SECTION II.

ENGINEERING AND ARCHITECTURE.

ADDRESS

By Percival Gordon Smith, F.R.I.B.A.

PRESIDENT OF THE SECTION.

The very wide scope of sanitary engineering and architecture with which this Section of the present Congress has to deal, and the comparatively short space of time which is available for the address that is expected of me, preclude me from making any lengthy prefatory remarks, or from offering any apologies for accepting the Presidency of this Section. Indeed, I was hardly aware until I began to consider the matter, how very wide is our range of subjects, and therefore I may, perhaps, be allowed to remind you of some of the questions coming within the scope of sanitary engineering and architecture. They include such matters as—

Water supply to all manner of towns and villages.

Sewerage.

Means of disposal of sewage as well as refuse of all kinds.

Prevention of pollution of rivers and streams.

Preservation of purity of the atmosphere.

The formation of cemeteries and mortuaries, and arrangements for the disposal of the dead.

Open spaces in towns.

Clearing crowded parts of cities and towns.

Providing wholesome dwellings at moderate rents for the poorer classes, in the country as well as in towns.

Then there are innumerable other matters, as abattoirs and slaughter houses, markets, baths and washhouses, free libraries, common lodging houses, crêches, &c., which directly or indirectly affect the health of the people. Beyond these again, we have the intricate detail arrangements for carrying out these several matters in a proper manner, the street paving, scavenging, watering and cleansing; the drainage, water supply, ventilation and other points about our domiciles; the distribution of the various parts of our institutions for insuring the greatest hygiènic advantage, whether in the school, hospital, asylum, prison, barrack or workhouse. All these (and others could be mentioned) are among the subjects which we may have to consider, and I think I have said enough to make you agree with me as to the magnitude of the subject. It is quite beyond my power, even did time permit, to deal in the most cursory manner with all these subjects. I therefore propose to touch upon only a few of them, and in doing so, to endeavour to review very generally the present condition of certain sanitary works in the country—to "take stock," so to speak, though necessarily in an imperfect and incomplete manner, of the work that has been done under modern sanitary legislation; to see how far we are making progress, and whether that progress is such as can properly be regarded as satisfactory.

The legislation of recent years would seem to have given a great impetus to sanitary progress. It is stated in a recent Annual Report* of the Local Government Board that the total amount of loans which were sanctioned by the old General Board of Health under the Public Health Act, 1848, up to 1st September, 1858, when the Local Government Act, 1858, came into force, was £2,956,178, and the sanctions granted by the Secretary of State under the latter Act, and the Sewage Utilization Act, 1865, prior to the date of the constitution of the Local Government Board, amounted to £7,363,366. Thus in the twenty-three years prior to the constitution of the Local Government Board an aggregate sum of £10,319,544 was authorised, while in the first thirteen years of the Local Government Board a sum of £29,890,353 has been sanctioned in connection with the administration of the sanitary laws of England and Wales, outside the Metropolis. These figures will serve to convey not only an idea of the extent of the works that have been, and are, going on for sanitary purposes, but of the enormous increase that has taken place in such works during the last ten or twelve years. The larger proportion of these amounts, as may be expected, is for sewerage works and water supply, and upon these works alone the amount authorised to urban and rural authorities has averaged during the last five years over $1\frac{1}{8}$th million a year. The total amount of sanctions for public health purposes authorised by the Local Government Board averages upwards of $2\frac{1}{4}$ millions a year, which sum includes, besides sewerage and water supply works, a variety of other matters, such as street improvements, markets, recreation

* Thirteenth Annual Report of Local Government Board pages lxxi., *et seq.*

grounds, disinfecting stations, infectious hospitals, &c. It must further be remembered that these figures represent only the *public debt*, or the extent to which the local rates are mortgaged, whereas there is a vast further expenditure for sanitary works of the kind known as "private improvements"—works of a public nature, but which are not ripe for public use, and for the cost of which therefore the owners of the property to which the works relate are responsible. The outlay upon these has been estimated as equal in cost to that of the public works; and, assuming that that is an approximately correct estimate, we arrive at the enormous outlay of nearly sixty millions in sanitary works outside the Metropolis in the last twelve or thirteen years, or on an average a sum approaching five millions a year. This large outlay, again, is wholly independent of the cost incurred for sanitary improvements in private houses and public institutions, which must be very considerable, but of which we have no means whatever of forming an estimate.

This large increase of expenditure, which falls on the increased population and improved resources of the country, unquestionably represents a vast amount of really useful work. But it by no means represents all the useful sanitary work of the country, for there is other work of much importance which involves practically no cost whatever. The benefits derived from supplying our towns with house to house water supply, and our villages with the more modest main pipes and public water taps and fountains, are indeed great. The advantages of providing properly constructed sewers in our populous places, whether cities or villages, and of disposing of the sewage in a harmless and efficient, if not always in a useful or profitable way, are enormous. The success which has over and over again resulted from the possession of an efficient hospital in which the early cases of infectious fevers have been isolated, so that what might otherwise have become a dangerous epidemic, has been averted, is gradually being recognized, as is shown by the increasing number of hospitals that are being built for the purpose, as well as by the diminishing reluctance of patients to go into them.* The benefits conferred on the communities by the vast street improvements in many populous towns, by the

* In no sanitary district, perhaps, have the arrangements for the isolation of cases of infectious fevers been better managed and attended with more useful results, than in Leicester. The compulsory notification of infectious disease has tended to the isolation of cases in their earliest stage, and the hospital has acquired a reputation for comfort; payment has been regarded as quite a secondary consideration, the isolation of the patients—and indeed of any friends of the patients who had attended them immediately prior to admission, and thereby become a possible source of infection—being the primary object of attainment.

provision of excellent pleasure and recreation grounds, by the construction of good markets and abattoirs, cemeteries and the like, are universally admitted; and indeed it is impossible to form any estimate of the wide extent of the advantages resulting from these important works when efficiently carried out. But there is still other useful work of less costly kind that has made gigantic progress in the last ten or twelve years; I refer to the education of the public in the appreciation of sanitary work of all kinds, which has advanced in a most encouraging manner; without this, I contend, in this country of *local* government, no practical progress would have been possible. The enthusiast may be somewhat disappointed when he sees apathy in regard to health matters displayed by some corporation or local board, or neglect of some important duties, such as the control of house construction for example, or other equally important detail; but taking a broad view of the present state of public feeling on the subject, compared with what it was some twenty years ago, and looking at the improved acquaintance with sanitary matters generally which has resulted from these annual gatherings, from the Health Exhibition and the various local sanitary exhibitions so commonly held, I think we have every reason for congratulation.

It is only about thirteen years since the constitution of the present central authority for the control of matters relating to public health. The Local Government Board Act, 1871, not only constituted that authority, but transferred to it a variety of duties which had previously devolved upon a number of different departments of government, and thus a step was taken which tended to facilitate the controlling of such matters and the discharge of those functions with greater uniformity, precision and certainty than previously. That Act was immediately followed by the passing of the Public Health Act, 1872, but this was superseded by the comprehensive Public Health Act, 1875, which at once put the numerous sanitary laws, which had previously existed in a most inconveniently scattered and dispersed form, into a concrete and manageable shape. It is these Acts, with certain more recent Amendment Acts, which may be said to constitute the machinery by which throughout the country (the Metropolis excepted), all matters relating to public health are controlled. These general Acts have in some places, as in the town in which we are assembled, been supplemented by Local Acts for certain purposes, but this has been done mainly to satisfy local wishes and to meet local circumstances, and though in some instances this shows a commendable disposition for advancement beyond the general laws of the land, and upon some points at any rate is no doubt beneficial, I am by no means sure that Local Acts have invariably satisfied their promoters, or indeed been commensurate with the large cost involved in obtaining them. An able writer* speaking of these Local Acts, says, "Since the Statute of 1875, as before that date, Local Acts, amending the General Law, in one view, confusing and obliterating in another, continue to be passed. They have arisen, in many cases, from an exaggerated sense of the peculiarities of the town, or a desire to make minute provision by statute instead of bye-law. For some populations it must be admitted that a convenient code in one statute has been thus provided. These codes would be more capable of defence if supplementary Acts for the same town did not so soon rob them of that comprehensive character which is their best justification. For our great towns precision and directness have not been attained by Local Acts, inasmuch as their number and complexity so often reduce the whole to a chaotic state. These Local Acts are unsound in principle, because sold by Parliament for fees, and because in practice, at any rate, they cannot be amended without the employment of legal assistance, which is itself a source of expense." I am bound to express my general concurrence with those remarks, and especially as to the difficulty and expense of obtaining a Local Act as well as of amending it. Whatever can be done by means of bye-laws under the provisions of the general statutes clearly ought not to be embodied in any Local Act. The Public Health Act, 1875, specially provides that bye-laws may be made with respect to new buildings for securing their stability, for the prevention of fires, and for purposes of health, hence none of these matters ought to be dealt with by Local Acts. Proper bye-laws can generally be obtained at little or no expense and in a very short space of time; they can be altered, extended or repealed with the least possible difficulty, and can be so framed as to include nearly every necessary requirement. When these matters are embodied in Local Acts, the details often fail to obtain, in the preparation of the Bill in Parliament, that careful and skilful attention that is requisite. The Local Government Board in their 13th Annual Report observe (page cii.) upon this subject:—"In several Bills which came under our review we found clauses ostensibly designed to secure to the local authority a more effective control over building operations than bye-laws under the Public Health Act, 1875, would enable them to exercise. In many instances, however, it appeared to us that the clauses were of an objectionable character as, while purporting to lay down rules having for their object the prevention

* Mr. Francis S. Powell, Health Exhibition Literature, Vol. II., p. 341.

of sanitary defects in the structure and surroundings of dwelling-houses, they omitted to enforce the observance of precautions which would have a place in any properly framed code of regulations, and in some cases would have prescribed, with regard to such matters as drainage, ventilation, the provision of open space, &c., requirements which we were compelled to regard as tending to perpetuate structural arrangements now generally condemned as sources of probable danger to health." I may state that in recent years Parliament has appointed special committees to consider and report upon Local Bills, and by this means much needless and defective local legislation is arrested.

The education of the public in the appreciation of what is healthy, and in the desire to adopt proper sanitary arrangements, cannot fail to encourage, among other measures of advancement, the adoption and efficient application of proper codes of bye-laws as a means of controlling the details of the construction of domiciliary buildings; and this—the value of which can hardly be over-estimated—is, I think, gradually progressing in a surprisingly rapid manner. Looking back some fifteen or twenty years, how rare was it to find even such common arrangements as disconnected waste-pipes and ventilated soil pipes, arrangements which now-a-days many people look for in one form or another as a matter of course. Then there are the arrangements for drain ventilation, for rendering building sites wholesome, for securing adequate open space about houses, for ensuring a proper kind of closet, proper privies and ashpits, and a host of other details of importance. All these matters can be dealt with in new buildings by means of bye-laws, and although one may regret that so many places retain old-fashioned regulations which are exceedingly indefinite, arbitrary, and often erroneous, it is satisfactory to gather from the annual reports of the Local Government Board that this subject is being taken up by the public in a way which, as it seems to me, is highly satisfactory. In 1877 the Central Board caused to be prepared a form of building regulations which it was suggested should be used by local sanitary authorities as a model upon which to frame bye-laws relating to new streets and buildings adapted to the requirements of their district. This "model" series deals with the various subjects upon which bye-laws may be made, and it contains very complete and definite regulations based upon what are generally recognised as sound principles; and when I say that in the short period of eight years which has since elapsed, the model code has been adopted in a more or less complete form by some 400, or 25 per cent., of the urban and rural sanitary authorities of England and Wales, I am sure you will agree with me in regarding the matter with some degree of gratification.

In some of these districts I have reason to know that the new bye-laws are found to be working most satisfactorily and without difficulty, and it is to be hoped that wherever in operation they will be intelligently enforced, though I fear, from what I have observed in a few places which possess good bye-laws, that there is much yet to be desired for ensuring their being uniformly and efficiently carried out. Upon this particular point I would observe that the education of the people in the importance of sound and healthy dwellings may be expected to bring about improvement, for at present it frequently happens that, owing to the apathy of the ratepayers who annually elect the members of the local sanitary authorities, the successful candidates are persons who are directly or indirectly interested in evading some of the most valuable bye-laws, with the main object of effecting some saving in the first cost of building. This unfortunate circumstance which, so far as certain sanitary matters in the Metropolis are concerned, is also severely commented upon by the Mansion House Council on the dwellings of the poor in their first annual report,* not infrequently results in some degree of damage to the reputation of a district; but until the electors as a body can, by being taught its importance, be induced to secure the return of competent and thoroughly disinterested members, I fear matters will often be not as satisfactory as could be wished.

This should really be a feature in the education of the people. Sometimes a candidate will advocate his claim for support at a local board election on the ground that being a builder he is a "practical man," and therefore would be more eligible for the post than any one else. Another candidate asserts that his first object on election will be to oppose expenditure. I say that all these candidates deserve no support at the hands of the ratepayers. The so-called "practical man" is generally one of the most unpractical, who has some other object in view than the common interest of the district. The Sanitary Authority has, or ought to have, competent skilled advisers in the persons of the medical officers of health, the surveyor or engineer, the clerk or lawyer, and so on; and they should appeal to those officers for advice on the several matters with which they are respectively concerned, and then use their own common sense in the adoption of that advice just in the same way as any

* "Great blame for this state of things rests with the ratepayers who, mainly from sheer idleness or indifference, permit too often the election of men who have their own interests to serve rather than the welfare of the people to promote."

individual who consults his doctor, architect, or lawyer, uses his own judgment as to the adoption of the advice he receives. Again, the man who goes on a local board to oppose all expenditure clearly is unfit for the post, as he overlooks the fact that the very *raison d'être* of the Board is to perform certain duties necessary to the health and well-ordering of the district, and that the question of finance is necessarily a secondary though not much less important matter, the duty attaching to this being to secure the most complete efficiency at the least possible cost to the ratepayers.

I occasionally hear complaint that regulations commonly regarded as suitable for universal application can only be put in operation in urban districts, and that consequently certain comparatively sparsely populated places are precluded from possessing themselves of the advantages available in those respects to more populous places. I am therefore glad to avail myself of this opportunity of pointing out that by section 276 of the Public Health Act, 1875, any rural authority can, if it be desired, obtain the same powers as an urban authority to deal with nearly every matter of importance needing control in their district. In this way a rural authority can be invested with urban powers to make bye-laws on various subjects, including regulations as to new streets and buildings in their district or in any portion of it. In the year 1883 as many as 55 rural districts were thus invested with urban powers, and of these 27 obtained power to make bye-laws as to new streets and buildings.

Before leaving the question of bye-laws I may briefly refer to the subject of common lodging-houses and slaughter-houses, respecting both of which it is the duty of every sanitary authority to make bye-laws for their efficient control. The arrangement of buildings for these purposes, whether as adapted old buildings or as new buildings, involves a number of points having important sanitary bearings, but it will suffice for me here to refer to the bye-laws and memoranda which have been prepared by the Local Government Board to serve as models for the guidance of sanitary authorities when framing regulations upon those subjects. I may likewise refer in the same way to the model bye-laws and memoranda respecting the construction and management of mortuaries and cemeteries provided by sanitary authorities, both of which matters concern the sanitary engineer and architect.

Turning to the subject of water supply we find a growing demand for an unstinted water supply in our cities, towns and villages. Thus the subject of improved means of water supply in the Metropolis and in numerous large cities and towns is receiving constant consideration, not only with reference to increased quantity, but to pure and soft quality. The careful investigation of outbreaks of disease has, during the last 15 or 20 years, largely increased our knowledge of the part which defective and deficient means of water supply plays in the cause and spread of local epidemics, and steps are now commonly taken in well administered districts to guard against the possibility of such occurrences. Notwithstanding our increased knowledge in these matters, however, we hear from time to time of serious outbreaks consequent upon neglect of the local authority to ensure the purity of the water distributed among the inhabitants, and we have accordingly seen the most disastrous results occurring. In one town of some 10,000 inhabitants, as many as 486 cases of enteric fever (of which 37 terminated fatally) occurred in a period of five months. In another town of about 8,250 inhabitants, 548 cases of enteric fever occurred (of which 42 proved fatal) in a period of six months. In a third town, having a population of some 25,000 inhabitants, an outbreak of enteric fever occurred in the latter half of the year, and during those six months over 1,200 cases were recorded, of which some 90 were fatal. In all these instances (many others could be cited) the public water supply was more or less directly connected with the distribution of the disease, and who shall estimate the whole cost, mentally as well as financially, of such occurrences to the districts concerned. In the smallest of the three towns just referred to, the keeper of the principal hotel, where I happened to find myself the solitary visitor during a stay of a few days towards the close of the outbreak, estimated that the town had lost between £50,000 and £60,000 in hard cash, while the anxiety and sorrow, not to speak of impaired health, consequent upon the illness and death of so many inhabitants was appalling. In another town an epidemic is known to have cost the rates an aggregate sum of £35,000 in money irrespective of serious loss from partial stoppage of trade. Instances of this kind cannot be too strongly impressed on the public in order to show that undue parsimony in the carrying out of whatever works are indispensable for the protection of the health of the inhabitants really defeats its object, as it inevitably leads to ultimate large expense, to say nothing of loss in other ways, instead of effecting any saving in money.

Referring to the question of water supply in rural districts, I wish to direct attention to the Public Health (Water) Act, 1878, which casts on the rural sanitary authority of a district, or on the urban authority if invested with the powers of the Act, the duty of seeing that every occupied dwelling house in

their district has, within a reasonable distance, an available supply of wholesome water, sufficient for the consumption and for use for domestic purposes of the inmates of the house; and where it appears on the report of the officers of the authority that an occupied dwelling house has not such supply within a reasonable distance, they may take proceedings to compel the owner to furnish such supply if they consider it can be done at a reasonable cost, not exceeding a certain limit laid down in the Act. This Act, which includes provisions for the protection of the individual owners and others against unreasonable demands from the sanitary authority, deserves, I think, to be more widely known than it is, for although it appears that in some cases difficulties arise in the practical application of the Act, I cannot but think it ought to be more frequently resorted to, inasmuch as at present the water supply to individual houses in rural districts is very often insufficient and almost invariably liable to contamination. It is indeed hardly sufficiently realized, I think, by the general public how commonly the village water supply is polluted. This happens from a variety of circumstances. The water is usually chiefly surface water and thus it is liable to contamination by cattle. It is also liable to pollution from farmyards, manure heaps, middens, and surface drainage generally. Another common source of contamination is the proximity of water supply to the village churchyard or burial ground. In one rural district, of which I recently had the opportunity of perusing a report by its Medical Officer of Health, it was shown that of some twenty-three burial grounds in the district, only ten could be said to present no serious sanitary objection. In one of the others, it was stated, "there are two dipping wells which are under the walls of, and at a lower level than the churchyard," and the water from these is said to be at times "extremely offensive." In another, where all the available space for burials had been used repeatedly, the drainage was said to percolate through the walls and under the floor of a number of cottages. In a third, the water supply to the village inn was said to be conveyed along a stone rubble drain passing beneath part of the churchyard, and the covering stones of this drain were frequently exposed when graves were dug.

In view of such conditions as I have just referred to, it will be admitted that the powers conferred on rural authorities by the Public Health (Water) Act, 1878, are urgently needed, and ought to be applied more generally than is at present the case.

I have a strong conviction that during wet seasons we allow much wholesome water to escape which ought to be carefully collected in suitable underground tanks for use in the following dry seasons, and that the time will come when proper storage tanks for this purpose will be required by statute to be provided in rural localities where scarcity of water is experienced every summer. Indeed, even now, without further legislation, the provision of suitable storage tanks, such as I have just referred to, might possibly suffice to meet the requirements of the Public Health (Water) Act, 1878, where no other proper means of supply were available. The quantity of rainfall in the year varies considerably in different parts of the country. In some of the eastern districts it is as little as 20 or 25 inches, while in the west 60 to 100 inches, or more, is not uncommonly recorded. It is worth bearing in mind that if only 12 inches of rainfall over a collecting ground of one acre were to be properly stored, it would suffice to supply thirty persons with twenty-five gallons of water each per day for a whole year.

In regard to the question of sewerage, the different methods of sewage disposal, whether by ejectment into the sea, by precipitation, by surface or by sub-irrigation—the liquids in a comparatively pure state passing into the rivers and streams—all are receiving attention at the hands of sanitary engineers, and the details are being greatly improved upon year by year. In the same way the means of disposing of house refuse is receiving more attention than formerly, and there is certainly need for improvement in regard to some of the methods of dealing with the contents of dust-bins and ash-pits. I notice the increasing number of destructors that are being used for "cremating" all manner of refuse; in one instance that I know of, even the solids of the sewage of a district of some 15,000 to 20,000 inhabitants, after precipitation, are collected and mixed with the ordinary house refuse, and the whole is then passed through fire in destructors, from which the "output," in the form of clinkers, is ground up and made into concrete, paving slabs, mortar, &c. Although the various schemes for sewage and refuse disposal that have been adopted in different parts of the country, and upon different scales, have been attended with varying degrees of success, I am decidedly of opinion that the result as a whole is satisfactory, and the money expended on these works has been generally well laid out, having regard to the prime object in view, namely, the getting rid of sewage and refuse in a fairly harmless way at the least possible cost to the ratepayers.

There is another point in connexion with sewage disposal which I think calls for our special consideration. I mean the permitted construction of cesspools. Under all the modern sanitary acts cesspools are permitted to be used for the collection of sewage wherever there is no available sewer within a distance of 100 feet from the building to be drained. If the cesspool is situated in an urban district it must be so arranged and constructed as not to allow its contents to overflow, leak out, or soak away into the ground. If it is in a rural district, however, there is no such provision, and the cesspool may be so constructed that its contents may overflow into a ditch, or may soak continually into the ground. Notwithstanding the statutory prohibition* in urban districts of cesspools which allow their contents to escape into the ground, there are many towns—and, indeed, some health resorts—where this system is in full force, with populations of twenty thousand to fifty thousand inhabitants, the ground being almost completely honeycombed with such cesspools. Although such arrangements cannot but promote unwholesome conditions by certain degrees of pollution of soil and ground air, it is far less dangerous where there is a good public water-supply than where, as in many rural districts, each house draws its water from its own or from some common well. For here, even if the cesspools are required by bye-law to be made water-tight, it rarely happens that either cesspools or the drains leading to them are actually water-tight, and consequently, what with leaky drains and cesspools, the soakage from manure pits, dust-bins, pigstyes, and the like, the shallow wells in rural districts are almost always more or less contaminated. So far as cesspools are concerned, I desire to enter my protest against the system altogether, and I cannot but think that the time is not far distant when they will be universally prohibited by statute. Possibly sewage tanks of proper construction might be permissible in some conditions where they would be emptied without fail so frequently that the sewage in them would never be other than fresh, but otherwise I think the system of cesspools ought to be abolished. They are radically bad in principle and disgusting and dangerous in practice. They are bad in principle because, under the most favourable circumstances, they retain the sewage in near proximity to buildings for a considerable period, and always long after the sewage has become putrid. The walls of the cesspool once impregnated with putrid sewage will always remain so, and leaven the fresh sewage brought into the cesspool. Any more dangerous and objectionable system it is difficult to conceive, and it is probably, directly or indirectly, the cause of more injury to health than is commonly supposed. For these reasons I hope to see the system absolutely prohibited, in rural as well as in urban districts. Indeed,

*Section 47 (3) of the Public Health Act, 1875.

I think there would be little real difficulty in prohibiting cesspools altogether in the case of new buildings. Where a house or an institution has to be built, there ought to be proper sewers, or some other suitable and proper means of getting rid of the sewage while it is still in a fresh and comparatively harmless state. If the local conditions would not permit this, I think the erection, or at any rate the occupation, of the building should be deferred until proper arrangements could be made. This would surely be better than either that the soil and ground water should be poisoned by the constant discharge into it of foul sewage, or that the sewage should be collected and retained in close proximity to the building until its removal is inevitably attended with danger as well as with nuisance. The use of cesspools is, I venture to think, continued to a great extent merely from force of habit. People have been so accustomed to regard the provision of cesspools as a necessity that it is assumed as a matter of course that they are indispensable. This is, however, by no means the case, and in support of my contention I would refer to what has taken place in regard to the use of middens in many of the large towns of Lancashire, Yorkshire, and elsewhere. It was formerly the custom in those towns to construct huge midden pits that were emptied only when full, at intervals of many years, and it was alleged that these were indispensable. But in the best-administered towns where this was the case, such middens have been abolished, and indeed are now prohibited, while small receptacles, wholly above ground, and from which the filth is frequently removed, and always before putrefaction has set in, are now invariably adopted. I venture to hope the same action may be taken with regard to cesspools.

We have heard a great deal during the last few years about the dwellings of the poor, and quite recently we have had the advantage of considering the reports of the Royal Commission on the Housing of the Working Classes. It is, however, often forgotten that the subject is an old one. Shortly after the first constitution of the Poor Law Commission, about 1835, the condition of the labouring classes attracted attention, and in 1839 the Poor Law Commissioners were directed by the Queen to make an inquiry on the subject, and in 1842 the results of that inquiry were framed by the secretary of the commission, Mr. Edwin Chadwick, in a report which, to this day, is regarded as quite a standard work on the subject. The author of that report, I am pleased to say, is still among us, and actively works to promote the sanitary welfare of all classes. The name of Edwin Chadwick, C.B., will ever be honourably associated with

the subject of sanitary engineering and architecture. That report also contains a plan suggested by Mr. Sydney Smirke, the eminent architect of that day, for a so-called "public lodging house," containing in three storeys some 50 or 60 separate single-room tenements. Shortly afterwards societies were formed for the purpose of improving the condition of the dwellings of the labouring classes, and one of these societies, under the presidency of the late Prince Consort, exhibited at the Great Exhibition of 1851, a block of model houses. Other societies, having similar objects, became established in the provinces, and various model villages were formed, as at Saltaire, near Bradford, Ackroydon, near Halifax, &c. Still later we have the effects in the Metropolis of Sir Sydney Waterlow's Society, and the trustees of the Peabody Bequest, besides numerous other societies which have produced numbers of small houses, such as those of the Queen's Park and Shaftesbury Park Estates in London, and others elsewhere.

There is thus evidence of much useful work having been done in the way of providing improved dwellings for the people, and some idea of the extent of it may be inferred from the fact that in London alone no less than twelve millions of money is said to have been invested in buildings containing separate tenements for the accommodation of the working classes. But notwithstanding all that has been done in this direction in the last fifteen or twenty years, the problem seems still as difficult as ever, and, according to evidence taken by the Royal Commission, the condition of the working classes is still, in many places, more or less a scandal to the times. The normal death rate of London as a whole is about 21 per 1000, and when we read that in some parts of the Metropolis the death rate is stated to have reached, in 1882, 44 and 53·7 per 1000, while the rate, calculated for a small number of houses in one particular part, reached 70 per 1000, or two or three times as great as the average, and in certain parts of some of the large provincial towns the rate is still said to be "very high," the necessity for agitation, in order to remedy this state of things, is at once apparent. There appears in this, as in other matters demanding attention, to be a vast quantity of remedial power available, but a lack of readiness on the part of those in local authority to apply that power. Here, again, we come to the necessity, as it seems to me, for stirring the public to demand that those elected to positions of responsibility in the matter, should use the powers vested in them for dealing with these important subjects. Important they certainly are, for the results of neglect to use the existing powers already possessed, have led to such serious overcrowding as to affect the health and working power of the inhabitants in a manner that altogether fails to be illustrated in the death rate returns, even high as they are. The children are permanently injured by it, and the adults are likewise injuriously affected by it in health as well as in means; for it has been found on inquiry that, on the lowest average, every workman or workwoman in certain overcrowded localities, loses about twenty days in the year, not from illness, but from sheer exhaustion and inability to do work; and this at a very moderate wage per diem would amount in the aggregate to a not inconsiderable sum in the year. Overcrowding in a house is, by statute, a nuisance which can be dealt with by law. Local authorities, moreover, have, or can have, full power to control the number of persons, not members of one family, who may occupy a house or part of a house which is let out in lodgings; they can also have such houses registered, inspected, and put into and kept in proper sanitary condition. But hitherto very few authorities have assumed these powers, while many that have been invested with them, have entirely failed to enforce them. The provisions of the Artizans' Dwellings Acts of 1868 and 1882 (Torrens), and of the Artizans' and Labourers' Dwellings Improvements Acts of 1875 and 1882 (Cross' Acts), and the Labouring Classes Lodging Houses Acts of 1851, 1866, and 1867, contain very extensive and useful powers for dealing with the subject where desired by the local authority. Local authorities throughout the Kingdom have been reminded of these powers, and useful digests of the Acts have been sent to them, and still all the evils—moral and sanitary—of overcrowding continue. Let us hope that one of the useful results of this Congress will be to help to stir up the public to demand energetic action of sanitary authorities to use the powers they already possess, and thus diminish the scandalous conditions which have been recently referred to in the Report of the Royal Commission on the Housing of the Working Classes.

With regard to the blocks of artizans' dwellings and model lodging houses which have sprung up in various parts of the Metropolis and in some of our more populous provincial towns, all will agree that the clearing of crowded areas covered with the worst forms of dwelling-house is in itself a most excellent move; but I look with grave apprehension upon the vast piles of buildings that are often erected with the avowed object of affording accommodation for the people who have been displaced, but which actually get occupied by a different and higher class occupier, thereby tending to aggravate the overcrowding already existing in neighbouring districts. One sees huge blocks—five, six, or seven stories high—sometimes

connected with each other and sometimes detached but in such close proximity to one another that the sun can never reach parts of the internal open spaces, and so that the air in those spaces must be more or less stagnant. Some of these buildings contain hundreds of separate dwellings, each dwelling holding on an average four or five persons. Such buildings, I maintain, are unworthy of their prime object. They may deceive their promoters at first by appearing fairly wholesome and, in comparison with the houses and tenements previously occupied, as being an improvement; but I fear that after the lapse of some years they will become unwholesome and be regarded with diminished satisfaction, while their death-rate, which in their early years is generally low, will increase. Indeed, in some of the blocks that have been erected in London, there are not wanting indications that, from some cause not at present definitely explained, the infant death-rate has been excessive, and even greater in the block of dwellings than in the surrounding unreformed neighbourhood.

I am confident that the massing together of vast numbers of human beings in dwellings of great height and capacity—rooms piled one upon another to a height of 60 or 80 feet or more—is not a proper system. We cannot with impunity crowd an unlimited number of human beings on a given area. This has been decided with respect to the sick, and is equally evident with respect to children, and similar conditions will, I believe, come to be recognized with respect to people of ordinary health and habits. There are doubtless degrees of relative proportion of people to area according to their condition, and to a certain extent according to the character of the building and its surroundings, but hitherto we have not arrived, so far as I am aware, at the precise limits of proportion of ordinary population to area. The subject is one which deserves careful attention, and indeed has not been altogether overlooked by some of those concerned with the more recently designed blocks of dwellings in London. The danger of piling up these dwellings in buildings of great height has received illustration in the older parts of Edinburgh, where the houses, as you are aware, reach eight or nine storeys in height, and have no internal connection with drains; the refuse is removed in tubs daily, and there is an excellent water supply. I am assured on high medical authority that notwithstanding these arrangements, the first cases of typhus almost invariably occur in the upper storeys.

