SECTION II.

ENGINEERING AND ARCHITECTURE.

ADDRESS

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PRESIDENT OF THE SECTION.

The development of Sanitary Science in recent years has led to the gradual formation of what may be termed a special branch of the Engineering profession. The very earliest engineering works on record were connected with sanitation as exemplified by ancient aqueducts, the *Cloaca maxima* of Rome, &c., &c. It is, however, only within the latter half of the present century that much real attention has been paid to the science of Sanitation in its various branches, resulting, *inter alia*, in the assistance of the engineer being sought for the purpose of designing and carrying out works for providing a health-giving supply of pure water, for disposing in a satisfactory way of the filth which would otherwise accumulate wherever people are aggregated in large numbers, and for the realization of other desirable sanitary objects.

It is not only in the more pressing instances of cities and large towns that greater attention has been paid to these matters in recent times, but the awakening to the importance of the subject has become universal. The engineer is now called on to deal with a great variety of sanitary works—differing not only in kind but in magnitude—from the sewerage of a hamlet, or even of one mansion, to the complicated main drainage system of a city—from the sinking of a pump well to the construction of works on a vast scale, such as those of the Vartry, by which the city we are now meeting in is supplied with water.

Such works have been increasing in number, following good

examples, the benefits from which are at once felt and appreciated, and doubtless to a great extent owing to the instrumentality of this Institute, the proceedings at whose annual congresses are now eagerly looked forward to, attentively watched during their progress, and subsequently discussed with the greatest interest by the public.

A great impetus was given to sanitary engineering works of a public character by the passing of the Public Health Act, 1875, and the Public Health (Ireland) Act, 1878. By these Acts sanitary authorities in England and Ireland have had important duties thrown on them, coupled with extensive powers to enable them to fulfil those duties, and—last but not least in importance—means are provided by which the funds required for carrying out the necessary works can be obtained on easy terms, both as regards the interest and the repayment of the principal.

It will not, I trust, be thought inappropriate if I take for the subject of my address to you the operation of the Public Health (Ireland) Act, 1878, in as far as it relates to engineering.

For the purposes of sanitary supervision, Ireland is divided into urban sanitary districts and rural sanitary districts, the former consisting of the larger towns, in which there are legally constituted municipal authorities, and the latter consisting of the Poor-law Unions, exempting for this purpose from each union so much of it as lies within any urban district.* No urban district can exist without a local authority, such as town commissioners, but small towns, even though they may, for other purposes, have such a local authority, may be comprised in a rural district, and be under the sanitary supervision and control of the guardians of the union acting as the rural sanitary authority.

The sanitary authorities, urban and rural, have, as I said before, many important duties thrown on them, foremost among which are some which compel them to seek the advice and assistance of the engineer, such as the improvement of the water-supply of the district, the provision of a new supply of water, proper and sufficient for public and private purposes, and the repair of all sewers belonging to them, and the construction of such new sewers as may be necessary for effectually draining their district.

The architect is concerned with other and very important provisions of the Act, such as the regulation of buildings and formation of bye-laws for that purpose, the construction of new streets, baths and wash-houses, dwellings for labourers and artizans, &c., &c.

Other provisions of the Act impose duties and confer powers

* NOTE.—A list of the urban districts is given on page 213.

of the greatest importance as to matters which come within the province of the medical officers of health, such as the abatement of nuisances, provision and care of burial grounds, scavenging, and depôts for that purpose, mortuaries, places for *post-mortem* examinations, slaughter-houses, markets, disinfecting chambers, &c., &c.

Lastly, the Act, directly, or indirectly through the operation of other Acts incorporated with it, provides for matters which *primâ facie*, are less immediately connected with the health of the public, such as town halls, public clocks, town parks, &c., &c.

I propose to confine my remarks chiefly to the operation of the Act in respect of sewerage and sewage disposal and water-supplies.

Since the power of sanctioning loans for sanitary purposes was given to the Local Government Board for Ireland, loans for various purposes under this Act have been sanctioned to a large amount. In the nine years ending March, 1884, the total amount of such loans was £1,206,419 (see Annual Report, 1884). Of this about £700,000 was sanctioned for water-works and £230,000 for sewerage works. Loans to the extent of over £100,000 have been sanctioned for paving streets and flagging footpaths; the balance consists of loans for labourers' and artizans' dwellings, new streets in Dublin, town halls, cemeteries, baths and wash-houses, scavenging, &c.

The time of repayment of money borrowed under this Act cannot exceed sixty years, but if the loan (as is the all but universal custom) is sought to be obtained from the Commissioners of Public Works in Ireland, the term cannot be extended beyond fifty years, and in determining the time when such a loan is repayable regard must be had to the probable duration and continuing utility of the works in respect of which the loan is required.

The cities and large towns have all, as a matter of necessity, had to make provision of a more or less complete kind for a supply of water for public and domestic purposes, but many of the smaller towns are still badly in want of improvement in this respect; the sanitary authorities not being pressed on the subject, and being often in ignorance of the expense to which they may be led if they once embark on sanitary improvements, are apathetic or unwilling to do anything by which the rates might be raised.

Of the large works for the supply of the cities and principal towns I propose to say but little, descriptions of many of them will be found among the proceedings of the Institution of Civil Engineers, and of the Institution of Civil Engineers of Ireland, and of kindred societies, but I think some remarks as to what

has been done in cases of less important towns may not be without their use.

As a rule the supplies of water to the cities and larger towns have been provided under powers conferred by private Acts of Parliament, but since the introduction of the Act of 1878 several urban authorities of towns of importance have availed themselves of the machinery therein provided for obtaining by provisional orders the powers of purchasing lands and water under the Lands' Clauses Acts otherwise than by agreement. These powers of compulsory purchase are identical with those conferred by a private act, and are obtainable at a very trifling cost compared with that of a private act. In some cases where private acts containing borrowing powers have been obtained for water works the sanitary authorities have elected to borrow, not under their own Acts, but from the Commissioners of Public Works under the Act of 1878. Loans have been sanctioned in this way for the water-works now in progress for the supply of the town of Sligo and the township of Rathmines.

Although there has been a great improvement in the water supply to towns in Ireland generally, there are still cases of important towns which are badly in want of new supplies or considerable improvement of the existing supplies.

There are cases where by a spasmodic awakening to the fact that a supply of pure water is desirable the Sanitary Authorities have commenced the proceedings for obtaining the requisite powers of acquiring the property rights, and have even acquired them and obtained sanction to a loan for defraying the expenses of the works, and then from some cause or other have allowed the powers to lapse and the project to be abandoned.

No doubt the proceedings of this Congress will be disseminated through the medium of the newspapers throughout the country, and will perhaps direct the attention of Sanitary Authorities of towns where deficiencies exist to the necessity for improvement, and I hope that whoever, on the next visit of the Institute to Ireland, occupies the place which I have now the honour to fill, may be able to point to a marked improvement in this respect.

The Sanitary Authorities of the smaller towns where deficiencies admittedly exist are frequently discouraged by the fancied, because unknown, extent of the responsibility they might assume, and expenses they might be led into if once they embarked on such an enterprise as a "water-works scheme." Probably they have heard rumours, and exaggerated rumours, of thousands spent on Parliamentary contests and of expenditure mounting up until the original estimate was, so to say, *nowhere*, and they decline even to discuss the question.

It may encourage the authorities of such towns to have some information as to what has been done in cases similar to their own, and to which they can refer.

It is usual to say that engineers' estimates are always exceeded, but my experience is that a sanitary authority placing themselves in the hands of a competent engineer, may safely rely on the estimates as far as the engineer is concerned, the elements of uncertainty, and the invariable origin of supplemental loans for water-works, are the cost of the land and water and water-rights, and the law costs. I advise engineers not to estimate for these items, but to recommend the sanitary authorities to employ an experienced valuator to inform them as to the probable cost of the former, and to refer to their solicitor to inform them as to the probable amount of the latter. The mistakes, if any there be, will then fall on the right shoulders.

I have had printed a list of some of the towns in Ireland supplied, or in course of being supplied, with water under the Act of 1878, which towns have been selected as embracing ordinary cases, and you will there find in each case the population, the annual valuation (of the *town* if it be an *urban* district, and of the *area of charge* if it be a *rural* district), and the amount of loans sanctioned for a water-supply in each case, and I have added the ratios of the loan to the valuation, of the loan to the population, and of the valuation to the population.

These towns may be grouped into the following classes :—

1st. Towns in which the annual valuation is large compared with the population. These are all towns of the better class of houses, in which a large proportion of the houses are or will be connected with the mains.

2nd. Towns in which but a small proportion of the houses are or will be connected, and in which the consumption of water will be less than in the first class.

3rd. Small towns and villages, in which the supply is given almost exclusively by fountains.

In the urban towns of the first class, with populations of from 2,000 upwards, the cost of the water-works is from £2 to £3 and more per head, but does not exceed the annual valuation.

In the urban towns of the second class the expense of the waterworks has been, or will be, under £2 for each resident, but exceeds one year's valuation.

In the cases of towns that are in rural districts a separate area of charge has been assigned to each, so that a comparison between the cost of the water supply and the valuation only shows the amount of taxation which the districts have to bear in each case, as assigned at the discretion of the Guardians with

the approval of the Local Government Board. In some cases no comparison can be drawn, as the expenses are charged on different districts in different proportions, but where there is no such differential rating the cost of the water-works is on an average two-thirds of the annual valuation of the area of charge. In some of these towns the proportion of the expenses incurred to the population is very large, as in the cases of Greystones, Enniskerry, Portrush, Lisdoonvarna, Buncrana, and Rostrevor, but these are all watering places, with a much larger population to be provided for in the summer than that resident at the time of year at which the census is taken.

The villages comprised in the third class which, of course, are all rural districts, have been supplied with water through street fountains, at a cost of about one-third of the annual valuation of the areas of charge.

In this class are some small and unpretentious works undertaken by rural sanitary authorities for the accommodation of districts where there are no aggregations of houses that could be dignified by the name of villages even. The works I allude to consist in leading the water from streams or springs not easily accessible to a fountain or fountains on the side of the public road. In the district of Little Island, for instance, in the Union of Cork, where there were no springs nor water of any kind, the guardians have brought the water from a distant stream or spring to three or four fountains at convenient points on the public road, to the great benefit of the inhabitants scattered over the district, and also remedying the great inconvenience felt through the want of drinking water for a largely-attended national school.

The Guardians of Ballyvaughan Union, in the County of Clare, have constructed several small detached works of the same kind, at little expense, but with no small benefit to the inhabitants.

How the proportion of cost to valuation affects the rates necessary to meet the expenses, if the charge is thrown wholly on the general rates, will be seen from a consideration of the conditions on which sanitary loans are now granted by Her Majesty's treasury, through the Commissioners of Public Works in Ireland. The rates of interest vary with the time when the loan is repayable—viz., for a loan for fifty years it is 4¼ per cent. per annum; for forty years, 4 per cent.; for thirty years, 3¾ per cent.; and for twenty years, 3½ per cent. All such loans must be repaid by equal half-yearly instalments of the principal with the proper interest on the then outstanding balance of principal. The annuity system, or that of repayment by equal annual payments over the entire term of the

loan to cover repayment of principal and interest, does not now apply to sanitary loans.

The initial rate, or rate to meet the first year's instalment of principal and interest, will be the largest, and in the subsequent years the rate will be constantly diminishing. The following table shows at a glance the rates, at different periods of the terms of the loans, necessary to meet a loan of an amount equal to the valuation. For any other proportion the rates in the table are to be multiplied by the ratios of cost to valuation which I have before alluded to.

Term of loan.	Rate of Interest.	Initial rate per £	At 5 years.	At 10 years.	At 15 years.	At 20 years.	At 25 years	At 30 years.	At 35 years	At 40 years.	At 45 years	Final rate.
years	%	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.	d.
50	4¼	15·00	13·93	12·96	11·94	10·92	9·90	8·88	7·86	6·84	5·82	4·80
40	4	15·60	14·40	13·20	12·00	10·80	9·60	8·40	7·20	Final. 6·00	...	...
30	3¾	17·00	15·50	14·00	12·50	11·00	9·50	Final. 8·00	...	...	...	...
20	3½	20·40	18·30	16·20	14·10	Final. 12·00	...	...	...	...	...	...

Loans for water-works are usually sought for the longest term which the Commissioners of Public Works can give—*i.e.*, fifty years. It does not appear that there is any great advantage in this. The initial rate for a fifty years' loan is only a fraction less than that for a forty years' loan; and in seventeen years, before half of even the shorter term has expired, the rates to be paid for each loan are identical, and from that year onward the shorter loan has the advantage of entailing *lower*

NOTE.—Since this Address was delivered a very important alteration has been made in the rates of interest of Government Sanitary Loans. The rules now are:—

For a term of repayment, not exceeding 35 years, 3½ per cent. per annum.

For a term of repayment, exceeding 35 years, and not exceeding 40 years, 3¾ per cent. per annum.

For a term of repayment, exceeding 40 years, and not exceeding 50 years, 4 per cent. per annum.

This change does not affect loans granted before 15th May, 1885. The following Table should be substituted for that given above:—

Years.	Per cent.	1st Year.	10th Year.	15th Year.	20th Year.	25th Year.	30th Year.	35th Year.	40th Year.	45th Year.	50th Year.
		d.	d.	d.	d.	d.	d.	d.	d.	d.	d.
20	3½	20·31	16·62	14·52	12·42	...	...	...	...	...	...
30	3¾	16·31	13·88	12·48	11·08	9·68	8·28	...	...	...	...
35	3¾	15·26	13·10	12·90	10·70	9·50	8·30	7·10	...	...	...
40	3¾	15·00	12·97	11·84	10·72	9·59	8·47	7·34	6·22	...	...
50	4	14·40	12·67	11·71	10·75	9·79	8·83	7·87	6·91	5·95	4·99

annual rates, besides being entirely wiped out in the fortieth year, when there are still ten years remaining encumbered with payments on account of the fifty years' loan.

When the loan for a water supply equals or exceeds the valuation of the premises of the district assessable in respect of it, the initial rate is seriously felt, and though it may be gladly paid by those who are directly benefited by having a supply of pure water brought to their doors or into their houses, it is no wonder that the expense is grudgingly agreed to by those ratepayers living outside the actual limits of the supply. Hence in some cases that I know of, and probably in many others that have not come to my notice, it has been found impossible to reconcile the conflicting interests so that an agreement may be come to as to the area of charge on which the loan for the works in a rural district is to be secured.

Some *urban* towns also contain a considerable extent of district that is essentially rural; in such cases, when the water is supplied under a private act, it is possible to exempt from the water-rate, wholly or partially, premises to which the mains do not extend, and thus avoid the injustice of full rating on those who are only slightly and indirectly benefitted. When such exemptions are not made a similar difficulty will be found to exist sometimes in urban districts.

The operation of the Act, as regards loans to *rural* sanitary authorities for water supplies, is this:—

When the works are of sufficient magnitude to require to be constructed out of borrowed money, the sanitary authority applies for and obtains the sanction of the Local Government Board to raise the requisite funds under Section 238.

Then under Section 232 the cost of providing and maintaining the water supply is made "special expenses," and declared to be chargeable on the contributory place or places which constitute the area of charge.

This area of charge is selected by the sanitary authority and submitted for the approval of the Local Government Board, and if they confirm it by a sealed order the area of charge so fixed becomes liable for the discharge of so much of the loan expenses as are not provided for in any other way.

As it is not usual to make any other provision, the rates on the area of charge are generally burdened with the entire charge.

Previous to the Act of 1878 an area of charge could not include portions of a townland, and as the townlands are sometimes very extensive great injustice was done by either excluding the residents in the part close to, or perhaps in, the town from any contribution to the cost of a water supply or by including

the residents at the distant boundary of the townland. Hence arose a difficulty in practice which has been removed by allowing any portion of a townland to be included or excluded, and a more fairly adjusted area of charge constituted, by which the burden of taxation is more justly distributed.

It would not be proper to confine an area of charge to the area continuously built on, nor to extend it so as to include residents at such a distance from the town that its sanitary state is not properly of importance to them. It is not possible to lay down any general rule as to how far the indirect benefits from the improvement of the sanitary condition of a centre of population are felt, at least how far the benefit is of such an extent as to warrant a pecuniary claim on the ratepayers, and therefore the question must be considered and decided in each case independently.

That such a question is not easily decided may readily be imagined, the outside ratepayers wishing to confine the area of charge, and, with it, the liability to special sanitary rating, to the town proper as far as possible, while the ratepayers of the town desire to be relieved, by including the ratepayers living in the neighbourhood, though not actually in the town, but who constantly frequent and use the town, and cannot, or, at all events *should* not, be indifferent to its being kept in a healthy state. Hence a dead-lock sometimes arises where there is no question whatever of the *necessity* for a new or improved water supply. The difficulty would be greatly diminished if it were possible to assess differential rates in proportion to the beneficial effects of the expenditure on the urban and suburban portions of the areas of charge, or district.

The rates assessable on the area of charge are the security on which the loan is advanced, but it is not necessary that the *entire* amount required to meet the repayment of instalments of principal and interest should fall on such rates if other provision, in whole or part, can be made.

Section 66 of the Act enables the Sanitary Authority to provide funds by striking a compulsory water-rate and by entering into agreements for water-rents. The words are:—

"Where a sanitary authority supply water to any premises they may charge in respect of such supply, a water rate to be assessed at the net annual value of the premises, to be made assessed and levied in the like manner in every respect as the rate out of which the expenses incurred by such sanitary authority in the execution of this Act are defrayed; moreover, they may enter into agreements for supplying water on such terms as may be agreed on," &c., &c.

Such water-rates and water-rents would be applicable to dis-

charging the expenses incurred in providing and maintaining a water supply, and it would be only in so far as they were insufficient for this purpose that the cost of providing and maintaining the works would become chargeable as "special expenses" and assessable over the whole district of the area of charge.

I cannot see how residents in a town who would have the great benefit of a supply of pure water to their premises could object to such water rates in addition to a smaller rate common to the whole area of charge, they would be paying the latter as members of the general public concerned in the general sanitary condition of the place, and the former as it were in payment for a luxury.

If it were understood beforehand that by putting the 66th section in force there would be practically a differential rating established, the difficulty in an area of charge being agreed on which sometimes occurs, would often be got rid of.

I am not sure that it would not be better if the striking of rates under section 66 were made compulsory on the Sanitary Authority and the proportion of them to the general rate on the area of charge, fixed.

I may refer on this matter to the evidence given before a Committee of the House of Commons on a Bill for amending the Public Health Act, 1875, which is published for sale as a blue book. On this point I may also mention the recommendations of the Commissioners appointed in 1878 to examine and report on the boundaries of the municipal towns of Ireland, and the incidence of taxation in connection with any proposed alterations. The Commissioners were of opinion that the benefits of municipal control and expenditure were in no case confined to the town proper, but extended to a certain distance outside the area continuously built on. Besides being interested in the sanitary condition of a town which they frequented and used, the suburban residents, in the opinion of the Commissioners, derived advantages from the town being well lighted and paved, and from the existence in the town of markets, schools, churches, &c., &c., of which they and their families availed themselves, for which advantages it was but fair that they should to some extent assist in providing the necessary funds. The Municipal Boundaries' Commissioners with this view recommended in the case of each municipal town that there should be an inner area consisting of the town proper liable to full rates, and an outer area subject only to half rating.

There were other recommendations in the Commissioners' Report which I need not mention, it is the proposition of differential rating that concerns the matter in hand.

The structural works connected with the water supplies to these towns are of the ordinary kind, but the list contains some of each type of construction suited to the different circumstances that occur in practice, and I have prepared a second table in which the groups are arranged so as to show this. Where storage reservoirs are found to be necessary, the ordinary impounding embankment, with a central puddle wall, is usually adopted. In some cases, however, this has been varied, and the principal part of the dam has been constructed as a hollow or cellular concrete wall, within which the filters are self-contained. The small reservoirs at Greystones and Enniskerry have been formed in this way by Mr. Price, M.Inst.C.E., who is about to carry out the same design on a larger scale at Bandon. Mr. Strype, M.Inst.C.E., has also constructed a similar dam at Wicklow, with the addition of a clay embankment against and below the concrete structure.

Some of these water-works have a service tank near the town subsidiary to the storage reservoir, and in some the supply is furnished directly from the storage reservoir to the distributing pipes. The advantage of a service tank near the town in effecting an economy in the cost of a large main to the storage reservoir and in reducing the risk of accidents by pipes bursting is sometimes more than counterbalanced by the cost of its construction; it had to be omitted in certain cases in which it was at first proposed in order to bring the expenses within the outside limit that the Sanitary Authorities were willing to go to for the improvement of their water supplies.

Filtration has not been provided for in all cases. Generally speaking, this has been from the wish to keep down the expenses, but it has only been omitted where there was no decided reason for the water being filtered. In some cases filtration has been provided for where it might probably be omitted without real detriment to the quality of the water, though, perhaps, the appearance might be a very little improved, and it is certainly a fact that in such cases filters not properly attended to are worse than none at all, especially in the case of covered filters, such as those within the cellular concrete dams I have just referred to. Of course this remark does not refer to large water-works in charge of a special department of a corporation or urban authority, but it is different with small works, carried out and maintained by a rural sanitary authority.

As to providing for filtration or dispensing with it, the first thing to be looked at is the water-analysis and the analyst's expressed opinion on the result of it. Sometimes a decided opinion is given for or against the purity of the sample submitted, and

sometimes the water is pronounced to be sufficiently good for a town supply *if filtered*, but more generally there is an ambiguity in the report of the analyst arising from want of information as to the *origin* of some small impurity indicated by the analysis. This takes usually the shape of an opinion to the effect that were certain constituents, named, of animal origin the water could not be pronounced good, but that they might arise from a peaty origin, in which case their presence would be of less consequence. The difference is a very important one, and it would be very desirable that the doubt should be cleared up as far as possible. I think that this is possible to some extent, in cases where the supply is taken from a stream, by taking samples not merely from one place, but from several points at intervals up the course of the stream. A comparison of the variations in the analyses, carefully considered with a map on which the nature of the surface of the different portions of the catchment area is marked, might, on the one hand, lead to a clear opinion that the slight impurity was due to a peaty origin and comparatively harmless; or, on the other hand, contamination from an animal source might be localised and eliminated.

Filtration through spongy iron has been brought prominently into notice by a paper on the Antwerp water-works, read before the Institution of Engineers, by Mr. Anderson, and by the discussion which followed. It is claimed for this process that it effects a chemical as well as a mechanical purification of the water, and it seems to be peculiarly adapted to places where the only possible source of supply is open to possible contamination of animal origin. It was proposed in one case in Ireland that filtration by this process should be adopted, and a loan would have been sanctioned for the purpose but the proposal was deferred or abandoned.

I may mention that only two loans have been sanctioned for providing filtering arrangements after the completion of the rest of the works, and no other application has been made.

In the case of such water-works as I have been considering the data on which to calculate the requisite storage capacity that should be provided for in the reservoir are seldom sufficient in kind or in detail to enable a clear deduction to be drawn. The proposal to provide a water supply is *immediately* followed by a design for the works being called for, and there are not often reliable gaugings of the streams or of the rain-fall available for the proper calculations. The error is usually found to be on the right side, and I am only aware of one case where the storage capacity provided is insufficient, and this, I was informed by the engineer, was caused by a reduction of the capacity of the reservoir proposed by him in order to reduce the first cost.

The storage required depends also on the probable consumption, and on this point we certainly are in want of information in the case of small towns; but here, again, the error is sure to be on the right side. It would be very interesting and of considerable use if the actual consumption in the various towns could be measured and recorded. No small town, probably, has a meter on the supply, or the means of measuring it over a gauge-weir or notch, but wherever the supply comes directly from a tank, the supply to which can be shut off for a time, the measurement can be readily made. In some cases of very small supplies from springs, directly enclosed in tanks the consumption can by a little ingenuity also be estimated. The consumption during twenty-four hours is an important item in the design of the reservoir, filters, and clear water basin, or service tank; but it is also desirable that the consumption at different times of the day should be known.

A few measurements have been kindly communicated to me, and the results show, I think, the desirability of their being more generally made. In Loughrea, a town of about 3,000 inhabitants, the consumption was measured and found to be between 12 and 13 gallons daily for each person; in Belmullet (population 900), it was between 5 and 6 gallons; in Enniskymon (population 1,300), it was 5·87 gallons including a large supply to one mansion and one or two small factories; and in Miltown Malbay (population 1,400), it was only 1·8 gallons. These towns are almost entirely supplied through street fountains.

Mr. Cope, clerk of the Rathdrum Union, informs me that the consumption in the workhouse of that union in 1883 was 6·38 gallons per head daily.

Mr. Leonard, C.E., has supplied me with returns extending over some years from ten fountains in Drumcondra Township, supplied by meter; from these returns it appears that each person consumed an average quantity of 2·16 gallons daily.

In Enniskillen, Mr. Wray, C.E., kindly gave me the measurements of the hourly consumption from 6 a.m to midnight, which indicate a considerable increase of the draught at 9 a.m. which continues *without much variation* till after 8 p.m., and it would appear that one half the total consumption took more than nine hours to run off.

In making calculations for the purpose of designing water-works any probable increase in the size of the towns should be looked to. The examination of former census returns and of evidence given at local inquiries shows but very few instances indeed of an apparent necessity of providing now for an increased consumption in the future in this country.

Where the source of supply is a mountain stream with steep sides to the catchment area, storage has been dispensed with, as at Tralee, Killarney, and Rostrevor. At the latter place a good example of the well-known plan of automatic supply to the tank at times only when the stream is low and clear, can be seen.

In other cases where the source of the supply is a spring, or small stream from springs and not subject to floods, a tank containing a day's supply is usually found sufficient, and this tank may be near the source or at a distance from it and near the town. Examples will be found in the table.

Pumping has also been employed for the supply of two small towns, Loughrea and Strokestown, and it has been proposed in two other cases. In each of the above cases the motive power is provided by turbines, and the water is pumped up to a service tank containing over thirteen days' supply, the level of which commands the highest part of the town.

It is important for sanitary authorities to acquire a clear right to the water they propose to take and to the land on which they may require to erect any works. Where compulsory powers are required for this purpose they can be given by a Provisional Order if the proposed scheme be approved of by the Local Government Board after a local inquiry, but such powers cannot be *exercised* until the Provisional Order is confirmed by an Act of Parliament. Where the Bill for confirming the Order is unopposed the cost of this should be a trifling item in the total cost of the water-works.

Where the land for structural works and a right to the water can be acquired by agreement, a provisional order is not required to obtain way-leave or a right to open the ground along the pipe-track and lay the pipes. The right to lay water-pipes within their district, and subject to certain conditions *without* their district, is given to all sanitary authorities by the Public Health Act, but compensation must be paid for all damage done. Lands that are only required for way-leave are, therefore, not to be included in a provisional order for the purpose of acquiring lands otherwise than by agreement.

In the first table I have given in the different cases the initial rate to meet the loan. This is not to be taken as the actual rate required, for in the first place the charges to meet instalments of the loan and interest may be relieved by water-rates and water-rents as I before mentioned; and secondly, many of the loans referred to were made on the annuity system, requiring a lower rate, but one that would continue the same instead of diminishing with efflux of time of repayment. In some cases the income from water supplied to various concerns by

agreement very largely contributes to meet these charges; in one case, where the works have been in existence only a few years, they are wholly met in this way, and no rate for the purpose is now struck; and in others, agreements to considerable amounts have been made beforehand, and these facts I commend to the consideration of sanitary authorities contemplating a water-works loan. Persons who are specially interested in having the supply and require more than an average quantity, are much more willing to contract beforehand if they see that the adoption of a scheme somewhat depends on the support they thus offer, and also any sum assured to the sanitary authority in relief of taxation, so far disarms or nullifies opposition.

The improvement of the sewerage arrangements in towns has attracted perhaps more attention than that of the water supply, at least since the Local Government Board was first empowered to sanction loans for sanitary purposes, the applications for sewerage loans have been more numerous than those for loans for water-works. This arises partly from the necessity where it exists for improvements in the drainage of towns coming more readily home to the minds of the ratepayers, and partly because the burden of taxation entailed by such works is usually small compared with the taxation necessary to meet the charges of a water-works loan.

The number of sewerage loans has been swelled by numerous applications during the period of distress in 1880—1, with the object of combining relief through the employment of labourers with utility in the work on which they were to be engaged. The result was that applications flowed in for small loans for sewers in villages and hamlets, which would probably otherwise never have been asked for by their respective Sanitary Authorities. Of course very many of the works executed under such circumstances presented a minimum of utility, indeed it was not easy to stretch the meaning of the word "sewers" to include some of the drains proposed; but every latitude was given, and on the whole I am convinced that a vast amount of good has been effected by works of this kind the execution of which was prompted by the desire to afford relief to distressed labourers, and encouraged by the low rate at which the money was lent by the Government.

As was to be expected there was a general anxiety to have as much of these loans as possible expended in labour and as little as possible on materials and skilled work, hence designs for drains of a primitive character in which almost the whole work could be executed by unskilled labour were often submitted, some of which could not be approved of without modification.

Many of the proposals at that time were for constructing sewers or a sewer down the centre of the road, passing through small hamlets in which the idea of a house connection with the sewer was not dreamt of, in fact, in such a case the sewer had only to convey away the surface water, and remove and prevent the recurrence of pools that might have formed on the sides of the road, as was very commonly the case, and which if left to stagnate would cause a nuisance. The design of such sewer was not therefore of paramount importance, nor was the method of disposal of its contents, though of course no sanction could be given to a drain of any kind directly discharging into a natural stream.

From such cases in which the loans were only for a few pounds the sewerage loans have ranged up to very large sums for some of the more important towns.

The question of the disposal of the sewage continually presents difficulties in dealing with applications for sewerage loans. There is a wide-spread opinion that the sewage of a district should follow the rain-water to the nearest stream by which it will be carried off, a very convenient system for the district in question but inconvenient to its neighbours down stream. The law is now so explicitly stated by the 19th section of the Public Health Ireland Act that sewerage schemes in which this method of disposal of the sewage is adopted cannot be sanctioned, and are invariably rejected.

In the case of a small village, irrigation of a small portion of land if it can be managed, is perhaps the best plan of disposal of sewage, but there are great difficulties in the way; it is next to impossible for a rural sanitary authority to get any land for this purpose by agreement, and they do not consider the matter of importance enough to take the proceedings necessary for the compulsory acquisition of the land necessary, and besides, the irrigation would require constant supervision and give continual trouble if not attended to.

The disposal of small quantities of sewage on osier-beds, on swampy margins of rivers has been suggested, but this method has not, that I am aware of, been adopted in Ireland. I should like to see it get a fair trial here.

Discharge into tanks, to be emptied by scavengers, if regularly attended to, would also answer well for small towns, but there are difficulties in the way of getting any one to regularly remove or even to receive the contents of such tanks for their manurial value. In only one case that I know of is the sewage of a small town in Ireland taken by farmers, who have constructed carriers for its distribution over their farms, and who have, as I am informed, expressed themselves ready to take any amount

that can be delivered on to their lands by gravitation. But this is almost a unique case, and the example has not even spread to any town in the neighbourhood.

The larger the town, the greater the difficulty of dealing with this question, though when the authority is an urban one it has greater facilities for carrying out anything requiring supervision. In one case, where the population is about 4,000, it was attempted to deal with the sewage by filtration before discharging it into a mill-race, but after a little time the process was found to be a failure, and the nuisance became so great that an injunction was obtained to compel the sanitary authority, a rural one, to abate the nuisance, and they have obtained loans for a large sum to carry the sewage to a distance from the town to depositing tanks, the effluent liquid being intended to be used to irrigate land prepared for the purpose.

