SECTION III.

CHEMISTRY, METEOROLOGY AND GEOLOGY.

ADDRESS

By R. Angus Smith, LL.D., Ph.D., F.R.S., F.C.S., &c.

PRESIDENT OF THE SECTION.

Ladies and Gentlemen,—The history of this Institute is not a long one, if we look to its name only; but if we look at it as the result of a great national movement which has been in progress for fully forty years, we shall find that it is full of interest.

Attention to health has been more or less the subject of thought, of writing, and of legislation, from the earliest times, and you have already heard opinions given by the early Egyptians, Israelites, Greeks, and Romans, coming down to our own time. A few scientific thinkers have occasionally in ancient days attempted to lay down laws, and their attempts, more or less well founded, are interesting; but perhaps in olden times the most careful attention to health was observed chiefly amongst the wealthy, and, as a national movement, we are not aware that in any country it was widespread, although separate acts of legislation are to be found amongst the nations mentioned. It is not my intention to go back to history, but I cannot help making some slight reference to our more immediate past, at the time when the nations of Europe, and, we may say, of the four continents, have been agitated by fears regarding the great epidemic which is still unsuppressed in Egypt.

It would not be boasting if we were to speak with some satisfaction of the work which this country has done in the cause of national health, when we have seen so many writers on the Continent discussing our modes of operation, and showing

dissatisfaction with systems which have been so carefully thought out. It is difficult to tell in what country of the most civilized parts of Europe the first ideas on any subject chiefly arise. There are many men who are considered to be the first promoters of an object who, after years, have been found to have been preceded a long time by others; but it surely can be a matter of little doubt that in sanitary practice relating to public health, and its attempt to scatter that knowledge and practice widely amongst the people, England has been the first amongst nations. To those who travel much upon the Continent even in places most advanced in material civilization, it is still a wonder that the crude appliances for cleansing towns or houses which are everywhere observed can be tolerated; and it is a common thing for people of this country to refuse to travel abroad, or to prefer to confine their travels in certain directions, only because of the discomfort arising from habits offensive to the senses and to health. I think it is fair at this time to make this claim; and whilst I make it for England, I am sorry not to be able to say that Scotland preceded her; but, at least, I am glad that the principles and practices worked out in the former country have taken such deep root in the North, and that the comfort of life has been greatly increased amongst the population since the time when I spent my early days in Glasgow. This work has not been done without the anxious and severe labour of many men: nearly a whole generation of enquirers may be said to have died in the struggle. Nevertheless, the leader of them all is still amongst us; and one can scarcely speak upon the subject of Sanitary Reform without mentioning the name of Edwin Chadwick. I doubt if his labours are sufficiently known even now to the general public; but, having had the pleasure and the advantage of being at an early period of life more or less associated with him in his work, I am one of those who have had the opportunity of witnessing his earnestness, his unselfishness, and his power.

It is not easy to tell how many lives he has saved, although calculations have been made on good foundations; but even the number of lives which he has saved would give a small idea of his merits, because we must also take into consideration the enormous amount of discomfort and imperfect health which sanitary appliances remove. Surely we ought to honour such a man. To have led an army so as to have killed but a small portion of those whose lives he has saved would probably have given him the rank of a leader, a Dux—a duke. Can the nation not give him some equivalent honour, or put some stamp on the noble metal of his life?

But whilst we look on the progress of this country in matters relating to public health, and take to ourselves that honour which we think is our desert, we cannot have any feeling but pleasure when we look at the work of a scientific kind which has been done on the Continent, and which is at this present moment claiming the attention of all sanitary reformers. The work done by Pasteur in France is of a kind which cannot be too highly admired. He has probed into the more immediate causes of disease in man, in the lower animals, and in plants, and he has found results scarcely suspected even by those who for a long time had believed that the microscope would continue to reveal to us many wonderful and important secrets. It is true that in very early days it was suspected even by Terentius Varro that small animals in the air and low places in swampy grounds produced disease in man, a suspicion founded on what observations we have no means of knowing. The history of the microscope from the days of Leeuwenhoek is a history of marvels; but during the days of Pasteur the marvels must have astonished even its greatest admirers. There have no doubt been many workers besides Pasteur, but I have selected in the case of England only one name—one that seemed eminent amongst all others in promoting the cause of public health; and I think it fair to bring forward Pasteur prominently before you, although you are already familiar with his name, and I am not quite sure if it be not the case that, by some peculiarity of the action of fame, his name is better known in this country than even that of Edwin Chadwick.

If I mention Pasteur at present it is in order that I may allude to one of his latest discoveries, viz., the attenuation of the virus of at least one disease, viz., that of chicken cholera, by the action of air or oxygen. I do this because it comes in well with the object which I have in view in this address, specially to call attention to the action of oxygen; it is an old subject but not exhausted, and I hope you will not be too much wearied by listening to the advantages of pure air. It may be well to quote Pasteur's words—

"Now that we have arrived at this point a question presents itself which relates to the cause of the attenuation of virulence.

"The cultivations of our virus must take place in contact with air, because our virus is aërobian, and, without air, its development becomes impossible. We are, then, naturally led to ask whether the attenuation of the virus is not due to contact with the oxygen of air? Would it not be possible that the small organism which constitutes the virus, when left in contact with the oxygen of pure air, in the medium of cultivation in which it has developed, may have been modified, and the change remain permanent, even after the organism has been withdrawn from the modifying influence? We may also enquire whether some chemical principle in the atmosphere, other than oxygen, does not intervene in this phenomenon, the singularity of which almost justifies my hypothesis.

"It is easy to understand that the solution of this problem, in case it depends on our first hypothesis, that the phenomenon is due to the oxygen in the atmosphere, may be tried by experiment. If oxygen is in reality the cause of the attenuation of virulence we may have, to a certain degree, a proof of it by noting the effect of suppressing it.

"To test this, let us conduct our cultivations in the following manner:—We may take a certain quantity of our chicken broth and place in it the most virulent virus, and fill with it a series of glass tubes up to two-thirds, three-quarters, &c., of their volumes. These tubes may then be closed over the lamp. By the presence of the small quantity of air left above the liquid the development of the virus may be started, which is ascertained by the increasing turbidity of the liquid. The development of the cultivation gradually absorbs all the oxygen contained in the tube. The turbidity then diminishes, the growth is deposited on the sides of the tube, and the liquid becomes limpid. This takes place generally in two or three days. The microscopic organism is then deprived of oxygen, and will remain in this condition as long as the tube is not opened. What will become of its virulence? To be sure of our results, we will have prepared a great number of such tubes, and an equal number of flasks, which last, will continue to be left in contact with pure air. We have already spoken of what becomes of cultivations carried on in presence of air. We know that they experience a progressive attenuation of their virulence, and we will not return to this subject. Let us now only pay attention to the cultivations in closed tubes. Let us open them—one after an inverval of a month, another after three months, and so on until we open one that has stood ten months. I have not gone any further at the present time. It is a remarkable circumstance, that the virulence in all these cases is of the same degree as that of the liquid which served to fill up the tubes. As to the cultivation exposed to the air, they are found either dead, or in a condition of feebler virulence.