It has been my good fortune to have opportunities of noticing the arrangement of various institutions having for their object the housing of large numbers of persons, old and young, both in health and in sickness of body and mind. I look back at many old buildings, whether hospitals, asylums, workhouses, schools, or the like, and find enormous blocks containing wards ranged along both sides of dark passages, and holding vast numbers of human beings under one roof in practically one atmosphere. That arrangement of building may now be regarded as wholly obsolete, and as having given place to what is known as the pavilion system, under which the building is sub-divided into a number of separate blocks or pavilions, each containing a comparatively small number of inmates, and affording far greater facilities for effectual ventilation of the apartments, as well as for the access of light and circulation of air about the pavilions. This system in one form or another, is now, in principle at any rate, invariably adopted for all well-arranged institutions intended for large numbers of persons, but in many instances I have noticed that the advantages of the separate pavilion system are completely counteracted by the way in which the several pavilions are joined together, solely for administrative reasons, by enclosed corridors in basement, ground, and one-pair storeys, and thus, by means of lifts for coals, lifts for inmates, shoots for dust and for soiled linen, staircase well-holes and the like, the several blocks or pavilions have been most successfully transformed into one uniform building, having one and the same atmosphere throughout every part of it. The objections to these arrangements, by which the prime object of the pavilion system is defeated, are perhaps more conspicuous when adopted in buildings occupied by a number of sick persons or by children, than in any other class of building, and I am under the impression that in England, while we aim with much success at perfection in detail arrangements, we are considerably inferior in many of the broad principles of arrangement to some of our continental neighbours. The hospitals erected in the last eight or ten years in some of the continental cities and towns are specially worthy of attention in these respects. Spread over large areas of ground—in some instances perhaps needlessly large—the wards being only one storey high, absolutely detached one from another or having only a covered way between them, and being limited in size to the requirements of some 14 to 20 beds each, being raised on arches well above the ground, and arranged so that the patients while still in bed may be wheeled into outside balconies, so as to have the advantage of treatment in unenclosed air. Such hospitals, and they have been fully described in recent works on the subject, seem to me to approach very nearly perfection of arrangement, and to afford examples such as it is difficult to find at home. In respect of children's buildings, again, the dangers of concentrating large numbers of children in dormitories, or indeed in any confined space, have

long ago been demonstrated as tending to impair the health and to aggravate any tendency to disease. There is no necessity for placing many children in dormitories, and the massing together of large numbers in school and class rooms is only tolerated by reason of the comparatively short time those rooms are occupied. And even here it would be a boon, having regard to the small amount of space usually allowed to each child, if the school and class rooms could be completely vacated, as recommended by Mr. C. E. Paget,* for ten minutes or so every hour, so that, by means of open windows, they could be completely flushed out with fresh air at frequent intervals. The system of arranging domiciliary schools upon what is known as the cottage-home principle, has so many advantages, sanitary and otherwise, that it deserves attention by all who are concerned in the welfare of the young. It has been adopted in recent years for many charitable and poor law institutions, and I have invariably heard it spoken of most favourably. The schools of the Leicester Poor Law Union, which are at Countesthorpe, are upon this system, and will well repay a visit.

You will perceive that I have taken an encouraging view of the present condition, and a hopeful view of the future of sanitary engineering and architecture. In saying this, however, I would not have it supposed that what has already been achieved should be regarded as adequate under every head. There is still a great deal to be done, and perhaps the most useful way of furthering this is by educating the people to appreciate all that tends to healthiness of body and mind. By doing this the public may be led to demand that more use shall be made of the powers already in existence. One hears occasionally a desire for more legislation, but it has been shown conclusively that there are already many valuable powers relating to health matters that are allowed to remain a dead letter, owing, not so much to any ignorance of the existence of these powers as to the apathy of the authority immediately responsible for putting them in force, and, as the late Royal Commission observe in regard to the making of certain bye-laws, no action will probably be taken "until the people show a more active interest in the management of their local affairs." The creation and the increase of this interest I regard as one of the chief aims of this Congress. These annual gatherings in different parts of the kingdom must not only be utilised for keeping alive the interest in sanitary matters which has so far been awakened in the

* Health Exhibition Literature, Vol. I., page 378.

public, but each year's Congress must give fresh impetus to the work, and so keep it actively progressing during the ensuing twelvemonths. Former Congresses have done good work in this direction, and the present one promises to be no less successful; but in order to insure its complete success, as well as that of the Sanitary Institute, we must one and all—individually and collectively—use our utmost efforts to gain the confidence of the public and to carry them with us.

Prof. F. S. B. F. de Chaumont, M.D., F.R.S. (Southampton), moved a vote of thanks to the President of the Section for his address.

Mr. Rogers Field, M.Inst.C.E. (London), in seconding the motion, remarked that Mr. Gordon Smith had modestly refrained from mentioning several facts that ought in justice to have been mentioned. The model bye-laws to which allusion had been made were among the most important things that had ever been done by the Local Government Board. Those bye-laws very greatly tended to advance sanitary improvements generally and to improve the health of the community. Mr. Gordon Smith, as Architect to the Local Government Board, had a very large share in drawing them up, and the public was very greatly indebted to him. As to the question of cesspools, he entirely agreed with the President that they were radically bad in principle, and disgusting and dangerous in practice; and he thought that it was an exceedingly fortunate circumstance, for the progress of sanitary practice, that the chief architect to the Local Government Board should have expressed the strong opinion on the subject which he had done.

Mr. P. Gordon Smith briefly acknowledged the vote.

On "The History of Sewerage and Sewage Treatment at Leicester," by John Underwood.

At the time of the passing of the Public Health Act in 1848, Leicester was, in common with many other large towns, in a condition much needing sanitary improvement.

In 1846 a local Act had been obtained by the corporation

entitled "An Act for Improving the Borough of Leicester," but the powers conferred by that Act were found to be quite inadequate as related to the more important measures necessary for improving the sanitary state of the town.

"The Public Health Supplemental Act, 1849," which constituted the town council the local board of health, received the Royal assent, and came into operation on the 1st August, 1849. In the same year a preliminary enquiry was held at Leicester under the Public Health Act by William Ranger, Esq., C.E., superintending inspector of the General Board of Health, and a report founded on that inquiry was made to the board on the "Sewerage, Drainage, Supply of Water, and the Sanitary Condition of the Inhabitants of the Town of Leicester." In this report the intrinsic difficulties of the question were recognized. The town itself was described as in the main situated on a saucer of loam, the brim of the saucer being formed by a range of shelving hillocks broken to the east only, in which quarter the town was much exposed, and from which it principally derived its ventilation, being thus unfavourably situated. The peculiar course of the river to the west of the town was also remarked upon, its high level compared with the land adjacent, and the aspect it assumed of a series of stagnant pools in dry seasons, being held up by mills and locks, and with scarcely any flow. The sanitary state of the town was found to be very bad, fever was rife, and of a fatal character, and not confined to the lower parts of the town, but extended to the higher. The most palpable source of the fever was said to be the miasma arising from the evaporation of the foul water, which inundated certain parts of the town during the summer floods, and by which the impurities from the larger sewers were carried back into many of the houses, yards, and streets.

Mr. Flint, an eminent local architect, said: "At the back of the various blocks of houses there is in almost all cases a common yard, whose surface, from the retentive nature of the subsoil (and where it is of a different character it is thoroughly inoculated with the liquid refuse and effluvium from privy pits and rainwater), offers an extensive area for the exhalation of noxious effluvia, and in other parts where the property abuts on the streets, and in large portions of the unoccupied land, as well as parts of yards to the houses which are enclosed by the embankments of streets and by adjoining higher ground basins are formed into which the rain is received and stagnates. From these basins there is no efficient or regular drainage, and the water can only pass away by the slow process of percolation and evaporation."

Dr. Shaw reported: "I have been shocked on entering some of the confined courts and alleys to find the inhabitants living amidst masses of decomposing animal and vegetable materials, totally unconscious of their danger, and even speculating on their heaps of infection, and amassing with anxiety the filth deposited in the neighbouring streets."

Mr. Stallard, in speaking of the physical condition of the poor, said: "I believe it to be gradually deteriorating."

In reference to the streets, Mr. Flint said: "Although the streets are generally paved, there is a total absence of proper inclinations for conducting the surface water off, consequently, water hangs upon the surface, and with it every kind of filth, including blood and offal from slaughter houses, which is swilled down on the surface in front of the dwellings, and in one instance to the extent of about a quarter of a mile."

The population of the town was slightly over 50,000. The number of streets was given as 242; of these only 112 were culverted, and no less than 130 either not culverted, or but partially so. There were no regulations for draining the streets or courts, and what had been done was the result of arrangements at different times among the owners themselves. The culverts were originally intended for the conveyance of surface waters, and mostly took the place of the old open ditches or water courses; by degrees the owners had been allowed to connect house drains with them, and they became the receptacle for every kind of filth, conveying it to their natural outfall the river Soar, which was thus constituted virtually the main sewer of the town.

This was the state of things when, on the 5th September, 1849, the highway and sewerage committee of the Corporation, realising their responsibility as the local board of health, passed unanimously the following resolution: "That Thomas Wicksteed, Esq., of London, should be appointed engineer, for the purpose of reporting as to the best mode of draining and sewering the borough, and of presenting a plan with an estimate of the expense."

Mr. Wicksteed was said to be personally unknown to every member of the Board, and to have been selected solely on account of his high professional reputation, and the admirable evidence given by him as published in the first report of the commissioners for "inquiring into the sanitary state of large towns and populous districts." The result was, that Mr. Wicksteed accepted the appointment, visited Leicester, and made a survey of the town and neighbourhood, and on the 12th March, 1850, presented a "preliminary report," which was ordered by the committee to be printed, and it was largely circulated.

In the introduction to this report, an interesting summary is given of the principal objects which Mr. Wicksteed and the committee considered were to be attained:

"1st. The diversion of *all* sewage, dye, and scouring waters from the river Soar and the Leicester Canal, and their removal, as speedily as possible, from *under* and near the town of Leicester, so as to relieve the town from noxious exhalations, and to restore the river to the salubrious state in which it was before it was made the common sewer of the town.

"2nd. The removal of this sewage to such a point in the river *below*, that the process of collecting and disinfecting may be carried on without injury or annoyance either to the inhabitants of the town itself or to those of the adjacent villages; and that the process to be adopted in its disinfection be such that the water, before it is returned into the river Soar (*below* the town), shall be in a state of at least as great purity as it was in the river *above* the town, before any sewage or dye waters had contaminated it.

"3rd. That the level of the sewers shall be at such a depth that the lowest parts of the town shall at all times be capable of being well and thoroughly drained.

"4th. That the fall in each sewer shall be sufficiently great to produce a velocity that will not only carry off rapidly the liquid filth poured into it (so as not to allow of stagnation or of time for decomposition), but also to produce a sufficient scouring power to prevent the accumulation of *débris*, or heavy deposits of road drift.

"5th. That there shall be a daily and *nightly* supply of water, abundant in quantity, for cleansing the sewers, and neutralising any bad odours remaining therein, after the bulk of the daily sewage shall have ceased to flow.

"I am also of opinion that no scheme for the sewerage of a town can at the present time be considered complete unless it embraces the means for converting the sewage water to useful and profitable purposes, so as to *reduce*, as much as possible, the expenses of sanitary improvement, if not to merge them altogether in the receipts arising from the sale of the *manure*."

This report was termed a "Preliminary Report," because it left open for further consideration the exact position of the outfall of the sewage, and also the detailed plans and estimates. A further written report was made to the committee by Mr. Wicksteed, on the 14th July, 1851, followed by plans, specifications and estimates. An Act of Parliament was applied for and obtained in the Session of 1851 for enabling the corporation to carry out the scheme as recommended by Mr. Wicksteed and the General Board of health was memorialised for sanction to the borrowing on mortgage of the rates for the execution of the works.

Mr. Lee, Superintending Inspector, visited Leicester, and reported to the general board; and his report may be described as an adverse detailed criticism of Mr. Wicksteed's scheme as a whole. The following remarks as a "recapitulation" at the conclusion of his report, will give an idea of the Inspector's views:—"I think it has been shown that there is no proper survey upon which alone any efficient and economical system of drainage of the town can be devised; that even for purposes of main sewerage the scheme before you is very incomplete; that the proposed main sewers in the town are neither fit for the sewage alone, nor for the rain water, nor for the two combined; and that they would be unnecessarily expensive, even if unobjectionable, on other and strictly sanitary grounds of consideration.

"That every slight shower, even if the sixty-sixth part of an inch in an hour, would cause more than half-a-million of gallons of sewage to be impounded in the main sewers under the town, displacing and driving back into the dwellings the same quantity of noxious sewer gases. That a great part of the town, at least, might have been drained by gravitation.

"That the reservoirs, and the drying process together, will convert on the average 5,395 gallons of sewage daily into vapour, contaminating the air. That Mr. Wicksteed has misquoted, and misstated the report of the chemists, and neither can nor does propose to use the same re-agent for disinfection as was used in all their experiments; and that, notwithstanding the use of lime water by them, in the proportion of one-third the volume of sewage, the fluid remained offensive.

"That the whole of the works connected with the engines and reservoirs, and the so-called process of disinfection, would be enormously expensive, and would inflict incalculable evil upon the health of the inhabitants of the town.

"That it is very doubtful if the lime-water, or lime-process would pay its own expenses, even as against spontaneous subsidence in these immense reservoirs, irrespective of any sanitary considerations. The following were Mr. Lee's "Conclusions":

"For the reasons above-named, and fully discussed in the body of this report, I cannot advise your honourable board to sanction the mortgage of the public rates of the borough of Leicester for the execution of this scheme; and I recommend that, for the protection of the Local Board and the preservation of the health and lives of the inhabitants, you should altogether refuse such sanction."

The general board forthwith, in a letter to the local board, expressed their regret that they were compelled to withhold their sanction to mortgage the rates for carrying out the proposed plan of drainage, for the following reasons:—

"1st. Because it is incomplete, and, having been prepared on insufficient plans and information, not only is there no security afforded that the partial lines of drainage are the most judicious, but there is, on the contrary, abundant evidence to prove that their direction is not well selected, and that they would be inefficient and unnecessarily costly.

"2nd. Because instead of leading the whole refuse of the town into sewers at the lowest levels, merely to be pumped up again, the larger proportion might be conveyed so as to discharge by gravitation; thus not only effecting a saving in the dimensions of the work, but avoiding a perpetual tax upon the ratepayers for unnecessary engine power.

"3rd. Because even if the sewers were properly laid out, they are neither properly graduated nor properly adjusted to the work which they would have to perform.

"4th. Because the proposed mode of dealing with the refuse would be attended with the utmost risk to the health of the population, and would be of very questionable expediency in a financial point of view. It would commit the local board to a vast speculation, which the most favourable results of chemical experiments in no way justify, and which in case of failure would entail a most serious lasting tax upon the inhabitants.

"5th. Because of the £35,000 for which application for a mortgage is made, no explanation is afforded; nor does any estimate appear to have been prepared with regard to £5,000; and because the whole of the partial works proposed might be much more efficiently carried out, and the beneficial results more certainly attained, at a very considerable saving in their estimated cost of *thirty thousand pounds*."

The local board was, therefore, in a dilemma, the council having obtained Parliamentary powers to carry out the scheme; they were refused authority to borrow for the execution of it, and in reference to this refusal in their report on March 17th, 1852, they said:—"The committee deeply regret the obstruction which has thus unexpectedly arisen to the immediate progress of sanitary improvement, as they are fully satisfied that there is a great amount of preventible disease in the borough, which would be remedied to an appreciable extent by an improved system of sewerage, and that the mortality, which in some of the undrained parts is no less than five per cent. per annum, might have been very materially reduced."

The report of the inspector of the general board was sent to Mr. Wicksteed, in order that he might have an opportunity of explaining and defending his scheme, and answering the objections of Mr. Lee. This Mr. Wicksteed did, in a very able reply, which was presented to the council simultaneously with the inspector's report to the local board, and after consideration it was decided by the local board to wait by deputation upon the General Board in London; which they did with the proposition that the plan and reports should be submitted to either Mr. Robert Stephenson or Mr. Rendel for opinion and advice. Lord John Manners, on behalf of the General Board, thought the proposition not at all unreasonable, and said the Board would therefore wish that the matter should be submitted to Mr. Stephenson, and that his opinion and recommendation would be received with the greatest respect and attention, and have due weight with the Board, but that as a public board they could not of course give any pledge.

A report from Mr. Robert Stephenson was therefore obtained, and it was, on the whole, decidedly favourable to Mr. Wicksteed's scheme. One or two paragraphs in Mr. Stephenson's report may be quoted, as they refer to points which are at present matters of interest and discussion in the town:—

"1st. With reference to the drainage of the *higher district*, as suggested by the inspector, I think it may be effected through an intercepting drain without pumping, although misgivings have, I understand, been entertained about it; but there can be no doubt that a separate system for this particular district will add to expense without increasing efficiency.

"2nd. The low level of Leicester generally with reference to the Soar, into which the drainage must eventually flow, and the very little fall in that river, make the sewerage of the town of considerable difficulty, and not to be accomplished without pumping as proposed. The outfall might be carried lower down below the Belgrave mill tail, but at an increased expense of construction, and the same expense of pumping, the fall of the valley being no more than is necessary for giving the required velocity through a prolonged sewer, the only advantage from which would be, that any exhalation would be further removed. If the chemists be correct, there is no danger to be apprehended in the site of the reservoir now intended, and in this opinion my experience leads me to concur."

On consideration of Mr. Stephenson's report, the general Board waived their objections, and consented to the carrying out of Mr. Wicksteed's scheme. Several modifications in detail were adopted; the outfall was removed to the western side of the river, the size of the depositing reservoirs which had been contemplated in the "preliminary report" as of $3\frac{1}{2}$ acres in extent and situated in the Abbey Meadow, was abandoned in

favour of smaller and covered tanks on the site of the present works, and as now in existence. But the sewers were carried out mainly as designed, but were in some cases reduced in size as the distance from the works increased, and they may be briefly thus described:—The sewer in Abbey Meadow, 4ft. 8in. in diameter; (1) West main sewer, 39in. diameter; (2) East main sewer, 27in. diameter; (3) Central main sewer, 27in. diameter, and other sewers varying in size according to circumstances, the whole length about 40 miles, the depth varying, but generally speaking about 12 feet below the surface, excepting the foregoing main sewers, which were deeper than 12ft. Estimated cost—£55,000.

In connection with the scheme for sewering the town, of course it was necessary that the question of sewage treatment should be considered, and Mr. Wicksteed appears to have given great attention to it. The successful application of sewage in its liquid state to land at Edinburgh, had been commonly referred to. The rare combination of circumstances there existing were admitted, but it was still held as a primary condition that, whatever system was adopted, the operation must "be useful and commercially profitable."

Mr. Wicksteed accepted with great enthusiasm this condition, and with energy set himself to prove its truth. As to the application of sewage to land, Mr. Wicksteed satisfied himself that, although there might be localities favourable for a limited adoption of such a plan, nevertheless, to provide for the distribution of the whole of the sewage water of a large town by such measures would, in his opinion, be a most "imprudent speculation." He discussed its distribution by pipes analogous to a water supply, and concluded with the remark:—

"I think it will appear very evident that the distribution of the *whole* of the sewage water could never be *profitably effected* by such means. At the same time it is but right to observe, that the distribution of a *portion* of it over the Abbey Meadow, and the lands in the immediate neighbourhood, would not involve so great an expense, and in a commercial point of view this might be worthy of consideration, were there no objection on the score of *health*."

The reports of the eminent chemists, Messrs. Aikin and Taylor, Professors of Chemistry in Guy's Hospital, appeared to prove conclusively that the application of lime would do all that was necessary to purify the sewage, and would leave a deposit which, if quickly dried, would be a cheap and useful manure in a concentrated form, and which might be readily packed for disposal similarly to guano.

Mr. Wicksteed had long leaned to the side of the chemists, and a solid manure scheme as against a liquid manure scheme, and during his preparation for Leicester sewerage he had also actively pursued his investigations in this direction, and had become fully convinced that a solid manure of great value could be obtained. So satisfied was Mr. Wicksteed that his conclusions were sound, that he foreshadowed in his report that "he had but little doubt that responsible parties might be found who would supply the necessary capital for constructing the works for the manufacture and sale of the manure, and deliver up the said works to the town council in a state of good repair and good working order at the expiration of 30 years from their establishment."

Imbued with these ideas, and having received encouragement in various directions, Mr. Wicksteed himself, in 1851, took out a patent for the manufacture of sewage manure, one of the principal features of the process being the application of centrifugal force for the separation of the water from the deposit in the bottom of the reservoirs. In the following year an Act of Parliament was obtained, incorporating the "Patent Solid Sewage Manure Company," and enabling the company to raise capital to the extent of £100,000.

In a report to the Metropolitan Commission of Sewers in 1854, Mr. Wicksteed referred at length to the operations of The Patent Manure Company in their purification of the sewage and manufacture of solid manure at Leicester, and, at the risk of making rather a long extract, I think it will be best to take Mr. Wicksteed's own description of his processes, which was written at a time when he was anticipating their complete success, and these temporary works were adopted as a model for all further operations. The reference is as follows:—

"In February, 1852, the directors resolved that temporary works should be erected in Leicester for the purpose of manufacturing the manure upon a sufficiently large and practical scale, having in view three objects: the first being to ascertain whether the lime process effectually disinfected the sewer-water, and if so, whether it could be practically used upon the large scale; the second to ascertain whether the removal of the precipitate from the bottom of the reservoir, and the abstraction of the water from it by means of centrifugal force, could be practically carried out upon the large scale and at a sufficiently small cost; the third object being to manufacture a sufficient quantity of the manure to enable agriculturists to prove its commercial value, considering that their practical opinions would be a much better test than chemical analyses only, and it was resolved that upon the result of these trials the question of proceeding with the company should be decided. Works were accordingly

erected, and after many alterations and improvements upon the original scheme, which probably would not have suggested themselves unless the opportunity of carrying the plan out practically had been afforded, the directors were so satisfied with the result, that they felt justified in entering into a contract with the town council of Leicester, undertaking in return for the exclusive right to all the sewage water for a period of thirty years, to disinfect it, and discharge the water in an innoxious state into the river Soar for the same period.

"I will now proceed to describe the temporary works and the process, to the maturing of which I have devoted the greatest portion of my time for the last two years, and have completely satisfied myself that the scheme is not only practicable and remunerative, but may be made very profitable when carried out on a larger scale than opportunity has hitherto afforded.

"The temporary works at Leicester were erected upon ground belonging to the town council, upon the banks of the Leicester navigation, near the outfall of the filthiest sewer in the town, a branch from which supplied the works with sewer water. The use of the ground was granted to the company at a merely nominal rate by the town council, who in this, as in other instances, have afforded every facility to enable the company to demonstrate to the public the practicability of disinfecting the water and manufacturing the manure.

"As regards the size of the temporary works, they were calculated for a population of 5,000, previous to the introduction of a supply of water into the town from the new water works. I do not mean to imply that we have actually deodorized the sewer water from a population of 5,000 during twelve months, for this would be inaccurate, as the constant interruption arising from the practical modifications and improvements of the machinery used in the process would of itself have prevented such a course; but the works have, for different periods, been kept in continuous operation day and night, that I might have the opportunity of assuring myself that the process was complete as affecting the sewer water during any of those periods, the object of these temporary works being, as I have before stated, to ascertain whether the process could be practically and remuneratively carried out by the means proposed.

"At the commencement of our operations, it was found that the process of deodorizing was not perfect, and it was discovered that its partial failure was due to the sewage water being in too concentrated a condition, the new supply of water to the town having only been introduced at Christmas last, while the operations of the company commenced more than a year and a half ago. To prove whether this conjecture was correct, a portion of the partially deodorized water was returned into the engine well, and when the concentrated sewage was reduced to a quality equal in strength to that of the Metropolitan sewer water, the process was completely successful.

"Professors Aikin and Taylor ascertained the strength of the London sewer water, and determined what amount of dilution was necessary to reduce the Leicester sewer water to the requisite strength, and by their experiments I was guided in my practical operations.

"Again, it was found that at night, when the manufactories were not at work, and the waste water from the engines had ceased to flow into the sewer, their contents being chiefly urine and excrementitious matter in a state of far greater concentration than the day sewage, the effect of the lime was only partial; but upon diluting it as in the former case, the process of deodorizing was completely successful—the effluent water from the reservoir after the process was completed being perfectly free from all taste and odour, excepting occasionally from the lime when it had been used in excess.

"A quantity of the effluent water from the reservoir was taken in August last by Mr. Theodore West, chemist, of Leeds, and subjected to an analysis; and he found that there was not a trace of any other matter than carbonate of lime, sulphate of lime, and chloride of sodium; proving clearly that all noxious matter had been abstracted during the process.

"The mode of operation in this process is as follows:—the water is pumped up from the sewer, and into the pipe conveying it to the reservoir a smaller pipe is introduced connected with the lime pump, which works stroke for stroke with the sewer water pump, and the process of deodorizing is so rapid, that when the mixture of sewer water and lime is discharged into the reservoir, there is no noxious odour arising from it; the discharge takes place into the first part of the reservoir divided into three compartments, in each of which is an agitator worked by the engine; a thorough mixture having thus been effected, it flows through the upper end of the reservoir, and is from thirty to forty minutes passing through this portion, during which time seven-eighths or more of the separated matter has been precipitated on the bottom of the reservoir. There still remains, however, about one-eighth of solid matter, which, being lighter than the first portion, requires a longer time for precipitation, so as to render the water clear and bright.

"The water is, in fact, two hours in passing from the sewer to the farthest end of the reservoir, where it is discharged, and arrangements are made to enable the water to flow continuously through the reservoir, with as nearly as practicable the same velocity over the whole section, the openings of the discharging gates being proportioned to the depth of water in the cross section, and thus the necessity of having two reservoirs, for the purpose of filling one while the water in the other is being cleared by deposition is avoided, for although the stream is continuous, its velocity being only about one-fourth of an inch per second, it does not interfere with, or arrest, the precipitation of the solid matter.

"The operation of moving the precipitate from the bottom of the reservoir, so as not to interfere with the continuous flow of the water in the reservoir, is performed by means of a screw, which removes the precipitated matter into an adjoining well or shaft as rapidly as it is formed, without disturbing the process of precipitation which is carried on above it.

"The bottom of the first portion of the reservoir is made to slope towards the centre, along which a culvert runs, semicircular at bottom and open at top; in the bottom of this the screw is laid, and the precipitate collecting upon it from the sloping slides, is, as the screw revolves, carried into the adjoining well; the practical working of this arrangement is now completely successful.

"It is the combination of these two arrangements, viz:—the continuous current and the removal of the deposit without disturbing the supernatent water—that has enabled me to reduce the size of the reservoirs to so great an extent; this will be seen hereinafter, when I give the sizes of the reservoirs I propose for the Metropolis.

"The next operation is to raise the deposit or mud from the well or shaft, by means of a Jacob's ladder, very similar in appearance and construction to the ladder of buckets in the dredging machines used on the Thames, excepting that its position is vertical and its construction much slighter; the mud thus raised in a semi-fluid state into a tank, flows through a pipe to the centrifugal machine, the machine is then set in motion at the rate of about 1,000 revolutions per minute, and in half-an-hour from the time the precipitate was laying on the bottom of the reservoir, it is in a sufficiently dry state to pack in casks, or to mould in the form of bricks for farther drying.

"A given bulk of the manure, when introduced into the centrifugal machine, is reduced to about one-third of its original bulk, two-thirds, as water, having been separated from it by the operation.

"The machines which are now making for the new Leicester sewage works, are each calculated to turn out 360lbs. of manure in an hour in the state of consistency previously mentioned.

"Thus it will be seen that the whole operation of disinfection and conversion into manure is very simple, and I think it must appear evident after the experience of a year and a half of what may be done in works sufficient for a population of 5,000, that by simple multiplication of the means, it may be made available for any population, however great; as in this case the increased quantity of sewage water merely involves a simple increase of machinery in proportion to this increase, the increase of power for raising it being in direct proportion to the quantity.

"As regards, however, the proposed large works for Leicester, there will be two reservoirs, about 200 feet long and 44 feet wide, two-thirds of the area will be covered with an iron girder and brick arch floor for the warehouses above, to economise space, and the whole will be roofed over; and as this portion of the design is intended to be carried out in all future works, however large, all chance of nuisance from exposure is avoided; but the fact is completely established, that no nuisance does arise either from the reservoirs or in the process used in manufacturing.

"Although not in a position at present to state what the 'actual commercial value of the residual manure' will be, because, as before intimated, the desire of the directors of the Patent Solid Sewage Manure Company has been to leave this to be determined by the result of its practical application by the agriculturist, and at present the manure that has been so applied has been *pro tanto* inferior to what is intended to be supplied, in its having been chiefly collected from the day sewage unmixed with the richer night sewage, and also from the fact of its containing 60 or 70 per cent. of water instead of 20 per cent., which is the quantity it would have contained if the extent of our temporary works had afforded us room for drying it in larger quantities than has hitherto been practicable; nevertheless, our experience has been quite sufficient to prove that without the necessity of having recourse to expensive applications of artificial heat, simple exposure to atmospheric influence for a few weeks will reduce the moisture to 20 per cent., so that bulk for bulk the manure intended for sale will contain twice as much fertilising matter as that which has at present been forwarded to agriculturists for trial. The present results, however, show that, taking guano at £10 per ton, the manure as proposed for sale is at least worth £2 13s. per ton; but as I stated to the commissioners verbally, I have considered it safest to calculate its commercial value at £2 or £2 2s. per ton, and this amount would yield, after deducting the cost of manufacture and repairs, a fair percentage upon the capital expended in the construction of the works.

In discussing the financial aspects of the case in relation to the sewers and water supply for Leicester, Mr. Wicksteed stated his anticipations as follows:—"The quantity of manure that will be collected in the bottom of the depositing reservoirs will be equal to at least 10,000 tons per annum in the first fifteen years, and 20,000 tons per annum in the second like period. This, when fit for removal, will contain 33 per cent. of water, and supposing it, when high dried, to be worth £2 per ton, in the damp state it will be worth 27s. per ton, and thus deducting 7s. for expenses, will leave 20s. as the net produce per ton.

"If, therefore, a market can be found for the sale of the quantity manufactured (of which there is probably but little doubt), it would give a revenue of £10,000 per annum during the first fifteen years (a sum which would be nearly equal to the estimated expenses of water supply and sewers for that period), and during the subsequent fifteen years the income from the same source would probably amount to £20,000, a sum that would much more than cover these charges."

In estimating the character and value of Mr. Wicksteed's sewerage scheme, although great fault has been found with it, I think it ought to be admitted that considering the views held, and the lack of experience at that time, it was a very able and enlightened effort to deal with a difficult question, and that it fairly met the wants of that day, and it is a somewhat singular coincidence that the thirty years for which Mr. Wicksteed estimated his sewers adequate has just expired, and our experience proves that the time has come when some important alterations must be made. The carrying out of the scheme undoubtedly effected at once an enormous improvement in the sanitary condition of the town; the sewers being laid deep had the effect of draining the shallow wells and of leading to the new waterworks supply being substituted.