The spongy iron process of filtration is proposed for application to sewage. It appears to possess an element of chemical purification which may be usefully applied to a clear effluent from a depositing tank, but I am not aware that its application to sewage is in practice in this country.

Purification by chemicals has been provided for in full detail at the Ballymena Sewerage Works, and many other works are so designed that this method of dealing with the sewage may be resorted to if found necessary.

I should like to say a few words as to the expression "purification of sewage water, &c." The words "purify" and "purification" are, to a certain extent, misleading when applied to processes connected with water supply or sewage disposal. The word "pure" is defined by Johnson to mean "clean, not dirty, not muddy," and its origin, the Latin "purus," meaning "spotless," applies to a *visible* purity; hence it is often supposed that mechanical filtration, by rendering the effluent, in Johnson's words, "clean, not dirty, not muddy," complies with the requirements of the law and Sanitary Science in *purifying* the liquid. Water containing deadly constituents may be rendered bright and clear by natural or artificial filtration, but it is not thereby rendered *wholesome*, nor is sewage simply "purified" by filtration rendered fit for discharge into a natural stream. I think it would be advantageous if some word were introduced more expressive of what is the object aimed at, such as "sanification," instead of "purification," embodying the idea of a process rendering an unwholesome thing, or state of things, wholesome, without regard to the visible improvement effected. Such a meaning attaches to the words now in use, derived from the Latin "sanus," such as "sanitation" and the very title of this Institute, which words, implying simply a relation

to health, I may add, are themselves of quite recent introduction, the words in "Johnson," derived from the same source, exclusively refer to curing, or healing, that is, restoring a body to a healthy state. A more suitable word may be found; what is wanted is an expression which will describe the process of rendering an unwholesome thing wholesome, an idea which is not conveyed, except perhaps to a chemical mind, by "purification."

Ventilation, in connection with a sewerage system, is now recognised generally as an essential, and no sewerage loan will be sanctioned unless the ventilation of the sewers is provided for. There is a prejudice in many towns against free ventilation in the streets, and recourse is had to ventilation by means of piping carried up the houses, but in the principal towns the ventilators open directly in the street surface.

With properly shaped sewers, so laid that the sewage finds its way freely and quickly through and out of them no inconvenience whatever results from such ventilating openings being in the streets, if in sufficient number—in fact the more of them the better. I have seen, years ago, sewer-gas pouring back through a sink into a house in one of the best parts of Dublin (indeed, my attention was attracted by the *noise*) owing to the filling of the low levels of the sewer by the tide, but such a thing is, I am sure, not now to be met with; a complete system of ventilation has been introduced, by which pressure on house drains is relieved, and the air in the sewers is purified. For the purpose of constructing ventilators to existing sewers, loans of considerable amount have been sanctioned. The report of the Royal Commission on the Sewerage and Drainage of Dublin, in 1879, and the evidence given before it, contain much of interest on this subject.

With regard to the effect on the rates of the improvements in sewerage arrangements, I find that in only one or two cases has the initial sewerage rate exceeded sixpence in the pound, it varies from twopence to sixpence. In this case there is no relief afforded by incomings such as I have referred to as relieving the charges for a water supply, and the whole charge has to be met by a rate. Loans for sewerage works are repayable by instalments and interest, in not more than thirty years.

Other loans than those I have been referring to have been sanctioned under the Public Health (Ireland) Act, 1878, to a considerable amount. Over £80,000 has been sanctioned for the construction of new streets in this city, which not only are a direct advantage in facilitating traffic, but also aid indirectly, but largely in improving the health of the place by clearing unhealthy areas and opening fresh air spaces. The evidence of

the Medical Superintendent of Health was very clear and strong as to this at the inquiry as to the issue of a provisional order and loan for the new street at Cork Hill, in this city.

Over £130,000 has been lent for paving and flagging streets and footways, by which their state, from a sanitary point of view, has been greatly ameliorated.

New cemeteries have in many cases been provided by provisional order for the acquisition of the sites for them, and by loans for the construction of the structural works. The advantage of closing old burial places and providing new ones can only be realised by those who have heard the evidence at the inquiries held on applications for closing orders. The powers of the Act have also been most usefully put in force to properly enclose rural burial grounds which by the Act come under the charge of the sanitary authority.

Loans have been made, but only to a small extent, for disinfecting chambers and baths and wash-houses, perhaps the experience derived from the wash-houses now in course of construction in Tara Street, in this city, may lead to their further development. On this subject I may also refer you to the report of the Royal Commission on the drainage of Dublin.

Loans of some magnitude have been sanctioned for town halls, markets, gasworks, &c., which only slightly bear on sanitary matters. Large loans have also been sanctioned by the Local Government Board under the Artisans' and Labourers' Dwellings Acts.

An Act of Parliament was passed last year which, it is to be hoped, will be attended with very beneficial results to a large number of the labouring class. I refer to the Labourers' (Ireland) Act, 1883.

It would be premature for me to say more than that provisional orders confirming schemes made by rural sanitary authorities for the erection of over three thousand houses have been issued by the Local Government Board. The loans which will be required for these will exceed in amount £300,000.

At the next meeting of this Institute in Ireland, I hope it may be reported that results very beneficial, especially from a sanitary point of view, have been attained by the action taken by the rural sanitary authorities in this direction.

Though the works to which I have now briefly alluded as being directly, or indirectly, connected with the operation of the act of 1878 and its predecessors, may not present a large total in the eyes of any one conversant with the long lists of similar works under similar acts contained in the reports of the Local Government Board in England, I think all who know the circumstances surrounding such matters here, and the

sensitiveness of the ratepayer's pocket to the least increase in the rates, will agree with me that good work has been done, and the successive annual reports of the Local Government Board show that it continues to be done.

I hope that our proceedings at this Congress may attract the attention of those who have the health of sanitary districts in their charge, and who, perhaps, from learning what other sanitary authorities have been and are doing, may be led to look into the state of their own districts; should they find sanitary defects calling for remedies which they were formerly powerless to provide, it is to be hoped, now that they have the power to act, they will use the powers conferred on them, and availing themselves of the facilities afforded, acquit themselves of the responsibility they are under to the people in their charge and to the community at large.

Sir Robert Rawlinson, C.B. (President of the Congress), said he could only express his unbounded admiration for the able address which had just been read by one whom he would venture to call his colleague, for he was proud to be associated as Engineering Inspector for England with Mr. Cotton, the Engineering Inspector for Ireland. The address was worthy of consideration in many respects. With regard to the subject of loans, he held that Parliament and the Government had made a very grievous mistake in altering the rates of interest for loans for long periods, bringing it up to 4¼ and 4½ per cent. thus putting direct taxation upon improvements. One of the first principles of a Government should be to assist the people at the cheapest possible rate without subjecting the Exchequer to any loss; and he had no hesitation in saying that every loan might safely be granted at 3½ or possibly 3¼ per cent. which would give a great impetus to the carrying out of works and be a great relief to the local ratepayers. When he was sent into Lancashire during the cotton famine to advise the Government as to the mode of giving relief, it was a great experiment, yet not a new one, because they had had a previous experiment in Ireland on a great scale, which had not turned out so satisfactorily as it might have done. When he went into Lancashire the ministry of the day made up their minds that it was necessary to provide money to relieve the distress, but they did it with the certainty that almost half that money, as had been the case in Ireland, would be wasted. It was, perhaps, right to state that at the outset he said to the Right Honourable Mr. Villiers, M.P., who was the Cabinet Member under whom he was working, "If these works are carried out under our direction, I undertake to pledge myself that if the Cabinet will let us have our way there shall not be one farthing of loss." It was very satisfactory that nearly two millions were expended upon works of sanitary improvement. Over four hundred miles of good roads were made, sewers were constructed, and everyone admitted that in a sanitary sense Lancashire was put forward

twenty-five years ahead of the rest of the country by the advancement of that money. The term had now nearly run out for the repayment of the whole of the loan, and up to that date not one sixpence of the debt had been repudiated, but every farthing due had been honestly repaid. In distributing State money on previous occasions large sums had been spent on administration and supervision. In the case of Lancashire the supervision of the expenditure centred in himself, and the total cost to the State for administering the 1¾ millions of money did not amount to 3/6 per cent. Loans of this sort should be administered at the lowest possible cost to give the greatest possible benefit; and the State, instead of attempting to make a gain by charging a high rate of interest, would do wisely to lend the money under proper guarantees, even at a trifling loss to itself, though there was no necessity for that.

URBAN SANITARY DISTRICTS.

	Population as by Census, 1881.	Valuation.		Population as by Census, 1881.	Valuation.
		£			£
Armagh	10,070	16,925	Kilkenny	12,299	17,288
Athlone	6,755	9,517	Killarney	6,651	7,698
Ballinasloe	5,052	8,743	Kilmainham	5,391	7,241
Ballymena	8,883	21,414	Kingstown	18,586	78,000
Banbridge	5,609	12,646	Kinsale	5,386	5,760
Bangor	3,066	10,916	Letterkenny	2,188	3,401
Belfast	208,122	549,560	Limerick	38,562	66,343
Blackrock	8,902	49,139	Lisburn	10,755	18,383
Bray	6,535	25,570	Listowel	2,965	—
Carlow	7,185	11,125	Londonderry	29,162	69,032
Carrick-on-Suir	6,583	8,914	Lurgan	10,135	18,408
Cashel	3,961	3,690	Monaghan	3,369	5,913
Clonakilty	3,676	4,856	Navan	3,873	5,890
Clonliff, Drumcondra, & Glasnevin	4,865	17,978	New Ross	6,670	8,038
			Newry	14,808	32,760
Clonmel	9,325	15,336	Newtownards	8,676	10,347
Clontarf	4,210	17,520	Parsonstown	4,955	8,731
Coleraine	5,899	12,805	Pembroke	23,222	91,684
Cork	80,124	152,070	Portadown	7,850	17,458
Dalkey	3,234	13,196	Queenstown	9,755	20,867
Drogheda	12,297	19,104	Rathmines and Rathgar	24,570	113,118
Dromore	2,491	4,503	Sligo	10,808	19,019
Dublin	249,602	651,443	Templemore	2,800	3,926
Dundalk	11,913	21,477	Thurles	4,850	6,110
Dungarvan	6,306	8,269	Tralee	9,910	12,044
Ennis	6,307	6,907	Trim	1,586	2,154
Enniscorthy	5,666	6,944	Warrenpoint	1,887	7,388
Enniskillen	5,712	11,331	Waterford	22,457	38,161
Fermoy	6,454	9,875	Wexford	12,163	15,784
Galway	15,471	26,135	Wicklow	3,391	6,270
Hollywood	3,293	11,571	Youghal	5,396	9,571
Kells	2,822	3,530			

PARTICULARS OF SOME LOANS FOR WATERWORKS.

PLACE.	Population, 1881.	Valuation.	Loan.	Proportion of: Loan to population	Loan to valuation.	Valuation to population.	Initial rate (possible maximum)	
		£	£	£	£			
Urban Districts.								
Bangor	3,066	10,916	9,878	3·22	0·90	3·58	14·40	In progress
Warrenpoint	1,887	7,388	6,000	3·18	0·81	3·91	12·15	
Hollywood	3,293	11,571	10,000	3·04	0·87	1·51	13·05	
Sligo	10,808	19,019	28,000	2·60	1·47	1·76	22·05	In progress
Ballymena	8,883	21,414	23,000	2·59	1·07	2·41	16·05	In progress
Wexford	12,163	15,784	30,000	2·47	1·90	1·30	28·50	
Dundalk	11,974	21,477	26,000	2·17	1·21	1·80	18·15	About to be commenced.
Fermoy	6,454	9,875	13,000	2·01	1·32	1·53	19·60	In progress
Wicklow	3,391	6,270	6,000	1·77	0·95	1·85	14·25	
Ennis	6,300	6,907	11,000	1·75	1·59	1·10	23·85	
Tralee	9,396	12,044	15,666	1·67	1·30	1·28	19·50	
Coleraine	6,694	12,805	9,300	1·39	0·73	1·91	10·95	
Enniskillen	5,712	11,331	7,700	1·35	0·69	2·00	10·35	
Killarney	6,651	7,698	8,000	1·20	1·04	1·16	15·60	In progress
Rural Districts.								
Greystones	355	2,125	2,500	7·04	1·18	5·99	17·70	
Rostrevor	600	3,602	3,900	6·50	1·08	6·00	16·20	
Portrush	1,196	5,949	6,500	5·44	1·11	4·97	16·65	
Lisdoonvarna	398	2,236	1,950	5·00	0·87	5·62	13·05	
Kilfenora	307	3,669	1,266	4·01	0·37	11·95	5·55	
Enniskerry	400	998	1,400	3·50	1·40	2·50	21·00	
Dungannon	4,081	10,456	13,500	3·31	1·29	2·51	19·35	
Omagh	4,126	9,000	12,115	2·94	1·30	2·18	19·50	
Kildorrery	400	15,896	1,050	2·63	0·06	39·70	0·80	
Buncrana	764	2,382	2,000	2·62	0·84	3·11	12·60	About to be commenced.
Strabane	4,196	13,070	9,400	2·24	0·72	3·12	10·80	
Limavady	2,954	5,364	6,000	2·03	1·12	1·81	16·80	
Ballymoney	3,049	7,000	6,000	1·97	0·86	2·30	12·90	In progress
Ramelton	1,600	2,768	2,820	1·76	1·02	1·75	15·30	
Moville	1,129	1,970	1,846	1·64	0·90	1·75	13·50	
Strokestown	700	2,439	1,100	1·57	0·45	3·50	6·75	
Keady	1,598	4,690	2,500	1·56	0·53	2·94	7·95	
Mallow	4,439	11,250	6,250	1·48	0·55	2·53	8·25	
Larne	3,995	9,556	5,000	1·25	0·52	2·39	7·80	In progress
Miltown Malbay	1,400	3,450	1,650	1·17	0·48	2·46	7·20	
Loughrea	3,159	¾ on 4506 / ¼ on 2959	3,770	1·16	...	...	9·41 / 4·80	
Lisbellaw	335	623	300	0·89	0·48	1·86	7·20	Rate paid by landlord, J. G. V. Porter, Esq.
Irvinestown	800	1,487	650	0·81	0·44	1·86	6·60	
Kilfinane	1,299	5,143	800	0·62	0·15	3·95	2·25	
Bushmills	1,008	1,901	600	0·60	0·32	1·89	4·80	
Ennistymon	1,331	4,385	650	0·48	0·15	3·30	2·25	
Ligoniel	3,497	3,838	1,650	0·47	0·43	1·10	6·15	
Galbally	200	333	300	1·50	0·90	1·67	13·50	
Little Island	500	2,990	1,250	2·50	0·42	5·98	6·30	
Belmullet	900	⅔ on 1773 / ⅓ on 9153	1,422	1·58	...	...	9·72 / 0·47	

The rates in the last column show the maximum possible rate if the Loan were for 50 years repayable by instalments. The actual initial rate may be less, owing to income from other sources.

WATERWORKS.

DIFFERENT TYPES OF CONSTRUCTION.

1.—*Artificial Storage Reservoirs.*

Ballymena	Population,	8,883	Capacity of Reservoir,	—	Million Gallons.
Bangor	„	3,066	„	20	„
Dundalk	„	11,913	„	32	„
Ennis	„	6,300	„	25	„
Hollywood	„	3,293	„	11	„
Moville	„	1,129	„	2	„
Fermoy	„	6,454	„	27	„
Omagh	„	4,126	„	25	„
Portrush	„	1,196	„	9	„
Dungannon	„	4,081	„	15	„
Ramelton	„	1,600	„	7	„
Wicklow	„	3,391	„	17	„
Mallow	„	4,439	„	3	„
Sligo	„	10,808	„	50	„
Buncrana	„	764	„	—	—

2.—*Lakes made to act as Storage Reservoirs.*

Armagh	Population,	8,797	.....	Lowry's Lough.
Newry	„	15,084	.....	Cam Lough.
Ballina	„	5,760	.....	Lough Broghly.

3.—*Service Tanks only.*

Tralee	Population,	9,910	Capacity of Tank,	855,000	Gals.	Supplied from a Stream.
Killarney	„	6,651	„	150,000	„	„
Belmullet	„	900	„	59,000	„	„
Greystones	„	700	„	476,000	„	„
Enniskerry	„	400	„	100,000	„	„
Coleraine	„	6,694	„	600,000	„	Supplied from Springs.
Larne	„	3,995	„	370,000	„	„
Limavady	„	2,954	„	135,000	„	„
Lisbellaw	„	335	„	169,000	„	„
Bushmills	„	1,008	„	10,000	„	„
Galbally	„	200	„	2,800	„	„
Kilfenora	„	307	„	37,500	„	„
Irvinestown	„	800	„	32,000	„	„
Little Island	„	500	„	3,200	„	„
Ballymoney	„	3,049	„	Drumbest Lake		Full of Springs.

4.—*Pumping by Turbines.*

Loughrea	Population,	3,159	Capacity of Tank,	118,000	Gallons.
Strokestown	„	700	„	400,000	„

On "Sewage Disposal," by Professor HENRY ROBINSON, M.INST.C.E., F.G.S., F.R.MET.SOC.

THE outcome of several public enquiries which have taken place during the last year or two, and of much valuable data derivable from other sources, establish, we think, a well-marked advance with reference to sewage disposal; and it may be of use, as well as of interest, if we lay before this Congress the conclusions which, we conceive, are deducible therefrom. We propose to deal with the subject under the following heads: 1. Sewage disposal on land. 2. Sewage disposal by chemical treatment. 3. Sewage disposal by discharge into a tidal river, or into the sea, without treatment.

1.—SEWAGE DISPOSAL ON LAND.

The object of dealing with sewage on land may be taken as twofold, namely, to purify it (which is the sanitary object), and to utilize its manurial products (which is the agricultural object). Where want of skill, or where prejudice has existed, these two have not been properly separated, and the results have been in many cases unfavourable to sewage disposal on land from either of the beforementioned points of view.

It has been regarded as an axiom that clay land cannot be employed to clarify sewage. This is true when it is proposed to pour the sewage on it as if the land were porous. Very recent experience, however, has led to clay land being converted from an impervious to a pervious condition, by which it has been successfully utilized. This is effected by digging out the clay to a depth of about 6 feet, burning it into ballast and replacing it in layers, interposed with an occasional layer of open alluvial soil, the whole area being well drained with a free outlet for the effluent. We have successfully carried this plan out, and with the result, that whereas it was not possible previously to clarify the sewage of 100 people to an acre of clay land, the prepared filtration area has been able to continuously clarify the sewage of about 1,500 people to the acre. The cost of converting clay land into this form of filter may be taken as varying from £750 per acre to £1,000 per acre according to local circumstances. One area which we have just completed has cost £1,000 per acre. Before sewage is passed on to these filters (or on to land) it should be strained so as to remove the larger particles. The best arrangement for this purpose is to pass the sewage upwards through a straining medium (not downwards), and to run the solids from the bottom of the straining tank on to a low-lying piece of land for digging in as they are run out.

Where such a filtration area is made to form part of a sewage farm it acts as a safety-valve, and enables the land and crops to have a rest when they do not require further irrigation; at the same time the process of purification is not interrupted.

If open porous land is available for sewage purification, and if it can be drained 6 feet deep to a good free subsoil, so that the effluent can get readily away, we find that the sewage of from 600 or 700 people can be dealt with on each acre per annum with both good agricultural and sanitary results.

In our Address as President of the Engineering and Architectural Section of the Congress of this Institute at Newcastle-upon-Tyne, in 1882, we directed attention to the important investigation which had been conducted by Mr. R. Warrington, of Rothamsted, the result of which was to show the action which goes on in the soil when sewage is passed through it. Further information, which the same observer has published since that date, is of equal value, and deserves to be read by all who have to advise in regard to sewage disposal on land. The process of "Nitrification" (as it is termed), which he has so fully investigated, consists in the conversion into nitrates (which serve to nourish plant life) of the organic matter in sewage. This takes place by the action of a living ferment of the bacteria family, which is created by and feeds on the impurities in sewage, and these organisms both consume the impurities and convert them into nitrates.

The action of living agents thus brings about the oxidation of the organic matter in sewage, just as worms, larvæ, fungi, and insects, feed on the vegetable matter in the soil, increasing the amount of nitrogenous material in it.

Experience during the past year or two has proved the feasibility of preserving green crops in a succulent state by compressing them in Silos, so that they can be utilized for cattle fodder in the winter. This system deserves notice in connection with Sewage Farming, as we are of opinion that it will prove a valuable means of getting over the well-known practical difficulty which is experienced of finding a market for the large amount of green crop which is produced by sewage irrigation. In speaking of this system the term "Silo" is applied to the artificial chamber or receptacle for green crops (such as grass, vetches, clover, &c.). The term "Silage" is applied to the crop thus treated, and the term "Ensilage" is applied to the process of making "Silage." The details of the construction of Silos cannot be referred to here beyond stating

that what is required is to construct a pit or chamber either in the form of an excavation in the ground, with a brick or other lining, or by building it above the ground. The object is to enable the green crop to be deposited in an air and water-tight chamber, in which pressure can be applied to the crop to compress it. This is effected in some cases by well treading the crop after it is laid in the Silo, and then spreading layers of earth to about a couple of feet and pressing the covering well down. Another way is to construct the Silo with a movable covering of the exact size and shape of its interior. This cover is raised and lowered by suitable chains and rollers. After the crop is placed in the Silo the cover is lowered and weighted, so that a thorough compressing is effected; the weight applied giving about 200 lbs. or so per square foot of surface. Salt is sometimes added as the crop is placed in the Silo. A crop thus dealt with is stored for months; when the Silo is opened the fodder is found preserved, and in a state readily taken to by cattle. It is desirable to choose the site for the Silos so that the fodder is preserved somewhere near the place of consumption; also to lay out the works so that as little handling as possible is required. For instance, the Silo should be on sidelong ground, so that the crop can be carted and tipped at a high level, and the silage taken out for use at a lower level.

2.—Sewage Disposal by Chemical Treatment.

In the last edition of our book on "Sewage Disposal," in speaking of precipitation, we said "the purification of sewage by Chemicals has been the subject of misapprehension, owing to the extravagant advantages which have been claimed for the system by its advocates." This is even more true now than it was two years ago, inasmuch as in the recent scheme for dealing with the sewage of the Thames Valley chemical treatment *per se* was relied on to produce from the sewage of a future population of 350,000 an effluent at all times fit to be discharged at one point into the river Thames above London, but the Parliamentary Committee rejected it. One part of the report of this Committee deserves attention, when speaking of sewage treatment by chemicals. It is as follows:—"Your committee believe that in these cases the process of filtering the chemically purified effluent through earth ought, if possible, to be adopted, which was not provided for in the scheme under their consideration." This opinion is exactly in accordance with our experience, and is that which we have held throughout. It is at the root of the whole matter, because efforts are made by those interested in chemical processes to attain as high a standard of purity as possible with the attendant heavy expense

of chemicals. Experience shows that it is impossible at all times and seasons to be sure of a constant and uniformly high standard of purity, and that chemical works should be supplemented by a filtration area, however small. The addition of this, however, enables a lower standard of effluent from the precipitation tanks to be admissible, and this can be attained with very simple and inexpensive chemicals.

In the course of our practice we have had to advise as to the majority of the processes, and to design the works for their being carried into operation. We have found that the cost of such works complete varies from ·091 to ·166 of a £ per head of the population, and that the average cost of the works at several towns which we have been connected with is ·123 of a £ per head. This figure may be conveniently followed by that of the cost of treatment, which we find varies from ·036 to ·110 of a £ per head per annum, and an average of several places gives ·06 of a £ per head per annum. The above figures apply only to places where the very highest standard was sought to be attained, but our more recent experience leads us to modify the arrangement of the works and the cost of treatment, so as to rely on filtration of the effluent as an important factor. We estimate that under these conditions the cost of the works complete would be about ·075 of a £ per head, and the cost of treatment ·04 of a £ per head per annum.

The disposal of the sludge has always been a difficulty in these works, but this is now overcome in two ways: either by digging it into the ground, as is done at Birmingham now, or by pressing it into cakes in filter presses. It is found at Birmingham that one ton of sludge with 90 per cent. of moisture is produced from 1,000 people. There the lime process is used. We have found that about one ton to 2,000 people is produced where a salt of alumia or iron is used with the lime. At Birmingham the sludge is dug into the land adjoining the works, and it is found that one square yard of land will take one ton of sludge with 90 per cent. of moisture once in three years, which results in three yards of land being required to be provided for each ton of sludge. This system of digging in sludge is successfully carried out as regards freedom from nuisance. Where land is not available to dig in the sludge it is necessary to make it portable for removal and disposal away from where it is produced. This is best effected by filter presses. Appliances are made for this purpose, by which the sludge is pressed to a consistency of about 50 per cent. of moisture. The cost of effecting this is about ·007 of a £ per head per annum. It is found in practice that where the sludge is produced by straining the solids from sewage before

passing it on to land for purification, it requires a little lime to enable the press to work well. About two barrow loads of lime for each ton of pressed sludge suffices.

It has been thought that the cost of precipitation would be covered, and even a profit gained, by the sale of the sludge. This hope, however, is not nearer realization now than it was in the time, now gone past, when chemical processes were relied on to turn sewage from a profitless into a profitable commodity. There is, consequently, less justification now than there was at that time for adopting a precipitation system for sewage disposal. It is entirely a question of carefully considering the engineering and financial points involved, regardless of the sanguine representations of interested or enthusiastic advocates of any particular system.

As the estimated manurial value of the sludge which is precipitated from sewage by the addition of chemicals does not seem to be capable of realisation, we think that probably the reason may be found in the fact that the chemicals arrest that process of decomposition which is essential to the conversion of the organic matters into nitrates for vegetation to utilize. This explanation will be understood in the light of what we have already described in regard to "nitrification." If this view is correct it would follow that the more completely and permanently the sludge is deodorized by the chemicals the less capable is it of passing through the necessary stages of decomposition by which its manurial value can be realised.

As mistakes are constantly being made in regard to the weights of sludge with varying degrees of moisture, the following table may be useful:—

100	tons of sludge with	90	per cent. of moisture=	50	tons with 80	per cent.
100	"	"	"	33·3	" 70	"
100	"	"	"	25	" 60	"
100	"	"	"	20	" 50	"
100	"	"	"	16·6	" 40	"
100	"	"	"	14·3	" 30	"
100	"	"	"	12·5	" 20	"
100	"	"	"	11·76	" 15	"

3.—Sewage Disposal by Discharge into River or Sea.

We will next deal with the conditions which should be fulfilled where it is sought to utilize a river or the sea into which to cast the sewage of a town. If it can be ascertained beyond question that at the proposed point of discharge the currents at all times will carry the sewage right away, and will not at the same time produce mischief at a distance (which is often

omitted from the consideration), then that arrangement may be accepted as a good one. This, however, seldom occurs.

A river has been looked upon by manufacturers and local authorities as the natural carrier of the refuse from their district. This view has been persevered in in spite of the Rivers Pollution Prevention Act of 1876, which is practically a dead letter. The public, however, who use a river either for pleasure purposes or for obtaining their water supply, have of late years grown more and more united in their efforts to stop this abuse; and there is no doubt that these efforts will eventually succeed. In a paper which we read last year at the Congress at Glasgow we pointed out the steps that were necessary to be taken to render this Act operative, and we refer our hearers to that paper if they wish to follow the matter further.

The effect of discharging sewage matter into a river has been the subject of much controversy amongst chemists. Some allege most positively that the injurious properties in the sewage are indestructible. This has led to alarmists demanding that under no circumstances ought sewage to pass untreated into a river. We have given considerable attention to this vexed question, as it requires to be grasped by any engineer who has to advise on the selection of sewer outfalls, and it appears to us that the balance of evidence is against the alarmists. Every river has a certain power of oxidizing impurities in proportion to the extent of oxidization of the river itself. Besides this, there are the powerful purifying influences exercised by the plants and animalculæ which exist in rivers.

It has been ascertained that entomostraca consume dead animal matter, and where this is wanting they do not live, but where it is in abundance they thrive. It follows, then, that these minute animals exercise an important function in absorbing sewage impurities. They multiply prodigiously in these impurities, and are both created by them and fed upon them, converting foul and dangerous matters into harmless ones, in a similar way to that which we have referred to as nitrification when speaking of the action of bacteria in the soil. Considering that these organisms arise from and are fed on concentrated filth, it is obvious that they cannot live when the conditions favourable to their existence disappear. This would be the case when the sewage is discharged into a large volume of water with a different temperature to that which suits them, and with powerful oxidizing influences at work. These conditions, added to the difficulty they must experience to find their natural food—namely, concentrated sewage—where the sewage matter becomes so greatly diluted, accounts for the fact that in a short run of a good river, sewage impurities

largely disappear. The action of weeds and plants also aids purification to a very large extent. Minute plants, such as confervoid algæ and the like, also assist in oxygenating the river, as when exposed to light they decompose carbonic acid, and liberate oxygen.

The practical question which has to be answered in every case where sewage is proposed to be discharged into a river requires to be approached from two points. The first is whether a nuisance will be caused at the spot to which objection would be taken. If this is likely to be the case then the fact that the sewage will get purified in a short run of the river does not meet the objection. The second point requires a careful consideration of the condition of the river, both from an engineering as well as from a chemical and biological point of view. Decisions on these matters have too often been arrived at in a rough and ready way. They require skilful treatment, as the interests—both commercial and hygienic—which are affected are too great to permit of them being dealt with by any who are not well-informed and careful.

The general conclusions which we deduce from our observations are as follows:

1. That chemical precipitation is not so necessary now, as it was considered to be a few years ago, in cases where land for irrigation is not procurable.

2. That the efforts to profitably remove the manurial elements from sewage by chemicals not having been successful, the system should be adopted *per se* only where a filtration area cannot be obtained.

3. That the success which has attended the construction of filtration areas where the land is clayey, and the successful results which have been obtained from a combined straining of sewage and of subsequent filtration through small areas of artificial filters, point to the adoption of one or other of these systems in many cases where chemical treatment would previously have been advised.

4. That the injurious effects of passing untreated sewage into a river depend upon not merely the relative volumes of the sewage and the river, but chiefly upon the power of the river to oxidize the sewage, which power is in proportion to the extent of oxidation of the river itself.

[*For discussion on this Paper see page* 239.]

On "The Collection and Disposal of House Refuse," by W. EASSIE, C.E., F.L.S., F.G.S.

It is most interesting, as well as instructive, to read in the pages of medical and sanitary journals how the dry refuse from houses is dealt with in various home, continental, and transatlantic towns and cities. But it would be a work of supererogation to lay before you even a digest of this, and in the few remarks which I have to make I will confine myself, as far as I can, to the method of dealing with the dust from houses in our home towns and cities, giving express notice to the methods which rule the disposal of dust in the London Metropolitan district. This information has cost me much time and considerable expense to collect.

I have not been able to find any statistics giving anything like the exact analysis of the various materials which go to make up ordinary house refuse, such as is thrown into the dust-bin, but whilst Paris was scavengered in the ordinary way by rag-pickers or *chiffoniers*, and before the present municipal cart system was introduced, that city possessed about 500 rag merchants, who employed each some half-dozen rag pickers, whose duty it was to collect and sort the house refuse thrown outside the houses. Out of every 136 lb. of refuse thus collected in Paris the following gives the analysis of what can be sold: Paper, 40 lb.; rags, old linen, and wool, 18 lb.; bones, 28 lb.; glass, 8 lb.; waste cloth, dressmakers' scraps, thread, &c., 19 lb.; iron, brass, and lead, meat tins, and capsules from bottles, 13 lb.; old shoes, leather, &c., 6 lb.; corks, indiarubber, and broken toys, 4 lb.

