

The most serious false economy commonly made in connection with external walling is the omission of overhanging eaves in all but the front walls. By an overhang equal to only one-twentieth of the height of a wall, about nine-tenths of the rainfall may be kept off it, and its dryness and warmth materially increased. At the same time such overhanging eaves on all sides give a much enhanced appearance to the house.

Cavity-walls are advisable where much exposed to driving rain, or where bricks are somewhat porous; but they are objectionable as forming harbours for vermin, and also means of airway and possible contagion between adjoining houses.

Artistic effects scarcely come within the range of this paper, but as comfort is certainly promoted by tasteful appearance, I may call attention to the excellent effects attainable by suitable corbellings, arches, salient courses, and other very inexpensive uses of common bricks, infinitely preferable to the patches of wrought stonework or fancifully coloured brickwork, often used as decorative features on cottages.

The smoke flues offer an opportunity for considerable economy and increase of comfort. We usually see similar flues, 14 in.

by 9 in., applied to the huge kitchen range of a mansion and to the little fireplace of a cottage. For a cottage such a flue is most inconveniently large; it is too large to heat, and therefore draws poorly, while in windy weather it causes an excessive draught through the room. A flue, 9 in. by 7 in., is large enough for a cottage kitchen or bedroom; it will draw better, and require less sweeping than a larger flue. It has been objected that by retaining less soot it evidently discharges more soot than a larger flue, but any such tendency is more than balanced by the great economy of fuel resulting from the avoidance of irregular and excessive draught.

By reducing the size of flues, the bulk and cost of chimneys is materially economised.

In connection with smoke-flues, I strongly advise the provision of vent-flues from the upper part of each dwelling room or bedroom. None of the outlet valves, from Dr. Arnott's original type down to the latest so called "improvement," will practically work satisfactorily; but a much simpler and cheaper appliance has long been proved efficient. This is simply a short vertical tube, 4 or 6 in. in diameter, built into the chimney breast or else placed beside it, open at one end to the room near the ceiling, and at the other end into the smoke flue close to the fire-place. A regulating valve may be added if desired; and it is well to have a damper or fire-board to close the fire-place opening when out of use, so as to cause the whole draught of the flue to act in extracting the hottest and least pure air from the room, thereby having an important advantage over ventilation by the fire-place, which carries off the lowest strata of air, the coolest and purest in the room.

An important economy of space may be effected in cottage parlour or bedroom fire-places by setting back the grate, &c., some six inches within the projecting chimney breast, turning the flue from the fire-place directly sideways into its smoke flue, and forming an arched recess over the mantel, deep enough to contain shelves for ornaments, &c. A similar recess may be made over a cottage kitchen range, where bright pans, &c. can be kept.

For flooring of kitchens and sculleries flagging is a very cheap and durable material, but coloured tileing on a good concrete bed is far preferable in appearance, and but little more in cost. It is much cleaner and freer from chinks and cavities than boarded flooring, thereby reducing the usual liability of kitchens to mice, cockroaches, &c.

Popular taste will scarcely tolerate yet the use of hard brick window cills and door steps, in place of the stone ones on which the cottage housewife expends so much bath stone and needless

work: but economy, in this brick making district, should induce a preference for hard bricks set in cement for cills, &c.

In districts where stone walling is as cheap as brickwork and equally dry, it may be used with great advantage in appearance; and here again it will be well to study the bold and effective artistic features produced with almost unwrought stonework in many old buildings; the adoption of such homely features, being much more suitable than the attempts at rich mouldings and even carvings found on some modern stone cottages.

Turning now to the carpentry and joinery, the most important question is the best form of flooring.

The common system of scant one inch boards on joists at 16 in. centres has many serious faults, and I think that a modification of the plank flooring commonly used in warehouses would be far preferable.

For upper room floors in cottages, it would be usually a saving in cost to adopt plank flooring properly arranged. The width of room seldom exceeds 12 ft., and 3 in. planks would suffice for this bearing if well tongued and bolted together. By using 3½ in. or 4 in. planks, a very stiff and strong floor would be made.

Each room floor could be completely prepared in the workshop: the separate planks machine-planed, squared and grooved: two one-inch bolt-holes bored laterally through each plank: iron tongues inserted in the grooves: bolts inserted from side to side of the set of planks and screwed up tightly: the surface finally dressed off, and the complete slab of flooring conveyed to its place and laid down on salient courses in the room walls prepared to receive it. In many cases it would be more economical to make each room floor in three pieces, joined together by an under board and coach screws. The shrinkage could be easily taken up by tightening the through bolts. The chink round the walls would be flushed with cement; and thus a strong, warm, draught-proof and vermin-proof floor would be made at a cost not exceeding that of a common floor and plaster ceiling. Such plank floors are more sound-proof than ordinary floors; they also save about one step in each flight of stairs and in the height of the walls. For the ground floors, usually supported on sleeper walls four to six feet apart, two-inch plank flooring, grooved, tongued, and through bolted, would be much warmer than the usual one-inch boards on joists, and very little more costly.

A similar economy of space and materials may be effected by forming slated roofs on grooved and tongued boarding, carried on purlins, &c., at from four to eight feet span, without any roof spars. Very light boarding will suffice where inner ceilings

are used; and where the roof forms also the ceiling, 1¼-inch boarding with roofing felt under the slating forms a warm and draught-proof structure at a moderate cost. Like the solid flooring it has the important advantage of not harbouring vermin.

One of the weakest and most troublesome fittings in a cottage is the panelled door, with its casings, mouldings, lintel, wall-plugs or nogs. I suggest a means of simplifying and solidifying this complicated structure by forming the casing and mouldings of Portland cement, just as external cement mouldings are formed. The door hinges and lock plates to be screwed to fixing-blocks built at definite heights in the walls.

Window casings and mouldings for hinged or sliding casements might be similarly made of Portland cement.

Wood lintels and bond timbers, which often injure a wall by shrinking, and thus causing settling cracks, may be advantageously replaced by very light 4⅛ in. rolled iron joists, laid flat, so as to bond the brickwork. These would suit well to the cement casings above described.

Wood skirtings would be replaced by cement with the same advantages as above described for door and window casings and mouldings.

Wood shelving should be replaced by light cast iron, protected by the Bower-Barff process of bi-oxidation, to prevent rust: and these shelves could be directly built into the brickwork.

Plastering of walls should be substituted by a thin facing of cement, the brickwork being more evenly set than usual, so as not to require much thickness of cement to form a true surface. This cementing would completely prevent any piercing by vermin.

The interesting examples of ideal furniture and structure for cottage homes exhibited in the present Manchester Exhibition, in the Manchester Art Museum in Ancoats, and at other exhibitions, give many excellent hints for practical use; but too often they are cumbered by fantastic cupboards, tables, &c., that would ill stand the trial of rough every-day use.

Still, we may hopefully notice that the rapid spread of education and a higher civilization among the working classes, is fostering in them a taste for more elaborate cottage furniture, and this improved taste warrants the introduction in cottage building of refinements and elaborations which but a few years since would have met with no appreciation.

The ordinary coal fire cooking range is still most popular, but the addition of a strong jointed gas bracket with a large burner to swing into the oven, thereby providing a useful gas

oven when the coal fire is not in use, would enable an early breakfast to be prepared, or a Sunday's dinner cooked without risk of burning while the house-wife was out.

Wherever cottage dwellings are massed in large numbers, and especially where they are built near a manufactory using steam boilers, it would promote health, comfort, and economy, to supply a limited amount of steam heating to each cottage by means of an oven enclosed in a steam casing in communication with flow and return pipes from a steam boiler.

Each oven should be about 14 inches cube inside, with an ordinary iron door; the oven enclosed in a 15-inch cube; the intervening space constantly filled with superheated steam at a moderate pressure, so as to maintain an ample heat for boiling in the oven. This arrangement would prevent any waste of steam, while yet providing an ample heat for the following services:—

On rising early in the morning a hot breakfast could be prepared without waiting to light a fire. A can of water could be heated for washing the pots, the floor, &c. On washing days the clothes could be boiled and presently aired or dried. Dinner might be completely cooked with ample variety, including boiling or stewing, and baking of puddings, cakes, or bread; these last only requiring a finishing browning, which would be effected, as would the roasting of meat, &c., by lighting a large gas jet to supplement the steam heating of the oven. The room might be sufficiently warmed during cool evenings by opening the oven door, and thus letting hot air circulate into the room. Tea or coffee could be most perfectly prepared. Hot water for an evening bath for either children or parents might be provided; the scullery or a bedroom being used as a bath-room. Infected or unduly inhabited clothes might be purified without risk of burning them.

All these advantages might be provided at half the cost now expended in fuel, by the well-known economy of having one large fire properly used in a furnace, instead of many small fires wastefully used in open grates, which also involve much dirty work and waste of time. Domestic fires being thus almost superseded, the smoke nuisance would be reduced to a minimum, and thus cleanliness, culture of gardens, enjoyment of the open air, and many other advantages would be secured.

Almost every town cottage in this district has a constant supply water tap placed over a slopstone in its scullery. It would be a great improvement to replace the porous and rough-surfaced slopstone by a glazed earthenware washing-sink, capable of being kept clean and sweet.

As to closet arrangements, it is not difficult to construct

simple and efficient tub-closets, but after inspecting thousands of cinder-sifter and other such closets, I conclude that they are not satisfactory with ordinary careless and rough usage. I am strongly of opinion that simple hopper and trap water closets are the least objectionable and most economical appliances for their purpose.

Time does not permit of my entering on other departments of cottage construction, though the subject is of such extremely wide interest as to encourage its complete discussion; and I conclude with the hope that these suggestions, and the accompanying drawings, may result in some practical improvements in the homes of the working classes.

Prof. T. Hayter Lewis, F.R.I.B.A. (London), said this paper was upon a subject which in reality affected them all very deeply. A person going through the country places in which he was a stranger, had often pointed out to him the grand mansions in which the wealthy classes lived. It often happened they could not see the mansions from the roadside, as they were generally hidden in the midst of parks, gardens and trees; but what they did see, fringing the road and giving a tone to the whole country, were the homes of the working classes. They could not take up the writings of any domestic English poet without finding that he drew his inspiration from the cottage homes. He would now request the many gentlemen present who were so competent to discuss the subject, to furnish some comments on Mr. Corbett's excellent paper.

Mr. J. J. Bradshaw, F.R.I.B.A. (Bolton), said he had taken down a few notes whilst Mr. Corbett was reading the paper. He must thank Mr. Corbett for having taken the trouble to bring this matter forward, for it affected the bulk of the population far more than most subjects dealt with by the Congress. The first note he had made was as to the couple of coats of boiled linseed oil. This substance evaporated, and a better plan was to use a solution of wax. In addition to that, oil discoloured the bricks, and the other substance would not do so to the same extent. With regard to the arrangements shown on the diagram for small flues for cottage ranges, he was afraid they would not always answer. The arrangement of the side flue for the air vent was nice and effective. Tiling was suggested for kitchens and sculleries, but the objection to it in this district, where flags were reasonably cheap, was that tiles were much colder to the feet than flags. The brick available in this district was very porous, and if used in sills led to a more speedy rotting of the woodwork. There was one little remark he must object to. Mr. Corbett suggested that the flooring should be made up complete, and then taken to the place and put in. The exigencies of building suggested one remark from him. He was reminded by Mr. Corbett's suggestion of the man who made a cart in

his bedroom and then, after finishing it, found that he could not get it out. Then again, if the flooring were made as suggested, the wood would be green and the shrinkage of the timber after a little lapse of time would leave it open at the joints. The same remark applied to the roof boarding. He had done it often enough in the erection of sheds, but to use that method in a house would cause the joints to become open in a very short time. He was not quite satisfied with the idea of hanging hinges to anything prepared in the way suggested, because the fixing blocks would have to be of wood, instead of patent cement blocks; and in the event of wood, which was ordinarily the case, they would soon shrink and become loose. He was glad to see that wood skirtings were recommended to be replaced by cement. Even the speculative cottage builders in this district had adopted that plan, both for bedrooms and kitchens. The plastering of walls with cement was a good idea; but the objection to it was that of expense, as cement was more costly than ordinary plastering. The only objection to the glazed earthenware washing sink was that they were liable to crack. Any one who would take the trouble to walk down a back street of cottages where pails were in use, as in new property in this district, would go away with the idea that something ought to be done, as the stench was intolerable; and if the water-closets were used, it would be better, especially as there was such a good water supply in this district. There was no question that the hopper and trap water-closets were the best for the immediate removal of excreta from the premises.

The Rev. Canon Atkinson, M.A., D.C.L., (Bolton), said he did not rise to make any observations upon the paper, but to express his great satisfaction that this subject should have come before the Congress. There was no subject which in these days was more important. The great enemy, both of the owners of cottage property and the tenants, was the jerry builder; and if they could only get good substantial houses built which were healthy, comfortable, and economical, a great problem would have been solved. As to cavity walls, all he knew of them was with regard to rats: if cavity walls were dispensed with, then they would have one less resort for the rats. As regarded coal fires, many of them had been abroad and had seen the miserable fires there; he did not think they would get the working classes of England to do away with coal fires. Gas ovens, however, would prove very valuable and useful to inmates of cottages. He should like to ask Mr. Corbett if he could give any idea of the cost of a cottage, or a row of cottages carried out on his principles.

Mr. W. R. E. Coles (London) said he should like to ask a question as to the steam cookery spoken of, for he understood Mr. Corbett to say that the advantage it possessed was that it prevented overheating: this would depend upon the amount of pressure under which the steam was generated. He also asked Mr. Corbett to explain the use of a certain recess shown in one of the diagrams.

Mr. J. Corbett (Manchester), in replying to the discussion, said that Mr. Bradshaw spoke of wax solution as being better than oil. He should like to know whether that was the new mineral wax or the common beeswax?

Mr. Bradshaw—The mineral wax.

Mr. Corbett said that might do, as the mineral wax was getting cheap now. He might explain with regard to the bricks, that the best obtainable in Manchester, which was very near to Bolton, were not porous, but good and hard. As to the floors, he did not propose to build the bedroom before placing its floor; a small travelling crane would answer the purpose of raising the floor. As to the alleged greenness of the timber, he did not know why they should be compelled to use green timber, and if it were well seasoned before being placed in position, he had had the contrary experience to Mr. Bradshaw; for he had known the floor to burst upwards because it was too dry. The subsequent moistening of the timbers from new plaster, &c., had caused this. Having been asked whether he had practical experience as to his plan being workable, he might say that with regard to cottages, it was still in the range of theory; but he had quite enough experience as to plank flooring to give him an assurance of its practicability. As to the cost of a cottage carried out on his principles, he took it that it might not be materially more—not more than ten per cent. more—than the ordinary cottage. With regard to the cost of cottages, he had known them built for £57 and £70 each; but for a well-built and tolerably good cottage, he did not think they need go below £100. In answer to Mr. Coles, he thought the temperature of the steam they would use would not burn anything, and practically he was warranted in saying that overheating would be prevented. It was very easy in building a house to make a recess over the mantel-piece, turning the flue quickly aside; he took it that it would be very easy, and that it would pay to do it, simply because it would be less costly to make the cavity than to fill it with brickwork.

