NATIONAL REGISTRATION OF PLUMBERS.

DISTRICT COUNCIL FOR GLASGOW AND THE WEST OF SCOTLAND.

PUBLIC LECTURE

ON

"Plumbing and House Drainage in relation to Public Health,"

BY

NEIL CARMICHAEL, Esq., M.D.,

Examiner in Public Health to the Faculty of Physicians and Surgeons in Glasgow.

Delivered in the WATERLOO ROOMS, GLASGOW, 28th February, 1893.

GLASGOW:
PRINTED BY ROBERT ANDERSON, 22 ANN STREET.

c

14

NATIONAL REGISTRATION OF PLUMBERS.

PUBLIC LECTURE

ON

"PLUMBING AND HOUSE DRAINAGE IN RELATION TO PUBLIC HEALTH."

A PUBLIC LECTURE on the above subject, under the auspices of the District Council for Glasgow and the West of Scotland of the National Registration of Plumbers, was delivered in the Waterloo Rooms, Glasgow, on Tuesday, 28th February, 1893, by Neil Carmichael, Esq., M.D., Examiner in Public Health to the Faculty of Physicians and Surgeons in Glasgow. There was a numerous attendance of master and operative plumbers, and of members of the public interested in sanitation and good plumbing. In the absence, through indisposition, of Councillor Crawford, Convener of the Health Committee of the Town Council of Glasgow, and President of the District Council, the chair was taken by Thomas Russell, Esq., of Ascog, Chairman of the Governors of the Glasgow and West of Scotland Technical College, who was accompanied to the platform by a large number of gentlemen interested in the subject of the Lecture, including Mr. J. H. Kerr, Convener of the Property Committee of the Glasgow School Board; Bailie Hamilton; Councillors Paton, M'Cutcheon, R. Anderson, Edward Watson, and Mayberry; ex-Councillor Paterson; Dr. J. B. Russell, Medical Officer of the City of Glasgow; Dr. Ebenezer Duncan, President of the Sanitary Association of Scotland; Dr. Lapraik; Dr. Glaister, Professor of Medical Jurisprudence and Public Health, St. Mungo's College; Dr. Barlow, Professor of Physiology, St. Mungo's College; Dr. A. K. Chalmers; Messrs. David Thomson, ex-President of the Glasgow Institute of Architects; W. P. Buchan, James Anderson, W. A. Rattray, John Speirs, William Fyfe, David Fulton, James Costelle, Richard Livingstone, and Isaac Low, Jun., master plumbers; George Galloway, Francis M'Culloch, and William Spraggan, operative plumbers; A. Charlier, Manager of the White Lead Company, Limited; J. M'Auslan, architect; William MacLeod, metal merchant; H. A. Jack; Neil Sinclair, civil engineer; and Archibald Craig, Secretary of the District Council.

Apologies for absence were received from Professor Gairdner, M.D., LL.D., and Professor Simpson, M.D., both of the University of Glasgow; Professor Jamieson, Glasgow and West of Scotland Technical College; Bailies M'Farlane and Bilsland; Councillors Sinclair, Maclay, Macfarlane, D. M. Stevenson, and Dick; John Honeyman, Esq., F.R.I.B.A.; Peter Fyfe, Sanitary Inspector of the City of Glasgow; Dr. John Clark, City Analyst; A. B. Macdonald, City Engineer; T. Eaton Robinson, City Registrar; Dr. Dougan, Physician to Glasgow Post Office; Messrs. R. Scott, President of the Glasgow Institute of Measurers; Gilbert Thomson, C.E.; John Young, Secretary, Glasgow and West of Scotland Technical College; Robert Stevenson, lead manufacturer; ex-Provost Morrison, Crosshill; and others.

The Chairman, in introducing Dr. Carmichael, said it was a source of regret to all present that Bailie Crawford had, unfortunately, been prevented, by illness, from being present, as from his large experience as Chairman of the Health Committee of the Town Council, he would have been able to enforce the importance of sound knowledge in sanitary science. Medical experience had demonstrated the intimate connection between inefficient or imperfect sanitary arrangements and disease, and it was, consequently, for the benefit of the public health absolutely necessary that those who designed and carried out the drainage and ventilation of our dwellings should be thoroughly instructed in regard to plan, and also to carry out the work in a conscientious manner. From the attention and study Dr. Carmichael had given to this subject, the meeting would to-night hear the truth and the whole truth; and the purpose of the District Council of Plumbers, who had arranged this Lecture, would be best fulfilled by their carrying out in their daily work the ideas he would propound. (Applause.)

Dr. Carmichael then delivered the following Lecture :—

"PLUMBING AND HOUSE DRAINAGE IN RELATION TO PUBLIC HEALTH."

In the public mind, for long, the plumber and defective drainage have stood in relation to the production and propagation of disease in much the same position as Satan to the production of sin. Faults undoubtedly have existed, and still do exist to some extent, in plumbers' work—faults which undoubtedly are sometimes associated with the presence, and even the production, of disease. But to the faults of plumbers' work have been attributed results which, in very many of the cases, could not by any possibility have been due to them. The general public has not been concerned to understand plumbers' work; has not considered the difficulties of the tasks undertaken, often under conditions rendering satisfactory issues almost, if not quite, impossible. But faults in work or plan have been exaggerated by ignorant criticism, and by the tendency which the race is said to have inherited from Adam—of endeavouring to lay the blame of their own sins on the shoulders of any convenient victim. If typhoid fever or scarlet fever broke out, it was convenient to condemn the plumber. The milk supply and water supply were not thought of as possible sources of infection. If diphtheria or erysipelas appeared, the plumber was blamed. The conditions of water supply, of the soil on which the house stood, of the accumulations of filth within the house and without it, were not questioned as possible causes. Such has been long enough the tendency. And in recent years, when any such disease appears in the house, the smoke test is forthwith applied; the smoke escapes somewhere, the pipes are declared defective; and the defective drainage and the wicked plumber, as scapegoats, have to bear the opprobrium and the penalty. Such is the general position taken up by a hasty and not wellinformed portion of the public. Sometimes, on the other hand, of late years, we have been told that defective drainage does little harm; that soil pipe and sewer air, being chemically not very different from air often found in crowded rooms, can do little harm to general health, and certainly cannot produce any specific disease.