"The question we have proposed is then solved: it is the oxygen of the air which attenuates and extinguishes the virulence.

"To all appearances we have here what is more than an isolated fact. We must have reached to a general principle. We may suppose that an action which is inherent to atmospheric oxygen, an agent present everywhere, has the same influence on other viruses. At any rate it is worthy of interest that possibly a general cause of attenuation exists dependent on an agent which is in a manner cosmical. Can we not suppose, even now, that it is to this cause that we can attribute in the present, as in the past, the limits set to great epidemics?

"The facts which I have had the honour to communicate to the Academy suggest many proximate and remote inductions. From all these I must hold back with reserve. I will not feel authorised to present them to the public unless I make them pass into the domain of demonstrated truths."

It was an Englishman that discovered oxygen—Priestley. He called it vital air, with a due appreciation of its wonderful powers. It was a Frenchman, Lavoisier, who gave it, we may say, its scientific work to do, and called it by its present name. The two nations have worked together for many years, thinking on similar subjects, whether friendly or at war.

If we leave for a moment the attention to individual workers, and consider the ordinary observation of moderately observing men, we find how wonderful is the difference noticed between places and objects which have been closely shut up and those which have had the clear sweep of the air of heaven upon them. We call the former places close or musty, or depressing, or in various ways endeavour to define our objections to them. The Arab, in the free air of the desert, is afraid of even the outskirts of a town. Some people can smell great cities at a considerable distance, and coming this year from wandering about Norwegian seas and valleys, I fear I was right in thinking that I had acquired the power of perceiving the near approach of places supposed to be intensely civilised.

When a room is shut up even for a day, unless the room be very large indeed, there is always that peculiarity observed by sensitive persons, to which would be given the name of closeness. Yet there are people who do not seem to observe this, and who live their lives in rooms in which this closeness may be constantly observed. I have often reflected on this peculiar condition. Surely, if oxygen removed all impurities, these impurities ought to have been removed, since the oxygen of the air is never absent from these rooms, except to such a small extent that the estimation of the change is extremely difficult. If we lift up a window and allow the air to blow into the room, so as entirely to replace the original air, we do not at all times attain sufficient aëration. It takes but a few minutes in a climate like this, where there is considerable motion of the air, to renew the atmosphere of a room entirely; we may judge of this by making a trial upon a visible atmosphere, viz., one pretty well filled with smoke. We see how rapidly with an open window every trace may be removed from the farthest corner, and yet

this new air is not sufficient to refresh the room, and closeness is the characteristic still complained of. It is the custom in well regulated houses not merely to renew the air, but to cause the air to blow through the house for a considerable time every day when the weather permits it. Knowing this for a long time, I wondered very much what was the reason. Surely, I said, there was vital air enough without this long continued current.

Then that remarkable discovery made by Schönbein came to my mind, as I suppose it has to the minds of many other chemists, and I thought it must be the ozone in the air that does the work, and as there is little ozone in a volume the air requires many repetitions of bulk. There may be some truth in this still; but whether, because the air receives imperfect contact with the substances to be purified, or whether the mechanical action of the current is necessary, or some other cause, it is certain that a continual current is necessary for perfect purification. Looking further at this subject, it occurred to me that really clean houses were preserved in this condition by something more than currents of air generally, and that good housewives resorted to the practical method of rubbing by hand, and it seemed clear that no furniture could be preserved from that peculiar condition of mustiness in any house where the doors and windows must be frequently closed, unless the absolute removal of certain substances from the surface were resorted to. And what was this substance that required to be removed? I suppose it to be one of organic origin. In speaking of this, perhaps you will excuse me if I enter with more detail upon my own work than the works of other men. I shall, naturally, feel more at home; and as this Institute will take care that you are made acquainted with all the discoveries relating to sanitary appliances made in all parts of the world, this may be a reason for contracting the field of my observations, and I cannot hope to keep your attention so long as a consideration of the whole range of enquiry would demand, even if I had power to speak so widely.

I may here bring in an account of an enquiry concerning ammonia, which will explain some of my meaning. It is taken from the Memoirs of the Literary and Philosophical Society of Manchester:—

"If organic matter is everywhere, the presence of ammonia is everywhere possible; and if that matter is decomposing, ammonia is everywhere. That is the general statement which this paper illustrates. It is now many years since it was observed by me that organic matter could be found on surfaces exposed to exhalations from human beings; but it is not till now that the full significance of the fact has shone on me, and the practical results that may be drawn from it in hygiene and meteorology. These results are the great extension of the idea that ammonia may be an index of decayed matter. The idea itself has been used partly, and to a large extent—as illustrated in my 'Air and Rain;' the facts now to be given enable us to claim for it a still more important place. The application seems to fit well the conditions already examined; and by this means currents from foul places have been readily found. This does not apply to the substances which may be called germs, whether it be possible to see them or not, because these are not bodies which have passed into the ammoniacal stage, although some of them may be passing—those, for example, which are purely chemical and exert what we may call *idiolytic* action.

"Ammonia must ever be one of the most interesting of chemical compounds. It comes from all living organisms, and is equally necessary to build them up. To do this, it must be wherever plants or animals grow or decay. As it is volatile, some of it is launched into the air, on its escape from combination; and in the air it is always found. As it is soluble in water, it is found wherever we find water on the surface of the earth, or in the air, and probably in all natural waters, even the deepest and most purified. As a part of the atmosphere, it touches all substances and can be found on many; it is in reality universally on the surface of the earth in the presence of men and animals, perhaps attached more or less to all objects, but especially to all found within human habitations, and, we might also add with equal certainty, the habitations of all animals.

"If you pick up a stone in the city and wash off the matter on the surface, you will find the water to contain ammonia. If you wash a chair or a table or anything in a room, you will find ammonia in the washing; and if you wash your hands you will find the same; and your paper, your pen, your table-cloth, and clothes, all show ammonia; and even the glass cover to an ornament has retained some on its surface. You will find it, not to be a permanent part of the glass, because you require only to wash with pure water once or twice, and then you will obtain a washing which contains no ammonia; it is only superficial.