Mr. Corbett was then asked if he proposed that the flooring when put in in one piece should be used as a scaffold, because that would injure it.

Mr. Corbett replied that he should recommend the flooring to be covered with loose boards to prevent damage.

Professor T. Hayter Lewis (London) then closed the discussion. He apologized for curtailing the discussion, because he thought it was a subject particularly interesting in this district; it was also a subject which was highly interesting to him personally. Nevertheless as the next subject which was to be brought forward—that of Smoke Abatement—was of special interest in this town, and the time for reading the papers on it was now very limited, he had felt obliged rather to shorten the discussion upon Mr. Corbett's paper.

On "Smoke Abatement," by Herbert Fletcher.

To Members of the Institute, who are probably surprised at the dirtiness of a town, that invites them, it must appear either, that dirt is thought to be sanitary, and that the town is therefore proud of it, or that it wants to be shewn how to clear it away, and seeks their assistance.

In both these opposite conclusions they will be right; for opinions are divided between the two, or, at least, interests are, and they sway opinion.

The smoke is the cause of the dirt, not the domestic but the manufacturing smoke. The difference is shewn on Saturday afternoons and Sundays, in the air, but the weekday soot of the big chimney remains spread over everything, and it is this which gives a character of hopelessness to every attempt to redeem a manufacturing town from that condition which causes it commonly to be contemptuously described as that "vile hole."

But, we are told, that the dirt is wholesome,—that the soot is a disinfectant,—and, that the gas, into which it should be converted by complete combustion, is more noxious;—that its prevention, although required by law, would be a tax on employers, and a hindrance to trade; and, that the dirt by debasing the conditions of life lowers wages, by which lowering every one profits, except perhaps the workman himself.

The last argument should need no answer; it amounts to an advocacy of an injustice to the producers in the interest of the consumers. As to the prevention of smoke being a tax on employers;—if the right means are adopted, and of these means hereafter, its prevention is remunerative,—as there are many examples to prove.

The soot if consumed forms a gas, which is that constituent of pure air upon which all vegetation depends for existence, and its consumption does not at all affect the quantity of sulphurous acid gas produced, the quantity of which depends entirely on the sulphur in the coal. This sulphurous acid is carried further away and is harmlessly diluted, in proportion as there is less solid soot to absorb it and drag it down to the ground. This is the gas which does the mischief, and it is the black part of the smoke—the soot—which by its every particle prevents the

sulphurous acid from obeying the natural law of diffusion in the boundless space of air above.

There remains now only the first assertion unanswered—that the soot is a disinfectant, a smell destroyer—and does the work of the public distributor of disinfecting fluid, and this at less cost than he can.

Could this be established, we could still claim a right to choose between the rival disinfectants, and might prefer to trust for the prevention of disease to the removal of its causes rather than to either Condy's fluid, or to smoke.

Here the Sanitary Institute can help us by showing whether by the prevention of the smoke we should lose a friend, and not only a friend, but one we cannot replace. Sixty per cent. of deaths in the borough of those above five years are from diseases of the lungs. It cannot be denied that smoke is an irritant; yet, if it can be shown that deaths from fever will increase more, than those from bronchitis will diminish, should the existing law be put in force effectually against the tall chimneys, they, in whose power it lies to enforce the law, may hold their hand awhile, till the causes of fever, which require the smoke as a disinfectant, are removed.

The sanitary staff of this borough, however, will not allow things in their department to come to such a pass as this, and, unless it can be shown that the smoke is nourishing, there should remain no reason for tolerating it, beyond the difficulty of burning coal without making it. That coal can be so burnt, there is ample evidence in all parts of the country; and there are several makers of efficient mechanical stokers and perfect smoke preventers, who can provide anyone, whose chimney is complained of, with the means of entirely, not partially only, discontinuing his nuisance. A mechanical stoker or machine fire grate is necessary, for, though hand-firing *may* raise steam without smoke, the circumstances have to be very exceptional;—the draught must be strong,—the coal must be of first-rate quality,—well screened,—and of uniform sized lumps, so as to permit the passage of air;—the coal must be allowed to coke on the dead plate of the boiler, and part with much of its gas before being pushed forward on to the incandescent fire upon the bars,—the fires must never be pressed,—and, there being thus a slower rate of combustion, the number of boilers required for smokeless hand-firing will be greater, than where there is no check imposed by the authorities on the commission of the nuisance.

A few years ago, in order to show to the Admiralty that the Lancashire coal could be burnt economically and without smoke in the Navy, a boiler and testing plant was erected at Wigan,

and it was proved to their satisfaction that this could be accomplished by ordinary means without the assistance of machinery. Most careful firing, however, was required, and the fireman, who was an expert, had only one boiler to attend to. Where ordinary small and "dirty" coal is used, that is, fuel containing over 20 per cent. of shale and fireclay too minutely divided to be separated except by the process of "washing," and where the utmost power of which they are capable has to be got out of the boilers, as is generally the case, it is necessary to stir the fires continually, and to spread the fuel thinly over the whole area of the grate. Each of these operations is attended by a suddenly increased yield of gas, which by its own volume checks the inlet of the very air, of which, in order to produce perfect combustion, a suddenly increased supply is required, nine times in excess of the sudden increase in the volume of the gas.

Every particle of gaseous carbon in this suddenly increased yield of gas that is then unable to find the oxygen supplied by the air, cools down without developing the heat it otherwise would have done in combining with that oxygen, and in forming the colourless carbonic acid gas, which is the result alike of all combustion and of our own breathing, and becomes solid and black, and appears as a particle of smoke floating from the chimney-top in the volumes of gas, whose chemical combinations have been completed, and of whose existence there would be no coloured evidence but for these particles of solid carbon.

It is customary to abuse the firemen for the smoke; but except with an unusual amount of boiler power, permitting slow combustion, and also with such an unusual quality of fuel as admits of being coked at the front of the fire, he is powerless to prevent it.

Neither are all mechanical stokers smoke-preventers. They may be comprised in two classes. Firstly, those by which the fresh fuel is thrown on to the burning fuel over the whole area of the bars like hail; and, secondly, those by which the fuel is slowly introduced, and coked, as it is passed forward over the bars, with a movement comparable to that of a glacier down a valley. Those of the *First* class are useful chiefly for increasing the evaporative power of the boiler:—they enable a larger quantity of fuel to be burnt in a given time;—they relieve the attendant, not of the feeding but of the spreading of the fuel:—the intermittent discharges of dense smoke do not occur, as might be expected,—the feed being continuous; but where the fire has to be urged by the poker, or the burning fuel has to be levelled or arranged by the rake, the use of this class of stoker is attended by but slight diminution of smoke;—of these facts

there is ample evidence in the borough and neighbourhood. If the clinkers and ashes have to be withdrawn at the front from off the bars, the labour of the attendant is not lightened by their use:—they afford easy access to the fire—an advantage which is abused, where boilers are over-fired, by the constant introduction of the poker:—they cost from £10 to £30 per boiler more than hand-firing apparatus, and this small difference, together with the facility for urging or over-firing, are probably the chief causes of their having the larger sale:—they effect an economy in fuel;—but their claims to smokelessness depend for realization on their not being urged, and on their being combined with self-cleaning bars.

The distinguishing feature of the *Second* class of mechanical stoker is, as was said, the glacier-like motion of the fuel imparted to it by the movement of the fire-bars;—like the stream of ice so does the stream of fuel gradually evaporate and grow thinner in its progress, and both alike give up their earthy matter—the one its stones—the other its ashes, as they disappear. The ashes fall from off the inner ends of the bars, and are removed without interfering with the fire. The thickness of the fuel on the bars depends either on the height of a door or shutter, under which it is drawn by the movement of the bars, or on this movement combined with that of pushers at the front.

These machines perform perfectly that work of the attendant in coking, which is required, as was said, for smokeless hand-firing;—they cannot be so easily urged, as can the first-class;—but are quite smokeless and economical;—they are specially adapted for inferior fuel, as they render easy the cleaning out, which with ordinary steam-fuel constitutes the hardest part of the work.

Imparting motion to the bars, which are the heaviest parts of the apparatus, renders the machines of this class more massive than those of Class I., and their first cost is about twice as great; but without this motion of the bars mechanical firing is simply mechanical feeding, and for the object of smoke prevention is a useless compromise. The machines used by the writer are of this class. Six of them have been in use for eleven years at the Ladyshore Colliery, and three have been lately erected at Farnworth Bridge, where those interested will be always welcome. The fuel used is of the poorest description, —firing by hand with it was impracticable from the labour required in continually stirring the fires and cleaning out, yet with the machines the rate of combustion is from 20 to 30 lbs. of fuel per foot of grate surface, or 8 cwt. per hour per boiler;—the evaporation 900 galls., or 10 lbs. of cold water raised to steam

of 80 lbs. pressure per pound of slack;—there is absolutely no smoke, or, to put it scientifically, the resulting gases contain no soot. And, finally, the labour of the attendant is greatly lightened. The cost was £100 per boiler, and the repairs are inconsiderable. It is not maintained that these machines are the best; but merely that they prove the entire prevention of smoke to be both practicable and economical.

Taking the difference between the cost of such a machine and a hand-firing furnace at £70, and, considering that one first-class boiler will drive £40,000 worth of modern mill plant, the percentage on the capital required to prevent the smoke nuisance is too small to be pleaded in excuse for breach of the law, and the infliction of a public injury;—neither can ignorance be pleaded as an excuse, yet the new mills are amongst the worst offenders! What is to be done?

A town council determined to enforce the law could remove the smoke nuisance and obtain everybody's blessing in a year or two, and they would be irresistibly urged to that course, if it were known by the municipal electors how practicable is the remedy for the evil of which we are ashamed before you and all strangers.

If our magistrates, themselves often smoke makers, will not fine more than 10*s.* after all the trouble the nuisance inspectors have to take to obtain a conviction, we might perhaps get such cases removed beyond local influences to another court. It is probable, however, that authorities will lean to public opinion, and if they have evidence that those who live in and near the borough really desire a change, they will procure it for them. There would be no opposition to an earnest majority of the Council, who would appoint a smoke inspector, and support him faithfully.

It was to push this grievance to the front, that the writer was asked to stand for a ward of the Borough, and the election of a few more to help in the same cause would soon turn the scale in the corporation of a town, where we are all naturally afraid of treading on each others toes. The subject is not a favourite one with the Sanitary Committee, and is not likely to receive attention till it becomes a plank in the local political platforms. We all dislike compulsion, and a premium on sanitary boiler plant might be better and be well laid out money, and such "coaxing be better than scratching." Compulsion, however, or inducement of some kind, is necessary, as, without it, it will not be worth the while of any firm to make the necessary changes. A proposal to do so by any manager on public grounds alone would be rejected as a sentimental use of their shareholders' money, by many directors, who, as private citizens,

are liberal enough;—moreover, the effort would appear useless to any one firm surrounded by careless neighbours. Improvement seems now to consist only of extension, but, as we grow bigger, we grow dirtier, and the outlook for those who have no prospect of early retirement from the "vile hole," and are not by that prospect rendered indifferent to everything but cash profit, grows blacker and blacker. If we do nothing, we increase the difficulty for those who follow.

[*For discussion on this paper see page* 335.]

On "Smoke Abatement," by D. J. Russell Duncan.

Existing Acts of Parliament, their defects and omissions, enactments and penalties, qualifying clauses relieving persons who create smoke nuisance from the necessity of consuming *all* their smoke.

Omission from the Acts of domestic fireplaces. Exemption of Glass Works and Potteries from Act of 1853. Repeal of the Act in 1856. Extension to steam vessels plying to the Nore in 1856.

Inclusion of Baths and Wash-houses.

Power granted to Local Authorities to institute proceedings under Local Management Act, 1855. The Sanitary Act, 1866.

Lord Stratheden and Campbell's Bill: Necessity for enlarging Metropolitan Area.

Evidence before Select Committee of House of Lords on Lord Campbell's Bill.

Usual practice adopted by Metropolitan Police when commencing prosecutions.

Railways not under any restrictions for Smoke Nuisance.

Hotels and Eating Houses not affected by existing laws.

Donkey Engines on board vessels evade the laws.

Counsel's opinion anent same, S.S. "Era" case.

Magistrates as offenders. Police prosecutions in Bolton. Supplement No. 1. Copy of Regulations from the Bolton Corporation Act. Communications from Provincial Authorities. Supplements Nos. 2, 3, 4, 5 and 6.

Application by National Smoke Abatement Institution to Home Secretary.

Police and other Reports—inadequacy of fines imposed.

Improvements in Smoke Consuming Apparatus for industrial purposes. Particulars of official tests conducted by Mr. D. K. Clark, the Testing Engineer to the National Smoke Abatement Institution. Supplement No. 7.

Improvements in Domestic Apparatus.

Progress in Inventions during last 10 years.

Fuels—solid and gaseous.

Functions of the National Smoke Abatement Institution.

Unhealthiness arising from fogs.

Smoke abatement is a subject of so comprehensive a character that it will be impossible at the present time to deal with all its numerous and important points, and in introducing a paper under this heading to the Sanitary Institute Congress, it is merely hoped that it may be of some service in directing public attention to some of the chief points, and forming a basis for the useful discussion of the subject.

The subject daily becomes of greater national importance, on account of the increasing number of industrial works, and also to some extent in consequence of the increase in population.

In towns, this matter is of the greatest importance from a sanitary point of view. Scientific evidence has demonstrated that dense unhealthy fogs, such as are frequent during the winter in London, are due to the large volume of solid particles floating in the air, which promote the condensation in the atmosphere under certain conditions of pressure and temperature. The presence of smoke in the air intensifies its impurity, adding to the normal volume of dust to be found in large towns great quantities of soot, carried through the chimneys of furnaces and domestic fireplaces.

The existing Acts of Parliament which chiefly control the emission of smoke in London became law in the years 1853, 1856, 1866.

No. 1. An Act to abate the nuisance arising from the smoke of furnaces in the Metropolis, and from steam vessels above London Bridge. 20th August, 1853.

No. 2. An Act to amend the Smoke Nuisance (Metropolis) Act, 1853. 29th July, 1856.

No. 3. An Act to amend the law relating to Public Health. 7th August, 1866.