Between these extreme views we will probably find the truth. There, doubtless, have been defects, and still are, in plans, in material, and in workmanship. But efforts are being made, and by none more than by the plumbers themselves, to improve their work. Much more study is now being devoted to the principles of good drainage, and much more care is being devoted to the execution of the work, than was the rule in the past. There is still bad plumbing to be found, as there is also bad preaching, bad practice of medicine, and bad work in many departments; yet you do not condemn preachers, doctors, and workmen indiscriminately. The improvements made in this department of work of late years have been very great, and the earnest efforts of the trade to secure the best conditions in their work for the comfort and health of their clients is a hopeful augury of further advances.

We may now, perhaps, with advantage make an effort to fairly weigh the injurious influences which defective drainage and plumbing may produce on health. What are the injurious agents at work under those circumstances? How do they gain entrance to houses? How do they operate? What are the precise influences which they exert on health? How may they be excluded? It may seem a formidable task to attempt answering these questions, but even if our answers only approximate to the truth, they may help us some steps toward the end we have in view.

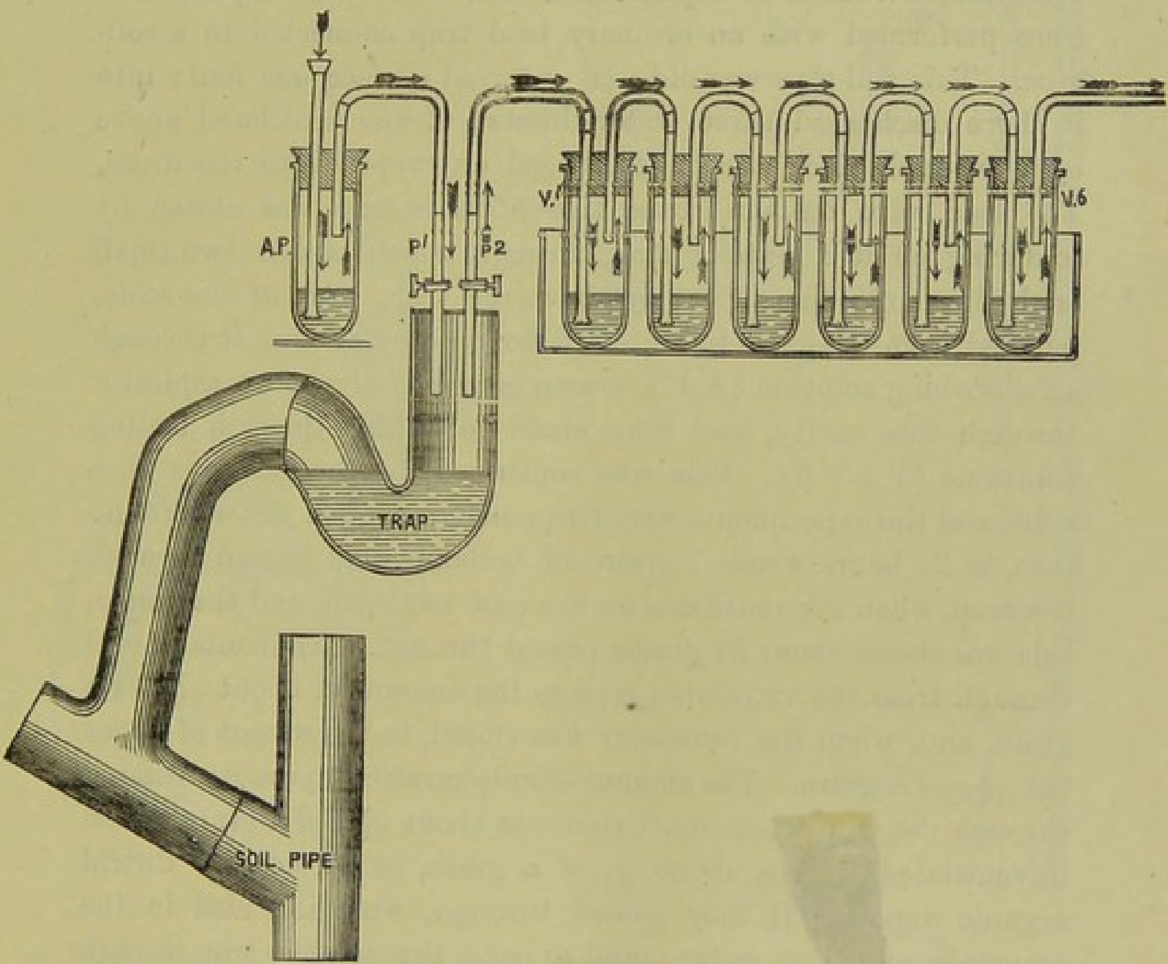
What are the agents which, in defective drainage, may be the cause of disease? They are, first, the liquid and solid organic refuse discharged through baths, sinks, washhand-basins, water-closets, and other apparatus; and, secondly, the products of the putrefaction of this matter. The putrefaction of this matter gives rise to the formation of gases, which, mixing with the air contained in soil pipes, drains, and sewers, make what is loosely spoken of as sewer gases. But the atmosphere of these pipes does not consist of sewage gases. It consists of ordinary atmospheric air, with the addition of less than one per cent. of the gases, vapours, and particles given off by decomposing sewage.