The above will not give any fair estimate of London refuse, because it represents only the weight of the assorted articles taken from out of the dust, and does not include household ashes, the excrement of which, in our country, where coal is so abundantly used, would, it must be remembered, largely increase the amount. In most towns there would be a much heavier item for broken earthenware, for old blacking-pots, ink bottles, and the like. In the analysis of the Parisian refuse, I only mentioned articles which were of value to the rag-picker, and there must of course be a great deal of earthenware thrown away there, but taking into consideration the inhabitants of the two cities, Paris and London, there could be no question that in the item of glass and earthenware the quantity yielded in London would preponderate. One thing I dare be certain about,

and it is that London would beat the whole of continental Europe in a show of empty ink bottles and medicine bottles. Some time ago, my friend, Dr. Roth, of Dresden, the eminent state sanitarian, put himself under my care, to show him among other things how we managed the disposal of our house and street refuse. I took him to Paddington, which is the most complete establishment I know of, and we were amused upon seeing the number of full medicine bottles which had never been emptied, as compared with the empty bottles which had been thrown into the dust-bin.

The most complete treatise dealing with the collection and removal of refuse from houses, as enjoined upon every local authority by the Public Health Act, 1875, is that of Mr. Percy Boulnois, C.E., which will be found under the head of Scavenging, in his work published in 1883, entitled "The Municipal and Sanitary Engineers' Handbook." He enters fully into the law of dust removal, but I have not time to allude to this, and desire rather to make a few remarks concerning the practice of dust removal as it is carried on at present.

House dust in London and its suburbs is either collected by scavenging carts, the bells attached to which in some towns inform the householder that the dustman is passing, and that his portable receptacle of dust and other refuse, which he has previously placed in a handy spot, will be carted away on pointing it out. Or if dust-bins are the rule, the letter D placed in the window will indicate to him that the bin is full and must be emptied. It is not often that the dustman calls without invitation, and more often he requires the solace of a small honorarium, especially if there is any garden refuse, wall plaster, old paper-hangings, green-house clinkers, or extraneous matter of that kind, which according to most authorities the local board are not expected to remove. Only ashes, peelings, kitchen vegetable leaves, and inside house refuse is bargained for.

All sanitarians, medical or engineering, are of opinion that something better than our present system of dust-bin storage might be devised. Not that the dust-bin is outrageously evil in its conception, but rather that it is abominably treated. It should not contain vegetable and animal matter commingled, rendering the neighbourhood, during the upheaving and emptying of the fermenting matter noisome with dangerous gases, and not only this, but causing the dust-cart to give off these foul gases during its progress through the streets.

Undoubtedly, the dust-bin could be made portable, the contents kept automatically disinfected every time the lid was raised, but the chief amelioration would result from a constant

burning of the vegetable refuse in the kitchen fire. This, however, would require almost to be made incumbent upon the householder by some bye law, which is hardly likely to be enacted. One word more about these fixed dust-bins and I have done with them. They are seldom water-tight, mostly placed against the wall of the house, and allow the liquids to drain under the floors and cause a rising dampness in the wall or the porous walls permit of the foul air being sucked through the walls into the warm rooms.

In London they are mostly constructed underneath the area steps, and their exhalations are breathed by servants, tradesmen, and passers by; but frequently it will be found that one of the area vaults has been appropriated, and it needs no argument to show how such large receptacles must affect the sweetness of the basement. I have more than fifty times also found the dust-bin inside a vault which is enclosed in the house, and thus virtually poisoning its atmosphere. Very often, too, just above the dust-bin will be found a cistern, with a badly fitting cover, and supplying some of the sinks in the basement.

The contents of all dust-bins, at least in London, resolve themselves in four products:—1st, the "ash," or that compound of fine ash, boot brushings, house dust, &c., which is for the most part moulded into bricks; 2nd, the ashes or cinders and fine coal which will not pass through the sieve with the foregoing, and which is called "breeze" and used as fuel wherewith to bake the bricks; 3rd, "hard core," such as broken pottery and other hard refuse which is not worth selling, and is chiefly used for road making; and lastly, "soft core," which means all kinds of animal and vegetable refuse, of course the most difficult material to deal with, necessitating, as in the case of Lambeth heaps, sprinkling with carbolic acid powder before it is barged away for agricultural purposes.

By far the greater number of the Metropolitan vestries, viz.:

The Strand,	Poplar,
Westminster,	Hampstead,
St. Giles,	St. Pancras,
Holborn,	St. Saviour's, Southwark.
Rotherhithe,	Lambeth,
Shoreditch,	Camberwell,
Hackney,	Wandsworth,
Bethnal Green,	St. Marylebone,
Whitechapel,	Chelsea,
St. George in the East,	Limehouse,

contract with different parties to call round at every street in the district from twice a week to once a fortnight, and in

most cases, they pay the contractor to cart the dust away. The contractor has in the majority of cases, a wharf on the river or canal, as the case may be, where he either sifts and sorts the refuse and disposes of it piecemeal—the "ash" and "breeze" to brickmakers, the "hard core" to contractors for road foundations, and the "soft core" to market gardeners and farmers for manure, or he shoots the refuse direct into barges, without sifting, and disposes of it as it is to brickmakers. If he finds no ready market for the dust, &c., he either lets it accumulate or takes it down the Thames, presumably beyond Lee Reach, and shoots it into the water.

In the case of some of the outlying districts, such as Hampstead, the contractors simply cart the refuse and dust in bulk to brickfields in the neighbourhood. Many of the vestries contracting as above are thinking of adopting better methods of disposal and working the system themselves, thus saving expense. The Poplar Vestry has just instituted pails in place of dust-bins, and is negotiating for a piece of land, where they propose to erect a furnace and to try burning the greater part of the refuse.

The system adopted by St. Olave's, Hammersmith, St. George the Martyr, and Bermondsey is somewhat similar to the above; they each have a wharf in their respective districts, where they shoot the dust, sift and sort it, and then contract with a man to take it away.

Islington, Plumstead, Mile End, Woolwich, Lewisham, Clerkenwell, Greenwich, Kensington, St. Mary's (Newington), Paddington, St. Luke's (City Road), and the City Commissioners dispose of all refuse themselves. Of these Clerkenwell, St. Luke's (Paddington), and Plumstead have wharves where they sort, and whence they barge away to sell for brick-making, road-making, and manure.

Islington, Mile End, and St. Mary's (Newington) have each a depôt, where they screen into trucks and send off to the country by rail.

Lewisham, Greenwich, and Kensington shoot at various places, without sorting; in fact, at any place in their districts where they can find a market, the places being mostly brickfields.

Woolwich shoots at Charlton, where there is a place wants filling up.

The City Commissioners burn their refuse. Of the above special mention should be made of St. Mary's (Newington), Paddington, and the City Commissioners.

St. Mary's (Newington) has a large depôt in their district of Walworth, on the London, Chatham and Dover Railway, and

one in the country at Longfield. Their carts call round at each street once a week and take all dust, refuse and slops to their depôt in Walworth. Here the dust and refuse are sifted and sorted in the way common among the contractors by women. The ashes and breeze are sold to brickmakers, the hard core for road foundations, and the soft core and slops (after being treated as explained hereafter) for manure.

The manure or "mixture," as they term it, is made in the following way:—A large bed is made about eight inches deep, of old straw, bought by the vestry from the various stables in the district. On this foundation the soft core, consisting of paper, rags, peel, &c., is spread, then another layer of old straw, which is heaped up at the edges so as to form a basin or tank about four feet deep. In this basin the slops obtained in wet weather are emptied, and dry dust is sprinkled on the top of all. The bed thus formed is then allowed to stand for a week or so, at the end of which time all the superfluous water has drained away through the straw, and the "soft core" has fermented and rotted and become thoroughly decomposed. The bed is then mixed up and sent away in trucks to the country, where there is a very ready sale for it among the farmers for manure. As many as thirty trucks a day are sent away from here sometimes. The Commissioners have six of these beds, which they work alternately, and there is very little perceptible odour arising from them.

The country depôt at Longfield is used for storing the ashes, &c., when there is not a ready market for them. The system appears to work very well.

The Paddington system is chiefly remarkable for the method of sifting and sorting by machinery, thus to a great extent obviating the necessity of employing the manual labour of women. The dust, &c., brought in by the carts is shot into a large screen, which separates the larger materials such as flower pots, bottles, and culinary utensils. The smaller material is carried up by buckets fixed on an endless chain, and is emptied into two sieves placed at an angle to each other like the roof of a shed.

The paper, bones, &c., collecting on these is raked off by women and sorted, and the dust and ashes falling through is brought up by another system of buckets on an endless chain, and conveyed along a wooden trough into the barge, where it is taken away and sold to brickmakers. The soft core sorted out is sold as manure or burned, and the hard core is used for road foundations as usual, the flower pots, &c., being taken out, of course, and sold separately.

The slops are emptied into a large tank built of wooden planks, the planks being placed some two or three inches

apart, and the crevices thus formed filled with straw. Through this straw the water drains, and runs away into the sewers. The resulting dry mud is barged away and makes a good mould.

The yard is kept in very good order and is quite extensive, all the vestry carts being made here, and the horses being stabled and shod here.

The City Commissioners of Sewers burn their refuse, and the system is said to give every expected satisfaction. The other vestries who make use of a furnace for burning some of their soft core—the Newington and St. Olave's—are of opinion that the refuse burns very slowly and is very troublesome.

The system of destruction of all kinds of house refuse by burning it in suitable furnaces was reported upon by Dr. W. Sedgwick Saunders in 1851, and it may be taken as forming the most complete essay upon the subject. In this process, which has been largely adopted in Leeds, Bradford, Warrington, and Manchester, &c., &c., and in Continental cities, an apparatus which is termed a "destructor" destroys by fire everything combustible in house and trade refuse; and the second apparatus, which is called the "carboniser" deals with the vegetable matter and converts it into charcoal. At Leeds, large masses of refuse, house dust, market and paved street sweepings, midden night soil, are delivered on the top of the "destructor," and as the material perishes from below it sinks down the surface holes, and at the front, pots, pans, glass, crockery, clinkers, and all coarser materials are extracted. The large quantities of iron utensils fall to the front and are raked out and allowed to cool, and afterwards sold. When the clinkers, molten metal, and glass, all of which are fused together, has been drawn from the "destructor," the clinkers which result from the process of burning the refuse are in some places ground into powder, and when mixed with lime and water it forms a cement which is much sought after; hard bricks are also made from the same material.

I have nowhere in this paper referred to or intended any reference to the treatment of condemned meat and the best method of dealing with that, but have confined myself simply to the disposal of the dust from ordinary dust-bins. I may mention, however, incidentally, that there can be no doubt that "the carcass-crusher, or devil" at work near Warrington, &c., which breaks up the body which is afterwards treated by the rotary fat rendering machine of Mr. Firman, is the completest and most satisfactory method of dealing with that.

Mr. Healey, of Brig House, near York, has lately brought out an improved furnace for converting town and other refuse into clinkers, which appears to be very simple. It would have the apparent advantage over some other methods, that very bulky articles could be destroyed in it, such as bedding, mattresses, and the like.

Anyone who thinks that a system of taking the refuse of towns or cities by barges out to the sea and emptying it there, must have a very poor notion of how much more satisfactorily and economically this material can be disposed of by separation, appropriation, or destruction. At New York, and I believe in Liverpool, a great deal of refuse has been got rid of by sea immersion, but it would appear that it was simply for want of space and convenience to utilise it that this crude system of disposal was resorted to.

After a due consideration of the foregoing statements, I think it will be taken for granted that the burning of the refuse is the most satisfactory system extant. There seems to be a very general feeling in favour of this mode of disposal, provided it can be effected easily, and numbers of the vestries are watching with interest the results obtained by the City Commissioners and the system adopted by St. Mary's (Newington).

[*For discussion on this Paper see page* 239.]

On "Public Cleansing," by JAMES YOUNG, Superintendent of Cleansing, Dublin.

The cleansing of towns cannot be termed a pleasing topic, but its consideration is none the less necessary, and cannot be excluded from the subject of sanitary reform. Public cleansing is closely allied to public health, and its efficiency undoubtedly tends to lower the zymotic death rate, and promote the general health and comfort of the citizens.

For this reason, therefore, the following observations regarding the scavenging of Dublin, and our general experience of cleansing work may be of some interest to the Sanitary Institute of Great Britain.

To those connected with cleansing or sanitary work, it is gratifying to remember that the illustrious Pericles was chief scavenger of Athens. On assuming this position he stated that

if he could not derive dignity from the office, he would confer dignity upon it. Unfortunately history gives us no record of his experience.

A distinguished modern sanitarian describes perfect scavenging as "the immediate removal of all matter liable to pollute earth, air, or water."

Dirt in a large city is certainly in the wrong place, the difficulty is to find the right place and remove it thither without delay, in the least objectionable manner and at the least possible cost. Each city must solve this problem for itself, according to its peculiar circumstances—its situation, water supply, sewerage, and the habits of the population must all be considered.

In Dublin all these points were amply and ably discussed at the sittings of a Royal Commission in the year 1879. In the report of the Commissioners, the state of the tenement yards and the efficiency of the then existing scavenging arrangements, is referred to in anything but complimentary terms, and one of their recommendations was, "That the entire scavenging of Dublin, both public and domestic, be undertaken and carried out by the Corporation."

Subsequently the cleansing committee was formed, action was promptly taken, and the public scavenging was re-organised. Loans were obtained, ground was acquired, stables and other offices were built, horses and plant were purchased, and in 1882 the domestic as well as the public scavenging of the city was undertaken.

The city of Dublin includes an area of 3,754 acres, and contains a population of 250,557, or 65·8 per acre, the assessable value may be taken at £652,000, one penny in the pound producing, in round numbers, £2,450. The cleansing of the city, public and domestic, cost in 1883, £26,745, and at present 440 men and 102 horses are employed in the work.

The new premises forming the head-quarters of the cleansing department are centrally situated, having a frontage on Wood Quay, and extending in rear to Winetavern Street.

The buildings include the superintendent's offices, foremen's dwelling houses, stabling for sixty horses, forage lofts with steam power for preparing the forage, cart sheds, goods stores, also joiners, cartwrights, smiths, farriers, saddlers and mechanics' workshops, with muster-room and lavatory for the workmen. The amount expended on the purchase of the site, the erection of buildings, and paving work, has been £6,350.

We have also stations at Stanley Street, Caroline Row, Marrowbone Lane, and Hanover Street, situate respectively in N.W., N.E., S.W., and S.E. districts of the city. At these four stations fifty horses with corresponding plant are kept, but

all are managed from Wood Quay, with which they are in telephonic communication.

The cleansing of the city, under one management, is divided into three sections, viz: (1) the cleansing of the tenement yards; (2) street scavenging; (3) domestic scavenging, or house-refuse and night-soil removal.

The city is divided into eight cleansing districts, which apply to all the three sections of scavenging.

1. *The Cleansing of the Tenement Yards and Urinals.*—In this, the last organised section of the work, we have sixty-nine men employed, including foremen. Their working hours are from 6 in the morning till 11, and from 12 noon till 5 p.m. Each man has his own beat, which includes on an average about 90 yards, and each ganger is responsible for all the yards in his district. In this way the 5,000 tenement yards, which are common to a number of families, are swept daily, and, at the same time, the closets are mopped and washed. We also wash with hose some of the filthiest courts and yards which are sufficiently well paved to admit of this highly commendable process.

The habits of the occupiers of tenement houses are a source of difficulty in the cleansing of all large towns; but it is unreasonable to expect people to be cleanly in their habits unless their surroundings are kept in a tolerable state of cleanliness; and, until a tenement yard is properly sewered and paved, it is almost impossible to keep it as clean as it ought to be.

In Dublin, I am glad to say that a decided improvement is apparent in the condition of the tenement yards since we undertook the daily cleansing of them. To further improve the habits of the occupiers of these tenement houses, the power vested in the sanitary authority of the Scottish metropolis by the Edinburgh Municipal and Police Act, 1879, and the Edinburgh Municipal and Police Extension Act, 1882, would, in my opinion, be of immense service to us in Dublin. By Section 98 of the above Act, 1879, power is given to prosecute the occupier of a tenement house in cases where refuse has been thrown upon the surface of the yard, although the actual offender has not been discovered. I now quote it.

"Every person who shall throw or cast from any window or other opening or place above the street level of any house or building any water, soil, dirt, filth, or any offensive matter or thing into or upon any street or court, back ground, garden, or place, shall be liable to a penalty not exceeding forty shillings; and in the event of the person committing any such offence not being discovered, the occupier of any room or other apartment, or passage from the window or other opening or place of which

any such water, soil, dirt, filth, or any offensive matter or thing shall be thrown or cast, shall be liable to the said penalty."

In Section 41, Sub-sections 3 and 5a of the Edinburgh Police Extension Act 1882, there are also excellent regulations regarding the house refuse from tenements, and the regular washing of the stairs of these dwellings.

2. *Street Scavenging and Watering.*—There are in all about 113½ lineal statute miles of streets within the municipal boundary of Dublin.

Of these there are—

20¼	miles of	new set paving.
22¾	„	boulder do.
70½	„	macadam.

On account of this extensive area of macadamised streets we have a larger amount of dust and mud to contend with in proportion to the population than most cities.

In 1883, 27,000,000 gallons of water were spread on the streets, and 100,748 loads of scavenge were removed, 36,645 from paved streets, lanes, and markets, and 64,103 from the macadamized streets and roads.

In this section of the work 224 men, including foremen, and 63 horses are employed.

We have ten horse-drawn sweeping machines in use, with which all the principal streets are swept by night; the back streets and lanes are swept with hand brushes by day.

The horse-brushes turn out at eleven o'clock at night, and the day scavengers commence work at 4.30 in the morning, the carts turning out promptly at five o'clock to water or scavenge as required.

All the first and second class streets are cleansed daily, and the third and fourth-rate streets are done three times a week. The asphalted streets are washed regularly with hose.

The lanes of Dublin require and receive quite as much attention as the main streets, on account of the quantity of vegetable and other refuse which is thrown upon them. The abatement of this nuisance, however, has of late received considerable attention from the Chief Commissioner of Police.

3. *The Removal of Night Soil and Domestic Refuse.*—This section of the work commenced in May, 1882, is now fully organised, and a staff of 110 men, including foremen, and 39 horses are employed.

During the present year the quantity of house refuse removed per day has exceeded 250 tons.

The cleansing of the ashpits is done by night—that is between

the hours of 10.30 p.m. and 9 a.m., and the men are paid according to the weight of refuse removed.

When the domestic scavenging was undertaken there were in the city 18,165 ashpits, of which number more than one-half were wet sunken pits, and in addition there were 11,577 common privies.

From more than 10,000 ashpits the refuse could be removed through the house only, and from 13,000 ashpits the refuse had to be carried out in baskets or buckets.

The regular and systematic cleansing of these places revealed in full the necessity for structural and other improvements.

The abolition of privies in all the main streets was first accomplished, and subsequently a system for the daily removal of the shop sweepings and house refuse therefrom was organised. Galvanized iron dust-bins, suitable to the respective requirements of the shopkeepers and householders, are supplied by us at cost price. Three different sizes of covered bins are used for the collection and removal of shop sweepings and dust by the morning bell-carts, and an oblong open bin is supplied for the reception and removal of house refuse.

We have already more than 2,000 dust-bins in regular use, and the number is rapidly increasing. Having insisted on the use of dust-bins of a uniform pattern from the commencement of this branch of our domestic scavenging, Dublin has been spared the nuisance caused by the use of orange boxes, tea chests, hat boxes, and such articles, which are still commonly exposed with house refuse in nearly all large cities.

We have thus two systems in operation: portable dust-bins and fixed ash-bins or ash-pits. The former system is extending in the centre of the city, where fixed ash-pits are being gradually abolished. The latter system however predominates, and the great bulk of the domestic refuse of Dublin is still collected in ash-pits. Much has been done to improve these ash-pits during the last two years, but I freely admit that there is still abundant room for improvement.

Soon after the Cleansing Committee commenced the domestic scavenging, the Public Health Committee undertook the abolition of privies, and the general improvement of the sanitary accommodation provided for the citizens, more especially in the yards attached to the tenement houses. The systematic reconstruction of closets and ash-bins on a uniform plan approved by the Corporation is now in progress.

During the last two years about 3,000 privies have been abolished, and a corresponding number of water closets have been erected; there are now about 18,000 water closets in use,

so that in a few years more we hope to see Dublin a water-closeted city.

The removal of excreta by water carriage has its weak points like any other system, still I feel certain that it is the best that could be adopted for Dublin, considering its proximity to the sea, its abundant water supply, and efficient system of main sewers.

While the excreta, the most noxious, but at the same time the most valuable of the domestic refuse, is thus got rid of by means which sanitary science considers the cleanest, quickest, and best, the remainder of the house refuse becomes to a large extent valueless as manure, and a large portion of it is altogether unsaleable.

We shall now give a brief description of the arrangements for the disposal of the city scavenge, saleable and unsaleable.

The total quantity of scavenge removed during the year 1883 was as under :—

Scavenge from Paved Streets, Lanes, and Markets	36,645 loads.
Do. from Macadam Streets and Roads	64,103 „
House Refuse from Ash-pits	71,476 „
Do. from Portable Dust-bins ...	2,201 „
Total	174,425 loads.

Our saleable scavenge or city manure is composed of the scavenge from paved streets, lanes, and markets, the wet ash-pit refuse and night-soil, and amounts in round numbers to 75,000 loads per annum.

Our unsaleable scavenge, or city refuse, consists of the scavenge from macadamized roads, dry ash-pit refuse, and the contents of dust-bins, amounting in all to no less than 100,000 loads yearly.

To dispose of the saleable scavenge advantageously, as it is produced, in the least objectionable manner, and to get rid of the unsaleable scavenge by the most rapid, efficient, and economical method possible, a variety of circumstances must be considered.

The disposal of the saleable scavenge of any city depends largely on the agricultural area to which there are means of transit, and to which it can be despatched at a profit.

In Dublin we are confined to the farmers around the city, who draw the manure in large quantities from the depôts, and to those having land convenient to the canals, by which we now despatch a considerable quantity annually. But we have no railway traffic in manure, and on the whole the demand for

city manure in the country districts is slow, and the prices obtained for it so very low, that it was apparent, from the commencement of the domestic scavenging, that any scheme which would involve the riddling of the refuse, and its preparation as a manure, would not yield a revenue which would justify the expenditure.

Besides, in the Dublin refuse the proportion of heat-giving cinder is so very small, that it would be inadequate to produce the steam-power required for the riddling and preparation of the manure as carried on in Glasgow and Manchester.

I shall now describe briefly the arrangements at one of our manure stations.

Stanley Street, which is the only manure depôt on the north side of the Liffey, was purchased in 1882, and extensive buildings have since been erected there by the cleansing committee. On the east side of the ground is the stable yard, with stables for eighteen horses, forage and harness rooms, cart-shed, foremen's offices, and stableman's house.

At the entrance gate is the yardman's house and weigh-office, which has telephonic connection with the offices of the department on Wood Quay. From the weigh-bridge a paved inclined roadway, thirty feet in width, provides easy access for the dust-carts to the upper floor of the manure-shed, which covers a space 154 feet in length and 78 feet in width. Within this building the refuse is tipped, mixed, and again dispatched, by the farmers' carts, which remove in rotation the manure from the three bays into which the ground floor is divided. Cinders and other combustible refuse, valueless as manure, are passed through the cremating furnace, which stands conveniently in a separate building at the end of the manure shed. Old iron, leather, bottles, &c., are also collected for sale.

In order to prevent the escape of noxious odours, special attention has been given to the ventilation of the main building. The foul air is conveyed under the bars of the cremating furnace, and is thus purified before passing into the chimney, which is 140 feet in height.

The yards, incline, and floor of manure-shed are paved with granite sets on a concrete foundation, so that the whole premises present a clean and orderly appearance. To the work as now carried on there has been no complaint, nor is there the slightest cause for objection. The amount expended at Stanley Street on the purchase of the ground, erection of buildings and paving, has been £7,850.

The saleable refuse dealt with at our three manure depôts forms about three-sevenths of the whole scavenge, so that we have about 100,000 loads of unsaleable scavenge to dispose of

annually. Regarding this class of refuse, the consideration is what is the cheapest and best method of getting rid of it at once and for ever? I am glad to state that we have decided to convey the Dublin unsaleable refuse to sea in a hopper barge.

The cost of this vessel will be £5,950. She is specially designed to meet all our requirements, and is now almost ready for launching. A suitable and convenient berth has been obtained on the river near the Swivel Bridge, and is now dredged out to the required depth. A jetty, 120 feet in length, and 16 feet in width, has been there built, and upon it a five ton steam crane with novel and efficient loading appliances has been erected for the purpose of transferring mud as well as dry refuse direct from the scavenge carts to the barge, with which we propose to commence operations in a few weeks.

The following are the principal dimensions of the vessel:—

	Ft.	In.
Length	116	6
Breadth, moulded	30	0
Depth moulded, amidships... ...	12	0
Length of hopper	50	0
Breadth „	18	0
Sheer, forward	2	9
„ aft	1	6
Camber of deck	0	6

She will carry about 340 tons of refuse, and the trip to the place of deposit off Howth and back will take less than five hours in average weather. By this means the refuse will be conveyed to its ultimate destination at an estimated cost of fivepence per ton. Considering all the circumstances, I think it will be admitted that we have adopted the most expeditious, efficient, and economical method possible for the disposal of our unsaleable refuse.

Every city must adopt the means best suited to its circumstances and requirements, but I believe other water-closeted seaport towns might safely follow the course adopted by Liverpool and Dublin for the disposal of city refuse.

In an age remarkable for the communization of the resources of civilization it is surprising to find how little has actually been done even in our wealthiest towns to provide the working population with suitable dwellings, having the sanitary accommodation actually necessary to cleanliness and compatible with decency.

In nearly all our large cities, Dublin not excepted, the material change caused by the exodus of the better classes to rural or suburban residences has necessitated alterations in the

urban houses now occupied by the lower classes, and more especially improvements in the sanitary accommodation provided for them, but in many instances these improvements have not been effected.

The drains, closets, ash-bins, water-supply, and paving in the yards connected with the tenement houses forming the dwellings of the working population are frequently defective or inadequate.

In every tenement yard there ought to be (1) a proper house drain not less than 6 inches in diameter, carefully laid with a proper fall to the main sewer and properly jointed; (2), a large gully trap connected with the sewer for the reception of slops; (3), two closets, one for each sex, with a cistern capable of containing not less than 4 gallons of water; (4), a covered ash-bin not less than 5 ft. by 4 ft. by 2 ft. 6 ins.; (5), an impervious surface of asphalte, or paving sets grouted with tar, laid with a proper fall to the gully grate; and (6), in addition to the ordinary water tap, a tap to which a hose can be attached for washing out the yard.

Simple and necessary as these requirements may seem, so far as my experience goes there are few tenement yards in which all of them have been provided.

With regard to water-closet accommodation, in the absence of compulsory power it is a difficult matter to induce landlords to go to the expense necessary to provide good substantial closets, with cisterns sufficiently large, and adequate sewers laid as they ought to be; when all these have been provided, it is still more difficult to train a population to use water-closets without abusing them; and it is discouraging to house-owners to find closets broken or choked with rags or straw soon after erection. Yet withal we regard the water-carriage system as the cleanliest and best that can be adopted in a city circumstanced like Dublin, but at the same time we regard strict supervision over the erection of the closets with their sewers and water connections as an absolute necessity.

A large gully trap conveniently situated in every tenement yard is also requisite, and unless such is provided, the slops must find their way into the ash-bin, as they frequently do.

I have said that we have both fixed ash-bins and portable dust-bins in use in Dublin, and the latter system is rapidly extending. The daily removal of house refuse by portable dust-bins of a uniform pattern is a system admirably adapted for the removal of shop sweepings and dry house refuse in the main thoroughfares, and it also works well where you have a population living in self-contained houses or cottages, each provided with a water-closet. But from experience in Glasgow

and Dublin, I consider it unsuitable for the lower class tenement houses, where in many cases the people have not yet learned to put the slops into the sewer, and the solid refuse into the ash-bins.

The constant exposure of filth in the number of bins requisite for a large tenement, cannot fail to have a demoralizing effect on the occupiers, and besides it is much more difficult to keep the yard or court clean with dust-bins than with a larger fixed ash-bin.

The fixed ash-bins now being erected in the tenement yards of Dublin, at the instigation of the Sanitary Authority, are calculated to contain the house refuse for one week or thereabouts.

The walls are 9-inch brickwork, the roof galvanized corrugated iron or slates, the floor is from 3 to 6 inches over the level of the yard, and the floor and sides are rendered watertight with cement.

Its advantages are (1) a child can throw refuse into it, (2) it is easily cleansed, (3) no filthy water is allowed to escape and permeate the subsoil, and (4) in the event of portable bins being used at a future date, it will form a stand and shed for them.

Necessary as the sewering and paving of private yards undoubtedly is to domestic cleanliness, the proper formation and drainage of the public streets in like manner must invariably precede efficient street scavenging. I regard a macadamized street, suitable as it may be for light traffic, as quite out of place in the centre of a large city, where no amount of attention will keep it entirely free from its usual accompaniments of dust and mud.

A street calculated to sustain heavy traffic should have a good foundation of concrete carefully laid to the required levels. If the surface is formed of granite sets these should be carefully dressed, so that they can be placed close together, and the interstices should be grouted with cement or pitch.

Wooden blocks, well laid and grouted, also make a good street surface, less noisy and more pleasant than granite, for a city that can afford to pay for their frequent renewal. The blocks should be carefully selected before creosoting, otherwise they will wear unevenly.

Provided with a good surface of granite or wood, street scavenging, though requiring constant attention, is comparatively an easy matter, and can be efficiently accomplished at a moderate cost.

The vegetable supply of Dublin is a matter which also affects our cleansing operations. An excellent supply of fresh vegetables has created a large demand, and they form an important item in the diet of the lower classes. But, unfortunately for the cleansing department, the cabbages and other vegetables are brought into the city wholly untrimmed, and consequently in the height of the vegetable season we are called on to remove per week not less than 200 loads of vegetable refuse. The prompt removal of all vegetable, fish, fruit, and similar refuse, is a most necessary part of city cleansing, but there is no valid reason why the vegetables should not be trimmed in the country, and we are glad to state that a scheme for providing a wholesale market for the sale of vegetables under the control of the Corporation is now under consideration.

The work of our cleansing department, thus described, we do not by any means consider perfect; indeed, no one is more sensible of its defects than the writer of this paper. Still, we have carefully considered and earnestly endeavoured to decide upon the best lines of action, and working patiently upon them during the last three years in our untiring desire to render dear Dublin less dirty, we are glad to believe that our efforts have been not entirely without success.

[*This discussion applies to the preceding three papers by* Professor Henry Robinson, Mr. W. Eassie, *and* Mr. J. Young, *which were discussed conjointly.*]

Mr. C. P. Cotton, M.Inst.C.E. (President of the Section), in opening the discussion, said that he had been greatly struck by Prof. Robinson's allusion in his paper to the relation between ensilage and sewage farms, leading to a probable solution of a common difficulty in connection with this method of disposal of sewage. In Mr. Eassie's paper the difficulty of removing refuse had been very ably dealt with. He had also been very much interested by the relation of the facts which were contained in the paper of Mr. Young, who had handled the subject in a very able manner.