The working of the main sewers was for some time satisfactory, and their construction, though it has been much decried, was not so bad as has been sometimes represented, being formed mostly with double brick rings, and intended to act as subsoil drainers to some extent. They must have been fairly well executed, no serious collapse having occured. Considerable cleansing has, however, of late years been necessary, the deposit being principally road *detritus*, and caused in a measure by insufficient engine power at the works, the sewers having been left gorged for a long time together. As seen in the light of experience, however, the weakest point was the insufficient size of the main sewers; for years this has led to cellar flooding, and it was an especial weakness with the central sewers. The large area of rising and high land which finds its natural drainage line through the centre of the town, has intensified this state of things year by year as the districts became built over. The Gallowtree Gate sewer, for instance, was laid down 24in. in diameter, being 3in. less than originally intended, and a glance at the district of the London Road beyond, and its great elevation will show at once that the difficulty must arise. The storm waters gorge the sewers and the pressure due to the head in the higher levels causes the water to rise, as from a fountain, into the basements. This has been remedied to some extent by storm water sewers, and part of the district has a duplicate system, *one* solely for storm water.

From observation the construction of main sewers of insufficient size, appears to be a frequent cause of weakness and difficulty. The trunk of a tree grows with its extending branches, but a trunk sewer remains the same, and too often becomes overcharged by the great number of subsidiary sewers attached to it in course of time; and sometimes such sewers are made to do duty for a district beyond the ordinary natural watershed, as it is possible for engineers to pierce a ridge and so to get a fall into an existing sewer. Local Boards are apt to encourage such operations, in order to postpone the expense necessary for the construction of a new main sewer for the district unprovided for.

I think, however, that Mr. Wicksteed should receive some consideration in this matter; in fixing the size of his main sewers he took a middle course, whereas he estimated that in thirty years, five million gallons of sewage per day would have to be provided for, he calculated his mains to be capable of delivering twenty-eight million gallons. Mr. Wicksteed was necessarily influenced by the means at his disposal, and even then, on his moderate estimate of fifty-five thousand pounds, the General Board reported, as we have seen, that a much better scheme might have been devised at much less expense. Of course, the greatest portion of expense was for the main sewers, and it is not easy to see how Mr. Wicksteed could have increased the size of his main sewers, without greatly increasing the cost of his scheme.

In reference to the undertaking of the Patent Solid Manure Company, their works for treatment and manufacture were opened in May, 1855. The new sewers and the lime treatment soon caused an immense improvement in the river and canal, both in the neighbourhood of the town and below. The supply of the dried manure, however, from the first, much exceeded the demand. At the end of twelve months working, the original centrifugal machines were superseded by those of Messrs. Manlove & Elliott, of Nottingham. At the end of two years there

was an immense accumulation of the dried manure in the form of brick stacks, and the order to discontinue all processes for artificial drying was given—this having the effect of at once greatly reducing the working expenses. The further operations of the company were confined to the pumping, and the treatment by lime of the sewage, simply running the sludge into earth-banked receptacles. During the third year of working, however (viz.: on the 25th November, 1858), the Corporation took responsibility of the operations, and the Company handed over the works.

The Corporation continued the lime treatment, and the accumulations of sludge have gone on from that time to the present, what has been removed having been mostly given free to parties who would undertake the cost of removal. Various other recognized modes of treatment, however, besides the lime have been tested. In 1868, the A.B.C. company experimented for some time. In 1871, the Phosphate of Alumina Company used their system and had possession of the works altogether for about 18 months. In 1877, the patent of Mr. Hillé was worked for some months. Black ash has also been tried. During the past two years, the compound treatment recommended by eminent chemists has been applied, viz:—Lime, Alumina, and Sulphate of iron, and this season, in addition, the effluent has been deodorized by permanganate of soda as largely used in the Thames by the Metropolitan Board of Works.

The two last exceptionally dry seasons have put a great strain upon the resources of the Corporation at their works and there being for a long time together during the summer droughts no water flowing, other than the small quantity passed from one pond to another by a very slender canal traffic, the river below the town has, at the end of the summer, been composed mainly of the Leicester sewage effluent.

In September last year an enquiry into the condition of the Soar was held in Leicester by Major Tulloch, R.E., of the Local Government Board, at the instance of the adjoining authority, on the downward course of the river. The enquiry resulted in a decision that the state of the river was too bad to be much longer tolerated, and the Council undertook to proceed at the very earliest time to consider the matter with a view to an improvement, and this they have been engaged in doing during the last year. Looking to our experience one point was by most people considered settled, namely, that the mere treatment by lime or chemicals would not meet the case of Leicester, and that the application of the sewage to land was the only solution. It was also decided that the brave attempt which Mr. Wicksteed and those associated with him had made to prove it true that sewage treatment might be so managed as not only to yield common interest but large profits, was a fallacy, though very creditable to them. We are no longer under such illusions, our efforts must be directed to minimise the loss, and our object should be to keep down the capital expenditure, and also the working expenses as much as may be compatible with efficiency.

In our consideration of this very important question, preconceived opinions and the schemes of the past, of course, came under review. A "free outfall" had been so much in the minds, and the phrase upon the tongues of those who had considered and discussed the subject, that almost everybody had come to the conclusion that this was the thing to be sought after, the phrase sounded well, but, it is to be feared that the conceptions of many of those who summed up their ideas of the problem by the demand for "a free outfall" were of rather a vague character; at any rate, no clear description has ever been given of what was intended or how it was to be obtained. A free outfall and a gravitation scheme is no doubt quite right theoretically, but practically it was found that even if at all attainable it would be most costly and difficult in the Valley of the Soar. On the whole, the Soar Valley Schemes for sewage disposal appeared to the committee fraught with risks too many and too great to encounter.

Another proposal was made, viz., to utilise and extend the present pumping outfall station, and lift the sewage to a height of 150 to 170 feet on to an estate of about 1,360 acres under the control of one owner, at a distance from Leicester of only 1½ miles. On 30th June last the council approved a report from the highway and sewerage committee, that 100 acres of this estate should be purchased, and the remainder leased for 30 years at an annual rent of 45s. per acre. The idea of the Committee is to use this mainly as a broad irrigation area, and it is confidently believed, that with this estate in hand, the Corporation will be able to deal with the sewage of the town without risk or interference for many years to come. The Inspector of the Local Government Board has expressed himself favourable to this scheme, and it is quite expected that it will be carried out. The Council at the present time await the official report of the Local Government Board to their memorial in favour of the scheme, and requesting authority to raise the requisite funds.

[*For discussion on this paper see page* 198.]

On "The Drainage of Continental Towns," by J. Gordon, M.Inst.C.E.

Introductory.

It is presumably owing to the Author having resided for over fifteen years upon the Continent as a practising Sanitary Engineer, that the Council of the Sanitary Institute has requested him to prepare a paper under this heading.

The subject is, however, such a comprehensive one, that, even with the advantage just alluded to, it is scarcely possible to do it justice within the limits of a single paper. It is also obvious that, even with the fullest and latest details available, they could not be fully utilised on the present occasion. The Author proposes, therefore, dealing only with the leading features of such representative instances of Sewerage and Sewage Disposal Works as have come more immediately under his own observation during the time referred to. In doing so, he would observe that a paper fully describing the complete works of any one town would probably give a clearer idea of the amount of attention paid on the Continent to the theory and execution of such works, where they have been undertaken, than can be conveyed by a paper on the more general question. The latter, however, doubtless possesses the greater degree of interest for this Congress, as bearing upon the position and prospects of foreign sanitary work, and comparing these with the corresponding elements in our own country.

History of the Sanitary Movement in Germany and Switzerland.

Referring more particularly to Germany, in which the greatest advance has been made during the past twenty years, it may be said that the active prosecution of sanitary measures was for a long time considerably behind our English experience, in other words, no such exciting stimulus there existed as the Public Health Act of 1848 has been proved to be in this country. The exception to this statement is to be found in the case of Hamburg, which, at the passing of that Act, was considerably advanced in the execution of a well-devised system of sewers, based on the example set by the late Mr. John Roe, surveyor to the Holborn District of London, who had adopted the egg-shape for brick sewers, and introduced flushing gates for cleansing them.

The great Hamburg fire of 1842 had destroyed so large a portion of the city as to involve the preparation of plans for its rebuilding, a project which included a general system of sewers. The design and execution of the latter were entrusted to Mr. W. Lindley, an English engineer, who, to some extent following up the London experience already referred to, adopted an oval sewer section in preference to the then prevailing vertical sides and flat bottoms.

After Hamburg, Berlin was the first city of importance to recognise the necessity for an improved system of sewerage; but it was not until 1860 that a commission of engineers was appointed to report on Belgian, French, and English towns, with a view to the preparation of a scheme for the Prussian capital. As the result, an elaborate plan and report were prepared by Privy Councillor Wiebe and Mr. Veitmeyer, civil engineers.

Closely following the publication of the Berlin Report, Mr. Eckhardt, the city engineer of Frankfort-on-the-Main, presented a report, which was referred to a commission of experts, who, in August, 1863, presented a report laying down the general principles upon which the sewerage system should be designed.

An important report on the town of Dantzic, which gave an undoubted impetus to the sanitary movement throughout Germany, and one of a most exhaustive and detailed character, was presented in 1865 by Privy Councillor Wiebe, in the preparation of which he was again assisted by Mr. Veitmeyer. The works recommended in this report were, however, not commenced until the Frankfort works were well in hand. Mr. Wiebe continued to advise the municipal authorities throughout the works, but by an arrangement between the city authorities and Messrs. J. & A. Aird, the general contractors for the work, Mr. B. Latham was called in to prepare the working plans for the works, which are familiar to English engineers through being illustrated in Mr. Latham's well-known book on sanitary engineering.

About the same time, Mr. Bürkli-Ziegler, town engineer of Zurich, was commissioned by the authorities of that town to go over the same ground as in the case of the Berlin Commission, with a similar object as regards Zurich, the question of water supply being added. His illustrated report of March, 1866, at once established his reputation, and, with that of the Berlin Commission and the Dantzic Report, became a text book for Continental engineers, so that a new departure may be said to have been made in Germany and Switzerland dating from that period.

Somewhat later (1868) a valuable report and book of reference appeared on a proposed scheme of sewerage for Stettin, by Mr. Hobrecht, civil engineer, who is now chief engineer to the Municipality of Berlin.

In January, 1866, Mr. Lindley and the Author were appointed to design and carry out the Frankfort sewerage works on the general lines and principles laid down in the report of the 1863 Commission, of which Mr. Lindley had been a member. Owing to the war between Prussia and Austria in 1866, it was not until the following year that a commencement was made with the works, the special character of which soon became widely known, in consequence of the attention directed towards them by the meetings of various scientific bodies being held in the city, and also by the visits and subsequent reports of municipal engineers and sanitary specialists.

The vacuum pneumatic system of Capt. Liernur was about the same period first brought prominently before the public, and served in several instances to retard for years the adoption of any system of filth removal in towns, which felt the necessity of amendment, but which were ready at the same time to acquiesce in delay, until the battle of the systems had been fought out at the expense of others.

The town of Basle, in Switzerland, was next reported on in 1872 by a commission of engineers, consisting of Messrs. Lindley, Wiebe, and Bürkli-Ziegler.

Reports now followed upon other towns, amongst which may be mentioned, in the year 1873, Breslau, Winterthur, Mayence, Bochum, and Düsseldorf.

After having completed the chief and more difficult portions of the Frankfort works, the Author reported upon and prepared plans and estimates for sewering the following cities and towns: Stuttgart, Heilbronn, Hanau, Landshut, Munich, Bockenheim, Dortmund and Ludwigshafen, with an aggregate population of 530,000. He also reported on schemes of sewerage prepared for Nuremberg and Homburg, and acted as engineer for the contractors in the execution of the sewerage works of Düsseldorf, Crefeld, and Linz (Austria), and for similiar works at Carlsruhe and Darmstadt, representing, including the first-named towns, a population of about 983,000.

Mr. Lindley has also reported on Crefeld and Elberfeld, as well as St. Petersburg and Warsaw, and on additional works at Homburg.

Mr. Bürkli-Ziegler, in addition to having carried out a complete system of sewers at Zurich, has reported upon and prepared schemes for Heidelberg and Mannheim, and, in conjunction with Professor Kulmann, of Zurich, for Bucharest.

Mr. Hobrecht, of Berlin, must be mentioned as having inaugurated, and being now engaged in completing an entirely different scheme to that propounded for Berlin by the 1860 commission, he has also reported on Mayence, and other places.

Comprehensive schemes have also been prepared for sewering the towns of Gotha, by Mr. Hennoch; Freiburg in Baden, by Mr. Lueger; Riga, by Mr. Malcher; Königsberg, by Mr. E. Wiebe; and for Vienna by the town engineers, Messrs. Niernsee, Arnberger and Berger; while the Liernur system has been introduced at Leyden, Dordrecht and Amsterdam; and the town of Winterthur, in Switzerland, has had under consideration the adoption of the same system, but has now abandoned it.

It will be seen from this hasty enumeration, that the adoption of sewerage works upon the general lines of the English water carriage system is steadily progressing on the Continent of Europe; and attention may next be directed to the leading principles on which these works are based as a whole.

Leading Principles of Sanitary Works on the Continent.

The Franco-German war of 1870—71, considerably interrupted the progress of the Frankfort works, and retarded the adoption and commencement of similar works throughout the country; but since then much good work has been done, that is to say, good work as far as it goes, for it will no doubt be considered by this Congress that many of the works, which the author is about to describe, are imperfect in two essential particulars, viz., in the ultimate disposal of the water-carried sewage, and in the exclusion in many instances of the excreta from that mode of conveyance in towns where complete and thoroughly efficient systems of sewers have been laid down. Further reference is made to both these points in the following recapitulation of the leading principles adopted.

Rainfall.

Contrary to the practice long greatly recommended, and now frequently, if only partially, adopted in England, nearly the whole of the sewerage schemes to which reference has been made are designed to accommodate the rainfall in addition to the ordinary sewage by one set of sewers.

In Frankfort a rainfall of seven-eighths of an inch in twenty-four hours has been provided for, without bringing the storm overflows into action.

In Dantzic the engines and pumps are calculated for a rainfall of one-quarter inch per day of twenty-four hours, to be pumped to the Irrigation Works; but irrespective of this, the outfall sewer is large enough to allow of men passing through it. The tributary sewers are calculated to discharge a fall of half an inch per hour, the main trunk sewers (leading to the outfall) being relieved by storm overflows.

In Berlin it was intended, by the original scheme, to provide for half an inch in twenty-four hours, but this was altered in the report of a commission to $\frac{5}{16}$ of an inch per hour, or fifteen times the original limit.

Mr. Bürkli-Ziegler made a larger provision for rainfall in Zurich than in any of the preceding cases, and in the Mannheim and Heidelberg schemes provided for $\frac{3}{5}$ of an inch per hour.

In the Author's schemes, designed after Frankfort, he has always endeavoured to provide for the main trunk sewers being capable of carrying off at least an inch of rainfall to the main outfall in twenty-four hours, without bringing into play the storm overflow sewers, the subsidiary sewers being designed to take from $\frac{1}{4}$ to $\frac{1}{2}$ an inch of rain per hour, according to the extent of the district drained, the general declivity thereof, and the average distance from an overflow outfall.

The greatest exception he has met with in the most recent returns which have been obtained is that of Mayence, on the Rhine, where the rainfall, for which the new sewers are said to make provision, is given at 30 millimetres in half an hour, one-half of which is expected to reach the sewers in that time, and be carried off by them when the storm overflows are brought into play. This is equivalent to $1\frac{1}{5}$ inches of rainfall in an hour actually carried off, or, on the assumption of 50°/₀ reaching the sewers in the same time, to $2\frac{2}{5}$ inches of rain in the hour, and is therefore an unprecedented provision, leaving some room for doubt as to the accuracy of this return, when it is considered that the largest sewer of the system is not more than 5ft. 11in. by 3ft. 11in. in section.

In Cologne also an unusually large provision for rainfall is made, the main trunk sewers being calculated to carry off half an inch, and the subsidiary sewers $1\frac{1}{5}$ inches per hour. The largest main sewer, however, is in this case

8ft. 2in. by 7ft. 3in., with a contracted channel for the dry weather flow and a small footpath on one side, similar to the section adopted by the author for Munich, where, however, the main outfall sewer is not more than 7ft. 3in. in diameter.

Depth and Mode of Laying out Sewers.

In Frankfort, Munich, Stuttgart, and other cities and towns with which the author has been connected, the sewers have been laid at such depths as to insure a proper and efficient drainage of the cellars and basements of the houses, even when the sewers are running full, and of the laying of the house drains below the cellar floor levels, whether carried inside or outside the houses. Dead ends are also practically non-existent, owing to the sewers being laid at such levels as to join them to each other at street ends, thus making it possible to flush the lateral sewers from the main trunk sewers by means of flushing gates and stops, without having recourse to supplementing the flushing power from the water supply of the town; the system being by this arrangement, to a large extent, interchangeable and self-balancing no serious difficulty can possibly arise from any mishap in the way of a block, or in the case of one sewer being more surcharged than another, inasmuch as the branch sewers will always admit of the passage of the sewage or rainfall round a block until it has been removed. By such an arrangement so serious a block as was experienced in Leicester in 1881, in one of the main sewers draining an area of 316 acres, and with a length of 12¾ miles of sewers to the point at which the block occurred, would have been impossible.

Flushing Arrangements.

In Frankfort an elongated gallery or reservoir, into which land drains are laid to collect the subsoil water from the higher lying land beyond, has been constructed at the summit of the system, from which upwards of 100,000 gallons of water can be sent through almost any part of the system by means of the arrangements described. Two other similar arrangements are made at the summits or ends of the two lowest districts of the town, one on the extreme east, and the other at the west end of the city. The sewers may be said to be laid out in three zones—a higher, middle, and lower zone, the lateral sewers of each being capable of being flushed from the main trunk sewer of the zone immediately above it, or having the flushing power from the galleries alluded to directed through them.

The system of sewers now in course of construction at Munich in accordance with the Author's plans is arranged on the same principle, as are also those of Stuttgart, Düsseldorf, Crefeld, Dortmund, and Mayence.

Those of Berlin, Dantzic, and Breslau, are also, to a great extent, carried out on the same principle, excepting that there are no special reservoirs constructed for flushing purposes, and the mode of flushing is of a somewhat more primitive character. In Berlin and Dantzic, a disc faced with india-rubber, with a rope or chain attached to it, is used. A workman descends a manhole and places the disc into the mouth of the pipe which carries the sewage forward from the manhole, and, if the manhole be at the crossing of two streets, with two pipes entering and leading from it, then a second disc is required. After inserting the discs, the workman brings up the ends of the ropes or chains to the surface, and waits until the sewage has backed up to a line marked on the inside of the manhole, which indicates the level to which the sewers may be backed up in that neighbourhood without back-watering the cellars. He then withdraws one or both of the discs as he may desire to flush one or both sewers. Personally, the Author thinks there are some objections and risks connected with this mode of flushing the sewers, as he pointed out to the author of it, Mr. Wiebe, when that gentleman showed him its working in Dantzic. It backs up the sewers and puts them under a greater pressure of water than is, in his opinion, wise, or than there is any necessity for; whilst on the other hand, reliance has to be placed upon the trustworthiness and patience of the workmen for watching that the water does not rise beyond the height fixed upon, which might easily have been provided for by an overflow in each manhole. In both cities the sewers are chiefly pipes, so that it is absolutely necessary with such flushing arrangements that the jointing of the pipes should be such as to withstand pressure. In Berlin they are made with oiled yarn and a fine plastic clay. The only thing the Author can see in favour of this method of flushing is that of economy in first cost, avoiding as it does the cost of flushing gates, hand penstocks, and other valve arrangements, as used in Frankfort and the other towns enumerated.

Materials and Construction of Sewers.

In Dantzic the sewers are chiefly pipes, not more than $10\frac{1}{3}$ per cent. of the total length of sewers being of brickwork.

In Breslau the sewers are also chiefly stoneware pipes. The main sewers are of brickwork with large granite blocks for the invert.

In Berlin too, as previously referred to, the sewers may be said to consist almost exclusively of pipes, the main trunk sewers, which are of brick, bearing but a very small proportion in length to that of the pipe sewers. The largest sewer is 10ft. 1in. × 8ft. 9in., and the smallest 8 inches in diameter.

One noteworthy feature in the drainage of Berlin is the principle adopted of having a sewer on each side of the street, which, so far as the Author is aware, has not been attempted elsewhere. This principle has no doubt enabled the author of it, Mr. Hobrecht, to adopt pipes in cases where brick sewers would otherwise have been requisite, and accounts to a great extent for the great excess of pipes over brick sewers for a city of such a metropolitan character as Berlin, with its million-and-a-quarter of inhabitants, now is. Various reasons may be given for the choice of this system beyond that of desiring to confine the sizes of the sewers to that of pipes. The subsoil is surcharged with water, and consists of fine running sand, making it most difficult and costly to construct brick sewers watertight; but the means which had to be adopted to obtain this result must be passed over here, as being incompatible with the limits of this paper. The streets being generally wide, the adoption of a sewer on each side enabled the traffic to be carried on without interruption, and so shortened the length of the house drains that the necessary fall for them could be obtained without the street sewer being laid so deep as would have been requisite if one sewer had been constructed in the centre. It can scarcely be conceived, however, that the plan has not been more costly than if one sewer had been adopted. Another noteworthy feature in the sewerage of Berlin is also the theory of the engineer, Mr. Hobrecht, that to prevent the formation of sewer gases as much as possible steep gradients should be avoided. His argument is, that with branch sewers of steep gradients, a state of things is involved in which, during the night, and also with the minimum day flow, so small a portion of the invert of the sewer or pipe is covered by the flowing sewage as to leave a large portion of the sides of the pipe covered with slimy matter exposed to the action of the comparatively high temperature of the sewer. This acts upon and tends to dry it by evaporation, and thus to evolve in a greater degree a more pungent and dangerous sewer gas than would be the case if a greater portion of the surface of the invert could be kept covered with sewage flowing at a slower velocity. He urges also that branch sewers with steep gradients run practically dry, and that with a minimum flow matters that would float with a given depth of water on the invert are deposited and not removed by the greater velocity of the maximum flow, and that consequently, on this head also, it is better to ensure a sufficient depth of water on the invert moving at a velocity not more than sufficient to float forward all such solid matters as find their way into the sewers. Mr. Hobrecht has had the courage of his opinions, and has carried those views into practice by flattening all steeper gradients to 1 in 500, and any one inspecting the sewers of Berlin, as the Author has had the opportunity of doing, may see evidence of this at any of the crossings of the streets, where in a manhole may be found pipes coming in at different levels, sometimes two and three feet above the invert of the manhole or outgoing pipe, showing that the whole of the available fall for the ingoing sewers has not been made use of.

In Frankfort the largest sewer is 6ft. 1in. × 4ft. 8in., and the smallest brick sewer 2ft. 3in. × 1ft. 6in. Fifty per cent. of the whole of the sewers are of the size of 3ft. × 2ft., and only about 20 per cent. are of pipes.

The largest sized sewer in Munich is, as previously referred to, 7ft. 3in. in diameter, with a contracted channel for the dry weather flow, and a small footpath on each side.

The largest sewer for Stuttgart is 6ft. 7in. in diameter, similarly constructed, whilst the main sewers for Düsseldorf, Crefeld, Mayence, and Nuremberg are 5ft. 11in. × 3ft. 11in. The brick sewers in these cities are constructed of the very best brickwork built with the best Portland cement mortar. Nuremberg is an exception, the sewers there being constructed of cement concrete, as are also the sewers of Mannheim and Heidelberg and of nearly all towns in Switzerland (Basle, Zurich, &c.).

One-half of the sewers in Linz, in Austria, are built of brickwork with hydraulic lime, but of exceptional thickness, the other half are of cement concrete.

Ventilation.

The system, first initiated on the Continent in connection with new sewers at Frankfort, of ventilating them by means of surface gratings in the centre of the roads and of trapping the street gullies, is now the most prevalent, and has in fact been adopted in all the towns with which the Author has been connected, with the exception of Linz. In Berlin, Breslau and Dantzic, it has also been adopted, although probably not to such an extent as in Frankfort, Stuttgart Munich, Düsseldorf and Crefeld. In all those towns in which the water closet system is in vogue, and the closets are connected to the sewers, as in the towns just enumerated, with the exception of Crefeld and Stuttgart, the soil pipes act both as ventilators to the house drains and to the public sewers, and in this respect will probably meet with the condemnation of this Congress as contrary to the commonly received and now prevailing opinion of English sanitarians, that all house drains and pipes should be disconnected from the public sewers at a point between them and the houses. Whilst therefore the Author may not defend the practice on principle, he is bound to say that with thoroughly well-constructed sewers, such as he has described, without any dead ends, and with such ample provision for flushing and cleansing them, and a staff of workmen regularly employed exclusively on this duty, and with an equal amount of care bestowed on the designing of the house drainage itself, the system has so far been successful that practically scarcely any complaints have arisen as to the surface gratings having become a nuisance. The circulation of air within the sewers, and the great dilution of it with atmospheric air through the open gratings, placed so numerously as they have been in Frankfort and many of the other towns as to be only 40 yards apart, assisted as they are also by the rain water pipes, has resulted in the sewer air being (if such a description can be applied to sewers) comparatively sweet. If anyone wished to inspect the Frankfort sewers, and were desirous of avoiding what have been termed by visitors the show-places, where especially convenient staircases, &c., have been constructed, and would follow the example of a Government and Town Commission from Munich, by marking on a plan of the town any points they might choose, and desire to be shewn the sewers at those points, the author would be extremely surprised if they did not find the sewers comparatively free from smell, such as might be expected in the sewers of a thoroughly and completely water-closeted city of 147,000 inhabitants, with 26,900 water closets joined on to the sewers. The 7,570 soil pipes of cast-iron—all the new ones being varnished inside and outside, with Dr. Angus Smith's patent varnish—jointed with lead, carried through the roof with open tops, together with rain water pipes, act as powerful up-cast shafts, and materially assist in the ventilation of the street sewers, and in keeping up a continuous circulation and dilution of the air within the sewers and house drains.

The Author must, however, also state with reference to Frankfort, that two special shafts, each 100 feet high, and of 5 feet internal diameter, were built at the two summits of the system to assist in the ventilation of the sewers, but that whilst they are powerful ventilators within a given radius, it would take a very large number of such shafts indeed to be of much service.

Tables.

It is impossible within the limits of such a paper to dilate on each particular case, but for all those anxious to become acquainted with more of the details of each city, the Author has appended what he hopes may be an interesting and useful summary, in as condensed a form as possible, giving the latest information with respect to the sewerage and sanitary condition of a large number of continental towns.

He takes this opportunity also of most heartily and cordially acknowledging the courtesy and readiness with which magistrates, mayors, and city engineers throughout Germany, Switzerland, Austria, Holland, Belgium and France have supplied, at great labour and trouble, the fullest information with regard to the sewerage works executed in their respective cities, together, in many instances, with elaborate details relating to the mortality before and after the execution of the works of drainage. There have been one or two exceptions, notably Gotha and Mannheim, where information has been refused. The Author trusts, however, that the collection of information appended to the paper, even in its condensed form, will to some extent repay all those who have so readily contributed their quota to it, and he can only regret that it is impossible to do justice in the present paper to such valuable material as is now in his hands, but as many of the town authorities referred to are looking forward to its publication, he purposes dealing with it hereafter in a more detailed form, and in such manner that he hopes its publication will be assured.

House Drainage.

Very great attention has been paid to the character of the work in carrying out the house drainage in most of the towns which have been enumerated. Comprehensive and stringent regulations have been issued, and special offices established on behalf of the authorities, to check, correct, and amend all plans sent in for approval, whilst a sufficient number of inspectors has been appointed to see every pipe laid. In the case of Frankfort, so far back as 1868, regulations, drafted by Mr. Lindley and the Author, accompanied by a series of drawings illustrative of the manner in which the drainage was required to be carried out, and of the character of the drawings which would be required to be sent in by all persons proposing to drain their houses, were issued. The use of varnished cast iron water pipes was, the Author believes, for the first time proposed in these regulations and made imperative for all drains, soil pipes, fall pipes from kitchen sinks, urinals, &c., of upper storeys within the houses. It has already been stated that the soil pipes are not disconnected, but act together with a large number of the rain water pipes as ventilators to the house drains and public sewers. On the other hand, all the remaining branches passing into the interior of the buildings were cut off by a syphon placed outside the house in a circular brick shaft or manhole 3 feet in diameter, with a proper cover to it as a means of access. This was subsequently abandoned, or at any rate not made compulsory by the magistrates of Frankfort, owing to the syphons not being periodically seen to. The severity of the climate in winter made it impracticable to disconnect by delivering on to surface gratings, and many explanations and reasons might be given on this head which must be passed over in this paper.

The houses on the continent are chiefly on the flat system, so that the kitchen sinks and water closets were generally in tiers one above another. This facilitated the extension of the soil pipes and waste pipes of the kitchen sinks, lavatories, baths, or urinals through the roofs, and this system was made obligatory by the regulations, so that the house drainage generally is well ventilated, independently of special pipes not infrequently carried up to the roof from the end of house drains.

Junction blocks and pipes were built in as the street sewers were constructed, and their position carefully noted and put on to the town plans, and in practice it was found that not more than about two per cent. of the houses in Frankfort required other blocks or junctions than those provided. This the Author considers of great importance in all well-regulated systems of sewerage, as nothing is more destructive or injurious to sewers than breaking into them for the purpose of making side connections, a matter in which some experience has been gained in Leicester.

Duplicate copies of every house-drain plan, with sections of every branch and tier of closets or sinks, showing every junction pipe and connection to a scale of 10 feet to the inch, are deposited with the authorities, and these plans, showing the gradients and depths of the drains with the interior arrangements of the house, are again transferred to the town plans drawn to a scale of $\frac{1}{250}$ natural size, or about 20 feet to the

TABLE showing Statistics relating to the D

Compiled from original communications to the Author. J.