The air of soil pipes, drains, and sewers, when these are fairly ventilated, is not very much worse, from a chemical point of view, than ordinary atmospheric air as sometimes found in inhabited rooms, in crowded halls and in school-rooms.

In sixty analyses of sewer air made by distinguished chemists, and recorded in Buck's "Hygiene," it was found that there was a slight increase of nitrogen, a slight decrease in the oxygen, to the extent of about 2 per cent., a decided increase of carbonic acid, and sometimes traces of sulphuretted hydrogen. There were also found to be present minute traces of putrid organic vapours and putrefactive germs. The carbonic acid averaged in amount 0·36 per cent. — that is nearly ten times the amount found in outside air of the greatest purity. But the late Professor Carnelly found that the carbonic acid in schools is sometimes as high as 0·34 per cent.—that is nearly the same. And probably the air of soil pipes and drains, especially when these are badly flushed, and at the same time are maintained at higher temperatures by the heat of the house, is frequently worse than the air of well-flushed and well-ventilated sewers. The putrefying organic materials clinging to the rough sides of soil pipes through which pass, as we too often find, only driblets of water, and through which too little air flows, may give off considerable quantities of gaseous impurities. Still, even in such pipes, if there is any ventilation, the carbonic acid and other injurious gases which collect are never such in amount as to render the air acutely poisonous. Sulphuretted hydrogen, ammonium sulphide, organic vapours, and marsh gas, exist in soil-pipes in very minute quantities. Soil-pipe air, if breathed directly without further admixture of air, would doubtless be highly injurious to health, but probably not much more hurtful than the atmosphere of a crowded workshop, school, or hall. And we must remember that when soil-pipe air enters a house it is diluted by the atmosphere with which it mixes. The putrid organic vapours which are present in soil-pipe air, although in very small amount, are very injurious, because they seriously lower the quality of the oxygen, and because to the system they are poisonous.

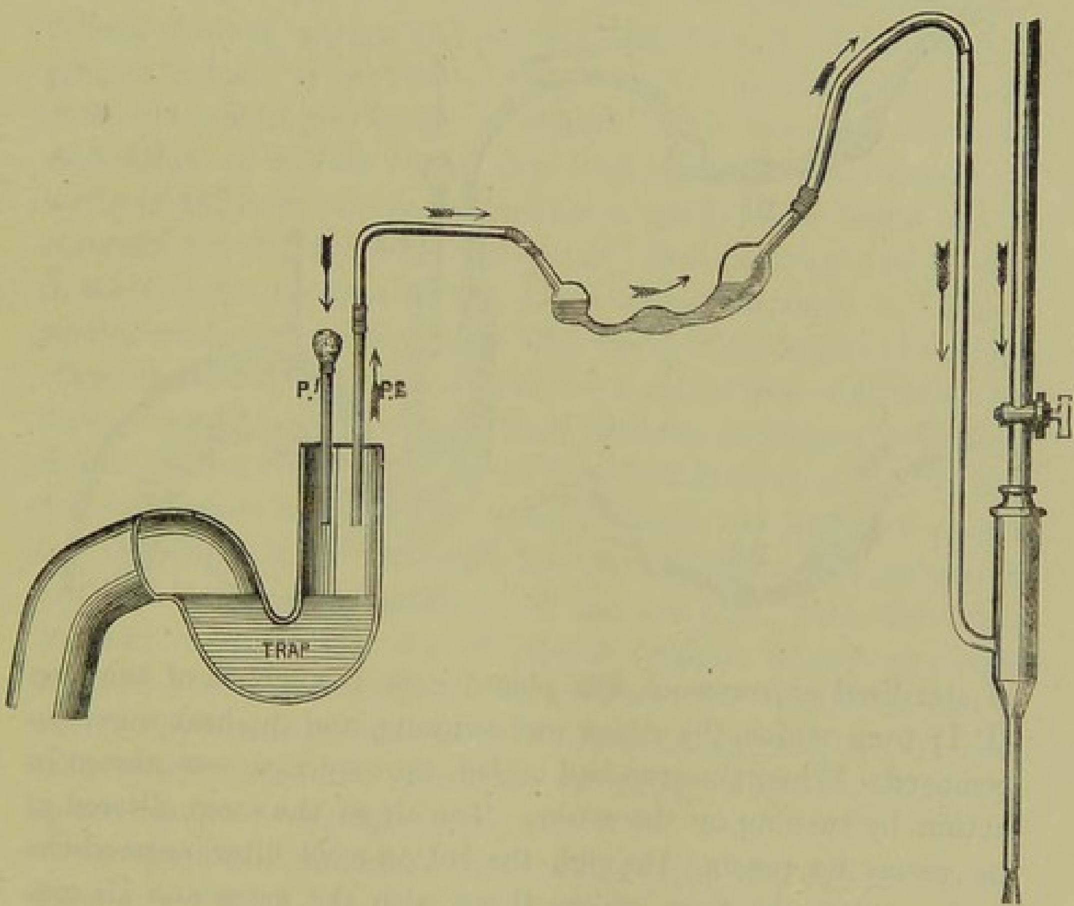
But in addition to the gases there are also found in the soil-pipe air solid organic particles in process of putrefying, and the organisms or germs of putrefaction. The processes of putrefaction take some time to complete, and the rapid passage of organic matter through the soil-pipes and drains does not afford time enough for such processes to do more than begin. The organic matters which adhere to the sides of the pipes, or which remain for a day or two in an unflushed trap—say in a wash-hand basin not much used—and the organic matter which soaks into the earthenware of basins and of drains through cracks in the glazing, have abundant time to putrefy and to give off their hurtful products. The processes of putrefaction and of fermentation of organic matter result from the growth and the chemical action of minute organisms, named generally bacteria and fungi or mould. These organisms attack dead organic matter in the solid state or in solution. They reduce the complex chemical compounds of these matters to simpler chemical forms. They are the great scavengers of nature, and they are the great food providers of nature, because their function is to reduce the complex compounds to such simple forms as carbonic acid, ammonia, and water, and so to provide food for plants. The processes take place normally in the soil, and render decaying animal and vegetable matter—manure, indeed—available for the support of plant life. The final products of the normal action of these organisms are usually not hurtful, but the intermediary products, and especially those formed in the absence of light and with an imperfect supply of air, are often highly poisonous. The presence of air in abundance greatly affects the processes of putrefaction and fermentation. It oxidises some of the products and so renders them innocuous, and it enables the organisms more completely, and, therefore, less hurtfully, to do their work. Putrefaction and fermentation for our present purpose may be considered as identical, although the term "putrefaction" is usually applied to the process when offensively-smelling products are evolved. In general language the term "germs" is used for the organisms which produce the changes. But you must remember that there are germs and germs, widely differing in form, in nature, and in action; and you must also remember that the germs of putrefaction are not identical with the germs which produce specific diseases. The germs which cause putrefaction in a soil-pipe or drain are not the germs which produce scarlet fever, typhus fever, or smallpox. If, however, the germs of putrefaction gain entrance to our houses from the soil-pipe or drain, they are capable of producing considerable mischief; they are hurtful to the health of those subjected to their influence. The processes of putrefaction and the products of putrefaction should, therefore, be rigidly excluded from our houses, and this is one of the main objects of good plumbing.