Mr. W. C. Sillar (London) protested against any disposal of sewage being considered satisfactory which did not provide for the preservation and utilisation of its valuable component parts. The systems of Nature are, he said, complex, and we cannot violate one without mischief to all; and it is a flagrant violation of a fundamental law of Nature when we neglect to restore to Mother Earth what she has so liberally given to us, when we have received it, enjoyed it, and have no further use for it. The throwing it away into the sea is wilful and wicked waste—proverbially the parent of woeful want, that now frequently threatens us. The possibility of this utilisation is not now a question of theory, it is one of fact. It has been demonstrated successfully for eight years at Aylesbury, in Buckinghamshire, where the

sewage is purified, and all that otherwise would have been offensive is arrested, and the effluent water allowed to run to its proper place, the river, whilst this matter, so arrested, is preserved in a portable and inoffensive condition for use in the agriculture of the country. We sometimes hear the cost of this objected to, but when this is compared with the cost to the community of *not* doing it, it sinks into insignificance. It is seriously proposed to throw the whole sewage of London into the sea. This sewage would produce 220,000 tons of native guano each year. This manure is readily bought by farmers at £3 10s. per ton, and declared fully worth it. This would be £770,000 per annum gained by the country, and this gain would not be modified by any reduction of market price. The reduction of this by one half would not interfere with the manurial power, but unquestionably it would afford immense relief to our sadly and terribly overweighted agriculture.

Mr. H. P. Boulnois, M.Inst.C.E. (Portsmouth), said that the question as to the disposal of sewage had always been one which had excited the attention of alarmists. There was no doubt that sewage if passed into a river in a crude state did pollute it, but with a little preparation there was no doubt that it would be eventually purified by the action of the river mile by mile as it went along. Fourteen miles above the city of Exeter the town of Tiverton passed its sewage into the river Exe, and analysis showed that the water became gradually purified, until a few miles below the town it was almost quite pure. They had not yet discovered any process by which the disposal of sewage could be made really profitable to the public, and the whole question was one entirely of cost. With regard to Mr. Eassie's paper he believed that everything was pointing towards cremation as the best means of disposing of house refuse.

Mr. Jones expressed the pleasure which he had derived from hearing the excellent paper of Prof. Robinson read. Many years ago they had heard a good deal about irrigation and the utilisation of sewage: of its value and the profits to be derived therefrom. Now, however, these fictions had been exploded, and they all knew pretty well the real facts of the case. These works could not be made to pay sufficiently to justify such a large expenditure of money. He expressed himself greatly pleased with the general state of cleanliness which Dublin presented when compared with other cities which he had visited.

Mr. Parke Neville, City Engineer to Dublin, was of opinion that the great difficulty in dealing with sewage was one of cost. In preparing it for manure a considerable expenditure was necessary, and great difficulty would be experienced in making it a paying commodity.

On "The Water Supply and Drainage of small towns in Ireland," by F. F. MacCabe, F.C.P.I.

The Public Health (Ireland) Act of 1878 divides Ireland into urban and rural sanitary districts. It declares the following to be urban districts: the City of Dublin, Towns corporate —in these the Corporation is the sanitary authority; Towns with a population exceeding 6,000, having Commissioners under the Act 9 of George IV.; Towns with a population exceeding 6,000, having Municipal Commissioners under the Acts 3 & 4 Vic., cap. 108 (the Municipal Corporations (Ireland) Act); Towns with a population exceeding 6,000, having Town Commissioners under the Acts 17 & 18 Vic., cap. 103 (the Towns Improvement (Ireland) Act); and, lastly, Towns or Townships having Commissioners under local Acts. In all these the commissioners, the municipal body, and the town or township commissioners, are the sanitary authority. The Public Health Act also contains a provision (section 7) enabling the Local Government Board for Ireland, by Provisional Order, to constitute any town or township having town or township commissioners, under any Act, an urban district; and provision is made for the transfer to any urban sanitary authority of the jurisdiction exercised by county grand juries over roads, bridges, and footpaths, within such urban sanitary district (section 206).

From these provisions it will be observed that all towns having a population not exceeding 6,000, or not possessing township commissioners under local Acts are, for sanitary purposes, under the jurisdiction of the Boards of Guardians of the Unions within which they may be situated, the whole of Ireland being divided into 163 poor law unions. The board of guardians of each union constitutes the rural sanitary authority.

Urban sanitary authorities have power to appoint committees to carry out the purposes of the Public Health Act—no similar power is given to rural sanitary authorities.

The expenses of urban sanitary authorities in carrying out the provisions of the Public Health Act are to be provided for, in the case of a borough, out of the borough fund or rate, and in other cases, out of any rate leviable by the town or township commissioners throughout the whole of their district. (s. 226). Urban authorities also possess the important power of declaring certain expenses to be private improvement expenses, and to levy them on the occupiers of the premises in respect of which they have been incurred, in the shape of a private improvement

rate—the occupier in such cases can deduct three-fourths of the rate from the rent payable to his landlord (ss. 229, 230).

The expenses of rural sanitary authorities, in other words boards of guardians, in the execution of the Act, are divided into general expenses and special expenses. General expenses may be described as expenses connected with the sanitary staff, and are to be paid out of a common fund raised out of poor rate (s. 232). Special expenses include the principal sources of sanitary expenditure, such as water supply and sewerage works, and must be charged upon a contributory place or places, either the dispensary district, the electoral division, the townland, or part of the townland, and the power of determining the area of charge in each case is vested in the Local Government Board for Ireland (s. 232).

I have thought it desirable thus briefly to refer to certain provisions of the Public Health Act, which have an important bearing upon the subject, to which I ask permission to draw the attention of this Congress.

Of towns in Ireland, by far the largest number are so situated with respect to population and local government, as to come for all sanitary purposes within the jurisdiction of boards of guardians as the rural sanitary authorities of the districts within which they happen to be included. Except where the population of a town exceeds 10,000, there is no provision in the Poor Law Acts for special representation of the population by division of the town into wards (2nd Vict., c. 1, s. 2). It thus happens that urban populations which are large enough to suffer from the absence of sanitary works, such as water supply, sewerage, and drainage, are not represented at the meetings of the sanitary authority (the boards of guardians) in proportion to population, or in a measure bearing any relation to their sanitary requirements. Poor law representation is in fact founded more upon a territorial basis, having the electoral division as its unit, than with any regard to the distribution of population. It appears to me that whenever the inhabitants of any place, whether it be called a town or a village, exceed in number 500, some arrangement for a supply of pure water, taken from outside the inhabited area, becomes necessary; some drainage works are required, and some general plan for the removal of the sewage, or for the periodical removal of excreta from the dwellings, is much to be desired. When the population of any town exceeds 6,000, the Public Health Act imposes upon the urban sanitary authority the obligation of providing adequate water supply, drainage, and sewerage. When, however, the population exceeds 500 but does not exceed 6,000, the small urban districts included within these limits must, except in the

few cases in which orders have been issued under Section 7 of the Public Health Act, depend upon the boards of guardians, as the rural sanitary authorities, to provide for their water supply, their drainage, and their sewerage, or other means of filth removal.

There are 338 small towns in Ireland, with a population between 500 and 6,000, thus depending upon rural sanitary authorities to provide for their wants, and the object I have in view in submitting this paper is to draw attention to the actual condition of a large proportion of these towns, and to elicit an expression of opinion on the part of the Congress as to the means which would appear best calculated to place them in a fairly satisfactory sanitary condition. At present the vast majority of these small towns depend for their water supply upon wells sunk within the inhabited area, and therefore exposed to all the dangers incidental to the consumption of a water supply drawn from a more or less filth-polluted sub-soil. For drainage purposes the small towns depend upon the water-courses constructed under the roadways by the grand juries of the counties. These grand jury drains are almost invariably constructed with side flags or loose stones resting on the earth, and are covered in by flags across the top. They generally lie under the channel gutters, and empty their contents at intervals into open ditches adjoining the roadway. Inasmuch as grand juries possess no statutory powers to construct proper sewers, the county drains are intended to carry off only surface and storm waters so as to keep the roadways properly drained. On country roads they answer all the purposes for which they were designed, but when the county road passes through a small town where there are houses of the better class, the practice has become very general for householders to put up water closets and to construct a house drain, which is carried as far as the county water drain, and allowed to discharge sewage matter of every kind into such county drain. Having regard to the mode of construction of these county drains, which are insufficiently flushed by occasional storm water and cannot be self-cleansing, the inevitable result of this practice is, in a short time, to block the drain. It is then reported to the board of guardians, as the rural sanitary authority, that the so-called sewers in the town are stopped. The board of guardians disclaim responsibility, as there are, properly speaking, no sewers in the town; and as the county grand jury have jurisdiction over the roadway, the subject is referred to the county surveyor. This officer, on behalf of the county grand jury, generally disclaims responsibility, alleging that the county drains having been improperly made the receptacles for sewage matters, have become

sewers, and ought to be looked after by the sanitary authority, in which all sewers are vested; and it thus becomes difficult to decide who is to remedy a condition of affairs which constitutes a very serious nuisance. If, as sometimes happens, a board of guardians are willing to improve the construction of the county drains within the limits of the town, and to attempt to render them self-cleansing, they have to encounter serious difficulties. The sewerage of even a small town requires to be undertaken as a whole, with due regard to levels and to the provision of some outfall which shall not pollute a watercourse. This is a work involving an outlay which is considerable in relation to the assessable value of the town. If the board of guardians decide upon a system of filth-removal by other methods than sewers, the establishment and working of such a system requires a sanitary staff and a constancy of supervision to which their administrative resources are quite unequal, and it further requires an amount of intelligent co-operation upon the part of the inhabitants which it is a work of time to establish. Boards of guardians have also to my knowledge been advised by competent authority that a system of sewerage will not work in an efficient manner unless there is a water-supply much more abundant than that furnished by a few wells within the inhabited area. If, therefore, they are disposed to construct a system of sewers, they feel constrained to undertake at the same time a pipe water-supply. The amount of outlay involved alarms them, and, bearing in mind that the great majority of the guardians have no direct interest in providing for the sanitary requirements of urban populations which happen to be included in the union, they are not disposed to give the subject the amount of sustained attention necessary for perfecting plans and applying for the loans required. When the question of outlay comes to be considered, boards of guardians are also generally disposed to confine the area of charge as closely as may be possible to the neighbourhood which is expected to derive benefit from the works to be undertaken. The advantages to be derived from sewerage works are no doubt directly confined to the town itself, and the Local Government Board for Ireland, in determining the area of charge for such works, have, as a rule, adopted the recommendations of the guardians, and confined the area of charge to the townlands, or parts of townlands, upon which the town is built. In considering areas of charge for water-supply, they have generally encouraged boards of guardians to recommend much larger areas, inasmuch as the benefits conferred by an abundant water-supply make themselves felt over a considerable district, extending on all sides of the town thus provided for. In practice, however, it is found that

boards of guardians, acting as rural sanitary authorities, evince an almost insuperable unwillingness to undertake both water-supply and sewerage works for the benefit of those small urban populations entrusted to their sanitary supervision, and it must be added that the townspeople encourage this apathy by their own opposition to any undertakings which will involve considerable outlay and consequent taxation.

I have had considerable experience of boards of guardians acting as rural sanitary authorities in Ireland, and as the result of personal intercourse with such authorities, extending over many years, I am glad to be able to bear testimony to the readiness they have evinced to make due provision for the protection of the public health, whenever they have received any encouragement from the persons who would be called upon to bear the cost of the improvements. I have, however, found that when a considerable outlay became necessary, with the object of placing one of these small towns in a satisfactory condition as to drainage and sewerage, the assessable value of the property within the townland or townlands on which the town was built was so small that for public sewers constructed out of a loan advanced, say for 35 years, the annual charge necessary to meet interest and sinking fund was so great that householders recoiled from the prospect of the liability involved. The boards of guardians thus often found the most strenuous opponents of such undertakings in the persons who, from a sanitary point of view, would be most benefited by the execution of the works. With regard to schemes for the supply of pure water collected at some spot in the neighbourhood of the town, removed from sub-soil contamination, and thence conducted by a system of pipes into the town, the area of charge may be much larger than that usually adopted for sewerage; but it is to be observed that with the extension of the area there is a corresponding enlargement of the circle from which objections may arise—ratepayers outside the town objecting to become contributory towards an outlay from which they conceive that they derive no immediate advantage. There can be no doubt that very imperfect knowledge is possessed by boards of guardians on the subject of the economy of sanitation as a security against disease, suffering, and death. They have never had any precise information placed within their reach respecting the amount of preventable disease, suffering, and death, with consequent loss of wage-earning or productive power, which may be avoided by the provision of suitable drainage and pure water. They have regarded only the direct cost, without taking into account the indirect gain, which I believe would fairly more than counterbalance the much dreaded taxation. Some most interesting light has been

thrown upon this aspect of the question by the publication in the Reports of the Medical Officer of the Local Government Board for England of the amount of sickness and suffering as disclosed by the death-rate due to preventable diseases *before* and *after* the execution of sanitary works in certain English towns.

The practical difficulty which obstructs the path of progress in the direction of the sanitary improvement of small Irish towns in respect of water-supply and sewerage is really the general unwillingness to bear the cost—the incidence of taxation exciting opposition from its burthen when the area of charge is limited, and from its including those not directly benefited when the area of charge is more extensive. The question then suggests itself whether it may not be possible so to modify the existing application of the provisions of section 232 of the Public Health Act of 1878 as to diminish the force of this opposition. I think this may be accomplished. As section 232 is at present applied to special expenses, areas of charge press equally upon all the rated occupiers within such areas. It appears to me that this principle might admit of modification. If the rural sanitary authority decide that the area of charge for water-supply of a town shall be the electoral division within which that town is situated, it will be found that the rated occupier living in the town will have to pay exactly the same amount, in the shape of a poundage rate upon his valuation, as the rated occupier who lives at the most distant part of the electoral division, although the townsman uses the water at all hours of every day, and the dweller at the end of the electoral division perhaps comes into town only once in the week. It appears to me that the cost of the water-supply might be divided so as to fall in unequal proportions upon the contributory area. I can see no reason why, for instance, three-sixths (or one-half) of the total poundage rate should not fall upon the townlands on which the town is built, two-sixths upon townlands within a certain distance of the town, and the remaining sixth upon the more distant parts of the electoral division. In the same way, with regard to sewage works, I can see no objection, in principle, to the adoption of some sliding scale of assessment, by which the heaviest part of the charge would be made to fall upon the town, and a certain charge, decreasing *pari passu* with the increase of distance from the centre of population, imposed upon an area much more extensive than the town itself.

I have referred as shortly as I could do, consistently with a clear statement of the facts, to the actual position of the small towns of Ireland with respect to the water-supply and sewerage, and I am anxious to obtain an expression of the opinion of the

sanitary authorities I have the honour of addressing as to the best means for dealing with a subject which I have found to be one of great difficulty. I have purposely refrained from discussing the best methods of dealing with town sewage, which have been suggested or put in operation in large centres of population. These methods are dealt with in a manner which leaves nothing to be desired, in the lucid report of the committee appointed in 1875 by the Local Government Board for England, under the chairmanship of the President of this Congress. The report of that committee seems to me to be applicable to towns the governing bodies of which are themselves the sanitary authorities within the municipal, or town, or township boundaries. My remarks have been confined to the small urban populations, ranging between 500 and 6,000, which, for sanitary purposes, are subject in Ireland to the jurisdiction of boards of guardians, acting as rural sanitary authorities.

Mr. GEORGE HODSON (Loughborough) thought that the general district about such towns as those referred to in Mr. MacCabe's paper should contribute to these rates when there was a likelihood that they would in time require to have provision made to supply them, in the event of the town enlarging. A certain area in the district, he was of opinion, should contribute towards the carrying out of sanitary works in the town.

Mr. R. O'BRIEN FURLONG (Dublin) said that in Ireland the Public Health Act of 1878 gave power to the Local Government Board, on the application of the sanitary districts affected, to combine such districts, in cases where it was found that singly they would be unequal to the burden which would be imposed upon them, in bearing the cost of sanitary works. He cited instances in which poor law unions and electoral divisions had been amalgamated in this way, for the purpose of bearing unitedly the cost of sanitary works.

Mr. G. J. SYMONS, F.R.S. (London), expressed the pleasure which he had derived from hearing Dr. MacCabe's ably-written paper. The subject was one of very great importance, and deeply concerned the inhabitants of the smaller towns in Ireland. It was a matter of the very gravest importance, from a sanitary point of view, to ensure that the inhabitants of these towns should have a proper water-supply, and he was of opinion that where they were unable to bear the cost themselves, a portion of the expense should be borne by the district immediately about the town.

Mr. L. L. MACASSEY (Belfast) thought that the best way of meeting the difficulty was to make the centres in such cases more local. Boards of guardians were too unwieldy to work out sanitary matters efficiently.

Guardians were elected for a large district, and the villages and small towns in such districts were only indirectly represented by a farmer in the vicinity, who had a strong dislike to spending money. Under the present state of things it was practically impossible to get any improvements made in the small towns and villages. Committees might perhaps be formed to deal with the cases brought forward by Dr. MacCabe; these committees to be made up of local persons, and to have powers in their district somewhat similar to those of town commissioners in the larger towns. Some change was required in the present state of things if our small towns and villages were to share at all in the advantages of sanitary improvements and progress.

Mr. H. H. Collins, F.R.I.B.A. (London), said that the question raised was a most important one, and would require to receive every attention.

Mr. C. P. Cotton, M.Inst.C.E. (President of the Section), pointed out the difference between the English and Irish Public Health Acts in that in striking rates for special expenses on "contributory places" under the English Act the occupier of any land used as arable, pasture, or meadow ground only, or as woodlands, market gardens, or nursery grounds, &c., is assessed in one-fourth part only of the rateable value thereof, whereas in Ireland the occupier of such properties is rated for the full value; this has an important bearing on the question of fixing the area of charge.

Mr. Stirling, Mr. Gardiner, and Dr. J. Byrne Power also joined in the discussion.

Dr. MacCabe (Dublin), in replying, thanked the members of the Congress for the attention they had bestowed upon his paper.

Sir Robert Rawlinson, C.B. (President of the Congress), wished to modify an expression of opinion which he had given on a previous day, and which was liable to some misconception. He was, as a general rule, opposed to the use of small pipes for the conveyance of water to towns with populations of and above two thousand, although such pipes might be more economical than larger ones. He was opposed to the use of a cast-iron pipe which was anything less than three inches in diameter. At the same time, in certain cases, there was no doubt that isolated houses and small farm residences might, in cases where there was water in the district, convey the water by a pipe $1\frac{1}{2}$ inches in diameter. He would not, however, recommend the laying down of lead pipes, as they might be there for a short time, but very likely would have disappeared next day.

On "Isolation versus Ventilation," by H. Percy Boulnois, M.Inst.C.E.

Analogous to the question of the disposal of sewage is that of the danger arising from it as it passes along the public sewers, and the object, therefore, of this paper is to open up discussion upon the somewhat vexed points as to the best methods at present known for the so-called ventilation of our sewers, as to what methods have hitherto been attempted, and whether these attempts have been successful. An endeavour will be made to show that the modern practice of openings in the centres of the streets is unsatisfactory and unnecessary, and that it is a far more important sanitary measure to isolate the house from the sewer by means of simple and effective traps, than to make these openings in the sewer, and that if this isolation is perfected, the sewer ought to be buried completely out of smell as well as out of sight, which is now unfortunately far from being the case.

The present system of ventilation seems to have originated about the year 1830, when grievous complaints were constantly made by the inhabitants of the City of London that great stenches arose from the gully pits at the sides of the roads; these upon being trapped caused the foul air to pass through the untrapped house-drains into the houses themselves, and the remedy proved more unsanitary than the original cause of complaint. The cure that then immediately suggested itself was the relief of the pressure of the foul air by making openings in the crown of the sewer, carrying shafts to the centres of the roadway and protecting these shafts with iron gratings, a practice which has been steadily copied since the year 1840.

These openings, however, were speedily found not to be all that was necessary, for in spite of them the foul air still entered the houses through the untrapped drains, and the object had not at all been attained. Consequently traps were introduced in order to break the continuity of the house drain; first, the now old-fashioned brick pit, with slate or stone tongue, called a Mason's trap, and then the syphon; the seal was deepened, double traps were inserted and flaps were placed in different parts of the system in order to secure the isolation of the house. It is only of quite recent date, however, that the real secret of pneumatic separation, or isolation of the house, has been discovered, and this was done gradually—first, the

cascade action in the trap was introduced, and then the important addition was made of leaving the soil pipe open for ventilation. This was followed by cutting off all connections between the drain and the waste pipes from sinks, baths, lavatories, &c., and causing them to empty on to gratings, and other methods; and then the pneumatic separation was devised, by which fresh air is introduced on the house side of the trap, and a current is thus constantly passing through the house drain, and with the help of the deep trap entirely cuts off the house from the common enemy, the public sewer, and renders it as completely isolated as modern sanitary science can effect.

Owing to the varying level of the fluid in the public sewer, some escape must be provided for the air contained in it, otherwise one or more of the house-drain traps would be unsealed by the air as the fluid rose, and this can easily be effected by carrying a shaft of about 6 inches in diameter from the crown of the sewer near its highest level to some convenient and safe height against an adjoining building. One such shaft for each 200 yards would be sufficient for nearly any ordinary street sewer to relieve the pressure upon the traps until long after the connection of the house-drain with the sewer was below the level of the sewage, and this would meet the requirements of the most violent rain-storm, and prevent the unsealing of the deep sealed traps. Should, however, a trap become unsealed, the open character of the house-drain and the traps of the water-closets, which should be of some simple wash-out pattern, would quite prevent the chance of entry of any of the foul sewer air into the house, and thus the sewer ventilation as it is called becomes perfectly unnecessary.

Before proceeding further to discuss the question, it will be interesting to observe the following chronological list of different methods which have from time to time been suggested or actually attempted, not only for the purpose of ventilating sewers, but also for processes of destruction, retention or harmless conversion of the different gases contained in the sewers.

The list is as follows:—

1840. Open shafts, as already described, were first introduced.

1848 to 1853. Captain Shrapnel made a suggestion that high cast iron cylinders should be constructed over the sewers in which furnaces should be placed to consume the gases.

Messrs. Warr and Armstrong proposed to build domes over the sewers from which pipes should conduct the foul air to a central gasholder, whence after purification it should be distributed for street lighting. Another proposal, about the same date, was that sewers should be hermetically closed, except at one

point where an air pump would extract the foul air and drive it through fire or a solution of chloride of lime. A suggestion was also made that coke factories should be established near the lines of sewers, and the gases therefrom passed through the ovens.

1854. Sir Joseph Bazalgette, in London, successfully ventilated a sewer on the south side of the Thames, by carrying pipes from the crown of the sewer into the tall chimneys of two factories. In another case, however, in Friar Street, where this was again attempted, an explosion occurred which led to the abandonment of experiments in this direction for a time. Mr. Gurney, in the same year, tried the effect of steam jets introduced into a sewer, but without any good result.

1855. Mr. Mumby proposed that the gas lamp posts or columns at the sides of the streets should be used as sewer ventilators, but as these are only lighted at night Mr. Robins suggested that the posts should have trays filled with disinfectants placed in them over which the sewer air should pass.

1856. Shafts were erected at the ends of streets connected with the dead ends of sewers, and carried up the gable ends of houses.

Furnaces in connection with these shafts were also recommended.

1858. Mr. John Chisholm tried the effect of electrical or galvanic action upon the air in sewers, but without beneficial result.

1866. Trays filled with charcoal were introduced by Sir Joseph Bazalgette and others into the ventilating shafts.

1870. Sir Joseph Bazalgette successfully neutralized the foul emanations from a sewer by the introduction of trays filled with sulphurous acids.

1872. Screens or flaps were placed in sewers to regulate the currents of air in them. Messrs. Johnson and Hill proposed that ventilation should be effected by connecting all the house drains with the chimney flues. Mr. Miller suggested that the smoke from chimneys should be drawn into the sewers for the purpose of purifying the bad air in them, and at the same time of settling the London fog question satisfactorily.

1873. General Scott introduced lime into a main sewer, with the result, to use his own words, that "the main sewer was perfectly freed from stinking sewer gases."

Dr. Keates devised an apparatus for subjecting the foul air to the action of chlorine gas.

1875. Mr. Parker, the surveyor of Poplar, England, patented a method by which air was to be forced into the sewer by the action of the wind impinging upon a cowl.

Sir Joseph Bazalgette erected a ventilating chimney, sixty feet in height, with a furnace burning coke, when, to use his words, "It was found that about 1 per cent. of the sulphur was given off by the coke, and acted as an efficient disinfectant."

Mr. E. Rumbold originated a method for passing the foul air through a spray of water introduced on all sides of the ventilating shaft.

In the same year, being struck by the absence of smell in an old sewer, in which quantities of stagnant sewage were giving off gases of decomposition, I came to the conclusion that this absence of smell arose from defects in the crown of the sewer, which allowed the foul air to be absorbed in the earth which covered the sewer. The outcome of this observation was the invention by me of what I have designated "The Sewer-gas Annihilator," the principle of which is based upon the well-known fact that earth has a powerful action in absorbing and deodorising any noxious gases or emanations arising from matters undergoing decomposition.

In 1882 Mr. Read, the surveyor of Gloucester, suggested that all house drains should be used as up-cast shafts to ventilate the main sewers, for he argued that as the sewer was used for the benefit of owners of house property, so should they contribute to the ventilation.

Mr. Harrington, the Mayor of Ryde, Isle of Wight, proposed in the same year a system by which air should be forced into the sewers by shafts furnished with cowls, his system being somewhat similar to that proposed by Mr. Parker in 1875, and already described.

1883. Mr. Rowan suggested the sub-division of the sewers into sections, so as to ensure their thorough ventilation, "each exhauster drawing from the inlets on either side of it, and the inlets consequently delivering air to the sewer in both directions." The abstractor to be of special construction, and to perform a double function—abstract the sewer air, and burn and destroy any organic matters or germs contained in it, the sewer air being made to pass through a number of small tubes heated by a gas jet. Mr. Rowan claims that not only is heat thus made to destroy the danger in sewers, but that fresh air is also admitted into them—the two most important points in connection with this question.

No reference has purposely been made to the almost numberless exhaust cowls that have been from time to time introduced, for experience and experiment have shown that their effect has not warranted their adoption. Mr. Ellice Clark, of Hove, has made several experiments in this direction, and in a report which he published in January of last year upon the benefit to be

derived from what are known as Banner's cowls, he says "a greater velocity of air is obtained when the shafts have open terminations than when Banner's cowls are fixed upon the shafts."

With regard to the systems of ventilation at present in vogue, that of open gratings in the centre of the streets is the most general. By a return recently published, it is found that out of sixty-six important towns in England, fifty-five of them adopt this system, and it certainly has the merit of being economical and simple, both in construction and maintenance, and it relieves the sewer from any air-pressure when its contents are running at a higher level than usual.

The system, however, does not comply with sec. 19 of "The Public Health Act, 1875," which states that sewers shall be ventilated "so as not to be a nuisance or injurious to health." The street gratings are an undoubted nuisance, as they unload their foul air under the level of our noses, and it is possible they may be injurious to health, for although on being liberated the dangerous qualities of the sewer air are said to be diluted, dispersed, and rendered harmless and innocuous, it has never been satisfactorily proved that the atmosphere kills the disease germ should he be there lurking, or, if it does kill him, how long is taken in the process; certainly not the short time elapsing on the journey between the grating and the footpath. There is no doubt that excessive dilution lessens the risk of contagion, but the system does not seem successful unless immunity from nuisance and disease can be assured.

It is said that where the sewers are in a good condition no nuisance arises from the ventilators; if this is so, the question may fairly be asked if they are of any use in such cases, and whether the perfect sewer is not just as perfect without them. Advocates of the system state that it is impossible to have too many openings, and thus open sewers would, no doubt, be the most desirable. The town of Leeds is frequently held up as a model in respect of the ventilation of its sewers; let us compare its death rate with that of the town of Bristol, where not a single sewer ventilator exists:—

Leeds has a population of 15·2 per acre.
Bristol " " 64·5 "
Leeds had a death rate for 1883 of 23·30.
Bristol " " " 17·80.

Of this death rate those arising from the principal zymotic diseases were, as regards Leeds, 4·0 per thousand, as regards Bristol 1·1 per thousand.

The Commissioners of Sewers for the City of London have for a long time felt that the open gratings were not all that

could be wished, and have consequently, quite recently, passed a resolution to enable their officers to treat with builders and owners of property for the purpose of erecting shafts, either in the walls of, or against new and existing buildings.

Open shafts carried up to safe heights certainly have many advantages over the foul smelling gratings in the centres of the streets; and the fashionable watering place, Scarborough, has, I believe, the whole of its sewers ventilated in this manner, there are, however, some objections to this system, which may be summarised as follows :—

The want of fresh-air inlets, the expense, and the difficulty in obtaining permission to erect the shafts just at the points where they are required, and of course, in new streets that are being sewered, and other localities, there are no houses against which they can be fixed.

The fresh-air inlets, as by Mr. Parker's and Mr. Harrington's systems, are an improvement, but they involve that great bug-bear to the ratepayer, extra cost; and there would no doubt be some objections raised to obstructions of the kind being placed against the sides of the streets; otherwise these systems have much to recommend them.

The use of the rain-water pipes for sewer ventilation has often been justly condemned; they not only cease to act as outlets during rain, but also carry more air into the sewer; and, from their position and possibly bad jointing, are sanitarily dangerous. The town of Carlisle, however, ventilates its sewers in this manner, there being upwards of 2,150 rain-water pipes in direct communication with the sewers.

Charcoal trays are too well known to require any comment.

Large hollow lamp-columns have many recommendations, but they cannot be extensively used, and unless the gas is constantly kept burning they are of but little use.

Pipes carried from the sewer into neighbouring chimney shafts or under furnace fire bars is a practice that is gradually extending and has much to recommend it; it is well known that the most potent destroyer of all forms of germinal life or organic matter at all stages of their development is heat, and it is probable that in this direction scientific purification of sewers will be eventually attempted. At Leicester there are upwards of thirty chimney connections which answer satisfactorily.

The early dangers encountered by explosions in connection with this system seem to have been entirely accidental, and probably arose from the admittance of coal gas into the sewers from defective mains, and no recurrence seems to have taken place for many years.

With regard to special lofty shafts fitted with furnaces, these seem to be effectual under certain conditions, as, for instance, upon main intercepting or outfall sewers where there are few openings, as in the case of Brighton, where a large shaft of this description has been in successful operation for some years; but Sir Joseph Bazalgette proved several years ago, and subsequent experiments have confirmed his opinion, that the effect of such shafts upon the general system of sewers would be very ineffectual, as the tendency of the exhaust produced by such a furnace is only to draw in sufficient air to feed it from the nearest opening.

In conclusion, I wish to lay the following points before you, in order that they may be discussed.

Is the present system of open sewer ventilation in the centres of the streets satisfactory? Does it comply with the requirements of the Public Health Act, 1875?

Do any of the systems which have been enumerated fulfil these conditions?

If the drains of all buildings are properly and efficiently trapped, ventilated, and the buildings thus isolated from the sewer, is any ventilation beyond a few relief pressure shafts necessary?

Should not this isolation of the house be made legally compulsory?

Mr. Dobson said he must at the outset declare himself one of the opposition in dealing with this paper. It would be, he thought, going back to the system of twenty years ago. He believed that there should be from end to end a thorough ventilation of the sewers. In London, Liverpool, and large cities, it would be advisable that great lengths of sewers should be divided into sections. In his opinion the ventilation of sewers would not be complete until it was carried out upon the principle adopted in coal mines.