"This ammonia on the surface is partly the result of the decomposition, continually taking place, of organic matter adhering to everything in dwellings. The presence of organic matter is easily accounted for; but it is less easily detected than ammonia. It is probable that the chief cause of the presence of ammonia on surfaces in houses and near habitations is the direct decomposition of organic matter on the spot. If so, being more readily observed than organic matter itself, it may be taken as a test, and the amount will be a measure of the impurity. A room that has a smell indicating recent residence will, in a certain time, have its objects covered with organic matter; and this will be indicated by ammonia on the surface of objects. After some preliminary trials, seeing this remarkable constancy of comparative results and the beautiful gradations of amount, it occurred to me that the same substance must be found on all objects around us, whether in a town or not. I therefore went a mile from the outskirts of Manchester and examined the objects on the way. Stones that not twenty hours before had been washed by rain, showed ammonia. It is true that the rain of Manchester contains it also; but, considering that only a thin layer would be evaporated from these stones, it was remarkable that they indicated the existence of any. The surface of wood was examined; palings, railings, branches of trees, grass (not very green at the time), all showed ammonia in no very small quantities. It seemed as if the whole visible surface around had ammonia. I went into the houses and examined the surfaces in rooms empty and inhabited, tables, chairs, walls, plates, glasses, and drawing-room ornaments. A (Parian) porcelain statuette under a glass showed some ammonia; a candlestick of the same material (but uncovered) showed much more. The back of a chair showed ammonia; when rubbed with a common duster, there was very little. It seemed clear that ammonia stuck to everything.

"If, then, ammonia was everywhere, the conclusion seemed to be that it was not at all necessary to do as I had been doing—namely, wash the air so laboriously; it would be quite sufficient to suspend a piece of glass and allow the ammonia to settle upon it. For this purpose small flasks were hung in various parts of the laboratory, and examined daily. The flasks would hold about six ounces of liquid; but they were empty; and the outer surface was washed with pure water by means of a spray-bottle: it was done rapidly, and not above 20 cub. centims. (two-thirds of an ounce) of water was used. This was tested for ammonia at once with the Nessler solution. The second washing, taken immediately, produced no appearance of ammonia. Ammonia could be observed after an hour and a half's exposure at any rate; but I do not know the shortest period."

To me it seemed perfectly clear that the character of closeness was connected with the existence of organic matter, and the organic matter with the ammonia. That ammonia should be found almost everywhere, but in small quantities, was not to be wondered at, considering the universal presence of organic matter in the air and waters of the world. It was when considering these things, and the effect of oxygen on this organic matter, that I came to the conclusion that long continued currents of air either carried away the organic matter with it, decomposing it and turning it into gases, or, if it were not possible for the oxygen alone to do this, it might happen that the oxygen destroyed those minute forms which have been shown to be concomitant with putrefaction and decay. A similar mode of thought had previously led me to consider that it was the want of this excess of oxygen that caused confined sewer gases to be so dangerous, whilst the enormous amount of gases coming from decomposing matter, such as on the Clyde, seemed to pass away, leaving comparatively little effect beyond the disgust and the sickness of the present,—but to this point I must return. On speaking of the subject I might as well quote my own words to save the trouble of a second expression (see Proceedings of the Philosophical Society of Glasgow, 1880):—

"This raises a question to be solved; but the fact is certain that fevers have not been traced to the escape of gases of putrefaction when there has been a large amount of water and exposure to the air. But they have been found when the water is not very great in amount, and the decomposition is made under cover, as in sewers. The question arises—Is this owing to the concentration, or to the difference of decomposition in darkness, or to the better supply of oxygen? The effect of sunlight in warm countries does not allow us to suppose that the daylight always produces in vapours an innocent state, although it has a great effect in that direction when there is little water. With us, at least, innocence in the atmosphere seems to be rather something connected with the abundance of air in proportion to the impurity. This air, again, may act in two ways. It may act by rapid oxidation of the substances in water, or by dilution of the gases when formed; and the destruction of putrid matter in water is really very rapid when plenty of air is allowed. This air is brought to the Clyde by the water, and also by the waves, both artificial and natural, exposing a great deal of surface. The air may act also merely by rapid dispersion of the gases. Still we must not forget that these gases or vapours are not reported to us to produce any marked type of disease over the Clyde, even when they come in a state so concentrated as to produce sickness; whereas gases from sewers, in a condition which may not produce immediate illness, may produce in time typhoid fever, as we are credibly informed. We must conclude, then, that it is not mere dispersion, but that it is a more thorough putrefaction and oxidation which takes place in the Clyde, and a more complete destruction of the organic substance by the abundance of air, than can take place in sewer water, whatever the senses may indicate to us. Of course, we must ever give some credit to the flow of air up the river, and the ever-fresh breezes that come from the Atlantic, as well as the mixture of air with water caused by steamers."

If nature had contrived no method of destroying such seeds of death populations such as this is would never have grown up. And what is the method? That method is, first, putrefaction, at least I know of none other, except the concluding portion of the work, viz., thorough oxidation. When, therefore, you see the Clyde seething with gases of putrefaction, and when you smell it to such an extent that a feeling of loathing is produced, you may remember this, that the work of destruction is going on with a wonderful rapidity, and that the enemies of life are being slaughtered there millions upon millions, never to appear again in a similar form, though other generations of them may rise up.

As putrefaction seems not to take place without the action of organisms, I had the idea that it might be arrested by an abundant use of air, and I had some belief that the oxidation took place very rapidly after putrefaction. It was when examining this subject that I found it necessary to touch also upon the question of nitration in water. When nitrogenous bodies decompose with an abundance of oxygen, the nitrogen becomes oxidised and nitric acid is formed. I had long suspected that the reverse also took place, and that when there was an excess of putrefactive matter, oxygen was absorbed and even removed from the nitrate, whilst free nitrogen was given off. This process I was able to verify by carrying it on in the laboratory. It was clear, then, and beyond all cavil, that rivers could purify themselves in time, and organic matter be thoroughly removed. It was my belief that organic substances, that germs of disease, that microbes or the smallest organisms themselves were all subjected to this universal and unsparing attack of putrefaction and oxidation. The results, as expressed in my Report of the Rivers Pollution Prevention Act, were in the following terms—(pp. 26 & 27):—

"Putrefaction destroys organic matter without the influence of oxygen; it breaks up organic compounds, and destroys organisms. The evidence seems to indicate that it destroys even those bodies that produce disease, but that in certain conditions it produces others. This is a point not to be enlarged upon without more knowledge, but it is evident that, by putrefaction, we get rid of an enormous amount of offensive matter. Oxygen cannot enter under the surfaces of actively putrefying bodies; but wherever it is allowed to enter by the putrefaction being less active, an action begins which in time completes the destruction of the body. We are not, therefore, to suppose that the germs of disease can resist all these efforts of nature to destroy noxious things, nor are we to suppose that an invisible germ of disease can pass on from stage to stage unaffected by the putrefaction of sewage and the action of air. We must believe, for the present, that it is not so. In water we see perfect purification, nitrogen itself being lost.

"In ordinary putrefaction, sulphuretted hydrogen comes off in abundance, with much carbonic acid and some nitrogen. Oxygen resists this action, and if the oxygen is supplied in a concentrated condition a change takes place; nitrogen is evolved as the principal gas, and a decomposition of nitrogen compounds takes place. Nitrogenous bodies are thus destroyed—in one manner by their voluntary putrefaction, in another by oxidation. Up to a certain point, not determined, the greater the amount of nitrogenous bodies, the more rapid is their decomposition.