They are incomplete in many ways. No attention was given, at the time the Act of 1853 was framed, to the nuisance created by steam vessels (except those above London Bridge), and, with

regard to this Act, which applies to London, the area defined has long since been exceeded, numerous cases of smoke nuisance having arisen from the many industrial works that have sprung up beyond the limits prescribed, with which the Act is powerless to deal.

This Act of 1853, stipulates that every furnace "shall be so constructed as to consume or burn the smoke arising from such furnace," and goes on to say that every person offending "without using the best practicable means for preventing or counteracting such smoke," shall be liable to a penalty of not less than forty shillings, nor more than five pounds (£5) upon a summary conviction; upon a second conviction, a sum of ten pounds (£10); and upon each subsequent conviction a sum double the penalty imposed upon the last preceding conviction. This applies also to all steam vessels on the River Thames above London Bridge.

This Act, if it had no qualifications, would no doubt have been of greater value over the area of the metropolis as defined at the time, had it not contained a clause which has tended to render it, in a great degree, inoperative, and which says, in reference to the enactments already mentioned—"Provided always that the words 'consume or burn the smoke' shall not be held in all cases to mean 'consume or burn *all* the smoke.'" Also that the Magistrate is empowered to remit penalties in cases where he is of opinion that the persons summoned, have constructed or altered the furnaces so as to consume, as far as possible, all the smoke arising. Nothing whatever is said in this Act about regulating the emission of smoke from domestic fireplaces, or from hotels, clubs, &c.

The Act also contained a clause exempting glass and pottery works, already existing at the date of enactment, but this was repealed by the Act of 1856, and the same Act also extended the power of the Act of 1853, to all steam vessels plying between London Bridge and the Nore.

The inclusion of "baths and washhouses" was made to the list of buildings enumerated in the Act of 1853. This Act also authorised the Secretary of State or Commissioners of Police for the Metropolis and City of London to take proceedings against offending parties, and this power was extended to the local authorities by the Act for the Better Local Management of the Metropolis, in 1855.

The Act of 1866, called the Sanitary Act, covered the nuisance resulting from all fireplaces and furnaces used within the district of a nuisance authority for trade purposes, but it carefully excluded the chimneys of private dwelling houses. It also authorised a magistrate to dismiss any case where he felt

satisfied that the fireplace or furnace had been constructed to consume smoke as far as practicable, or had been carefully attended to by the person in charge.

Lord Stratheden and Campbell some time ago introduced a Bill into the House of Lords "to amend the Acts for abating the nuisance arising from the smoke of furnaces and fireplaces within the metropolis;" the object of which was to empower local authorities to make bye-laws prohibiting and regulating the emission of smoke from buildings, whether industrial or domestic.

This Bill was introduced after careful enquiry had been made into the state of the existing laws. It was found that urgent necessity existed for enlargement of the metropolitan area, as cases had arisen at Hammersmith, and elsewhere in the suburbs, creating great nuisance, with which the Acts in force were powerless to deal.

Numerous factories in the East-End of London cause great discomfort to the poorer public inhabiting that district, who are comparatively powerless to protect themselves against such nuisances, and who have also difficulty in bringing them under the notice of the authorities.

It has been argued that potters' kilns cannot be fired without emitting smoke; but that this idea is erroneous has been proved, to mention one instance only, by the arrangements adopted in Staffordshire, whereby Messrs. Minton's potteries have been rendered smokeless.

The evidence brought before the Select Committee of the House of Lords to consider the Smoke Nuisance Abatement Bill contains much valuable information upon the defective legislation, to remedy which is the purpose of Lord Stratheden and Campbell's Bill.

Regulations exist in Paris restricting the production of smoke by domestic dwellings, and a similar legislation ought to be practicable in this country. The thing can be done, and might be enforced without creating any great expense, and in such a manner as not to depend upon the persons attending to fires, who are often careless and negligent. Time fails for a full description of the various enquiries that have been made into this subject, but they were minute and careful, and the results may be found in the Report from the Select Committee of the House of Lords on the Smoke Nuisance Abatement (Metropolis) Bill.

The Report explains the usual practice adopted in the metropolis when smoke is observed issuing from a manufactory. Notice is given to the occupier of the works, and, if the nuisance is not abated within a reasonable time, a second notice

is sent; if still unabated, the engineer appointed by the Home Secretary to examine furnaces against which complaints are made, is apprised of the nuisance—he inspects the place and reports to the Commissioners of Police, and, when proceedings are taken, attends on behalf of the Home Office to support the proceedings, and advise the Bench on the technicalities of the case.

The Report also shows that railways are not under any control, excepting that of the Railway Clauses Consolidation Act, and practically the clauses of that Act relating to smoke are not worked at all.

The effect of new legislation, so says the Report, would be to bring railways, and all other sources of smoke, under some sort of control, and proceedings could be taken by local authorities. The evidence also shows that the law, as it stands, does not adequately control or prosecute hotels or eating-houses, unless steam engines are employed on the premises. In this case, when the nuisance is observed, the police caution the proprietors, and, if not abated, evidence is forwarded to the local authorities, who may prosecute under the Sanitary Act of 1866.

Club-houses, which are very great offenders, do not come under any of the Acts, and it is of the greatest consequence that remedial action should speedily take place with respect to these buildings.

Then again, with regard to donkey engines on board vessels, no measures can at present be taken to stop the nuisance which they create when belching forth large volumes of dense black smoke.

The following extract is taken from Counsel's opinion in the case of the S.S. "Era," belonging to the General Steam Navigation Company. After some preliminary remarks, the Counsel goes on to say:—

"I have come to the conclusion that the case of a donkey engine on a vessel which is only used for the working of cranes to hoist cargo in or out of the vessel, is not within the Statute. A steam engine furnace used in the *working of this steam vessel* is clearly not within the Statute, as such vessel is an ocean-going steamer; and I think that a donkey engine is not within the Statute, because the engines and furnaces of vessels are dealt with under Section 2, which only relates to steam engines and furnaces used *in the working of the steam vessel*, and that the case does not come within Section 1, because, although the first part of that section would apply to this donkey engine, yet the person who is made liable to the penalty *is every person so offending being the owner or occupier of the premises*, &c. In this case the donkey engine was used on a vessel when floating

in the river, and the Steam Company, which was the offending person, was not *the owner or occupier of any premises* on which the donkey engine was used. The only way, therefore, of getting rid of the nuisance complained of arising from donkey engines on board ocean-going steamers is, at a convenient opportunity to have the Acts on the subject amended."

The Acts in force have frequently been rendered inoperative, as administrators of the law are, in many cases, large producers of smoke themselves, especially in manufacturing districts, and they either refuse to convict, or, when fines must be imposed, they reduce them to sums so much below the minimum prescribed by the Act that they become quite useless, and the nuisance continues as great as ever.

By the kindness of the Chief Constable of Bolton and the Medical Officer of Health information has been obtained with reference to the police prosecutions which have taken place in this town during the last ten years. Not more than five or six cases of prosecution for smoke nuisance have occurred during that time. The last was on 28th April of this year, when a conviction was obtained and a fine of five shillings and costs imposed.

The local regulations for the restriction of the smoke nuisance are appended in Supplement No. 1 to this paper.

Communications from several of the leading Provincial Authorities have been received with reference to the prevention of smoke, and are appended as Supplements at the end of this paper: Nos. 2, 3, 4, 5 and 6.

The Council of the National Smoke Abatement Institution some time ago drew the attention of the Home Secretary to the inefficient administration of the Smoke Abatement Acts, and showed that in many cases reported no proceedings are taken; that, when proceedings are instituted, the fines imposed are inadequate; that nothing is done to restrict or prevent the nuisance arising from river steamers; and that the Acts no longer cover the enlarged area of the metropolis. Unfortunately no action resulted from the course then taken; it is, however, to be hoped that legislation will by-and-by bring about an improved condition of affairs.

The Commissioner of Police, in his report about four years ago, drew attention to the great changes which had taken place in the construction of bakers' ovens, and which had resulted in a diminution in the number of prosecutions; but his report also showed that, notwithstanding the introduction of ovens heated by coke and gas, bakers were still the chief offenders.

The National Smoke Abatement Institution summarized the report issued by the Commissioner of Police for the Metropolis

for 1885. The number of prosecutions was 124; the convictions 120; the average fine being £2 5s. 11d. Sixty-six of the fines were under the minimum of forty shillings specified by the Acts.

In his report for 1886 the Chief Commissioner of Police of the Metropolis states that the number of prosecutions was 92, convictions 82, and the average fines £1 17s. 5d., and he says, further:—

"The smallness and irregularity of the fines inflicted are again very noticeable. The average fine for the year 1886, it will be observed, is lower by 18½ per cent. than the previous year, and the number of cases in which the fine inflicted was *below* the minimum prescribed by the Act was also lower, equalling nearly 54 per cent. of the total number. The fines inflicted for similar offences varied between the extremes of 1s. and £20. The furnaces used for generating steam and for baking bread have been again those chiefly complained of during the year. Attention has again been called to the fact that smoke from these sources might readily be prevented entirely, and that, while some steam users and bakers carry on their trade without causing any nuisance whatever, others allow their chimneys to emit more or less smoke almost continuously."

Considerable attention has been paid in recent years to improvements in industrial appliances for the prevention of smoke. Evidence laid by competent persons before the National Smoke Abatement Institution, and a series of careful tests conducted by that Institution, both prove that smoke can be entirely obviated in the furnaces of potteries, breweries and steam vessels (all great offenders in the metropolis), and that not only with benefit to the public, but with economy to the proprietors. This is effected mainly by the fires being supplied with fuel in small and continuous quantities, by means of movable firebars on to which the coal is fed automatically; and these advantages are gained even while still using bituminous coal. Bakers' ovens can be made smokeless by the employment of coke, anthracite, or gas, the last being best in several ways; the reason that it is not more widely employed, being that the initial cost of gas is greater than the initial cost of solid fuel, even though the after economy is greater.

Mr. D. K. Clark, the testing engineer to the National Smoke Abatement Institution, has prepared a short memorandum, giving particulars of some apparatus examined and reported upon by the Institution during the last twelve months. This memorandum is embodied in Supplement No. 7, at the end of this paper.

With regard to domestic fire-places, the under-feeding system

is applicable to them as well as to furnaces, and will prevent smoke, even when bituminous coal is burnt, requiring only an addition to the ordinary grate. The cost is inconsiderable, and in new houses grates and kitcheners on this system could be supplied at no greater expense than that of the existing arrangements. So many methods exist by which the abolition of smoke from domestic chimneys can be effected, either by structural alteration of a slight description or by change of fuel, that it is not necessary to advocate any one in particular. Very careful tests and experiments were made at the Smoke Abatement Exhibition of 1881, and between that time and the Health Exhibition of 1884, numerous improvements were made in domestic heating apparatus, and all information on the subject, with particulars regarding alterations in grates, the advantages of fire-tiles, and the employment of coke and anthracite as fuel, can be obtained by the public from the reports of those Exhibitions, or from the National Smoke Abatement Institution.

To illustrate what attention has been given to these subjects, and what improvements have been effected in the last ten years, it may be mentioned that during that time over 4,200 patents have been taken out for all kinds of apparatus: for condensing gases; for improving fireplaces, kitcheners, and stoves of every description; for improving furnace fire-bars, stokers, steam generators, town refuse consumers, and the methods for supplying air to the same; also for various systems of heating buildings. This gives an average of more than 420 inventions per annum during the last decade, all helping in some measure towards the result we have in view, and tending to prove that public opinion is in favour of the attempt to abolish smoke.

It may be objected that any change in the fuel of daily domestic use would tend to increase the price of anthracite and to diminish the industry in bituminous coal; but this is not the case. There will probably always be persons who prefer this coal to other fuel, and it has been shown that it can be burnt without producing smoke. Its uses in other directions would suffer no diminution. Employed in the manufacture of gas (which involves also the production of coke), the value of its waste products alone creates several important industries. Sir William Siemens declared that the ideal of smokelessness was a perfectly gaseous fuel, and if the stimulus of legislation were applied in this direction, interest rather than compulsion would induce the gas companies to supply a cheaper kind of heating gas (as distinct from lighting gas), and the results to them in the combined profits to be made on heating gas, coke, and the products of distillation, would be enormously beneficial. Sooner

or later the advantages of gas as a cooking and heating agent must make themselves apparent to the public, and wherever large quantities of gas are used there can be no fear of injury to the coal trade.

The chief aims of the National Smoke Abatement Institution will have been gathered from the foregoing remarks, but it may not be amiss briefly to summarise them. Foremost, of course, as its name indicates, its aim is to promote the abatement of coal smoke, and it has enquired, with this end in view, into the state and practical working of the law regarding smoke; it has endeavoured to gather reliable information as to the effects of smoke upon public health and property; it has investigated the appliances at present available for the reduction of smoke and their comparative value, and it has encouraged improvements in domestic and industrial apparatus, and in the economical use of solid and gaseous fuel. It has carefully analysed the administration of the law in London for several years past, and repeatedly made representations to the Home Office showing wherein the operation of the law is inadequate and needing amendment. Although hitherto these representations have not succeeded in obtaining further legislation, or a greater amount of activity under the existing laws, yet the Institution keeps the matter before the mind of the public and the attention of the Government, and it is hoped that ere long these exertions may be rewarded.

The figures quoted with regard to the number of patents testify to the impetus given by the Institution, and by the Smoke Abatement Exhibition of 1881, to inventors in this line of work, and the encouragement offered towards bringing forward improvements of all kinds.

By reference to the Reports of the Institution the public can obtain detailed information of every description, regarding existing patterns of apparatus for domestic and industrial use. They can also furnish themselves with the results of elaborate tests conducted by the Institution as to the respective merits of various systems and different forms of apparatus. These results have already been widely circulated, and can be easily procured. Want of funds prevents these valuable tests from being still further extended, as it is desirable they should be, in view of the legislation which it is hoped will ere long be brought about in the matter of abolishing, or at least diminishing, the production of smoke in our large towns. An Institution whose aims and exertions are entirely in the public interest deserves some considerable measure of support and encouragement.

It can scarcely be necessary here to dilate upon the extreme unhealthiness of the black fogs which every winter afflict large

towns like London, Glasgow, and Manchester, and which are caused mainly by the vast quantities of smoke allowed to escape into the atmosphere. They differ entirely from the mists of nature, which may and do arise in marshy districts, and which are moist and white. No one who has once experienced a bad fog in town is likely to forget the dense, heavy, oppressive feeling of the air, and the unnatural darkness at midday that can almost be felt.

Housewives see the effect of these fogs in the thick and clammy deposit of "smuts" which is to be found, while they prevail, even in the innermost recesses of the dwelling.