1. NAME OF TOWN.	2. Name of Country.	3. Population.	4. Number of Houses.	5. Years of execution of sewerage.	6. Length of sewers carried out. Miles.	7. Cost of sewerage. £ sterling.	8. Cost of sewage disposal works. £ sterling.	9. Has the system of water-carriage for removing the excreta been adopted in your Town?	10. Has the "Separate System" been carried out in your Town?	11. Quantity of rainwater the sewers are capable of carrying off. Depth in inches per hour.	12. Size of sewers. Minimum.	12. Size of sewers. Maximum.	13. Dry weather flow of sewage in 24 hours. Gallons.	14. Are house-drains disconnected from street sewers by water traps outside the buildings?	15. Are open gratings over inspection shafts for ventilation purposes in use in your Town?	16. If open gratings are in use, what distance are they apart? Yards.	17. If open gratings are in use, are there any complaints of smells from them?	18. Have you for ventilation purposes any direct connexion between the sewers and factory chimneys?	19. If chimneys are connecte with th sewers, what is their number
AIX LA CHAPELLE ...	Prussia	90,898	5,198	....	......	......	......	Yes.	No.	....	12in.	11ft. 6in. × 9ft. 10in.	2,100,000	Partly.	No.	......	......	No.	......
AMSTERDAM	Holland	302,000	About 30,000	In October, 1877 (Munich report) 752 houses, with 9,904 inhabitants, were drained by Captain Liernur's system, whilst in 135 houses, with 2,365 inhabitants, the tub system had been															
BASLE	Switzerland	69,000	4,963	1865 to 1885.	11	27,560	......	No.	No.	$\frac{3}{8}$in. to $\frac{5}{8}$in.	12in.	5ft. 5in. × 3ft. 7in.	....	No.	No.	......	......	No.	......
BERLIN	Prussia	1,263,196	19,250	1873, not yet completed.	$286\frac{3}{4}$	1,332,000	1,505,968	Yes.	No.	$\frac{5}{16}$in.	8in.	10ft. 1in. × 8ft. 9in.	17,303,000 (in 1884.)	No.	Yes.	......	......	No.	......
BOCHUM	Prussia	40,000	3,000	1875 to present time.	$7\frac{1}{2}$	15,000	......	....	No.	1in.	9in.	....	1,761,000	Yes.	No.	......	......	Yes.	1
BRESLAU	Prussia	300,000	6,000 to 7,000	1849 to 1885.	74	316,554		Yes.	No.	$\frac{1}{25}$in.	9in.	8ft. 10in. vertical dia.	4,402,000 to 6,603,000	No.	Partly.	......	Yes.	No.	......
BRUSSELS .... (Without suburbs.)	Belgium	165,000	18,000	During the last 30 years.	$74\frac{1}{2}$	400,000	......	Yes.	No.	....	12in.	14ft. 9in. × 7ft. 3in.	9,508,000	No.	Yes.	55	No.	No.	......
CARLSRUHE	Baden	53,000	3,000	1879 to 1885.	$21\frac{3}{4}$	110,000	......	No.	No.	$\frac{3}{8}$in.	24in. × 16in.	17ft. 1in. × 15ft. 1in.	1,782,000	No.	Yes.	109 to 218	No.	Yes.	1
CHEMNITZ	Saxony	105,000	2,960	1865 to present time.	$25\frac{1}{4}$	70,000	......	Not generally.	No.	$\frac{5}{16}$in.	10in.	17ft. 1in × 9ft. 2in.	....	No.	No.	......	......	No.	......
COLOGNE	Prussia	160,000	14,500	1881 to 1885.	$18\frac{3}{4}$	61,500	......	Partly.	No.	$1\frac{1}{2}$in., $\frac{1}{2}$in.	12in. × 8in.	8ft. 2in. × 7ft. 3in.	7,043,000	Partly.	Yes.	109	Yes.	No.	......
CREFELD	Prussia	90,000	6,600	1875, not yet completed.	$12\frac{1}{2}$	72,644	......	No.	No.	$\frac{1}{20}$in.	....	5ft. 11in. × 3ft. 11in.	9,792,000	No.	Yes.	......	No.	No.	......
DANTZIG	Prussia	90,000	4,500	1869 to 1871.	$27\frac{3}{4}$	125,000	......	Yes.	No.	$\frac{1}{2}$in.	9in.	4ft. 11in. × 3ft. 3in.	2,201,000 to 2,641,000	No.	Yes.	22 to 109	No.	No.	......
DORTMUND	Prussia	75,000	4,000	1880 to 1885.	$6\frac{3}{4}$	28,700	1,300	No.	No.	$\frac{3}{16}$in., $\frac{1}{4}$in. to $\frac{1}{2}$in.	12in.	6ft. 5in. × 4ft. 3in.	2,422,000	Yes.	Yes.	55 to 77	No.	No.	......
DRESDEN	Saxony	236,000	8,500	Since 1866.	$85\frac{1}{2}$	......	......	No.	No.	....	....	6ft. 7in. × 4ft. 4in.	3,610,000	No.	No.	......	......	No.	......
DÜSSELDORF......	Prussia	110,000	6,600	1874, not yet completed.	$4\frac{3}{4}$	54,000	......	Yes.	No.	$\frac{1}{2}$in.	12in.	5ft. 11in. × 3ft. 11in.	....	No.	Yes.	33 to 44	No.	No.	......
EISENACH	Saxe-Weimar ...	20,924	1,950	1878, not yet completed.	$1\frac{3}{4}$	6,675	......	No.	No.	$\frac{3}{8}$in.	6in.	2ft. 6in. dia.	550,200	Yes.	No.	......	......	No.	......
ERFURT	Prussia	59,000	3,800	1876, not yet completed.	$24\frac{3}{4}$	21,000	......	No.	No.	$\frac{1}{3}$in.	6in.	4ft. 11in. × 3ft. 3in.	....	No.	No.	......	......	No.	......
ESSEN	Prussia	64,700	4,550	....	......	......	......	No.	No.	....	9in.	6ft. 1in. × 4ft. 0in.	4,845,000	No.	No.	......	......	No.	......
FRANKFORT-ON-M. ...	Prussia	147,000	11,000	1868 to present time.	100	517,861	28,759	Yes.	No.	$\frac{1}{4}$in.	12in.	6ft. 1in. × 4ft. 8in.	4,000,000	Partially	Yes.	40 yards.	No.	2 special ventilating towers.	....
HALLE	Prussia	81,000	3,630	1850 to 1885.	$27\frac{1}{4}$	55,000	......	No.	No.	$\frac{1}{4}$in.	10in.	5ft. 11in. × 3ft. 7in.	1,100,500 to 1,321,000	Yes.	No.	......	......	No.	....
HAMBURG	....	400,000	....	1843 to present time.	$141\frac{3}{4}$	905,000	......	Yes.	No.	$\frac{1}{31}$in.	2ft. 10in. × 1ft. 10in	9ft. 10in. diameter.	....	No.	Yes.	44 to 50	......	......	
HANOVER	Prussia	131,200	7,000	1845 to 1885.	49	107,500	......	No.	No.	$\frac{1}{50}$in., $\frac{5}{16}$in.	12in.	....	2,519,000	No.	No.	......	......	No.	
HEIDELBERG	Baden	27,000	1,642	1875, not yet completed.	$6\frac{1}{2}$	20,000	......	No.	No.	$\frac{3}{8}$in.	12in.	5ft. 11in. × 3ft. 11in.	550,000	Yes.	No.	......	......	No.	
HOMBURG	Prussia	8,336	780	1865 to 1885.	$3\frac{1}{2}$	8,700	......	Partly.	No.	$\frac{4}{5}$in.	12in.	5ft. 7in. × 2ft. 4in.	176,000	No.	Yes.	109	Yes.		
KÖNIGSBERG	Prussia	146,000	5,400	1880, not yet completed.	5	15,000	......	No.	Partly.	$\frac{3}{4}$in., $\frac{7}{16}$in.	10in.	4ft. 5in. × 2ft. 11in.	....	No.	No.	......	......		
LEIPZIG	Saxony	168,976	6,700	Since the middle of the 17th century.	$55\frac{1}{4}$	165,600	......	No.	No.	$\frac{1}{4}$in.	8in.	....	9,627,000	Not generally	No.	......	......		

TINENTAL TOWNS.

ch the drainage was required
acter of the drawings which
all persons proposing to drain
e of varnished cast iron water
or the first time proposed in
ative for all drains, soil pipes,
rinals, &c., of upper storeys
ady been stated that the soil
ict together with a large num-
entilators to the house drains
her hand, all the remaining
r of the buildings were cut off
ouse in a circular brick shaft
with a proper cover to it as a
quently abandoned, or at any
he magistrates of Frankfort,
periodically seen to. The

...LE showing Statistics relating to the Drainage of Continental Towns.

Compiled from original communications to the Author. J. GORDON, M.INST.C.E., LEICESTER.

...ystem er- or re- the been n your ?	10. Has the "Separate System" been carried out in your Town?	11. Quantity of rainwater the sewers are capable of carrying off. Depth in inches per hour.	12. Size of sewers. Minimum.	12. Size of sewers. Maximum.	13. Dry weather flow of sewage in 24 hours. Gallons.	14. Are house-drains disconnected from street sewers by water traps outside the buildings?	15. Are open gratings over inspection shafts for ventilation purposes in use in your Town?	16. If open gratings are in use, what distance are they apart? Yards.	17. If open gratings are in use, are there any complaints of smells from them?	18. Have you for ventilation purposes any direct connexion between the sewers and factory chimneys?	19. If chimneys are connected with the sewers, what is their number?	20. Is the sewage treated before it flows into the river or stream?	21. If the sewage is treated, what are the means of treatment?	22. In case the sewage is not purified, have any complaints been made about the pollution of such river or stream?	23. Discharge of such river or stream into which the sewage flows. Gallons in 24 hours.	24. Is the system of water closets with cesspools adopted in your Town?	25. Are privies in use in your Town?	26. Is the tub system in use in your Town?	27. In case the tub system is in use in your Town, 27a. What is the number of tubs used?	27b. What is the number of inhabitants served thereby?	27c. Do the receipts for manure cover the expenses of collecting, &c., the excreta?	28. Average annual rate of mortality per 1,000 living before the commencement of the sewerage of your Town.	29. Average an... rate of mortality per 1,000 living si... commencem... the sewerag... your Tow...
	No.	....	12in.	11ft. 6in. × 9ft. 10in.	2,100,000	Partly.	No.	......	......	No.	......	No.	....	Yes.	3,750,000 49,100,000† 880,400,000**	......	Yes.	No.	...	...	...	29·86 (1864 to 1874)	28·02 (1875 to 1...
...uses, with 9,904 inhabitants, were drained by Captain Liernur's system, whilst in 135 houses, with 2,365 inhabitants, the tub system had been adopted. The rest of the houses are provided with cesspools, which drain more or less directly into the river and canals by which the town is intersected.																							....
	No.	$\frac{3}{8}$in. to $\frac{1}{8}$in.	12in.	5ft. 5in. × 3ft. 7in.	....	No.	No.	......	......	No.	......	No.	....	No.	19,016,400,000 114,098,000,000**	......	Yes.	No.	...	...	...	....	....
	No.	$\frac{1}{12}$in.	8in.	10ft. 1in. × 8ft. 9in.	17,303,000 (in 1884.)	No.	Yes.	......	......	No.	......	Yes.	Broad irrigation.	....	....	......	Yes; in districts not yet sewered.	No.	...	...	...	31·73	29·00
..	No.	1in.	9in.	....	1,761,000	Yes.	No.	......	......	Yes.	1	Only one half is treated.	Milk of lime in Precipitating tanks.	Yes; and several injunctions have been granted against town.	....	......	Yes.	No.	...	...	...	34·41	30·89
	No.	$\frac{1}{12}$in.	9in.	8ft. 10in. vertical dia.	4,402,000 to 6,603,000	No.	Partly.	......	Yes.	No.	......	Yes.	Broad irrigation.	....	380,327,000	......	Yes	Only in a very few cases.	...	...	...	....	....
	No.	....	12in.	14ft. 9in. × 7ft. 3in.	9,508,000	No.	Yes.	55	No.	No.	......	No; only a very small portion is treated.	Broad irrigation.	Yes.	....	......	No.	No.	...	...	...	31·0 (1865 to 1871)	23·0 (1872 to 1...
	No.	$\frac{3}{8}$in.	24in. × 16in.	17ft. 1in. × 15ft. 1in.	1,782,000	No.	Yes.	109 to 218	No.	Yes.	1	No.	....	No.	....	......	Yes.	No.	...	...	...	....	20·55 (1879 to ...
...rally.	No.	$\frac{1}{12}$in.	10in.	17ft. 1in × 9ft. 2in.	....	No.	No.	......	......	No.	......	No.	....	Yes.	22,820,000 2,282,000,000**	......	Yes.	No.	...	...	...	32·86	34·80 (1865 to ...
...y.	No.	$1\frac{1}{2}$in., $\frac{1}{2}$in.	12in. × 8in.	8ft. 2in. × 7ft. 3in.	7,043,000	Partly.	Yes.	109	Yes.	No.	......	No.	....	Yes.	28,500,000,000	......	Yes.	In use only in a few public institutions.	...	...	...	....	....
	No.	$\frac{1}{10}$in.	....	5ft. 11in. × 3ft. 11in.	9,792,000	No.	Yes.	......	No.	No.	......	No.	....	Yes.	....	......	Yes.	No.	...	...	...	27·5 (1865)	27·4 (18...
	No.	$\frac{1}{2}$in.	9in.	4ft. 11in. × 3ft. 3in.	2,201,000 to 2,641,000	No.	Yes.	22 to 109	No.	No.	......	Yes.	Broad irrigation.	....	....	......	....	No.	...	...	...	36·51	28·66
	No.	$\frac{3}{16}$in., $\frac{1}{4}$in. to $\frac{1}{2}$in.	12in.	6ft. 5in. × 4ft. 3in.	2,422,000	Yes.	Yes.	55 to 77	No.	No.	......	Yes.	Milk of lime in Precipitating tanks.	....	9,508,000	......	Yes.	No.	...	...	...	34·37	27·65
	No.	....	....	6ft. 7in. × 4ft. 4in.	3,610,000	No.	No.	......	......	No.	......	No.	....	Yes.	9,508,000,000†	......	Yes.	Yes.	...	14,000	...	28·74 (1859 to 1874)	25·27 (1875 to 1...
	No.	$\frac{1}{2}$in.	12in.	5ft. 11in. × 3ft. 11in.	....	No.	Yes.	33 to 44	No.	No.	......	No.	....	No.	38,032,800,000†	......	Yes.	No.	...	...	...	....	26·1 (18...
	No.	$\frac{1}{8}$in.	6in.	2ft. 6in. dia.	550,200	Yes.	No.	......	......	No.	......	No.	....	No.	73,783,000	......	Yes.	Only in a few houses.	...	...	...	38·0	....
	No.	$\frac{1}{3}$in.	6in.	4ft. 11in. × 3ft. 3in.	....	No.	No.	......	......	No.	......	No.	....	Yes.	....	......	Yes.	Yes.	...	15,000	No.	29·39	24·2
	No.	....	9in.	6ft. 1in. × 4ft. 0in.	4,845,000	No.	No.	......	......	No.	......	Only one quarter is at present treated.	Röckner-Rothe's process.	Yes.	....	......	Yes.	....	...	...	...	....	25·16 (...
	No.	$\frac{1}{4}$in.	12in.	6ft. 1in. × 4ft. 8in.	4,000,000	Partially	Yes.	40 yards.	No.	2 special ventilating towers.	......	No.	Precipitating tanks in course of construction.	Yes.	2,400,000,000	......	No.	....	...	...	...	17·92	20·61
	No.	$\frac{1}{4}$in.	10in.	5ft. 11in. × 3ft. 7in.	1,100,500 to 1,321,000	Yes.	No.	......	......	No.	......	No.	....	Yes.	....	......	Yes.	No.	...	...	...	30·00 (1850 to 1868)	[illegible] (1858 to ...
	No.	$\frac{1}{17}$in.	2ft. 10in. × 1ft. 10in	9ft. 10in. diameter.	....	No.	Yes.	44 to 50	......	......	......	No.	....	....	1,901,640,000	......	....	....	...	...	...	....	[illegible] (187...
	No.	$\frac{1}{16}$in., $\frac{1}{12}$in.	12in.	....	2,519,000	No.	No.	......	......	No.	......	No.	....	Yes.	228,200,000 5,704,910,000**	......	Yes.	No.	...	...	...	....	....
	No.	$\frac{5}{8}$in.	12in.	5ft. 11in. × 3ft. 11in.	550,000	Yes.	No.	......	......	No.	......	No.	....	No.	....	......	To be abolished.	Yes.	390	7,400	No.	27·04	
...	No.	$\frac{4}{5}$in.	12in.	5ft. 7in. × 2ft. 4in.	176,000	No.	Yes.	109	Yes.	No.	......	Only a portion is at present treated.	Broad irrigation.	Yes.	1,981,000	......	....	In use only in the barracks.	4	500	Yes.	22·86 (1855 to 187...	
	Partly.	$\frac{3}{4}$in., $\frac{7}{8}$in.	10in.	4ft. 5in. × 2ft. 11in.	....	No.	No.	......	......	No.	......	No.	....	....	....	......	....	Yes.	...	...	No.	....	
	No.	$\frac{1}{4}$in.	8in.	....	9,627,000	Not generally	No.	......	......	No.	......	No.	....	Yes.	244,172,000†	......	Yes.	Partly.	...	...	...	....	

...tain Liernur's pneumatic system in 1871; the length of the 5in. cast iron pipes is about one mile, the cost of the whole of the works £2,840, and the [illegible]

e Drainage of Continental Towns.

J. GORDON, M.Inst.C.E., Leicester.

8.	19.	20.	21.	22.	23.	24.	25.	26.	27. In case the tub system is in use in your Town, 27a.	27b.	27c.	28.	29.	30.
e you venti- tion poses direct exion ween the rs and tory neys?	If chimneys are connected with the sewers, what is their number?	Is the sewage treated before it flows into the river or stream?	If the sewage is treated, what are the means of treatment?	In case the sewage is not purified, have any complaints been made about the pollution of such river or stream?	Discharge of such river or stream into which the sewage flows. Gallons in 24 hours.	Is the system of water closets with cesspools adopted in your Town?	Are privies in use in your Town?	Is the tub system in use in your Town?	What is the number of tubs used?	What is the number of inhabitants served thereby?	Do the receipts for manure cover the expenses of collecting, &c., the excreta?	Average annual rate of mortality per 1,000 living before the commencement of the sewerage of your Town.	Average annual rate of mortality per 1,000 living since the commencement of the sewerage of your Town.	Name of Town.
o.	......	No.	....	Yes.	3,750,000 49,100,000† 880,400,000**	......	Yes.	No.	...	...	...	20·86 (1864 to 1874)	28·02 (1875 to 1884)	Aix la Chapelle.
had been adopted. The rest of the houses are provided with cesspools, which drain more or less directly into the river and canals by which the town is intersected.													....	Amsterdam.
o.	......	No.	....	No.	19,016,400,000 114,098,000,000**	......	Yes.	No.	...	...	...	....	....	Basle.
o.	......	Yes.	Broad irrigation.	....	....	......	Yes; in districts not yet sewered.	No.	...	...	...	31·73	29·00	Berlin.
es.	1	Only one half is treated.	Milk of lime in Precipitating tanks.	Yes; and several injunctions have been granted against town.	....	......	Yes.	No.	...	...	...	34·41	30·89	Bochum.
o.	......	Yes.	Broad irrigation.	....	380,327,000	......	Yes	Only in a very few cases.	...	...	...	....	....	Breslau.
o.	......	No; only a very small portion is treated.	Broad irrigation.	Yes.	....	......	No.	No.	...	...	...	31·0 (1865 to 1871)	23·0 (1872 to 1880)	Brussels.
es.	1	No.	....	No.	....	......	Yes.	No.	...	...	...	....	20·55 (1879 to 1884)	Carlsruhe.
o.	......	No.	....	Yes.	22,820,000 2,282,000,000**	......	Yes.	No.	...	...	...	32·86	34·80 (1865 to 1874)	Chemnitz.
o.	......	No.	....	Yes.	28,500,000,000	......	Yes.	In use only in a few public institutions.	...	...	...	....	....	Cologne.
o.	......	No.	....	Yes.	....	......	Yes.	No.	...	...	...	27·5 (1865)	27·4 (1884)	Crefeld.
o.	......	Yes.	Broad irrigation.	....	....	......	....	No.	...	...	...	36·51	28·66	Dantzic.
o.	......	Yes.	Milk of lime in Precipitating tanks.	....	9,508,000	......	Yes.	No.	...	...	...	34·37	27·65	Dortmund.
o.	......	No.	....	Yes.	9,508,000,000†	......	Yes.	Yes.	...	14,000	...	28·74 (1859 to 1874)	25·27 (1875 to 1876)	Dresden.
o.	......	No.	....	No.	38,032,800,000†	......	Yes.	No.	...	...	...	....	26·1 (1883)	Düsseldorf.
o.	......	No.	....	No.	73,783,000	......	Yes.	Only in a few houses.	...	...	...	38·0	....	Eisenach.
o.	......	No.	....	Yes.	....	......	Yes.	Yes.	...	15,000	No.	29·39	24·2	Erfurt.
o.	......	Only one quarter is at present treated.	Röckner-Rothe's process.	Yes.	....	......	Yes.	....	...	...	...	....	25·16 (1884)	Essen.
pecial tila- ng vers.	......	No.	Precipitating tanks in course of construction.	Yes.	2,400,000,000	......	No.	....	...	...	...	17·92	20·64	Frankfort-on-M.
o.	......	No.	....	Yes.	....	......	Yes.	No.	...	...	...	30·00 (1850 to 1868)	25·00 (1868 to 1884)	Halle.
....	......	No.	....	....	1,901,640,000	......	....	....	...	...	...	....	26·88 (1872 to 1879)	Hamburg.
o.	......	No.	....	Yes.	228,200,000 5,704,910,000**	......	Yes.	No.	...	...	...	....	....	Hanover.
o.	......	No.	....	No.	....	......	To be abolished.	Yes.	390	7,400	No.	27·04	23·18	Heidelberg.
o.	......	Only a portion is at present treated.	Broad irrigation.	Yes.	1,981,000	......	....	In use only in the barracks.	4	500	Yes.	22·86 (1865 to 1874)	21·98 (1875 to 1884)	Homburg.
o.	......	No.	....	....	....	......	....	Yes.	...	...	No.	....	....	Königsberg.
o.	......	No.	....	Yes.	244,172,000†	......	Yes.	Partly.	...	...	...	....	....	Leipzig.
he works £2,840, and the working expenses about £133 per annum. The rest of the houses drain directly into the canals, which serve as main sewers.												27·72 (1872 to 1874)	26·81 (1875 to 1884)	Leyden.

OF CONTINENTAL TOWNS.

n which the drainage was required
e character of the drawings which
t in by all persons proposing to drain
The use of varnished cast iron water
eves, for the first time proposed in
imperative for all drains, soil pipes,
ks, urinals, &c., of upper storeys
already been stated that the soil
but act together with a large num-
as ventilators to the house drains
he other hand, all the remaining
nterior of the buildings were cut off
the house in a circular brick shaft
eter, with a proper cover to it as a
subsequently abandoned, or at any
by the magistrates of Frankfort,
being periodically seen to. The
inter made it impracticable to dis-
o surface gratings, and many ex-
ht be given on this head which
paper.
nt are chiefly on the flat system, so
ater closets were generally in tiers
acilitated the extension of the soil
kitchen sinks, lavatories, baths, or
d this system was made obligatory
he house drainage generally is well
pecial pipes not infrequently carried
of house drains.
were built in as the street sewers
position carefully noted and put on
actice it was found that not more
the houses in Frankfort required
n those provided. This the Author
nce in all well-regulated systems
more destructive or injurious to
hem for the purpose of making side
ch some experience has been gained

house-drain plan, with sections of
ets or sinks, showing every junction
scale of 10 feet to the inch, are
ties, and these plans, showing the
drains with the interior arrange-
ain transferred to the town plans
atural size, or about 20 feet to the

15,000

BRESLAU	Prussia	300,000	6,000 to 7,000	1849 to 1885.	74	316,554		Yes.	No.	1/16in.	9in.	8ft. 10in. vertical dia.	4,402,000 to 6,603,000	No.	Partly.	......		
BRUSSELS (Without suburbs.)	Belgium	165,000	18,000	During the last 30 years.	74½	400,000	......	Yes.	No.	....	12in.	14ft. 9in. × 7ft. 3in.	9,508,000	No.	Yes.	55		
CARLSRUHE	Baden	53,000	3,000	1879 to 1885.	21¾	110,000	......	No.	No.	⅜in.	24in. × 16in.	17ft. 1in. × 15ft. 1in.	1,782,000	No.	Yes.	109 to 218		
CHEMNITZ	Saxony	105,000	2,960	1865 to present time.	25¼	70,000	......	Not generally.	No.	1/16in.	10in.	17ft. 1in × 9ft. 2in.	....	No.	No.	......	......	
COLOGNE	Prussia	160,000	14,500	1831 to 1885.	18¾	61,500	......	Partly.	No.	1¼in., ½in.	12in. × 8in.	8ft. 2in. × 7ft. 3in.	7,043,000	Partly.	Yes.	109	Yes.	
CREFELD	Prussia	90,000	6,600	1875, not yet completed.	12½	72,644	......	No.	No.	1/10in.	....	5ft. 11in. × 3ft. 11in.	9,792,000	No.	Yes.	......	No.	No.
DANTZIC	Prussia	90,000	4,500	1869 to 1871.	27¾	125,000	......	Yes.	No.	½in.	9in.	4ft. 11in. × 3ft. 3in.	2,201,000 to 2,641,000	No.	Yes.	22 to 109	No.	No.
DORTMUND	Prussia	75,000	4,000	1880 to 1885.	6¾	28,700	1,300	No.	No.	3/16in., ¼in. to ½in.	12in.	6ft. 5in. × 4ft. 3in.	2,422,000	Yes.	Yes.	55 to 77	No.	No.
DRESDEN	Saxony	236,000	8,500	Since 1866.	85¼	......	......	No.	No.	....	....	6ft. 7in. × 4ft. 4in.	3,610,000	No.	No.	......	......	No.
DÜSSELDORF	Prussia	110,000	6,600	1874, not yet completed.	4¾	54,000	......	Yes.	No.	⅛in.	12in.	5ft. 11in. × 3ft. 11in.	....	No.	Yes.	33 to 44	No.	No.
EISENACH	Saxe-Weimar	20,924	1,950	1878, not yet completed.	1¾	6,675	......	No.	No.	⅛in.	6in.	2ft. 6in. dia.	550,200	Yes.	No.	......	......	No.
ERFURT	Prussia	59,000	3,800	1876, not yet completed.	24¾	21,000	......	No.	No.	¼in.	6in.	4ft. 11in. × 3ft. 3in.	....	No.	No.	......	......	No.
ESSEN	Prussia	64,700	4,550	....	......	......	......	No.	No.	....	9in.	6ft. 1in. × 4ft. 0in.	4,845,000	No.	No.	......	......	No.
FRANKFORT-ON-M.	Prussia	147,000	11,000	1868 to present time.	100	517,861	28,759	Yes.	No.	¼in.	12in.	6ft. 1in. × 4ft. 8in.	4,000,000	Partially.	Yes.	40 yards.	No.	2 speci ventila ting towers
HALLE	Prussia	81,000	3,630	1850 to 1885.	27¼	55,000	......	No.	No.	¼in.	10in.	5ft. 11in. × 3ft. 7in.	1,100,500 to 1,321,000	Yes.	No.	......	......	No.
HAMBURG	....	400,000	....	1843 to present time.	141¾	905,000	......	Yes.	No.	1/32in.	2ft. 10in. × 1ft. 10in	9ft. 10in. diameter.	....	No.	Yes.	44 to 50	......	......
HANOVER	Prussia	131,200	7,000	1845 to 1885.	49	107,500	......	No.	No.	1/20in., 1/16in.	12in.	....	2,519,000	No.	No.	......	......	No.
HEIDELBERG	Baden	27,000	1,642	1875, not yet completed.	6½	20,000	......	No.	No.	⅜in.	12in.	5ft. 11in. × 3ft. 11in.	550,000	Yes.	No.	......	......	No.
HOMBURG	Prussia	8,336	780	1865 to 1885.	3¼	8,700	......	Partly.	No.	⅜in.	12in.	5ft. 7in. × 2ft. 4in.	176,000	No.	Yes.	109	Yes.	No.
KÖNIGSBERG	Prussia	146,000	5,400	1880, not yet completed.	5	15,000	......	No.	Partly.	¾in., 1/16in.	10in.	4ft. 5in. × 2ft. 11in.	....	No.	No.	......	......	No.
LEIPZIG	Saxony	168,976	6,700	Since the middle of the 17th century.	55¼	165,600	......	No.	No.	¼in.	8in.	....	9,627,000	Not generally	No.	......	......	No.
LEYDEN	Holland	43,000	About 5,500	170 houses of this town were drained by Captain Liernur's pneumatic system in 1871; the length of the 5in. cast iron pipes is about one mile, the cost of the whole of the														
LINZ	Austria	39,000	1,682	1875, not yet completed.	12½	64,600	......	Yes.	No.	½in.	12in.	7ft. 0in. × 3ft. 11in.	77,000	Yes.	......	......	......	No.
LUDWIGSBURG	Wurtemberg	16,100	1,002	Executed in 20 years.	4¾	10,113	......	No.	No.	....	12in.	5ft. 1in. × 2ft. 11in.	....	Yes.	No.	......	......	No.
LUDWIGSHAFEN	Bavaria	21,000	914	1881 to 1883.	2¼	12,050	......	No.	No.	⅛in.	15in.	4ft. 11in. × 3ft. 3in.	352,200	No.	Yes.	44 to 66	No.	Yes.
MAYENCE (Old town.)	Hesse Darmstadt.	50,000	2,400	1876, not yet completed.	15	59,000	......	No.	No.	1½in.	12in. × 8in.	5ft. 11in. × 3ft. 11in.	2,600,000	No.	Yes.	......	No.	Yes.
MUNICH	Bavaria	240,000	9,116	1868 to 1884.	27½	200,000	......	Yes.	No.	¼in.	12in.	7ft. 3in. dia.	....	No.	Yes.	50 to 80	No.	No.
NUREMBERG	Bavaria	107,100	7,380	1874, not yet completed.	41	295,000	......	No.	No.	¾in. to ⅜in. stoneware pipes. ⅛in. to ⅜in. egg shaped sewers.	12in.	5ft. 11in. × 3ft. 11in.	....	No.	No.	......	......	No.
PARIS	France	2,239,928	78,417	1853 to present time.	536¾	4,000,000 to 4,400,000	......	No.	No.	....	6ft. 7in. × 2ft. 11in.	18ft. 4in. × 14ft. 5in.	57,225,000	No.	No.	......	......	No.
ROTTERDAM	Holland	169,477	19,800	....	......	......	......	Yes.	No.	⅜in.	18in. × 12in.	3ft. 11in. × 2ft. 8in.	22,010,000	No.	No.	......	......	No.
STUTTGART (Without suburbs.)	Wurtemberg	110,000	5,550	1870 to 1884.	37½	92,250 for 17½ miles.	......	No.	No.	1/16in., 3/16in., ¼in.	18in.	7ft. 10in. × 5ft. 3in.	3,600,000	Yes.	Yes.	66 to 83	No.	No.
VIENNA (Without suburbs.)	Austria	769,889	12,464	The present century.	151½	500,000	......	Partly.	No.	¼in.	3ft. 7in. × 2ft. 8in.	23ft. 4in. × 10ft. 11in.	....	No.	Yes.	......	Yes.	No.
WIESBADEN	Prussia	57,000	4,000	1866 to 1884.	16¼	40,000	......	No.	No.	1in.	8in.	14ft. 9in. × 11ft. 2in.	1,104,000	Yes.	No.	......	......	No.
ZURICH	Switzerland	86,000	5,384	Since 1867.	50	109,460	......	No.	For a small portion of town.	⅜in., ⅜in., 5/16in.	6in.	5ft. 11in. dia.	2,606,000	Yes.	No.	......	......	No.

* Medium flood. ** High water.

