

Some observations on our present methods of disposal of human excreta, and their relation to the spread of epidemic disease : being a paper read to the Glasgow Philosophical Society, 30th March, 1881 / by Eben. Duncan.

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SOME OBSERVATIONS
ON OUR
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SPREAD OF EPIDEMIC DISEASE:

BEING A PAPER READ TO THE GLASGOW PHILOSOPHICAL
SOCIETY, 30TH MARCH, 1881,

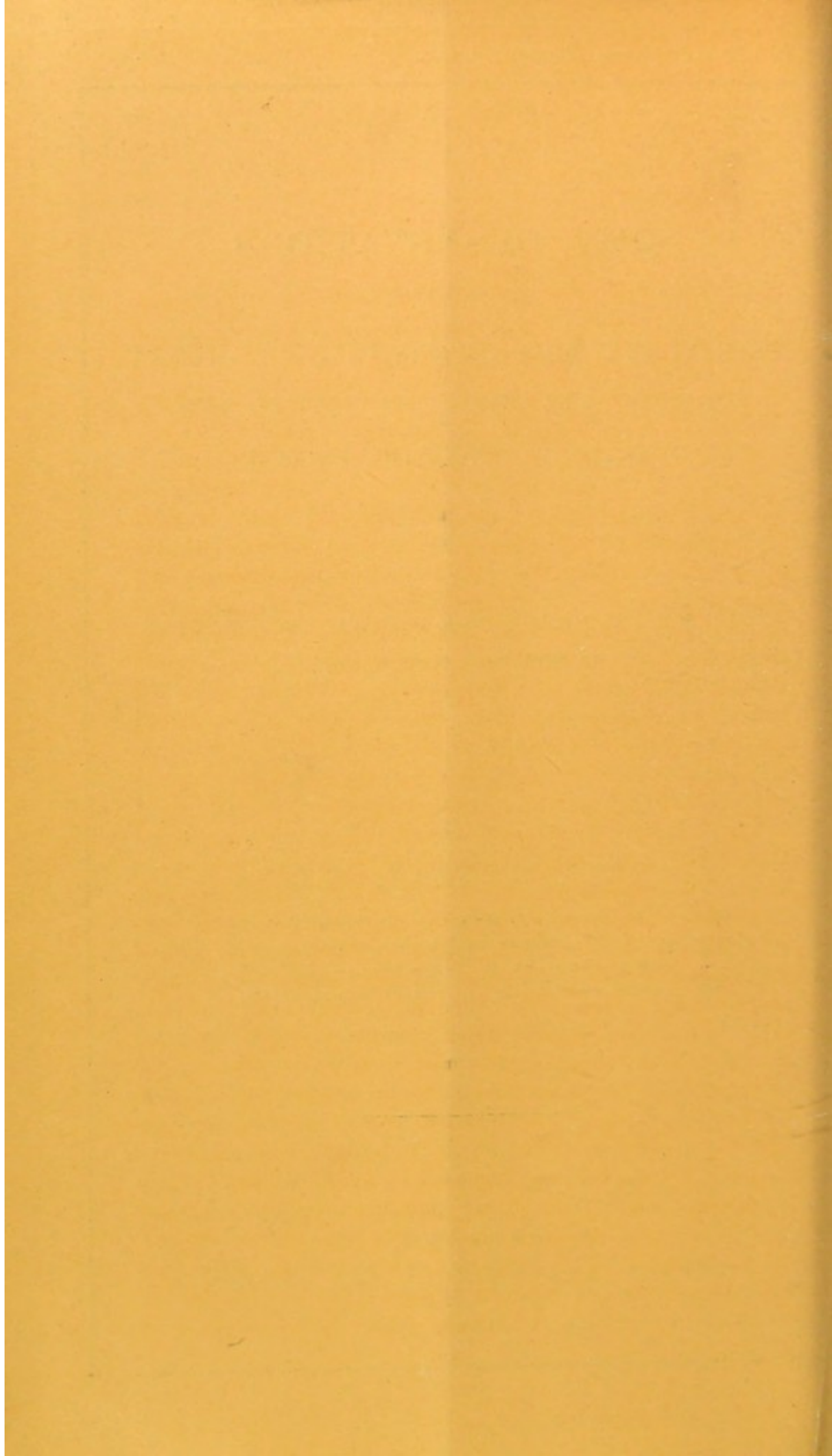
BY

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1881.



Some Observations on our present Methods of Disposal of Human Excreta, and their Relation to the Spread of Epidemic Disease.
By EBEN. DUNCAN, M.D., F.F.P.S.G.

[Read to the Society, 30th March, 1881.]

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IF the recommendations of the last deputation of the Glasgow Corporation, which reported upon the question of sewage disposal, are carried out, the excreta of the vast population of this city will continue to be disposed of as at present—about one-half by the dry method and one-half by water carriage. Looking at the matter purely from the point of view of a sanitarian, the modifications of existing methods, which they recommend, only affect to a very limited degree the sanitary problems which we have been discussing for so many years.

It is now well known that the most dangerous constituents of our organic refuse matter are human excreta.

Most of the common forms of epidemic disease—such as measles, scarlet fever, typhus fever, and small-pox—are known to be spread through the atmosphere. Although it may be true that, by dust collected in the houses of such patients, by water in which their persons are washed, or by the rags of clothing which they have worn, the germs of these diseases may gain access to the ashpit, manure heap, or sewer, yet up to the present time very little evidence has been adduced which connects outbreaks of these diseases with any of our ordinary methods of sewage disposal. Of all the epidemic diseases with which we are familiar, the one which has been most conclusively traced to air or water tainted with human excrement is typhoid fever. It is now proven most conclusively that the fever is propagated by the alvine discharges of those who suffer from it. Their poisonous effects are as clearly established as the poisonous properties of arsenic or strychnine. Wherever the drinking water of a community becomes tainted with these discharges, the fever appears. The investigations of the last ten years have all tended to prove that an outbreak of

typhoid fever cannot arise in the absence of specific germs. Whether these germs are living or dead does not matter : they are derived from some pre-existing case. The old notion was that all forms of fever might arise *de novo* from the noxious vapours of decomposing organic matter. At the present time, noxious vapours of this description are only credited with the origination of typhoid fever and diphtheria. When the water-closet system was introduced into this country, going upon the old notion of bad smells breeding fever, every outbreak which happened in a water-closet town, the cause of which could not be easily ascertained, was attributed to bad smells from our sewers. And so arose the sewer-gas theory of the propagation of epidemic diseases. To this sewer-gas theory, which is a very popular one in the city of Glasgow, I wish first to direct your attention in the observations which follow.

It is very important that we should have all the light which careful observation can throw upon the possibilities of disease propagation by sewer gases, because, while the deputation already referred to recommend various measures for the precipitation of the sewage, and for the inspection of the drains and soil-pipes of houses to be built in the future, the water-closets and drains of existing Glasgow and its suburbs are left unchanged, and the masses of the people will be still as much exposed to the inhalation of sewer gases when these recommendations are carried out as they now are.

The late Dr. Murchison, of London, may be held to be the author of the modern view as to the propagation of typhoid fever by sewer gases. He published an essay in 1858, in which he endeavoured to prove that typhoid is the only fever which arises from sewer emanations. It is a well-known fact that the mere smell arising from the recent liquid discharges of the fever patient does not communicate the disease ; and it is also a well-known fact that there are many trades in which numbers of men work daily with decomposing organic matter, and are subjected to the most noxious smells, without contracting fever of any kind. In order to account for these difficulties, he asserted that the poison of typhoid fever was only generated during the decomposition of faecal matter in a confined space, such as a drain or sewer in a state of stagnation. In the absence of any better explanation of the outbreaks of typhoid which occur in cities, the water supply of which is derived from pure sources, these views, first promulgated by Dr. Murchison, have been

generally adopted. I shall quote a few extracts from various publications to show how strongly they are expressed at the present time. In a report to the Privy Council, Mr. J. M. Radcliffe states, "That the condition chiefly productive of diarrhoea and typhoid fever exists in its most dangerous form in improperly constructed and arranged and imperfectly acting or stagnant sewers containing excrement." At the conference on the Health and Sewage of Towns, held in 1878, Dr. Elliot, the Medical Officer of Health for Carlisle, concludes a paper on the dangers arising from defective soil-pipes and water-closets thus:—"The mention of a great and realised fact I may emphatically conclude with. It is this. That typhoid fever prevails pre-eminently more amongst the wealthier classes who have water-closets within their houses, than amongst the humbler classes who have outside closets." At the same conference, Mr. C. N. Cresswell expresses the popular view of the matter in the following still more emphatic but very erroneous statement:—"The system of sewage disposal by water carriage has produced a fresh type of zymotic disease, traceable to sewage sources, but especially to the vicious construction of houses, whereby typhoid fever is laid on with the same precision as hydro-carbon gas for the purposes of illumination. Dr. Murchison has distinguished this new revelation from its prototype typhus, and Dr. Fergus has proved abundantly that in Glasgow, where it has raged at intervals from the year 1836, it arose from a badly constructed system of flushing by water."