Statistics inform us of the sudden deaths, among cabmen and others long exposed to the pernicious influence, which invariably occur during a real "London fog;" and medical papers have told how the respiratory organs of persons so dying have been found, on examination, to be blackened and choked by the amount of actual soot they have been forced to inhale.

Besides being unhealthy, these fogs are costly in the extreme. Setting aside the enormous waste of fuel existing wherever smoke is not properly consumed, it is a painfully evident fact that houses, statues, monuments, and the finest historic and public buildings decay and corrode rapidly in an atmosphere so highly charged with carbon and sulphur; and someone, curious in these matters, has calculated that the sum spent on gas by London, during one day of bad fog, over and above the usual daily expenditure, would be more than sufficient to pay for the alterations necessary to make every fireplace in the metropolis smokeless. The saving that would be effected in a thousand ways, should this happy consummation ever be reached, is beyond calculation. Houses, furniture, and decorations, clothing would all last longer, and the beauty, as well as durability, of our surroundings be materially increased. A smoky atmosphere is almost universally deleterious; upon inanimate objects, upon vegetation, upon human life and well being, its baneful effects may be seen everywhere and at any time.

London fogs may benefit the shareholders of gas companies, but they are good for no one else. The increase of mortality in a week of fog has equalled that in a week of a cholera season, running up the rate by an extra forty per thousand. The climate of London and other large towns becomes, especially in winter, less endurable; a state of things which cries aloud for remedial measures of a wholesale and sweeping description.

From force of circumstances to which it is unnecessary to allude, this paper has been prepared in a somewhat hasty manner, but by indicating the subdivisions of the subject, it is

hoped that special papers may hereafter be prepared; and it is further hoped that gentlemen present, familiar with one or other of the subjects named, will take the opportunity (if time permits) of expressing their opinions and practical experience.

Supplement No. 1.

Communications from the Medical Officer of Health, Bolton, Edward Sergeant, Esq., L.R.C.P.Lond., M.R.C.S.

We have not been very successful in the proceedings which we have taken before the magistrates in cases against owners or manufacturers, they being very loth at giving decisions against the manufacturers, especially if the latter have made the least pretence at doing something, either in constructing the furnace, or providing apparatus necessary for consuming the black smoke which may arise from the combustible burned; the magistrates holding that if the furnace is constructed in such manner as to consume, "as far as practicable," the smoke arising from such furnace, then the manufacturer has done all that is required of him. However, by taking frequent observations and continually watching the stokers, and letting them know that they are being watched, and giving them a copy of the results of observations, we are enabled to exercise a salutary check upon gross carelessness on the part of the major portion of firemen in the borough.

Notes on Smoke Abatement, by the Inspector for the Southern District, Borough of Bolton.

There are several appliances at work for the prevention of smoke, namely, Bennis' Patent Feeders; Proctor's, Hodgkinson's &c., appliances for self-feeding. I find in these cases, if left to themselves, that the smoke is somewhat regulated and successful in that respect; but the coal that has to be used, or is used, being small as a rule, does not get sufficiently burnt out, and comes from the chimney or shaft in coal dust or grit, and hence, though somewhat abating the smoke, creates a nuisance in the immediate neighbourhood.

There are other appliances, such as revolving bars, and either through the inferior coal used or mismanagement, the general complaint is that they are a great expense through getting burnt away so soon, and not supplying a sufficient quantity of steam.

The complaint from the large manufactories in the centre of the town is the want of boiler space, which they allege they cannot get in old established works; but I find great laxity on the part of firemen.

In some few places a small jet of steam is inserted under and over the fire at the front of the boiler and fireplace, to assist, and I consider with good effect, if there is careful firing.

Notes on Smoke Abatement, by the Inspector for the Northern District, Borough of Bolton.

Many of the large firms have provided various means of reducing the amount of dense smoke by mechanical stokers, hoppers, louvre doors, steam jets, and movable bars; these are often neglected by carelessness on the part of stokers or persons having charge of the boiler, by breaking up the fires with rakes and throwing on coal by hand, and not using the appliances provided by their employers. Any carelessness in this respect can be met by the Bolton Corporation Act, 1872, Section 97. Hand firing, if carefully managed by the fireman—"if not sufficient boiler room,"—is equal to many of the appliances supplied to boilers; the abatement of dense smoke is to a large extent in the hands of the fireman. Vertical boilers used by small tradesmen cause a great nuisance.

Bolton Corporation Act, 1872.

Consumption of Smoke by Engines, &c.

97. If any engine-worker, stoker, or other person having the care or management of any steam-engine, not being a locomotive engine used on the railway of any company incorporated by Act of Parliament, or of any furnace used for the purpose of any trade, business or operation other than those to which the provisions of the Nuisances Removal Act of England, 1855, are declared not to extend, at any time uses or manages any such steam-engine or furnace so that the smoke arising therefrom is not effectually consumed or burnt; so far as, having regard to the nature of the trade, business or operation carried on, may be practicable he shall, for every such offence be liable to a penalty not exceeding five shillings: provided that if it is proved before the Justices on the hearing of any information against any such engine-worker, stoker, or other person having the care or management of any such steam-engine or furnace, that he has carefully attended to the same and caused the smoke arising therefrom to be consumed or burnt so far as the construction of the steam-engine or furnace will allow, or as, having regard to the nature of such trade, business or operation may be practicable; or in case the defendant on the hearing of any information under this section proves to the Justices that the act complained of was committed within ten minutes from the time when the fire was first lighted in the furnace on the

day in question, then and in every such case the Justices may dismiss the information without proceeding to a conviction. Provided also, that one penalty shall be recoverable for any number of offences by the same person on the same day.

Supplement No. 2.

Communication from the Mayor of Manchester, F. J. Harwood, Esq.

In this city all proceedings are taken under the Public Health Act. A local Act, subsequently obtained, enables the Justices in their discretion to increase the penalty to £10 per day.

Three officers are engaged specially in connection with Smoke nuisances, and the number of chimneys under observation is about 1760.

Proceedings are taken against offenders where the black smoke emitted amounts to two minutes or over in a thirty minutes' observation.

Where black smoke is emitted for one minute and under two, the inspector makes a report of the case, and an intimation to this effect is forwarded by the superintendent to the offending firm.

During the year ending April 30th, 1887, the proceedings taken under the powers conferred upon the Corporation will be seen from the accompanying Tables:—

Statement of the Proceedings taken under the direction of the Smoke Nuisance Sub-Committee for securing the Abatement of Nuisances arising from Smoke.

Description of Works.	Observations taken.	Number of Firms served with Notices.	Mills Visited, and Owners cautioned.	Totals.	Number of Persons and Firms Summoned before the Sub-Committee.				
					Number Summoned.	Number Fined.	Number Excused, Dismissed, or Reprimanded.	Number referred to Magistrates.	Amount of Fines imposed.
									£ s. d.
Breweries	175	2	28	205	...	...	...	...	.....
Corn Mills	132	4	30	166	...	...	...	...	.....
Calender Works	820	10	90	920	...	...	...	...	.....
Machinists	875	18	109	1002	5	3	...	2	4 0 0
Manufacturing Chemists	592	5	70	667	...	...	...	...	.....
Print and Dye Works	720	6	115	841	5	4	...	1	4 0 0
Saw Mills	820	6	110	936	...	...	...	...	.....
Silk and Cotton Mills	856	6	131	993	17	9	4	4	11 10 0
Smallware Manufacturers	475	...	65	540	...	...	...	...	.....
Miscellaneous	1173	37	247	1457	57	29	6	22	34 10 0
	6638	94	995	7727	84	45	10	29	54 0 0

Showing the Number of Cases in which Magistrates' Summonses were taken out, and the disposal of the same.

Description of Offence.	No. of Summonses taken out.	No. of Persons Fined.	No. ordered to pay Costs only.	No of Orders Granted.	No. of Warrants Granted.	No. Excused, Dismissed, or Reprimanded.	No. of Summonses Withdrawn.	Amount of Fines imposed.
								£ s. d.
Smoke. Allowing black smoke to be emitted from chimneys	24	...	...	23	...	...	1	.....
Smoke. Neglecting to comply with Magistrates' orders to abate nuisance from black smoke ...	29	26	...	...	...	...	3	22 10 0

Supplement No. 3.

Communication from the Mayor of Liverpool, Sir James Poole.

In Liverpool smoke nuisances are for the most part dealt with under a local Act, and the same is in many instances preferable to the general statute, because fewer preliminaries are requisite before taking action. The following extract from the Report of the Medical Officer of Health for the years 1885 and 1886 shows the proceedings which are taken in this city for the prevention of the excessive emission of smoke.

Proceedings for Excessive Smoke—Year 1885.

Number of informations against Manufactories 486
" " " Steamers ... 220
" fined 581
" acquitted or withdrawn 125
Amount of Fines and Costs, £562 19s. 0d.

Year 1886.

Number of informations against Manufactories 352
" " " Steamers ... 200
" fined 545
" acquitted or withdrawn 7
Amount of Fines and Costs, £543 10s. 6d.

Liverpool Sanitary Amendment Act, 1854.

And whereas it is expedient to make further provision for the prevention of nuisances arising from the emission of smoke, be it enacted that the section of the said "Act ninth and tenth

of Victoria, chapter one hundred and twenty-seven, Liverpool Sanitary Act, 1846," number one hundred and twenty-six shall be and the same is hereby repealed; and in lieu thereof be it enacted that all furnaces employed or to be employed in the working of engines by steam, and all furnaces employed or to be employed in any mill, factory, forge, foundry, sugar refinery, pottery, distillery, chemical works, dyehouse, brewery, bakehouse, gasworks, waterworks, and other buildings used for the purpose of any trade or manufacture whatsoever within the said borough (whether a steam engine be used or employed therein or not), and all furnaces employed in working the engines of any steamboat plying on the River Mersey between the said borough and any place in the Counties Palatine of Chester and Lancaster, and of any steamtug or boat employed for the purpose of towing or hauling any ship in the said river, or plying for such employment, or of any steamboat plying for hire between the port of Liverpool and any place in the United Kingdom of Great Britain and Ireland, shall in all cases be constructed or altered so as to consume or burn the smoke arising from such furnace; and if any person shall use any such furnace which shall not be constructed so as to consume or burn its own smoke, or shall so negligently use any such furnace as that the smoke arising therefrom shall not be effectually consumed or burnt, or so that an unnecessary or excessive quantity of smoke shall be emitted, or shall carry on any trade or business which shall occasion any noxious or offensive effluvia, or otherwise annoy the neighbourhood or inhabitants without using the best practical means for preventing or counteracting such smoke or other annoyance, every person so offending, and the owner or occupier of the furnace from which such smoke is emitted, or of the place where such trade or business is carried on, and the owner of such steamboat, and the master or other person in command or charge of the same, shall forfeit and pay a sum of not more than five pounds for and in respect of every day during which or any part of which such furnace or annoyance shall be so used or continued, Provided always, that the words "consume or burn the smoke" shall not be held in all cases to mean "consume or burn all the smoke"; and the Justice or Justices before whom any person shall be summoned may remit the penalties enacted by this Act if he or they shall be of opinion that such person has so constructed or altered his furnace as to consume or burn as far as possible all the smoke arising from such furnace, and has carefully attended to the same, and consumed or burned as far as possible the smoke arising from such furnace. Provided also, that no information or other proceeding for the recovery of any

penalty under this enactment shall be laid or taken except by some officer of the Council duly authorised by the Health Committee in that behalf. Provided also, that the penalty for any such offence committed on the River Mersey may be recovered in the same manner as other penalties imposed by this Act are directed to be recovered, or before any two Justices acting for the Counties Palatine of Lancaster or Chester respectively.

That it shall be lawful for any Justice, upon complaint made to him by the Medical Officer of Health or the Inspector of Nuisances that any smoke, gas or vapour from any chimney is a nuisance to any of the inhabitants of the borough, to issue his summons calling upon the owner of such chimney to appear at a time and place named therein to answer such complaint; and if upon the hearing of such complaint the Justice shall think fit so to do, he may make an order requiring such owner to cause such chimney to be raised, or a funnel or pipe to be placed thereon for conveying away such smoke, gas or vapour, or such other means to be adopted as may seem fitting to such Justice for preventing or mitigating such nuisance, within such time as shall be specified in such order; and any such owner as aforesaid who shall neglect or refuse to obey such order, shall for such offence forfeit and pay a sum not exceeding five pounds, and a further sum not exceeding forty shillings for every day during which such neglect or refusal shall continue.

Whereas doubts have arisen respecting the application of section twenty-four of the Liverpool Sanitary Amendment Act 1854, which doubts it is expedient to remove; it is therefore hereby declared that the provisions of section twenty-four of the said Act of 1854 apply to all steamboats and to the furnaces of all steamboats plying for hire between the port of Liverpool and the Isle of Man.

Supplement No. 4.

Communication received from the Mayor, Sir H. Stephenson, and from the Medical Officer of Health, Sinclair White, Esq., M.D., Sheffield.

Under the provisions in the Public Health Act, 1875, a Smoke Inspector has been at work in this town for some years. His labours have resulted in an appreciable diminution in the amount of preventible smoke emitted; but the condition of the town in this respect is still very unsatisfactory.

There are, in addition to the chimneys carrying off smoke from engine fires, very many converting and other furnaces connected with the manufacture of steel and iron in the town.

These are, rightly or wrongly, held to be without the provisions enacted in Section 91 of the Public Health Act, 1875. The trade of Sheffield apart from these is of such a character as to favour the emission of black smoke. Unlike what is the case in the cotton and woollen producing towns, the amount of boiler power required in most manufactories varies largely from time to time, and a manufacturer must either erect boiler accommodation sufficient for the maximum at much additional cost, or be obliged to overfeed his fires from time to time. Speaking of boiler chimneys only, the factors engaged in producing black smoke are—

1. Too little boiler room.
2. Careless firing on the part of the engine tenter.
3. The use of inferior kinds of coal.

The first is the most important factor here. Mechanical appliances have met with indifferent success, and we rely much more on intelligent and regular firing.

The penalties to which offenders are liable are, in this town, practically a dead letter. Almost all the magistrates are in sympathy with the defaulters, and a compromise is the usual result of legal proceedings. This sympathy on the part of the intelligent public is the great drawback to improvement, and I see little hope of progress until it disappears.

Bearing in mind that the Smoke Inspector has to fight against wealthy and influential defaulters, I am of opinion he ought to be a man of education, possessing the knowledge of an expert, and occupying an independent position.

It is very desirable that some degree of uniformity should be arrived at as to what amount of black smoke constitutes a nuisance. We have here a general understanding that it should not exceed ten minutes per hour per chimney; but as the number of boiler fires going into any one chimney varies, it would be better to make the rule apply to fires rather than to chimneys. I am not without hope that the use of compressed air as a substitute for steam may do away with much smoke.