Mr. Rogers Field, M.Inst.C.E., quite agreed with Mr. Boulnois as to the great importance, from a sanitary point of view, of having the houses isolated from the public sewer by means of an efficient system of "disconnection"; but could not agree with his proposition that the ventilation of the sewers should be omitted. Mr. Field used the word "omitted" advisedly, as he considered that the few small pipes which Mr. Boulnois proposed to have for relieving the pressure in the sewers would have such a slight effect that the ventilation might be practically said to be omitted. Mr. Boulnois' proposition was based on the assumption that every house drain in the town was efficiently "disconnected" from the sewer, but in practice this assumption would never be true. Even in the case of new houses it would be very difficult always to ensure perfect disconnection, and in

the case of old houses it would be quite impracticable to do so. The only way in which such disconnection could be secured would be by a thorough house to house inspection, and by opening up the drains wherever necessary. Leaving out of consideration the difficulty about legal powers, he was not aware of any town in the kingdom which possessed a sufficient staff of competent sanitary officers to undertake such a task. If all the houses were not efficiently isolated from the sewer then the omission of the ventilation of the sewers would be very dangerous.

Mr. Stirling, C.E. (Dublin), was of opinion that if the plan suggested were adopted all the noxious gases in the sewers would be liable to be sucked into the houses by the heat of the fires and kitchen ranges. In Dublin it is inevitable that most of the house drains shall pass under the houses; here also, in most instances, there are sunk basements, with narrow sunk areas, towards or beneath the pathways; most commonly the drains cross beneath the kitchens, the walls have either no anti-damp course or none that is perfect, there is no impervious underfloor of concrete; these, he should think, were conditions common to many, if not most, towns of importance. It has been suggested that the joints of the house drains and sewer pipes should be left open for about four inches wide at the top, with lumps of broken stone over such open joints to collect the subsoil soakage water; this has much to commend it, especially in clayey and other retentive soils such as that in Dublin; isolation as against ventilation is not to be recommended for adoption with these conditions.

Mr. D. Emptage (Margate) was of opinion that the best way to ventilate the sewers was by means of shafts carried from the sewer side of the drain traps to the top of each house; by this means, owing to the number of shafts employed, air would be drawn in at the road gratings and discharged at a point high above all breathing places, the constant currents causing this outgo to be comparatively harmless. The great difficulty would be to procure the consent of house owners to these shafts being fixed; but he felt sure that this system, if carefully carried out, would remove the evils now so often experienced.

Mr. J. Wallace Peggs, Assoc.M.Inst.C.E. (London), thought that the paper would be valuable as indicating what had already been done in the question of ventilation of sewers. As mention had been made during this discussion of utilizing rain-water pipes for the purpose of ventilating public sewers, he thought that at a meeting of this kind it would be well to condemn in the strongest manner any such use of rain-water pipes. It must be obvious to anyone that the danger of ventilating a public sewer by the rain-water pipes, which, as we all know, terminated in all kind of positions near windows, is very great. There is not very much difficulty in ventilating a system of new sewers carefully laid down upon the best modern principles and made

self-cleansing. The difficulty of ventilation occurs in our older towns, where we have sewers of deposit acting as retorts for generating foul gases and where the weight of flow in the sewers varies at different times of the day. It is necessary to keep up a constant movement of fresh air in all parts of a system of sewers. The usual method of ventilating sewers is by openings at the surface of the road, and Sir Robert Rawlinson, our president, has laid it down in his valuable "Suggestions" that ventilation should be provided for in all sewers at frequent intervals, not greater than 100 yards apart. The true principle of ventilation for sewers and house drains is to have the foul air constantly replaced by the admission of fresh air. A sewer must always have a constant current of air passing through it. There must be no resting places for foul air in a properly constructed system of sewers. The question of sewer ventilation is intimately connected with the house drainage question, and I will endeavour to explain what I mean from a case occurring in my own practice. A town was sewered on the best modern principles, and the old house connections were made good to the new sewers. After a short time great complaints were made about the ventilating openings at the surface of the streets emitting foul smells. Upon careful examination it was found that the old overflows of cesspools had been joined up to the new sewers, and the foul matters from the cesspools overflowed into the sewer. The remedy was to search out and entirely remove all cesspools, and carry the house drains direct into the sewers, without any such resting places. The sewage from houses should be carried away direct to the sewers and away to the outfall within a short time; and if this is done there will be very little difficulty in dealing with the ventilation of sewers. As a rule the openings for the ventilation of sewers and drains are much too small, and there are not sufficient of them. The value of ample ventilating space along a public sewer recently came under my notice, where I was called in to examine into the cause of bad smells along the public road, emanating from the sewer. For the purposes of examination I had several holes of large size made along the course of the sewers and at frequent intervals. The foul air coming from these openings when first opened was very offensive, but after the first day no nuisance was experienced at all, although in this case the sewer was laid very flat and the velocity of the flow of sewage was not much.

Dr. Alfred Carpenter (Croydon) related an instance which had come under his personal observation, in which catarrh had been caused by emanations from an opening in a sewer, for it happened to himself. He recommended a thorough ventilation of sewers, and the placing of intercepting traps between the houses and the sewers in all cases in which it was found impossible to make the local authority do their duty by providing sewers which should not be sewers of deposit, and which would not then contain anything that could ferment and give out the result of sewage decomposition. He intended publishing a history of the case in which catarrh had been caused by the emana-

tions from a sewer. The circumstances were very peculiar, and he believed that the subject was one which should be fully investigated.

Sir Robert Rawlinson, C.B. (President of the Congress), said that great care should be taken that the putrid matter and excreta from houses should be made to pass away instantly. Noxious gases should be liberated from the sewers, and not allowed to remain and endanger the health of the inhabitants of the houses by entering them. The subject of the ventilation of sewers was one of vast importance, as in many cases where typhoid fever was found to prevail in cities it might be directly traced to this cause. He recommended that the sewers should be carefully made, kept perfectly clean, and carefully ventilated.

Mr. Boulnois (Portsmouth), in reply, said that he had accomplished all he desired, in having by his paper led to such a large amount of instructive discussion upon this important subject. The whole point of his paper was the effective isolation of the dwelling house from the public sewer, and of course if this could not be effected his arguments fell through. He complained of the limited number of inspectors who were appointed under the different corporations. He was of opinion that they were entirely too few to be able to accomplish, in anything like a thorough or satisfactory manner, the proper supervision of house drainage, or the rest of the work required of them.

On "The Necessity for Efficient Ventilation of Sewers," by John Collins, F.C.S., F.G.S.

It is not difficult to realise how readily the public mind lends itself no less to an unlimited sense of security than to a gross and unreasoning panic; and it has been so exercised in both ways on this subject during a very recent period.

It has seemed to the writer, who has for some years been studying the subject, an opportune moment, when zymotic disease again threatens us so directly, to direct attention to the subject of this paper.

When we are assured that adequate ventilation is necessary to health, and that it is so for the purpose of effecting changes in the atmosphere we breathe—of removing effete and noxious matters no less than for the supply of fresh air and its contained oxygen—we might be expected to pay more attention to

the subject than is commonly found to be the case. It is no less evidently true that a constant and sufficient supply of fresh air and a removal of waste matters is as essential to our comfort as to our health.

All organic matter is subject to change, and to what is commonly called decay or putrefaction. This putrefactive process may destroy living organisms, and so destroy the germs of disease. But it is also true that, under certain conditions, it may actually produce other germs.

In ordinary putrefaction of organic matters the azotized compounds are decomposed with evolution of nitrogen, giving rise to nitrates and nitrites, as the supply of oxygen is plentiful or otherwise. The carbon is oxidised, forming carbonic dioxide, while considerable quantities of sulphuretted hydrogen and of carburetted hydrogen are evolved.

Our modern system of sewers is intended effectually to collect and carry away alike from dwelling and workshop all that is used up, decaying, noxious, or even hurtful and dangerous. Hence we may assume for sewage that it will contain all these matters in a solid, liquid or gaseous form.

The organic matters therein are all more or less putrefactive, and constantly give off large volumes of the gaseous products of putrefaction.

These "sewer gases," as they have been termed, are ever present in greater or less quantity, and I am desirous in this paper to direct your attention to them, and to the absolute necessity for providing for them and for dealing with them.

They certainly seem to produce greater evils, more sickness, than would at first sight appear; and it is a well-observed fact that more sewer gas is evolved from liquid sewage than, under similar circumstances, from an equal amount of solid excrementitious matter. It is further ascertained that water assists most rapidly the growth of most organisms.

These gases are most noxious—they contain a "stinking vapor" which is in the highest degree offensive, and which inhaled produces headache, giddiness, and nausea.

Certain fevers have been directly traced to them. They always include that poisonous product of decomposition, sulphuretted hydrogen.

Several samples of liquid sewage have been examined, and are found to give, of gases in solution 36 to 75 cubic inches per imperial gallon. Of these

Carbon dioxide ...	... =	34 ...	70 %
Sulphuretted hydrogen...	=	0·9 ...	3·5 „
Ammonia ...	... =	0·003 ...	0·0048 „
Marsh gas, &c. ...	...	Not determined.	

On fermentation setting in the sewage is decomposed, and we get liberated gases, shewing—

Carbon dioxide	17·4 %
Carburetted hydrogen	70·9 „
Nitrogen	10·07 „
Sulphuretted hydrogen	2·3 „
Ammonia	0·0046 „

It is obvious that these gases must, by some means or other, obtain egress from the sewers, and they will effect this in face of the greatest obstacles. They find the smallest vent; they dissolve in water, to be liberated under other conditions; they percolate through the earth; they rise through "sink" pipes and rain-water butt overflow pipes as surely as they are formed day by day;—this, of course, in default of our providing an outlet for them where we may get rid of them with the minimum of evil consequences.

It is a fallacy of the most dangerous kind to say that sewer gases are no longer hurtful when they are no longer offensive to the sense of smell, for there is no necessary connection between bad odours and zymotic poisons. There may have been oxygen enough available to prevent disease, while there may not have been sufficient to prevent smells which nauseate and cause sickness.

The pestiferous matters which float over the African coast, the Indian Sunderbund, the Algerian plain, the Pontine marsh, and the English fen is not offensive to the nose though deadly enough to the body. And there are many horrible stinks that have no power to produce any disease.

It must be remembered that these gases are effluent at normal temperatures, and it will readily be seen how the increased heats of summer assist their increased evolution.

It is most difficult to say what is their condition and what the amount of their dilution which may cause sickness; but of this much we are certain, that a free admixture of air will kill all the germs of putrefaction and of disease; or if it does not kill, it so weakens them as that they are harmless.

Does not this fact alone teach the absolute need of effecting all that is possible in the immediate aeration of sewage by plentiful ventilation and every other available means?

One danger, which has only of recent years faced the dwellers in our large manufacturing towns, is found in the closed cellar dwellings. These dwellings were compulsorily closed by the sanitary authorities of the day. They were closed arbitrarily and summarily. No compensation was offered or paid for loss of rental. They were found in the lowest districts, and many

of them were closed ere it was incumbent on the owner or occupier to trap the sewers therein. Thus it happens that the old sewers of many of these disused dwellings are still open.

The timber and the glass of door and window have long given way in most cases to rough bricks and to still rougher boarding of the cheapest kind. The only "through draught" or ventilation which is possible is by the more highly heated and more open room above, through and by the accidental chinks and crevices in the floor of this occupied room.

The power for evil of these gases is here surely enhanced, for the damp and semi-fœtid atmosphere of the disused cellar is saturated with the sewer gas and its contained germs. That this is no imaginary evil is shown by the fact that in over 68 per cent. of these closed cellar dwellings the air from which has been examined, it was found so saturated with sewer gases.

That there should be found to exist an intimate connection between badly drained and ill-ventilated slums with their overcrowded, unwashed, underfed populations, and with an additional, though readily removable, danger like these "closed cellar dwellings" in their midst, and the constantly recurring outbreaks of epidemic disease is not surprising.

It is one of the objects of sanitary science to remove such blots on our civilization, and it must be to our satisfaction that we may feel we do something to this end by directing the force of public attention to them whenever they exist.

TABLE I.—"SEWER GASES."

Gases dissolved in raw Sewage.

The results are stated in C.C. per Litre. Averages 100 samples.

	Carbonic Dioxide.	Carburetted Hydrogen.	Nitrogen.	Sulphuretted Hydrogen.	Oxygen.	Ammonia.	
No. 1	2·69	5·01	16·2	0·60	1·21	0·004	
„ 2	11·04	3·27	19·4	1·37	3·06	0·006	
„ 3	7·32	1·56	15·8	4·02	2·51	0·006	
„ 4	4·06	6·72	17·9	2·49	1·04	0·004	
„ 5	17·49	2·04	20·6	3·06	3·23	0·004	

JOHN COLLINS, F.C.S., &c.
WALTER HEPWORTH-COLLINS.

The Laboratory,
Bolton-le-Moors, 22nd Aug., 1884.

TABLE II.—"ANALYSIS OF MEPHITIC VAPOURS"

From Disused and Unventilated Cellar Dwellings.

Results are stated in volumes per cent.

	Oxygen.	Carbon Dioxide.	Ammonia.	Ammonia Albumised.	Sulphuretted Hydrogen.	Nitrogen.	Marsh Gas.
No. 1	20·83	0·58	0·086	0·142	0·26		0·313
„ 2	20·85	0·64	0·088	0·139	1·02		0·206
„ 3	20·73	0·59	0·084	0·144	0·56		0·564
„ 4	20·71	0·49	0·087	0·153	0·64		0·606
„ 5	20·65	0·92	0·085	0·136	0·72		0·217
„ 6	20·62	0·95	0·084	0·146	1·13		0·393

WALTER HEPWORTH-COLLINS.

Bolton, 22nd Aug., 1884.

On "Dublin Main Drainage Outfalls," by JOHN PURSER GRIFFITH, M.Inst.C.E.

IN discussing the question of the most advantageous position for the outfall of a main drainage system for Dublin, I think it may be assumed that main drainage is necessary, and that the objects of such a scheme are to purify the River Liffey and remove the sewage to such a distance that it shall no longer be a nuisance to Dublin or its suburbs.

That main drainage is a necessity has been admitted, firstly, by the action of the Corporation in promoting a Bill for the purpose, after having spent years in discussing every possible alternative; secondly, by the action of Parliament in sanctioning that Bill; and thirdly, by the recommendation of the late Royal Sanitary Commission for Dublin.

For the information of those not acquainted with the history of the Dublin Main Drainage Scheme of 1871, it may be desirable to describe briefly its principal features.

By the Dublin Main Drainage and Purification of the Liffey Act, the City Corporation were authorised to borrow £350,000 for constructing a system of high and low level intercepting sewers, terminating in a single outfall at the end of the North Bull Wall, at the north side of the entrance to Dublin Harbour.

The district to be drained consisted of the City of Dublin, and the townships of Pembroke, Rathmines, Kilmainham, and Clontarf, and the outfall sewer was designed to provide for the discharge of more than 7000 cubic feet per minute.

As the position of the proposed outfall affected the interests of the port, protective clauses were inserted in the Act, at the instance of the Dublin Port and Docks Board.

Two of these clauses deserve special attention. The first limits the time for the discharge of sewage from one hour after high water to one hour before low water, or during four hours of the ebb, and the second prohibits all solid matter or deposit from being discharged into the river, harbour, or bay.

Both these clauses are of vital importance to the port. Under no circumstances can those who are responsible for the maintenance of the navigable channel sanction works which may result in irreparable damage to the harbour entrance across the bar.

In all such cases the onus of proof that works of the kind will not be injurious must rest with the promoters, and the Conservators of the Port are justified in insisting on every possible precaution being taken to prevent injury to the navigation.

Naturally such restrictions as those introduced into the Act of 1871 would add largely to the cost of the works. The limit of time for discharge necessitates large storage accommodation; and the removal of all solid matter requires costly appliances and heavy working expenses.

The main drainage works were tendered for in 1873, at a time when almost every material used in the construction of such works had risen to "enormous and exceptional prices," and the lowest tender received was over £775,000. As this far exceeded the borrowing powers authorised by Parliament, the plans were recast, with a view of reducing the cost. Early in 1874 tenders for the revised scheme were received, but the lowest tender was still in excess of the borrowing powers, and finally the scheme was abandoned on account of the financial difficulties involved.

The failure of the Dublin main drainage and purification of the Liffey scheme was shortly followed by the promotion of a separate drainage system for the townships of Rathmines and Pembroke. Both these districts had been included in the Dublin main drainage area.

Under the advice of Mr. Richard Hassard, the joint townships sought and obtained Parliamentary powers to construct an outfall for themselves at the White Bank, discharging into the Liffey about one mile inside the harbour entrance.

The plea upon which Parliament was asked to grant these powers was, firstly, the inaction of the Corporation; secondly, that legal proceedings were threatened for suffering the sewage of the townships to flow into the river Dodder; and, thirdly, that the townships had prepared, and were willing to undertake, an independent scheme, which would divert the sewage from the Dodder, and conduct it to an outfall removed from resident population, and leading directly to the sea.

The area of the joint townships is about 3,200 acres; their population in 1871 was 42,000, and the estimated quantity of sewage to be discharged 180,000 cubic feet in twelve hours.

In the Act authorising this scheme, as in the Act of 1871, the Port and Docks Board obtained clauses for the protection of the port. The most important of these refer to the limit of time for the discharge of sewage, the payment of an annual subsidy for any dredging necessitated by the discharge of sewage, and an indemnity of the Port Board from all responsibility for nuisance created by the outfall.

The purification of the Liffey formed naturally one of the most important subjects brought before the late Royal Sanitary Commission, and it is a matter of the utmost importance to remember that the commissioners in their report clearly state, "We are of opinion that the River Liffey and the port and harbour of Dublin ought to be freed from pollution, and that the sewage of the entire city and its suburbs ought to be so disposed of as no longer to constitute a nuisance within the River Liffey and Harbour of Dublin."

Of the five schemes for the main drainage of Dublin laid before the Royal Commissioners, three were rejected because, using the words of the report, "though intended to purify the River Liffey, they did not provide for carrying the sewage out of the harbour, but proposed to discharge it within the limits of the port, and consequently would not purify the port and harbour."

I wish to lay particular emphasis on this opinion of the Royal Commissioners, as I firmly believe that any scheme carried out should fulfil these requirements.

When the Royal Commission sat in Dublin the Rathmines and Pembroke main drainage works were in course of construction, and it was considered by the Commissioners that the drainage of these townships might be excluded from any scheme dealing with the drainage area of Dublin.

We have now, however, had several years' experience of the actual working of the Rathmines and Pembroke main drainage system, and the results prove the truth of the predictions that this scheme would result in the pollution of the lower reach of the river Liffey, and that a great proportion of the sewage would never get out to sea, but be carried by the flood-tide on to Clontarf strand.

The experience of the past summer seems to me to put this beyond the region of doubt, and so thoroughly impressed am I of the injurious character of the pollution caused by this outfall, that I believe no scheme will satisfy the conditions laid down by the Royal Commissioners unless it deals with the drainage of Rathmines and Pembroke, and intercepts the sewage at present discharged at the White Bank outfall, and thus frees the river and harbour of Dublin from pollution.

The main drainage scheme approved by the Royal Commissioners was that of Mr. Neville, the city engineer, whose thorough knowledge of the drainage of the city gives his opinion great weight, especially as regards the construction of high and low level intercepting sewers through the city.

His proposal, as laid before the Commission, was the same as that of 1871, with, however, some modifications, chiefly due to the construction of the Rathmines and Pembroke works. The

capacity of the sewers was reduced, and the omission of the large storage reservoirs on the North Bull appeared to be contemplated. As the Port clauses of 1871, relating to the period of discharge, and the total removal of solid matter out of the sewage before its discharge at this outfall, must be introduced into any Act authorizing this scheme, I am at a loss to understand how the storage reservoirs can be omitted, and the saving of £50,000 referred to in Mr. Nevill's evidence effected. The proposal seems based on the idea of a similarity between the Rathmines and Pembroke outfall and that at the end of the North Bull wall. The cases are totally different, for at the White Bank any deposit from the outfall can readily be dealt with by dredging, while at the North Bull outfall no dredging could be done, and therefore the Port Board could accept no money subsidy as compensation for such deposit.

There can be no doubt that but a small portion of the sewage discharged from the Rathmines and Pembroke outfall finds its way out of the harbour, and consequently that any deposit from the outfall will be found in the river channel or on the banks. If in the river channel it can be dredged, while if it deposits on the adjoining strands it becomes a nuisance to the neighbourhood, but not an obstruction to navigation.

Both these contingencies are provided for by the Port clauses in the Rathmines and Pembroke Main Drainage Act. The first by a payment of about £250 a-year for dredging, and the second by a saving clause indemnifying the Port Board from all responsibility for nuisance created by the drainage works. The North Bull Wall outlet differs entirely from that at the White Bank in this respect, that for no money consideration could the Port and Docks Board undertake the responsibility of permitting any discharge which might create deposit in the neighbourhood of the bar.

Now, from our present knowledge, it seems certain that a large proportion of the sewage discharged from the North Bull outfall will not go beyond the bar, that during neap tides it will return into the harbour and flow up on Clontarf Strand, converting this Strand into a pestilential slob of about 1,600 acres in extent. We can scarcely imagine what this means. Possibly if we remember that the area of the bed of the Liffey uncovered at low water, west of O'Connell Bridge, which is now so much complained of, is but the two-hundreth part of the area of Clontarf Strand, an idea may be formed of what this nuisance will become in hot summer weather, with a light wind blowing in from the sea. In time it would simply become intolerable to the township of Clontarf, and, sooner or later, the outfall would have to be abandoned for a more distant one at Howth.

A Howth outfall has been talked of ever since Dublin main drainage has been seriously discussed, but Mr. Hassard has the credit of laying the details of a specific scheme with an outfall at the Nose of Howth before the Royal Commissioners.

While disagreeing with him as to the position of the outfall, which I should prefer to be either at the Bailey or Drumleck Point, I think the principle of his scheme correct, namely, to pump the whole of the sewage, and to have a constant discharge at the outfall, thereby requiring no storage.

Mr. Hassard's proposal for the city drainage forms a striking commentary on his Rathmines and Pembroke scheme. Surely if the White Bank outfall fulfilled the conditions of a good main drainage outfall, it would have answered for the city also. The mere fact of having to pay the Port Board an annual subsidy, even equal to ten times that paid by the townships, would not be a sufficient reason for incurring the additional outlay required to carry the sewage to Howth, and the annual expenditure for pumping, amounting to more than £3,000 per annum.

I do, however, believe that the removal of the outfall to Drumleck Point on Howth is fully warranted, as, although the interests of navigation can be protected by stringent clauses, such as have been inserted in the Acts of Parliament referred to, nothing short of this distant outfall will preserve the strands within the harbour of Dublin from sewage pollution.

My object will be attained, if by freely expressing my own views, based on an intimate knowledge of the port and harbour of Dublin, those into whose hands the main drainage of Dublin may be entrusted are led to reconsider carefully the position of its outfall.

The main drainage of Dublin and its suburbs is a work of so much difficulty and magnitude that I believe it can only be done by the joint action of the city and surrounding districts. I would therefore suggest the formation of a main drainage board for the whole drainage district surrounding Dublin Bay, including Dalkey, Kingstown, Monkstown, Blackrock, Pembroke, Rathmines, Kilmainham, Drumcondra, Clontarf and the city of Dublin, not necessarily with the object of discharging the sewage from all these districts by one northern outfall, but to ensure the proper drainage of each of these districts, and protect them from damage by the discharge of sewage from their neighbours' outfalls. As matters at present stand several of the townships cannot separately construct outfall works without injury to their neighbours.

The results of the Rathmines and Pembroke Main Drainage Works should be accepted as a warning against further isolated

action. A very large sum has been spent on these works, which I am convinced must sooner or later be abandoned if the strands within the harbour of Dublin are to be freed from pollution. Combined action has already been successfully carried out in the case of the reconstruction of O'Connell Bridge and the building of the Swivel or Butt Bridge. The cost was defrayed by what is known as the Bridge Area, a district specially formed by Act of Parliament, extending far beyond the limits of the City, and surely the purification of the Liffey and Harbour is even a work of greater importance to the districts surrounding the city of Dublin.

In conclusion, I would briefly summarize the foregoing remarks.

1. That it is necessary to free the River Liffey and Harbour of Dublin from sewage pollution.

2. That to carry this into effect, any main drainage scheme must intercept the sewage of the townships of Pembroke and Rathmines, as otherwise the Harbour of Dublin will still be polluted.

3. That in the interests of navigation, the proposed North Bull outfall will necessitate large storage accommodation and costly appliances for removing all solid matter from the sewage.

4. That the sewage will be brought back in large quantities on to Clontarf Strand during neap tides, thereby defeating one of the objects of the scheme, and causing an intolerable nuisance in the neighbourhood of Clontarf which must sooner or later be removed.

5. That the great cost of the works on the North Bull Wall, and the storage accommodation necessary, would go a long way towards constructing an outfall sewer to Drumleck Point, at Howth, through which a constant discharge could be maintained.

6. That to ensure successful results, the whole drainage district of the Bay of Dublin should be dealt with by a joint main drainage board.

Sir Robert Rawlinson, C.B. (President of the Congress), observed that Mr. Griffith was a representative of the Port and Docks Board, and might accordingly take a view quite different from persons examining the question solely from a public point of view.

Mr. Parke Neville (City Engineer, Dublin) spoke in support of his own scheme for bringing the discharge to the end of the North Bull Wall. Ample experiments had, he said, shown that the set of the tides would carry the discharged sewage away from the bar

without leaving any deposit on Clontarf strand or the bar. If Dublin were to be obstructed by the Port and Docks Board, a very long period would elapse before a system of main drainage could be executed. At the present time the sewage flowed down the harbour towards the bar. An outfall commencing so far down the harbour as the end of the North Bull Wall must be less injurious to the bar.

Mr. Patrick Doyle (Kingstown) remarked, with regard to the effect of the proposed scheme on Kingstown, that he was of opinion the harbour or surroundings would be in no way injuriously affected. For the sewage of Kingstown, to which Black Rock was now added, it was arranged to have an outfall near the end of the west pier of Kingstown harbour, discharging into thirty feet of water at low tide, and the current from the North Bull impinged against this point, and carried all away into the strong set of tide to the Mugglins, and this being so, he did not see of what use the drainage board, as proposed by Mr. Griffith, would be to Kingstown. They did not want it. To prevent the pollution of the River Liffey was a matter of great importance and interest. Any well-devised scheme to effect it was most desirable. He considered that the River Dodder, polluted as it was from its source, draining a large basin with a considerable population, and discharging into the Liffey at Halping Pool, tended immensely to add to the existing complained-of state of affairs, lodging all its filth and abomination on the foreshores up to the Pigeon House and on Irishtown Slobs. He believed the course of the Dodder could, with great advantage, be changed, and turned out on the Strand at Irishtown, and that thus a southern discharge for Dublin could be easily arranged, constructing a reservoir or reservoirs in the sandhills near the Poobeg, discharging all sewage matter at ebb tides, the current here setting strong for the west pier, Kingstown, and thence to the channel between the Mugglins and Dalkey Island. No doubt the abstraction of some scouring power from the Liffey might be advanced as an argument against this arrangement, but as the sewage would be delivered outside the bar, the loss was thus compensated for; also changing the course of the Dodder, as suggested, would reclaim a large tract of Slobs, thus far recouping this outlay. Any fear of the adjoining foreshores being polluted could, without difficulty or expense, be avoided. He considered, that on the lines above suggested, a southern discharge for Dublin sewage was desirable, which he was not aware had as yet been brought under notice and considered.

Mr. L. L. Macassey (Belfast Water Works) observed that he had given some attention to the subject of sewage outfall in Belfast, where things were nearly as bad as in Dublin; in fact both those cities were in a very similar position as regards outfall. They had to depend on the sea for taking away the town sewage. In questions of this kind the harbour interests were generally set up as hostile to those of the general community. Schemes for sewage outfall were often blocked because a little more annual dredging might be thrown on the harbour authorities. This was too narrow a view to take when the

health of a large population was concerned. It would be much wiser policy were the town and harbour boards to pull together instead of acting in opposition, as is so frequently seen now-a-days when questions of this kind are under discussion. Mr. Griffith had spoken in rather an unfavourable way of the scheme proposed by the city engineer for the disposal of the Dublin sewage. He apprehended that the sewage matter would be lodged on the Clontarf Sands, instead of being carried out to sea. Mr. Macassey had not sufficient information to enable him to go fully into the question raised by Mr. Griffith. This gentleman had given the meeting his conclusions, but had submitted no details or data to enable the members of the Congress to judge whether his conclusions were sound or otherwise. Mr. Griffith's views might be correct, but he had certainly failed to support them by any evidence. The city engineer had told the meeting that he had tested the currents near the proposed outfall at the North Bull, and the outcome of all the experiments made was clearly in support of the position selected for the outfall works. The city engineer had also given them full details on other matters connected with the scheme. This was intelligible to the Congress, and, on the data supplied it was possible to form some opinion. Mr. Macassey did not wish to be understood as advocating the scheme proposed by the city engineer as the best that could be adopted for Dublin. He had too little data in his possession to speak decidedly on this point, but he felt bound to say that in his opinion Mr. Griffith had entirely failed to prove that the city engineer's scheme was defective in the matter of outfall; in fact, Mr. Griffith's paper, if it had any positive tendency at all, went rather to support the views put before the meeting by the city engineer.

Prof. F. de Chaumont, F.R.S. (Southampton), one of the commissioners for inquiring into the condition of the Thames, unhesitatingly declared, in reply to Sir R. Rawlinson, that the discharge of crude sewage into a river should not be permitted under any circumstances. There could be no doubt that if a point could be found sufficiently distant from human habitations for discharging sewage into the sea that would be a safe way of dealing with it. But careful inquiry and experiments should be made to ascertain if the currents would return any of the discharged matter. The primary question for a sanitary authority ought to be the getting rid of sewage as a public nuisance; and the question of making money out it, which was too often made the primary object, ought to be regarded as very secondary. During one of their trips upon the Thames last summer to ascertain for themselves the state of the river, four out of the party of six (viz., three commissioners and the clerk) were seized with violent diarrhœa in consequence of the abominable stench, and if cholera had been prevalent at the time in London, the effects might have been much more serious.

Sir Robert Rawlinson, C.B. (President of the Congress), said the sewage tanks in London were originally constructed to equalise the

flow of sewage in the twenty-four hours, and it was laid down that under no conditions should the flow from the tanks take place until two hours after ebb tide had commenced, and thereby the volume of sewage collected during the preceding twelve hours would pass away to sea and not return. Either these tanks were too small, or the population had outgrown their capacity, because it was now found they did not answer their original purpose. A recent inquiry was held to ascertain whether sanction should be given to the Metropolitan Board expending £160,000 to acquire increased tank accomodation. Strong opposition was offered by the Conservators, and an appeal was made to the Home Secretary, which resulted in the appointment of the Royal Commission, of which Prof. de Chaumont was a member. Tanking was not a purification of sewage. He did not know that the Thames would be at all benefitted even if the tanks fulfilled their original purpose. Tanking sewage made it semi-putrid and capable of doing greater injury than if it were carried away immediately. Tanks would become more and more unnecessary, as that remnant of barbarism—macadam, disappeared from the streets. Macadam streets were simply a rude sort of mill for grinding stones into dust in summer, and into mud in winter.

Mr. J. P. Griffith (Dublin) in his reply, said it was suggested that he had viewed this subject solely in the interests of the Port of Dublin, regardless of those of the City. He, however, considered that the interests of the Port and City could not really be separated. In discussing the subject he had endeavoured to avoid taking a prejudiced view. His connection with the Port naturally gave him special opportunities for forming an opinion on this question, and he expressed his opinions in no captious spirit, but with the hope that they might induce those responsible for the execution of the main drainage of Dublin to investigate the problem afresh, so as to ensure that no scheme would be adopted without an adequate knowledge of the tides and currents of the bay.