But how do the gases and germs contained in soil-pipes and drains gain entrance into our houses? Not through solid lead or iron pipes. Gases do pass through these metals, but in quantities

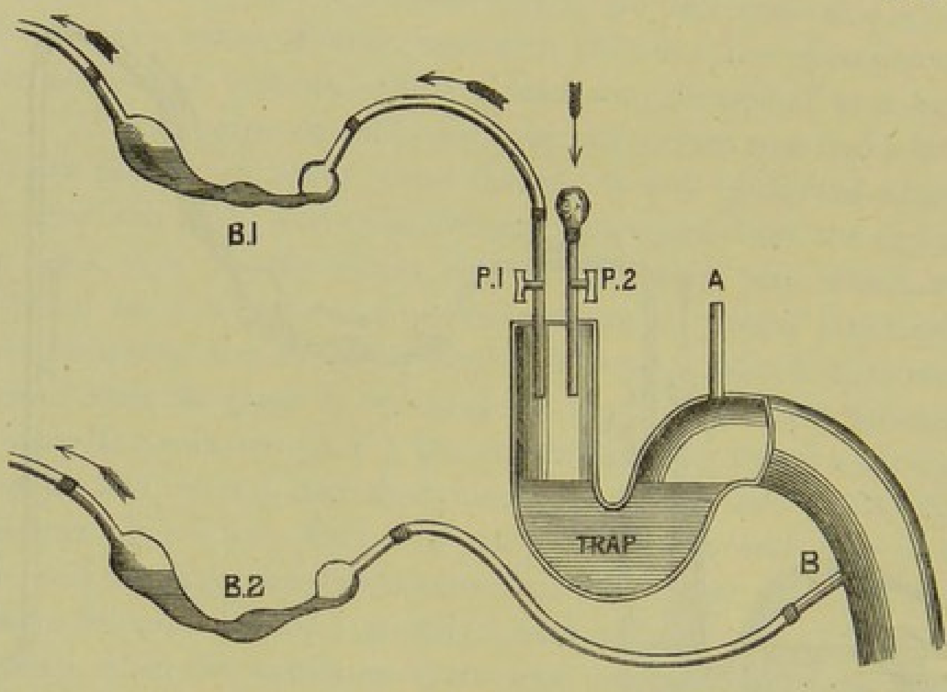


so infinitesimal as to be absolutely harmless. Do the gases pass through the seal of the water trap? The late Dr. Andrew Fergus of this city performed some very interesting experiments with glass tubes formed to represent traps. He found that carbonic acid, sulphuretted hydrogen, and ammonia, placed in one limb of the tube, passed through the water in the bend of the tube, and could be detected in the air above the trap on the free side in from fifteen minutes to three or four hours. When the tubes were ventilated, the time of transmission was slightly increased. These experiments determined the fact that gases could be dissolved by the water in the trap, and be passed out on the other side. In these experiments, the gases employed were presented to the surface of the water in a very concentrated condition. To what extent do the gases and germs of an ordinary soil-pipe pass through the water seal of a sound trap? To determine this point I performed a series of experiments in 1878-9. The experiments were performed with an ordinary lead trap connected to a soil-pipe. This soil-pipe was old; its internal surface was foul; into it there discharged three water-closets; it was ventilated above by a two-inch pipe; and it discharged untrapped into the drain. The lead pipe on the house side of this trap was closed by soldering on it a plate of zinc, through which passed two small lead pipes into the air cavity above the trap. Air of the room, purified from the gases to be tested for, was, by passing it through an absorbing solution (A.P.), drawn continuously by an aspirator through this cavity, and then made to bubble through testing solutions (V 1-V 6). This was continued for several days at a time, and the experiments were frequently repeated. It was found that, in 24 hours, about 7 grains of carbonic acid passed through the trap, when the ventilator on the roof was open, and that when this was closed about 32 grains passed through. Ammonia passed through from the ventilated pipe to the amount of about $\frac{1}{200}$ of a grain, and, when the ventilator was closed, to the extent of about the $\frac{1}{100}$ of a grain. The amount of sulphuretted hydrogen passing through the tr p when ventilated was about $\frac{1}{100}$ of a grain, when unventilated [illegible] as about $\frac{1}{80}$ of a grain, in 24 hours. Putrid organic vap[illegible] if they passed through, were included in the ammonia, a[illegible] ere never found to come through the trap in such an amount as to be detectable by smell. As the largest amount of ammonia found to pass through was about $\frac{1}{100}$ of a grain, the putrid organic vapour included in this amount must have been very small indeed. The quantities of injurious gases and vapours, therefore, which pass through the trap from the soil-pipe—even a foul unventilated one, directly connected with the drain—are exceedingly minute, and from a health point of view must be considered absolutely harmless. The foul gases of the soil-pipe and drain, therefore, do not gain entrance to our houses through a sound water trap.