Supplement No. 5.

Communication from the Medical Officer of Health, Portsmouth, B. H. Mumley, Esq., M.D.

I regret to have to state that up to the present time the sections of the Public Health Act 1875 referring to smoke nuisances have practically been of no effect at Portsmouth.

Notices to abate the nuisances caused by smoke have been frequently served, but no action has followed, although nothing was ever done in consequence of the notices.

The difficulty was in getting evidence to show that the furnaces were not "constructed in such manner as to consume, as far as practicable," all smoke arising therefrom.

This difficulty is now, I am glad to say, overcome, as the borough engineer and myself have seen the mechanical stokers at work at the Lion Brewery in London, and proceedings against several brewers in the town are being commenced.

Supplement No. 6.

Communication from the Chief Constable, Dundee.

In this borough prosecutions are raised in the Police Court under the Smoke Nuisance Act 1857, by virtue of powers contained in the Dundee Police Act of 1882, at the instance of the Chief Constable and Procurator Fiscal. The duty of taking observations of smoke nuisance is performed by the sanitary staff, not less than two of whom are employed in each instance. They are stationed at different points, out of view of each other, for usually two hours; and if black smoke is seen to issue for ten or fifteen minutes consecutively, the case is reported with a view to proceedings being taken.

Supplement No. 7.

Memorandum of test trials for twelve months ending August 12th, 1887, by D. K. Clark, M.Inst.C.E., Testing Engineer to the National Smoke Abatement Institution.

The testing operations of the last twelve months supply clear evidence of (*a*) the direction in which the minds of inventors are engaged: (*b*) the attainment of complete and economical combustion of fuel, with the prevention of smoke in the furnaces of steam boilers. Invention is prosecuted under the double motive of the need for economising fuel, and the growing demand for more stringent legislation and magisterial action.

The objects are arrived at by the old-established principles on which perfect combustion is effected, namely, the maintenance of a high temperature, and the intimate mixture of the combustible gases with the air for combustion.

For giving practical effect to these principles, the air for combustion is in many designs heated before mixing with the gases, and is in some systems forced into mixture by means of a fan or other propeller. According to another system, the fresh fuel is charged underneath the body of the fuel on the grate, in a gradual, continuous manner, from which the combustible gases rise through the incandescent fuel in a highly heated state, and are burned with the air supplied through the grate.

The first in chronological order is Mocrath's furnace. The fire-bars are hollow from end to end, and they are traversed by air which passes into them from the ashpit at the bridge-end, whence the air travels through the bars towards the front, being heated in its course, and is discharged through numerous openings in each side of each bar, passing upwards through the fuel, with the air direct from the ashpit. The flow of air into the bars is promoted by an "air-sucker" or guiding plate at the bridge.

In another system, that of Mr. J. E. Brown, an inverted cast-iron air-box, open at the lower part, is placed upon the fire-grate, at the back, against the bridge, and faced with firetile. From the front face of the box, the air which passes into the box through the fire-grate, is delivered into the furnace through a number of perforations, in order that the streams of air may meet and mingle with the burning gases before they pass over the bridge, and so complete the combustion.

The Thompson system of hollow fire-bar hot-air furnace, has been thoroughly tested, with results which demonstrate the effectiveness of a supply of heated air for the combustion of the gases, properly mixed. Mr. Thompson passes air from the front through a number of hollow fire-bars, in traversing which it is heated, and from which it is discharged at the back of the bridge, where it meets and mixes with the combustible gases from the furnace. The mixture is promoted by means of a second bridge behind the first, with an inverted bridge or baffler placed intermediately. A working economy of from 10 per cent. to 13 per cent. of fuel is effected, under favourable circumstances, by the adoption of Mr. Thompson's combination, in place of the ordinary furnace.

The Ashworth and Kneen system, recently submitted to test trials, likewise demonstrates the effectiveness and economy of a supply of heated air, with high temperatures and intimate mixture. A transverse partition is constructed in the flue behind the bridge, perforated with numerous zigzag passages, through which the draught is subdivided and is driven from side to side, and promptly and effectively mixed. Air heated in the flues is supplied under pressure, or as a forced current, and is delivered into and through the zigzag perforations, thoroughly mixing with and burning the combustible gases. The results of test trials show an economy of 30 per cent. of fuel, under the particular conditions of the trials with a special boiler. It remains to be determined what the practical economy will be in ordinary Lancashire boilers.

The Hopcraft system of revolving grate, with a central under-feed and a forced blast, is at present in course of trial by

the Institution. It is very effective as a smoke preventer, and it promises also to be economical in fuel. Welsh dust, which is difficult fuel, is successfully burned on this grate.

Economy of fuel, it should be kept in view, may be effected in two forms: by reducing the rate of consumption of the same fuel for the same duty, or by the substitution of a cheaper fuel, as the various coal slacks. There the mechanical stokers operate with good effect. With the Vicars' stoker, which has recently been tested by the Institution, a large degree of economy has been effected in the substitution of slack for Welsh coal, whereby the cost for fuel to evaporate 1,000 gallons of water was reduced from 10s. 7¼d. by the ordinary furnace, to 7s. 7½d. by the Stoker, showing 28 per cent. economy.

The recent advances made in the practice of coal burning in steam boilers, above indicated, according to the test trials made by the National Smoke Abatement Institution, are the more remarkable when contrasted with the results of professedly smoke-preventing furnaces tested in connection with the Smoke Abatement Exhibition in 1881-82. These were directed, for the most part, to the prevention of smoke, irrespective of economy, and the only systems in which the prevention of smoke was absolutely complete, Blocksage's and Barber's, depended upon a highly heated reverberatory furnace of fire-brick, enclosing the burning fuel, for completely burning the fuel and preventing smoke. But these were not economical of fuel. They evaporated a mean of 6·65 pounds of cold water per pound of Yorkshire slack; while, in the recent performances of Thompson's and Ashworth's furnaces, a mean of 9·64 pounds of cold water was evaporated per pound of Yorkshire slack. Taking the cost of the slack at 10*s.* per ton delivered, the contrast stands as follows:

Coal consumed per 1000 galls.	1881-82	1886-87
of water evaporated.....	13 cwt. 48 lbs.	9 cwt. 29 lbs.
Cost of fuel per 1000 galls.....	6s. 8d.	4s. 7d.

Here is an apparent economy of 31 per cent. in 1886-87 as against 1881-82, combined with complete combustion.

The result of the year's testing has been to show that further improvement has taken place, both in the furnaces designed to substitute mechanical stoking for hand-stoking, and in those wherein ordinary hand-firing is employed.

[*For discussion on this paper see page* 335.]

On "Smoke Abatement," by Orland D. Orvis, Chicago, U. S. A.

Mr. President, Members, and Gentlemen,

One of the greatest blessings which nature can confer upon mankind is good health. Every thing which can affect this priceless boon is of the most vital importance. How necessary then that we look carefully to the purity of the air we breathe, to the great supporter of life, *oxygen*, which we constantly inhale into our lungs. Air is a more indispensable agent than water or food. We cannot exist many moments without air. Water can be purified by boiling, by filtering, and by chemicals. But it would be practically impossible to effect a thorough filtration of the air before we inhale it.

The average composition of atmospheric air, according to Regnault, Bunsen, Dalton, and others, is in volumes:—

Oxygen	20·96
Nitrogen	79·00
Carbonic acid	0·04
	100·00

The purity of the air is more or less affected by other substances, such as the products of combustion of coal, vapour of water, ozone, ammonia, organic and inorganic dust, and the decomposition of organic matter.

One of the chief reasons why the atmosphere of cities is not so pure and healthful as it is found to be in the country, is because the enormous volume of coal-gas and smoke emitted from thousands of chimneys in large cities pollutes the air with noxious vapours destructive alike to animal and vegetable life.

From the vast forests of chimneys in all the great manufacturing towns in England, there arises a dense exhalation of inky blackness, which envelopes these cities in a pall of gloom from Monday morning until Saturday night. It is only on the Sabbath that we are permitted to catch a glimpse of clear blue sky, and breathe the pure air, so essential to health and comfort.

The sooty vapour finds its way to our food and drink, it is inhaled into the lungs, impairs the health, stains and discolours the walls of public and private buildings, soils the face and clothing, penetrates houses, smears carpets and furniture, almost destroys oil paintings, soils books and engravings and whatever precious objects of art or utility we try to preserve. Indeed it is difficult to say in what particular we are not harmed by the all-persuasive soot and smoke. However much opinions may have differed, there is little doubt now that the cause of the London fogs can be traced to the smoke. The infinitesimal particles of water-vapour floating in the atmosphere, become coated with the volatile products of combustion—the sooty particles of carbon which float in the hydrogen,—and these countless myriads of molecules or atoms, impervious to the sun's rays, envelope the great Metropolis in impenetrable gloom.

The highest medical authorities attest the injurious effects on the respiratory organs, and on the body generally, from living in a smoke-laden atmosphere. The fatal consequences of the fogs to which London and other great towns are periodically subjected are shown by a marked increase, on these occasions in the Registrar General's returns of mortality.

The prevention of smoke is the great want of the age.

In this era of invention and progress, when the fertile brain of the scientist and the inventive genius of the skilled mechanic are achieving such marvels of invention, it is almost a wonder that the great problem of abating the "smoke nuisance" of large cities should have remained so long unsolved. The secret art of burning bituminous coal without allowing a large part of its carbon to escape in a cloud of smoke, seems to have baffled the wits of inventors during the past 200 years. The alchemists, in 1685, tried various devices for the purpose of consuming the smoke in their furnaces. In 1785, Watt patented an apparatus for consuming smoke. His process consisted in feeding the coal in a hopper, and forcing the gas and smoke to pass through a body of hot coal.

As far back as 1306, the smoke of burning sea coal was considered to be so injurious to public health, that King Edward I. issued an order forbidding its use. It is alleged that one man who disregarded the King's order, was tried, convicted and executed for burning sea coal in London.

Much might be said relative to the history of the various fuels used by civilized man during the past few hundreds of years. It is a curious history, the progress from wood to coke, and from coke to coal. Wood and coke are now little used for steaming purposes in this country, and King Coal is the present ruling monarch on the throne of fuels. Anthracite is the most condensed form of mineral coal, and the richest in carbon. All

coals, including naphtha, petroleum, asphaltum, &c., are but representatives of the change from vegetable to mineral matters.

Anthracite is the condensed coke of bituminous coal. American anthracite possesses from 85 to 92 per cent. carbon, and 2½ to 4½ hydrogen. South Wales and Russian anthracite have been found to possess as high as 95 per cent. carbon. Bituminous coal possesses about 80 per cent. carbon and 5 hydrogen, and from 10 to 50 per cent. bitumen, from which smoke is produced.

Concerning the origin of coal, its connection with the vegetable kingdom is too distinctly traced to admit of any reasonable doubt that this fuel once formed parts of growing plants, requiring in its geological transformation many thousands of years. The coal, then, which we see burnt in our furnaces to-day liberates the heat and light of the sun's rays which have been stored in the coal through countless ages.

The total amount of coal consumed annually in the United States now exceeds 100,000,000 tons. The annual consumption of coal in Great Britain is now not far from 150,000,000 tons. The entire annual product of the world is estimated at 300,000,000 tons.

Should the coal supply ever become exhausted, Nature, in her bounteous wisdom, has provided us with a still better fuel, viz., *Petroleum*, which is now quite extensively used as fuel in the United States and in Russia. Liquid fuel, however, would prove to be rather an expensive luxury in England at the present low price of coal.

Some of our ablest scientists maintain that the area of the subterranean seas of petroleum is even greater than that of the coal beds of the world, and that petroleum distillation in Nature's vast laboratory is still going on as rapidly as ever.

It is only by the light of modern science that we are enabled to explain the meaning of the heat given off in the act of chemical combustion. Fifty years ago we possessed no knowledge of chemical dynamics.

Combustion consists in the oxygen of the air uniting (forming a chemical union) with the constituents of the combustible substance.

The chemical combination of atmospheric oxygen with the carbon of coal is always accompanied by the production of more or less heat, but it is only when the action is so rapid as to evolve intense heat, accompanied by light that the process is called burning or combustion. A few substances burn at ordinary temperature, such as phosphorous, which glows when exposed to the air. While the absolute amount of heat evolved during the combustion of any burning body is the same, yet the

sensible heat may vary according to the rapidity of the process. Thus, when phosphorous is exposed to the air at ordinary temperature it very slowly combines with oxygen, and gives out little heat at any one moment, but it is diffused over a great length of time, while if the phosphorous is set fire to in the air, it burns vividly, and gives out much heat and light for a short time, and still further, if the burning phosphorous be placed in pure oxygen, it enters into most vivid combustion, and evolves a most intense heat and brilliant light for a still shorter time. The same remarks apply to the coal consumed in a furnace. So long as the furnace-door is left open, and there is little draft of air through the fuel, a moderate amount of heat is evolved, which may last for several hours; but when the door is shut, and much air is drawn through the coal, the latter is more quickly burned, and more heat is evolved during a shorter period of time than before, but in the long-run there is the same amount of heat evolved.

A fresh charge of coal thrown upon a fire absorbs heat which liberates the gas from which flame is produced. This gas is composed of hydrogen and carbon—carburetted hydrogen. Coal gas will ignite only as it combines with the oxygen of air. The hydrogen then separates itself from its fellow-constituent, carbon, and unites with atmospheric oxygen producing steam. Carbonic acid is the result of perfect combustion, and is a compound of one atom of carbon with two atoms of oxygen. Carbonic oxide is composed of one atom of carbon and one atom of oxygen, only half of the required amount of oxygen to produce perfect combustion. The air in passing through the grate bars, gives out its oxygen to the incandescent carbon, producing intense heat, in the formation of carbonic acid. This acid passing upwards through the body of unconsumed coal, absorbs an additional portion of carbon and becomes carbonic oxide. This carbonic oxide, of which smoke is the visible part, inflames at a lower temperature than ordinary coal gas, and is often ignited at the top of the chimney, on meeting the air, as seen in the chimneys of blast furnaces, and steam vessels.

It requires, chemically, the oxygen of 152 cubic ft. of air to consume one pound of coal. The gas requires 45 and the coke 107 cubic ft. A furnace charged with fresh coal, generates a large volume of gas (about four cubic ft. to each pound of coal), requiring an equivalent quantity of pure air for its combustion. Now, by reason of the mass of fresh fuel thrown in, the passage of air through it is necessarily the most restricted. Thus the smallest quantity of air will be enabled to gain admission simultaneously with the greatest demand for it, and the largest generation of gas simultaneously with the most restricted means

of enabling the air to obtain access. And hence the absolute necessity of providing some other means of introducing air to the unconsumed gas, *above the fire.*

Coal in process of combustion yields volatile hydrocarbons equal to about one-third of its weight, which have to be burned in the open space above the fuel, or, for want of air, escape unconsumed. It is plainly necessary, therefore, that the required amount of oxygen to complete combustion should be supplied *above* the surface of the burning fuel.