"The oxygen of the nitrate passes in part to the carbon; some will be retained, forming a carbonate. I have not estimated how much, or if all, is taken by the carbon.

"If the solution is weak, the nitrogen takes up the oxygen, and does not allow it to pass away, thus forming nitrates.

"Putrefaction and oxidation are too well-known modes of destroying organic bodies at ordinary temperatures. The second is not proved to be connected with organisms.

"How far, then, can oxidation, or a great supply of air, be employed to destroy putrefaction or to purify?

"The bearing it has on the analysis of water will be clearly seen by chemists. The bearing on the sewage question is also interesting. Substances and living things may be carried by the rapid sewage system into the range of a new activity before undergoing that putrefaction which breaks them up in proximity to us or in the sewers themselves. It seems to point to a plan of causing the destruction of organisms by putrefaction and subsequent oxidation or by chemical action. At least, it seems to me that we require to learn if it be true that any of the germs of disease, or which germs of disease, will live in an abundance of good air. We know that abundant dilution will render them all ineffective. It is probable that there will be a difference amongst them in this respect, whilst all will yield to the double action of—first, putrefaction, and then oxidation."

Certainly at least this is one of the conditions, and now we may ask what is the character of these changes involved in the word decomposition? I have said the bodies arising from the decomposition may be very numerous; if so, the modes of decomposition must be very numerous, and the term used, viz., putrefaction, cannot represent only one chemical change. There

is one stage of it, however, which seems to be more efficient in breaking up the compounds than any other, and this takes place when the sewage has a certain amount of air allowed to it. How much is not very clear, but there is evidently a limit. Within that limit thorough putrefaction begins, organic substances rapidly disappear, and gases in great abundance come from them—Carbon and Hydrogen, Sulphur and Nitrogen, each in its own way, either in combination as the carbon for example always is, or as bodies perfectly free. It is this grand breaking up of fœtid organic matter which nature has contrived in order to produce purification, otherwise this city would be sending down its river such loads of impurity as even that willing stream would scarcely be able to bear. I wish, therefore, to bring forward now more emphatically the doctrine that putrefaction in a certain stage is one of the greatest of purifiers, and perhaps the most complete that nature has devised. It has often been asked what will become of those many poisonous emanations which arise from the human body even in health, and from those still more dangerous substances which are generated within it during many of those multifarious diseases to which man is subjected. The germ theory of disease has caused alarm in many directions, and it has been imagined that some little germ of disease passing into a sewer or pure river might carry with it power to infect other organisms to such an extent that there was reason to fear for the lives of all inhabitants on its banks. This extreme application of a theory might not be unreasonable were it not that we know from results (at least I think that I may use these words) that no such power exists in any of those germs known to us, when putrefaction and oxidation are abundantly given.

Let us consider the number of polluted liquids which pass from the houses and hospitals of such a city as Glasgow, and the fact that so many of its inhabitants go down to the banks of the Firth, towards which the waters of the Clyde flow, and receive their health and strength for themselves and their families, and we shall see how absurd the ideas have been concerning the power of individual germs, or even multitudes of germs in such situations.

We may now readily pass on to a subject which has long been important in the eyes of those who have any appreciation of the importance of the attention to public health. It is a subject which presses upon the attention of every town, and it is one which has for many years caused the inhabitants of Glasgow to think seriously, viz., the treatment of sewage. Now I must premise that I do not intend to give you advice regarding the waters of the Clyde. It would, perhaps, be taking advantage unfairly of the circumstances which bring us together, but it has happened that some of my latest work, as indeed some of my earliest, has been upon sewage. There is no subject that can be of greater interest to an institute of this kind, and no city, perhaps, is more interested in the matter than Glasgow. Still I do not come forward with any plan, but, as a Glasgow man, I have been interested in the Clyde, and have examined the water, to some extent, from the Broomielaw to the deep sea many years ago. Lately (that is, about three years ago) I dredged a good deal of the Clyde, and examined the mud, simply for my own satisfaction, having had the advantage of the use of the steam yacht and dredge of Mr. Duncan, of Benmore, who himself superintended the work. Having been appointed inspector under the Rivers Pollution Prevention Act, I have been led to reconsider the whole subject of foul water and pure water, and I was requested by the President of the Local Government Board, Mr. Sclater-Booth, to examine the results of the treatment of sewage by various methods in England, so that I was led to the reconsideration of sewage without any reference to the conditions of Glasgow; and I may add here, what those who have studied the subject will readily believe, that he is not a wise man who will venture to be very dogmatic in making out plans. It is, however, at all times a pleasant thing to add to our knowledge, and for this reason I have thought that some time spent upon this department would be of advantage to myself and perhaps to others—procuring some information which might serve in attaining ultimate results.

It is remarkable how rapidly sewage enters into putrefaction, and to know the results of this putrefaction has been a considerable difficulty. The emanations from sewers have been found guilty of producing a peculiar form of fever, very well known to medical men in some of its stages, and apparently so definite that it may be considered as ranking with one of the chemical tests in its strictness. The gases and vapours which come from it are the results of the decomposition of organic matter, and the number of compounds into which the material of animals may be broken up is so varied that at present it may be said to be entirely beyond our ken. These compounds vary in character to such a degree that they may form the most innocent gases, the most wholesome food, or the most virulent poisons, venomous substances that destroy entirely vital functions of the human body in a scarcely appreciable time. Some of these obnoxious bodies arise from the decomposition of sewage, and, as already said, seem to be formed at some particular proportion of the supply of air.

It is easy to see that it is a mistake to suppose that by sending putrefying liquids down to lands we are giving these lands all the sustenence which the sewage originally contained. If we wish to use them as sewage it is better to use them before putrefaction, the loss by putrefaction being great. I suppose we can scarcely doubt that putrefaction takes place more rapidly when the organic matters are diluted to a very considerable extent with water. Having made many experiments in order to find the condition of the air found lying over somewhat solid putrid substances compared with the same substances very diluted with water it was found that the greatest amount of ammonia, and the most offensive odours were from the more solid. This is quite in accordance with the explanation given of the more complete disruption of the organic matter in water, and it was these experiments that led me first to think of driving the air through sewage matter in order to produce oxidation, expecting readily to form nitrates, and in the belief also that excess of air would be offensive to the microzymes, although a small amount seemed necessary for their activity.

The most complete experiments on aëration which I was able to perform were done by the apparatus of Dr. Storer and Mr. Cranston. The Messrs. Storer were good enough to put at my service two of their revolving screws, which are used to agitate the water, to draw down air into the centre, and to send it out at the circumference of the vessel. For this purpose they put also up in my laboratory a gas engine, to drive these screws, and I was thus provided with very efficient apparatus, for which I cannot sufficiently thank them. The result of the aëration of sewage, and of other liquids containing organic matter to a similar extent, was, that, in all cases, putrefaction was delayed by aëration. The dissolved oxygen also recovers itself in the aërated specimens better than in the non-aërated. This shows that aëration not only prevents putrefaction, but prevents also the chemical action consequent upon it. It had, in fact, to a large extent, and for a considerable time, rendered the organic matter inert, or nearly so. Nitrates are formed also more readily in the aërated than in the non-aërated specimens.