With certain restrictions as to the discharge of sewage from the North Bull outfall the safety of the Port might be ensured, but he believed that if this outfall were adopted the Harbour of Dublin would not be freed from pollution. Mr. Neville had referred to certain float experiments in which the floats had invariably gone out in the direction of the Bailey, thereby proving that the sewage discharged from this outfall would be carried out to sea. That in itself indicated that these experiments were too limited. If float experiments were to be relied on, and he knew of no better evidence as to the direction in which sewage would be carried by a current, such experiments must be made systematically at all hours through neap tides as well as springs, and floats started from the proposed outfall must be traced not only on the ebb tide but through the following flood tide. Such a set of experiments, although involving a large expenditure of time and money, would be of immense advantage in the interests of the City of Dublin.

These experiments would, he believed, prove that a large proportion

of the sewage discharged from the North Bull outfall would be carried towards Kingstown by the ebb tide, and return into the harbour by the flood tide, and be carried upon Clontarf Strand.

The experience gained by the London Main Drainage Works should not be lost sight of. The result of not having carried the outfall sufficiently far from London was now evident from the polluted condition of the Thames, and costly works were in contemplation to remedy this defect.

If the North Bull outfall proved a failure no extension of it would be possible, and the only remedy would then be to abandon the costly works constructed along the North Bull Wall and carry the outfall to Howth. The necessity for reservoirs had been challenged on the ground that those in London had not been successful. The evidence given before the Royal Commission on the Metropolitan sewage by Sir Joseph Bazalgette, showed that the reason of their want of success was insufficient capacity, and that the Metropolitan Board of Works were prepared to expend £160,000 on their enlargement. No attempt was made in London to remove the solid matter before discharging the sewage into the Thames. This would however, in the case of the North Bull outfall, be essential in the interest of the Port of Dublin.

He wished to lay great emphasis on the advantages of a Main Drainage Board for the City and its suburbs, both on the north and south sides of the bay. The townships of Blackrock, Monkstown, Kingstown, and Dalkey, were at the present moment suffering from the evil effects of divided authority in the matter of main drainage. If some of the drainage schemes proposed for these districts were ever carried out, not only would the results be unsatisfactory to themselves but injurious to their neighbours, and probably prove a fruitful source of litigation.

Mr. Cotton had asked what the extra cost of the Drumleck outfall would be over that at the North Bull, and what advantages it had over that of Mr. Hassard.

The cost would not exceed the estimate for the North Bull outfall, including reservoirs, by more than £50,000.

The great objection to Mr. Hassard's proposed outfall was that it would be practically impossible to obtain permission to construct the outfall so close to the town and harbour of Howth and the most populated part of this seaside resort. Whereas no great opposition would be raised to Drumleck, and the discharge would be into the Rosley Channel, where the tide sets for nine hours to the eastward.

On "House Drainage in Connection with Town Sewers," by GEORGE BENJAMIN NICHOLS, F.S.A., F.G.S., F.R.M.S.

IN introducing the subject of house drainage connection on to the main sewers of a town, I think it will be admitted by everyone professionally connected with sanitary works, and others who take an interest in sanitary regulation, that this is a matter of the most vital importance, not only to the health of the individual inhabitant householders, but to the public at large.

I shall endeavour to bring the subject before you in as brief a manner as is possible, consistent with the various details connected with this branch of our sanitary regulations, and at the same time to lay before you some of my experience of recent date in connection with the sewerage of towns of large populations.

You will agree with me that the subject is of sufficient importance with regard to the proper construction of a perfect system of sewerage that any remarks or information that can be brought to bear on the matter is well worthy of our consideration at the present meeting of the Sanitary Congress, and I trust the introduction of the subject will lead to a discussion which may tend to the interest of the Sanitary Institute of Great Britain, of which I have the honour of being a member, and of those engaged in sanitary pursuits, and also to the welfare of the public.

We are fully aware of the large sums of money which have been expended in the construction of a system of sewerage for most of our large towns in England, and of the great care generally exercised by the town authorities to have the work well laid out and well constructed, and likewise we are aware of the care bestowed by the engineers of the Local Government Staff as inspectors who examine the various schemes brought under their notice and the value of their reports thereon, and how carefully these are considered by the chief of the engineering staff—I allude to our highly-esteemed and eminent friend Sir Robert Rawlinson.

It has been frequently observed how the skill of the engineer in laying out a scheme of sewerage is frustrated and his work condemned, not only during the progress of the work, but when it is completed, and proved to act in the most admirable manner for the use and benefit of the inhabitants, works on which a

large expenditure has been added for the purpose of properly and perfectly facilitating the discharge of the drainage from the houses and premises on to the main sewers in order to preserve them from injury and to insure that they should properly perform the work allotted to them. And what do we find? That there the work as regards its sanitary functions ceases.

Now, it is upon this most important feature in a scheme of sewerage that I have ventured to request your attention, "and for this reason." In many cases, the engineer having completed his scheme and handed it over to the authority, in every respect satisfactory, is afterwards blamed, and his scheme condemned, because of the neglect of the authority in not providing and insisting on the work of the house connections being carried out in due time and proper progressive order; and what is still more to the point, with proper and suitable materials, necessarily required in accordance with what the scheme demands for its success, and sometimes necessitated under the peculiar circumstances of the locality.

In all cases the work should be done under the control and supervision of a thoroughly qualified person paid by the authority, in accordance with a reasonable code of Bye Laws, specially adapted to be suitable to the district and the requirements of the scheme, and regulated by a fair schedule of prices based upon the cost of material and labour.

It is, however, a pleasing thing to be able to record that as far as I have been able to ascertain, with very few exceptions, has the work of town sewage, when intrusted to a qualified engineer, been a failure as regards the main works of the sewers themselves. But it is a source of regret that we find, in too many instances, an authority having laid down, at a great expense, a scheme of sewerage most admirably adapted to their district, consider that they have done their duty and all that is required of them, and the important work of the house connections is left to be done by the owners of the property, just as they please, the result of which is, as we are all fully aware, one of the greatest hindrances to the success of the best laid out scheme of sewerage that can be imagined.

To go into the multifarious details with which we are, I regret to say, but too familiar, would be only taking up our valuable time. Town surveyors know too well, from their own personal experience, these various defects, and the humorous dodges (if I may make use of the expression), exercised by the lower classes of builders, whose only object is to get the work done anyhow, so that they can say the premises are thoroughly drained and connected on to the main sewer.

With regard to my own experience of these matters I can only say, and I say it with great reluctance, that if the engineers of works or the duly appointed surveyor to a corporation, or an urban or rural sanitary board shows a disposition to insist on the work of the house drainage being properly connected on to the sewers, and with suitable materials adapted to the particular circumstances of the case, he more than often gets himself into trouble. The owners of property, as a rule, object to have their premises interfered with under any special rule, and they consider they know what ought to be done to their own property better than any one else can tell them, and that having to pay for the work they have a right to employ whom they like and get the work done as cheaply as possible, and any expostulation by the sanitary officers is at once complained of to members of the authority (who may or may not happen to be friends), which often leads on to a series of public meetings to condemn the action of the local authority on the grounds that if insisted upon it is interfering with the rights and privileges of the ratepayers.

I have maintained, and still maintain, that all schemes of sewerage should be designed and constructed to receive the house drainage in the most perfect manner, and that so soon as the sewers are ready to receive the sewage the owners of property should be compelled to carry out a perfect system of house drainage and connections to the sewer upon one principle, such principle to be maintained and supported by the authority and under their entire control, and any deviation therefrom should be subject to the highest penalties the legislature can enforce.

In two instances on some extensive works in England on which I have been engaged I adopted this principle, and I was supported by the chairman and a majority of the members of the authority. But the expense of having the work done in a proper manner and arranged to be carried out by the contractor for the main works, under a special schedule of prices included in his contract, led to complaints by some of the inhabitants, not on account of the manner in which the work was carried out (which, I may mention, was being carried out under the superintendence of the resident engineer in charge of the works), but on account of the cost. Some of the so-termed independent ratepayers condemning the action of the authority, simply on the grounds which I have referred to, and this arrangement was abandoned. Anyone was allowed to carry out the work in a manner after his own fashion, by the most ignorant of workmen, with the cheapest of materials. The junctions in the sewers were never looked for, and the sewers

consequently got broken into, and damaged to such an extent that, in many instances, they became partially blocked.

We are all aware that the local Government Board recommend the advance of capital to carry on these sanitary works, and, in doing so, I am of opinion that they would do well to insist that the house drainage and connections should be made to form part of the whole scheme of sewerage, and hold the authority responsible for this work, which, in every instance, should be carried out under the supervision of thoroughly qualified officers. If such a state of things could be accomplished under some enactment, we should have our habitations in a healthy condition, and be free from the effects of sewer gas, and the mortality reduced to a state which would not only gladden the hearts of those for whom the work was performed but of the whole community.

[*For discussion on this paper see page* 302.]

On "Domestic Drainage in Dublin," by W. KAYE PARRY, M.A., Engineer to the Dublin Sanitary Association, Examiner in Sanitary Engineering, King and Queen's College of Physicians, Ireland.

So much has been written on the subject of drainage, during the last few years, that the topic has become somewhat threadbare; and when Sanitary Protection Associations are springing up in every town, it may reasonably be asked what features of special interest can be claimed in connection with the drainage of Dublin houses to warrant the intrusion of this paper into the limited time at the disposal of our section.

The object of the following remarks is two-fold—firstly, to show to the members of the Congress that the proper machinery exists in this city to enable the residents to ascertain, for a moderate fee, the sanitary condition of their dwellings, and to afford them disinterested advice and assistance in remedying defects; and, secondly, to suggest some of the practical difficulties which assail the engineer in his endeavour to improve the existing arrangements.

In the year 1883 the Dublin Sanitary Association, which had for some considerable period been engaged in promoting sanitary reform, resolved to add to its other important functions the

duties connected with sanitary protection. The necessary rules were framed, a scale of fees was decided upon, and the writer was appointed Engineer to the Association and sent to Edinburgh to examine and report upon the working of the Sanitary Protection Association in that city. During the fourteen months which have elapsed since similar work has been undertaken here, some seventy inspections have been made, chiefly in Dublin County and City. This number, although far below what might reasonably have been anticipated, may be considered a fair inauguration, and each succeeding quarter shows a steady increase. Hitherto no attempt has been made to secure for the members the benefit of periodical inspections, but the committee is fully alive to the importance of this step and have it in contemplation.

It is hardly necessary to point out that the essential difference between the system of sanitary protection adopted by the association and others offered to the public is, that with the association there is nothing to be gained by putting the householder to unnecessary expense, as the fees both for the report and for the necessary supervision of any alterations that may be suggested, are fixed, and do not represent a percentage on the expenditure; and when members do not see their way to adopt all the recommendations, assistance is rendered to enable them to secure, at the least possible outlay, comparative immunity from risk.

Turning to the second object of this paper. Dublin, while in many respects it resembles other towns, presents some special features which demand exceptional treatment and entail corresponding difficulties.

Those who have read the Report of the Sanitary Commission which sat in Dublin in 1879 will understand that although much has been done to improve the condition of the main sewers, they cannot be said to be satisfactory; many of them are of an obsolete section and encourage the retention of sewage; others are tide-locked to such an extent as to interfere materially with their efficiency; while in other cases the position of the sewer is open to the gravest objection. As an instance of the last-named defect, it may be stated that in a leading street the main sewer runs parallel to, and partly beneath, the flank wall of one of the houses, and actually flows beneath the centre of the floor of the meat larder. The writer has seen the water of the Liffey bubbling up through the surface traps in the areas of the Four Courts, in spite of precautions which exist in the shape of a flap valve and a Penstock. Houses situated on the quays are periodically subjected to this tidal influence, which carries back the sewage and

compresses the gas to such an extent that traps can hardly be expected to offer an effectual barrier to its entrance.

Another difficulty arises from the fact that, as in other old towns, the house-drains in Dublin were formerly constructed of brickwork or rubble, tiles and flags, and the sewers are consequently not provided with suitable junctions for the reception of the pipes which are replacing the old-fashioned built drains. The connection between the pipe and the sewer cannot, therefore, be regarded as satisfactory, and in many instances it is feared that through the carelessness of workmen the wall of the sewer is not securely built up round the pipe, and the subsoil, for this reason, may become saturated with sewage.

Another cause operates more powerfully in the last-named direction, and it is this: that the drain-pipes which are laid by the Corporation workmen beneath the roadway, between the house and the sewer, are not jointed either with cement or clay, and a considerable portion of the liquid which passes into them must of necessity escape into the ground.

In connection with the last remark it is instructive to note that when the Dublin Port and Docks Board were repairing one of the quay walls they came upon the gravel which underlies that portion of the city, and the air of the diving bell in which they were working became charged with sulphuretted hydrogen to such an extent as to become almost irrespirable. Whether the presence of this gas is to be attributed to sewage or to other causes I must leave to the chemists to determine.

The sub-soil drainage of city houses has hardly been dealt with satisfactorily. Since the introduction of the Vartry into Dublin the wells have fallen into disuse, and the level of the sub-soil water has risen. The old-built drains permitted this water to percolate into them through the interstices of the walls and covering flags, and carried it off to the sewers, but the would-be sanitarian steps in, with the salt-glazed socketted pipe with cemented joints, and makes no provision for the removal of this water; the consequence is, that the basements of many Dublin houses are found to be more damp than under the former conditions. No doubt the problem is beset with difficulties, because while on the one hand we must guard against sand or loam being carried along with the water into the pipe drains, if any connection is made with it, on the other hand precautions must be taken to prevent the sewer gas escaping at the connection, and polluting the ground air in the neighbourhood of the house.

In addition to the foregoing there are the difficulties which must be grappled with in every case where a reformation in house drainage is attempted. Foremost amongst these may be

placed the intercepting trap between the house drain and the sewer. We are all familiar with the many forms of trap which have been designed for this purpose, but the problem can hardly be said to have been, as yet, satisfactorily solved. What is required is a trap which is not liable to choke, and which can be readily cleaned out, having an effectual water seal and yet holding as small a quantity of water as possible, which should be changed with every flush. What is found to exist in most cases is a running syphon, a man-hole syphon, or a Buchan buried underground in some unknown position, the existence of such a trap not being suspected until a stoppage occurs, and liquid sewage begins to well up through the surface gratings in the areas. If we are asked whether there is any interceptor which can be relied upon to do its duty without attention for a number of years with unimpaired efficiency, we must at present answer, "No!"

The second point of importance is the ventilation of the drain. Upon what are we to rely to set the air in motion, and what should be the direction of the current? The course which is usually adopted is to arrange the fresh air inlet near the intercepting-trap in the front of the house, and to carry up the soil-pipe full bore to the roof, to act as a foul air outlet, but there are some obvious objections to this device. In the first place, the area of the cross-section of the soil-pipe is seldom more than one-half that of the drain-pipe, and the passage of the air must be seriously impeded unless a powerful induced current can be set up; and, secondly, every flush of water sent through the pipe reverses the air current, the inlet becomes an outlet, and the olfactory nerves of sensitive people are unpleasantly excited. To meet this objection, the soil-pipe is sometimes arranged as the inlet, and a ventilating pipe carried up the front of the house to act as outlet; but again we encounter the difficulty of reverse currents, for there must be a considerable difference in level between the in-go and the out-go of the air-syphon to ensure a steady current. This necessitates keeping down the head of the soil-pipe, and if the pipe be exposed to the rays of the sun the current may even then be reversed, and sewer gas delivered at a dangerously low level. The only other alternative is to fix a ventilated soil-pipe intercepting-trap, such as that designed by Mr. Hellyer, at the foot of the soil-pipe, and provide independent drain ventilation. This generally means taking a pipe from the head of the drain to some point in the back garden, and running the risk of giving the children the benefit of whatever emanations the air may carry with it.

In many Dublin houses the ground floor water-closet is in a return building at the rear, and thus constitutes another difficulty.

If both the soil-pipe from this closet and the one from upstairs are directly connected with the drain and only one air inlet provided, we may have all the foul air at times passing out through the soil-pipe at the return building, the head of which cannot be much higher than the roof of the return, which is generally below the level of the upper windows of the main building; a second ventilated trap on the main line of drain in the back area will give two independent circulations, but the multiplication of such traps is in itself a fertile source of future derangement.

Theoretically we all know that house drains should be laid in straight lines, with man-holes for inspection at every change of direction; but in remodelling the drains of old houses how difficult it is to observe this rule without planting man-holes in the floor of the house itself, and if that be done can we rely upon the joints of the covers being really air-tight? Nor must we forget in enumerating the difficulties to include the grease. If we provide one of the many traps now in the market to arrest the fatty matter and prevent its entering and choking the drain, how are we to ensure the periodical cleansing of this appliance? will it not be often neglected, until it is found to be literally crawling?

Chloride of lime, in the hands of a fussy matron, is a dangerous enemy to the drains. Some people introduce large quantities of it, periodically, into the pipes, and the intercepting traps often get choked in consequence. But a worse foe than the lime, in the hands of the mistress, is the size in the bucket of the house painter, who regularly pours it into the most convenient surface trap, and neither thinks of nor cares about the evils that may result.

There is nothing original in the foregoing statements; every sanitary engineer encounters similar problems in his attempts to reconcile theory and practice, but we have met to exchange ideas, and it is hoped that a discussion will arise upon some of the points alluded to, and that the result will be profitable to those who are interested in the subject.

[*For discussion on this paper see page* 302.]

On "Practical Sanitary Lessons, derived from 1,000 *Sanitary Inspections of Dwelling Houses in Ireland," by* WILLIAM ROBERT MAGUIRE, F.R.Met.Soc.

WHILE it is customary and, indeed, quite natural to expect men of scientific and literary attainments to lecture and write on sanitary matters, practical sanitary workers are not often asked to state their opinions, and, being busy men, they cannot spend time in pressing them on the attention of the public. On some sanitary matters, however, they hold very decided opinions which, embodied in practical suggestions, may be serviceable to the public at large, and, therefore, worthy of the attention of a Congress of the Sanitary Institute of Great Britain. As the writer was the first practical sanitary worker to introduce and establish systematic sanitary inspections and insurance of dwelling houses in Ireland, he hopes for your indulgence while endeavouring to place before you some facts of practical sanitary moment, noted carefully during the labour involved in inspecting and reporting on the sanitary condition of over 1,000 houses in this country, a wide area of insanitary domestic existence, the extent of which can only be appreciated by those who have actually shared in similar work.

These sanitary inspections of dwelling-houses in Ireland, chiefly in Dublin, have abundantly confirmed the startling statement, first made boldly and publicly with authority by the President of this Congress (Sir Robert Rawlinson, C.B.), when chairman of the Royal Sanitary Commission, held at Dublin in September, 1879. During the progress of the enquiry, Sir Robert Rawlinson said:—

"235. CHAIRMAN—I wish at this point to state, for the information of the inhabitants of the better class of houses in Dublin, that I have no hesitation in saying there is not a single residence in Dublin or in its vicinity, or a single nobleman's residence in Ireland, I do not care where it is situated, which, if its drains and sewers have not been scientifically dealt with within the last half-dozen years, is in a satisfactory condition: that is, if there are any sewers or drains at all, they are in a bad, dangerous, and unwholesome condition. I have no hesitation in saying so publicly. I know these facts, and this induces me to draw the attention of parties residing under such conditions to the danger that they are running into, as if they value their money more than they value their comfort and their health,

they may be living under conditions where their life is not worth twelve months' purchase if anything occurs to develop the elements of evil to which they are quietly submitting, by leaving their residences in such a state. Now as to Dublin; you may sewer it to perfection, you may purify the Liffey, you may scavenge, and do everything that you possibly can, but if the persons who possess wealth, and who are living in these large houses which have old drains, do not take thought and get their premises properly examined, and face the expenditure, they will continue to live under conditions that must tend to great discomfort, and probably to shorten the lives either of themselves or some members of their families. Unfortunately, in one respect, these things cannot be done without cost. But the question every person should consider is, whether there is anything in this world that is of more value than means of comfort and health. I do not know of anything that can be compared to them."

This most important verbal public statement concerning Dublin, true absolutely in substance and in fact, was followed by the more deliberately considered written report to the Queen; no apology is needed, for the repetition here of the impressive words of such men as the Royal Sanitary Commissioners:—

REPORT OF ROYAL SANITARY COMMISSION, DUBLIN, 1879, ON HOUSE-DRAINAGE.

"*The evidence laid before us leads to the conclusion that house-drainage in Dublin is extremely defective, and we have reason to believe that this is the case in all classes of houses.* The house-drains, from the description given, would appear, in the vast majority of cases, to consist of loosely constructed rubble-walled channels, resting on the soil beneath the basement, and from their imperfect construction presenting numerous points of leakage, through which sewer gas and fluid sewage escape and saturate the sub-soil. Most of these house-drains were originally laid down with a view to the carriage of little more than waste water. Since the date of their construction, however, and especially since the introduction of the Vartry water, the abundant, constant, and high pressure service provided by this source of supply, has tempted house-owners largely to increase the number of water-closets in private houses; and such additional water-closets have been set up without corresponding improvement in the system of drainage with which they have been placed in connexion. The result of this attempted removal

of excreta by defective house-drains has been sewage saturation of basement sub-soils. Under conditions such as we have described, it is not surprising that the health of Dublin should have suffered, and that the mortality from diseases classed as constitutional should have remained high. *Our attention has also been drawn to the circumstance that in another form a defective system of house-drainage extends to the connexions between the drains and the public sewers, because no systematic attention has been paid to the importance of making a proper break at the point of such connexion, and that, in consequence, house-drains form in many instances the terminal points of sewers, thereby constituting them, at high levels, the points of maximum pressure of sewer gases.* We have found that in houses of modern construction upon suburban sites, the builders have taken no proper steps to break the house-drain connexion with the houses.

"The extreme importance of providing all houses with properly designed and constructed air and water-tight drains will be more readily appreciated by a consideration of the nature of town-sewage and the dangerous gases it is capable of producing and setting free."

ROBERT RAWLINSON, C.B.
F. X. MACCABE.

Out of more than one thousand dwelling houses inspected in Ireland, from noblemen's mansions to six-roomed cottages, only twenty could be truthfully certified free from danger to the health of the residents. No selection of these houses was made; they were examined in the order in which they were placed on the books. About fifty of these were tolerably secure though faulty, while twenty only were found free from defect.

This is not a mere statement of opinion, but a record of carefully ascertained facts.

Allotting 10 persons to each house, we have here over 10,000 persons living under conditions where their lives were continually in needless danger, and where it is known that many from these causes suffered serious illness, in some cases ending fatally.

Taking 550 inspections, of which the writer has preserved very accurate records, the details show the following results:—

480 house-drains so ill-arranged and constructed that foul gases of cesspools or public sewers had free entrance into the dwelling.

259 old-built drains of deposit acting as long foul cesspools under kitchens, pantries, and basement bed-rooms, and generally having rat burrows into the basement.

416 drains leaking sewage into basement sub-soil.

397 drains having defective junctions.

162 drains dangerously choked with foul deposit.

238 drains devoid of arrangement for ventilation, besides many modern unventilated pipe-drains conveying the concentrated foul air of unventilated cesspools direct into dwelling, as shown by smoke-test.

Many modern pipe-drains broken, or laid with open joints, leaking sewage into basements.

440 scullery sinks, so dangerously connected direct into drains, that polluted air flowed thence into houses day and night, as shown by smoke-test.

198 water cisterns supplying drinking water polluted by foul air from overflow pipes in connection with drains, or by surrounding impure air.

Many soil-pipes with open joints passing through pantries or larders, polluting milk, butter, meat, &c.

60 ashpits or cesspits dangerously located against house-walls or under basement of return buildings.

A list of fifty-one specific insanitary and dangerous defects actually discovered during sanitary inspections in dwelling houses may prove a serviceable indicator for enquirers.

1. Common brick or stone built drains under basements.
2. Large, built drains, under or near dwellings.
3. Pipe drains of larger diameter than actually necessary.
4. Pipe drains broken, or with leaking joints, saturating the sub-soil with sewage.
5. Pipe drains with built or imperfect junctions.
6. Pipe drains under dwelling without sufficient fall.
7. Pipe drains with fall in the wrong direction.
8. Drains of any kind without proper intercepting traps.
9. Drains of any kind without constant free current of air throughout.
10. Drains without easy means of inspection.
11. Drains carried from public sewer direct under hall door steps and under scullery floor instead of across open area.
12. Rat burrows from built drains undermining floors.
13. Rat burrows from public sewer worked along outside pipe drains into houses.
14. Defective connection between soil pipes and drain.
15. Soil pipes inside houses under almost any circumstances.
16. Soil pipes inside or outside without any or ample ventilation.
17. Soil pipes through pantries, larders, or stores.
18. Defective or ill-constructed water-closet apparatus.

19. Water-closet cisterns with overflows joined to soil pipe or drains.
20. Safe trays under water-closets joined to soil pipes or drains.
21. Two or more water-closets or sinks on one soil pipe, untrapping each other when used.
22. Overflow pipes connected to soil pipes liable to become untrapped.
23. Water supplies over troughs taken from water-closet or other contaminated cisterns, and liable to be used by careless servants to fill bedroom carasses for drinking.
24. Taps for supplying bed-room water fixed over housemaids' slop sinks, liable to be polluted by splash from slops emptying.
25. House cisterns, with overflows, joined to soil pipes or drain.
26. Traps of every kind, without ample ventilation to guard them.
27. Scullery sinks connected direct to drains, admitting foul air not only through traps but through joints of brickwork and plaster all round.
28. Bell traps, with loose covers on scullery sinks.
29. Gullies or traps in floors of sculleries, laundries, larders, or basement, &c., connected to drain, and usually dry and untrapped.
30. Ventilating foul air shafts, discharging near chimneys or windows or ventilating openings.
31. Rain pipes used as ventilators for drains, discharging foul air near bed-room windows or under roof eaves.
32. Rain pipes used as or connected to soil pipes, likely to freeze soil pipe solid in severe winter.
33. Rain pipes passing down centre of houses connected in any way to drains.
34. Open rain courses from valley gutters, passing under floors to outside down pipes connected to drain.
35. Rain pipes of low roofs, bow windows, or porches connected direct into drain.
36. Ashpits located near larder, pantry, or dwelling.
37. Ashpits liable to let moisture soak into house.
38. Ashpits capable of retaining moisture, or unventilated.
39. Rat burrows from defective drains in neighbouring premises.
40. Defective drainage or fittings in neighbouring premises.
41. Any direct communication with drains of neighbouring premises.
42. Water tanks in areas, near ashpits or sculleries, or with any connection of overflow to drain.

43. Bath waste or overflow pipes connected to soil pipes or drains.
44. Washhand basin wastes or overflows connected to soil pipes or drains.
45. Water-closet cisterns under bed-room or parlour floors.
46. Cesspools near houses, or unventilated anywhere.
47. Cesspools or drains near wells.
48. Drains crossing your house from neighbours' premises.
49. Field or surface-water drains, with open joints, under basement connected to house drains direct.
50. Damp basements or damp walls.
51. Drinking water defects of source, supply, or storage.

Each defect mentioned here, and how to avoid it, would occupy an essay in explanation, but in the brief time at our disposal we must pass them by in naming them, and endeavour to deal practically and usefully with one point of paramount importance in house inspection—the house drain.

Let us consider the house drain under two distinct sections.

The first section is that laid by and under the control of the sanitary authority, from the public sewer across the roadway up to the outermost wall of the premises drained, inside which limit the sanitary authority does not go.

The second section is that laid by and under the control of the occupier or owner of the houses and premises, beside, around, or under the houses, as circumstances require.

The opinion has long been held and is growing steadily that we are making very serious mistakes in Dublin, decidedly injurious to the health of the citizens and increasing the death-rate—

1st. By using pipes of 9 in. diameter for the house-drain, laid across under the streets, connecting the houses with the public sewers.

2nd. By laying them on the soil without cement concrete foundation, and so that they are liable to sink.

3rd. By not imperviously cementing the joints.

4th. By leading them into the house direct under the scullery instead of invariably leading them across under the open area.

5th. By not compelling the use of approved Interceptor traps to exclude the public sewer air.

The 9 in. diameter drain-pipes used in Dublin are 50 per cent. too large in diameter and area for their purpose of conveying drainage rapidly from the houses into the public sewer.

The speed and carrying power of the ordinary water flush sent through a 9 in. drain is very much less than the same would be through a 6 in. drain. This may be illustrated by sections of the two pipes, 6 in. and 9 in. diameter, and 3 feet long

each, glazed transparent at each end. An ordinary flush of two gallons of water poured into each shows 3¼ inches depth of water in the 6 in., but only 2½ inches depth in the 9 in. drain.

This water, when flowing, will be attenuated to 2½ in. and 1½ in. deep respectively.

Here, then, the power of carrying solids is evidently much greater in the 6 in. drain, because the water is deeper and the friction surface of pipe less extended. If we could prolong these two drains 50 feet, giving to each an equal inclination, we should find the two gallons of water flowing through the 6 in. drain at much greater speed and force than in the 9 in. drain. The smaller drain would carry the solids along more effectually, and therefore be less liable to hold deposits or to choke than the 9 in. drain. Of course, if we extend the experiment to a 12 in. diameter drain (a size which was specified recently as proper for draining a house in Sackville Street) we find that two gallons of water will not do much more than just wet the bottom of the pipe.

It is very important that the proper size of house-drains should be adopted in a great city. Dublin City, exclusive of suburbs, contains more than 25,000 houses in about 130 miles of streets, with a population over 250,000. Taking 7 yards or 21 feet of drain under Section 1 as a fair average for each house, we have 100 miles of drain laid across under roadways from houses to sewers under the control of the sanitary authority.

The length of private house-drains and branches, beside under and around houses, extends many hundred miles more, but at present we are only dealing with the section under the sole control of the sanitary authority.

Now, the internal surface area of this 100 miles of drain is more or less foul, and is constantly giving off exhalations to the air in the drain, the proportion of this internal surface area of 9 in. to 6 in. drain is as 2¼ to 1½, *i.e.*, the 100 miles of 9 in. drain now laid under our streets and connected with our houses contains 1,188,000 square feet of foul surface area inside, as compared with 792,000 square feet the surface area of 6 in. drain, an absolutely unnecessary excess of nearly 400,000 square feet of foul surface in our drains.

The manipulation of 9 in. drains is very much more laborious than with 6 in. drain, as may be seen by considering their respective weights.

The weight of a yard of 9 in. drain is 90 lbs., and of 6 in. 56 lbs.

The weight of a 9 in. interceptor trap is 130 lbs., and of 6 in. 70 lbs.

Therefore, in laying the 100 miles of cross drains, and the interceptor traps for our 25,000 houses, an unnecessary dead weight of 3,270 tons must be carried and manipulated, or 8,450 tons of 9 in. as compared with 5,180 tons of 6 in. diameter.

The difference in the cost of 100 miles of 6 in. and 9 in. drain is also well worth public attention.

The first cost, sea-freight, land cartage, warehousing, accidental breakage, workmen's time handling, excavation of trenches, refilling and packing trenches, cement foundations, cement joints and interceptor traps—all cost much less for 6 in. than for 9 in. drains. An estimate of these items will show that a total saving in cost to the citizens, if the more suitable 6 in. diameter drains had been used, would be a capital sum in round numbers of at least £25,000, and a very notable saving in money may be effected in future if 6 in. drains are adopted, besides the saving to life and health.