Of all those who have laboured to point out and remedy the defects of our water-closet system certainly our esteemed ex-President, Dr. Fergus, occupies the foremost place. By his discovery of the frequent perforations in our leaden soil-pipes, and by his numerous publications on the multifarious defects of our house drains and sewers, he has certainly done a great service to the cause of Sanitary Science. But what we are concerned with in this inquiry is his reasons for connecting the prevalence of typhoid fever in Glasgow with these defects of sewerage. In a paper on the Sewage Question, published in 1872, having shown that all modern investigations agree in tracing outbreaks of typhoid fever to excremental pollution, he says—"In most of these cases the water was befouled, but, as this is a well-known cause of disease, and has been so amply proved, I shall not dwell upon it, but rather enter upon another source of typhoid and other zymotic diseases which is not so well known . . . perforated soil-pipes . . ."

After describing these and their causes, he goes on to say, "for some years back I have insisted on a careful examination of the soil-pipes wherever I have had cases of typhoid fever or diphtheria, and in every case where I could get this carefully carried out I have detected these perforated soil-pipes. What first led me to connect this state of the soil-pipes with disease was the fact that, as regards water supply, Glasgow should not be exposed to diseases resulting from excremental pollution; and if we have these diseases, we must attribute them to some other source." At that time Dr. Fergus adhered to Dr. Murchison's theory, stated above, and concluded that these cases were caused by gases generated from decomposing fæcal matter in the sewer gaining access to the houses through these perforated pipes. The same opinion, modified by the germ theory of disease, was expressed by Sir Thomas Watson in a recent number of the *Nineteenth Century*. He writes thus:—"During the prevalence of enteric fever in a large town a vast quantity of the dejections peculiar to that disease must be daily and hourly poured into and through the drains and sewers, impregnating the sewer gases with the specific poison. In our present faulty arrangements these gases, so infected, enter many a house, the inmates of which are unsuspecting of such a source of fearful peril. Mr. Rawlinson, the well-known engineer, has stated in print that in the year 1859 disinfectants were freely used in some of the main sewers of London, and 'the smell of the disinfectants was found to pervade all the houses in the district connected by drains with these sewers, showing to demonstration that such houses must, at all other times, be pervaded with diluted sewer gases.' Wherever (writes Dr. Budd) the alvine discharges from enteric fever patients travel—wherever exhalations from them penetrate—there the most specific of all the exuviae of the sick body are in operation. *The sewer, which is their common receptacle, is the direct continuation of the diseased intestine.*" Looking at these statements, my first observation is, that if, with gases from sewers containing typhoid excreta, swarms of disease particles were really pouring into our houses at every crack or perforation in our soil-pipes, the result would have been disastrously different from what it has been in water-closet towns, as compared with country districts, which have no water-closets. Dr. Russell informs us that in Glasgow the greatest amount of typhoid fever, in proportion to the population, is found in small houses with no sewer connections whatever, and that, both in respect of typhoid

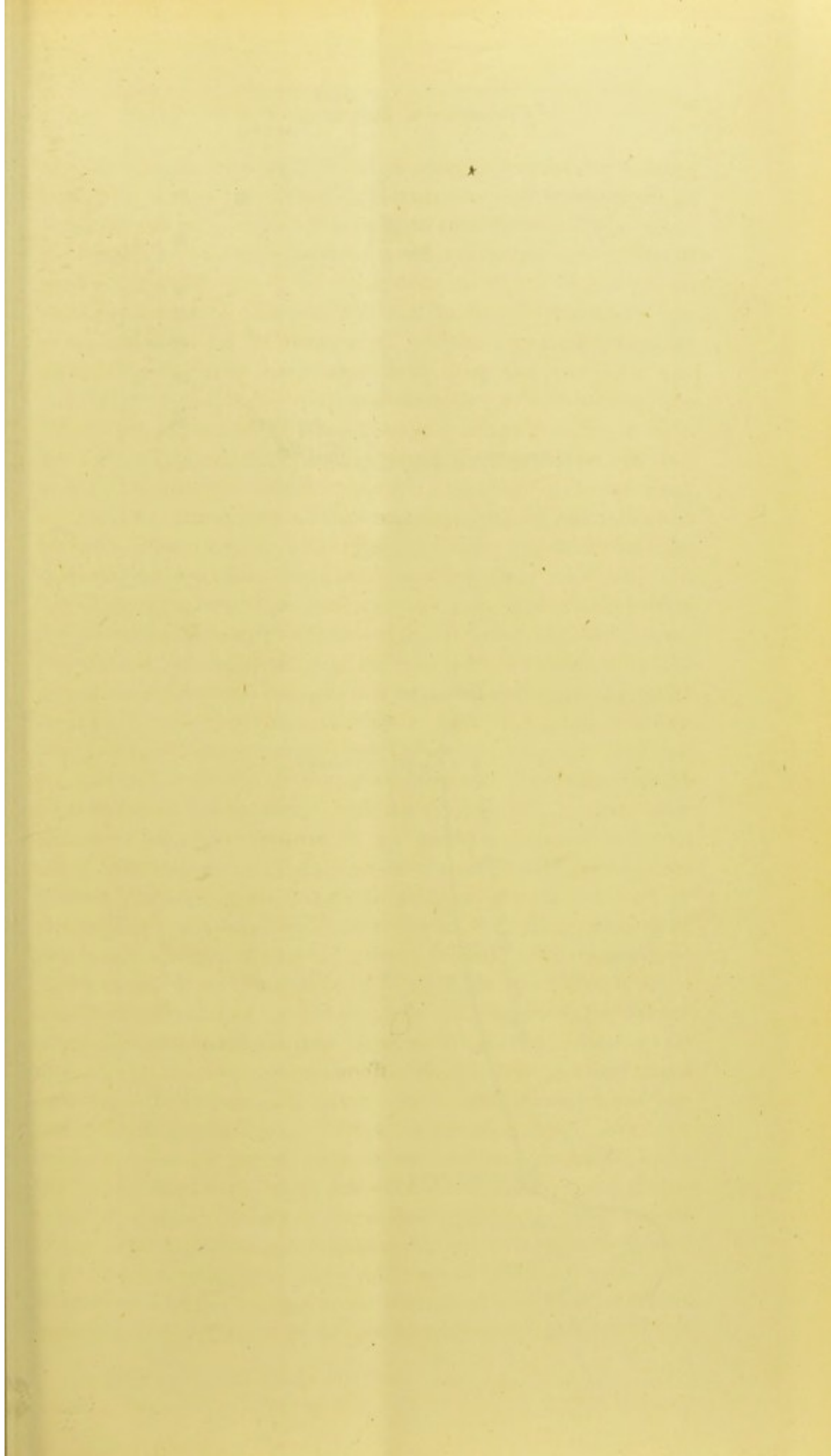
fever and diphtheria, we compare very favourably with the rural districts of Scotland. Another theoretical objection to the above views has arisen in the minds of those who now hold the germ doctrine. The poison of this, as of other zymotic diseases, is now held to be a particle, and most advanced sanitarians believe it to be a living germ analogous to the organisms found in vaccine lymph, small-pox matter, or, perhaps, analogous to the infective germs of splenic fever.