There are some curious peculiarities connected with the formation and disappearance of nitrates, but with these details I shall not trouble you. It was in looking for nitrates and measuring the amount of ammonia in the aërated and non-aërated solutions, that I observed how much the ammonia diminished in amount, and sometimes the air passing out from the water contained a strong smell of ammonia. In working with the apparatus described, a constant loss of ammonia was observed. The sewage was tossed about, the volatile matter was carried up with the currents of air, and had no opportunity of returning.

"It is well known that to obtain the ammonia from sewage has been the aim of chemists for many years; and to make use of it in some form or other, without extracting it, has been the study of many engineers. The amount of ammonia, as we have long known, is great in sewage, but we have not known how to remove it. The amount, however great in the bulk, is small indeed in proportion to the amount of water, being from four to seven grains, very often but not more, in a gallon of 70,000 grains. The loss of ammonia, when using the apparatus described, suggested at once a method of obtaining a revenue from sewage."

Work of a similar kind had been done by Monsieur Lauth, and published in the "Comptes Rendus," where the following is stated:—

Paris Sewage. By Ch. LAUTH (Compt. Rendus, 84, 617–620).—Two vessels, one containing ordinary sewage, the other sewage saturated with air, were placed aside, to watch the effect. The former soon became black and offensive, whilst the second, after two months, was still inodorous. The chemical action of the aëration was as follows:—

	Insol. N.	Sol. N.	N. as Nitric Acid.	N. as Ammonia.	Total N. by vol.
Before aëration	14·70	20·65	1·176	8·4	38
After „	8·05	26·95	1·122	14·0	38

The effect of lime on the sewage was next tried; it remained inodorous and colourless after two months, and gave on analysis the following results:—

	Insol. N.	Sol. N.	Nitric Acid.	Ammonia.
Without treatment..................	14·70	20·65	1·17	8·4
Treated with lime	10·15	25·55	2·60	18·20
Treated with lime and aërated...	6·65	28·87	2·12	21·35

These results show that the development of putrefaction producing sulphuretted hydrogen may be avoided, not only by treating sewage with lime, but by mere aëration.—*Taken from the "Chemical News."*

It will be seen that the results obtained are far greater than those obtained by me, and the product increase of ammonia by putrefaction is remarkably so. Could he obtain such results in our sewage I think I could scarcely doubt the possibility of profitable working; but probably the material itself, and the temperature of the country, may explain its most important differences.

If we could take only one grain of ammonia out of one gallon of sewage we should have from 1,000,000 gallons 1,000,000 grains = 142·8 lbs., or 140 lbs. Let us suppose that there are in Glasgow flowing from the sewers daily 50,000,000 gallons, and we should have 7,000 lbs. of ammonia daily, this would give us in a year above 1,100 tons which might be put down as somewhere nearly £60,000 in value. But can we obtain one grain out of every gallon? In the laboratory with a small apparatus this has not always been the case, but if lime is added to the solution the ammonia comes off more freely, and experiments have been made in which about two grains per gallon were obtained. In one experiment made in Glasgow with one hour of aëration two grains per gallon were obtained without lime, but this was in a very strong sewage containing nine grains of ammonia per gallon. Sanitarians are very glad to hear of great sums of money being obtained by processes which tend to health, and in order to please them with a certain vision of glory we may draw out the calculation on the supposition that all the ammonia was obtained. Let us take only a moderate sewage containing only six grains ammonia per gallon and we should have an amount of ammonia produced per annum equal to £360,000. But is this within our grasp? The ammonia is removed from the liquid, but it is carried away in enormous volumes of air, and from these volumes it must be extracted. I think this may be done, but I shall not dwell upon it. You may suppose I was very much pleased in obtaining even some slight hope of the solution of the great question. We sometimes expect a little credit for doing any useful work or even making a step in advance, but when writing the account out and making some inquiries I found that instead of deserving credit for my labour I deserved only blame for my ignorance. It was found that the idea had come into the mind of another ten years before, and had been thrown away.

A provisional specification had been made out in 1870. The first projector seemed to have lost confidence in his principle, but another patent was taken out by Messrs. Hills and Biggs in 1872 for a similar purpose, one by Messrs. Welch and Scott in 1876, and one by W. L. Wise in 1878.

I can only, therefore, give my version of the subject; still, I think it is a useful one, and I published it in my report to the Local Government Board on the Prevention of the Pollution in Rivers, so that others might make the next step, and have given details not elsewhere given, so far as I know. In the passage of air through water the gases are removed and some volatile substances, whilst the air, being greater in volume, takes their place. The volume of air is a decided objection in working this process. I was desirous of diminishing this, and therefore resorted to the air pump, and tried if it were possible to exhaust the water of its dissolved gases.

This may be done to a large extent by pumping them out; and it is remarkable how much is done, at least on a small scale, in a minute or two. I cannot say that a result has been obtained equal to that by a current of air; and we must remember that the current acts oxidizingly as well as by displacement, but a great deal is effected by the exhaustion methods. The gases come off strongly impregnated with organic matter. They may in this case be sent through a disinfecting process if the ammonia cannot be got out. It was expected that by taking them out in a concentrated state they could be passed through acid, and the ammonia removed in a small absorbing space, thereby getting over the difficulties which may be expected when we try to absorb the ammonia from a large amount of air. This, however, was not found in practice to take place to a sufficient extent. Very little ammonia was removed by pumping.

At the same time it is very probable that the failure was not inherent to the process, but caused by the limited and imperfect scale of laboratory operation. In some cases it is probable that ammonia would come off in this way (that is when the sewage was stronger than usual). I should be inclined now to expunge the words "imperfect scale of laboratory operation." Still I looked to the air pump as a valuable addition to the aëration, or rather as a preliminary to it. As I mentioned, "if this method of pumping out the gases were adopted, it would only be a preliminary to aëration, which might be affected either by allowing the air to enter, or by assisting it."

It has happened that I have found it convenient to bring before you a subject which certainly is very interesting to Glasgow; and I now wish to bring to your mind the name of a man who certainly I incline to think, of all men in his generation, had most influence in Scotland, by creating almost single-handed one of the largest branches of trade, and being influential in causing his work to be imitated over large portions of the world. I speak of Dr. James Young, who has only of late left us. Dr. Young, however, requires little of my recommendation. I may almost say that he found the cottages of our country in darkness during at least half the time of active life, and he lighted up the winter nights and mornings for them to such an extent, that life became doubly valuable and labour more profitable. It is difficult to imagine how miserable life is in a house where the inmates cannot afford light from four o'clock in the afternoon till ten o'clock at night, and from five a.m. until eight, and when people must go to bed and sleep from mere dreariness and listlessness: it is a frightful loss of human life and happiness. I know from sufficient observation in places where darkness enveloped the people in the hours mentioned, light, and a brilliant light too, has taken its place, and I have observed the difference with pleasure and astonishment.