Some writers of note on combustion, and many scientific men, still hold that smoke, after it is once formed, cannot be burned. I am frequently told that the term "smoke consumer" is a misnomer. C. Wye Williams, the great English apostle of combustion, has benefitted the world by writing a book. All ambitious writers of books do not benefit mankind. Mr. Williams says:—"When smoke is once produced in a furnace or flue, it is as impossible to burn it, or convert it into heating purposes, as it would be to convert the smoke issuing from the flame of a candle to the purposes of heat or light." Mr. Williams undoubtedly wrote in advance of his time, and yet modern science has placed him far behind the advanced column of progress, and rendered some of his theories obsolete.

The visible part of smoke is composed of floating particles of detached carbon, and the invisible part is rich in coal gas and carbonic oxide, all of which is, of course, easily ignited and burned.

An interesting experiment in proof of the correctness of the above assertion may be made with a common tallow candle by extinguishing the flame, and then, with a lighted wax match or taper, the smoke can be *ignited* and *burned* several inches away from the wick, the blaze at once relighting the candle; thus conclusively proving that smoke is combustible matter, and can be burned after it is formed.

A steam boiler furnace in action is analogous to animal life, inasmuch as both require carbonaceous food and atmospheric air to support life, and each emit a product of carbonic acid gas.

The books say that the ordinary steam-boiler converts 8 to 10 per cent. of the energy of the fuel into steam, and the *very best* boilers convert 12 to 14 per cent. But the human stomach of a healthy young man realises from 60 to 67 per cent. of the food's energy, and converts it into heat and work. Steam of say three or four atmospheric pressure contains about 1,000 to to 1,100 units of heat, three-quarters of it "latent," so called. In passing this steam through the cylinders in work, the temperature is only reduced 200 to 300 degrees, according to

the expansion. Hence, speaking roundly, three-quarters of the energy, or steam-heat, escapes up the exhaust-pipe without having done any work, so that we only realise 3 to $3\frac{1}{2}$ per cent. of the energy or power of the coal in the steam-engine in the form of work, but in the stomach of a man about two-thirds of the power of the carbon consumed as food can be converted into effort or work.

Thus are we reminded of the superiority of nature over the inventions of man. This has been truly called the age of invention. One of the grandest roles in the great drama of human progress has been filled by invention. Invention and civilisation have come up out of the ages hand-in-hand. Fancy for a single moment what this world would be if deprived of the inventions of the Stephensons, the Morses, the Fultons, and others of their kind. But it should be borne in mind that the solution of the great problem of abating the smoke-nuisance has many difficulties to overcome. It is not sufficient simply to consume the smoke. There are several other important points required. The perfect smoke-consumer must possess the merit of combining all of the following cardinal virtues: (1) Burn smoke; (2) Save fuel; (3) Make steam; (4) Be durable; (5) Not injure the boiler. If the apparatus fails in a single point, although it possesses all the others, it is condemned.

Some of the methods which have been tried for the purpose of preventing smoke are:—

1. A small steam-pipe is run from the dome down the front of the furnace, and a blast of steam is injected into the furnace over the fire. This plan entails a loss of fuel, for the reason that the extra heat produced will not generate an equivalent amount of steam used in creating the blast.

2. The addition of atmospheric air with steam by the *induction* principle is no improvement on the process.

3. Directing this oxyhydrogen current under the grate bars is a mistaken theory, unsupported by either chemistry or good practice.

4. The various bridge-wall contrivances for admitting air, or air and steam, only partially prevent smoke, and are liable to injure the boiler-sheet by the volcanic action produced in concentrating the heat. Any principle is defective which allows imperfect combustion to take place at all and then tries to correct it afterwards.

5. The idea of a steam-jet in the chimney to increase the draft sufficiently to consume smoke on stationary boilers, is too unscientific and wasteful to merit further comment.

6. Brick arches are good enough in their way, but they are not very effective in consuming smoke, unless aided by a

combination with some contrivance for assisting the draught, such as the steam-jet, or under-blast.

7. Efforts have been made to precipitate the soot and smoke by a wheel, or a shower of water falling through a perforated diaphragm placed in the chimney. In this process of smoke-washing, or smoke-condensing, the principle is wrong, the evil should be prevented in the furnace, and then no "shower-bath" will be required.

There has been nothing new patented in steam-jets for upwards of a hundred years, according to the sixty-page report of M. Armangeau of Paris, excepting the principle of the "air vacuum." This principle consists in arranging a steam-jet within a closed globe in such a manner as to make the velocity of the air, just as it comes in contact with the steam, as nearly as possible equal to that of the steam. It was a knowledge of principles which led to this conclusion, and the reason is the same as that for causing the velocity of corn when it falls upon a carrying-band to be equal to that of the band. The corn would have been left behind if it had not this velocity, and so also the air would be left behind by the carrying steam, and would be whirled into eddies with a loss of force, if it had not sufficient velocity at the point of contact with the steam. All steam-jet appliances on the old "induction" plan use a much greater quantity of steam than is required by the "vacuum" principle to force a given quantity of air into a furnace. The inventor has been awarded eleven gold and silver medals, and several diplomas and decorations for this discovery.

It is well known that oxygen, or atmospheric air in rapid form, produces combustion, and in slow form oxidation. Heat is evolved by the clashing of atoms. To consume smoke in a furnace, therefore, it becomes necessary to supply the air in rapid form. The steam-jet is the most simple, practical, economical, and effective means known for accomplishing this result.

The oxyhydrogen currents should be injected at the front end of the furnace on a horizontal plane, in converging lines, a little above the burning fuel, in order that they may travel with the natural draft of the furnace, and where the temperature is at least 830° F.

The most economical results will be obtained by using a mixture of superheated steam, hot air, and carbonic oxide.

I am often asked how these oxyhydrogen currents can produce extra heat in a furnace without burning more coal. The principle of the jeweller's lamp and the blow pipe, fully answers this question.

The *rationale* of this principle is to supply the furnace with just enough oxygen of the air, hydrogen of steam, and carbonic oxide, to unite with the volatile hydrocarbons and other rising products of combustion given off in the distillation of coal, and form a mixture of carburetted and olefiant gas, which readily ignites at a temperature of about 800° F., and burns with a bright clear flame, creating perfect combustion, and no smoke. These remarkable results are produced from the chemical affinities of carbon, oxygen, and hydrogen respectively.

The principle of the air vacuum has been amply demonstrated on the boilers of the Paris Water Works, and is now largely in use both in France and America. In London, also, several chimneys have been rendered smokeless by the adoption of this simple remedy. Some of the enterprising citizens of Bolton, not to be behind the times, have already tested the efficacy of this improved system of fuel economy and smoke prevention on their own boilers, and we may soon expect to see this beautiful city free from smoke, her worthy citizens enjoying the luxury of pure fresh air at home, and thereby enabling the ladies to cultivate beautiful flowers and healthful rosy cheeks at the same time. Then will the fame of this fair city become a household word in the land for having set an example so worthy the emulation of all smoke-laden towns in England.

[*This discussion applies to the three preceding papers by* Mr. Herbert Fletcher, Mr. D. J. Russell Duncan, *and* Mr. Orland D. Orvis.]

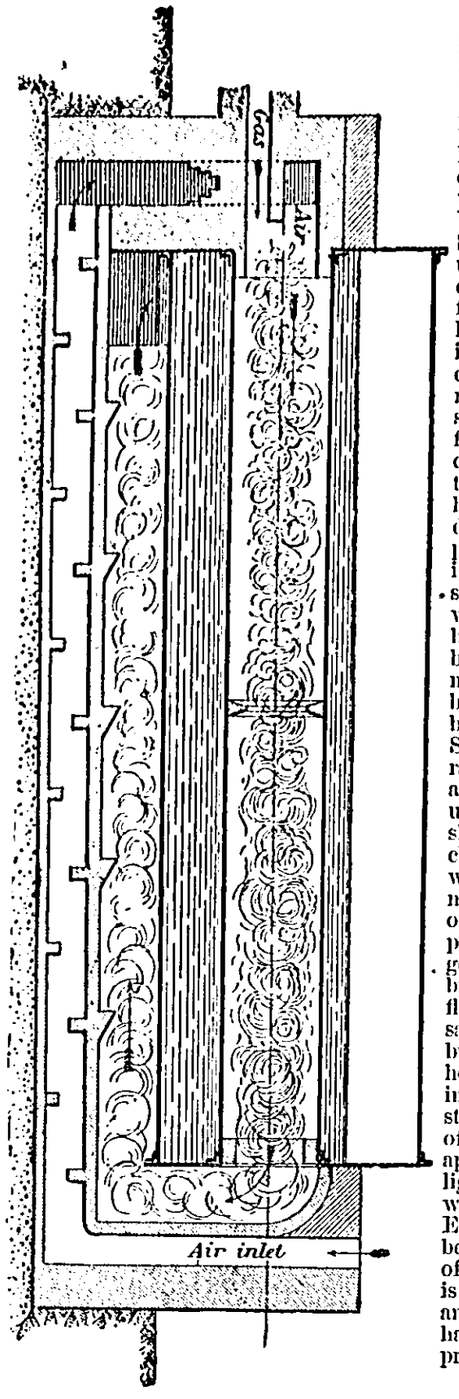
Mr. R. K. Freeman, F.R.I.B.A. (Bolton), who took the chair in the absence of the President, remarked that they had had the question brought before them in all its bearings. It was one of the utmost importance to them in Bolton, because although they did not like, in consequence of depression in trade, to see chimneys not smoking, they would be glad if they could be in full work, but without turning out the volumes of smoke they did at present.

Mr. W. R. E. Coles (London), called on by the Chairman to open the discussion, said that as the subject was a large one, and papers were only read at such a late hour as to allow but barely ten minutes for the whole discussion, he would not attempt to consider them in detail. He would only say he did not think the author of the first paper was right in speaking so lightly of domestic smoke, the quantity of which was undoubtedly very considerable in the aggregate. The action of the legislature against smoke had been directed, as the meeting knew, to industrial processes only. This was obviously not

quite fair, and anything which was not fair did not generally work out to a successful issue. Where the law was thus defective the administration of it was likely to be defective also. There was a natural objection to enforce the law fully against one class of offenders when another class was permitted to go free. He thought the question of domestic smoke was to be considered from that point of view as well as from the standpoint of its quantity. Mr. Duncan's reference to Lord Stratheden and Campbell's Bill, which he said had been for the fourth time before the House of Lords, was well worthy of notice. The chief aim of that Bill was to deal with smoke from all its sources, domestic chimneys as well as industrial. And, in regard to the former, it proposed to do what seemed to be a wise thing, viz., to discriminate between new buildings to be erected and the already existing ones. In regard to new buildings it proposed that the regulations should be so framed as to bring the heating arrangements of the houses of the future under some supervision and control, analogous to that already exercised under various building Acts and bye-laws, with the object of securing the efficiency of other branches of house construction and equipment; while in regard to existing domestic chimneys, it proposed that the local authority should be invested with power to make such bye-laws as were considered judicious, and it seemed to him that that was a good provision because the local authorities were duly conversant with what was going on; they knew what could and what could not be done in their own houses, and moreover they were not likely to act in advance of general public opinion. In speaking of new buildings it was very important to remember what was the actual rate of building. He had looked into that matter three or four years ago, and found that in London the rate of building amounted to *three new houses an hour* from the 1st January to 31st December. Since that calculation was made, however, the rate of increase had been somewhat reduced, but he found it still amounted to one and a half new houses per hour for every hour of the year. With regard to the question of patents taken out for so-called smoke preventers, he thought Mr. Duncan's remarks were worthy of consideration, for a great deal of smoke was produced by reliance upon patents, which might be avoided if only the existing arrangements were properly used.

Mr. JOHN HEAD, F.G.S.* (London), said that had his occupations permitted of his doing so, he would have prepared a paper upon Gas-Fired Boilers to be read at the present meeting—in the form of an address; however, he would lay some facts before the meeting which would help those interested in the question of the best method of firing boilers, to consider the subject from a different point of view to that which had been so ably brought before them by the authors of the papers whose practice was limited, however, to boilers fired with solid fuel. Members, or at any rate, some of them, had certainly heard of the Siemens Regenerative Gas Furnace. The Siemens Furnace had been employed in the manufacture of iron, steel, glass, &c., for more than a quarter of a century. In the first instance, and indeed, until quite recently, the flame was utilized in the Regenerative Gas Furnace in

* Communication received by the Secretary in continuation of the discussion on the papers.