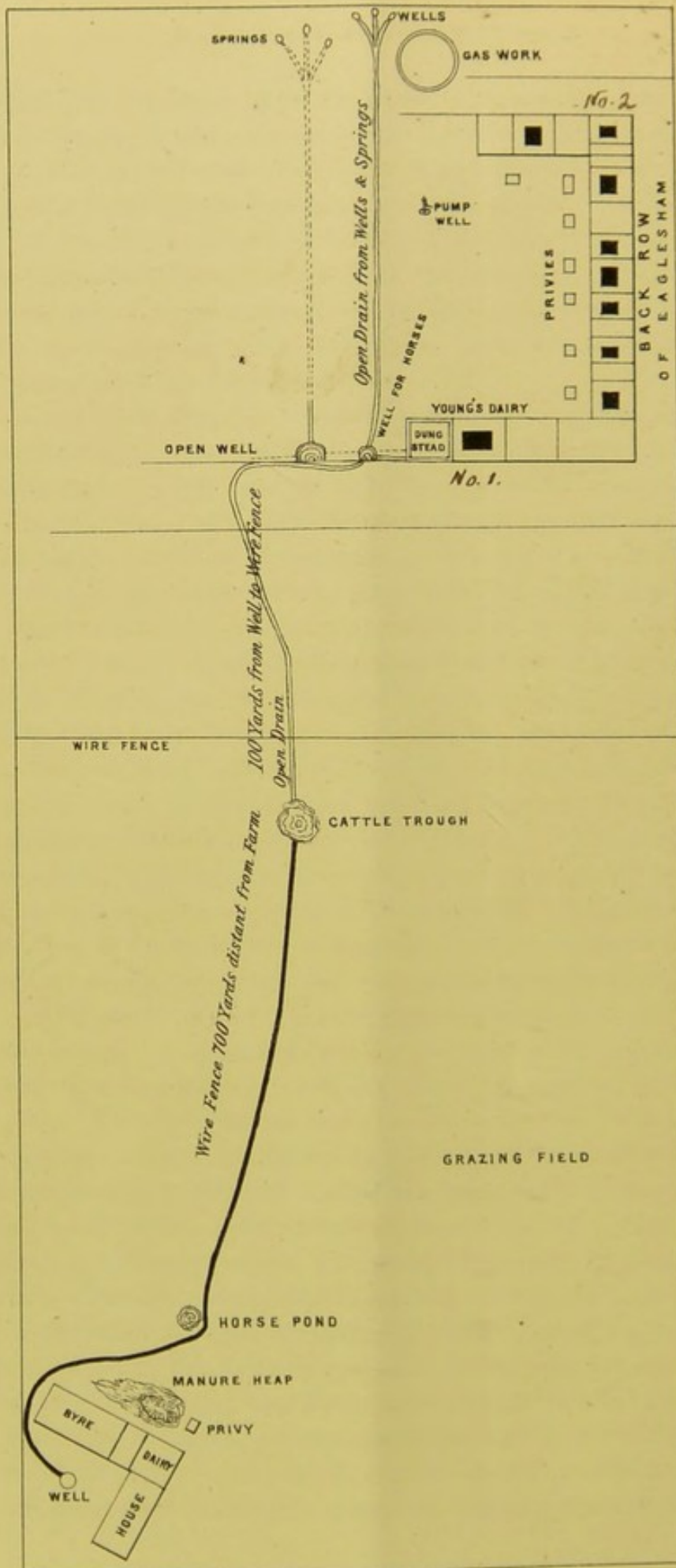
A few years ago it was commonly believed by scientific men that in the process of evaporation, and in the evolution of gases from decomposing organic fluids, the resulting vapours and gases carried into the atmosphere quantities of the minute particles which are known to abound in such fluids—viz., the germs of bacteria, and, by analogy, the germs of such diseases as are supposed to resemble these. But recent experiments have shown that this opinion has no solid foundation. In a paper read before this Society last session, Dr. Carmichael established, by the most complete experimental evidence, that, although small and unimportant amounts of sewer gases did pass through water traps, the germs of bacteria could not be got to do so. Mr. Mactear, in some experiments, read before this Society in 1874, had previously recorded the same fact. His experiments are all the more interesting because they were made with the special object of trying to get these germs to pass through the water of the trap. But Dr. Carmichael establishes a more important fact. He proves that neither in evaporation nor in gaseous emanation from decomposing organic fluids do the vapours carry with them the germs of bacteria, however numerous these may be in the fluid. I was very much interested in this discovery, because I had stated six years ago as an opinion, based upon my own personal observation of disease, that sewer gases did not propagate typhoid fever to any serious extent, even when quantities of the specific discharges of typhoid patients were flowing and exhaling vapours in our sewers. In the numerous milk epidemics which have occurred in Glasgow and its neighbourhood since that time, we have now a means of testing the truth of that assertion, and of making further observations on the behaviour of sewer gases impregnated with the vapours arising from typhoid excreta. Before entering upon this inquiry, I wish to point out that the kind of evidence on which the propagation of typhoid fever by contaminated water or milk is founded is essentially different from the kind of evidence on which its

propagation by sewer gases is based. In the first case we can generally prove that at a particular time the poisonous discharges of a typhoid fever patient or patients got access to the water, or the milk; and we can further prove that, within a certain definite period of time from this occurrence, the disease broke out among the people who drank of it. We can generally compare these people with a larger mass of the population in the same vicinity who were supplied with pure water, and pure milk, and who remained unaffected by the disease.

In the other case the supposed cause is in constant operation, and the whole community is exposed to its influence. Until lately we could not explain why, in a city like Glasgow, where sporadic cases of the fever are constantly present with us, for months, the masses of the people should be exposed with impunity to an atmosphere tainted with these sewer gases, and then by some mysterious influence in a circumscribed locality a large number of people should be simultaneously struck down as if by poison.

My attention was first directed to this subject in the spring of 1875, when I was engaged in investigating the causes of a severe epidemic of typhoid fever in Crosshill. Having a large share in the treatment of the affected families, I began, from the first appearance of the disease, to take notes of every circumstance connected with my patients and their surroundings which seemed to me to have any bearing on its causation. As the sewer gas theory was at that time universally held by sanitarians, I was inclined at first to blame the drainage, and endeavoured to find faults in all the houses in which the fever occurred. Although in some houses I did discover glaring instances of defect, which gave a colour to that theory, I failed in most instances to find anything wrong with the plumber work or house drains. What puzzled me most was that the fever broke out simultaneously in various localities which had entirely different systems of drainage, and in one house which had neither drain nor sewer. Having read accounts of two epidemics of typhoid fever—one in London and one in Glasgow—in which the disease was supposed to be conveyed through milk contaminated by the faecal discharges of typhoid fever patients, I turned my attention to the milk supply. I need not trouble you with the difficulties I encountered in this inquiry. They were detailed in a pamphlet which I published at that time. Of 68 cases of fever treated by me in Crosshill and its neighbourhood from 18th of January, when the epidemic began, till the end





of March, when it suddenly terminated, 67 got their milk either wholly or partially from four dairies which were supplied by an Eaglesham milk agent. I therefore directed my inquiries to Eaglesham, and I shall give you a brief account of what I learned there.

About the end of November, 1874, a boy, aged 7 years, sickened of typhoid fever in the house of his grandfather, a dairyman and carter, who lived in house marked No. 1 on the map. At the same time his sister, who lived with her parents in house marked No. 2, sickened with the same disease. These children were in the habit of playing with rag-bags which their grandfather carted to a mill in the neighbourhood, and which were often thrown down at his door. It was supposed that these bags had contained pieces of cloth contaminated with typhoid discharges, and that the children had inhaled the poisonous dust from these rags.

During the course of his illness, which lasted for several weeks, the poisonous discharges of this dairyman's grandson were thrown into the dungstead figured upon the map. The drainage from this dungstead actually ran into an open well which was used for washing and watering the carter's horses, and for washing clothes. The overflow from this horse well ran into the gutter, and was conducted past the mouth of another open well, which supplied the inhabitants of the back row with drinking water. After every shower of rain the contents of this gutter overflowed into well No. 2. In this way a communication was established between the typhoid discharges in the dungstead and the drinking water of the inhabitants. Following upon this, during the ensuing month of December, 20 cases of typhoid fever occurred in the back row. There was no fever in any other part of Eaglesham. While these 20 cases were running their course a severe frost prevailed, during which the poisonous discharges of these 20 patients were thrown into the privies and dungsteads behind their houses, and there frozen up. Then followed rains, by which this five weeks' accumulation of filth and typhoid virus was washed down over and through a bed of gravel, into the water-course indicated upon the map. This water, after joining the drainage from the dairyman's dungstead, formed an occasional source of water supply to one of the farmers whose milk was sold in the Eaglesham dairies in Crosshill. This farmer had a well beside his dungstead, which was fed by a spring, but the water so supplied to it was sometimes insufficient for the wants of his dairy. He found it necessary to

fill up his well occasionally with water conducted by a pipe from the horse well in Eaglesham, above mentioned. When his well was full he diverted this Eaglesham water into a horse-pond, the overflow of which watered a neighbouring meadow. When the frost broke up in the end of the first week of January, having run short of water, he turned on this poisoned water supply, and replenished his well. In due time, allowing for the known period of incubation, two of his children took typhoid fever. They sickened in the end of January, and for the three or four weeks during which the fever ran its course their poisonous discharges were thrown into the dungstead, and, as shown in the plan, had every opportunity of draining into his well. This water, so poisoned, was used for washing the milk dishes, and we may suppose that at every rinsing of the milk cans a quantity sufficient to poison the milk was left in every can or pail. We need not accuse the farmer of any intentional dishonesty in such circumstances. The result of the importation of this milk to the four Eaglesham dairies in Crosshill is seen in this table of cases of typhoid which I personally attended. I have noted here the day on which the first symptoms of the illness showed themselves. It will be observed that the cases are grouped so as to indicate apparently two epidemics:—

FIRST EPIDEMIC.