Scotland cannot forget James Young, and Glasgow will remember his name and his gratitude, as he has shown the latter by planting the "Young Laboratory" on the scene of his early studies and by placing in St. George's Square a statue of his distinguished teacher, Thomas Graham, also a native of Glasgow. As Dr. Young was to me an old and intimate friend, it was natural that I should speak to him of my work on water; but at this time he was very feeble, living at Kelly, but unable to walk about its grounds, glad, however, to look out and see the varied scene before him, and always glad of a visit from his old friends. He was extremely interested in the results, and after thinking about them, told me that he had an improved method for the treatment of sewage, as mine would be too expensive. The latter part I was willing to believe, because, as already said, I brought it forward more as a scientific study than a practical process. It was long before I knew what his ideas were, for he seldom gave his thoughts out rapidly, even to one who was so long intimate with him as I was. After some time I found from him the following:—

His experiments shewed that strong ammonia liquor lost ammonia, until the amount remaining was only 1 in 210,000, whilst weaker solutions became concentrated until they reached that point, and his idea was to boil off the ammonia. This seems certainly a very bold thing. It was found that by distilling 5 per cent. of the sewage at 212°, the bulk of the ammonia was contained in the distillate. By increasing temperature and pressure it still increased, whilst at 70lbs. pressure almost the whole of the ammonia could be obtained by distilling over $1\frac{1}{2}$ per cent. of the liquid, the expulsion of the ammonia being also facilitated by the injection of a small quantity of air. Dr. Young's idea at this time was to distil off ammonia at a high temperature and pressure, so as to obtain a concentrated ammoniacal distillate, and afterwards to recover the heat by passing the exhausted liquid through a series of pipes surrounded by cold sewage, to be heated to the boiling point in turn, thus making heat a part of the working plant; but on enquiry it was discovered that to cool a quantity of liquor from 280° F.=(138° C.) to 60 F.=(14°.5 C.), by raising an equal quantity of liquid from the lower point to the higher, such a great conducting space would be required as to make any such process quite impracticable on such an extensive scale.

It was found that a low temperature became one of the primary conditions of success. He found that, by using an exhausting air-pump and raising the temperature to about 80° F.=(26°.6 C.) only, sewage which contained five grains of ammonia per gallon was almost entirely deprived of it in a few minutes. This is the central experiment upon which his process is founded. I do not purpose, however, to give the various details of the work as it was carried on, with great perseverance, during his last illness, as one may say.

In other words, he found that, instead of passing air through the sewage, it was sufficient to pass steam at a very low tension, and, consequently, with an enormous bulk. This did the work of the air, and the ammonia was absorbed from it instantaneously by acid. It is difficult to know from smaller experiments what may be done on the large scale for the sewage of a great city; but it may be mentioned, as a result obtained by Dr. Young, that when he passed the sewage down a coke-filled tower, which was rendered vacuous, and which gave, from a great expansion of surface, a ready means of evaporation, he considered that he had put the problem in a satisfactory form. From a tower, or cylinder, 5 ft. 6 in. high, 5 in. in diameter, filled with irregular pieces of coke, about 4 in. cub. sewage was exhausted, of 80 per cent. of its ammonia, at the rate of 5 litres per minute, and with a distillate of 1 part ammonia in 1,200 liquid. Taking this result as a standard of calculation, it was believed to demonstrate that the process was theoretically capable of extracting ammonia from sewage on a commercial scale, and that any practical difficulties ought not to be beyond the powers of chemical engineers to surmount. It was believed that addition to the height of the tower would enable the steam to be charged with ammonia to 1 in 800, while increased pumping and condensing power would lower the working temperature to 70°=(21°·1 C.) or less. The vacuum used in this experiment was equal to ½ inch, or 12·7 mm. of mercury. It was believed that the temperature of 70°=(21°·1 C.) was one which could be obtained on a large scale, perhaps at all times, whilst at other times it may be said to be the temperature of the sewage.

I cannot forbear remarking here on the boldness of this conception of Dr. Young's. Perhaps some of his assistants will write out fully the details of his work as they were obtained with a care which never ceased as long as he had strength. One never knows what may be the end of any careful enquiry, and I do not presume to give a very decided opinion on this subject, but I incline to think that for some strong specimens of sewage this plan may be found both practical and profitable. Though Dr. Young fully believed that his idea of the steam was perfectly novel it cannot be asserted that it was so. It is exceedingly difficult to obtain ideas which none of the great multitude of mankind that have gone before us ever perceived. But I believe that amongst the papers left by Dr. Young there are extensions of the idea sufficient to shew that he had mastered the whole thoroughly, made advances, and explained the matter better than had previously been done. Many of these points I have not had an opportunity of examining carefully, I suppose they will be brought into order by the work of his successors; and I hope that engineers and others directly interested in such matters will not allow the promising results to pass away without leaving benefits behind.

It is probable that I have said enough concerning sewage, and have become too technical for most of my audience, and others may think that I have rather defended the pollution of the Clyde, and shewn it to be a reservoir of purification. I certainly believe that it is so to the extent explained by me; but do not suppose I can ever imagine that the remaining conditions so palpable to the senses, and so evidently injurious to those immediately connected with it can have any defence from me. My knowledge does not permit me to give an opinion on the general effect on the health of the town. I trust, however, that I have said something that will encourage thought and action on the very important problem which is before you, and before many other cities in a similar situation.

It was not my intention to say so much about sewage. The subject which I mainly intended to bring before you was that of oxidation. This is a very old problem for chemists, and every beginner must learn the strange effects produced by this wonderful gas—oxygen. We must still think as beginners, and go back to our earliest thoughts in the science. Some physiologists tell us that our life is a mere product of oxidation, that even our death is a result of the more violent attack made on us by the same gas. It would seem, therefore, as if this wonderful agent had the remarkable power of blowing hot and cold, of producing strength and weakness, being our greatest friend and an enemy from which we cannot escape. No wonder, then, if we give it many contradictory duties to perform. It was always known that pure air had a cleansing power, and it has long been known that oxygen was the main agent there, and I have already spoken of the value of wind blowing through a house to render it pure; but it has somehow happened that its rapidity of purification has never been brought so clearly to my mind as by these experiments on the purification of sewage.