The importance of forming a hard unyielding foundation for the drain should never be forgotten. Concrete formed of one part Portland cement to four parts clean coarse gravel, laid in a layer at the bottom of trench (between two boards afterwards removed), 3 in. deep by 6 in. wide, on ordinary ground, or 4 in. deep by 9 in. wide, on soft yielding ground, will form a sound foundation. It should be given the proper fall equally throughout, as carefully determined beforehand. The drain should not be laid until the concrete has set hard. As the laying of drain proceeds cuts or hollows, partly across concrete, should be made about 2 in. deep, and only sufficiently wide to receive the sockets of the pipe drain in such a manner that they shall lie over and in the hollows without touching any part, thus distributing the weight on each length of drain resting on the hard foundation, instead of allowing the whole weight of drain to press on the sockets, while from socket to socket the drain hangs unsupported, though pressed on by the weight of earth above.

If an unyielding foundation is not formed the drain will sink at certain points, forming dips or festoons underground, which cause stoppage eventually. These points have been noted by sanitarians often, yet sanitary authorities permit the continuance of the ancient defective and dangerous system. The chief difficulty we find in securing sound drains lies in the fact that they are laid and hidden underground. The aim of sanitary engineers should be to bring them to the light, and so to arrange their drainage that each portion shall be within easy inspection and cleansing distance.

There is no valid defence for the dangerous practice of laying drains dry without stanch joints. Drain layers when asked

why this is done, say it is in order that the pipes may not have to be broken when they are removed or altered!

Of course we know that drains ought to be laid down with the object of fulfilling their purpose of being sound and stanch to carry drainage safely for the health of the citizens, rather than with the ulterior object of removing the pipes safely at remote periods to the risk of the citizens' health in the meantime.

Perhaps the open joints may drain the subsoil, but if they admit sub-soil water in wet seasons they will allow the escape of liquid sewage to saturate the soil in dry seasons, and at all times permit the escape of sewer air in a dangerous manner.

The insufficiency of clay or soft yielding material has been clearly demonstrated, but it is still tenaciously defended by many professional men on the ground that clay yields if unequal pressure comes on any part of the drain and thus saves the pipe from fracture.

Here we actually find the dangerous elements of bad foundation expected and calculated upon, else the drain could not yield even with clay joints; we find the neglect of careless filling in over-pipes so as to cause unequal pressure looked for, and we find apparent forgetfulness of the fact that if a drain sinks or falls below its true level or inclination it is no longer a safe and reliable drain, but contains, whether fractured or not, dips or hollows which retain the drainage dangerously, and therefore such drain ought to be removed.

Clay will of necessity wash away out of the joints, as little by little the passing water disintegrates it. Portland cement is the best, the easiest obtained, and the most simply applied material for earthenware joints.

Roman cement is now little used, and experts have condemned its use for house-drains on the ground that the chemical action of sewage affects it injuriously and converts it into mud.

The dangers of this open-joint system are very serious:

1st. The open joints allow the escape of the water which is carrying the solids along, a portion escaping at each opening into the surrounding earth, till the liquid remaining is insufficient to carry on the solids, and they are deposited in the drain, and eventually cause a stoppage, which cannot perhaps be cleared until the drain is opened up.

2nd. The soil surrounding the drain becomes saturated with liquid sewage, which decomposes and becomes dangerous.

3rd. The drain is more liable to settle unequally, making hollows underground in which solids accumulate.

4th. The three or four joints nearest to the house under the coal-vault or scullery, being open, allow the foul sewer-air to be

forced rapidly through them into the house, and thus, owing to the rarified condition of the house-air, the foul air is pressed in day and night, unsuspected and in large quantities, as explained in diagram.

The discharging or sewer ends of the 9 in. pipe drains under roadways in Dublin are built into the walls of the public sewer, and these sewer walls are found sometimes so close to the outer walls of the coal vault adjoining the scullery as to appear formed by the one wall.

If breaches occur in these cases, caused either by too careless workmen or by too careful rats, the dangerous effect will be the same in either case.

Instead of allowing a mason to build well or ill according to his humour round the drain-pipe at its outfall through the main sewer wall, special glazed earthenware blocks should be used in each case, built carefully and neatly into the wall, and the drain should then be laid from them towards the house.

These blocks should be splayed to deliver the drainage current in the direction of the main sewer current.

One most important point in connection with this subject, which does not appear to have been considered, is the proper point or position in front of the houses to which the drain should be laid by the sanitary authority, and left for the house-drain to be connected with.

In the great majority of cases in Dublin the drains are laid in from the public sewer to the coal vault adjoining, and opening direct into the scullery under the hall steps, and therefore in direct unbroken connection with the kitchen and the dwelling.

Many deaths and much illness have been caused by this dangerous position for entrance of drains taken in connection with the open joints on the drains. Rats frequently make burrows along the outside of pipe-drains at this point to get from public sewer into houses, admitting the foul air also, which neither cat nor trap can catch.

The law or the sanitary authority should require all drains to be brought into the open areas in front of houses, and should forbid all direct drain connection under any vaults having direct covered access to the houses.

That interceptor traps are required on the line of drain, at some point before they reach the houses is held by sanitary engineers and now generally admitted. If interceptions choke, the fault lies in bad form, defective fitting, or insufficient flush, combined with the total neglect of observation on the part of the householder. There are now several forms of interceptor which in 6-in. size will clear every time an ordinary flush is used, nevertheless they should be fixed and arranged so that they can be easily inspected,

and that any serious stoppage will reveal itself at once on the surface. The fact that the drainage of all the houses in the streets on higher level than yours must pass by the mouth of your house drain, and that possibly this drainage is further polluted by the drainage from fever hospitals, which also discharges into the public sewers, ought to afford sufficient reason for the importance of intercepting sewer gas traps on private house drains. Their absence frequently allows infectious diseases to spread from house to house; indeed, without interception and thorough ventilation a system of supply and conveying infected drain air into houses exists, similar to that adopted by the water works committee for the purpose of supplying pure water, the only difference being that in the case of polluted sewer air the pipes are 9 in. diameter instead of ½ in., and the supply is unrestricted. Householders can have any amount of dangerous sewer air, but pure Vartry water must be very carefully and sparingly used, or the water inspector will cut off your supply at seven days' notice.

The diameter of interceptors generally corresponds with the diameter of the drain. Here may be seen a 9 in. and a 6 in. interceptor, side by side, for comparison of one of the best forms. You observe the necessarily large, clumsy, unmanageable dimensions of the 9 in., and the handiness of the 6 in. for manipulation, and you can at once see that no ordinary house-flush of two or three gallons of water would clear the larger trap, and consequently that foul deposits would be likely to remain, decomposing dangerously, and finally will choke the trap and drain unless a flushing tank is in use to discharge large bodies of water at intervals through the drain and trap. The need of these interceptors afford a very strong reason, therefore, in favour of 6 in. drains over 9 in. The two traps standing side by side ought to convince you.

The sanitary authorities do not provide or fix intercepting sewer gas traps on the section of drain under their control, the ends of the drains are left open, and the option of using interceptors is left with the householder, consequently drains are being daily laid without interceptors, or with interceptors of too large size and bad form, which choke in a short time and are worse than useless. Intercepting chambers should be placed in the open areas in front of every house, easy of access, and furnished with air-tight iron covers and abundant ventilation.

It might be a fair question for consideration whether the sanitary authority or the householder should provide this chamber, but I strongly incline to the opinion that it should be the duty of the sanitary authority to lay the drain from the public sewer in a straight line into the area, in every case also

providing and fixing a uniform intercepting sewer-gas trap on the house end with a splay junction to enable the drain to be cleared, while the building of the chamber, together with the house-drain and branches, at the house side of the interceptor should be the duty of the householder. This is common sense; the sanitary authority thus controls and prevents escape of the foul air of their sewers into houses, and no dispute as to position of interceptor can arise, as the angles at which house-drains join the intercepting chamber may vary, provided it be in the open area.

These intercepting chambers can be seen at the Exhibition.

Summing up the evidence on the question of the diameter of the drain we find that—

A 6 in. drain will carry sewage better and quicker than any larger size; that it is easier carried, lifted, cut, and manipulated; that the internal surface area giving off bad air is much less; that its interceptor is easily flushed; and lastly, that the cost is much less, an advantage sometimes appreciated above all others.

Some of our sanitary authorities still approve of 9 in. pipes for house-drains, but if this Congress shall be the means of convincing them that 6 in. pipes are better, the benefit to the citizens will be so great that it shall not have visited Dublin in vain.

The health of Dublin would be notably improved if the sanitary authority undertook a systematic examination and test of every house-drain, and compelled their universal reform. Practical sanitarians will be found in favour of stringent inspection and supervision of sanitary work, especially where it is hidden or covered up. They aim at having as much exposure as possible, and seek to arrange every part so that it may be easily seen and cleaned.

We hold that the sanitary authority of every city should keep plans, not only of the public sewers, but also of the branch cross drains as far as the interceptor in the areas, for reference.

There should be a stringent official inspection of the internal fittings of every house.

Although honest and capable contractors might be caused additional trouble where the special care needed is already exercised, yet such men would press for this salutary supervision of all, and even find benefit from it, in face of the terrible amount of downright bad and dangerous work which is done.

The manner in which unsanitary work has been, and still is, done is something awful, considering all the future evils it is working out with the certainty of a mathematical problem.

Turning now to Section II.: the private house-drains solely

under the control of the householder; there are two classes, drains inside the house walls and drains outside the house walls.

If it is possible to place drains outside the walls we are all agreed that they should be kept there even at considerable trouble and expense.

In the great majority of cases, however, in towns the drains must pass under the basement floor inside the house walls to convey drainage from the back of the house to the public sewer in front street.

No kind of work causes greater anxiety to an honest and competent contractor than the laying and jointing of drains underneath dwelling-houses entrusted to his care, for he knows that the health and perhaps the lives of the residents will be dependent on the soundness of the work.

Thorough sanitary inspections have revealed, among many other dangers, the scandalous manner in which pipe drains are sometimes laid under houses. We could name at least six householders in one of our fashionable Dublin squares who ordered new pipe drains to be laid under their houses, but were soon compelled to incur all the worry and expense of ripping them up and laying new drains properly, because the work had been ignorantly planned and carelessly executed. One cannot wonder at the deep concern and indignation of householders in such circumstances, though one does wonder why it is that the cost is so much considered in such vitally important work. The contractor is expected to lay drains and to become responsible for them at less per foot run than would be paid for a gilt moulding round a drawing-room.

In view of the extreme importance of sound work in drains and fittings, does it not seem the most extreme folly to try to get such work done at low rates? If tenders are invited and sanitary work allowed to be competed for, and given to the cheapest contractor, how in common sense can the best work be expected?

The drain is laid, and the evil results may appear soon or perhaps not for years, but eventually cheaply, rapidly-laid drains have to be ripped up and new drains laid at a cost of double the original value.

The present habit of some contractors scamping work is very largely due to the present habit of some employers scamping the amount to be paid for it.

Good work costs good money and cannot be had without it, and the sooner the community learn that they are losing fast in permitting competition for work involving life and health, the better will it be for the community.

The health of a household depends very much on the durability as well as on the initial soundness of each joint and piece of drain.

It is easy enough to lay a drain as drains go, or rather as drainlayers go, by rule of thumb, but to lay a drain sound and well is very difficult.

Passing by the difficulty of jointing, there remains the difficulty of obtaining earthenware pipe drains sound, true, and straight, so much as 60 per cent. having to be rejected from some lots even by the best makers. This has turned attention to cast iron as a suitable material.

You can see a specimen in the Exhibition that will bear a pressure of 300 lbs. per square inch without leaking one drop; there are also specimens of traps and all connections likely to be needed. Cast iron drain pipes to be desirable must be heavy, with turned and bored or leaded joints, and coated with a preservative solution. They are then naturally true in circle, straight in run, and strong to resist outer or inner forces.

There are difficulties, of course, requiring to be surmounted, but all can be overcome as they occur. Costly patterns have been prepared for every form of connection likely to be needed. There is no form of trap or junction made in earthenware that may not be easier and better made in cast iron once the cost of pattern-making is met.

The earthen drain is made in 2 ft. and 3 ft. lengths, requiring three or four joints of doubtful quality, when a 9 ft. length of cast iron drain can be laid in at once, with a perfect joint capable of resisting 300 lbs. pressure.

Cast iron drains may be laid close to the surface, or even over ground, with absolute certainty and security, free from the dangers attendant on concealment.

Nothing, however, that can be done to secure a perfect drain can compensate for the danger incurred by carrying the drain under the scullery and coal-vault to the sewer in place of carrying it across under the open area, or so that an open air space may occur between the house and the public sewer on the line of drain. I have not seen this danger pointed out before, but it is so common in Dublin that I wish to press it very specially on the attention of this Sanitary Congress, and of all persons engaged in the arrangement of house-drains.

This common and dangerous course of the house-drain leaves an unbroken line of covered-in connection between the public sewer and the house along the course of the drain.

Our sanitary inspections have revealed rat-burrows carried direct from the sewer, and outside along the pipe-drain into the coal-vaults and scullery. A rat-burrow once so formed supplies

a constant dangerous inflow of foul air from the sewer into the house. By the same inspections pipe-drains have been found laid inside the old square-built drains, so that the foul sewer air, with an occasional rat overture and accompaniment, had free access to the house. Inspections have also shown cases where the drain layer forgot to close up the opening made into the public sewer for the pipe drain from the house, and as this neglect occurred in the vault off the scullery, of course the foul air freely flowed in.

A coal vault under the footway or road adjoining a scullery with any door or opening between is always unsafe and often highly dangerous, even without any drain passing under it to the sewer. It is generally preferred as a convenient coal store by the cook, who thus has not to go out into the air to bring in coals from an outer coal vault. Foul air is always percolating more or less from the public sewers or from leaking gas mains, or from the surface of the street, saturated as it always is with foul matters, through the soil and through the walls and floor and arched roof of such a vault, forced in by the heavier column of cold air outside, upweighing the lighter rarified column of warm air inside the house.

There should be a rigid law that no vault under the road or footpath should have any opening into a house direct. That every subway vault should only be entered from an open area, and that the wall dividing such vault from the scullery or house should be cemented imperviously to exclude from the house all bad or doubtful air that may find access to the coal-vault.

If circumstances are such that the house-drain must be laid or remain under the scullery and this vault, the vault should then be concreted, and the doorway built up and cemented, and an entrance or access hole made through the wall dividing this vault from the next vault off the open area.

The fact still remains that the only proper course for a house-drain (when it must pass beneath a house at all) is a straight line from open back-yard to open front area, with man-hole chambers at each end, and with an intereeptor and drain continued from front area chamber to sewer.

A sanitary house inspection in a Dublin mansion revealed the fact that all the public drainage of several stables in a lane behind was carried through the drain under the kitchen into the public sewer, excepting a considerable portion, which was deposited through leaking joints under the kitchen and basement floors. This stable-drain deposit was found to have nearly choked the house-drain.

When the attention of the Dublin sanitary authority was called to this danger, they laid a new public sewer under the stable lane, and abated the nuisance, although, legally, they might have objected to do so: a creditable instance of the readiness of the Dublin authorities to act promptly, unfettered by routine, when a case requires action.

I shall not weary you further by detailing the defects that systematic sanitary inspections daily bring to light.

The expression on a sanitary inspector's face a short time ago was one of constant surprise; now he has ceased to be surprised at anything.

He at one time cherished a hope that if a drain was highly commended in any particular house that there might be some truth in the statements; now he does not believe anything about a drain unless he sees it.

If it be happiness to be able to confide and trust in those you are brought in contact with, the sanitary inspector cannot be a happy man. He can trust no statements about drains or fittings at all.

When house-hunters discover a suitable residence, and they ask invariably concerning the state of the drains, what answer can they expect to receive?

If the owner is asked, probably he knows no more about them than the questioner.

If he knows that the last tenants suffered illness in his house does he usually say so, candidly?

But if somebody told him, that somebody said, that somebody else, had somewhere read that the drains were really no worse than in other houses, does he not use the statement liberally, and finally bring himself to believe and say that he has been informed by some sanitary authority (probably his ashpit cleaner) that his drains are excellent drains and in very good order?

If the house-hunter is dealing through house agents how is the question concerning the drains answered?

House agents in duty to their clients are almost bound to believe that their drains are either good, better, or best; they are wise not to encourage or make any inquiry whatever about such matters; they are not sanitary engineers, and it is their simple business and duty to their client to let the house as you see it overground, and not to poke into the drains which are underground and away out of sight. Great sympathy should be felt for house agents in this matter, they should never under any circumstances be asked concerning the drains of any house they are trying to set. You lead them into a temptation which it seems almost a positive duty to their clients on their part to yield to.

If an owner or a house agent told you that he had some doubts about the drains in the house you were looking at, would any of you, in your senses, take the house?

When a proportion of about 1200 houses out of 1250 examined were found badly drained, would not house-hunters act wisely to see and to test the sanitary arrangements before believing in their reputed excellence?

If a sanitary engineer, who knows his business, be employed to make a sanitary inspection, he will make no statement in his report which he cannot verify; he will neither believe nor ask others to believe his report unless he can point out the defects he states to exist.

That is our strong point and vantage ground when assailed by landlords, by house agents, and even by the very house-hunters themselves, who may wish to take the house owing to its outward attractions and suitability, and may want, therefore, to be told that it is a healthy house. We sanitary inspectors, if we know our duty, simply answer and say "come and see."

It does seem odd to us day after day to be consulted by house-hunters as to our opinion concerning No. 10, Blank Square; whether we don't think it is healthy, because the agent or the owner says that the best sewer in Dublin passes in front of it, and that the late tenants were healthy. We would positively be thanked, and considered very smart and intelligent (not merely by the owner or agent, *cela va sans dire*, but by the intending tenant, interested in knowing the exact truth) if we at once, without seeing the house, or knowing anything of the actual facts, declared that, in our opinion, the house must be a healthy house. The inspection fee would be saved, at all events, and the trouble of further house-hunting avoided.

Although sanitary principles are now well established, their application in sanitary work will not be complete in detail for some time. Like electric lighting, sanitary reform needs careful nursing to develop its powers and resources and prevent mistakes. Every day some new difficulty presents itself, which taxes the inventive powers. We see in the Dublin Sanitary Exhibition many new forms of traps and connections, designed to overcome difficulties met in practice, some of which are successful, and become universally adopted, while others pass away and are forgotten.

As the writer passed through the ordeal himself, he can strongly recommend to all sanitary inspectors some such course of study as that prescribed by the Sanitary Institute of Great Britain, followed by the examination before the Board of Sanitarian Specialists, held biennially in London for the purpose of qualifying practical men for duty as sanitary surveyors.

The sanitary inspection of a dwelling, when undertaken by a Sanitary engineer, should be considered by him as a sacred trust, to be carefully and faithfully carried out for the protection of the health and the lives of the future residents. The suggestions of interested persons, too often made, in order to mislead or prejudice the inspector, should be cast aside, and an unbiassed judgment formed and expressed in the report, founded solely on ascertained facts, capable of proof if questioned.

The public are not easily convinced of hidden dangers when money has to be spent in order to avoid them. They will chance being caught by such preventible diseases as typhoid and cholera, rather than face the trouble and cost of getting beyond their reach. Many householders bring certain death on their first-born rather than take the little trouble necessary to secure the passing over of the Angel of Death.

It has been said that in questions of sanitary reform some of us, like the Israelites, require a plague to make us do our duty, while others resemble the Egyptians, who refused to be convinced at all. Many of the sanitary reforms determined on in 1866, when cholera visited us, remain yet to be carried out, and if another plague comes we shall be found unready.

Is not the often repeated advice of family doctors in sanitary matters constantly neglected by the heads of families living in dangerous houses, who harden their hearts not to believe in the danger that exists; or, believing, postpone facing it until illness or death comes to them or their children? People are more willing to take a doctor's nasty medicine than his sound advice, which would, if taken, save them from the need of his medicine.

To the steadfast unselfishness of medical men in connection with voluntary sanitary work, far greater honour is due than a careless public has ever yet paid.

Typhoid, diphtheria, and other preventible diseases, must add largely to their incomes, not only as a profession but individually, and yet we find hundreds of doctors, in pure unselfish pity for human suffering, going far out of their way to advance sanitation and suppress these diseases—cutting down their own incomes and earning the dislike and enmity of the wealthy, the landlords, the Poor Law Guardians, and the very classes on whom their incomes must depend, while they labour day and night to benefit the sick and suffering poor who can never repay them. I think there is nothing grander than the quiet heroism of the daily life of such men as these.

In conclusion, while thanking you for your attention, let me claim for the systematic sanitary inspection of houses a more important place in our social economy, as year by year passes and men become more alive to their real interest in such

matters; and also let me ask, on behalf of all men honestly engaged in sanitary work, that respect which they are entitled to in working for the public health; from the drainlayer and plumber, who faithfully perform the work entrusted to their care, to the chief engineering inspector, whose wisdom and experience frame our sanitary laws. Upon the man, whether high or low, who wilfully or carelessly scamps the sanitary work, on which he knows that the life and health of his brother depends, we call down unmitigated scorn, and desire to see stringent legal penalties enforced. It remains for me now only to say that it is the duty and the interest of every householder to take advantage of the various means of sanitary inspection and reform of houses now open to him; to secure himself and his family from many of the dangers which threaten our houses; and I conclude, not with the well-worn English proverb, that "Prevention is better than cure," but with our Irish version of it, "The best way to prevent what's past is to put a stop to it before it happens."

[*For discussion on this paper see page* 302.]

On "Some Defects in House Sanitation in and around Dublin," by P. F. Comber.

The Council of the Sanitary Institute having invited the co-operation and support of all who are interested in the diffusion of sanitary knowledge, I beg leave to describe briefly some serious defects in house sanitation, which in my professional experience have come under my observation, in Dublin and the neighbourhood.

Water Supply.—The Vartry water, which is supplied at high pressure to Dublin and the neighbouring townships, does not leave much to be desired if the water be used direct from the main; but the way in which it is sometimes stored for domestic use is most objectionable and dangerous to health.

I was called upon some time ago to make a sanitary inspection of a terrace of houses in a fashionable locality, the rental of each house being about £100 a-year. The terrace was supplied abundantly with the Vartry water, but each house had a cistern to receive the water, and in every case the cistern was placed partly in a covered ash-pit and partly in the servants'

water-closet adjoining. There was no ceiling to either the ash-pit or the closet, nor cover to the cistern to protect the water from dust or from being contaminated by the poisonous gases arising from decomposed vegetable, and other organic matter. The cistern also served the servants' water-closet by means of a stool-cock. And yet, incredible as it may appear, the occupants of these houses used the water for drinking and cooking purposes.

The cisterns were abolished after being in use upwards of a quarter of a century, and as they had not once been washed out during that period, their sanitary condition can be better imagined than described.

Water for drinking purposes is frequently drawn from water-closet cisterns, which are rarely, if ever, cleaned out, and very often they are so placed that they are inaccessible for that or any other purpose.

Drainage.—As a rule the house drains are too large and are not laid with sufficient fall nor with uniform gradients; 9 in. and 12 in. drain-pipes are used where smaller drains would be more effective. And the old square-built drain with flat bottom still exists in many houses. The main drains are not always taken direct from each house to the public sewer, but are connected with the drains of the adjoining houses, and they are not disconnected from the sewer, nor ventilated, except in the comparatively few houses where more approved and scientific principles have been adopted within the last few years. Waste-pipes and rain-water down pipes are to be found entering the drain direct, and frequently without a trap of any kind. Soil-pipes are seldom properly ventilated. An attempt is sometimes made to do so by carrying up a small bore pipe ($\frac{1}{2}$ in. or more), from the soil-pipe, and terminating it not unfrequently near a bedroom window.

The workmanship too in many instances is very defective. I have seen drains passing through and under a building with the joints laid dry without cement or other jointing material; and the connections of the drain pipes are frequently very imperfectly made, without proper junctions, simply by breaking a hole in the side of the main drain pipe, sticking the branch pipe into it and jointing with pieces of brick and mortar. And these defective connections are often made within the building. In cases of this kind the rats are afforded free ingress and egress to and from the house through the drains. I examined a house a short time ago which was infested by rats owing to this cause. They had a free run between the house and the public sewer, as the house drain was not trapped. Where the house drains are so defective the sewage gas has of course free

entrance into the house, and the ground on which the house stands becomes foul by the escape of sewage matter from the open joints of the drain-pipes; and the house itself is connected with the adjoining house through the drains probably with as much danger in case of infectious disease as if there were a doorway from one to the other.

I have seen a house-drain, not far from the City, which, perhaps, deserves to be mentioned. The drain ran under and through the building to the public sewer in the front, and was originally square-built with flat bottom, and about 14 in. by 12 in. in sectional dimensions. Subsequently a 9-in. stoneware drain-pipe was put down, which was simply laid into the square-built drain with dry joints, and the old drain was covered over with rough flags as before. When I examined the house I found that the old drain had become a receptacle for sewage matter passing through the open joints of the enclosed drain-pipe; and it is needless to add that foul odours were experienced by the occupants of the house.

Ventilation.—Special provision for ventilation is very rare, except in some modern houses; and even the ordinary means of preserving the purity of air in rooms by the proper use of the windows is not generally resorted to or appreciated.

The drawings illustrate the defects to which I have referred, and also the proper method of house drainage.

No. 1 shows defective house drainage.

No. 2 shows the cistern in the ashpit from which water was drawn for drinking and cooking purposes.

No. 3 shows the house drain arrangements for detached houses, based on the model bye-laws.

No. 4 shows the house drain arrangements for semi-detached houses, ditto ditto.

No. 5 shows the house drain arrangements for attached houses, ditto ditto.

No. 6 shows in detail two methods of disconnecting the house drain from the public sewer.

[*This discussion applies to the four preceding papers by* Mr. G. B. Nichols, Mr. W. Kaye Parry, Mr. W. R. Maguire, and Mr. P. F. Comber, *which were discussed conjointly.*]

C. P. Cotton, M.Inst.C.E. (President of the Section), said that under the 25th section of the Public Health Act a sanitary authority had power, where a proper drain was not made from a house to the main sewers, to require it to be of such materials, size, and construction as they might think necessary.

Mr. J. Rawson Carroll (Dublin) said that if the section of the drain instead of being circular was illiptical it mattered not what quantity passed through it, because there would always be about the same amount of flush. He thought that in all the arrangements they advocated they should keep economy in view: for if people got into their minds that calling in an architect or engineer to improve their drainage meant heavy expense, he was afraid they would not be often called in, and the work would be unskilfully done.

Mr. Parke Neville (City Engineer, Dublin) thought the condition of Dublin had been much exaggerated in these papers. It was impossible that every system of sewerage could be water-tight. Workmen, although they gained nothing by so doing, scamped their work. When he became engineer to the Corporation there were practically no pipe drains—the old fashioned square drains, built of rubble masonry, were general. He was anxious to use medium-sized pipes, but the people almost rose in rebellion about it, and the 9-inch pipe was introduced as a compromise. He knew 6-inch would, in many cases, be sufficient. Most of the house drains in Dublin run right through from the back door to the front door. They constantly had complaints about house drains, but when these people were asked to lodge £5 or £10 for the expense of substituting pipes for old brick drains they instantly went away.

Mr. Stirling (Dublin) thought that if the clauses of the Public Health Act were enforced there would be few of the defects mentioned in these papers.

Mr. D. Emptage (Margate) said that in dealing with house drainage they must not overlook the fact that, no matter how completely their drains were disconnected or thoroughly ventilated, if they had a defective apparatus, such as a "pan closet" fixed at its head, bad gases would be generated in its own cesspool (very properly designated a container), which would belch forth upon the tilting of the copper pan, causing smells as offensive and, in some cases, as dangerous as bad air from the sewers.

Mr. R. O'Brien Furlong (Dublin) hoped the Section would bear with him if he intruded amongst so many engineers. When he was Secretary to the Royal Commission, which sat in Dublin in 1879, he learned sufficient about house drains to enable him to lay claim to some knowledge of the subject. The Congress had heard a good deal of the necessity of a system of intercepting sewerage for Dublin with the object of purifying the Liffey. He ventured to say that important as that subject was it was of infinitely more importance that the drains and sanitary arrangements of the Dublin houses should be put into proper condition, and so maintained. He strongly urged the necessity for periodical sanitary inspections of houses. He

defied any man to keep his own house healthy if his neighbour's house drains were out of order. He knew business men to spend large sums in perfecting the sanitary arrangements of their private houses, while they neglected the offices in which they spent the greater part of the day. One thing which had done much to retard sanitary improvements was that engineers recommended the very best possible system, instead of a system which would be sufficient for the requirements. His advice to the public was: employ a competent person to say what the system of drainage should be, employ a competent plumber to carry it out, and then have it periodically inspected.

Mr. Rogers Field, M.Inst.C.E. (London), entirely agreed with the last speaker that a main sewerage system was not sufficient if house drainage was neglected. He had had in his practice cases without number of houses where the system of main sewerage was excellent, especially in London, but where the house drainage itself was so bad as to cause typhoid fever or other serious illness. There was one very general defect which he would specially call attention to, viz., the unsoundness of the house drains. He found this defect more frequently overlooked than any other, as it was a concealed defect, and one which was costly to remedy. In the case of town houses, where the drains so often passed beneath the house, the soundness of the drains was of vital importance. If leaky drains were left beneath the house no amount of care expended on the ventilation of the drains or on the sanitary fittings would render the house healthy. The only remedy was to remove the leaky drains and contaminated earth, and construct new watertight drains. He agreed that it was a mistake to have the house drains too large. Six-inch pipes were ample according to his experience, for any ordinary house. Many large mansions and public institutions had only six-inch pipes. Every case, however, must be dealt with by itself, and it would be wrong to lay down any fixed rule. The drains should be so constructed that everything passed into them would wash away to the main sewer. A nine-inch pipe was too large for an ordinary house, as the small quantity of water which passed would spread out on the bottom of the pipe, and not have so much force as it would if the flow were concentrated in a smaller pipe. Deposit would therefore take place, unless some special means for flushing were provided. He had generally found it advisable to make the siphon trap smaller than the drain. He frequently put a four-inch siphon in connection with a six-inch drain, and so on. The siphon should always be placed where it could be readily examined.

Sir Robert Rawlinson, C.B. (President of the Congress), said Mr. Rogers Field was called in to examine Bagshot House, the residence of the Duke of Connaught, after the Duchess was very severely smitten with disease, and to remedy the sanitary defects, and if he would state briefly what he found it would be of great interest.

Mr. Rogers Field, M.Inst.C.E. (London), in complying with Sir

Robert Rawlinson's request, said it was a remarkable case; for the Duchess's bedroom, where she was taken ill, was a long distance from where the sanitary defects were found. He found a very defective drain underneath the basement, from which noxious gases could pass up through a hollow in the wall behind the dining room to the upper floor, upon which the Duchess's room was situate, though at a considerable distance from that point. He tried experiments by generating smoke where the foul air from the defective drains passed, but the smoke did not penetrate to the Duchess's room. Then he lighted a fire in the room so as to place the room in the same condition as would exist when the Duchess occupied it, and repeated the experiment, but still the smoke did not pass into the bedroom. He began to think that the experiment would only lead to negative results, but before giving it up he carefully considered what other conditions there could be which were not the same as when the Duchess occupied the room. He then noticed that there was no carpet down and that there were air bricks outside, and it occurred to him that the fresh air passing between the joints of the floor boards (which were not very close) might feed the fire, and interfere with the suction it would otherwise exert on the foul air in the house. He therefore determined to experiment with the carpet down. The carpet could not be obtained, but brown paper was laid down instead, and very shortly afterwards the smoke entered the room, thereby indicating how the noxious gases from the bad drain had made their way up. A peculiar fact was that until a certain day after her confinement the Duchess did not show any sign of illness. He said to himself, was it possible that that particular day she got out of bed; because he had found that the current of foul air did not pass her bed, but would pass her while sitting beside the fire. On inquiry from the nurse he discovered that the very day the Duchess first left bed and lay on a sofa beside the fire she was taken ill; next day she remained in bed and felt better; the day after she again sat by the fire and became ill again.