Do the germs of putrefaction, or other germs contained in the soil-pipe, pass through the trap into the house? To determine this point I performed a large number of experiments, a few of which may be briefly described. The lead trap, already mentioned,



connected with the soil-pipe, and closed on the house by a plate of zinc having two pipes passing through it into the cavity above the water, was connected by one of the pipes (P 2) with a nitrogen bulb—that is, a glass tube—with alternate contractions and expansions. In this bulb was placed a cultivating solution—that is, an organic solution, in which microbes can readily grow when they have been introduced. The bulb was connected with an aspirator, which, when the water was turned on, drew the air through the bulb. The other tube (P 1) leading into the cavity above the traps was at first left open. A pot, containing melted paraffin wax, was placed under the lead trap, so as to immerse the trap in the wax. This was heated till the water in the trap boiled freely and steam was blowing out freely through the open pipe (P 1). The liquid in the bulb also was boiled. This boiling killed all germs which were contained in the trap and in the bulb—it sterilized the apparatus. A large pad



of sterilized cotton-wool was placed over the mouth of the pipe (P 1) from which the steam was escaping, and the heat was then removed. When the trap had cooled, the aspirator was started in action by turning on the water. The air of the room, filtered of its germs by passing through the cotton-wool filter, entered the cavity above the trap, mixed there with the gases and air contained in it, and was then drawn in a series of bubbles through the liquid in the bulb. If any germs passed through the water-trap from the soil pipe, they must have been carried into the bulb. The aspiration was usually continued for from 24 to 36 hours. The bulb was hermetically sealed before removal, and was placed in a room heated to cultivating temperature. The liquids in those bulbs, though kept for several months in some instances and at cultivation temperature, remained perfectly clear, and exhibited, on careful microscopical examination, no trace of life; that is to say, no germs had passed through the water trap. For comparison, the air of the soil-pipe was made to bubble directly through a similar bulb (B 2). The liquid, in this case, became hazy from particles, and developed fungi and bacteria in abundance. It might be objected, to the experiment with the trap, just described, that the water contained in this trap was sterilized, and that the water ordinarily found in a trap is more or less putrid. Would putrid liquid give off its germs to the air above it? To determine this, I poured into the trap already mentioned, through a pipe (A) on the soil-pipe side of it, about a pint of urine. A portion of this remained in the trap mixed with the water previously contained. This speedily putrefied. Aspiration of the air above this trap, through the cultivating liquid in the bulb, was continued for a week. The liquid in the bulb did not putrefy nor develop life; that is, the putrid water in the trap did not give off its germs to the air above it. These results are in entire consonance with the results obtained by many other modes of experiment, and have since been confirmed by many experimenters, and have been officially confirmed by experiments performed by the National Board of Health of the United States. Sound water traps, properly placed and having a proper seal or waterlock, are therefore, for the exclusion from houses of injurious substances contained in the soil-pipe, perfectly trustworthy. They exclude the soil-pipe atmosphere to such an extent that what escapes through the water is so little in amount, and so purified by filtration, as to be perfectly harmless; and they exclude entirely all germs and particles, including, without doubt, the specific germs or contagia of disease.

Yet there are conditions under which traps may fail to protect. They may be so placed that the water seal is destroyed. The water in the trap may be siphoned or aspirated out till the seal is destroyed. Expansion of the atmosphere in an unventilated soil-pipe may cause the soil-pipe air to bubble through the trap. To determine the condition of the air which bubbled through the trap, the following experiment was performed:—With the apparatus arranged as before, except that the pipe (P 2) through which the air had previously entered was now closed, the aspiration was started, and air not being obtained through the small pipe, the soil-pipe air bubbled through the trap. The liquid in the bulb in this case became hazy and developed bacteria and mould. Soil-pipe air bubbling through the trap carries with it the germs, and if this soil-pipe air contained the germs of specific diseases, these would doubtless be conveyed to the atmosphere of the house.

These experiments establish the reliability of the water trap, if sound and well placed, and emphasise the importance of ventilation of the soil pipe, and of so arranging the pipes that pressure and siphoning may be avoided.

Another of the modes of entrance of soil-pipe air to the house is through loose joints, or cracks, chips, or holes in the pipes. These defects may be due to bad material or bad workmanship, they may be due to subsidence in a new building, or they may be due to decay of the materials through time. They will, of course, admit the soil-pipe atmosphere and also its germs. The late Dr. Fergus drew attention to the perforation of lead pipes on their unwet surfaces, through the action of the carbonic acid gas contained in the soil-pipe air, and showed that this action was much more severe and much more speedy when the pipes were badly or not at all ventilated. To determine what might pass through small holes in a soil-pipe, I performed the following experiment. A piece of lead gas pipe (B) was inserted in the side of the soil-pipe, was flattened to closure at its extremity, and was then perforated by a pin. The end of this pipe passed through a cotton-wool plug into a flask containing cultivating liquid. The flask remained for 24 hours in communication with the soil-pipe by the pin hole, and on being removed it contained numbers of motes, and it developed fungi and bacteria. A pin hole, therefore, in a soil-pipe is a source of some danger.

In considering the influences of loose joints and of holes in soil-pipes, we must remember that the soil-pipe air is drawn in forcibly through these openings by the greater heat in the house, and by the action of the chimneys, and that during the night, if the doors and windows are too securely closed against the admission of air, a large proportion of the air which enters the house may be coming by way of the openings in the soil-pipe.