The act of purification is to be seen here rapidly. It is not the work of days or weeks, but the work of minutes, and the belief is taken out of the region of reasoning into that of the simplest observation. It might seem rather absurd to attempt to prove this; nevertheless, there may be many minds to whom this proof may be useful, since it has been useful to myself, who may claim more familiarity with the subject than is common to the generality. It brings us, also, to that point which may be said to be the central point in all sanitary reforms, viz., the importance of pure air. There are many other points, but this I incline to hold as the first. Its importance has been recognised in a magnificent manner in this city, and I might almost fancy that I hear the authorities say that on this subject, at least so far as regards our streets, you do not require to speak to the people of Glasgow, seeing how much they have done towards tearing down old buildings incapable of giving wholesome shelter, and destroying the narrow courts and lanes, which have the power of producing misery to a population already sufficiently oppressed. Much has been done, and I do not doubt that the public authorities are sufficiently acquainted with their duties, but there are still many people to teach, and, I fear, a large population unwilling to be taught. I should be better pleased if I could see in the reports of Dr. Russell, your distinguished Officer of Health, that the number of houses with the lowest number of apartments was not so great as it is.

I still consider that it often happens that in entering houses in Glasgow there is a feeling that the air might pass more abundantly through them. The reason of this may be perhaps the climate, and the artificial conditions of a town, making it inconvenient or unpleasant to keep windows long open. Or does some of this arise from a condition of things for which Scotland has been blamed — a want of sufficient cleanliness of the interiors? I hope this complaint against Scotland is being thoroughly removed; my belief is that it is being greatly removed. In country places perhaps the evil, so far as private houses are concerned, has a more lasting residence, and even in the midst of abundant draughts of the sweetest air people are found to be living subjected in dark and unclean corners to the dangers arising from putrefaction and decay. I often wonder at this among the farmers of Scotland, who must have learnt surely, as they are not without reading, the value of those substances which they allow to pass away, although more suited perhaps in some respects for the land than the artificial manures which they buy.

A learned Professor, just come from the Continent, called on me the other day and spoke of the wonderful instinct of washing which seemed to pervade the households of Holland; he had observed one woman washing down the outside of her house, and another washing the trunk of a tree which stood opposite her. The very boys seemed to enjoy themselves by picking out weeds. And he asked me then the question—Does this extreme of cleanliness conduce towards longer life? Can we say to any man, wash and be clean and you will live longer? Yes; but the question is an extremely complicated one, as all questions regarding natural phenomena are. Cleanliness is wholesome, and I believe that those who are clean will live longer than those who live in filth. But there are some curious anomalies regarding this nevertheless: we do not hear of the longest lives, those above 100 years, being found in that class of society which is most attentive to cleanliness. It seems rather in the opposite direction. I have found it interesting for some time, on receiving the Quarterly Returns of Births and Deaths, to observe the number of persons who die at very advanced ages in Ireland. These persons do not belong to the higher but to the lower classes.

In this country also it seems to be the case that it is in the lowest class, in classes where cleanliness is least cared for, where these extreme cases occur. There are people who simply solve the question by denying the extreme age. I have not seen the propriety of questioning these higher ages to such an extent as some have done, any more than those ages which are lower; and I feel rather inclined to attempt the solution instead of resorting to a course so old fashioned and easy as that of Alexander the Great, viz., cutting the Gordian knot by denial. At the same time I do not deny that enquiries made on this subject with a desire to obtain the truth, have been very valuable, and have abundantly proved that gross exaggerations have been made, and that care is absolutely necessary. Although I think a good deal in Ireland is due to tenacity in the race, which gives the people a lightness and a vigour even in very trying circumstances, the results seem only explicable by supposing that those who have lived so long in conditions so unfavourable to health, have been deprived of that sensitiveness of body and mind which in one case would have raised them above the lower levels, and in the other have made them more liable to give way to the wear and tear of life.

The same Professor told me that amongst the scattered cottages of the country there was much poverty, but cleanliness everywhere was remarkable. There was a time when many of the Scotch students went to finish their education in Holland, but it was not a time for ladies' colleges there or here, or we might by this time have been rivals with Holland in all the arts of purification.

But now we must return to think more closely on the action of oxygen. If the oxygen is found to diminish the activity of those minute moving particles which form or produce a disease called chicken cholera as Pasteur has shown, and if oxygen also puts an end to the decomposition in sewage in a manner rapid and decided so that decomposition will not begin again for some two or three weeks, according to the weather, we may ask how far it may be used directly in the destruction or weakening of microbes in other situations. When Dr. Koch found Bacilli peculiar to consumptive patients and existing in their lungs, it was natural for me to ask him whether some excess of oxygen might not prevent their growth, as I found a similar result in sewage. However, it was a question more easily put than answered, and I suppose we must leave it. We get here into a number of difficulties which can only be solved by careful observation, and I do not know yet how far we are to understand what is the tenacity of life of various forms of microbes in various gases. It is clear that experiments relating to the existence of life in particular gases are not sufficient for us, because, as Pasteur shows, although the germs may live, they have in certain conditions, if not entirely, lost their power of giving disease, or, as he says, become attenuated. Here we have a large field before us, and it is to the attenuation or destruction of these forms of life that microscopists and physiologists must now attend. In the long discussions, and somewhat bitter ones, that have taken place regarding vaccination, I do not know that any one has attempted to act upon the agents in a manner suggested in the case of chicken cholera. I am not a medical man, and must speak of these things only as a chemist; but it seemed to me natural to think that if some modification of the matter of small-pox could be obtained by oxidation, another step would be to attain that modification in a still greater form upon the bodies of the patients. As we have seen that oxygen is the great purifier in the regions of the air over the great oceans and in them, and is working even in the soil in our towns, and in our houses amongst our furniture, and upon ourselves within and without, and that it so rapidly removes that disagreeable matter of our town sewage, let it be compelled to purify even disease itself when it has attacked the human body. This is only an extension of the great idea of sanitarians that pure air is wanted all around us, and that by pure air we can obtain one of the first steps to health, although there may be cases where even this idea must be modified.

It is interesting to consider the cause and the production of zymotic diseases according to the various views which mankind have had. The angel of death has always been sure in his work, but his work has been unseen unless the darts of Apollo which caused the plague in the Grecian army were the well-seen beams of the sun acting on masses ready to decay. Now the agent is believed to be armies of numberless living particles, one may almost say, totally invisible to the naked eye and known to a few only who use the microscope. Whence do these armies come, and how are they fed? If they are formed readily out of the substance of the person whom they attack

they do as other armies do, feed upon the plunder taken from the enemy. But if so why do they ever cease as long as food for them remains? There surely must be some limit to their capacity of growth, otherwise destruction to the attacked would always follow. I do not know if I have read sufficiently on this point to know the general opinions, if indeed there are any; it may be that there is formed within men and other animals a certain amount of material from which Bacilli may feed even in healthy bodies. It may be that this material may be more in some persons than others, and it is just possible that this may be removed by certain agents, one of them being the oxygen or pure air which I wish you to think of, and by the various exercises and changes of place which enables the oxygen to be more active within us.