January 18th till January 24th inclusive,	. . .	6 cases
" 25th " 31st "	. . .	3 cases
February 1st till February 5th, "	. . .	2 cases
No cases from February 5th till February 15th.		

SECOND EPIDEMIC.

February 15th till February 21st inclusive,	. . .	13 cases
" 22nd " 28th "	. . .	16 cases
March 1st till March 7th inclusive,	. . .	18 cases
" 8th " 14th "	. . .	2 cases
" 15th " 21st "	. . .	4 cases
" 22nd " 28th "	. . .	4 cases
		68 cases

There is a period of incubation in this disease, varying from a few days to four weeks, during which there is no symptom of the poison germinating in the patient's body. It is therefore evident that when the farmer filled his well, in the second week of January, with the poisoned water from Eaglesham, he not only poisoned his own children, but he poisoned also, through his milk tainted by

this water, the people of Crosshill. In this way we account for the first epidemic. My explanation of the interval which apparently elapsed between the first and second epidemic periods is this: The disease in the back row of Eaglesham came to an end—burned itself out, so to speak—in the beginning of January, and by the end of that month the accumulation of virus in that locality had been washed away by the rains. Had the farmer's children not been poisoned we would have had no more of it. But when their discharges began to soak into the farmer's well the disease broke out afresh in Crosshill. The typhoid discharges being in this case close at hand, the well became more poisonous than before, and so what I have called the second epidemic was worse than the first. I communicated the result of my inquiries to the Burgh Authorities, and on the 26th of February the dairy proprietors of Crosshill were interdicted from selling any Eaglesham milk. The epidemic came to an end within the period of incubation from that date. I do not think it possible that we can ever have more conclusive proof of a milk epidemic than we have here. Wherever that milk was carried, there the disease broke out in tenements and houses draining into sewers running north, south, east, and west, and having no connection with each other. I need not occupy your time further with proof of the milk origin of this epidemic. For further details I refer you to my pamphlet, of which two copies may be found in the library of this Society. Assuming that this Eaglesham milk was a sufficient cause for the fever in the case of those who could be proven to have partaken of it, the question I have now to consider is—Was the disease propagated to any extent by emanations from the sewers which received the poisonous discharges of these patients? In the pamphlet above referred to I stated a number of facts which led me to believe that, under ordinary conditions, sewer gas would not propagate typhoid fever, even when typhoid excreta were present in the sewers. Since I published that statement I have, as opportunity offered, made further inquiry into the circumstances of the affected families whom I did not personally attend, and also into the condition of the house drainage of the tenements most severely affected by the fever at that time. I shall now give you in detail the results of a few such inquiries, which have an important bearing on the question at issue. I have here a plan of the sewerage of the affected district. Into sewer No. 1 I ascertained that the discharges of 220 fever patients were

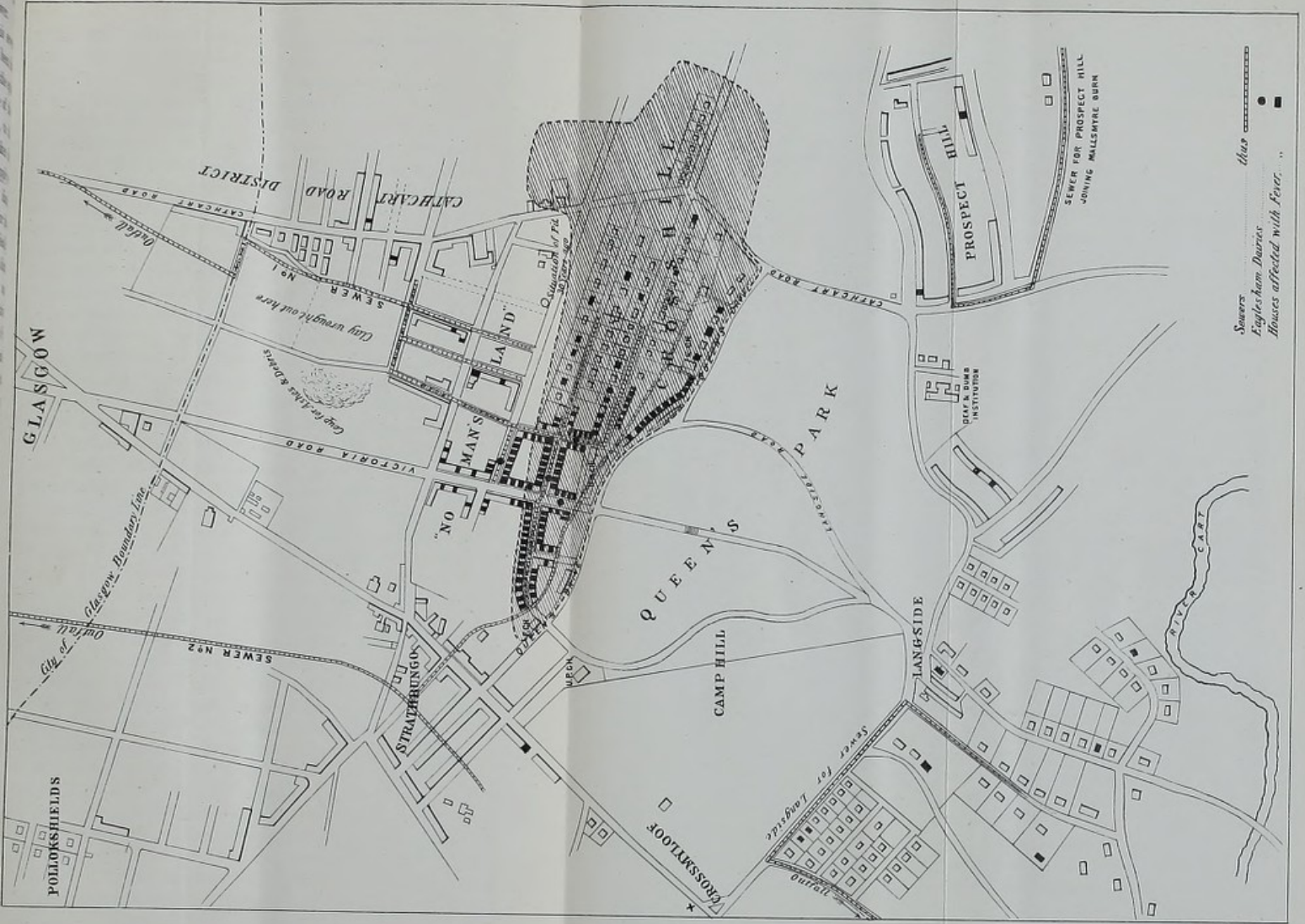
thrown during the continuance of the epidemic. Every affected house had a water-closet draining into this sewer.

After receiving the sewage of Crosshill, this sewer runs to the north-east through a district which has since been formed into a burgh and named Govanhill. At the time of the epidemic it was divided into "No Man's Land"—in which one of the Eaglesham dairies was situated, and which was therefore, to the extent to which it was supplied by this milk, a fever-stricken district—and the Cathcart Road district, in which the milk supply was entirely derived from other sources. Through these two districts a mass of typhoid poison was draining daily and hourly for three months, exhaling the gases which are supposed to be such deadly factors in the spread of the disease. Every house in these districts had a water-closet draining into this sewer, with all the usual defects which water-closets possess in houses built by speculative builders.