Sewage products gain entrance to houses from drain pipes in many ways, as, for example, through joints originally bad, or rendered bad through subsidences. The air escaping from defective drains into the soil under the house is very readily drawn into the house by the greater heat, and by chimneys. The liquid portion of the house sewage, and sometimes also solid portions, escape into the soil from perforated or badly-jointed pipes. In the soil it goes through the complete process of putrefaction, daily and hourly discharging into the air of the house its gaseous products, and the germs of bacteria and fungi. The clay drain pipe also becomes, after the glazing has cracked, a sodden mass of putrefying material, giving off its offensive and hurtful products to the house. This putrefaction in the soil is probably a more serious source of danger than even a perforated soil-pipe, because, in the dark, and with very little air, the processes of putrefaction continue in their worst form. The microbes of putrefaction are drawn into the house through chinks and cracks in flooring and walls, and the whole of the gaseous products are drawn in through the same openings, and even through sound wood and stone.

These are some of the ways by which the soil-pipe air and germs, and the products of putrefaction of sewage, may gain entrance to a house. But having gained entrance, What effects do they produce on health? It has often been asserted, and even by some who have been reckoned authorities, that the entrance to the house of soil-pipe atmosphere, with its germs, may cause specific diseases, such as typhoid fever, scarlet fever, measles, diphtheria, and erysipelas. The relation of drain and soil-pipe air to the causation of typhoid fever in particular has been very frequently asserted. When typhoid fever appears in a house, the drains and soil-pipes are usually tested, and usually found defective. The conclusion, that this exhibits cause and effect, is too readily adopted. It would be necessary, in support of such a conclusion, to show that serious defects exist in a very much larger proportion of the houses in which this fever appears than amongst houses in which the disease has not appeared. This has not been proved—indeed very much the reverse has been established, by the examination of drainage by smoke test and otherwise. In the application of drain and soil-pipe testing carried out by the

Sanitary Department of Glasgow in 1891, out of 786 tenements (the new tenements are not reckoned in these figures) it was found that 639, that is fully 81 per cent., were defective. These figures are a decided improvement on those of a few years back, but they indicate a serious state of matters from a health point of view. But why does not typhoid fever appear in all, or at least in very many of the houses which are found defective in their drainage, if, as is sometimes asserted, the ordinary contents of a soil-pipe or drain can produce this disease? There has been discovered a specific organism or germ, the *Bacillus typhosus*, which is believed to be the cause of this disease. This organism grows and multiplies readily in the human intestine, producing the specific fever. It grows vigorously in milk, it lives long in water and in ice, but it does not exist in soil-pipes or drains, unless it has been put into these with discharges from patients suffering from the disease. So that, when these organisms have not been put into the drainage system from a typhoid fever case, we do not find that the atmosphere of these pipes, even when inhaled pretty freely, produces this specific disease. More careful investigations made into the causation of this disease, within late years, have well established the fact, that in all cases where the cause has been clearly made out, the disease has resulted from eating or drinking food or liquid—including ice—which has been contaminated by discharges from the bowels of some one suffering from the disease. Typhoid fever is probably not directly infective through the air. This is the opinion generally held by physicians having large experience of this disease. In some general hospitals it is customary to treat cases of typhoid fever side by side with non-infectious diseases. This practice does not seem to be attended with any risk of infection of the other patients, notwithstanding the fact that many of the microbes of the disease must get blown about the ward from discharges of the patient, on the bed-clothes, and on his own person. Dr. Wynter Blyth,* one of the most recent and reliable authorities, says—"Occasionally typhoid excreta may be dried and blown about in dust, become breathed, and thus, getting access to the mouth, be swallowed

* "A Manual of Public Health," page 505. A. Wynter Blyth. Macmillan & Co.

with the saliva; while, admitting this as possible, there is no instance on record, in which this mode of transmission has been rendered more probable than other ways. The whole pathology of the malady points to the cause gaining access to the alimentary canal by drink or food." Now, if the many germs which in this way may get blown about do not readily, if at all, infect those who inhale them, is it likely that the few germs, which possibly may enter the house from the soil-pipe, can directly infect the inmates? If, however, the microbes gain access to milk or other rich form of nutriment, or to drinking water—say, in a well, through typhoid discharges cast on the ground—they then find a soil in which they can grow, and a medium by which they may be passed into the stomach and bowels, and thus produce infection. Improvements in the drainage of a district in which the drinking water is obtained from wells decidedly reduces the prevalence of this disease. But the improvement of the house drainage of a district which has a supply of pure water by gravitation, while it materially improves the general health, has no marked influence in reducing the prevalence of typhoid fever. Dr. Hay, of Aberdeen, points out that very thorough and general improvement of the house drainage of Aberdeen was followed by a very marked diminution of consumption, but by scarcely any diminution of typhoid fever. We may thus safely conclude that the inhalation of ordinary soil-pipe and drain air does not produce typhoid fever.