						......	......	Yes.	1	treated.	rrigatio of lime in Precipitating tanks.	have been granted against town.	....	......	Yes.	No.	...	...	...	[illegible]		
1/12in.	9in.	8ft. 10in. vertical dia.	4,402,000 to 6,603,000	No.	Partly.	......	Yes.	No.	......	Yes.	Broad irrigation.	....	380,327,000	......	Yes	Only in a very few cases.	...	...	...	....	....	
....	12in.	14ft. 9in. × 7ft. 3in.	9,508,000	No.	Yes.	55	No.	No.	......	No; only a very small portion is treated.	Broad irrigation.	Yes.	....	......	No.	No.	...	...	...	31·0 (1865 to 1871)	23·0 (1872 to 1880)	B[illegible]
3/8in.	24in. × 16in.	17ft. 1in. × 15ft. 1in.	1,782,000	No.	Yes.	109 to 218	No.	Yes.	1	No.	....	No.	....	......	Yes.	No.	...	...	...	....	20·55 (1879 to 1884)	CAR[illegible]
1/16in.	10in.	17ft. 1in × 9ft. 2in.	....	No.	No.	......	......	No.	......	No.	....	Yes.	22,820,000 2,282,000,000**	......	Yes.	No.	...	...	...	32·86	34·80 (1865 to 1874)	CHE[illegible]
1 1/8in., 1/2in.	12in. × 8in.	8ft. 2in. × 7ft. 3in.	7,043,000	Partly.	Yes.	109	Yes.	No.	......	No.	....	Yes.	28,500,000,000	......	Yes.	In use only in a few public institutions.	...	...	...	....	....	COLOGNE.
1/30in.	....	5ft. 11in. × 3ft. 11in.	9,792,000	No.	Yes.	......	No.	No.	......	No.	....	Yes.	....	......	Yes.	No.	...	...	...	27·5 (1865)	27·4 (1884)	CREFELD.
1/3in.	9in.	4ft. 11in. × 3ft. 3in.	2,201,000 to 2,641,000	No.	Yes.	22 to 109	No.	No.	......	Yes.	Broad irrigation.	....	....	......	....	No.	...	...	...	36·51	28·66	DANTZIC.
in., 1/4in. to 1/2in.	12in.	6ft. 5in. × 4ft. 3in.	2,422,000	Yes.	Yes.	55 to 77	No.	No.	......	Yes.	Milk of lime in Precipitating tanks.	....	9,508,000	......	Yes.	No.	...	...	...	34·37	27·65	DORTMUND.
....	....	6ft. 7in. × 4ft. 4in.	3,610,000	No.	No.	......	......	No.	......	No.	....	Yes.	9,508,000,000†	......	Yes.	Yes.	...	14,000	...	28·74 (1859 to 1874)	25·27 (1875 to 1876)	DRESDEN.
1/2in.	12in.	5ft. 11in. × 3ft. 11in.	....	No.	Yes.	33 to 44	No.	No.	......	No.	....	No.	38,032,800,000†	......	Yes.	No.	...	...	...	....	26·1 (1883)	DÜSSELDORF.
5/8in.	6in.	2ft. 6in. dia.	550,200	Yes.	No.	......	......	No.	......	No.	....	No.	73,783,000	......	Yes.	Only in a few houses.	...	...	...	38·0	....	EISENACH.
1/3in.	6in.	4ft. 11in. × 3ft. 3in.	....	No.	No.	......	......	No.	......	No.	....	Yes.	....	......	Yes.	Yes.	...	15,000	No.	29·39	24·2	ERFURT.
....	9in.	6ft. 1in. × 4ft. 0in.	4,845,000	No.	No.	......	......	No.	......	Only one quarter is at present treated.	Röckner-Rothe's process.	Yes.	....	......	Yes.	....	...	...	...	....	25·16 (1884)	ESSEN.
1/4in.	12in.	6ft. 1in. × 4ft. 8in.	4,000,000	Partially	Yes.	40 yards.	No.	2 special ventilating towers.	......	No.	Precipitating tanks in course of construction.	Yes.	2,400,000,000	......	No.	....	...	...	...	17·92	20·64	FRANKFORT-ON-M.
1/4in.	10in.	5ft. 11in. × 3ft. 7in.	1,100,500 to 1,321,000	Yes.	No.	......	......	No.	......	No.	....	Yes.	....	......	Yes.	No.	...	...	...	30·00 (1850 to 1868)	25·00 (1868 to 1884)	HALLE.
1/17in.	2ft. 10in. × 1ft. 10in	9ft. 10in. diameter.	....	No.	Yes.	44 to 50	......	......	......	No.	....	....	1,901,640,000	......	....	....	...	...	...	....	26·88 (1872 to 1879)	HAMBURG.
1/50in., 1/16in.	12in.	....	2,519,000	No.	No.	......	......	No.	......	No.	....	Yes.	228,200,000 5,704,910,000**	......	Yes.	No.	...	...	...	....	....	HANOVER.
5/8in.	12in.	5ft. 11in. × 3ft. 11in.	550,000	Yes.	No.	......	......	No.	......	No.	....	No.	....	......	To be abolished.	Yes.	390	7,400	No.	27·04	23·18	HEIDELBERG.
4/5in.	12in.	5ft. 7in. × 2ft. 4in.	176,000	No.	Yes.	109	Yes.	No.	......	Only a portion is at present treated.	Broad irrigation.	Yes.	1,981,000	......	....	In use only in the barracks.	4	500	Yes.	22·86 (1865 to 1874)	21·98 (1875 to 1884)	HOMBURG.
3/4in., 1/12in.	10in.	4ft. 5in. × 2ft. 11in.	....	No.	No.	......	......	No.	......	No.	....	....	....	......	....	Yes.	...	...	No.	....	....	KÖNIGSBERG.
1/4in.	8in.	....	9,627,000	Not generally	No.	......	......	No.	......	No.	....	Yes.	244,172,000†	......	Yes.	Partly.	...	...	...	....	....	LEIPZIG.
ic system in 1871; the length of the 5in. cast iron pipes is about one mile, the cost of the whole of the works £2,840, and the working expenses about £133 per annum. The rest of the houses drain directly into the canals, which serve as main sewers.																				27·72 (1872 to 1874)	26·81 (1875 to 1884)	LEYDEN.
1/4in.	12in.	7ft. 0in. × 3ft. 11in.	77,000	Yes.	......	......	......	No.	......	No.	....	Yes.	17,114,700,000 72,262,000,000**	......	....	In use only in a few localities.	...	...	...	42·9	32·73	LINZ.
....	12in.	5ft. 1in. × 2ft. 11in.	....	Yes.	No.	......	......	No.	......	No.	....	No.	....	......	Yes.	Only in a few private buildings.	...	...	...	....	....	LUDWIGSBURG.
1/8in.	15in.	4ft. 11in. × 3ft. 3in.	352,200	No.	Yes.	44 to 66	No.	Yes.	2	No.	....	No.	....	......	Yes.	No.	...	...	...	....	....	LUDWIGSHAFEN.
1 1/8in.	12in. × 8in.	5ft. 11in. × 3ft. 11in.	2,600,000	No.	Yes.	......	No.	Yes.	1	No.	....	No.	30,426,000,000*	......	Yes.	In use only in the barracks.	...	...	No.	29·8	26·7	MAYENCE.
1/4in.	12in.	7ft. 3in. dia.	....	No.	Yes.	50 to 80	No.	No.	......	No.	....	No.	57,213,537	......	....	....	...	...	...	36·9 (1872 to 1880)	31·4 modern sewers (1880 to 1884)	MUNICH.
1/4in. to 5/8in. stoneware pipes. in. to 5/8in. egg shaped sewers.	12in.	5ft. 11in. × 3ft. 11in.	....	No.	No.	......	......	No.	......	No.	....	No.	228,200,000	......	Yes.	No.	...	...	...	....	....	NUREMBERG.
....	6ft. 7in. × 2ft. 11in.	18ft. 4in. × 14ft. 5in.	57,225,000	No.	No.	......	......	No.	......	Only a small portion is at present treated.	Broad irrigation.	Yes.	2,472,122,000	Yes.	....	Yes.	14,952	...	...	29·75	24·28	PARIS.
3/8in.	18in. × 12in.	3ft. 11in. × 2ft. 8in.	22,010,000	No.	No.	......	......	No.	......	No.	....	No.	....	......	....	Yes.	3,850	...	No.	33·90 (1866 to 1872)	26·80 (1873 to 1883)	ROTTERDAM.
in., 3/16in., 1/4in.	18in.	7ft. 10in. × 5ft. 3in.	3,600,000	Yes.	Yes.	66 to 88	No.	No.	......	No.	....	Yes.	171,600,000 228,200,000	......	Yes.	No.	...	...	...	....	21·4 (1883)	STUTTGART.
1/4in.	3ft. 7in. × 2ft. 8in.	23ft. 4in. × 10ft. 11in.	....	No.	Yes.	......	Yes.	No.	......	No.	....	Yes.	1,901,640,000	......	Yes.	No.	...	...	...	....	26·06 (1874 to 1883)	VIENNA.
1in.	8in.	14ft. 9in. × 11ft. 2in.	1,104,000	Yes.	No.	......	......	No.	......	No.	Precipitation tanks in course of erection.	Yes.	3,300,000	not generally.	Yes.	No.	...	...	...	28·00	22·00	WIESBADEN.
in., 5/8in., 5/16in.	6in.	5ft. 11in. dia.	2,606,000	Yes.	No.	......	......	No.	......	No.	....	....	323,278,000 380,327,000 570,491,000†	......	Partly.	Yes; liquid excrementitious matter goes into the sewer.	2,928	40,000	No.	....	....	ZURICH.

* Medium flood. ** High water. † Average flow.

				treated.	Precipitating tanks.	granted against town.										
.....	Yes.	No.	......	Yes.	Broad irrigation.	....	380,327,000	......	Yes	Only in a very few cases.	...	...	...	....	....	BRESLAU.
55	No.	No.	......	No; only a very small portion is treated.	Broad irrigation.	Yes.	....	......	No.	No.	...	...	...	31·0 (1865 to 1871)	23·0 (1872 to 1880)	BRUSSELS.
to 218	No.	Yes.	1	No.	....	No.	....	......	Yes.	No.	...	...	...	....	20·55 (1879 to 1884)	CARLSRUHE.
......	......	No.	......	No.	....	Yes.	22,820,000 2,282,000,000**	......	Yes.	No.	...	...	...	32·86	34·80 (1865 to 1874)	CHEMNITZ.
109	Yes.	No.	......	No.	....	Yes.	28,500,000,000	......	Yes.	In use only in a few public institutions.	...	...	...	....	....	COLOGNE.
.....	No.	No.	......	No.	....	Yes.	....	......	Yes.	No.	...	...	...	27·5 (1865)	27·4 (1884)	CREFELD.
to 109	No.	No.	......	Yes.	Broad irrigation.	....	....	......	....	No.	...	...	...	36·51	28·66	DANTZIC.
to 77	No.	No.	......	Yes.	Milk of lime in Precipitating tanks.	....	9,508,000	......	Yes.	No.	...	...	...	34·37	27·65	DORTMUND.
.....	......	No.	......	No.	....	Yes.	9,508,000,000†	......	Yes.	Yes.	...	14,000	...	28·74 (1859 to 1874)	25·27 (1875 to 1876)	DRESDEN.
to 44	No.	No.	......	No.	....	No.	38,032,800,000†	......	Yes.	No.	...	...	...	....	26·1 (1883)	DÜSSELDORF.
....	......	No.	......	No.	....	No.	73,783,000	......	Yes.	Only in a few houses.	...	...	...	38·0	....	EISENACH.
...	......	No.	......	No.	....	Yes.	....	......	Yes.	Yes.	...	15,000	No.	29·39	24·2	ERFURT.
...	......	No.	......	Only one quarter is at present treated.	Röckner-Rothe's process.	Yes.	....	......	Yes.	....	...	...	...	....	25·16 (1884)	ESSEN.
ards.	No.	2 special ventilating towers.	......	No.	Precipitating tanks in course of construction.	Yes.	2,400,000,000	......	No.	....	...	...	...	17·92	20·64	FRANKFORT-ON-M.
...	......	No.	......	No.	....	Yes.	....	......	Yes.	No.	...	...	...	30·00 (1850 to 1868)	25·00 (1868 to 1884)	HALLE.
50	......	......	......	No.	....	....	1,901,640,000	......	....	....	...	...	...	....	26·88 (1872 to 1879)	HAMBURG.
..	......	No.	......	No.	....	Yes.	228,200,000 5,704,910,000**	......	Yes.	No.	...	...	...	....	....	HANOVER.
..	......	No.	......	No.	....	No.	....	......	To be abolished.	Yes.	390	7,400	No.	27·04	23·18	HEIDELBERG.
9	Yes.	No.	......	Only a portion is at present treated.	Broad irrigation.	Yes.	1,981,000	......	....	In use only in the barracks.	4	500	Yes.	22·86 (1865 to 1874)	21·98 (1875 to 1884)	HOMBURG.
..	......	No.	......	No.	....	....	....	......	....	Yes.	...	...	No.	....	....	KÖNIGSBERG.
.	......	No.	......	No.	....	Yes.	244,172,000†	......	Yes.	Partly.	...	...	...	....	....	LEIPZIG.
the whole of the works £2,840, and the working expenses about £133 per annum. The rest of the houses drain directly into the canals, which serve as main sewers.														27·72 (1872 to 1874)	26·81 (1875 to 1884)	LEYDEN.
.	......	No.	......	No.	....	Yes.	17,114,700,000 72,262,000,000**	......	....	In use only in a few localities.	...	...	...	42·9	32·73	LINZ.
	......	No.	......	No.	....	No.	....	......	Yes.	Only in a few private buildings.	...	...	...	....	....	LUDWIGSBURG.
66	No.	Yes.	2	No.	....	No.	....	......	Yes.	No.	...	...	...	....	....	LUDWIGSHAFEN.
	No.	Yes.	1	No.	....	No.	30,426,000,000*	......	Yes.	In use only in the barracks.	...	...	No.	29·8	26·7	MAYENCE.
80	No.	No.	......	No.	....	No.	57,213,537	......	....	....	...	...	...	36·9 (1872 to 1880)	31·4 modern sewers (1880 to 1884)	MUNICH.
	......	No.	......	No.	....	No.	228,200,000	......	Yes.	No.	...	...	...	....	....	NUREMBERG.
	......	No.	......	Only a small portion is at present treated.	Broad irrigation.	Yes.	2,472,122,000	Yes.	....	Yes.	14,952	...	...	29·75	24·28	PARIS.
	......	No.	......	No.	....	No.	....	......	....	Yes.	3,850	...	No.	33·00 (1866 to 1872)	26·80 (1873 to 1883)	ROTTERDAM.
38	No.	No.	......	No.	....	Yes.	171,600,000 228,200,000	......	Yes.	No.	...	...	...	....	21·4 (1883)	STUTTGART.
	Yes.	No.	......	No.	....	Yes.	1,901,640,000	......	Yes.	No.	...	...	...	....	26·06 (1874 to 1883)	VIENNA.
	......	No.	......	No.	Precipitation tanks in course of erection.	Yes.	3,300,000	not generally.	Yes.	No.	...	...	...	28·00	22·00	WIESBADEN.
	......	No.	......	No.	....	....	323,278,000 380,327,000 570,491,000†	......	Partly.	Yes; liquid excrementitious matter goes into the sewer.	2,928	40,000	No.	....	....	ZURICH.

water. † Average flow.

inch, so that the authorities are in possession of a set of plans, of a kind entirely unknown, the Author believes, to any English or other municipality outside the confines of the German Empire.

The same care and attention is devoted to these points in Munich, Stuttgart, Düsseldorf and Crefeld, but so far as the Author is aware only Hamburg, Frankfort, and Mayence are favoured with an elaborately detailed survey to so large a scale as $\frac{1}{250}$.

Old Sewers.

A noteworthy feature in the sewerage of Frankfort, and one which the Author believes has not been attempted elsewhere, was that of abolishing and not merely putting out of use, but opening out and filling up the old sewers, and all their ramifications, as soon as the house drainage was sufficiently advanced to admit of this being done.

Sewage Disposal.

The question of sewage disposal has made but comparatively little progress on the Continent. This arises from a variety of causes. There are not such a large number of towns yet that have adopted the water carriage system in its entirety. The chief towns that have done so are: Berlin, Frankfort, Munich, Dantzic, Düsseldorf, Breslau, Linz, Hamburg, Brussels and Rotterdam. In Stuttgart, Crefeld, Dortmund, Ludwigshafen, Mannheim, Darmstadt, Heidelberg, Mayence, Basle and Zurich, although new systems of sewers have either been constructed or are in course of construction, thoroughly and completely adapted to the water carriage system, the authorities have not yet made up their minds to admit the drainage from water closets into them. Much might be said in reference to the methods adopted for the collection and removal of the excreta in these towns where it is not admitted into the sewers, but it would be quite beyond the limits of this paper. It may generally be said that where the cesspool system is in vogue, as in Stuttgart, Carlsruhe, Strasbourg, Dortmund, Ludwigshafen, Landshut, Hanau, Crefeld, &c., they are supposed to be of a watertight character, and perhaps one of the best regulated towns in this respect is Stuttgart. The cesspools are here small, and the emptying of them is in the hands of the authorities. This is done on the pneumatic system, so as to avoid nuisance from the operation, but the Author cannot say that it is always successful in this respect, although no doubt much that is unpleasant is due to the carelessness of the workmen. Specially designed boiler railway waggons, carrying three small boilers each, have been built, by means of which a large portion of the manure is sent long distances into the country. Large reservoirs have been built near the town for storage when it does not suit the farmers to take the manure. Storage tanks have also been constructed at various stations along the railways, from which the farmers can draw at their convenience, and the emptying and filling even at these stations is all done on the pneumatic principle. For many years after its establishment in 1873, the loss upon the cost of the collection of the manure was considerable, but within the last year or two the receipts more than balance the expenditure. It must not be supposed, however, that the receipts are only from the sale of the manure. They are chiefly from the house-owners or occupants, who have to pay from 3s. 9d. to 5s. for every ton of manure removed. The income from this source amounts to 67½ per cent. of the total receipts.

In Carlsruhe and Strasbourg the same system is in force, but with this improvement, that the engine which creates the vacuum in the boilers goes with the latter and pumps the air from the boilers through the furnace fire, so that all possibility of a disagreeable smell escaping during the operation is prevented in a much more perfect manner than at Stuttgart and elsewhere.

At Heidelberg, Nuremberg, Gratz and Zurich, the tub system is in force, after the fashion of that in use for a considerable portion of Paris, with the exception that at Heidelberg and Nuremberg the urine is retained in the tub, whilst in the other cases it is allowed to pass into the sewers. Notwithstanding this the town of Zurich has had to adopt the system of irrigation to prevent the pollution of the Limmat.

Paris, as is well known, has also had to adopt irrigation at Gennevilliers, although on much too limited a scale, as only a very small portion of the sewage of the city is dealt with.

Berlin and Dantzic are the most successful examples of irrigation on the Continent. These two towns are most fortunate in the selection of their irrigation areas, both consisting of nothing but sand as a subsoil, that of Dantzic being, in fact, a sandy waste on the sea shore, and, previous to the application of sewage to it, without any covering of soil.

Frankfort, originally intended to be dealt with by irrigation, is the only city at present on the Continent, so far as the Author is aware, which has finally adopted the system of precipitation on a comprehensive scale. Wiesbaden, a town of importance and well known to English tourists, is also constructing at the present moment settling tanks to deal with

their sewage before it enters the small stream into which it is at present delivered. The adoption of a more comprehensive scheme of sewerage is also now under consideration.

A proposal has been made for dealing with a portion of Homburg in this way, and settling tanks were designed by the Author and carried out for Dortmund, but with the ultimate object of intercepting the grosser solids only after the town had adopted the water-closet system, for which an irrigation area was selected for the ultimate disposal of the sewage.

Proportion between Flow of Rivers and Sewage.

The rivers of the Continent are much larger, and the populated towns upon their banks much smaller, in proportion to those of the United Kingdom, consequently the dilution of the sewage finding its way into the streams is so very much greater than we are accustomed to in England, that the pollution of such streams as the river Main, the Rhine and the Danube, is, as compared with that of our own rivers, infinitesimally small. Take for instance the river Main, at Frankfort. Its exceptionally lowest summer flow is about 2,400 million gallons per day, or 600 times that of the dry weather discharge from the sewers of Frankfort, whilst there is no town of importance below the point of sewage discharge until the river Main joins the Rhine, 22 miles lower down. The lime process, or any other of the chemical methods of precipitation which would clarify the sewage, would therefore no doubt be sufficient in such a case.

The Rhine at Basle, in Switzerland, has a flow of 19,016 million gallons per day, and at Cologne 28,500 million gallons per day, the distance between these cities being 580 miles. The chief large towns on its banks between the points named are Speyer, Mannheim, Ludwigshafen, Mayence, Coblentz and Bonn, with an aggregate population, including Basle and Cologne, of about 405,000, so that the volume of sewage effluent would range from 1 to 9,186 of that of the river at Basle, to 1 in about 2,345 at Cologne, even if the whole of these populations were pouring their sewage into the Rhine at the latter point, instead of its being distributed over a distance of 580 miles.

In all these cases a fairly good effluent resulting from the adoption of any chemical precipitating process would probably meet the case, were it not for the fact that some of these towns, notably Cologne and Düsseldorf, in the lower reaches of the river, draw practically their water supplies from the Rhine, their pump wells being sunk close to the banks of the river.

The following summary shows what has been done, and what money has been spent on new sewerage and sewage disposal works in 33 of the chief towns:—

	Length of Sewers in Miles.	Expenditure on Sewerage Works. £	Expenditure on Sewage Disposal Works. £	Total Expenditure. £
Basle	11	27,560		27,560
Berlin	286¾	1,332,000	1,505,968	2,837,968
Bochum	7½	15,000	......	15,000
Breslau	74	316,554	......	316,554
Brussels	74½	400,000	......	400,000
Carlsruhe	21¾	110,000	......	110,000
Chemnitz	25¼	70,000	......	70,000
Cologne	18¾	61,500	......	61,500
Crefeld	12½	72,644	......	72,644
Dantzic	27¾	125,000	......	125,000
Dortmund	6¾	28,700	1,300	30,000
Düsseldorf	4¾	54,000	......	54,000
Eisenach	1¾	6,675	......	6,675
Erfurt	24¾	21,000	......	21,000
Frankfort-on-the-Main	100	517,861	28,759	546,620
Halle	27¼	55,000	......	55,000
Hamburg	141¾	905,000	......	905,000
Hanover	49	107,500	......	107,500
Heidelberg	6½	20,000	......	20,000
Homburg	3½	8,700	......	8,700
Königsberg	5	15,000	......	15,000
Leipzig	55¼	165,600	......	165,600
Linz	12¼	64,600	......	64,600
Ludwigsburg	4¾	10,113	......	10,113
Ludwigshafen	2¼	12,050	......	12,050
Mayence	15	59,000	......	59,000
Munich	27½	200,000	......	200,000
Nuremberg	41	295,000	......	295,000
Paris	536¾	4,200,000	......	4,200,000
Stuttgart	17½	92,250	......	92,250
Vienna	151½	500,000	......	500,000
Wiesbaden	16¼	40,000	......	40,000
Zurich	50	109,460	......	109,460
Totals	1860¾	10,017,767	1,536,027	11,553,794

The detailed returns from Berlin are of an elaborate character, but cannot be dealt with in this paper. They are especially interesting as giving details of what are probably the largest irrigation works in the world for the disposal of town sewage, the area of land irrigated being over 13,000 acres.

RATES OF MORTALITY.

The mortality returns from the various towns show that there is generally a marked improvement after the execution of the drainage works, although it would probably be unfair to claim that this is entirely due to these works, because in all probability as much is due to new supplies of water having been carried out at the same time. This is especially noticeable in Dantzic, as will be seen from the following Table by Dr. Albert Liévin:—

Before the execution of Sewerage and Water Works.				After the execution of Sewerage and Water Works.			
Year.	Mortality per 1,000.	Epidemics occurred.	Deaths from Typhoid Fever per 1,000.	Year.	Mortality per 1,000.	Epidemics occurred.	Deaths from Typhoid Fever per 1,000.
1863	36·71	Measles... ...	11·2	1872	31·39	Small-pox ...	8·0
1864	31·29	... ...	7·6	1873	26·50	Cholera ...	4·1
1865	34·60	... ...	9·8	1874	25·28	... ...	5·1
1866	49·18	Cholera ...	9·6	1875	30·80	Diphtheria ...	3·3
1867	34·80	... ...	12·3	1876	28·72	... ...	2·6
1868	40·00	Scarlet Fever	12·3	1877	29·01	Diphtheria ...	2·7
1869	29·53	... ...	8·9	1878	29·33	... ...	1·9
1870	30·98	... ...	7·0	1879	28·64	Measles ...	1·8
1871	41·51	Small-pox and Cholera ...	11·0	1880	31·51	Diphtheria ...	0·8
				1881	26·68	... ...	1·4
Aver.	36·51		9·97	1882	29·09	Infantile diarrhœa ...	2·1
				1883	27·02	... ...	1·0
				Aver.	28·66		2·9

In Mayence an improvement took place during the progress of the works from 1875 to 1877, but there was no further improvement until the works were resumed in the beginning of 1880, the death rate having improved every year since as the works have progressed.

CONCLUDING REMARKS.

The author feels, in bringing this paper to a close, that he must have trespassed on the patience of his hearers by the length of the paper, but trusts that the largeness of the subject which he has endeavoured to deal with will be taken as some excuse for introducing it, in the hope that it may be followed further by dividing it into branches with profit to every sanitarian, and more especially to every municipality, inasmuch as it must be of immense importance to the community at large that the municipalities of Europe should know what other governing bodies are doing in regard to the improvement of the sanitary condition of the city or town over which they have control, and to have the opinions of sanitarians generally on the course each municipality has thought fit in its wisdom to adopt. If, therefore, the paper has no other effect than to direct attention to the system and regulations which each municipality has adopted, and to lead to a rejection of that which is condemned by sanitarians, and an adoption of that which is approved by them, the object of the Author will have been fully served, and the labour bestowed on the collection of the information respecting continental towns amply repaid.

[*This discussion applies to the two preceding papers by* Mr. J. UNDERWOOD *and* Mr. J. GORDON.]

Mr. PERCIVAL GORDON SMITH, F.R.I.B.A. (London), said, from the first paper a great deal might be learned as to what to do and what to avoid. Mr. Gordon's paper was one of the utmost value. It was a unique record of the sewerage arrangements of different countries, and contained information that was very much wanted in this country. As a rule we did not know sufficient about the details of what was being done in other countries, and on the subject of sewage treatment this paper appeared to supply the deficiency. He had often wished that the British Government would depute commissioners to visit the different foreign countries, and to report upon what was going on in regard to health matters generally—if only to teach us what to avoid. In the matter of sewage treatment this paper contained a vast amount of information which could not fail to be most advantageous in our future works. Both papers went to prove one very important point—viz., that we must not aim in the least at making a profit out of the products of sewage. The first object should be to get the sewage out of the town, and next to dispose of it in a way that should not pollute the streams or the land or the atmosphere. Having attained these two objects, every effort should be made to carry on the works at the least possible loss rather than at a profit. If any local authority could make a profit out of sewage let them do so by all means, but never at the expense of the efficiency of the system.

Mr. J. LEMON (Southampton) agreed that the idea of making a profit on sewage was altogether illusory. They must now look to getting rid of it at the least possible cost. Sewage management should be left to the local authorities, and never entrusted to public companies, who sought to earn a profit. The inhabitants of Leicester appeared pretty well agreed that the present system of sewerage, which subjected the low-lying districts to periodical floods, must be removed at any cost. He suggested that the town should be divided into zones for the separation of the high level system from the low level, and the consequent avoidance of floods. He had carried out this principle elsewhere, and had found it to answer admirably. A pumping station might be placed at the gravitating point of the high level and an ejector adopted for the relief of the low level. He asked the Corporation of Leicester to pause and seriously consider the responsibility they were about to assume in raising the sewage 170 feet. There was no excuse for it whatever, unless the land was exceptionally adapted to the purpose. This, he believed, was not the case. No doubt it was the intention of the Corporation of Leicester to dispose of the sewage by what was known as "broad irrigation." If they had a good subsoil and everything were favourable, broad irrigation was the right system. But in Leicester he feared those conditions were absent. For instance, it must not be lost sight of that the river Soar could never attain a very high standard of purity. He was inclined to think that a lift of 70 or 80 feet, with a combined system of precipitation and intermittent filtration over a smaller area, would answer all the purposes of Leicester, and could be carried out at a very much less cost. As to Mr. Gordon's paper, he believed French engineers were now alive to the evils of the Continental system. The sooner the prevalent idea was removed that sewage should be made a profitable speculation, the better.

Prof. H. ROBINSON, M.Inst.C.E. (London) assumed that the scheme for the sewerage of Leicester had received careful and mature consideration, and had been approved by Mr. Gordon. On this assumption, and without all the data bearing on the subject, it would not be desirable or possible to enter into a critical examination of the scheme. Looking at the matter broadly, however, there must be some good reason which was not apparent to him (Prof. Robinson) why all the high level sewage should be brought to a low level outfall, and for the whole to be pumped the great height of 170 feet on to clay land, which was unsuitable for sewage irrigation. The scheme would involve a serious burthen to the town of Leicester. It was desirable to exclude as much of the rainfall from the sewers as possible. Mr. Gordon's was one of the most valuable papers he had ever heard read, and contained data of interest to all engineers engaged in sewage disposal practice, and the Institute was fortunate in having this contribution to the proceedings.

Mr. Alderman KEMPSON (Leicester), admitted that the land taken by the Leicester Corporation for their sewage works was not altogether suitable for the purpose, and explained that the difficulties in the valley sites were in the opinion of the Town Council insuperable.

Lieut.-Colonel JONES (Wrexham) remarked that as he had resided in his neighbourhood (Leicester) many years ago, before entering upon his Sewage Disposal Works at Wrexham, he had always watched with much interest the Leicester experiments, and he congratulated Mr. Underwood on his excellent history thereof.

In entering at last upon sewage farming as the best mode of purifying their sewage, the Leicester Corporation should not be discouraged by the low estimates now prevailing on the financial side of the question, as the pendulum of public opinion will probably come to rest eventually about midway between the two extremes which it touched some twenty years ago and to-day. He would not presume to criticize, as others had done, the decision recently arrived at by the Leicester Corporation, because there were so many considerations which govern such questions not laid before their meeting, and he preferred to assume that the skilled advice of such an able engineer as Mr. Gordon had its due weight in any decision on such an important matter.

Mr. Peregrine Birch (London) was glad to hear from Mr. Alderman Kempson that the decision come to by the Corporation of Leicester was based, as he should have expected, upon information carefully obtained; and he thought that London engineers would be unwise to give opinions on the subject until they had the same means of arriving at a sound judgment.

With reference to Captain Lienur's system, the cost of dealing with the quantity of water made foul in English houses renders this method prohibitive here. He had himself adopted the plan mentioned by Mr. Gordon of laying a sewer under each pathway instead of one in the centre of the road. The advantages of this plan in wide roads, in saving the length and increasing the gradients of the house drains in which sewer gas is formed even more than in the sewer itself, is obvious. With regard to the 13,000 acres of land said to be irrigated at Berlin, he should like to know whether the land was pasture or arable, and whether irrigation was carried on constantly or only occasionally. Mr. Gordon had said that only a very small portion of the sewage of Paris was dealt with by irrigation; this was so, but a very large and increasing area of land was irrigated upon the optional system—that is, when the occupiers of the land required it for their crops.

The area of land in the Plain of Gennevilliers now sewaged in this way amounts to nearly 2,000 acres and this has grown up gradually from the start of a few acres some 15 years ago. He was surprised to hear from a previous speaker that the Soar must always be a foul river, and he should like to know why.

Mr. Laws (Newcastle-on-Tyne) was in favour of the ventilation of sewers through the soil pipes, provided the drainage system was properly carried out. Of course it was not advantageous where the sewers were known to be foul.