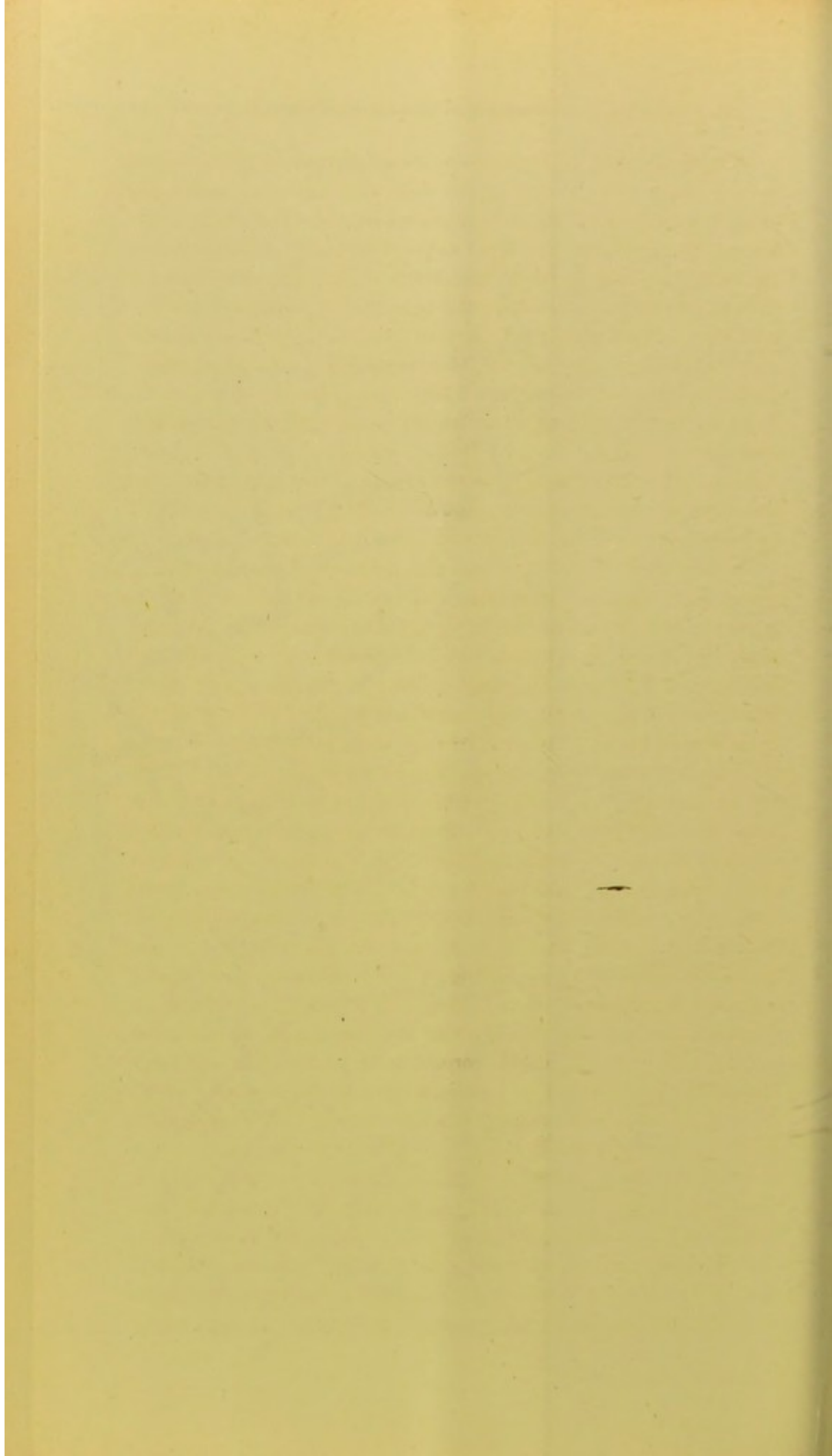
Bordering on the fever-stricken district there were 8 tenements of houses, inhabited by 59 families; these 59 families were seriously annoyed by smells from their water-closets, and by great deficiency and irregularity of their water-supply. They shared in the popular belief that bad smells cause fever, so that, when the fever broke out in their immediate vicinity, they became terrified, and appealed to the sanitary authorities of the district to have their houses inspected and the defects remedied.

The report of the inspector was published in the *Glasgow Herald* of 20th February, and showed that if sewer gases could carry typhoid germs, they had ample cause for fear. The report reads as follows:—

"A. The houses in this tenement are supplied from a cistern in the garret, which is fed by a $\frac{1}{2}$ -inch supply pipe, having $\frac{3}{4}$ -inch service pipes from cistern to water-closets and jawboxes in houses. The cistern, which is 3 ft. 10 in. long, 2 ft. 9 in. wide, and 2 ft. deep, was empty at the time of my visit, and there was no water running into it, therefore the whole tenement was without water. *The overflow pipe of cistern is untrapped, and a strong current of sewage gas blows up through the pipe, which I think must, more or less, contaminate the water.*" "The water-closet under stair in close was very dirty; the basin, which is cast-iron, tapering from seat to floor, has no proper flushing apparatus, having only a pipe bent over the side; the inside of the basin is consequently in a very filthy state. The floor has a step down of $8\frac{1}{2}$ in., and the floor was covered with filth.



Sewers thus
Engisham Dairies
Houses affected with Fever.



“B. This tenement I found to be in all respects the same as A; but the water-closet in close, the door of which was nailed up, being opened, I found the soil-pipe chocked, and the excreta overflowing the seat, and the floor covered with it. It appeared to have been in this state for a long time, as the filth was covered with white mould. The smell was most offensive, and almost unbearable.” The reports for tenements marked C, D, E, and F, are similar; no traps in overflow pipes of cisterns; sewage gas freely admitted; on the ground flats filthy water-closets; only two of these six tenements had water in the cistern at the time of the inspector’s visit.

G and H had kitchen jawboxes supplied from the main. No complaint of want of water, except in top flats. Two upright soil pipes in each tenement, only one of which was ventilated.

On the 22nd of April, when the epidemic was at an end, I visited these tenements and found that the conditions described in the above report remained unchanged. The owner of the property refused to remedy the defects, and the sanitary authority—having at that time no burghal powers—could not compel him to do so. There is nothing said in this report about the trapping of the house drains, but as a strong current of gas was found to be coming back from the drain, through the overflow pipe of the cistern, we may assume that if there were traps of any description on the house drains they did not act. Quite recently the house drain of one of these tenements was uncovered, on account of an invasion of rats, and as ~~two~~^{two} disconnecting traps were found in the house drain of that tenement, we may assume that the others, which were erected by the same builder, were in a similar condition. These 59 families were, therefore, living in direct communication with a sewer which contained a large amount of the fæcal discharges of typhoid fever patients. This sewer was, according to our great medical authority Dr. Budd, corroborated by the opinion of Sir Thomas Watson, “the direct continuation of the diseased intestines” of fever patients, and exhaled, what he terms, “the most specific of all the exuviae of the sick body.” What was the result? On the 22nd of April, when the epidemic was at an end, I visited every one of these 59 families, and inquired into the state of the family health, and as to the milk supply. Only 8 of these families had been supplied either wholly or partially with the poisoned milk, and 4 of these families had contracted the fever, and there had not been previously, nor was there at the time of my visit, a

single case of fever in the remaining 51 families who were inhaling the gases of this poison-laden sewer.

When we trace this sewer a little further, we come to a population of 3,500 in the Cathcart Road district, whose milk supply was quite different from that of Crosshill. Every house had a water-closet draining into this sewer. I made careful inquiries after the Crosshill epidemic came to an end, and could only hear of two cases of typhoid fever as having occurred in this population during the course of the fever in Crosshill. One of these cases was known to have been imported from Glasgow. How the other case originated I did not make out. The houses of these people were of a very poor description, and the drainage was known to be very imperfect. Seven tenements of houses in this district, which were inhabited at the time I speak of, have since been discovered to have no traps of any description on their house drains. In four of these seven tenements the water-closets were situated in the centre of the houses, and entirely unventilated. Other twelve tenements, which were also inhabited at this time, although their house drains were supposed to be trapped, were built on the same plan—an unventilated water-closet being in the centre of each separate house. In nine tenements the house drains were so badly laid that they have since been found to be completely choked up. One tenement was supplied with an ingenious arrangement for testing the typhoid-generating powers of faecal matter. A large square box, meant to form a V trap, had been placed under the flagstone of the common entry, and the house drain was laid with a fall in the direction of the houses. For two years the excreta had been stagnating under the basement of this tenement, yet no typhoid was known to have occurred in any of these houses during this time. Finally, in four of the tenements occupied at the time of the epidemic, the common soil-pipe was found to ventilate into an attic, which contained the common cistern for the water supply. For all these facts I am indebted to Mr. Steel, the late chairman of the Sanitary Committee of Govanhill, who has taken a great interest in sanitary matters, and visited these tenements personally to ascertain the facts.