But suppose that the bacilli of typhoid fever have been discharged from a patient into a soil-pipe, say through a water-closet, and that the soil-pipe air is escaping into the house, will the germs so gain entrance and produce the disease amongst the inmates? In endeavouring to answer this query, we must remember that germs in a putrefying solution are not given off to the air by the vapour rising from the fluid. Once entangled in the water, they are retained by the water, and carried along by it. The water of the Clyde contains micro-organisms in myriads, but the air over this water contains few germs, fewer, decidedly, than the air in our streets. Moist surfaces may contain germs in great numbers, growing and rapidly multiplying, but they retain them. Moistened germs are too heavy to rise into the air. Active bubbling in the liquid may raise a few germs, and when the moist surface—

say, of the soil pipe—becomes dry, currents of air may lift them. But, unless the water in the traps has become very putrid, by absence of flushing, the bubbling in the soil-pipe or drain is slight, and besides the internal surfaces of these pipes, when in use, rarely become so dry as to permit the air currents to lift the particles. We do, however, often find secondary cases of typhoid fever in the same house, or, perhaps, in neighbouring houses connected by the same soil-pipe. It may be that the first case was due to infected milk, and that in the secondary case this milk had not been partaken of. Has the disease not been conveyed by the soil-pipe or drain? But are there not much more ready means of conveyance of the disease than these? In typhoid fever the bed clothes, utensils of convenience, the hands of nurses, and many other things become soiled by the discharges. These being exposed to air speedily dry, and so the germs are apt to be blown about the house, contaminating milk or other food, in which they multiply and attain their maximum of vigour and infective power. For one germ of typhoid fever which might possibly become detached in the soil-pipe and obtain entrance to the house, probably thousands enter the atmosphere of the house from articles directly contaminated by the patient. And it is certainly more easy to understand that these find their way by skirting boards, by loose flooring, or otherwise into neighbouring houses, than that they have effected an entrance from the soil-pipe. Men working in sewers are not specially subject to typhoid fever; and plumbers, as Dr. Duncan lately showed, are, as far as evidence can be obtained, not more liable than others to this malady. But both classes of men work in the presence of sewage discharges and products, and the plumber is frequently at work in soil-pipes and traps into which typhoid fever discharges have been recently passed. We may, therefore, with safety conclude that the typhoid fever germ is not generated in the soil-pipe or drain, and that, if occasionally the germs of typhoid fever which have been passed into the soil-pipes do gain entrance to the house and produce the disease, it must be in extremly rare instances.

What we have just said as to typhoid fever, applies with even more force to scarlet fever, the poison of which is not by any means so much discharged through the drains. Scarlet fever is a specific disease, the germ of which is not found to originate in putrid materials. Careful investigation of outbreaks of scarlet fever have shown that the disease is generally, if not always, conveyed by personal contact of the infected with the susceptible, or by food which has become contaminated by contact with infected persons.

As in diphtheria and erysipelas the evidence is not yet so clear as in the cases of the two diseases just discussed. But, so far as the evidence goes, it tends in the same direction. These diseases are not so definitely specific as are scarlet fever, typhoid fever, and measles. It is possible that the germs producing them may develop in some forms of putrefaction outside the body. But it is certain that the entrance to a house of the products of putrefaction render the inmates susceptible to these diseases, as it does also to puerperal fever, and to septicœmia.

But while soil-pipe and drain air cannot produce definitely specific diseases, and probably cannot readily convey them, it has been found that the frequent and prolonged inhalation of this air, *by lowering the general tone of health*, *by slightly poisoning the tissues*, *by lessening the power of the system to perfectly cleanse itself as it does in a pure atmosphere*, lessens the power of resistance to the attack and to the progress of infectious disease, so that the disease is more readily contracted when its germ gains access, and is apt to become more severe. In this sense, and to this extent, defective drainage favours the development of infectious diseases. But if specific diseases are not caused by defective drainage, what are the effects on health which soil-pipe and drain air actually do produce? In the first place, there are what may be called the more immediate effects—the prominent and noticeable symptoms—viz., headache, sickness, loss of appetite, feeling of lassitude, sore throat, diarrhœa, and feverishness. These effects are very frequently produced in houses to which soil-pipe and drain air have free access. A continued residence in such an atmosphere produces occasionally a kind of toleration in the system, and those habituated to those influences seem to suffer seldom from these disorders. Strangers coming from a purer atmosphere to reside in a house so contaminated, are apt to suffer at once and severely from some of the disorders mentioned. And the regular inhabitants of such a house, when they have been for some time from home, even when the house has not been shut up, are very apt, on their return, to be attacked. When the house with imperfect drains or soil-pipes has been closed for some period—say, while the family is residing at the coast—on their return there is very often, likewise, a more or less acute attack of disorders, characterised by some of these symptoms. This is due probably in part to their residence in purer air having increased their sensitivenesss to such influences; in part to the accumulation in the unventilated house of the drain and soil-pipe air; and in part, perhaps, to the fact that the unflushed drains and soil-pipes have had time to dry on their internal surfaces, and so to discharge into the houses with the ingoing currents considerable quantities of putrid organic particles, and of the moulds and bacteria of putrefaction. The prominent symptoms just referred to, with the exception, perhaps, of the sore throat, are more or less symptoms of disorder of the digestive organs—sickness, diarrhœa, loss of appetite, headache, langour, and feverishness. It is probable that these symptoms are not always produced by the inhalation of the foul air directly, but are often due to contamination of water and milk, or other fluid contained in the house, and subjected to the influence of the gases and germs. The sore throat is sometimes a dryness, sometimes an inflamed condition, sometimes an ulcerated condition, and sometimes a condition resembling diphtheria. This class of symptoms is perhaps due to the inhalation of soil-pipe or drain air.

Besides those more acute symptoms, and even when those acute symptoms are absent, we find very often a general deterioration of health, a loss of vigour, an impaired appetite, a deteriorated condition of blood—sometimes considerable anæmia. The tone of health is lowered; the active and vigorous renewal of tissues is impaired; the power of resisting attacks of disease is lessened; the power of recovery becomes defective. In this way we find that bad drainage predisposes to specific and general diseases. The blood and the tissues slightly poisoned by the organic vapours, imperfectly nourished by the lowered nutritive quality of the contaminated air, and imperfectly cleansed of its normally formed impurities by the lessened quantity and lowered quality of the oxygen, render the system fitting soil for the development of specific diseases. And so in houses imperfectly drained, there may be an excessive prevalence of infectious diseases, not because the drains or soil-pipes have produced these diseases, not because they have conveyed these diseases, but because they have rendered the inhabitants suitable soil for their germs. The general deterioration of health produced by defective drainage may result in many diseases, and probably the long continued breathing of air so deteriorated is very frequently an important factor in the production of consumption. As has already been stated, great improvements made in the house drainage of Aberdeen were followed by a marked diminution of deaths from consumption.