Capt. Douglas Galton (London) believed Leicester was almost the first town to attempt on a large scale to prevent the pollution of their river by the adoption of a chemical system, although the chemical system had not been quite successful. Of course the main advantage of any system of drainage was the lowering of the death-rate, and yet it would be seen from the statistics in Mr. Gordon's paper that except in one or two cases there was no such diminution in spite of the expensive works constructed. What was the reason of it? It was probably because the house drainage had not been considered at the same time as the sewerage of the streets, and treated as an integral part of town drainage. Until there was a thorough combination between the house drainage and the main sewerage they could never overcome all difficulties. He had never seen a town in England in which he should have been willing to have his house-drain connected with the main sewer for the purposes of ventilation.

Prof. de Chaumont, M.D., F.R.S. (Southampton), thought Captain Galton had somewhat underrated the diminution in the death-rate in the continental towns mentioned by Mr. Gordon, for in some of them there was a very decided fall. But the difference would be much better appreciated if the zymotic death-rate could be ascertained. There was one thing, however, that must not be lost sight of in this very important question, and that was, that although a town was sewered, the dangers arising from the fæcal matters were not touched at all. For instance, the city of Paris had a magnificent system of sewers, but, out of a population of 2¼ millions, there were not more than 30,000 or 40,000 persons whose excreta went into those sewers. The great difference between the health of the English towns and the health of the Continent was the increase of zymotic diseases in the latter. Although in this country we had, unfortunately, had a large increase of diphtheria in recent years the increase was really nothing when compared with the Continent. The amount of typhoid fever, too, on the Continent was inordinately excessive, and he thought it was impossible not to connect that with the fact that the excreta were not dealt with at all. If continental towns were not prepared to have a separate system for carrying off the excreta, they had better turn everything into the sewers, and depend on ventilation, with a proper disconnection of the house-closets.

Mr. Rogers Field, M.Inst.C.E. (London), observed that there was something very attractive in the suggestion that the sewers should be ventilated through the soil pipes, as this would get over many difficulties with reference to sewer ventilation, but the cases were few and exceptional in which the plan could be safely adopted. Two conditions were absolutely essential for the safe adoption of this plan, viz., a perfect system of public sewerage, combined with a perfect system of house drainage. There were hardly any towns, and, as far as he knew, none in England, where those conditions could be found. Probably they existed in Frankfort, and also in Memphis, U.S.A. As to Frankfort, the public sewers are acknowledged to be some of the most perfect in the world, and he could speak of his own knowledge as to the exceedingly complete character of the plans and regulations for the house drainage, having studied them very carefully when he was drawing up the bye-laws for house drainage at Uppingham, nearly ten years ago; in fact, at that time (before the Model Bye-laws of the Local Government Board were issued) he found that the Frankfort regulations were the only complete ones he could meet with.

With reference to Memphis, it might be remembered that a Paper was read at the Congress at Exeter in 1880, by Col. G. E. Waring, the engineer who designed and carried out the work, describing the thorough way in which the sewerage was executed, and the stringent regulations enforced with reference to the house drainage.

He could not agree with Mr. Hobrecht as to the advantage of having flat gradients for the sewers. His experience was that the better the gradient the less chance there was of accumulations of foul matter and generation of foul gases.

Mr. Ellice-Clark (Hove) urged that the Institute should endeavour to obtain translations of such valuable reports as had been alluded to by Mr. Gordon. In sanitary, as in in other matters, we were too apt to allow our insular prejudices to overcome our better judgments, which taught us to obtain good information from whatever quarter it came. There were many discussable points raised by Mr. Gordon's paper, but he should confine himself to the question of the system adopted for the ventilation of sewers at Frankfort. The method of making each soil pipe do duty as a ventilation for the sewer was the antithises of the system of ventilation adopted in this country, where sewers were ventilated in the street, independently of any method of ventilating house drains. The English system was not perfect, but there could be no doubt of its efficiency, which had been proved by many thousands of observations made in the sewers, to determine the velocity of the currents, the temperature and humidity, and the chemical constituents of the sewer air; he had himself spent much time in sewers of all sizes, and was satisfied that with ventilators at distances approximating 300 feet apart, *cæteris paribus*, no dangerous sewer gases were formed; for instance he had hung two burnished electro-plated soup ladles, one in a room where coal gas was lighted every night, and one in a sewer where the ventilators were placed 200 feet apart, the former ladle became tarnished in 60 hours, the latter was a week before it was tarnished. Yet at times, with a rapidly falling barometer and a rising dew point, complaints were made of the smells arising from the open ventilators of this sewer. He endeavoured by increasing the number of openings and by flushing to keep the sewer air down to a temperature of 52° Far. Although it had been stated that the Frankfort sewer ventilation by shafts was a success, it would have been more satisfactory if observations such as he had alluded to had been made. Nothing was easier for the Borough Engineer than to stop up street gratings and place small vertical shafts in lieu thereof, and imagine because there were no smells that the sewers were ventilated, but until comparative observations had been made and it had been demonstrated that a lower or as low a temperature and decreased humidity of the air were obtained by shaft ventilation, he should continue to believe that the open street gratings, with all their unpopularity, best accomplished the object in view. He might state that at Hove in 28 miles of sewers, each sewer was flushed with fresh water twice a week; of course many of the main trunk sewers were necessarily flushed much oftener. Sewage water was never used for this purpose, but always fresh water. Sewage water headed up, might carry away deposit by increasing the velocity of the stream, but it failed to lower the temperature or absorb the more soluble and dangerous gases, both of which necessary objects were accomplished by fresh water; the price paid was 5d. per 1,000 gallons, and two men were equal to flushing the 28 miles of sewers twice in six days. Notwithstanding this, he was frequently having complaints and was compelled in a few instances of narrow streets to substitute shafts of about 30 superficial inches for open gratings; he had made many observations in the shafts and found that the direction of the wind determined the direction of the air currents in the sewer, whether the shafts were all long legs, or long legs and short legs, which were popularly, but erroneously, supposed to create an air current down the short leg and up the long leg. The question was one of increasing interest; it would not be satisfactorily determined until Engineers made careful observations, and accurately recorded them, on the different systems, such observations to be extended over a comparatively long period and in different towns.

Dr. Paulson (Loughborough) feared that ill results would follow the adoption by Leicester of the proposed sewage system, and suggested that plots of land should be purchased, willow poles planted, and the sewage turned amongst them. He condemned ventilation by soil pipes and recommended and suggested a system of ventilation by the medium of the street lamp standards with a charcoal arrangement for deodorization—the sewer gas being forcibly expelled and disinfected, and the charcoal being perpetually renewed by the heat of the gas flame.

Mr. A. M. Fowler (Leeds) pointed out that there had been no improvement in the ventilation of main sewers during the last 27 years. In the house drains and branches, however, great progress had been made in this respect. If Leicester adopted a main system of sewerage, let them be careful to confine all the scavenging to one end of the town.

Mr. Everard (Leicester) briefly replied on behalf of Mr. Underwood, confining his remarks principally to a vindication of Mr. Wicksteed.

Referring to the proposed scheme for dealing with the Leicester sewage he expressed an opinion that the best place for utilizing the sewage was on a large tract of open land below the village of Quorndon, but considered that the Corporation were now committed to Beaumont Leys.

Mr. J. Gordon, M.INST.C.E. (Leicester), said that he felt gratified at the character of the dicussion. With regard to Leicester and its sewage scheme, he did not propose to enter into the merits or demerits of the scheme before the Corporation of Leicester. He thought the case of Leicester was unique in the question of sewerage, and there had been no end of reports on that subject. Only recently the Corporation instructed him to look into the question, and they had no fewer than ten schemes before them, out of which two were finally selected for discussion. Of those the Government Inspector had a predilection for the scheme which was now being adopted by the Corporation, and the Council therefore thought themselves justified in going forward with that scheme. It was well known that he favoured another scheme, which he thought had, notwithstanding various difficulties in connection with it, some advantages over the one adopted. There were, however, great advantages in the scheme proposed as against the great height to which the sewage was to be pumped; but he thought they would not be able to pump all the rainfall up to 175 feet. An inch of rainfall for 24 hours over the drainage area meant about 29,000,000 gallons of water, in addition to 8,000,000 gallons of sewage. It would, therefore, be quite clear that it was perfectly absurd to think of pumping any considerable portion up on to the clay land they had selected, and also on technical grounds it was very inadvisable to do so. The irrigation works in Berlin were not sufficiently advanced when he was there for him to see all that would be done. The chief produce at that time was vegetables and rye-grass. There was a great deal of prejudice against the vegetables at first, but they had since been reported as satisfactory. He was not prepared to defend the ventilation of sewers by soil pipes, except under such conditions as he had described. The apparent increase of the death-rate of Frankfort, to which Capt. Galton had referred, was due to peculiar circumstances. Formerly the people of Frankfort, and more especially the working-classes, were under considerable disadvantages in regard to the marriage laws, having to show that they were in a position to maintain a household before they were allowed to marry. The consequence was a great many migrated outside of the town for the purpose of marrying. When the Prussians annexed Frankfort they opened the gates to all and made it a purely free city. An entirely different class of people at once entered it, causing so large an increase of population that the death-rate, especially among children, was at once affected. Then again the large suburb of Bornheim was incorporated in 1877, the death rate of which was 38·1 per 1000 in 1879. Such a high death-rate naturally affected prejudicially that of the city, until the remedial works could be extended to the suburb in question.

With regard to Capt. Galton's remarks as to rates of mortality given in columns 28 and 29 of the table attached to his paper, shewing practically no advantage accruing from the works of sewerage, that gentleman cannot possibly have examined the tables at all carefully, for there are only two cases—namely, those of Chemnitz and Frankfort-on-the-Main—where the mortality does not show an improvement. That of Frankfort I have dealt with, and that of Chemnitz is accounted for by a very severe epidemic of small-pox during the period referred to, whilst on the other hand, the following cities and towns shew the following reductions :—

Berlin......	2·73,	or from	31·73 to 29·00	per thousand.
Bochum....	3·52,	,,	34·41 to 30·89	,,
Dantzic	7·85,	,,	36·51 to 28·66	,,
Dortmund ..	6·72,	,,	34·37 to 27·65	,,
Erfurt......	5·19,	,,	29·39 to 24·20	,,
Halle	5·00,	,,	30·00 to 25·00	,,
Heidelberg ..	3·86,	,,	27·04 to 23·18	,,
Linz	10·17,	,,	42·9 to 32·73	,,
Mayence....	3·10,	,,	29·8 to 26·7	,,
Munich	5·50,	,,	36·9 to 31·4	,,
Paris	5·47,	,,	29·75 to 24·28	,,
Wiesbaden ..	6·00,	,,	28·00 to 22·00	,,

As to coping with rainfalls he remarked that in a district in Leicester in which the rainfall had been most completely separated from the sewage he found that still no less than 50 to 60 per cent. found its way into the deep sewers. It was quite true that a great deal of dissatisfaction was felt with open ventilators in cases, such as Leicester, where they had to deal with an old system of sewers. A large number of sewers with which they now had to deal were put in by private owners in a very defective manner. Many of them had consequently become sewers of deposit. They could not expect open ventilators to be so satisfactory under these circumstances as in such cases as he had alluded to as prevailing on the Continent, but he had yet to learn which was the better plan, whether they should keep the sewers hermetically sealed like gas retorts and allow the sewer gas to penetrate the interior of the houses, or put up with some little inconvenience by allowing the sewer gas to escape in the centre of the roadways.

On "Circular Hospital Wards," by H. Saxon Snell, F.R.I.B.A.

The proposition for constructing hospital sick wards upon what is known as the "Circular System," was first made in this country during the latter part of 1878, about the same time that the foundation stone was being laid in Belgium of a hospital intended to be built upon this principle.

The design for this building, the Antwerp Civil Hospital, having received the approval of the Communal Administration of the town, was referred to the consideration of the Council of Public

Hygiene at Brussels, but this body strongly condemned the erection of circular wards upon grounds which, now the building is erected, would appear to have been correct. Nevertheless, the work was proceeded with and the building is now opened and may be inspected by those interested in the question.

No other continental nation has, to my knowledge, considered this new system worthy of imitation, but in England, many similar hospitals have been erected, and it is, I believe, in contemplation to erect others.

There is something very fascinating about the conception of a circular ward, and superficial consideration of the question would lead to a belief in the soundness of the arguments advanced in favour of the system; indeed, I was myself disposed, before critically examining the matter, to allow that its adoption might possibly be productive of some if not all the benefits promised by its advocates. This illusion was, however, dispelled when lately I had occasion to study the question in all its aspects for the purposes of a report to a public body prepared to erect this class of wards upon my recommendation, and I propose now to show the reasons that led me to the conclusion that parallelogram shaped sick wards are in every respect much more economical both in first cost and in management, and that no advantage is to be attained by the increased outlay consequent upon the erection of wards of circular shape.

My present remarks will be confined to a consideration of the erection of wards for general hospitals, and I do not propose in this paper to deal with the question in its application to fever or other wards for special cases. Nevertheless I am equally convinced that the circular system as now advocated is wrong in any kind of hospital building whatever be its special use or locality; but to deal with the question in its application to other than ordinary hospitals would involve considerations which the time at my disposal on this occasion will not allow of being entered into.

It will be well to first consider what are the conditions necessary to be observed in the planning and construction of general hospital wards.

First as to the number of patients. I have the authority of Miss Nightingale and of many hospital superintendents, for stating it to be essential that besides the ordinary nurses and attendants every ward should have the constant presence of one head nurse in the day time and of one nurse at night time, and that these head and night nurses could each properly overlook forty patients as a maximum; but taking into consideration all the essentials for proper discipline and facility of administration, the number of patients in any one ward should not exceed

thirty-two or be less than twenty; also, that in all cases one or at most two separation wards, each for the accommodation of one or at most two patients, should be attached to the large ward, but not so as to communicate with it directly. All the wards should, however, adjoin the rooms occupied by the nurse having charge of the patients contained in them.

Except in the case of separation wards, wards of small size are decidedly objectionable, because they are (says Miss Nightingale), "unfavourable to discipline, inasmuch as a small number, when placed together in the same ward, more readily associate together for any breach of discipline than a larger number." * And it is also pointed out by her that one head nurse, or one night nurse, could not so efficiently superintend and overlook a number of small wards as one large one.

Each large sick ward, whether it contains ten or thirty patients, must have attached to it at least two w.c.'s and a slop sink, separated by cross ventilated lobbies. A bath room should also adjoin each large ward. It is therefore clear that the fewer the patients in each ward the larger will be the total number of nurses required in the establishment, and the greater will be the multiplicity of nurses' rooms, water-closets, slop sinks, bath rooms, and other sanitary offices.

Suppose a hospital, to be designed for the reception of 576 patients, 540 of whom are to be placed in eighteen parallelogram-shaped wards containing thirty each, and the remaining thirty-six in smaller and adjoining separation wards. If the buildings are three stories in height there would be six pavilions, but if, as I shall show, twenty-two patients only can be placed in the large wards because they are of circular shape, then eight pavilions would be required instead of six, and twenty-four wards instead of eighteen. In both cases these wards and pavilions are assumed to be of the same size.

It has been shown that the services of one head and one night nurse must be provided for each large ward, and it therefore follows that the adoption of this circular plan would involve the additional cost of twelve nurses for the six extra wards.

The two extra pavilions containing these six wards would also necessitate the additional services of one scrubber and one porter for carrying coals and meals and attending the fires, furnaces, &c., and the salaries, uniforms and maintenance of these 14 additional officers cannot be put at less on the average than £50 a year each, or a total of £700.

The additional cost of fuel for the warming and hot water supply to these two extra pavilions may be put at a minimum

* Notes on Hospitals, by Florence Nightingale, 1863.

sum of £200 per annum, and the outlay for soap, soda, &c., for cleaning and the periodical whitewashing, painting, and repair cannot be put at a less sum than £100 per annum. Therefore the total additional establishment charges consequent upon the adoption of the circular system would be £1,000, as follows, viz.:—

12 extra Nurses / 1 „ Scrubber / 1 „ Porter	at £50 per annum each ...	700	0	0
Extra Fuel	...	200	0	0
Soap, soda, &c. and repairs	...	100	0	0
	Total	£1,000	0	0

This sum capitalised at 3 per cent. (33 years' purchase) would amount to £33,000 and this represents the additional cost of maintaining the 576 patients supposed to be housed in wards designed upon the circular system.

The additional cost per 1,000 patients would be £57,392 and this cannot be considered a large estimate seeing that Miss Nightingale in her work on hospitals shews that where 9 patients only are contained in a ward as against 32 patients in a ward the additional capitalized outlay for nursing only would be £196,775.

Now as to the relative cost of erecting the buildings—a question involving primarily a consideration of the requisite sizes for the wards.

There must be much diversity of opinion amongst medical men and other authorities upon this point if we are to judge from the dimensions of recently constructed hospitals.

Capt. Douglas Galton considers that between 1,200 and 1,300 cubic feet of air space per bed is all-sufficient. Miss Florence Nightingale asks for from 1,200 to 1,500 feet. Dr. Parkes speaking of hospitals generally, says that the space should be from 1,500 to 2,000 feet (the latter quantity referring no doubt to fever and the former to general hospitals). Dr. de Chaumont in his Report upon the Norfolk and Norwich hospitals, shews upon mathematical bases that where good ventilation exists no advantage is gained by making the air space of large wards greater than 1,200 feet per patient.

The report of the committee appointed to consider the cubic space of metropolitan workhouses and infirmaries states that the cubic space to be allotted to ordinary sick patients in large wards "should not be less than 850 feet;" but it is stipulated that no space above the height of 12 feet from the floor-line shall be included in the calculation. This committee consisted of the following eminent authorities, viz., Drs. Thomas Watson (chairman), Henry W. Acland, Francis Sibson, W. O. Markham, and John Randall, Capt. Douglas Galton, Messrs. Uredale Corbett (Local Government Board Inspector), Timothy Holmes, F.R.C.S., and Charles Hawkins, F.R.C.S.

In my own practice, I have erected four large parish infirmaries, holding in the aggregate upwards of 2,500 ordinary sick patients, with less than 950 cubic feet of space to each, and the medical officers of these establishments have not found it necessary at any time to order the removal of any of the beds, as was contemplated, should one or more extraordinarily severe cases at any time be developed, and seem to call for increased space.

The Moabite Hospital at Berlin gives a space of only 864 cubic feet for each ordinary patient; but in this building one-fourth of the cases treated are stated to be of an acutely infectious character,* and we may presume that a larger space would be allotted for this class of patient. Yet the death rate at this establishment, I am assured by eminent men who have examined the returns, is not above the average of other German hospitals.

The proper size of hospital wards is not however to be determined by mere considerations of the greater or less quantity of air-space requisite for the well-being of a patient, for Prof. de Chaumont in his report before referred to, has clearly shown that where by good ventilation a proper change of atmosphere is constantly effected, it matters not within reasonable limits what is the size of the ward. The question must be decided principally by consideration of floor space, and here again examples and opinions are sadly diverse.

The Moabite Hospital, and the four parish infirmaries previously alluded to, contain about 70 superficial feet of floor space per ordinary patient, and this is the quantity recommended by the before-mentioned committee of experts.

Capt. Douglas Galton asks for from 90 to 112 feet, Miss Nightingale from 100 to 104 feet, and Dr. Parkes and Prof. de Chaumont, from 100 to 120 feet. In each case these authorities seem to determine their maximum and minimum by the question of whether or no accommodation is to be provided around the bed for students, *i.e.*, whether the hospital is or is not to be designed for a medical school.

The disposition of the superficial space determined upon, whatever it may be, involves two important questions, viz.: the

* Hospital Construction and Management, London, 1883.

width of the ward, and the distance apart of the beds. Twenty-four feet is conceded to be for all purposes of administration an all-sufficient width for any hospital ward, and inasmuch as it is of the highest importance that each bed should have the largest possible space surrounding it, this width would, I apprehend, never be exceeded, were it not for the desirability of reducing the length of a ward to within a limit not exceeding 120 feet.

In parish infirmaries the prescribed distance apart of the beds, *i.e.*, the bed space, is 6ft.; but 7ft. 6in. or 8ft. is the width more generally adopted, and hence it comes about that the breadth of the wards is necessarily increased in some buildings to as much as 30 feet. And here I would point out that the advocates of the circular ward system invariably and wrongly use the term "wall space" as synonymous with "bed space," or the distance apart from centre to centre of the beds; and they often improperly calculate this distance apart of the beds by dividing the total length of the circumference of the circle by the number of beds, and so arrive at a deceptive result.

Take, for example, the description given in *The Builder*, of May 9th last, of "A projected Military Hospital" designed upon the circular system. It is there stated that the wards are each to be 66ft. internal diameter, and that they are to hold 26 patients: thus (says the description) "each patient will have a wall space of 8ft."

As a matter of fact, if this military hospital is ever erected, and 26 patients crowded into its wards, each will have a lineal wall space at the heads of their beds of 7ft. 4 in., but the corresponding distance at the bottom of the beds will be but 6ft. 3in.; that is to say (the beds being 3ft. wide) the distance apart of them will be 3ft. 3in. only. And, therefore, if it is required to know what really will be the space given per bed in this proposed hospital, as compared with the quadrangular plan of ward, we must calculate the average distances apart as given above of the beds at the heads and at the feet, and then, instead of the delusive 8ft. of wall space, we shall find that the actual *bed space* per patient in this proposed hospital would only be 6ft. 9½in.

The above results would be arrived at by deducting 6 feet 6 inches in width for each of the entrance lobbies, and then planning out the feet of the beds at an equal distance apart, and radiating them towards the centre of the circle.

Then with regard to the height of hospital wards. It is only Professor de Chaumont who expresses any decided opinion upon this point, and the conclusion he arrived at that 12 or at most

13 feet is all sufficient, has since been confirmed by the results of experiments made by two eminent American physicians, Drs. Cowles and Wood,* who proved to their satisfaction that no benefit arises from making wards higher than 12 feet. It is also no doubt upon these conclusions that the recommendations of the cubic space committee before referred to were based.

Most other authorities regard the question of height as quite subsidiary to that of floor space, as decided by considering the width of the ward, and the distance apart from centre to centre of the beds.

I have been particular to cite the opinions of these great authorities as to the requisite dimensions of ordinary wards, because I am about to show that it is practically impossible to design a circular hospital ward within the limits they have laid down, without causing a useless multiplication of wards, ward offices, nurses and domestics, resulting in an enormous and wasteful outlay, first in the erection of the buildings, and for all time in the annual establishment charges; and my argument would therefore admit of contention if it could be shown that in the illustration I am about to give, I exceeded these limits, for it will be seen hereafter that the smaller we take the units of space the greater will be the cost of the circular, as compared with the parallelogram-shaped ward; and I therefore propose to take for illustration a ward of dimensions which shall approach, as nearly as possible, the maximum quantities asked for by the before-mentioned experts.

A parallelogram-shaped ward (see fig. 2, page 217), containing 30 beds, and being 28ft. wide, 120ft. long, and 14ft. high, will contain 1,568 cubic feet, and 112ft. of floor area per patient, whilst the bed space will be 8 lineal feet per patient.

A circular ward (see fig. 1, page 216) of equal superficial floor space would be 65ft. 6in. diameter, and if it is required (as for proper comparison it must be) to keep the beds the same distance apart as in the parallelogram shaped ward, this space would not contain so many even as 22 beds. For if we consider the feet of the beds to be 7ft. distant from the outer wall (6ft. 6in. for the length of a bed and 6in. space between it and the wall), and the width of the two lobbies as 13ft., we find that if there are 22 beds, the lateral distance from centre to centre of the feet of each is 6ft. 9in., and the corresponding distance between the heads 8ft. 8in., thus giving an average distance of 7ft. 8in. only as against the 8ft. space of the parallelogram shaped ward. The result is that by the adoption of this circular plan we should have a ward containing less bed space

* Report of State Board of Health of Massachussetts, 1879.

and in round numbers respectively 41 superficial and 571 cubic feet per bed more than we started by admitting was necessary for the healthy condition of the patients.

The dotted line upon the plan (Fig. 2) encloses the central space thus wasted in each ward, amounting respectively to 896 superficial and 12,553 cubic feet.

Various ingenious suggestions have been made for the disposal of part of this space. One proposes to erect a staircase which, according to his plan, would occupy 250 superficial feet out of the 896, and at the Antwerp Hospital, a still less quantity is enclosed to form a room (ostensibly, but never, I believe, in reality) for the use of a nurse. But besides the practical inutility of adopting these expedients, it will be seen that any such obstruction would only augment the difficulties of cross ventilation already created by the necessity of having the windows between 60 and 70 feet apart.

What then is to be done with this superfluous space? It has to be built, to be kept clean, to be ventilated, to be heated, but worst of all it has to be paid for; and at what cost I will now consider.

The two additional pavilions previously shown to be necessary would cost, including heating, lifts and fittings, £26,800, and the outlay for the additional accommodation of twelve nurses, including furniture and accessories, would amount to about £700, or together to £27,500. It will be observed that I have not taken into account the fact that the six remaining wards being built upon the circular system must of necessity be of more costly construction than if they were built up on the parallelogram principle.

This sum of £27,500 represents the additional cost for 576 beds, and is at the rate of £47,743 per 1,000 patients. Adding to this the capitalized cost of nursing these 1,000 patients, previously shown to amount to £57,392, we find that if the circular system is to come into vogue, we must be prepared for indulgence in the luxury (if it is one) at the rate of £105,135 for every 1,000 patients.

Should it suggest itself to any one to enquire how a circular would compare with a parallelogram shaped ward if both were designed to contain 30 beds, an average distance of 8ft. apart, it would be found that the circular ward must be 87ft. 9in. diameter, and consequently the waste or unnecessary space in the centre of it would amount to no less than 2,705 superficial feet. Moreover, it would be evident that the height of such a ward must be raised considerably if any sunlight at all is to approach the centre of it, and supposing this additional height to be, say 3ft., the quantity of waste or unnecessary space in one ward alone would amount to 64,180 cubic feet. But this is not all, for it would follow that the adjoining offices, separation wards, nurses' room, staircase, &c., must also be raised.

It will hardly be necessary I think to trouble you with the figures which would show the additional cost of this plan to be even greater than has been proved to result from a comparison of two wards of equal area, but with fewer beds in the one of circular shape. Neither need I point out to you how much all the other difficulties of ventilation, lighting, heating, and want of cheerfulness would be enhanced.

Advocates of the system however say, "we have nothing to do with the cost; what we desire is to erect that description of building, whatever it may be, which best adapts itself to the cure of the patients to be contained in it," and within reasonable limits this view of the question is no doubt a right one.

But I have searched in vain for any substantial arguments shewing that from this point of view the circular is any improvement upon the parallelogram shape of ward, and I have little doubt that no such arguments could exist unless it can be shewn that in contravention of nature's laws air would as freely pass through a room from one side to another when the windows are 60 or 70ft. apart, as it would if those windows were from 24 to 30ft. apart. It would also have to be demonstrated that in defiance of all mathematical rules, when the sun was shining or the wind blowing against the straight wall of a parallelogram shaped ward, less air and sun would penetrate through its window openings than would penetrate an *equal* number of window openings of the same size contained in the wall of a circular ward. And then, having proved this anomaly, it would be necessary to define the process by which as large a quantity of air and sun could be brought into the circular ward through its 22 windows as could be brought in through the 34 windows of the parallelogram shaped ward.

This being made evident the contention must be upheld that a ward having the distance of its parts from the windows varying from 1ft. to 33ft., is as cheerful as one the parts of which vary similarly from 1ft. to 14ft. only. And it must be shewn that this cheerfulness will not be diminished by the height of the circular ward being $\frac{1}{5}$th only of its diameter as compared with the parallelogram shaped ward, the height of which would be one-half its width.

But supposing all these difficulties to be surmounted, it will only have been shown that in the points referred to the circular is as good as the parallelogram system, and then what is left to compensate for the £105,000 outlay before referred to?

It cannot be contended that for the purposes of a medical school, where it is desirable the greatest space for students shall be given round and about the patient, that the constriction of the feet of the beds, consequent upon their radiation towards the centre of the circle, is an advantage. It cannot surely be argued that it is a desirable arrangement to place a nurse (as at the Antwerp Hospital) in the centre of a sick ward, breathing all day its more or less foul atmosphere, rather than that she should be assigned an adjoining room, having a window through which she could overlook the patients. Neither can it be said that if this central space is occupied by a staircase, that such staircase would not be better placed (as in the parallelogram system) away from the ward and adjoining and giving direct access to the nurses' rooms, separation wards, and other offices, and so avoiding the necessity of all persons and things passing through and disturbing the occupants of the large ward.

And if, then, these deviations from past practice cannot be shewn to be improvements, what is left for those who would still be admirers of the new system to put forward as a claim for its superiority over the old one? I cannot say, neither can I imagine.

Capt. Galton, C.B., F.R.S. (London) said he also had been struck with the radiation of the beds in the Antwerp hospital. The central room for the nurse was an impediment both to the cheerfulness of the ward and the free circulation of the air, besides being an utterly useless place for anyone to live in permanently. The building was designed to be very largely artificially ventilated, but unfortunately the apparatus was not at work when he was there. He had had similar experience elsewhere, and although he had often wanted to examine the arrangements in artificially-ventilated hospitals, it had always happened that they were not in working order. He agreed entirely with the arguments which Mr. Snell had adduced, and wished the various hospital authorities contemplating the construction of circular hospitals would read his paper.

Prof. de Chaumont, M.D., F.R.S. (Southampton), said he was at first attracted by the circular design, but he confessed the objections of Mr. Snell were very difficult to answer. The Antwerp hospital was by no means attractive in appearance, and to place a nurse in the cage in the centre would be simply monstrous. The adoption of this system would, he feared, not answer the expectations of its promoters. Yet the matter was one of great importance, seeing that it was now strongly advocated by the Director of Works at the War Office, and the proposal to build a hospital on this principle at Malta was now seriously entertained. He would take care that Mr. Snell's paper was brought before the notice of the War Office.

Mr. H. H. Collins (London) agreed with the views expressed by Mr. Snell. Circular hospitals were undesirable if on the score of expense alone. To construct a circular building was at least a third more costly than to build a parallelogram. At the same time, he admitted there might be some excuse for building a circular hospital in the case of a site which would ill adapt itself to any other form of construction.

Mr. E. C. Robins (London) thanked Mr. Snell for his paper, and was glad to know it would come under the notice of the War Office. He looked forward to the time when tents that could be taken down and destroyed when their purpose was fulfilled would supersede colossal hospitals, or better still, removable buildings on the Tollêt system. He felt he must concur with the views expressed by Mr. Snell, confirmed as they were by such high authorities as Professor de Chaumont and Captain Galton. He must confess, however, that he was much taken with the Antwerp Hospital on seeing it during its construction, and he thought it unwise to condemn beforehand the heating and ventilating processes so intelligently and scientifically designed and executed.

Mr. Gordon Smith (London) said he could not concur in all that had been said. He feared Mr. Snell had somewhat exaggerated his case, in addition to which there were some features about the circular ward system that demanded more attention than had been paid to them. For instance, the question of shape of site was of great importance. It was quite possible to have a site (upon which a hospital must be built) that would adapt itself to a circular building far better than to a rectangular one. A circular ward would stand less chance of interfering with a neighbour's rights of light and air, and would admit of freer ventilation. In aspect also, a circular building had advantages over an oblong one, while in regard to cost he had it on the authority of two architects who had actually built circular hospitals, that in some respects this form of building was really cheaper. He also urged that the circular ward afforded advantages in administration in the way of facilitating control and minimising fatigue which were not possessed by the rectangular or oblong ward, and he considered the circular form of ward, notwithstanding what had been said against it, deserved careful attention.