Let us now consider the case of sewer No. 2, which was built by the city authorities to drain the Queen's Park and the houses fronting the Park. Eight villas and a terrace of six tenements of houses, called Royal Crescent, drained into the sewer. Thirty cases of typhoid fever occurred among the people inhabiting these

houses. As I then resided—and still reside—in Royal Crescent, I had special opportunities of knowing all the facts with regard to the drainage arrangements, and the other circumstances of the affected families. I shall state in some detail the case of Royal Crescent, in which 25 cases of fever occurred. Here is a description of the state of the drainage of these houses, written by Dr. Fergus, our late president, who made a careful examination of the house drains. I quote from an article on the sewage question, published by him in the *Sanitary Journal* for December, 1878:—

“Two years ago I was requested to inspect a range of good, recently-erected, houses where typhoid had prevailed. We found the drains and rain water-pipes from the houses passing into a large cesspool at a higher level than the exit pipe into the drain, the outlet being several inches under water.

“The surface of the water in the cesspool was covered with floating fæces in a state of active decomposition. On this being stirred, sewer gas was given off freely. I desired that all the baths, sinks, and fixed basins in the houses should be fully turned on; but not one particle of fæces escaped, the whole mass only kept swirling round and round, the water escaping from below. In order to convince some parties who were sceptical, the process of flushing was repeated day after day, and the result was always the same. Let us inquire what became of the gas so generated. The cesspool was covered with an impervious stone lid, hermetically closed, so that none could escape into the open air, and it could not pass into the sewer on account of the large body of water which interposed. It must of necessity have been driven back, either into the houses or up the rain-water pipe. Typhoid had been introduced by milk; but I think it was clearly proved that it had spread by the decomposition of typhoid stools in this laboratory for the manufacture of sewer gas.”

I was present at the inspection which Dr. Fergus made, and can testify to the accuracy of his description. The statement as to cases of fever having been propagated by the gases arising from these cesspools further inquiry has rendered exceedingly doubtful. Since that time I have carefully inquired into the circumstances of every family in the affected tenements, and compared the results of my inquiry with a book which was kept by the burgh authorities, containing the results of a house-to-house visitation. This visitation was ordered by Dr. Littlejohn, of Edinburgh, who was sent by the Board of Supervision to inquire into the facts of the

epidemic. His report was published, and may be found in the volume of Health Reports issued by that body. There were three houses, in flats one above the other, on each side of the common stair. The three houses on the left side of the common stair drained into a common soil-pipe, which was conducted through the centre of these houses, and got exit at the basement flat into the drain and cesspool described by Dr. Fergus. There was no proper ventilation in this soil-pipe.

Family No. 1, on the ground flat, consisted of four adults and three children. Their wash-house had a bell-trap leading directly into the drain. The cover of this bell-trap had been removed, so that there was an open communication between this house and the cesspool. The milk supply was not got from the tainted source, and there was no fever in this family.

Family No. 2, on the second flat, consisted of five adults and five children. The case of these people exemplifies the kind of fallacies which occur in the returns of an official inspection by the ordinary sanitary officer. They were reported to be free from fever, and to get no milk from the Eaglesham dairy. On personal inquiry, I was told by the lady of the house that two of her children were ill for six weeks with feverishness and diarrhœa, and that her servant had been confined to bed for a fortnight with a very severe feverish illness. The doctor in attendance refused to name the disease, or to allow her to certify the cases as fever to the sanitary officer. She learned afterwards that he told her relatives that the children were suffering from the fever. Her entire milk supply was got from one of the tainted dairies, until her husband, who was a Magistrate of the burgh, caused her to change to another dairy, because he had become acquainted with the dangerous nature of his former milk supply. The house-to-house visitation did not begin until after the milk supply had been changed, and so, in the burgh reports of this family there is no record of the fever, and an erroneous statement about the milk supply. In this way Dr. Littlejohn's returns were rendered very inaccurate.

Family No. 3, in the topmost flat, consisted of four adults and three children. They got their ordinary milk supply from a pure source, but they occasionally got a little milk from the tainted source. The lady of the house informed me that this milk was used for making puddings, and always boiled. This family did not suffer from fever.

On the right-hand side of the stair there were likewise three houses, having a common soil-pipe, draining into a cesspool. There were two wash-houses on the basement flat, with bell traps, the covers of which had been removed, so that here also there was an open communication with the drain and cesspool. The family on the ground flat consisted of four adults and six children. They got their milk from the tainted source. Five of the children had typhoid fever. The house on the second flat was not occupied at the time of the epidemic. The family on the top flat consisted of three adults and seven children. They got a considerable supply of milk from the tainted source. Two of them had fever. I will not weary you by going over in detail the individual cases in the other tenements. I may sum up the result of my inquiries thus :—In every case of fever which occurred in Royal Crescent the patient was ascertained to have swallowed the tainted milk.

Eighty-four persons lived in Royal Crescent who were found to have got their milk supply from pure sources. No case of fever happened among these 84 people, although they were exposed to the emanations from the cesspools, containing the mass of decomposing typhoid excreta so graphically described by Dr. Fergus. In four of the tenements of Royal Crescent these cesspools remained unaltered until the 25th of August, and the typhoid excreta floating in them were allowed quietly to decompose and evolve their noxious gases into the soil-pipes of their respective tenements; yet the fever disappeared quite as speedily from these houses as from those in the house drains of which these laboratories for the manufacture of sewage gas were replaced by properly-constructed water-traps. When we trace the course of sewer No. 2, we find that the typhoid discharges from Royal Crescent were carried through the village of Strathbungo, which drained into this sewer. This village had an estimated population of 2400. Only one case of typhoid was known in Strathbungo at that time, and it was ascertained that that unfortunate patient, who died of the disease, had got her milk supply from the tainted source in Crosshill. The effect of the emanations from sewer No. 2 on these 2400 people was *nil*. One other illustration, and I am done with the Crosshill epidemic.

Typhoid fever occurred in seven families in the neighbouring suburb of Langside. Every one of these families got their milk supply from the tainted source. The drainage of Langside is quite unconnected with that of Crosshill, and runs in an opposite direction. Some of these families had separate drains for their

own houses. But a few cases happened along the course of a common sewer which drained all the houses on the western slope of the hill on which Langside is situated. On the highest part of the hill, and draining into this sewer, there stands an old residence, part of which was built 200 years ago. Two years ago the proprietor of this house asked me to give him some advice about the drainage, as, although he had renewed the whole of the plumber work a short time previously, and spared no expense in obtaining the arrangements which the plumber believed to be the best for preventing the admission of sewer gas, still he was annoyed by disagreeable smells, and said he always felt out of sorts when he remained long in that house without a change. I told him that, in the case of a house 200 years old, there were very likely some old forgotten drains leading to the common sewer, and advised that a trench should be dug all round the house, as deep as the foundations, so that any such drains issuing from it might be discovered and filled up. By these means we did discover five open channels under the floor of the oldest part of the house, leading directly into an old drain. This old drain communicated with the house drain, a few yards on the sewer side of the water-trap, which was supposed to cut this house off from sewer gases. There were in this way five open channels, by which rats and sewer gas were admitted freely under the floor of a house standing on the summit of a hill, and connected with a sewer which received the discharges of at least 30 families lower down. At the time of the Crosshill epidemic, five cases of typhoid fever occurred among those families whose discharges were carried into this sewer, and at various times, during the fourteen years of my residence in Crosshill, I have attended numbers of cases of measles and scarlet fever, and I have known of several cases of diphtheria among these people. From the year 1856 till 1873 this old residence was occupied by a family, consisting of father, mother, five children, and three domestics. The domestics were, of course, changed occasionally, so that a considerable number of domestics must have been habitually breathing the gases from this sewer during these seventeen years. On making inquiry as to the family health, I was informed that for the first twelve years they had no illness of any kind. Then in 1868 the eldest daughter died from the effects of a surgical operation. In the summer of 1869 two of the children had typhoid fever. I was informed that that was a very dry summer, and the Gorbals gravitation water, with which

the house was supplied, had a very offensive smell, and was infested by large numbers of insects. The doctor in attendance on the family decided that these children had been poisoned by this offensive water. From that time till they left the house, in 1873, this family did not suffer from serious illness of any kind. Although another family occupied that house from 1874 till last year, and were exposed to the same extraordinary invasion of sewer gases during the time of the Crosshill epidemic, and until the old drains above described were discovered and filled up, no member of that second family, and no domestic in that house, suffered from any form of infectious disease.