The injurious effects produced by defective drainage have been very frequently measured by the extent to which infectious diseases have prevailed. It will thus be seen that such a measure is a faulty one, and that much injury may be produced, while infectious diseases have been absent. Much serious injury to health, manifested in many different forms of disorder and debility, may follow from defective drainage, while no infectious disorders may have appeared.

Such is a sketch of the effects on health of defective drainage, but it is to be noted that the effects produced are not specifically connected with drain or soil-pipe air. The effects are very much the same as are produced by putrefaction of organic matter in the soil on which the house is built, in the damp walls of the house, under the floors of the house by putrefying dead rats or mice, or in the house itself by any collection of putrid material. And in connection with this, it may be said that the putrid fungoid masses so frequently found in lead safes or trays under baths and water-closets—hidden from view by the boarding, but slowly putrefying and giving off their gases and germs—are probably as dangerous to health as even a perforated soil-pipe. The foulness of the atmosphere resulting from overcrowding and from defective ventilation produce, indeed, much the same constitutional effects. The late Professor Carnelly found that, as to carbonic acid, the air of some crowded schools was about as bad as the average sewer; and that the air of the crowded school-rooms contained sometimes 1,500 micro-organisms, as against about 90 in sewers. Impure air, rendered impure by the products of respiration, or by the products of putrefaction inside the drainage pipes, or otherwise in connection with the house, produces effects much the same in kind, although differing somewhat in virulence.

How are these effects to be prevented? They are to be prevented by working on good plans, by using good material, and by applying the best workmanship. As much as possible, the drainage apparatus should be outside the walls of houses, in towers or shafts perhaps, but certainly not in the centre of a building. The principle of concealment which has regulated their arrangement in the past should be abandoned, and the whole of the appliances should, as far as possible, be exposed to view, or, at least, be so arranged that inspection and testing may be easily carried out, and that defects may be readily detected and repaired. The traps should be sound and well constructed, with a proper seal, and so placed that they cannot be subjected to unequal air pressure on the two surfaces of the water, and that they cannot be emptied of their water by siphon action. Nothing which has passed the house end of a trap should in itself or in its products be permitted to return to the house, or to lodge under the house. All pipes must also be freely ventilated—that is, have a clear and full passage for air—so that the gases formed may be freely diluted; that the processes of putrefaction may be of the least hurtful kind; and that the products may be, as far as possible, oxidised, and rendered innocuous. A plumber who respects himself, and who regards the welfare of his neighbour, should refuse to do work on a bad plan. The loss of the work will probably hurt him less than the injury to his reputation which may result from the carrying out of defective arrangements.

In addition to good plans, good material, and good workmanship, there must be periodical inspections of drainage. The drainage must not only be good at first, it must be kept in good condition. The present mode of testing soil-pipes and drains by the smoke test is, no doubt, a fairly good one, but it is by no means perfect. The aim must be set before the workman of having a soil-pipe and a drain so finished that while air passes freely through them, in their substance and in their joints they will be air-tight; and I have little doubt that, before long, a pneumatic air test, with pressure gauge, definitely telling whether a pipe is sound in its material and in its joints, will be employed.

But how is all this to be secured? How are plumbers to attain to the knowledge of the principles of drainage to such an extent as is desirable? How are they to attain the skill in their work requisite to the proper execution of their plans? And how is the public to distinguish those so trained and so skilled from those who are neither? The relation between the condition of the drainage and the health of the community is a close one. The principles of sound drainage require accurate and careful study, and are not to be acquired intuitively, or learned by rule of thumb. The safety of the public health demands that those entrusted with this work should be, in fact, thoroughly competent, and should be proved competent, before they are permitted to undertake it.

In the first place, education is necessary. In Glasgow, Greenock, and many other places, there are now being conducted very efficiently classes on plumbing. In the class in the Glasgow and West of Scotland Technical College, taught in this city by Mr. Fulton, it is satisfactory to learn that there are 135 students. Every apprentice, every journeyman plumber, who has not already attended such a class, should avail himself of this opportunity to attain precise and extensive knowledge of the science and of the art of plumbing. It is impossible to be a good and reliable plumber without an accurate acquaintance with the materials and the tools with which he works, without a clear understanding of the principles of drainage, and without a familiarity with the laws of physics, so far as these relate to the construction and the working of the various forms of apparatus with which he deals. Having so trained himself, the plumber should, by examination, satisfy a competent and responsible board of his fitness to be entrusted with the important work of drainage, should be by this board duly placed in the register of competent men, and should be so certified to the public. Let the plumber be so trained and certified; let him do his work well, and on a good plan; let him mix brains and conscience with his labour, and he will be found a benefactor to society to an extent that will make the opprobrium too often recklessly associated with the name of the plumber give place to the highest confidence, respect, and gratitude; he, too, will then become an efficient soldier of the army which is at war with all the causes of disease.

The lecture was followed with close attention and interest throughout; and at its conclusion, a cordial vote of thanks was given to Dr. Carmichael, on the motion of Mr. J. H. Kerr, seconded by Dr. J. B. Russell.

The proceedings were brought to a close by a vote of thanks to the Chairman, proposed by Mr. Buchan, who made special acknowledgment of the support given by the authorities of the Technical College to the movement for elevating the plumber's craft.

Objects of the National System of Registration—

To elevate, by Education and Registration, the status of the Plumber's craft;

To give every competent tradesman a diploma which will be recognised throughout the Empire; and

To ensure, by these means, the protection of the Public Health.