the same manner as in furnaces fired with solid fuel, that is, it was brought into contact, as much as possible, with the materials under treatment. For the last two or three years Mr. Frederick Siemens, who, conjointly with his brother, the late Sir William Siemens, invented the Siemens Furnace, had worked upon different lines, and, indeed, had made a new departure from the beaten track, whence had resulted great improvement in the efficiency, economy, and durability of the Siemens Furnace. Mr. Siemens, when considering the action of gaseous flame in a furnace heated by contact, came to the conclusion that the flame was misapplied; he found that combustion was disturbed, and the flame was partly wasted by being brought into contact with any solid substance whatever, and that this was particularly the case with boilers, the plates of which, being in contact with water, must necessarily and constantly be at a temperature considerably below that of the flame. Mr. Siemens inferred, from consideration given to the subject, that a gaseous flame, in order to be utilized to the best advantage, should burn freely in an enclosed space without contact with the materials under treatment or surrounding objects, in other words, that it should be placed under conditions analogous to those which apply to gas burners. If we consider a gas flame used for artificial lighting, say an Argand or a flat flame burner, we shall at once realize how undesirable it would be to introduce therein any solid substance; the result would be loss of effect, which would become apparent by diminution in the light and heat obtained, coupled with the production of smoke. Expressed in this manner it becomes evident that contact of flame with solid substances is detrimental to combustion, and where heating by radiation has been adopted, the result of practice in high temperature

furnaces, such as used for the production of steel on the open hearth, for heating iron and steel, for the manufacture of glass and other purposes, has been a saving of from 30 to 40 per cent. in weight of fuel, improvement in the quality of the product, and diminished wear and tear of furnaces. With these encouraging results before him, Mr. Siemens considered the application of his new method of heating to the firing of boilers. This application is shown in the accompanying diagram, which, however, does not exactly represent a gas-fired boiler as constructed, being only intended to show the means adopted for preventing contact of flame with the plates in the flame flue. The gas producer, which is not shown, may be located in any convenient place near to the boiler to which it has to supply gas, and is of the Siemens usual well-known construction. Gas coming from the gas producer to the boiler passes through a regulating valve, and thence onwards to the combustion flue of the boiler, where it meets with a current of heated air, and entering into combustion therewith, the flame circulates first through the combustion flue, as shown, afterwards around the boiler at the sides, and finally underneath on its way to the chimney. The boiler is set in brickwork in much the same manner as for firing with solid fuel, the chief difference consisting in the provision of a double series of channels underneath, through some of which, as indicated by arrows, the products of combustion pass away to the chimney, while the inflowing air to the boiler passes through adjoining channels. By this means the products of combustion leaving the boiler are completely deprived of most of their sensible heat, the action being so perfect that at large works where these improved gas-fired boilers are used exclusively, the temperature in the main chimney-flue, at a short distance from the boilers, has been found to be much below the point of boiling water. As shown in the diagram, inside the combustion flue of the boiler are placed fire-clay rings, the object of which is to prevent contact of the flame with the plates of the boiler. A ring at each end of the combustion flue will suffice in short boilers, but where the length of flame flue exceeds, say, ten or twelve feet, as is almost always the case with boilers in this country, additional rings are provided at intervals. The flame flue should be clear from end to end as cross tubes would interfere with proper combustion, and it is preferred to have boilers, such as Cornish boilers, with only one large flame flue, although at some works boilers with two flame flues are used. The character and quality of the flame is subject to complete control by means of the gas regulating damper already referred to, the air regulating dampers, and the chimney damper also provided. By means of these dampers the temperature of the flame may be increased or diminished at will, or, in other words, the production of steam may be augmented or reduced at pleasure, and in either case without the production of smoke. In the papers which have been read, it was said that it was possible to avoid the production of smoke in boilers fired with solid fuel, provided that they are not pushed for the production of steam, which implies that the fires shall be kept thin and supplied with an excess of air, as otherwise smoke cannot be avoided. But in the case of boilers fired with gas and heated by radiation, no smoke need be made under any conditions of working, that is—whether a large or small quantity of steam be required at any time; in fact, the presence of smoke would reduce the temperature of the flame and cause a diminution in the production of steam, so that the man in charge of such boilers will find it convenient, and to his own interest, to avoid the production of smoke. Where a range of boilers is fired by gas, it is preferable to place them under a foreman who understands how to regulate the production of steam by regulating the supply of combustible gases to the boilers, and who can keep the men attending to the gas producers up to their work. Under such conditions boilers at work give regularly an evaporative power of from 9 to 10 lbs. of water per lb. of coal burnt in the gas producers. These results compare favourably with the best solid fuel-fired boilers; but better results having been obtained under certain circumstances in later applications, it is confidently expected that an evaporative power of from 11 to 12 lbs. of water per lb. of coal will

be obtained as a constant result. Where small fuel is available it can be used in the gas producers for the production of the gas required for firing boilers, and the saving thus effected, added to that in weight of fuel, will in many cases produce an economy of from 40 to 50 per cent. in the firing of boilers upon the present practice with solid fuel; this result will be obtained with less attention or hard work in firing, and will be attended with greater durability of boilers, and last though not least, with total absence of smoke.

Colonel WINDER (Bolton), drew attention to a paragraph in Mr. Duncan's paper which said, "The Acts in force have frequently been rendered inoperative, as administrators of the law are in many cases large producers of smoke themselves." He contended that there was no unanimity as to the kind of machinery or appliance that ought to be used for the successful consumption of smoke, and yet the magistrates were to be called upon to fine, to the heaviest extent, any gentlemen who would not submit to use the contrivance of every person who came forward and said he had the true remedy with regard to the consumption of smoke. He had sat in that Court many years, and had always found when the defendant appealed to the witnesses what was the article the witness wished him to use, he had never yet been able to authoritatively say, "I recommend this as the only article that ought to be used for the consumption of smoke." Nevertheless, Inspectors of Nuisances and Corporations must not lose heart with regard to this matter, nor be slack in enforcing the Act of Parliament, but they must keep close up to the requirements of the times, and see that if there were a machine or an appliance that could be adapted to this purpose they should require the public to immediately put it into use. He could think of nothing better than that the Government itself should use its greatest exertions to find out the most appropriate article, and see that it was duly provided for the public.

Mr. FRED. SCOTT (Manchester) said the last speaker had aptly illustrated the fruitlessness of much of the effort to abate this nuisance. If people like magistrates would not take the trouble to read the literature on the subject, and take such other means as were provided by organisations and individuals of ascertaining what is practicable in the way of smoke prevention, it was almost hopeless to induce town councillors to do so. The magistrates ought to inquire if the persons brought before them for offences against the law relating to smoke had in use such appliances as were known to be effective in preventing smoke. The Manchester Society, organised to remedy this nuisance, had done the best it could during the last ten years to secure its abatement. They were often charged, however, with trying to do things which would injure trade, but they sought to do nothing of the kind; their efforts were to a large extent fruitless, because, as had been pointed out in many cases, the administrators of the law were the greatest offenders. They had gone to the Local Government Board and the Local Authorities, and had done everything possible, yet the nuisance was still allowed to prevail

very extensively. He could not help thinking that perhaps they were on the wrong tack, and that what was wanted was "stronger municipal life." They must send men into councils who would take a broad view of the question; that by compelling manufacturers and other smoke-producers to adopt effective methods of smoke-prevention, they caused no hardship in the long run to the individual, whilst they conferred a great boon upon the community.

Mr. GEORGE S. HOWATSON* (London) pointed out that the most efficient system of smoke-preventing machinery in the market could be had at about the same cost as any mechanical stoker. Mr. Fletcher remarks that "many mechanical stokers are not smoke preventers at all," and in making this statement Mr. Fletcher has, in my opinion, struck the key-note to the solution of the whole question under discussion, because many steam users, mill managers, and engineers have got the idea that any appliance to which the name "mechanical stoker" has been given must necessarily be a smoke-preventer. This idea is altogether erroneous. It will generally be admitted that a man under any circumstances cannot fire a steam boiler with small bituminous coal or slack day after day without making smoke. Not only will smoke escape when each shovelful of slack is scattered over the fire, but it will also escape during the necessary operation of "stirring up" and of "clinkering" the fire. In exactly the same way many appliances to which the name "mechanical stoker" is given, produce smoke continuously, and dense black smoke during the necessary operation of "levelling" the fire. These "mechanical stokers" are of the "throwing-on" type, and although they frequently succeed in throwing-on and scattering the small coal better than a man does, they generally cause much of the dust fuel to be carried by the draught right over the fire, through the flues, and out at the chimney-top in a partially-consumed state. In London where a special Smoke Abatement Act is enforced in the interests of the community at large, steam-boiler owners find it practically impossible to use these "throwing-on" stokers (whether man or machine) and small cheap bituminous fuel without subjecting themselves continually to police interference and Scotland Yard prosecution. The other system of firing steam-boilers referred to by Mr. Fletcher, and adopted by him at his collieries, is on the principle advocated by James Watt about a century ago, and it has been adopted by many of the principal steam-users in London, proving that it is a complete and practical smoke-preventer and a most effectual and economical system of firing steam boilers, kilns, &c., with the smallest and cheapest bituminous fuels. At the Smoke Abatement Exhibition of 1881-2 Messrs. T. & T. Vicars, of Liverpool, Earlestown, and London, exhibited a mechanical smoke-preventing appliance, which received the highest award; since then, this smoke-preventing stoker and furnace on the Watt principle has been adopted by Her Majesty's Government at the Royal Mint, and many of the principal firms in the City of London and throughout the country have now adopted it, enabling them to use a small cheap bituminous fuel without making smoke, smuts, or creating any nuisance whatever. Steam is easily raised and kept up at an even pressure without manipulating the fires in any way by hand.

Mr. NICHOLSON declared that Mr. Fletcher was good enough to hit upon one of the principal sources of trouble in the matter. There appeared to be no real desire in any place to get rid of smoke because it was thought to be expensive; many were heartily sick of so many appliances, some of which were found out to be perfectly useless when tried, though he believed there was an honest disposition in favour of getting rid of the smoke if they could. The right way he thought was for the Association in conjunction with the Smoke Abatement Societies of London and elsewhere, to take steps and find out four, five, or six of the best means to get rid of smoke, and take upon themselves to recommend those they found most suitable. Without something of this kind very little good would be done. In concluding, the speaker observed that it must be very disheartening to gentlemen who had to deal with this subject and to bring people up for making smoke, to see the miserable sums which people were fined: real penalties and not nominal ones should be imposed.

* Communication received by the Secretary in continuation of the discussion on the papers.

Mr. G. DARLEY (Leeds) said there were a number of energetic men in Lancashire and Yorkshire with sufficient means to form themselves into a sort of council and test the best known appliances side by side on the boilers at the Manchester exhibition; this experiment would be far better than taking a single man's word. In Leeds they had every known make of mechanical stokers, and although they came with great faith many of them got into disgrace. He knew for a fact that there was a firm in their town that adopted mechanical stokers to eleven boilers, their consumption being about sixty-five tons per working day; and they were saving £1,500 a year for the expenditure of £650; fuel was reduced in quality at the rate of two shillings per ton. The saving he referred to was very good, but it was only one in a multitude of cases. The firm he alluded to consumed their smoke, but not so well as Mr. Fletcher did: he must give that gentleman credit for his system because he had seen nothing to equal it. The London waterworks boilers had Vickars' stokers adapted to them, and they did their work admirably. He should like the course recommended to be adopted, viz., that Bolton, Manchester, Leeds, and other northern towns, should combine and form one council to work the matter fairly and test the machines on their merits, be they Vickars, Bennis, Proctor, Hutchinson, or any other.

Mr. LEACH (Eccles) said it appeared to him to be the proper duty of the Congress to investigate this question, as by so acting it would be doing a most important work for all manufacturing districts in the kingdom. He suggested that a test might take place in Bolton, and would also like to move a resolution that a committee of the Congress be appointed to make an investigation in London with the view of recommending such appliances as were found to be most suitable.

Mr. FREEMAN (Bolton) said he did not know whether this latter proposal was within the scope of the meeting.

Mr. LEE said the test should be made by practical men. They had no wish to disparage scientific men, but it was a fact that practical

men occasionally looked into practical matters in a way which perhaps men who were not accustomed to them every day did not.

Mr. W. Wilkinson (Bury) thought it would be much better if the appliances could be sent to Bolton and practically tested there in the centre of the smoke-producing locality; this would give more satisfaction than referring the thing to London.

Mr. F. Scott (Manchester) thought the idea of initiating an enquiry into the means of smoke prevention a good one, and hoped the Council of the Institute would take it up. He had much pleasure in seconding the motion.

Mr. Leach (Eccles) having been granted permission, proposed the following resolution: "That the Council of the Sanitary Institute be requested to institute an examination into the best methods of consuming smoke and to issue the result of their enquiries." The resolution was seconded and adopted.

Mr. H. Fletcher (Bolton) in replying, said the difficulty most frequently alleged to exist was that of an insufficient number of boilers. He thought no one who erected more machinery than his boilers would drive should be allowed to create a public nuisance, on the plea that compliance with the Public Health Act might possibly affect the profits of his trade. With regard to domestic smoke, he said he did not under-rate it; his paper only referred to manufacturing smoke. He believed it presented a great difficulty. The use of coke he understood was the only remedy for it consistent with retaining the open fire. Saturday afternoons and Sundays shewed what might be attained in improving the atmosphere by the suppression of the tall chimney smoke. Vegetation could exist in such smoke as was then seen. Referring to the remark of the Clerk to the Borough Magistrates, that they could not convict while experts differed as to the best appliances, he said, he understood it was their duty to fine unless it could be proved that the nuisance was not preventible having regard to the nature of the manufacture. All that was necessary to prove was the practicability of obeying the law. If steam could be raised without smoke, in one place, it could in another. The best question to ask a smoke preventive machine maker was, have you one in operation within the area embraced by the Metropolitan Smoke Act? If he had, they might assume the apparatus to be a pretty good one. Mr. Darley made an excellent suggestion in submitting that the Galloways boilers at the Manchester Exhibition should be used for so good a national purpose as ascertaining the merits of smoke preventing contrivances. The firing of those ten boilers resulted in the emission of a cloud of smoke that was a disgrace to an engineering country, let alone an exhibition of the best that Manchester and its neighbourhood could do. An opportunity had been lost that might never recur.

Mr. D. J. Russell Duncan (London) said one gentleman appeared to be under the impression that a magistrate should act as a consulting engineer, and advise the people who came before him. With regard to magistrates being offenders, he could mention one place in Scotland where magistrates were very heavy offenders indeed, and where there was no law for smoke abatement.

Mr. Freeman (Bolton) remarked that they could not say the question had been left where they found it, because an important recommendation had been forwarded to the Council of the Institute. It was a matter of regret that they had been unavoidably hurried, but he trusted the subject would have greater attention devoted to it in the future than hitherto. Mr. Fletcher, he might remark, had shown publicly what he had been able to do himself, and there was no doubt many other people would strive with him to remedy as far as possible what was one of the great curses of a manufacturing district. In conclusion, he hoped that that Conference, and the views expressed, would impress themselves very forcibly upon the public generally, and result in some good being done in Bolton.

On "Sanitary Sewage and Water Supply," by Edwin Chadwick, C.B.

I beg to submit some statements of experiences at variance with statements that have been made to the Congress on sewage irrigation. In the first place, no perception is evinced in them of the great distinction for sanitation of sewage which is undecomposed, and the sewage of the common conditions of putrefaction; of sewage which feeds fish, and of sewage which kills them; of sewage which, for agricultural purposes, is wasted by putrefaction, and of sewage which is unwasted by decomposition, which has generally about a third more of power for agricultural production. Nor do they recognise the power of the production of fresh sewage as a means of removing the popular objections to sewage farms near towns with sewage that is putrefied, the results of bad drainage and of internal stagnation; nor that with sewage which is fresh there is a reduction of the evils that arise from the common high culture with solid manure; as that of the market garden—the culture of marachere—by top dressings with the solid dressings with decomposing manures. The great principle, laid down by De Condalle, the greatest known vegetable physiologist of the last century, verified in

practical examples, and cited in our instructions, "that the future of agriculture would be in the distribution of food and water together at the same time," is neglected. The proofs are overlooked of the verifications that have appeared in various examples—that whilst the yield of ordinary agriculture is as one, that of the extraordinary agriculture, the marachere, or market garden culture, is as three and a half—the yield from the liquefied culture is as five and more. Thus at Croydon, on the fields irrigated with fresh manure, five cows are reared where only one was formerly. An adjacent well-conducted example gives a sixfold yield from the fresh liquefied manure culture.