If any further proof is needed of the erroneous nature of the popular sewage gas theory of the propagation of typhoid fever, it may be found in the published records of the numerous epidemics which have been traced to tainted milk since I published my first observations on this subject. Every epidemic which has occurred in Glasgow during the past five years has been traced to this cause. In former times these epidemics would undoubtedly have been ascribed to sewer gas, admitted by the well-known defects of our soil-pipes and house drains. In a paper published in 1879, Dr. Fergus says of Glasgow, "So far as I can remember, I have never yet inspected a house where I found the soil-pipes and drains in a satisfactory condition." In another place he states that, even if it were shown that the drains and soil-pipes of our houses were perfect, sewer gases find their way back through perfect water-traps. In a still more conclusive and striking manner, our respected member Mr. Buchan has proven the alarming extent to which the inhabitants of Glasgow are exposed to this supposed cause of typhoid fever. Lately, in conversation with him on this subject, he informed me that he had examined by the smoke-test 200 houses in the west-end of Glasgow, and that the smoke issued from some perforation or crack, or crevice, inside the house, in 199 cases; showing that, with one exception, the atmosphere of every house was being contaminated by sewage gases from the house drain. Further, 10 per cent. of these houses had no trap of any description upon the house drain, so that there was a free communication between the house and the public sewer.

Bearing these facts in mind, let us take the records of two of the Glasgow epidemics, which were traced to a tainted milk supply, and published by Dr. Russell, at the request of the Health Committee of the Town Council. We will take first the Washington

Street outbreak, which occurred in the autumn of 1875. At page 5 of this Report we find the following statement of the very striking manner in which the fever was confined to those who partook of milk which was proven to have been tainted by typhoid excreta:—In Washington Street, Bishop Street, Main Street, and Stobcross Street, among 483 persons who got their milk supply solely or occasionally from the tainted dairy, there occurred 58 cases of undoubted typhoid and 30 cases of a feverish illness, suspiciously like typhoid, while among 579 individuals, with a different milk supply, living in the same streets and tenements, having the same drains and sewers, and being exposed to the emanations from the typhoid excreta of these 60 or 80 cases, only one case of the fever could be discovered.

The only other epidemic which I shall refer to in this connection occurred in the west-end of Glasgow in December, 1877, and the following January of 1878. Cases of fever occurred in the following localities:—Hill Street, Berkeley Terrace, Royal Terrace, Lynedoch Crescent, Park Street (East), Park Circus, Park Gardens, Park Quadrant, Park Terrace Lane, West-End Park Street, Woodlands Terrace, Claremont Terrace, Woodside Crescent, Newton Place, and Bath Street. 122 families, living in the streets and terraces named, had their milk supply, either wholly or partially, from dairies which were proven to have given out a milk tainted with the excreta of typhoid fever patients. Of these, 29 families were affected with fever. 675 families, living in the same streets and terraces, were supplied with milk from other sources, and of these only one family was discovered to have fever. Here we have poisonous excreta introduced into the house drains and sewers of 15 localities, the soil-pipes and drains of which are proven to be extremely imperfect by the published statements of such competent authorities as Dr. Fergus and Mr. Buchan; and yet, with the exception of one family in Bath Street, these 799 families continued for several weeks to be exposed to the emanations from these poison-laden drains and sewers, without any evil result which could be proven.

Although I think the evidence which I have brought before you to-night is sufficient to warrant me in saying that no extensive epidemic of this fever can be propagated by the inhalation of the air which is carried back into our houses from the sewers, yet I think it quite likely that particles of matter containing disease germs do occasionally get into our houses through this agency.

In consequence of the rise and fall of the sewage leaving the sides of the sewer alternately wet and dry, particles of typhoid excreta, or other disease products, may occasionally get dried on its sides, and be carried back into our houses in the form of dust, where there is no intervening water-trap to stop its progress. Of course, the same thing may happen in a common soil-pipe or house drain. In this way, a few particles may gain admission through an untrapped house drain or a perforated soil-pipe. But even if these particles are inhaled by a susceptible individual, I do not think it likely that they will be absorbed in such a way as to produce the fever, unless they are actually swallowed into the stomach with the saliva or the mucus of the nostrils. I believe, in fact, that the poison of typhoid fever must be swallowed, if it is to germinate in the body. That this fever is occasionally contracted by the inhalation and subsequent swallowing of dust particles of typhoid excreta, I firmly believe. In a sewer which is constantly being deluged with water, the chance of dust particles of human excreta being allowed to form is very small, as compared with the danger from the same excreta in a midden or privy. The records of the epidemics I have just described show that cases of typhoid fever arising from the inhalation of sewer dust must be very rare.

It is often stated that free ventilation renders the emanations from sewers innocuous, but, if the views I have just stated are well founded, there is quite as much danger in breathing the particles in the air exhaled from a street ventilator as in breathing the same particles in soil-pipe air. No amount of surrounding air can, at once, make any chemical change in a dry particle of infective matter. Statistics prove that ventilation of the sewers of a town does not necessarily diminish the death-rate from typhoid fever. The following Table indicates the averages published by Mr. Baldwin Latham, which illustrates this point. I have added a five years' average of the typhoid fever death-rate for Glasgow and Dublin :—

	Average Rate per 1000.
1. Bristol, with no ventilation of house drains or sewers,	38
2. Plymouth, one ventilator on every five miles of sewer, and no house drain ventilation,	36
3. London, where the sewers are ventilated, but the house drains are for the most part unventilated,	26
4. Croydon, where both public sewers and house drains are ventilated,	59
5. Glasgow, sewers well ventilated, house drains, for the most part, ventilated,	37
6. Dublin, where there are comparatively few water-closets,	5

It therefore comes to be a serious question whether we may not err in making an unnecessarily large number of openings on our sewers and house drains. By so doing we may dry up a larger amount of the dangerous material, and promote its dissemination in dust particles.

The only other epidemic disease common in this country, which recent investigation connects with the exhalations from human excreta and sewer gases, is diphtheria; all the observations which I have made in the case of typhoid fever apply with even greater force here. We do not know what the essential poison of diphtheria is, and we cannot say that it certainly exists in the alvine discharges of the diphtheritic patient. Experiment rather goes to show that in this disease the poisonous matter is confined to the discharges from the throat, and that it is only disseminated by direct contact with particles of the diphtheritic exudation coughed out by the patient. It is possible that a certain amount of this poisonous matter may be swallowed by the patient, and if we concede—what we really know nothing of—that it may pass through the stomach and intestines without losing its virulent properties, it may in this way gain access to the sewers. But, as I have proven that large quantities of typhoid excreta may exist there without any proven extension of that disease by these channels, I would infer that these small quantities of diphtheritic matter can do very little harm. By analogy, I would affirm that epidemics of diphtheria do not arise from sewer exhalations.

I have looked carefully into the statistical evidence which Dr. Russell brought before this Society in his paper upon "Filth Diseases in Town and Country." I am quite satisfied, after careful consideration of this subject for some years, that we have no means of differentiating diphtheria from membranous croup. I have repeatedly known a case, which was at first termed diphtheria, ultimately registered as croup when the child died with croupy symptoms, and cases have been frequently reported in which, although the case was at first supposed to be croup, it was ultimately decided to be diphtheria, when diphtheritic symptoms appeared in another member of the family. I believe that the Registrar-General acts wisely in grouping these diseases under one head. In the small houses of the poor, where the parents do not send for a medical man until the child has shown dangerous symptoms of choking, the case is likely to be registered as croup; whereas, in a larger house, in which the child is seen at an earlier stage of the disease,