Mr. H. Saxon Snell (London) in the course of his reply, contended that no hospital ought to be erected upon a site so confined in area that rights of light and air had to be considered; and he did not hesitate to say that wherever, upon this plea, circular wards had been built, rectangular ones would have answered the purpose far better. He failed to see how circular wards could give greater facilities for ventilation than those of rectangular form. In the latter the foul emanations from the patients were removed by outlets into flues situated in the walls directly over the patients' heads. Surely this was a better plan than carrying the deleterious matter across the ward, a distance of 30 to 35 feet, into the central shaft, as recommended by the advocates of the circular system.

Plan of a Circular-Shaped Hospital Ward of equal area to Fig. 2.

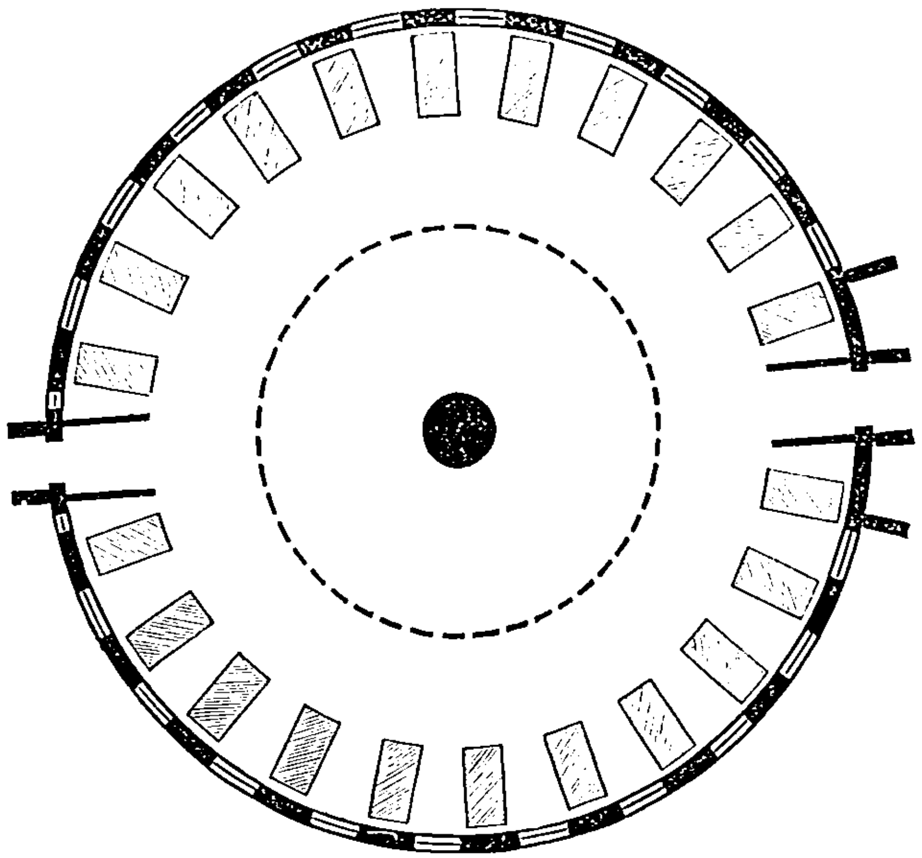

Fig. 1.

Dimensions—
65 feet 6 inches diameter.
206 feet circumference.
7 feet 8 inches average distance from centre to centre of beds.

Contains 22 beds. Scale 22 feet to an inch.

Plan of a Parallelogram-Shaped Hospital Ward of equal area to Fig. 1.

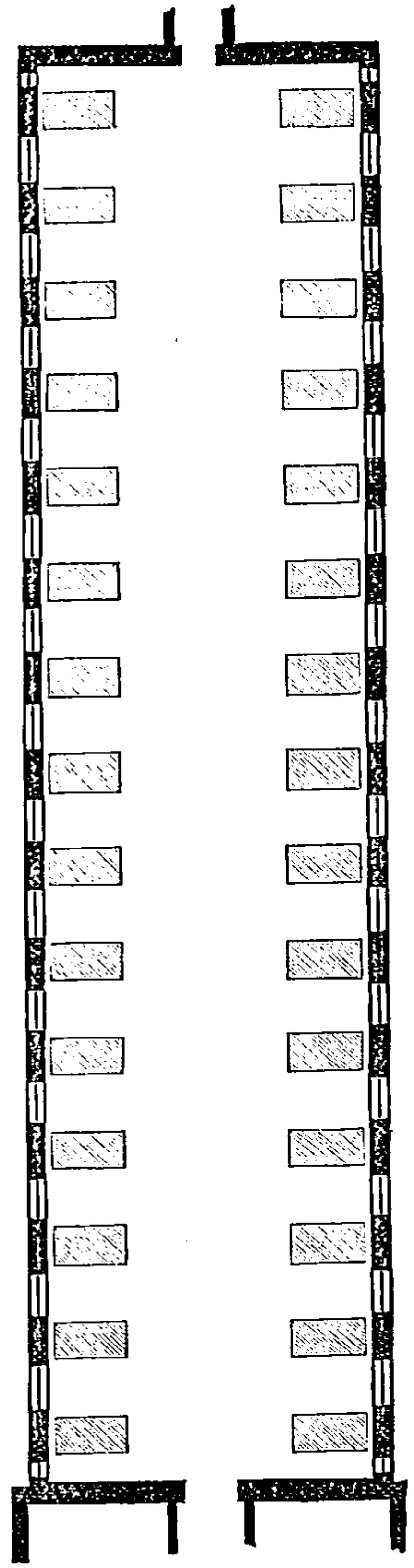

Fig. 2.

Dimensions—
120 feet long.
28 feet wide.
8 feet from centre to centre of beds.

Contains 30 beds. Scale 20 feet to an inch.

On "Smoke Abatement," by W. R. E. Coles.

That smoke should be prevented is now, to a large extent, admitted. But the *reasons* why it should be so have yet to be far more clearly and widely apprehended by the public at large, if the Sanitary Institute of Great Britain is to indulge any reasonable hope of ultimate success in that department of its work which relates to the purification of town atmosphere. I purpose to refer very briefly to these reasons, and to submit a few observations upon the subject, my remarks being based upon the result of the painstaking enquiries and serious reflections of many persons who have given special and earnest attention to the matter.

1. *The health aspect of the question.*—It cannot be too widely known that the death-rate of towns is considerably increased by the smoky condition of the atmosphere. Diseases of the respiratory organs and diseases of the zymotic class are alike more deadly in those towns which are most smoky. The evidence which has been collected in relation to the health aspect of the smoke question is very ample, and in a very notable degree it is free from conflict of opinion. The opinion of the medical profession has been expressed strongly and unanimously against smoke. Physiologists, too, have been consulted, and they have carefully determined, and clearly explained, the injurious operations of a smoky atmosphere upon animal life. Not only have health records supplied statistical proof of the fact that in smoky districts the duration of life is shortened and health is deteriorated, but scientific investigations have done much to explain the precise *causes* of these injurious effects of coal smoke. Among these causes may be mentioned one that is often overlooked, viz., that light is obscured by the smoke-cloud, and thus we are deprived of one of the most essential elements of animal life. It has been said by one of the most eminent physiologists that sunlight is almost as important to us as the food we eat. It may be, perhaps, well to mention that a few of that injurious class of persons, whose little knowledge is a dangerous thing alike to themselves and to those who receive and disseminate their statements without any reflection or the least inquiry into the truth or falsehood of what they hear, have said, and have actually written letters to the newspapers to urge that there is "a plea for smoke in town atmosphere," on the ground of its being antiseptic, or, in other words, that

smoke has the quality of destroying the germs of disease. Now, so far as the most careful inquiry and reflection enable us to judge, there is not only no single tittle of evidence in support of this assertion, but, as I have shown, the whole of the most reliable evidence obtainable points in exactly the opposite direction, and proves that a smoky atmosphere is positively deadly in many cases, and is always more or less injurious to health. I may add, because I think it is very important to prevent baseless assertions passing current, that our present knowledge goes to prove unmistakeably that it would be physically impossible to destroy any of those minute organisms or "germs," as they are popularly called, which are supposed to produce or propagate certain diseases, without making an atmosphere in which it would be absolutely impossible for human beings to exist. In other words, we should be obliged, in order to kill the "germs," to kill the people! Thus it would appear that the assertion that smoke is valuable as an antiseptic is not only baseless but is absolutely foolish. The same class of persons who have put forward the notion that smoke is antiseptic, have also advanced the idea that smoke may be good because the carbon in it is a "deodorizer." This theory would appear to be almost equally foolish with the other, for though carbon in some states and in some quantities has deodorizing qualities, we could not endure an atmosphere so charged with it as to be deodorizing. And I believe we may take it as a fact that the deodorizing agency of the carbon in our densest smoke is practically "nil." Any persons who wish to study these questions closely will have no difficulty in finding abundant means of advancing their knowledge; but I would beg all to consider the matter broadly in the light of their ordinary common sense and common experience, and they will, I think, need no other evidence to convince them that they are not so well and vigorous in a smoke-polluted and darkened atmosphere as they are in pure air under an unobscured sky.

2. *The moral aspect.*—You will not be surprised to hear that those persons whose knowledge of the poorer classes of the community is greatest, and whose labours are directed to ameliorating their condition, are *very* urgent in their desire to see smoke abated. Intemperance follows as the almost natural consequence of lowered vitality and debased surroundings. To the poorer classes the subject of smoke abatement is one of even greater importance than to any. Their homes are for the most part in the least ventilated and most smoky districts. They are less able than other persons to get away to fresher air and cleaner surroundings. To them the expense and the labour of keeping themselves and their homes clean are things of vital consideration. To war successfully against dirt is

practically impossible for the poor while they have to live in an atmosphere of smoke. There is often but one poor pair of hands to do all the work, and those the overwrought ones of a sickly woman, whose first care must be to attend to the more immediate wants of her husband and her infant family. To the cotter's wife in the country it is hard enough to keep her house, herself, and her family clean. To the labourer's wife in one of our smoky towns, where everything is soon covered with smuts which fall so fast as to blacken the clothes even while the poor woman strives to dry them, it is practically but a mockery to tell her to be clean, and that she *ought* to keep her home and family decent. It is unnecessary to dwell on this theme. All who have considered the subject and know anything of the actual condition of the poorer classes will admit the great practical difficulties which stand in the way of their becoming more temperate, more cleanly, and more elevated in their habits while smoke-dirt abounds, and the smoke cloud obscures those rays from the sun which have the power of invigorating the moral as well as the physical life of man. It may be added that the smoky condition of town atmosphere is one of the chief causes of many persons living out of town, and thus necessarily withdrawing in a great degree their active sympathies and various social influences for good from their poorer brethren who are compelled to remain continually in town.

3. *The Economic Aspect.*—It has been proved in almost every department of enquiry that money loss is associated more or less directly with the systems of heating which are generally accompanied by the production of smoke. Here, again, I think the poorer classes personally suffer most acutely. The sheer exhaustion and inability to work which is often experienced by them is, I fully believe, in a great measure due to the enervating influences of smoky atmosphere. Therefore, to them it is a wage-earning question. The public pay in one form or another an enormous aggregate amount in connection with the production of visible smoke and the wasteful uses of coal, and all classes are compelled to bear a portion of the tax whether they themselves contribute to the evil or not. Beyond the large losses which follow *directly* from wasted fuel, wasted labour, the cost of conveying unnecessary quantities of material through the streets, and the cost of cleaning and renewing articles deteriorated by smoke, the *indirect* losses resulting from imperfect and inconvenient heating systems are known to be so serious as to demand the utmost attention of all classes, and induce a general review of heating methods.

The Improvement of Heating Methods.—In some degree a review of heating methods has already commenced throughout the kingdom, and some substantial and beneficial changes have been made. In industrial as well as domestic heating processes the chief changes have been made in the direction of substituting gaseous fuel and coke for crude bituminous coal. Next to these changes it is observable that greater regard is generally paid to the character of the heating apparatus which is used, and especially to the avoidance of losses of heat by conduction, radiation, &c. Various methods of treating crude coal by processes of distillation in order to recover the volatile products which are ordinarily lost in the form of visible smoke, have been practically reviewed, and in some degree satisfactorily applied. The extended introduction of gas engines in substitution of steam engines is also noticeable. But *greatest* of *all* the changes is the enormous increase in the use of ordinary coal-gas for domestic heating and cooking purposes, particularly the latter. This change has been brought about by genuine public recognition of the vast convenience and other advantages which gas fires possess over ordinary coal fires. In fact, the advantages of the former are so marked and so many that wherever gas is obtainable at the relative price which ordinarily subsists between it and coal, and good stoves are to be procured, there is practically no room for comparison between the two systems. In fact, when we reflect for a moment that there is no labour involved in bringing gaseous fuel to the fire, or taking ashes, &c., away from it, and that the heat required can be obtained exactly at the time it is wanted, and that it can be dispensed with directly the work is accomplished by the mere operation of turning a tap, the question of superiority, so far as the convenience at any rate of gaseous fuel is concerned, is at once settled in its favour. The practical hindrances which formerly stood most in the way of gas being used for heating purposes were:—

1. The stoves obtainable were very imperfect, often failing from bad design or bad construction, and they were generally very difficult to keep clean. Moreover, they were very extravagant in the consumption of gas.

2. The expense of purchasing the stoves was prohibitory to many householders.

The first difficulty has virtually been removed by very great improvements having been made since the Smoke Abatement Committee commenced their organized efforts in the cause of smoke abatement in 1880, when practical trials of all kinds of heating appliances were made, and the results were made known among manufacturers and inventors. The second difficulty has been met, in a great degree, by the chief gas companies letting stoves on hire at very moderate charges. The price of gas having been reduced has also tended to increase its use.

The Sources of Smoke.—The smoke from industrial works has long been under a certain degree of legal restraint, but domestic chimneys, which in the aggregate generally produce the largest amount of smoke in our towns, are absolutely free to emit as much smoke as the occupiers choose. Therefore it is, I think, the more noticeable that it is now demonstrated that smoke from this source can be, and is being to some extent, prevented.

The chief reasons alleged for continuing smoke from domestic chimneys should be noticed, and they may be summarised as follows:

1. *The comfort of the open fire.*—This reason is a good deal shaken when people consider that there are a good many discomforts connected with the system, such as the warmth being unequally distributed, the operation of coaling being dirty and troublesome, chimneys requiring frequent sweeping, and their often smoking, &c.

2. *The advantage of ventilation derived from the open coal-fire.*—This reason also is considerably shaken by the recollection that instead of getting sufficient ventilation, we often get only draughts of cold air drawn direct to the fire-place.

3. *The expense of altering the existing stoves.*—This objection is untenable in the numerous cases where gas-stoves are available, from the fact before-mentioned, that they are to be procured on hire fitted ready for use; and they might advantageously be used for cooking purposes even though the existing system were maintained for warming living rooms.

4. *The impracticability of applying restraint.*—It is said to be impracticable to apply restriction of any kind to domestic fires, because the "Englishman's house is his castle." The fallacy of this objection is at once apparent when we remember that the restraints on domestic habits are already numerous, and in many instances they are far more onerous than those which would be necessary to check the evolution of smoke.

The prospect of abating smoke.—This lies, I think, in the hope of these several things:—

1. That the serious moral and material evils which are associated with a smoky atmosphere may become more widely recognized.

2. That it may become generally known that smoke is not a necessary concomitant of heating; that as a fact it may practically be prevented, and therefore it reasonably should be restrained in populous places, the operation of the law being extended gradually in the case of existing premises, and peremptorily in the case of new buildings.

3. That it may become popularly observed that our social habits and industrial arts have reached such a position as absolutely to require more economical and more convenient heating methods than those now generally prevalent, and which, for the most part, unnecessarily produce smoke.

In conclusion, I would particularly urge that the observations I have put forward for your consideration may be interpreted in their broadest sense. I do not by any means seek to imply, as some do, that the prevention of smoke is quite easy, and that in every individual instance an immediate benefit is to be obtained by preventing it. On the contrary, I know that it frequently pays the individual best, and saves him a good deal of trouble to continue making smoke. But that does not, I submit, in one whit invalidate the general conclusion of the whole matter, which is that on every ground smoke, in towns especially, should be prevented by the action of an enlightened public opinion and the restraining power of the law. I believe that the advantages associated with smoke prevention are only to be obtained, like all other advantages are, by certain sacrifices; but I equally believe that those sacrifices in the case of smoke prevention would, in the main, be but very trifling in comparison with the immense gain which would result.

Mr. Percival Gordon Smith, F.R.I.B.A. (London). We have heard some interesting remarks about this troublesome subject which Mr. Coles has put before us in a moral as well as a sanitary aspect—both of extreme importance. I am glad to find that he has referred to the domestic chimney, because I have often thought that the domestic chimney is as fruitful a source of nuisance as the manufacturers' chimneys. The old size of 14 by 9 inches I have often heard architects say is not the best for creating a proper draught up the chimney, but a great many architects and others are not aware that it is the size laid down by Act of Parliament. There is an old Act of Parliament, the Chimney Sweepers' Act, passed nearly fifty years ago, which says that every chimney from a habitable room is to be at least 9 inches by 14, and curiously enough the police are the parties to see that this is carried out. I believe the police are altogether unaware of this part of their duty. It is often suggested that 9 by 9 would be a better size, and perhaps that point may be referred to presently. Some of our provincial towns are certainly great polluters of the atmosphere, and I have heard it said that Sheffield, which is one of the smokiest towns in the kingdom, is exempt from the Smoke Abatement Laws.

Mr. Ernest Hart (London) observed that Mr. Coles said very truly that all physiologists agreed that the first and principal result of smoke was to obscure the rays of the sun, and thus destroy its influence; but if we substituted for that, that when the sun's rays are struck down by smoke, conifers die, flowers cannot be made to grow, wax cannot be bleached, every one would see at once how the influence of the sun, which was essential to the physiological processes of life, must influence inhabitants of cities, as it influences organic plants and animals which show more immediately the want of sunlight. When he was a boy, roses grew abundantly in Kensington Gardens, and his great delight was to go there and pluck them; but a rose could not be made to grow there now, and the last conifer in Kensington Gardens he believed died last year, and the last wax bleaching factory disappeared from Shepherd's Bush last year—all pointing to the lowering of human vitality by the smoke fall. As to the means of progress, a great deal depended upon voluntary co-operation of individuals, and a great deal upon the willingness of magistrates to enforce the law as it existed. As to manufacturing towns, according to their methods of government, which he did not think they were at all likely to alter, it was much the habit of taking care that legislation should not outstrip public opinion, and with that view the enforcement of penalties for the non-observance of the law was placed in the hands of gentlemen supposed to represent public opinion, and who would not enforce it more rigidly than public opinion would allow. Thus it was that in manufacturing towns laws existed which would prevent the smoke nuisance, but inasmuch as those who enforced the law were themselves producers of smoke, they interpreted public opinion to be in favour of the smoke which they produced, and as smoke inspectors were under the control of magistrates, who were probably leading manufacturers, it was difficult to see how the magistrates could err. Parliamentary smoke was defined as issuing from a chimney so densely that they could not see the sky through it. A man, however, saw more or less acutely according to the impressions which were passing through his brain, and a good many people could see the sky when everything was black and smoky. Unless they made laws more stringent, their only other power was the motor power of public opinion, and he thought they were disposed to rely upon that. He did not believe they could cure everything by putting into Acts of Parliament "must" or "shall" or "may." He did not think public opinion would bear that out, and his own experience was that the introduction of imperative words such as "shall" was apt to lead to a reaction, thus destroying the very objects they desired to meet. He was delighted to find that Mr. Coles, who felt it his duty to preach that crusade, had read that paper which he hoped would have its effect in that particular town, and that so far as the law went it would be enforced, and that individuals would use in their own houses that kind of fuel and those appliances which would most effectually prevent the unnecessary production of smoke. He should be quite rewarded for attending that morning by the information which the President had given, of the curious parliamentary regulation affecting the size of chimneys. It had evidently been laid down for another purpose altogether, and was one of those feudal relics that they would have to sweep away.

Prof. de Chaumont, M.D., F.R.S. (Southampton), said he could corroborate what had been said about the alleged antiseptic effect of smoke. It was an idea that people ran away with, and in scientific circles the illusion was not dispelled. The experiments he had made, in conjunction with Prof. McDonald, showed that the amount of sulphurous acid in the air necessary to kill bacteria exposed to it, would have to be so large that no human being could possibly live in it. That would dismiss altogether the supposed antiseptic effect of smoke in the air. By putting against it the terrible counter effects of the absence of sun-light, he thought the indictment against smoke was complete. With regard to the changes made in the methods of the domestic consumption of fuel, one of the great difficulties with reference to the adoption of gas was the high price of the commodity in certain places, and he distinctly charged that against the gas companies. He knew places where the gas companies, after paying the maximum dividend, were putting to the reserve fund a larger sum than they paid in dividends. He did not think that ought to be allowed. The legislature stepped in and put a limit to the amount of dividend, but he thought it ought to be clearly laid down that gas companies, after getting the maximum amount of dividend, should apply the surplus funds to reducing the price of gas to the lowest point. Then the employment of gas would be adopted on account of its greater cleanliness and easier management. Some people objected to the smell in the house, but that was simply because the apparatus was imperfect, for the smell could easily be got rid of. There was also the desirability of providing fuel gas of a cheaper quality than the ordinary highly carburetted gas that they used for lighting. In the case of lighting gas there was a small quantity of heavy carburetted hydrogen for the purpose of incandescence, but they did not want that in the case of fuel. They wanted the maximum amount of heat and no deposit, and if gas companies could be induced to make inferior gas for heating purposes, they might give it them at a price which would be sufficient for all incomes. He was told that it could be made for 1/- per 1,000 feet, and even lower than that. Some of those improvements would no doubt bring the use of gas within the reach of all, and if they could add to that the introduction of domestic electric lighting, they would have arrived at a perfection which was certainly ideal. His first visit to Leicester had impressed him with the freedom from smoke of the atmosphere, which he was informed was attained by the quality of the coal which was consumed.

Mr. Fred. Scott (Manchester) thought there was a difficulty in adopting the suggestions of the last speaker. In Manchester they had done a great deal to get the authorities to put down the smoke nuisance; they had got severe penalties legalized, and they now had the power of inflicting a continuing penalty of £10 per day on any manufacturer who exceeded the limit of smoke production. The increased powers held by the Corporation were however in abeyance. As had been pointed out by Mr. Hart, it was useless to expect that inspectors would report offences created by persons upon whose goodwill they were virtually dependent for employment. The Society with which he was connected had on several occasions employed independent inspectors, to show to what extent the official inspectors were failing in their duty, and they had proved that one man could, in a week, report as many breaches of the regulations as the town inspector had reported in a month. The result of the action of the Manchester and Salford Sanitary Association, in the first instance, was an immediate display of activity, the prosecutions for smoke offences increasing from three or four per week to many times that number; but as the requirements of the Corporation increased in stringency, all kinds of excuses were made, the familiar complaint of "interference with trade" doing good service in the interest of offenders. The inactivity of the authorities in enforcing their increased powers caused his Society almost to despair of any considerable permanent improvement. They were, however, directing their attention now to getting gas more generally used for motive power, and for cookery, &c. There was one great obstacle to the supply of cheap gas, as suggested by Prof. de Chaumont, viz., that it would involve laying a second set of mains, which would be a costly undertaking. In Manchester they were already very heavily taxed in connection with the gas supply, the gas department having to contribute £50,000 a year to the Improvement Committee. While that arrangement lasted it was not probable that gas would be so largely used for heating purposes as to call for the laying down of a second set of mains. If, however, Prof. de Chaumont's suggestion could be carried out generally, the smoke question would practically be solved.

Mr. Phené Spiers (London) thought that the size of chimney flues ought to be brought under consideration. Architects and builders were obliged to make chimney flues which were excessively large, even in cases where they were for fireplaces in small rooms. In Paris his attention had been especially called to the small fires maintained in kitchen ranges, the large size of the oven, and the quantity of heat which it was possible to obtain. The flues from the large ranges in France were never more than nine inches in diameter, and were circular in shape, so it was certain we were greatly in excess in the size of the flues used here in England. He was astonished to hear that that question, viz., the size of flues, had not yet attracted the attention of the opponents of smoke production, because it was one of the first things that ought to be attended to.

Professor de Chaumont, M.D., F.R.S. (Southampton). I apprehend that the Act compelling the construction of large flues was in order that the chimney sweeper's boy could go up them. Now that the boy has been abolished, I think the size of the chimneys ought to be altered.

Mr. W. Tattersall (Bradford) observed that in many places of manufacture where gas was used as a motive power, there was a great disadvantage in the smell which was evolved from the gas and

which permeated the whole buildings, so that special apparatus had to be put in to remove it, which would not have been necessary if steam had been used. With reference to the cheapened supply of gas for heating purposes, he remarked that he had lately come in contact with a gentleman who was endeavouring to introduce an appliance for the manufacture of gas by forcing atmospheric air through a certain liquid. If that idea could be carried out it would do away with the objection to lay extra mains for the supply of cheap gas.

Mr. J. Gordon, M.Inst.C.E. (Borough Surveyor, Leicester), said that Mr. Coles had dealt chiefly with the introduction of gas stoves for household purposes. Prof. de Chaumont recognised that in Leicester there was a very clear atmosphere, and he believed that was greatly due to the authorities carrying out the Smoke Abatement Act as fairly as in any other town, but it was also true that within the last year or two, Leicester had taken almost the lead in the introduction of gas stoves. The Gas Committee of the Corporation very wisely sent out pamphlets showing the advantages of gas stoves, the effect of which was that they had been introduced into over 3,000 houses. He should have been glad to hear from Mr. Coles some allusion to the character of the stoves themselves. There was in many instances room for complaint that they produced an unwholesome smell within the house. Then again, he should have liked to hear something about abating smoke in factory chimneys by the most approved construction of the furnaces and boiler fires. He would very much like to see more progress in the direction of improving the furnaces, so that they could get rid of the use of boilers for steam and other purposes, involving necessarily the production of smoke even for so long a period as that allowed by law.

Mr. Coles, in replying, said he had endeavoured in his paper to deal with principles and not with details. He had endeavoured to draw attention to the fact that smoke was injurious, that it could be avoided, and that it would be quite reasonable to put on additional pressure through the law in order to suppress the emission of smoke. With reference to the proper size of chimneys, he said that the area of a chimney should bear a relation to the magnitude of the operation which was to be carried on in the fire-space. He agreed with Mr. Ernest Hart, that they must not rely so much upon penalties as upon enlightened public opinion. He, however, recognised the fact that penalties in many cases were very inadequate, and if coercion was at all used it ought to be sufficiently strong to effect the object of repression. With regard to the price of gas, he said it was open to communities to follow the example of Leicester and acquire their own gasworks, whereby the profits of the undertaking could be utilized for the diminution of the rates or otherwise. The objectionable fumes from gas stoves arose mainly from the mistaken idea that they could use gas for heating and cooking purposes without efficient communication with the chimney. Gas stoves should always be connected with the chimney, so that the fumes could be withdrawn through the flue. Another fact was that many gas stoves burnt what was called Bunsen, or atmospheric gas, which was very liable to be blown out, and a smell was caused by gas coming into the room. It was important when thus burning gas to have the gas jet area properly apportioned to the air supply, and also to prevent the jets "striking back," as it was called, which caused a very unpleasant smell from the gas burning imperfectly. In answer to Mr. Gordon's query, he said that the smoke from steam boiler furnaces could be reduced to a considerable extent, by the use of mechanical stokers of the best construction, if the boiler power was adequate. The reason of smoke in many cases was that the boiler power was inadequate, causing the fires to be unduly forced. By the use of gaseous fuel known as "Producer Gas," instead of crude coal, the smoke from steam boiler furnaces could be entirely prevented.

On "*The Ventilation and Warming of Chemical Laboratories and Applied Science Schools Generally*," by Edward Cookworthy Robins, F.S.A., F.R.I.B.A.

The scope of the work of the Sanitary Institute of Great Britain is an ever widening one, spreading with the growth of general intelligence, and the public realisation of the usefulness of its mission. In my anniversary address, delivered in July, 1882, at the Royal Institution, I endeavoured to point out some of its more obvious aims and uses—incidentally mentioning the fact that "Contemporaneously with the spread of knowledge in sanitary matters in particular, has come a feeling of backwardness in technical education generally, and during the last 10 years, science schools of the character suggested by the conference of the Society of Arts on technical education of 1868 have been built, and are being erected throughout the country, by municipal authorities, as at Nottingham; by trade guilds, such as the City Companies of London and Bristol; and by private benevolence, of which the Josiah Mason College, at Birmingham, is an eminent example."

This year, Sir Lyon Playfair, in his inaugural address to the British Association at Aberdeen, has again brought into prominence the immense importance to this country of the scientific side of general education.

"My argument is," says he, "that no amount of learning *without science* suffices, in the present state of the world, to put us in a position which will enable England to keep ahead, or

even on a level with foreign nations, as regards knowledge and its applications to the utilities of life."

Others have followed Sir Lyon's lead, and enforced the necessity for a more systematic teaching of applied-science in buildings erected for the purpose and suitably fitted up.

In January, 1882, I accompanied Professors Armstrong and Ayrton of the City Guilds' Technical Institute on a tour of inspection of the science schools of Germany, Switzerland, Austria, and Bavaria, and in May following, read a paper at the Society of Arts upon the English and foreign schools and colleges we had visited together, and the systems of education they represented.

The contrast between the provision made abroad and at home for science teaching so impressed me that in 1883, I read a paper at the Royal Institute of British Architects on 'English and Foreign Buildings for applied-science and art instruction,' which I afterwards followed up by papers on the Fittings required for such buildings, and the various systems hitherto adopted for heating and ventilating the same. These studies opened my eyes to the fact that, in comparison with the continent, we may be said to have no professionally recognised scientific system for heating and ventilating *public buildings* in this country, and I resolved to embrace the first opportunity which occurred to introduce to this country the principles in vogue in Belgium and Germany. As a member of the Executive Committee of the City and Guilds of London Institute for the advancement of technical education, I was soon enabled to introduce Mr. Bacon, of Antwerp, to the Architects of the Institute, and the Finsbury Technical College and the Central Institution at Kensington were heated and ventilated by the firm established by him in Antwerp and London. The Yorkshire College was also put into the same hands about the same time.

The method of computation by which the amount of heat required to warm the building itself and the incoming fresh air was ascertained, and the system upon which the sizes of the flues for the extraction of foul air were calculated, are given in full detail as an appendix to my paper "On the Relation of Sanitary Science to Civil Architecture," delivered at the Royal Institute of British Architects, in November, 1880, and in a subsequent paper a full description is given of the various systems adopted for heating and ventilating the three institutions already cited, and also a fourth, viz.: the Merchant Venturers' School at Bristol.

The provocative cause of my writing the present paper on the ventilation and warming of chemical laboratories and of science schools generally is the fact that, through the munificence of the Merchant Venturers' Society of Bristol, I have had the opportunity of realising my own views of the requirements of such schools in designing and erecting the trade and mining school of that city—the whole expense of which has been defrayed by that society. The confidence reposed in me, as their architect, has given me the opportunity I desired of working out a sanitary problem, especially in connection with the heating and ventilation of such buildings.