It is extensively put about against the direct application of fresh sewerage to agricultural production that, as a rule, the utilisation of human excreta, either *per se* or in the form of sewage, is generally attended with very considerable loss, and that only in a very few cases has it been attended with a profit. Such statements denote very imperfect examinations, which would display the extraneous causes of loss from the application of the cheapest means of working. However, Professor Corfield, in his work on the utilisation of sewage, gives a table of the application of the sewage of sixteen towns, and states that, judging from the results of one year, after the repayment of capital for outlay in works connected with the sewage farms, in eleven farms out of the sixteen there is a profit to the ratepayers. That, as respects London, there should be any profit under the combined system adopted by the Vestries, would be a matter of surprise, when it is considered that of the water distributed full three-fifths is distributed in pernicious waste in the production of excrement-sodden subsoils; and as to the water-closets, two and three gallons are used where little more than half a gallon would suffice, altogether producing an extent of dilution that must render it worth little more than a fourth of its value under the separate system. At the time of our examination of the water supply of the Metropolis in 1850, it was found that by the service of large Cornish engines of ninety horse-power, upwards of seventy thousand gallons was raised one hundred feet high for a working expense of one shilling. With the improvement recently made in steam-engines, it will be possible to raise nearly double that amount for one shilling. And why could not sewage be distributed at a like charge by the like power? As to the profits of sewage farming, tenants are not in the habit of considering that they are obliged to disclose them; indeed, they generally be-little them for the apprehended increase of their landlords' unearned increments. In the case of the tenant for the farm of the sewage for Aldershot, he gave it up, and it was inferred at once and declared that he gave it up because it would not pay; he gave it up on account of a severe illness and a succession to a large estate which required his immediate attention. He thought himself at liberty to show me from his accounts that, under extreme difficulties, from an inferior soil, and inferior and partly putrid sewage, he had made a profit of ten thousand pounds in eleven years, from about ninety acres, under these extraordinary difficulties. As to towns, take the instance of Croydon. Under the mistaken notion that the sewage can only be distributed by gravitation on lands in immediate contiguity to the town, a rent of upwards of ten pounds an acre was exacted for it, for land of which the ordinary rent was twenty-three shillings per acre. Then there was the wastefulness of ignorance of the municipality. Town councillors—utterly unacquainted with the new management and the increased skill it required—gave the management as Dr. A. Carpenter may recount, to a man of inferior capacity for management of an ordinary farm at the lowest wages; and yet with such conditions the farm yielded a little over the working expenses.

In almost every case, storm and subsoil water has been conveyed with the sewage, diluting, and thus reducing its manurial value, and increasing in volume at the time when the rain-sodden land was least adapted for its reception.

As an example of the exactions with which sewage farms are frequently charged, it may be mentioned that one city desired to rent some land which rented at ten shillings an acre, but the Right Hon. Landlord exacted four pounds per acre for his supposed monopoly of a site where it could only be applied by gravitation. The average value of land was from twenty to thirty years' purchase, but 150 years' purchase have been charged by noble lords upon towns for the application of their sewage. These exactions of unearned increments—I have had the agreement of noble lords—might be well satisfied by a right of pre-emption for public purposes, at an average of two years of the previous rent. In addition to such factitious charges are the excessive legal expenses for obtaining the sanction of Parliament for local Acts for towns; expenses that would suffice for the construction of a large proportion of the really requisite works. Moreover, there are frequently large constructions of unnecessary and expensive works by civil engineers, who are unacquainted with the economies of construction required in agriculture. In addition to these there are the expenses of unnecessary works of disinfection, and construction of unnecessary reservoirs for stagnant detentions for "raw sewage" that would suffice for farm steadings.

In place of downward distribution through the soil for disinfection, and the discharge of the bulk of the sewage in waste—destructive of the fish of the river or the sea—there is properly the discharge of the sewage fresh, for inoffensive application on the surface of the land. Unscientific common agriculture gives usually only one top-dressing of manure a year (of manure in the solid form), in which it wastes in disintegration by the putrefactive insanitary decomposition, which makes the contiguity of market gardens at times specially offensive and injurious. The skilled horticulturist, the proper plant-feeder for sewage farming, gives two, three, or four dressings a week to the vegetation on the drained and prepared soil, as it may want to speed the growth of wood or leaf, or to develop superior fruit.

Where pipe distribution is used, as it may be the best for rapidity of distribution, over unequal surfaces, at from a halfpenny to a penny per ton, advice was particularly given for the large works at Rugby, as well as for farms, that plots of the land should be tested by distributions by hand or water-carts to determine its particular receptivity, and the extent of the pipeage that would suffice for it. By the common neglect of that advice, the extent and the expense of pipeage has been largely increased, often to double the extent of what would have sufficed, as well as double the area of land that was needed; and hence the like mistakes have occurred in the works for liquefied manure farms. And these defaults of want of skill and of competent science have been overlooked in the common allegation that sewage farms and "liquefied manure farms do not pay." Nevertheless, it may be observed that although liquefied manure culture is a delicate culture, requiring the skill of the horticulturist, and is beyond the capacity of the common agriculturist, the yield of the common liquefied manure farms has been from ten to twenty bushels per acre beyond the yield of common agriculture, with a real increase of profit. One detriment to the liquefied culture has frequently been that the highly superior quality of the produce in grass has brought from game preserves, and from extraordinarily long distances, rabbits and hares which the farmers were not allowed to kill in their own defence.

Competent superior administration would by competent central administration, and by that alone, protect the population of towns by the enforcement of the old common law responsibilities for nonfeasance, for misfeasance, and malfeasance which still subsist, although they may have fallen into desuetude and press for revival.

Insanitary chemistry only proposes to treat "raw" sewage—

"crude" sewage--that is to say putrefactive sewage, with expensive and really useless disinfectants. Such chemistry speaks of utilising the putrid sewage of one hundred of the population on one acre of soil; sanitary science will now utilise the sewage of more than a hundred and fifty of the population for a greatly superior agricultural production on the same area.

The people of Paris have had no experience of any condition of sewage except that of putridity, and hence, believing in none, and seeing but little except the irrigations with partially putrid, though very successful, irrigations at Gennevilliers, are much opposed to sewage irrigations immediately close to Paris. Even Dr. Jules Brocard, of the Academy of Medicine, who, in an able article in the *Revue des Deux Mondes*, advocates the removal of the anarchy of local administration in France, and the adoption of the principle I proposed a long time ago, of a centralisation of a scientific administration for the people, in place of the centralisation they now have—even he gives no exposition of the large organic difference and the economy of sewage which is undecomposed and fresh. He has probably seen nothing of it, and knows no more of it than the people of Paris. They, and indeed some members of the Institute, have noses vitiated by the putrefaction, and the common conditions of the filth diseases. They are, therefore, I am led to expect, as yet unprepared to accept the axiom that the condition and the capacity of superior legislation and of local executive administration may be popularly tested sanitarily by the nose. Members of the Political Economy Club of Paris, including the writer for the *Journal des Debats*, have to be informed, and to be impressed with the great maxim enunciated by H. I. Highness the Crown Prince, the President of the recent Congress at Vienna, that every subject has a money value, and how largely that value is depreciated, and strength and happiness is reduced by the existing removable conditions of insanitation.

It will, I expect, be found that at the present time double the expense is being incurred for disinfecting the sewage made putrid by the combined system in our Metropolis, by throwing away the productive power for the sustenance of some two hundred cows, than would suffice for the direct application of fresh sewage to the land, and maintaining conditions, despite of the report of Lord Bramwell's commission having declared them to be "a disgrace to the Metropolis and to civilisation."

When stripped of factitious adjuncts, water carriage, instead of being the dearest, will be found to be the cheapest and one of the most economical methods of agricultural production. It is to be observed that all the factitious charges which have been

specified—the results of bad legislation and maladministration by incompetent hands, from which, for the public protection, it ought to be removed—are usually passed over without any examination, and are presented as the natural and necessary results of sewage farming that unavoidably render it more expensive than the prevalent ancient methods of agriculture. It is proper to note these great fallacies, and submit them for close examination, as was done by the Sanitary Congress for Berlin, which led to the adoption of the principle of the circulation of fresh sewage against that of stagnation and putridity; that is to say, of carrying a constant supply of pure spring water at high pressure into every house and into every flat of every house, and by self-cleansing house-drains and apparatus, conveying immediately away, and before decomposition could commence, the fouled water into self-cleansing sewers, and by those self-cleansing sewers conveying it at once fresh and unwasted on to decimed and prepared land. This is what is being done in that city, though somewhat less perfectly, I believe, than might be, and very wastefully and slowly, as I consider, for the relief of the population. The principles of sanitation are now, I consider, so far established that, on the plans of sanitary engineers, they might warrant a capitalist in contracting for the attainment of large results in the improvement in the health and strength and the great pecuniary economy of the charges of premature mortality, and the excessive sickness of the lower classes of the population.

On "The Sanitary Condition of Water Supplies," by EDWIN CHADWICK, C.B.

MY earliest examinations led me to prefer, beyond all, supplies of soft water to hard water for the superior solubility of the soft water, for the saving of soap, of tea, and its superior potability over hard water. I do not remember that any question of supplies for the larger cities or towns in Lancashire came before our first General Board of Health, unless it was at Lancaster and one or two places where supplies on a correct sanitary principle were carried out by our Inspector, Sir Robert Rawlinson. At the time I heard of some infusions of peat in the common supplies of that period from the surface washings of lands I did not regard those infusions as very serious objections, as the peat was represented as containing tannin, an astringent of inconsiderable account. But later experiences have shown that the infusions of peat are seriously injurious—that in flood periods they produce serious dyspepsia; that at Glasgow, Aberdeen, Dublin and Manchester, during the floods of heavy rains, when the supplies are discoloured, they cannot be drank with safety for two or three months; and they are attended with the evil of creating a resource to alcoholic stimulants. It has been the practice of engineers who are not sanitarians to bring the water to the doors of private houses in bulk, and to leave the internal distributary apparatus to be provided by plumbers, who generally prefer and provide lead pipes for its superior convenience and for the profit of the expense. It fell to my own son, who is a sanitary engineer, to carry out a new system for working at Odessa, and he completed it with the capillories for the houses entirely with iron pipes. At all times soft water attacks and decomposes lead, and I am informed that at Manchester there has been a serious amount of lead poisoning, and so it will probably be at the other cities. The protection is, iron piping—armed by coating on Dr. Angus Smith's or other processes. All this goes to augment the importance of soft spring collections, and where only chalk or hard spring sources are available, to having the whole supply softened by the improvements on Clark's process, as is now done effectually at Canterbury Bushy, and an increasing number of other places. At these places water of eighteen degrees of hardness is reduced to not more than two or three degrees of hardness, or about the ordinary hardness of soft water supplies. In the lake supplies of towns such as Manchester, threads of water may be seen in dry months running down the hill sides, which a sanitary engineer should examine, when they will be found to be mostly the outcome of springs, which should be carefully collected at the outcome, and carried to a reservoir, whence the water may be distributed in its purity. As to the method of collection, I was led, from observation of the outcomes from land drainage, to propose that method of collection for the supply of the Metropolis from the uncultivated grounds of the Surrey sands. The method has been resorted to by the Grand Junction Company, at the instance of Mr. Best, a sanitary engineer, attended with a result never, I believe, known before of a collection of water in such a condition of purity as to need no first filtration from reservoirs, nor any second or domestic filtrations, and to be in every way superior to them. The first practice of engineers who are not sanitarians in the chief water supplies of our Metropolis displays the effects of ignorance of sanitary science in the omission of a due regard to the diverse sanitary effects of differences in the qualities of the *aëration* of the supplies. At

the sources of the Thames supply, as at Pangbourne, the water is clear and brilliant, and stones may be seen clearly at the bottom, some twenty or thirty feet deep. The water drank there is highly aërated and refreshing. Some way farther on the water was taken up for storage in open reservoirs. There algæ were generated, and died with extraordinary rapidity, leaving pernicious infusions of decaying animal matter. Taken from thence for urban distribution, under the intermittent system of supply, it was delivered into cisterns, whence it stagnated, was further de-aërated, and it absorbed town air. In the lower districts, in courts and alleys, in tubs over cesspools, it absorbs the cesspool air. Taken up by women into their overcrowded bedrooms, and kept stagnant in open vessels, it absorbed the pernicious foul air of the overcrowding. Surgeons who have performed operations there, and who have applied such water as there was there to wash their hands, usually find their hands smell disagreebly until they are rewashed. Generally, if there be any outbreak of malaria pervading a district, it is rapidly absorbed by exposed stagnant water, as in wells, and people are led to believe they have been poisoned. In these several conditions, the person drinking the water at its source may be said to be drinking pure and invigorating air. Drinking it after stagnation in the uncovered reservoir, he would be drinking it de-aërated, and with much vegetable and animal infusoria and some decaying animal matter. Drinking it after stagnation in a house cistern, he would be drinking inferior town air. Drinking it after stagnation in an open vat, in a court or alley, in the immediate vicinity of foul cesspools, he would be drinking cesspool air; or, after standing in the overcrowded single room, he would be drinking the foul and dangerous air of the apartment. The effective preventive of such insanitary conditions is direct delivery at constant high pressure of water from a pure source, which preserves the pure aëratum, and without any intervening cisternage or stagnant detention whatever. On the occurrence of the visitation of the cholera in 1848-49, we directed an examination of the conditions of courts and alleys, and then water supplies, when the supposition that the people did drink water—a supposition very extensively entertained at present—was treated with ridicule: they only drank beer. And this will be found to be very generally the conditions of distribution at present from the old insanitary works. The families of the poorer classes now also drink tea, or coffee, or water after boiling for cooking, which prevents, or considerably reduces, their dangers. The wealthy are protected by their Apollinaris, or other aërated waters, as their beverages. An instance is

stated of the dread of water supplies by the poor, that a mother who was taken with her children on an outing, was extremely anxious that they should not drink water, and only beer. The intake of water for the supply of the prisoners in the Millbank Prison was from the River Thames, sewer polluted, opposite. A change to a supply obtained from a spring source at Trafalgar Square, presented an overwhelming example of sanitary improvement in the health of the prisoners. In another paper submitted to the Congress I have presented other examples of errors prevalent in the treatment of water carriage for irrigation and sewage farming. The application of these great sanitary improvements for our Metropolis is at present impeded by the disunity of the private trading companies, which distribute their supplies with an injurious waste of not less than three out of five of the quantity consumed. I deem the application of the most advanced sanitary science to be requisite on every point of the question of water supplies, for the protection of the health and economy of the population, and against the wastefulness of ignorance, and of insanitary engineering.