before the croupy symptoms develop, it is more likely to be termed diphtheria. Then again, a large proportion of the children dying in the poorest houses are not seen by a medical man at all, and every case of diphtheria which ends in croupy symptoms is certain to be registered by these ignorant persons as croup. With all respect for Dr. Russell, I do not think that in the present state of medical knowledge he is warranted in drawing any deduction as to the etiology of diphtheria, as contrasted with the etiology of croup, from the statistics he advances. The conclusion that diphtheria is more prevalent in small houses which have water-closets than it is in those that have none, is based upon a mass of the most untrustworthy returns. Any man who has examined the books of a registrar, and seen the extraordinary declarations there recorded as to causes of death, must look with utter incredulity upon any statement with regard to a differential diagnosis of disease founded upon such a basis. In the closing paragraph of that paper Dr. Russell makes the following statement, and asks a question:—"Even with all the outrageous blunders of position and construction in our largest and best houses, and without that official inspection of new buildings in regard to details of sanitary arrangement which ought to be instituted, you have seen that in these houses, in the four years, 1873-76, the mortality from diphtheria was only 126 per million, and from enteric fever 186—rates which are far below those which constantly prevail in the majority of purely country districts, as depicted on those diagrams, and also much below the mortality from enteric fever in small houses which have no sewer connections whatever. But how do those diseases occur in houses with no sewer connection?" Dr. Russell's question—How do those diseases occur in houses with no sewer connections whatever?—brings me to the second part of my subject, the sanitary problems of the dry system. In illustration of these, I shall relate the story of an epidemic of typhoid fever which I personally investigated. In the autumn of 1875 I learned that two families, to whom I acted as medical adviser, had contracted typhoid fever in Millport. As Millport is situated on the small island of Cumbrae, in an isolated position, it seemed to me to be a very promising place for a successful investigation into the causes of these cases. On arriving there, I found that, at that time, all the excreta of the inhabitants were collected on the dry system in privies and middens behind the houses, and taken by the farmers to manure the fields behind the village. The first

case into which I inquired occurred in the Foulpart district, and the affected family drank water from a well, situated on the beach, called the "Tea-well." My suspicion naturally attached to the water of this well, and I had not far to seek for the source of contamination. This Tea-well is an open trough, fed by a pipe which collects the water from an open surface drain in an adjoining field. At the time of my visit a heap of manure, collected for the purpose of spreading over the field, was lying near the edge of the surface drain. I learned, on inquiry, that this manure was collected from the privies of a part of Millport, in which typhoid fever had occurred every year for some years previously, and it must therefore contain the specific poison of the disease. Every shower of rain drained this filth and poison into the well. From the date of the deposit of this manure heap six cases of typhoid had occurred among the people who drank this water, and also several cases of a feverish illness of an indefinite character—probably mild typhoid. The history of my other Millport patient is equally instructive. He lived in the Glasgow Street district, in which the fever had prevailed extensively for several years. The water supply of this district came from a well sunk in the centre of a large turnip field. I learned that this turnip field was manured with dung collected from the part of Millport which it supplied with water. As the well-water was simply the surface drainage of the turnip field, the people of that neighbourhood were therefore supplied with a filtered solution of their own excrement. On further inquiry, I learned that a still worse state of matters had existed in Millport. In 1872, I was informed that 26 cases of typhoid had occurred; in 1873, 35 cases; in 1874, 60 cases. In the latter year, when matters were getting so serious, the medical officer of the place noticed that the farmer who cultivated this turnip field had a large accumulation of manure, collected from the privies of Millport, on the top of an earthenware pipe with open uncemented joints which supplied the Glasgow Street district with water. When the water carried through this pipe was analysed, it was found to be loaded with organic matter. After all these facts had been ascertained, and meantime 60 persons poisoned, this manure heap was removed, and the fever disappeared, to break out again in a milder form when the field came to be manured with the excreta of these 60 patients.

There is no doubt that the soil performs a kindly office in concealing from our view these dangerous materials, and that, if you do not

over-tax its powers, it may even destroy their poisonous properties; but I am quite convinced that a water supply derived from the surface drainage of fields manured, as these fields were, with the poisonous discharges of typhoid fever patients, is certain to develop periodical outbreaks of that disease. The history of this village points to the great dangers of the dry system of disposal of human excreta. We frequently hear of outbreaks of various forms of zymotic disease in remote pastoral districts, where such diseases may have been unknown for a generation. What happened in Millport may help us to an explanation of such cases. What is more likely than that the disease germs have been carted out from the adjoining town in the manure cart, and by chance shunted down at the side of a water-course or on the top of a well? We know that the manure of Glasgow contains the excreta of one-half of the population, removed from the lowest, and, in a sanitary point of view, the worst parts of the city. This manure often contains in abundance the alvine discharges of typhoid patients. Rags stained and saturated with the contagious expectoration of diphtheria and the sweepings of the houses in which rage scarlet fever and measles. All this heterogeneous mass of poison is carted to the manure heaps in the outskirts of Glasgow, there mixed with other manurial refuse, without the slightest attempt at the separation or disinfection of the dangerous elements, and then transported to the farmers of the dairy districts around Glasgow. I believe that in some of the milk epidemics which I have already spoken of so fully we are being punished for what I can only characterise as the recklessness and ignorance displayed in the dry methods of disposal, as they are at present conducted. We are receiving back with compound interest the germs of disease which we have sent out. The cleansing authorities in the towns and villages of this country are as truly dealers in poison as are the traders in arsenic or strychnine, and the dangers of ignorant and careless methods of conducting their business are immensely greater.

We cannot speak too strongly on this subject. Until our parochial and urban rulers, and the farmers themselves, are convinced as to the dangers of using these poisonous materials as manures for fields, the surface drainage of which may pollute their water supply, we cannot hope much to diminish the spread of typhoid fever, 140,000 cases of which occur annually in this country, giving rise yearly to 15,000 deaths and an untold amount of misery. I need not speak of other dangers.

Before closing I shall indicate, very briefly, the bearing which the observations I have recorded in this paper have upon the modifications upon existing methods of disposal, which the last Glasgow Sewage deputation recommend for adoption in this city. At page 5 of the Report they say:—"Whatever may be said in a sanitary and economical point of view of the various dry systems of disposing of excreta—and we freely acknowledge that some of the arguments in favour of these are unanswerable—we regard their reintroduction into water-closeted towns as altogether hopeless; and we are the more reconciled to the conveyance of sewage, strictly so called, by water-carriage, since the ordinary house drainage, which is almost as offensive and quite as impure, cannot be disposed of, in this country at least, in any other way."

While I believe that the water-carriage system is a great sanitary blunder when introduced in towns and villages which drain into streams forming the water supply of the population upon their banks; while I hold it to be a dangerous source of disease, and, apart from that aspect of the question, an utter abomination, to compel the populations on the lower reaches of a river to drink water polluted with the excrement of towns and villages near its source—yet I think that the water-carriage system as applied to a town like Glasgow, which drains into a tidal river, or to a town situated on the sea-coast, where the water supply is pure and protected from contamination, is much less dangerous than are the present methods of disposal on the dry system. Although I have brought forward evidence in this paper which proves to me that epidemic disease is not spread to any serious extent by sewer gases, I do not mean to assert that the atmosphere of a house habitually tainted with these gases is harmless. The habitual breathing of an impure atmosphere is one of the surest means of deteriorating the health, and is one of the factors which tends directly to the development of constitutional disease. The various forms of organic degeneration—of which consumption of the lungs may be taken as a type—are the forms of disease which we associate most surely with all the various influences of bad food, impure air, insufficient clothing, and uncleanness of person. But I do think that, with the adoption of proper sanitary supervision of our house drains and soil-pipes, such as this Sewage Report recommends, the dangers from sewer gases to which our city populations are at present exposed will become recollections of the past. The adoption of the sewage precipitation scheme will remove the only objection which, as

a sanitarian, I can urge against the water-closet system in Glasgow.

I cannot speak with approval of the dry methods recommended, because, while they adopt a part of the Manchester pail and tub system, they stop short at what seems to me, looking at the matter from the sanitary point of view, begins the most important part of this method. They do not recommend for adoption the chemical and drying processes, which convert the dangerous excreta of diseased neighbourhoods into a valuable and harmless manure. They do not propose to destroy the dangerous contents of ashpits saturated with these excreta, and convert these valueless and dangerous materials into charcoal, mortar, and Portland cement, as is done more or less completely in 12 towns in England, which have had the enterprise to act as pioneers in these matters.

In the three forms of apparatus adopted by these towns, not—as far as I can ascertain from their reports—for any sanitary reason, but because of their convenience and the money-saving which they effect on the former methods of disposal, in the Destructor, Carboniser, and Concreter, patented by Mr. Fryer, of Nottingham, we have the most perfect means of destroying the germs of zymotic disease.

Whether any better system can be devised for Glasgow may be a matter for consideration, but it is clearly the duty of those who have the arrangement of the new methods of disposal of the excreta and refuse from the poorer parts of Glasgow, with all the light which has been shed on these matters of late years, and the example of these English towns, to adopt some efficient means of preventing the great dangers of the present manure heaps, which pollute the atmosphere and poison the inhabitants, alike of Glasgow and of the country districts to which they are transported.