A tabular statement of what we intended to do, and what we really achieved, hangs on the wall; and I venture to think that the theory and the practice have no need to be ashamed of each other, as we shall presently see.

Perhaps there is no class of buildings in which the application of sound sanitary principles is more important than public and private educational buildings, where large numbers congregate and remain for many hours in confined spaces, occupied all the time in work of an absorbing character, and necessitating in consequence the free circulation and constant renewal of pure, and the withdrawal of foul air.

But, as I have elsewhere shown, in applied-science schools we have not only to deal with the close atmosphere arising from the congregation of many persons in one room at the same time, and for a long time together, but we have to contend against the obnoxious smells caused by the experiments carried on in the various laboratories. The removal of these fumes with the greatest rapidity and certainty is best accomplished when the current of air in the extracting shafts of the ordinary room-ventilation is in the same direction as that of the draught closets and combustion hood shafts on the benches or around the walls. This is so obvious when thus plainly put, that it will be hardly credited that in the majority of cases the reverse is the fact, thus necessitating the closing of the extract gratings for the ordinary room-ventilation, that they may not pull against the extracting shafts from the operating benches and draught closets.

The velocity at which the extraction of the fumes created should take place in the draught closets must not be less than 5ft. per second, or 300ft. per minute. To ensure this draught at a constant velocity, it is necessary to be independent of casual winds and changing temperature as means of motion. This requires the employment of special apparatus to produce either a propelling or a sucking force, of which the latter has usually been a common upcast shaft or lofty chimney flue, either heated at its base by a special furnace, or by the product of furnaces required for steam engines or for heating apparatus.

Neither of these, however, can be depended on for constancy, and therefore the best motive power is a rotary fan, such as Blackman's or Aland's. The rotation of this fan is to be effected by a steam, gas, or electric engine, where water power is not available, which steadily exhausts the air from the air channels, and establishes an upward and outward current in the upcast shaft from the point at which it debouches.

The position in which this extracting fan is placed in the shaft determines whether the vertical air channels shall have an ascending or descending current established within them before reaching the shaft. If placed above the roof level the current will be ascending, and if placed below the basement at the foot of the shaft the current will be descending, to communicate in each case with horizontal channels graduated in size, in accordance with certain formula, until they reach the spot where the fan is situated in the shaft.

Of course it is apparent that a corresponding amount of fresh air, warmed on its entrance in winter and cold in summer, must be introduced through vertical shafts or gratings not fixed in the face of the side walls, so as to preserve an upward current, to replace the bad air extracted.

In summer the room openings or gratings for the escape of the foul air must be at the top of the wall opposite to that through which the fresh air enters; but in winter, if openings are not also provided at the bottom of the room so that the upper can be closed, the warm air will be carried away before warming the room; in either case the air may be pure, because it will never have time to get stagnant, but will always be changing as many times in the hour as may be predetermined, which is usually four times, allowing 700 cubic feet per person per hour.

In chemical laboratories, there are horizontal channels of communication between the extract flues and the operating benches, and draught closets either over or under the floors.

These channels vary in construction, but must be of calculated graduated sizes, proportionately increasing in size with the number of feeders in their length, allowance being made for friction. Those at Finsbury, very carefully laid down by Dr. Armstrong and Mr. Bacon, were of the same depth throughout, but graduated in width, and were formed in the layer of concrete, 8 inches thick, laid over the fire-proof floor of the laboratory, lined with Portland cement, pitched inside and covered with plate glass puttied in; over which were movable iron coverplates set flush with the floor. The wastes from the sinks were carried in similar channels to the outfall pipes. At Munich and Strassburg are asphalted channels for this purpose, and for gas and waterpiping. At the Bristol School these air channels are of wood, pitched inside.

The Finsbury College, the Central Institution, Kensington, and the Bristol Trade School, have all been calculated on the same basis of temperature and volume of fresh air for ventilation, —viz., from 60° to 65° Fahrt. in the class rooms, and 55° in the entrances, staircases, and corridors, during an external temperature of 25° Fahrt., with a ventilation equal in volume to 700 cubic feet per person per hour in the class rooms, and 3000 cubic feet per person per hour in the chemical laboratories.

At the Central Institution, and at the Yorkshire College, steam-heating has been employed. The air is propelled in each of these cases, and the result has been entirely satisfactory.

At Finsbury, high-pressure hot water piping has been used, and the piping has been concentrated in a chamber, through which the fresh air has been forced by a Blackman's fan, and so by vertical shafts in the walls, to the various rooms to be warmed.

Concerning this system of warming, Dr. Armstrong makes the following remarks: "Our experience has shown that the system adopted at Finsbury College is on the whole satisfactory, but several defects have been discovered which are partly inherent in the system, and partly faults in construction. The chief merit of the system of propelling fresh air through a heating chamber by a powerful fan is its simplicity, and provided that the flues are so proportioned as to deliver the exact amount of air required to maintain the various rooms at the proper temperature, there should be no difficulty on this score.

"Although calculated with the aid of Professor Wolpert's elaborate formulæ, we find in practice, by careful test experiments, that the various flues do not all deliver air at just the rate and at just the temperature which is required for the efficient warming of all the rooms, and in some we are overheated and in others under-heated.

"Whether this is due to a misapplication of the formulæ, or to the omission of sufficient allowance for distance, or to the irregularity in the direction or formation of the flues, further experiments will probably reveal.

"The most serious objection to our Finsbury system arises from the fact that ventilation and warming are inseparable; in other words, if the temperature in any room be sufficiently high, and it is required to introduce more air, this cannot be done by the apparatus only, without also raising the temperature. It ought to be possible to admit warm and cold air in varying proportions, or, which is the same thing, to increase or diminish the supply of air, and at the same time diminish or increase its

temperature, so as to ventilate more efficiently while maintaining the temperature constant."

The Josiah Mason College is also heated from a huge basement chamber, without the employment of a fan, with a similar defective result. Therefore, in designing the Merchant Venturers' School at Bristol, I adopted a different plan, the apparent success of which has made me think it worth while to draw the attention of the Congress to it. In this case a direct application of the high-pressure hot water system has been employed, the heating surfaces being distributed along the external walls of every floor of the building, and concentrated in coils placed in slate-lined chambers in the window backs behind the oak dados; the fresh air passing through them by external gratings with internal iron regulating valves working in grooved frames—while the fan is used as an extractor instead of a propeller—so that the fresh air is drawn in through the coils by the suction of the extract shafts, in which the air is exhausted by the action of the fan.

To make this understandable, it will be desirable to refer to the plans which illustrate the building, and the following is the brief description which appeared in the pages of the "British Architect," at the time of the opening by Sir Frederick J. Bramwell, the President of the Institution of Civil Engineers, and Chairman of the Council of the City and Guilds of London Institute for the advancement of Technical Education, in July last. The temperature of the great hall, within which the crowded meeting was held, was considerably below the external temperature, and the variation of temperature within the hall did not exceed 1° Fahrt. during the whole of the protracted meeting, nor did it rise above 71° Fahrt.

"The Merchant Venturers' School, Bristol."

"The building is in the 14th century Gothic style, and is faced with red bricks with Bath stone dressings. It is situated in the rear of College Green, having one frontage in Union Street, and the other in Denmark Street, forming a handsome corner edifice, which it is hoped ere long will be extended to College Green, after the removal of the old houses which now conceal it from view in that direction.

"It is four storeys in height, and the lofty topmost storey is devoted to science teaching; the laboratories and their associated rooms follow one another in order, commencing at the S.E. angle we have the chemical lecture room, between which and the chemical class room is the preparation room with large glazed fume closets in the walls behind the Professor's tables, communicating with the intermediate preparation room. Then comes the special balance room, between which and the special operations room and the gas and water analysis room is the head master's room, occupying the N.E. angle of the building. Beyond the gas analysis room is the general chemical laboratory for upwards of forty students, operating benches overlooked by the demonstrator's table on a platform with large and small draught closets and other fittings along the walls and benches.

"Opening from the western end of the large laboratory is the combustion room, and the north lighted general balance room.

"On the southern side of the central corridor is the metallurgical laboratory, with its wind and muffle furnaces and lofty chimney stacks sustained on arches rising on piers brought up from the basement. This room has a fireproof floor.

"Next comes the physical laboratory and lecture room adjoining. The upper part of this central corridor is thrown into these southern rooms, and forms an effective gallery reached by a special staircase.

"The first floor contains the engineering, drawing, and lecture rooms, and a series of general school class rooms, entered from the side gallery of the great hall, beyond which is the art drawing school at the north-west corner, over the caretaker's quarters.

"The ground floor contains a similar series of class rooms, entered from the arcade of the great hall or examination room, there being no closed corridor, in accordance with 'the hall passage system' recommended by the architect in his paper read at the Society of Arts on 'Secondary School Planning.' This hall is a striking feature in the building, its dimensions being 80 feet long by 44 feet wide and 26 feet high. It has a fine arcade of Portland stone shafts and arches on one side, and a series of fine lofty mullioned windows opposite, with an elaborately designed and skilfully executed oak roof, geometrically panelled with double sunk circular cusped ribs and boarding rising from fan-traceried pendants, richly moulded main timbers, and variously carved bosses, which with its pierced side and end gallery fronts and high dado of oak panelling all round, its red pressed brick and Bath stone banded walls, altogether produce a remarkably handsome 'tout ensemble.' The acoustic properties of the hall are excellent. This floor also contains the reception and waiting rooms, and the library and museum facing Denmark Street.

"The basement floor contains the main entrance gateway leading to the principal massa carrara marble staircase, with its marble mosaic landings and passages, which rises to the topmost floor of the building. The boys' fireproof staircase is at the other end of the building next the caretaker's house in Unity Street. On this floor is the dining hall and cloak-rooms (one for each class room) through each of which access is given to the covered and open playgrounds, at the ends of which are the lavatories and conveniences, which last, with the drainage and plumber's work generally, combine all the latest and most approved sanitary appliances. The remaining rooms next Denmark Street are intended for workshops and gymnasium. The massive basement walls having to descend to the rock for a good foundation, extensive and very lofty wine vaults have been constructed as a sub-basement under the major part of the building.

"The singularly complete series of fittings throughout, have been partly executed by Messrs. Brock and Bruce, of Bristol, the general contractors, and partly by the North of England School Furnishing Company. Messrs. Hodkinson and Clarke provided the lift, with its special safety self-closing door arrangement."

With this general description of the building as a whole, we shall better comprehend the heating and ventilating arrangements so carefully worked out and ably executed by Messrs. Bacon.

1st. *The Heating Apparatus.*—There are two coil furnaces pyramidally set in brickwork; half of the wrought iron hot-water piping proceeds from one furnace, and half from the other. Both furnaces will only be required in very severe weather, when it will be in the power of the stoker to raise the heat considerably above the temperature stipulated.

This building is one of the first to which high pressure wrought-iron pipes have been applied, the external diameter of which is $1\frac{3}{4}$in., instead of the usual $1\frac{1}{4}$in.; and it has been found to be equally manageable, reducing the length of pipe required in proportion to the larger convecting surface obtained.

There are six separate circulations from each of the two furnaces, by which expedient the return pipes are kept at a high temperature. The heat is concentrated in the coils of various calculated sizes enclosed in slate cases, so that the oak dados may be continued round them. The coils are situated in the window backs, and the two flows and two return pipes leading to them are covered with asbestos cement and give out no heat, harmlessly passing behind the plinth of the dados, so that the system of heating is invisible, though at all times get-at-able. Each coil is thus entirely under the control of the master present, in whose desk is the key which opens and closes the valves or disconnects the hot-water coils. For observe, each coil may be separately cut off from the general circulation without interrupting the flow elsewhere, or it may be but partially opened, as the temperature may demand, by turning the three way stop-cocks provided more or less fully on.

To prevent accidents by frost, the pipes are filled with a non-freezing solution of chloride of calcium, and the fresh air is freely admitted at all seasons of the year and passed through the coils at pleasure by the opening or closing of the valves over the gratings for the admission of cold air. To ensure its being well-heated on its entrance, the air is conducted in its passage through the coils over horizontal baffle plates, and so into the room, with an upward current, through the iron grating let into the window boards over the slate coil casing referred to.

The regulation of the exact amount of heat desired for each room, and the cutting off of any room or rooms not requiring to be heated, is achieved in this way, while the purity of the incoming air is preserved and the supply given independently of the heating apparatus, with which, however, it may be immediately associated.

2nd. *The Ventilating Apparatus.*—In every room there are at least two extract ventilating gratings opening into the flue or vertical shaft in the thickness of the wall, of calculated area, within which a descending current of air is provoked by the action of an Aland's fan, turned by a gas engine, which is competent to deliver a million and a half cubic feet per hour. These vertical wallshafts are connected with a collecting horizontal channel of calculated dimensions, situated under the whole length of the central basement corridor floor, and is in direct communication with the fan placed about 10 feet up the exhaust shaft. The upper of the two extract gratings in each room is for summer ventilation, and the lower is for winter ventilation.

A special wall-shaft communicates with the large chemical laboratory, and the various fume closets and operating tables, all of which are pitched inside, the air being drawn through them at the rate of 300 feet per minute. From every part of the building the air is changed about 4 times in the hour, the provision being generally 700 cubic feet per person per hour.

I think we may now say that Dr. Armstrong's suggestions have been met in the present instance. It may, however, be thought that so much ventilation would produce draughts, but the contrary has been the result. During the testing, to which I will presently refer, I threw my handkerchief against one of the class room wall extract ventilators and it stuck there, the pull overcoming its weight; but I found by applying the anemometer to the orifice, at a distance of only 12 inches, there was not sufficient draught to turn the wheel of the instrument.

I have only now to draw your attention to the table of results obtained, which I have caused to be placed on the walls. I think they fully justify my commendation of the system employed. In spite of my endeavours to get this tabular statement complete in time for the Congress, I am only able to give the *first trial before any adjustments or corrections have been made*, but the result of the comparison between the theoretical statement written in black ink, and the practical result written in red ink, shows that whereas 1,209,734 cubic feet per hour was proposed to be extracted from 21 of the rooms, 1,259,900 cubic feet per hour has been realised.

In the Great Hall 350,000 cubic feet were to be extracted in the hour, really 331,000 are extracted; the 8 class rooms were designed to extract 35,000 cubic feet per hour, and upwards of 41,000 cubic feet are extracted; the Chemical Laboratory, at 3,000 cubic feet per person, was to have 120,000 cubic feet per hour extracted, really 123,900 cubic feet are withdrawn in the hour.

Greater variation in detail takes place in other rooms, but these are capable of adjustment. The power of adjustment exists and will be exercised till the theory and practice coincide, Messrs. Bacon having staked their credit upon the ultimate success throughout.

Mr. H. Saxon Snell, F.R.I.B.A. (London), opened the discussion on Mr. Robins' paper by remarking that the building just described was apparently as unique in the completeness of its details as were all other buildings of a similar kind designed by Mr. Robins. The only point where he should fear failure was in the methods adopted for heating and ventilating the various rooms. The former was described as a system of heating by hot water, but it was in reality steam—compressed steam—and in England this was very generally condemned. What he feared, from Mr. Robins' description of the ventilation, was that sufficient heat had not been provided; for, as he understood it, the openings into the outlet shafts were situated in the upper and the lower parts of the room, but the upper outlets could only be used when the room had become sufficiently heated. It was a mistake that this necessity should exist for closing these upper outlets, for, in order that we should be prevented from re-breathing our foul exhalations, it had been ordained that they should leave our bodies at a higher temperature than the surrounding atmosphere, and so rise into the air above, and there become purified. But, during the time of insufficient heating, and when therefore the top ventilators of this building were closed, these foul emanations would rise towards the ceiling and then necessarily descend towards the outlets situated near the floor level; and so, passing by the breathing apparatus of the occupiers of the room, would wholly or partially be again drawn into their lungs. Mr. Robins had said that the air being drawn away from the room at the rate of 700 cubic feet per hour, the residue was pure; but if he had read Prof. de Chaumont's works rightly, it would be necessary, to ensure purity, that a much larger quantity per hour should be removed than 700 feet. He understood Mr. Robins to say that the anemometers employed in determining the rate at which the air was removed had not been tested, and therefore the results could not be looked upon as reliable.

Mr. Rogers Field, M.Inst.C.E. (London), said he had had a great deal to do with testing anemometers, as a member of the Cowl Committee of the Sanitary Institute, and had found the ordinary instruments to be incorrect. The committee went to the fountain head to buy instruments, and ordered them to be made as accurately as possible, but after being submitted to very careful tests the readings of the instruments (after applying the corrections supplied with them) were found not to be accurate. The tests were carried out by means of an experimental gas holder, only with air instead of gas, and then by drawing the holder up, or sending it down a certain distance a known quantity of air was forced through the instrument, and thus the actual velocity of the air passing through the instrument was ascertained and accurate corrections were deduced.

Mr. Ernest Day (Worcester) observed that heating and ventilation was a subject upon which a large number of theories were promulgated, and very often these theories did not in any degree answer the expectations of those who advanced them, therefore it was a matter of congratulation that Mr. Robins' experiment had been so satisfactory. With regard to the passage of air through hot water coils, he thought from practice the principle was a decidedly correct one, and the result of Mr. Robins' ingenuity upon this and other sections of the work carried out must be very gratifying. His experience had led him in favour of carrying off vitiated air from the upper part of a room. He had tried the lower part of a room and could not say that his experiments had been very successful.

Mr. W. R. E. Coles (London) said the method of heating adopted by Mr. Robins was doubtless a satisfactory one, because heat could be obtained from furnaces burning coke or other smokeless fuel, which was a great advantage. The system was also one that lent itself readily to methods of ventilation. With regard to the correctness of the tables submitted by Mr. Robins, based upon tests by the anemometer, so far as he (Mr. Coles) was able to remember the variations which Mr. Field and Mr. Snell had referred to as being found in the working of wheel anemometers, the mean variation was

substantially very small indeed. It would only be equal, in the case of some of the chief rooms mentioned by Mr. Robins, to something under 200 cubic feet of air; and, therefore, the correctness of the instruments was not an important factor in the consideration of Mr. Robins' plans. He (Mr. Coles) said that he must take exception in the most emphatic manner to Mr. Snell's and Mr. Field's wholesale denunciation of wheel anemometers. Those instruments had been used very largely by the Smoke Abatement Committee and others in testing fire grates and furnaces of various kinds, and it was found that the anemometers gave results consistent with the calculated velocity of air currents due to chimney levity. Thus there was a check upon the register of the anemometers, and though he did not say that they were absolutely accurate, he did say that wheel anemometers of good construction, properly corrected and properly used, were very useful and fairly reliable instruments for measuring the velocity of aerial currents.

Mr. D. Emptage (Margate) said the discussion had brought out, very clearly, the fact that there were great variations in the results given by different anemometers, and it would be very useful if some reliable information could be obtained respecting them. Some years since a committee was appointed for the purpose of testing cowls. Those gentlemen had given the question of anemometers a very large amount of attention, and were therefore in possession of valuable information respecting them, which he hoped they would shortly lay before the public.

Prof. F. S. B. F. de Chaumont, M.D., F.R.S. (Southampton), said that the difference in registration of the anemometer appeared to be considerable according to Mr. Snell. He would, however, modify the inference to be drawn from that by saying that if that error were constant, as they might presume it was, the error was not very material in considering Mr. Robins' figures, because if the instrument registered wrongly in one case it would do so in another; still, for the purposes of comparison, the figures might fairly hold good. With regard to the action of the Cowl Committee of the Institute, it was only when that Committee started that it was discovered what a large and important question came before it. The labours of that Committee were brought to a standstill from the fact that they found anomalies which could not be corrected in any visible way, and they were driven to the point that the anemometers themselves must be exhaustively tested. Mr. Snell made an ingenious apparatus by which he ascertained the actual error of the anemometer, but it became perfectly evident that the funds which had been collected were totally inadequate to carry out the extensive enquiry, and the Institute was not in a position to advance funds. Funds, however, had since been provided, and he believed the labours of the Committee were approaching completion, and they were in hopes that their report might soon be ready for publication. He need hardly say that when it did appear, it would be the result of a most exhaustive enquiry. With regard to the paper read by Mr. Robins, the subject of ventilation was always a difficult one, and the ingenuity of professional men was often sorely taxed. As to the question of taking foul air out at different altitudes, he thought the upper part was the natural point from which it should be drawn. In one well-known system, that of the model prison at Pentonville, the plan was followed of taking the foul air out at the bottom of the prison cells, and letting in fresh and warm air at the top. He made a careful examination of it and found that the plan was not satisfactory. Ventilation as an art was very much in its infancy, and one of the great difficulties which was to be overcome was the number of angles which it was necessary to introduce into the shafts. They must remember that every time they bent a shaft at right angles they diminished the current through it by one half, and of course every other angle would be in a proportionate degree affected, which could be stated in a mathematical formulæ, although it was not worked out at present. The paper said that the air was to be changed four times per hour; if so every person could only have 175 feet of air. When Mr. Snell referred to his (Prof. de Chaumont's) own writings on the subject, 3,000 cubic feet of air was recommended as the proper amount; that chiefly relates to dormitories, and to the condition of things when people were asleep. But in the case of rooms where people meet for a short time, although it would be highly desirable to have that amount of air, yet the difficulties in the way of that amount were practically insurmountable. It was shown that practically speaking the atmosphere of a room became in the uniform condition of permanent occupation after two hours, *i.e.*, if people remained more than two hours, it was the same as though they had remained twenty hours. The amount of impurity did not change, given that the amount of air supply was continuous. When they brought people together in a room, the difficulty of giving the amount of space to allow such a quantity of air was really insurmountable, therefore they were obliged to be content with a smaller amount of air, not that they thought it a desirable thing, but simply on account of the impossibility in practice. The question arose whether they could accept a lower standard of purity for temporary assemblies of people, or must they insist upon the standard for first-class ventilation. Arranged as matters were it was almost impossible to obtain that, so they must be content with a smaller amount of air, so the objection on that point was not so stringent as the statement of Mr. Snell would seem to indicate.

Mr. E. C. Robins, F.S.A. (London), in replying, said he hoped that the time was not far distant when they would know the results of the experiments of the Cowl Committee. Particular care was taken, on his part, and by Mr. Bacon, to ensure the accuracy of the figures he had submitted to them, which were the result of the first few days' testing; and he was bound to say that they were of value in connection with that subject, as showing theory and practice contrasted. He thought many of them must have forgotten that all the rooms

referred to by Mr. Snell were ventilated at the top, as he advocated. But they were also capable of being ventilated at the bottom, so that if the upper ventilators take away the heat too rapidly in winter, provision is made for a change by carrying the shaft down to the floor; so that the upper gratings may be closed, and the extraction take place through the gratings near the floor. He thought he had shown that he had sufficient heat, and for the most part of the year would require but one of the boilers: it was not want of heat, but proper circulation that had to be met, because he did not want to waste heat. He believed they heated their rooms too much, as a rule; and though he advocated artificial appliances in special cases, he most delighted in open fire radiation, in spite of the Smoke Abatement Society. Prof. de Chaumont had remarked on the practical difficulty of realising theoretical perfection. But though the entire space allowed for each of the fifty scholars in each class-room was small, yet 35,000 cubic feet of air was passed through them in the hour, which, divided by 50, gave 700 cubic feet per person per hour, as he (Mr. Robins) had said; and he was glad to find Prof. de Chaumont considered it sufficient.

On "Plumbing and Plumbers' Work," by Frederick Scott.

A movement has recently been inaugurated by the Worshipful Plumbers' Company of London, which may well claim the attention of the Congress and the hearty support of the Sanitary Institute of Great Britain. Its object is to raise the status of plumbing as a craft, and thus promote in the interests of the public an improvement in a class of work upon which health so largely depends. It is not asserted that all plumbers' work is now-a-days of an inferior quality; on the contrary, it is admitted that more good work is now done than at any former period, but most householders can, from sad experience, testify to the fact that inferior or "scamped" plumbers' work prevails to a very considerable extent. For the information of those who are so fortunate as not to have had any direct experience of bad plumbing, I would mention a series of illustrated articles on "Defective Plumbing" by Dr. Francis Vacher, the Medical Officer of Health for Birkenhead, now appearing in the *Health Journal* of Manchester. Here we have cases of the most atrocious character described, vouched for by Medical Officers of Health and others as coming under their notice almost daily.

In October 1884, the Plumbers' Company held a Conference at the Health Exhibition, and the decisions then arrived at are, shortly stated, as follow:—that the evils now experienced from bad plumbing are substantially traceable to four causes: 1st, the identity of the plumbers' craft being, to a great extent, lost or obscured through the merging or the amalgamation of the various branches of the building trade, houses are now built in large numbers without any sufficient definition of the plumbers' work, and the natural consequence is that it is done "anyhow" and by persons who are not really plumbers. Though it may perhaps not only be necessary but desirable that plumbers' work should be done by builders, it is still essential that the identity of the plumbers' craft should be preserved as a distinct craft. 2nd, The system of apprenticing lads for a term of years to learn the trade has fallen off to a great extent, and in consequence there is a great influx of men who are not properly qualified plumbers. 3rd, That while there have been considerable changes in the character of some of the materials used in plumbing work, the standard qualities of such materials have not been determined by custom or the general assent of the trade, and the result is that there is much uncertainty as to the selection of material, and much that is unsuitable is used. In former years when lead and solder were chiefly used in plumbing work, they were assayed and stamped by the Plumbers' Company to define the value, not only as a safeguard against fraud, but as a convenience and an advantage to traders tendering to do plumbing work, and to persons ordering it. 4th, The public regulations which deal with certain details of the construction of new houses and their connection with the public sewers, do not sufficiently recognize the importance of securing the efficiency of the plumbers' work done in those houses. To meet as far as may be these several evils, it is obvious that public knowledge and public interest in the subject must be enlarged, and it is equally obvious that it would be quite impracticable for any mere organisation of plumbers to carry out single-handed the necessary reform. With a view to remedying this state of things the Plumbers' Company have formed a Committee embracing plumbers, architects, engineers, builders, sanitarians, representatives of institutions for technical instruction, and of societies for the promotion of sanitary reform, and others who from their known sympathy with the object in view, and their connection with the legislature or municipal bodies, can help to forward the work. Only one meeting of this council has yet been held, when the following resolutions were adopted, viz: That the Plumbers' Company be requested to establish a system of Registration of Plumbers of the City of London, and within a circuit of seven

miles thereof. The Register to include master plumbers and journeymen. The Register to be open to the admission of those who satisfy the Court of their qualification by either of the following means: 1. Evidence of present status and experience in the trade. 2. Examination by Boards of Examiners composed largely of practical plumbers appointed for the purpose by the Court. 3. Production of Certificates of Competency granted by the Plumbers' Company and the City and Guilds of London Institute, due weight and consideration being given to the production of indentures of apprenticeship. That the Court reserve the right to remove names from the Register in cases of proved misrepresentation, or other gross misconduct injurious to the trade and the public. That plumbers admitted to the Register be authorised to use the letters R.P. (registered plumber) after their names. That it be remitted to the Plumbers' Company to adopt such working arrangements in regard to the Registration, and the public announcement of names and addresses of persons admitted to the Register as may be found most agreeable and convenient to the trade.

The consideration of the organisation of provincial boards of examiners of plumbing work and other business was postponed to another meeting.

In connection with the arrangements for Registration, provision will be made for instruction in plumbing at Technical Schools, similar to what has for some time been included in the curriculum of the City and Guilds of London Institute, whose Plumbing examination papers, as published in some of the sanitary journals, indicate that great thoroughness of training is required from students. In the prospectus of the Manchester Technical School for the current year the notice relating to Plumbing Classes is as follows: "The course of instruction is intended to meet the requirements of apprentices and young journeymen who desire to obtain a knowledge of the principles of their trade, and will be fully illustrated by drawings, examples and experiments. The theoretical instruction will be supplemented from time to time by practical demonstrations in the laboratories. During the session 1885–86 it is intended to deal with the following subjects: —properties, qualities, uses and manufacture of the various metals and other substances used in plumbing. Action of water, air, gas and acids upon various metals. Theory and practice of soldering. Tools used in Plumbing. Gas and Water fittings and meters. Methods of testing pressures. Sanitary arrangements. Methods of testing water and other closets. Water supply. Roofing. Rain drainage of houses. External work."

The Manchester and Salford Sanitary Association, recognising from the outset the great importance of the work undertaken by the Plumbers' Company, arranged for co-operation with that body as its plans should be developed, and all now bids fair for at least one important provincial centre keeping abreast of London in this useful work. Another important feature in the scheme of the Plumbers' Company is the inspection of plumbers' work in new houses, thus completing the system of protection of the public against inferior work. Besides Manchester, Leeds, Leicester, Birkenhead, Dublin and Gloucester are represented on the Council organised by the Plumbers' Company, and the list may be indefinitely extended; thus it may be regarded as only a matter of time for the movement to permeate the whole country. The more speedily it does so the better for the interests of the public health, and on this ground it is not out of place to bespeak for it the influential support of the Sanitary Institute of Great Britain.

Mr. D. Emptage (Margate) opened the discussion by remarking that he thought very great credit was due to the Plumbers' Company for the efforts they were making to improve the trade and protect the public from the evils arising from bad plumbing. At the same time he did not think that registration only would satisfactorily effect that object. He could see no reason why a plumber could not scamp his work as easily after as before registration. Bad plumbing arose from three sources: (1) the incompetent workmen; (2) competent workmen wilfully doing bad work; (3) the present system of competition, and the demand for cheap work. He hoped the Plumbers' Company would carry out their original programme, and not relax their efforts until legislation has been obtained, by which the public would be effectually protected. In America there was a very strong plumbing law in operation; only very recently a jerry builder there was sentenced to nine months' imprisonment, in addition to a fine of 2,000 dollars, for a flagrant violation thereof.

Mr. W. R. E. Coles (London) said he thought that the incompetency mentioned by the last speaker would to some extent be remedied by the spread of technical education, and the execution of bad work would be checked in some degree by the fact that registered plumbers would be liable to removal from the register in cases of wilful bad work. He further said, he thought it was all-important that a body of position and repute like the Plumbers' Company should come forward to represent the plumbing trade and initiate measures of reform.

Mr. E. C. Robins, F.S.A. (London), as a member of the Executive Committee of the City Guilds of London Institute for the advancement of technical education, said it was greatly to be regretted that plumbers had ceased to be masters in the sense of having pupils in whom they took an interest; but he hoped that plumbers would continue to take an interest in the young men apprenticed to them. A cause of bad plumbing was doubtless the low prices which existed in consequence of competition, and masters did not give themselves the trouble to see that the details of their work were properly executed. He could not help thinking that the new association was calculated to be of enormous advantage, if properly organised and developed; but if it was worked only in the interest of the masters, and to get rid of the necessity of taking and teaching apprentices, he hoped it would fail.

Prof. F. S. B. F. de Chaumont, M.D., F.R.S. (Southampton), said the question certainly struck at the root of the greatest part of domestic sanitary work, which was at the root of all sanitation and health. The stories of scamping plumbers were infinite; and the speaker caused some amusement by relating an anecdote showing the careless way in which some workmen performed their duties.

Mr. F. Scott (Manchester), in replying, said he agreed with Mr. Emptage that there was need of stringent legislation. If they found a man attempting to pick a pocket, they gave him in charge of a policeman; and that a man should be permitted to endanger knowingly the lives of a whole household, by bad plumbing, seemed incredible.