Mr. Clarke believed that good yellow or blue clay would be suitable for the joining of pipes. He thought every landlord should be required to give his tenant a certificate from an engineer that the house he was letting was in good sanitary order.

Mr. H. H. Collins, F.R.I.B.A. (London), thought it right to say that no worse method of joining pipes could be thought of than that suggested by Mr. Clarke; and to prevent it being accepted as a method of creating good work he had risen to enter his earnest protest against such a statement being promulgated from this Congress, as being in harmony with the practice of the members.

Sir Robert Rawlinson, C.B. (President of the Congress), said the best method of draining the house was in the long run the cheapest. London was now a water-closeted city entire, Paris remained a city of cesspools.

Mr. W. R. E. Coles (London) said that the Plumbers' Company,

one of the oldest of the guilds of the City of London, had given their sanction and support to a General Congress of Plumbers to be held at the Health Exhibition, South Kensington, on the 28th inst., and at the Congress all the chief subjects relating to plumbing would be considered, viz.: (1.) The technical instruction of plumbers. (2.) Apprenticeship, the duration and condition of indentures suited to the present state of the plumbing trade and to the modern system of technical instruction. (3.) The establishment of metropolitan and provincial boards of examiners of plumbing work. (4.) The registration of journeymen plumbers. (5.) The suitability of materials used in plumbing, and particularly of those materials recently introduced as substitutes for lead. (6.) The desirability of fixing upon a system by which uniformity in the quality of material used in plumbing may be insured. (7.) The formation of district associations of plumbers to investigate and secure, as far as practicable, correction of evils and abuses arising in connection with the trade. (8.) A general and executive committee to be formed for the purpose of receiving reports from district associations of plumbers and others, with a view to the preparation of a general report by the Plumbers' Company, to form the basis for an appeal to Parliament for necessary amendments and extensions of the law relating to plumbers' work, under the Building and Health Acts, and otherwise.

On "Electric Lighting, considered from a Sanitary Point of View," by J. ANGELO FAHIE, C.E.

IT may be asked at the outset, What relation is there between Electric Lighting and Sanitary Science? The author hopes to be able to show that the question of artificial lighting, and especially electric lighting, has a most important bearing on sanitation, although hitherto it has not received very serious attention from this point of view. Recollecting that foremost amongst the objects of the Sanitary Institute of Great Britain is the discussion and consideration of all questions affecting, directly or indirectly, our general health, the question of the good or evil influence exercised by artificial light thereon is of the highest importance, and is, in every respect, worthy the consideration of this Congress. When we reflect what a considerable portion of time is spent by modern society under light other than natural light, and how much more injurious are all modes of artificial lighting in comparison with sun-light, it is essential that we should consider anxiously the most desirable

form of light which shall exercise the least ill effects on our bodily health and comfort.

In olden times man paid little attention to the subject of artificial illumination. Content to work during the day by the light of Nature, he spent his life after sunset in semi-darkness, or in the imperfect light emitted by the rude fire which served to warm his dwelling.

To the inhabitants of the East may be ascribed the first attempts at producing light by artificial means, which consisted in burning fluid bitumen in rude vessels of baked earth. Attempts were also made to utilize the fat of fish and animals for the purpose, and later on the primitive pine torch came into almost universal use as the only means of affording light after sunset. It need hardly be said that these early attempts served to fill with odour rather than light the dwellings it was sought to illuminate.

Since the object of this paper is to consider the subject of electric lighting from a sanitary point of view, and since it is only with the general introduction of gas and petroleum the danger of injury to health arose, it is not necessary to dwell on the forms of lighting in vogue prior to the illuminants now so universally used. Nor is it necessary for our present purpose to enter into the consideration of the theory, or nature of light; suffice it to say that light is the medium by which bodies are rendered perceptible to the sight. Every form of matter when sufficiently heated, has the power of emitting rays of light, and thus becomes self-luminous. All artificial sources of light depend on the development of light during incandescence.

The conditions of life under all kinds of artificial light are less favourable to health than under daylight. During the day we have abundance of soft, pure, white light. The air we breathe is pure and unvitiated; it contains the heat only necessary for health. All nature delights in sunlight, the animal and vegetable organisms flourish under its influence; our energies are in a state of activity during the day. Under artificial light these conditions are completely altered; light which would be considered excessive at night is far inferior to ordinary daylight. The heat produced by all forms of light exceeds the temperature of the atmosphere in average daylight, and the air is vitiated to an extent proportional to the amount of light produced. How desirable, therefore, is it that we should seek, and by every effort in our power assist in, the development of that form of artificial light which approaches nearest the conditions existing under sunlight.

As will be seen hereafter, the light afforded by means of

electricity is far superior to all other illuminants in the fulfilment of these conditions.

All forms of artificial light hitherto in use depend on combustion, in order to sustain which a good and plentiful supply of air is necessary.

Gas, for example, the chief constituent of which is a combination of carbon and hydrogen, will not burn without the aid of the oxygen in the atmosphere. In the process of combustion the particles of carbon contained in the gas come into contact with the oxygen of the air, and float in an incandescent state in the interior of the burning vapour, and this constitutes the flame. The presence of the carbon in a finely-divided state may be easily shown by holding some refractory substance in the flame, when the carbon will be deposited upon it in the form of soot.

Should, however, the supply of oxygen be insufficient, partial combustion only takes place, the carbon escaping in an unburnt condition in the form of a dark cloud, when the flame is said to smoke.

The brightness of the flame, therefore depends on the supply of air necessary for perfect combustion.

That oxygen is absolutely necessary for combustion, may be shown by placing a tumbler over a lighted taper, when the taper will burn nicely at first, but soon a change will be observed: gradually the flame will diminish, and at length go out. This result is caused by the enclosed oxygen combining with a portion of the material forming the taper, producing a poisonous compound, called carbonic acid, which suffocates the flame. Similarly, if we take an Argand burner and stop the aperture in the centre, the gas burns poorly because there is a restraint to the supply of air.

The light afforded by candles and lamps does not differ essentially from that of the ordinary gas burner. The same elements which constitute the one are present in the other—they all owe their luminosity to combustion. A petroleum lamp burns imperfectly without a chimney, but when this is put on, a strong draft is caused, supplying the air necessary for thorough combustion, and the brilliancy of the flame is thus materially exalted.

From what has been said it is obvious that in order to obtain the highest illuminating power of a flame, a plentiful—and what is more, a fresh,—supply of air is essential. Thus it will be seen that wherever light is obtained by combustion it deprives the air of oxygen, that element which has justly been termed the "æriel" food of animal life, as it is dependent on it for existence. Moreover, in the process of combustion the air is contaminated with certain poisonous compounds, such as

carbonic acid, carbonic oxide, and sulphur, which, when breathed even in a limited quantity, are injurious to the human frame. Another effect of combustion is the production of vapour, formed by the oxygen of the air combining with the hydrogen, which constitutes a portion of the material consumed. The presence of this vapour will readily be detected if a decanter of cold or iced water is brought into a room where a number of lights are burning. The surface of the decanter will be speedily covered with a thick dew, caused by the vapor floating in the air being condensed by the action of the cold water within.

As we all desire to live in pure air, is it not strange that we should be content to use a light which not only robs the atmosphere of oxygen, thus destroying its life-supporting virtue, but actually loads it with noxious vapours, the products of combustion?

Considering the comparative merits of the various artificial lights now in use, the following table from Dr. Tidy's "Handbook of Modern Chemistry" will afford some idea of the heat-producing and air-vitiating effects of the different bodies enumerated. To this table Mr. R. Hammond has added the effects produced by a 12-candle incandescent electric lamp.

TABLE—Showing the oxygen consumed, the carbonic acid produced, and the air vitiated, by the combustion of certain bodies burnt so as to give the light of 12 standard sperm candles, each candle burning at the rate of 120 grains per hour:—

Burnt to give light of 12 candles, equal to 120 grains per hour.	Cubic feet of oxygen consumed.	Cubic feet of air consumed	Cubic feet of carbonic acid produced.	Cubic feet of air vitiated.	Heat produced in lbs. of water raised 10°F
Cannel Gas.....	3·30	16·50	2·01	217·50	195·0
Common Gas	5·45	17·25	3·21	348·25	278·6
Sperm Oil	4·75	23·75	3·33	356·75	233·5
Benzole	4·46	22·30	3·54	376·30	232·6
Paraffin	6·81	34·05	4·50	484·05	361·9
Camphine	6·65	33·25	4·77	510·25	325·1
Sperm Candles ..	7·57	37·85	5·77	614·85	351·7
Wax	8·41	42·05	5·90	632·25	383·1
Stearic.....	8·82	44·10	6·25	669·10	374·7
Tallow.....	12·00	60·00	8·73	933·00	505·4
Electric Light....	none	none	none	none	13·8

From this table it follows that an ordinary gas burner consuming 5 cubic feet per hour absorbs nearly $5\frac{1}{2}$ cubic feet of

oxygen per hour, or, in other words, it deprives 17 cubic feet of air of its oxygen in an hour. But, as has been already pointed out, gas not only deprives the air of its health-giving oxygen, but it contaminates it with poisonous compounds which are more or less—according to the extent to which they exist—injurious to animal life. Dr. Tidy considers that the contamination of the atmosphere in a crowded theatre at the end of the performance may be regarded as distressing; and many of us experience a disinclination to go to the theatre because of the inconvenience suffered from the heat and vitiation of the air caused by the gas, producing headache and oftentimes, giddiness. The effects of heat and vapour from combustion will be readily detected in a wareroom or shop, the lower portion of which may be only at a temperature of 60° to 70°, in consequence of the hot-air ascending, the temperature near the ceiling will probably be from 130° to 140°. When, therefore, goods, books, &c., are placed in such high localities it cannot be wondered at that they become injured or destroyed. Indeed, referring to the amount of water generated by the gas flame, it is stated on authority that sixty gas jets will produce on the lowest computation two gallons of water per hour! Thus it is we often see on a December evening streams of water trickling down the windows of shops brilliantly lighted by gas.

Turning to the table above quoted, we find that electric lighting by incandescence produces absolutely none of the evil effects just enumerated. There is no oxygen consumed, no carbonic acid or other compounds given off, and, consequently, there is no vitiation whatever of the atmosphere; and, as to the heat-producing effects, the table shows that the air of a room lighted by gas is twenty times more heated than if lighted by incandescent electric lamps. From this it will be readily seen how conducive to health and bodily comfort are the conditions fulfilled by electric light in contrast with all other illuminants. And not only is the health and bodily comfort affected by the influence of artificial light, but the temperament also; and it is very remarkable to notice the difference in the effect produced by gas light, and electric light, on the spirits of those obliged to work long hours at night. A brilliant light, we all know, exercises a cheerful influence on the animal spirits, and electric lighting affords unusual facilities for acquiring a higher degree of illumination without the accompanying heating and air-vitiating evils inseparable from gas and petroleum.

It has been said, as an argument against the use of electric light, that it is injurious to the eyesight, and, therefore, cannot be considered as conducive to health. This argument is more imaginary than real, and has no foundation in fact. As

compared with other lights, electric light is less injurious, when used under proper conditions. True, an unsteady or flickering light has an ill effect on the sight, and electric lighting on the *arc* system is open to this objection, a defect which, however, will, doubtless, be remedied in time. But the *incandescent* system leaves nothing to be desired. The light is pure, soft, and white, and is absolutely steady in its action.

It is this system which concerns us at present, since it is the most suitable for indoor purposes, and consequently bears directly on the question of health.

The flame of a candle, or a gas flame, is not absolutely steady, although considerable improvements have been made in gas-lighting, during recent years, by the introduction of better burners and more suitable globes; but in some cases—for instance, in factories—globes cannot be conveniently used, and the flame is ever subject to drafts, causing a disagreeable wavering or flickering in the light. It is impossible that the light of the incandescent electric lamp can be affected in this way.

The glare of the electric light is also commented on as being objectionable; but this is only applicable to the arc light, and even this form readily admits of being shielded in ground globes; and as it is only suitable for outdoor use and for large buildings, it is not necessary here to say much about it. It might, however, be said *en passant* that we have no right to stare at the electric arc any more than we have to stare at the sun, which makes our eyes weak, and otherwise inconveniences us. A strange story was told in the newspapers a few days ago, of a boy, aged about 14 years, who, for a wager, stared at the sun for some time, and died the same night in great agony. Professor Pickering, a German *savant*, recently made an investigation into the cause of weak sight amongst the students of his university, and traced it to the heat given off by their reading lamps, which dried up the humours of the eye. Seeing that the electric light gives off but a trifling degree of heat it is, therefore, far preferable in this respect, and far less injurious to the sight than gas, oil, or candle light.

Many institutions throughout the country are now lighted by electricity, and in every single instance with the most beneficial results to the health and comfort of the people who work by its aid.

It would be impossible in a small space to describe the lighting arrangements in these institutions, but the author may be permitted to refer to one installation which has been working under his charge for the past nine months, and which will serve as an illustration for many others. The installation referred to is that of the offices of the *Irish Times*. The composing

room here forms one large apartment measuring some 60 by 40 by 70 feet in height. Before the introduction of the electric light, this apartment was lighted by 100 gas jets, and, remembering that one gas jet consumes as much oxygen as five individuals, and adding to this the effects resulting from the breathing of the compositors, together with the long hours of night during which the work is carried on, we can readily conceive how extremely unwholesome and unhealthy must have been the air of this apartment. Indeed, as a matter of fact, the employés frequently suffered from ill health and discomfort, which they usually attributed to the vitiated state of the atmosphere, and it was not unusual to have several out on sick leave at one time. This was especially noticeable in summer. The temperature of the apartment frequently ran as high as 85° in winter, and 95° in summer. The discomfort occasioned sometimes in summer was very serious indeed, oftentimes rendering it impossible for some of the men to carry on their business for the usual number of working hours.

Since the introduction of the electric light the condition of things is entirely changed. The atmosphere is pure and healthy, the thermometer rarely marks higher than 70° during the night, the light is bright and perfectly steady in its action, the health of the employés good, and their spirits cheerful and buoyant, many of them being able to work for considerably longer hours now than formerly, and the sick list has all but disappeared.

This proves that not only from a sanitary, but also from a *commercial* point of view is the introduction of the electric light beneficial.

It may be argued that a proper system of ventilation would render the use of gas harmless; but the question of ventilation, although apparently so simple, is difficult to deal with. Sometimes arrangements adopted to ensure a good supply of fresh air may be admirable in calm or warm weather, and just the opposite in cold or boisterous weather. Again, a means of ventilation may work well for a period, and, unexpectedly, perhaps, owing to a change in the wind, instead of the noxious products of combustion passing off, the wind rushes in with occasional gusts causing the flame to become agitated and smoky and the air is vitiated to even a greater extent than otherwise. With the electric light the difficulty of ventilation is reduced to a minimum.

Amongst other advantages of the electric light, which, although not strictly relating to its sanitary aspect, have, nevertheless, an indirect effect on health, may be mentioned the following:—Plants grow in rooms lighted by it, and cut flowers exhibit their true colours, and do not quickly wither; paintings show

their natural tints and colours to better advantage. Its influence on the health of children is incalculable. An electrically-lighted nursery, even if the light remains on all night long, is free from the noxious vapours produced by candles or gas. The electric light also lends itself to artistic treatment in the most admirable way.

In the adoption of the electric light, therefore, we fulfil the following important considerations:—We do not deprive the air of oxygen, so necessary for our health and comfort; we do not adulterate the air with pernicious compounds of any kind; we avoid the accumulation of vapour; only a small degree of heat is produced; and we facilitate the means of ventilation.

In fact, by means of electricity we have at last obtained an artificial light, which is nearly all that could be desired; and, regarded from a sanitary point of view alone, its development and introduction should command our warmest sympathy and earnest support.

It may be expected that some reference might be made here concerning the expense of the electric light, but since the subject has been dealt with chiefly from a sanitary point of view, and as the question of first cost and maintenance involves considerations which could scarcely be fairly treated in a paper of this kind, the author may be excused for not entering into details or comparisons of cost.

So long as electric lighting is carried on in isolated installations, it will be found difficult, no doubt, to compete with its older rival, although there are cases where the cost of such installations compares favourably with gas. The expense of maintenance by isolated lighting is governed entirely by local considerations. Where the light is required only to a limited extent—say 100 incandescent lamps burning for less than 1,000 hours per annum—the cost will probably exceed that of gas; but where the number of lamps reaches 200 and the number of working hours amounts to about 2,000 per year, then electricity will undoubtedly beat gas. It is, however, unfair to compare the expense of lighting by isolated installations with that of lighting by means of a well-established and elaborate system, whose existence is founded on the experience of half a century. However, in considering the question of expense, the superior advantages which we have endeavoured to point out, inherent in the electric system should entitle it to a higher price than all other systems of artificial illumination.

The time will come, however, when the electric current will be supplied on a large and comprehensive scale, and when its merits will be fully appreciated by all; then the question of cost will no longer form an insuperable barrier to its universal adoption.

Sir Robert Rawlinson, C.B. (President of the Congress), said that two important questions were its certainty in use and its economy. With regard to the former question, the electric light had on repeated occasions gone out suddenly. There was a field for it in special purposes, but it was not nearly so cheap as gas, and it would be very difficult indeed for electricity to compete with gas.

A discussion followed, and

Mr. J. Angelo Fahie, in reply, said that no doubt there were still some difficulties which impeded the successful and economical application of the electric light, but it should be remembered that difficulties had always to be overcome in the introduction of every new industry, and those attending electric lighting were being removed from time to time, as electricians gained experience by actual practical work. As to the accident which occurred at the Health Exhibition, it simply arose from the attendant incautiously placing both his hands at one time on or in connection with the opposite brushes of the dynamo, thus receiving through his body the current which was being generated to feed some 23 arc lamps. It appears that the unhappy man had been cautioned against placing both hands on the machine, and the accident was wholly due to negligence.

During the reading of the paper, Mr. Fahie exhibited a specimen of the spectacles or goggles recently devised by Dr. W. H. Stone, for the use of electrical engineers and others connected with electric lighting. These goggles have blue glasses in the front, and are provided with side glasses tinted red. When looking at the incandescent light the blue glasses are used, and the red rays neutralized; while for the purpose of examining the arc light the red side glasses are turned down and both are used, by which means any danger to the eye arising from excess of blue rays is obviated.

On "Temporary Hospitals," by Howard Pentland, B.A.

There are two main classes of temporary hospitals—

I. Those that are built on the path of an epidemic.

II. Those that are built in the belief that permanent hospitals are a mistake.

The first may be suitably termed isolation hospitals, as in them it is proposed to isolate the patients from the public and if possible from one another.

As a general rule they bear the marks of hasty consideration,

and in no case show an advance proportional to that of permanent hospitals; whilst their remoteness has often entailed great inconvenience. These two evils may be eliminated if we apply to them the principles that guide us in the design of permanent hospitals, and adopt some means of rendering their nearness comparatively harmless.

Several materials offer themselves—

1. Galvanized corrugated iron.
2. Wood.
3. Tiles.
4. Slates.
5. Concrete.
6. Felt.
7. Willesden paper.

The first, used by itself on a framework of iron, or even wood, though proof against infectious matter, is too good a conductor; and the second, as well as being the inverse, is too liable to decay, considering its price.

A construction in the form of external iron sheeting and internal wood sheeting is an improvement, but with Willesden paper lining would be better still.

Slates and tiles nailed to boarding or battens on framing, and lined with wood sheeting, are more permanent than the last, but not so clean or so easily ventilated in the framing space.

Concrete or cement is not suitable, except in the form given to it by Mr. Lascelles, which consists of thin slabs screwed to wooden framing. It is good, but cemented to concrete framing as supplied by Mr. Lascelles, it seems less liable to infection. It may be lined with thinner slabs if desired. Concrete, however, in either form, or wood lined iron is, on account of its comparative expense, more suitable for hospitals of Class II, than for the cheap temporary buildings of Class I. Plastering may of course be used, but it should be executed on corrugated wire netting and not on laths.

Felt and paper remain.

The former requires wood sheeting for a foundation, whereas the latter does not, and, moreover, is capable of harbouring vermin and infection to a large extent.

Willesden Paper would, therefore, seem to be the best material for "Temporary Isolation Hospitals." It is an extremely bad conductor, has a very hard, smooth surface, and considerable strength.

Willesden Paper is much less combustible than either wood or felt, and burns with difficulty.

Taking the framing as constant in value, these materials are worth per square foot laid—

Galvanized Corrugated Iron	6d.
Wood Sheeting	4d.
Tiles	7d.
Slates	5½d.
Concrete Slabs (external)	6d.
„ „ (internal)	4½d.
Willesden Paper	2½d.

The cost, then, of the various coverings, exclusive of the framing, is as follows :—

Tiles lined with wood sheeting	11d.
Slates „ „ „	9½d.
Concrete slabs, externally and internally ...	10½d.
Galvanized iron, lined with wood sheeting ...	10d.
Galvanized iron lined with Willesden paper...	8½d.
Willesden paper alone...	2½d.

Willesden paper is, therefore, the cheapest, as well as being otherwise the most suitable for "Isolation Hospitals" for epidemics.

The Health Committee of the Corporation of Liverpool have just used a large quantity of this paper in the construction of hospital huts.

The next question is as to the best form.

All authorities are agreed that whatever disadvantages some of the details of the Tollet System in permanent hospitals may entail, that its intrinsic merit lies in its providing an open basement.

This, which is a difficult and expensive requisition as advocated by M. Tollet, is almost a necessity in a timber structure.

The whole concern could be carried on a few timber or H iron posts, planted in lumps of concrete or driven as piles. Underground air would thus be eliminated at once. So far we follow M. Tollet, but from this point we must borrow Burdon Sanderson's idea of annular wards as proposed in his evidence on the "Small-pox and Fever Hospitals'" Commission, and Dr. Richardson's idea of the wholesale disinfection of hospital air, as proposed in a paper in Vol. III. of the Transactions of this Institute.

If these buildings are to be in a populous district they must at least be rendered as harmless as an ordinary hospital, and this can only be done by a whole or partial application of Dr. Richardson's idea. This again cannot be practically realized, except in an annular ward, where air is drawn from the external circumference through the ring, and the internal circumference into the inner circle, and upwards and outwards through a disinfecting aspirator, such as a brazier of glowing pumice, or a

hot ring of bunsen burners, in connection with a spiral drain ventilator, charged with sulphurous acid.

Curves, again, cannot be very easily realized in timber, so we must replace the circle by a convenient polygon, which may be sub-divided to any extent desired. The accompanying diagram shows an attempted solution of the problem for four patients.

Many nurses might be required for four cholera patients, but one for every two patients is the maximum which should sleep in the Isolation Hospital, the others being accommodated in an isolated administration building, or in the main hospital, according as the Isolated Hospital was an independent institution or an offshoot.

A verandah runs round the whole to afford dry intercommunication, each room having a protecting porch.

The foul air is all concentrated in a central chamber approached from beneath, where the heating, ventilating, and disinfecting apparatus is placed. But the nurses' rooms have no openings to this, their ventilation being effected in the usual manner by a window; a sheet iron diaphragm protects the stoker from the foul air; an airtight pane in both partitions enables the nurse to view her two patients. The heating could be effected either by a stove in each room (stoked from the centre) and all gathered to the central shaft, or more expensively by a central stove, and a coil of hot water pipes with a stop-cock, placed similarly to the stove, or else to warm the incoming air. Such a building, which could accommodate six patients on an emergency, would cost about £160, including heating and ventilating, and would, with slight repairs, last 20 years in thorough efficiency and much longer with partial renewals.

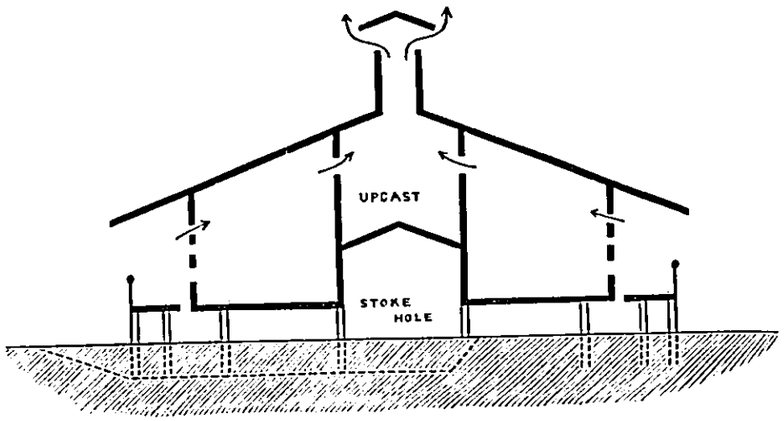
As the wall space of each room on the central chamber must have an inferior limit, and as the area of a regular polygon increases more quickly than its periphery, there is a superior limit to the number of patients that can be accommodated in one such Isolation Hospital. This number may be easily calculated for a particular case.

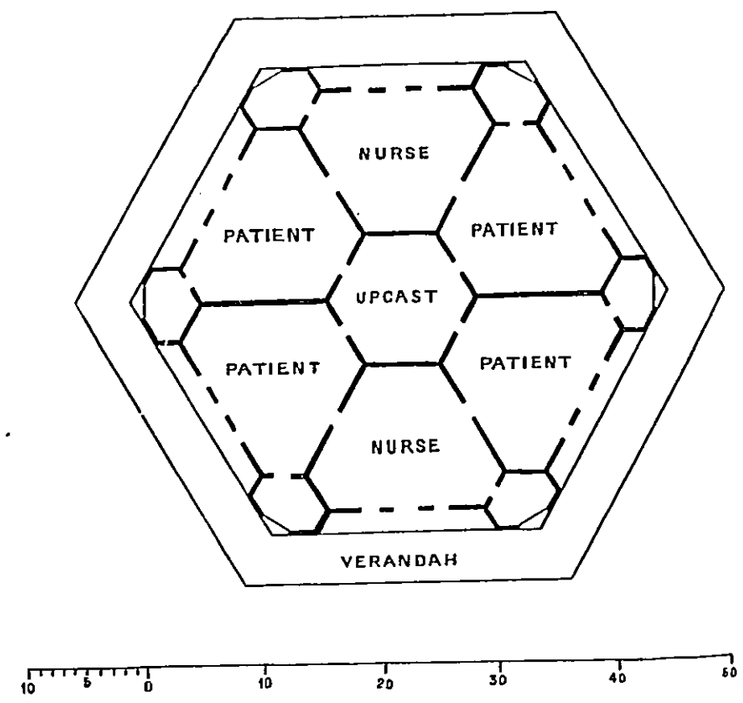
A=working area per room required in central chamber.
l=convenient wall space on central chamber per room.
n=number of patients.
r=ratio of nurses to patients.

$$An\,(1+r) = \tfrac{l^2}{4}\,n\,(1+r)\cot\frac{\pi}{n(1+r)}$$

$$\text{whence } n = \frac{1}{1+r}\cdot\frac{\pi}{\tan^{-1}\frac{l^2}{4A}}$$

for the values 11, 5, 4, ½. n=4 which with two nurses may be accommodated in a hexagonal hospital.





In the most advanced types of modern hospital construction, it is now usual to isolate the wards from one another and the administration. A large hospital might thus be laid out, consisting of a number of these polygonal units, disposed round a central administration, and connected thereto and to one another by a light tramway or passage under cover, and telephones. Were single wards dispensed with the cost would be proportionately reduced; but a shilling per week per bed is all that need ever be spent to provide efficient hospital accommodation for any class of patients.

Class II. brings us face to face with the hospital of the future. What this may be it seems hard to predict, but in view of the radical changes in hospital construction during the last fifty years, it will at least be admitted that another generation will see still further changes.

From the time that Erichsen first drew attention to the evils of "hospitalism" down to the present, when most of us accept Pasteur's theories as gospel, there has been a gradual series of attempts to eliminate infectious matter and infection holding matter from the vicinity of the patients, and the last to be removed will possibly be the hospital itself. But as the hospital itself, like air, is a constant necessity, the operation could only be performed periodically.

The period, which is known for air, is unfortunately not known for wood, concrete, plaster, paper, &c., but must sooner or later be determined. This belief, which is gaining ground, especially in Germany, points to the desirability of structures more of the nature of the Moabite Barrack Hospital in Berlin than of the new St. Thomas's Hospital in London. M. Tollet, whose expensive buildings are mostly constructed of concrete and iron, points to the fact that concrete walls, finished with a smooth painted surface, are virtually incapable of germ absorption, and can, moreover, be periodically flushed with flame, or hosed with antiseptic solutions.

But we are not as yet in a position to ascertain that any building material, except perhaps iron, is so non-absorbent of infectious matter.

Economy, too, favours the erection of hospitals that will last only for a short period. When the capitalization of the interest of the sums expended on permanent hospitals, and their repairs is taken into account, it will be found that hospitals of a cheap construction, such as that of the Moabite Barrack Hospital, or buildings of galvanized iron, lined with Willesden paper, have the advantage. A change of site which is often desirable, but impossible, could be easily effected when desired.

Hygiene and economy thus point to the erection of cheap

polygonal hospitals of one story, well raised from the ground on posts, destroyed after one generation's use, and transferred elsewhere for the next. The principle also relieves us from the necessity of providing for posterity.

These are strong arguments, but undoubtedly the strongest against costly permanent hospitals is the undoubted fact that in half a century ours will be thought of as we now think of the old Hôtel Dieu in Paris.

Should Portland cement concrete slabs prove to be tolerably non-retentive of infectious matter, Lascelles' construction seems the best of those mentioned, but otherwise galvanised iron buildings lined with Willesden paper, which could have their linings burnt and renewed, and the iron flamed every few years, would prevail in Class II.

In this class of hospital a greater number than six in each polygon should probably be attempted, but for large numbers, with a central administration and schools, the general scheme should be identical with that mentioned for Class I.

It is for the public to choose whether they will exercise their benevolence in this manner, which *cæteris paribus* would afford more relief than the present system, or in raising monuments which, however in accordance with the most advanced scientific views, may yet, for aught we know, propagate disease, and will most assuredly be despised by posterity.

Sir Robert Rawlinson, C.B. (the President of the Congress), said this was one of the best papers he had listened to, and he wished the promoters the best possible success. All his sympathies were with cheap temporary hospitals. Here was a proposal by which a man could have restoration to health in a hospital where the cost would only be 1s. each bed per week.

SECTION III.

CHEMISTRY, METEOROLOGY AND GEOLOGY.

ADDRESS

By Charles A. Cameron, F.R.C.S.I., C.S.S.Camb.

PRESIDENT OF THE SECTION.

That abnormal food is a factor in the production of disease and death in man is a fact acknowledged from time immemorial. The divinely inspired laws promulgated by Moses, direct that the flesh of animals that have died from disease shall not be used as food. They also prohibit the use of blood as food—a remarkable prohibition, when it is considered that it is chiefly in the blood that the virus of so many dangerous diseases circulates. The writers of the Babylonian Talmud make frequent references to the subject of diseased food, and clearly recognize the difference between the flesh of an animal affected with a specific disease, and that of an animal injured by purely accidental causes.

It is only within a very recent period that the particular causes which render both animal and vegetable food unwholesome or actually poisonous have been scientifically investigated. The information gained, though a substantial addition to our knowledge of the ætiology of disease, is still, in many respects, very imperfect. The further elucidation of this interesting subject offers a wide field of enquiry to the microscopist, the chemist, the pathologist, and the biologist.

For the purposes of this address I shall arrange diseased and otherwise unsound food into five classes:—

1st. Vegetable food infested by fungi and other parasities, chiefly miscroscopic.