Still there are other things to be thought of, and surely these little Bacilli which have been mentioned are under some other command, and they themselves may have a general whom they learn to obey. If their growth depends merely on the food supply, then we are brought to chemical agency affecting their increase or decrease, and this agency in a limited sphere, but their lives may be regulated by other movements, some on the earth and some in the stars. The sun's direct rays must affect them as it does all things around us, and its indirect action when it sends out magnetic currents that bring the earth in constant and varying sympathy may also influence the lives of the minutest creatures, as they no doubt influence the still less observable chemical action.

There was once a considerable discussion as to the part played by organic life in fermentation and putrefaction; and Liebig took up the chemical idea and objected to the belief that microzymes were necessary for chemical work. He lost, apparently, the day; but under the life of the microzyme chemistry and physics are at work, and how they manage to produce the result is still a problem to us. We must not suppose that when chemical action is not violent, as it sometimes is, that it is entirely absent. If we take a liquid containing a strong solution of a crystalizable salt, and add a minute crystal to it, how readily the whole mass takes the form of this crystal; and yet how weak, apparently, is the first, and how slight the connection between the two, whether chemical or physical, or both. This leads us to think that the various powers of creation are by no means inert in the production and the continuance of disease; and the lower we go in the scale of animal life more likely are we to meet with causes acting in a manner more allied to those of the inanimate world, but still affecting the lower and, through them, the higher organisms. This would bring us to think of changes caused by the conditions, both of the earth and of the air, and naturally show why this section should point to meteorology and geology.

Before leaving this subject I am inclined to refer to some speculations which were printed in 1848, and which seem now to be reviving in other minds. So early as 1848 I had come to the conclusion that, "permanent chemical compounds, gases or liquids, are not capable of acting as infectious or contagious matter, that is, cannot convey disease." I may add, also, some sentences from the same paper, printed by the first Board of Health.

"When fermentation has ceased, that is, when the materials on which fermentation acts are worked up, and their action begins under favouring circumstances:—When, for example, alcohol is formed to the utmost extent, the next substance is entirely different—vinegar appears; this induces another action, so that the cessation of one fermentation supplies the conditions for the commencement of another."

"If a pestilence were caused by the condition of the air generally, it would go with the wind, it would not take seventeen years to go round Asia, Europe, and America. It would act as constantly as the changes of the weather, that is, in many places at the same time, but it takes leaps, not very long, and acts fitfully and freakishly. Human beings are not the only conveyancers, but filth, that is, fermentable matter is, it is conveyed along all places, giving out effluvia, but the effluvia of filthy places did not produce cholera till the disease came near us from Asia. Organic matter may be called the conveyancer of cholera, that which takes cholera itself and conveys it to others."

"At the same time this shows us why clothes should be considered dangerous; not porous materials but organic materials, which are capable of taking the disease, whether from the amount of organic effluvia given out by the substance, or by the amount of matter which they retain from the body, may be a question. That is, whether the substance itself of clothes, or the person wearing them, be capable of taking pestilence or both. Moses mentions the fact of clothes and skins taking leprosy.

"This"—that is, the reasoning—"explains why other diseases should disappear when cholera and plague come. The one fermentation sets all the others in the same course, and absorbs the action of organic matter in the air. It is a matter of curious enquiry, this one power putting down all the other powers. New fermentations arise; when one is doing its work it produces entirely new conditions; where it works, these new conditions rouse new actions, and it seems, in the complexity of organic nature, as if the power of producing novelties were

increased by the number produced. Man, capable of one disease to-day, is capable of another to-morrow."

And in 1852 I used similar words:

"In this way various ferments would produce various substances, or a substance putrified might go into plague fever or small-pox, just as parts of the body do. Filth, therefore, is a conveyance of disease, taking the lead of any infection that happens to have the reins in its hands at the time. No wonder, then, if all diseases disappear before a great disease, one great ferment banishing the others. There cannot in one liquid be the mucous acetic and alcoholic fermentation at once. But they may come in succession. So, after one disease, another may arise on its remains. Is this the explanation of the rise of new diseases, on the history of the progress of some we knew, which go on from stage to stage?"

The action of weather upon health is one of the important points included in meteorology, and some people may suppose this to be the only point; but I think that although the complicated changes that occur giving various proportions of heat, of light, of wind, and of rain have an enormous effect upon us, and, as Mr. Baxendell has shown, are the greatest agents in producing rapid changes in the mortality of the country, there is still much to do in the examination of the constituents of the atmosphere, especially those minute bodies and agencies which are less under our observation. I should have been glad had I been able to say that the habit of the chemical examination of the air had taken deeper root in this country, and attached itself to establishments for meteorological study. I spent some years upon this, but hoped that it would be continued by others.

I have indicated here one simple method of observing ammonia as an indication of organic matter, and published after my book on Air and Rain. And I should like to call attention to another point, viz., the measurement of the light; and to bring this in as one of the phenomena which may receive constant attention, because it affects the health both of man, of animals, and of plants. There has been an attempt amongst meteorologists to give the amount of cloud day by day, observations, which are very imperfect, there is, however, a better attempt, and a more successful one, to give the amount of sunlight direct, and that is to be much admired. I have endeavoured to bring forward a mode for measuring total light, whether sunlight or otherwise, it was founded on a chemical decomposition of iodide of potassium, first observed by Dr. Leeds, of Philadelphia, but applied by me to find out the comparative light of town and of the adjacent country. The differences were found to be very great. I hope that experiments, such as these, which I have published, will be attached to observatories. I feel sure that if they be continued for some years they would enable us to account for much which is at present perfectly dark. I have applied the same reaction to the estimation of the brilliancy of water. Although I cannot say that brilliancy is an absolute test of purity of water, it is at least an important characteristic.

In this country we should come badly off indeed if we depended for our vitality on direct sunshine, and I consider it much more important to obtain the total luminosity under which we are compelled to live, whether the sun's rays are direct or not; however gloomy our climate may be, and at times depressing to the spirits, the darkness does not seem to exist amongst us to such an extent as to prevent this country from being one of the healthiest in the world.

The effect of meteorological conditions as affecting disease in many of its stages, or, as we may say, affecting health, has been examined so well by Mr. Alexander Buchan and Dr. Arthur Mitchell that he will be a very diligent student indeed, and a very fortunate man who advances before them in such knowledge, although, I suppose, some day even this must be done.

It does not seem at all probable that we shall, at any time, be able to affect, in any substantial way, meteorological conditions, but this is rather hastily expressed: we have, unquestionably, altered the climate of a large portion of England. Drainage has removed many sorrows from the population—fever, ague, rheumatism, and the various affections which we put usually under the word cold. How much these surface changes, which may be called geological, have affected the atmosphere, so as to alter the rain-fall, may not be so clear. Interesting data, however, have been collected by Mr. Alfred Fryer of late years, showing that the effect in some cases has been considerable.

We can sometimes affect meteorological influences by the use of cannon-balls, shooting our enemies in the air, as we shoot other enemies, for instance, in the case of the waterspout, or by the use of explosions, set the atmosphere shivering until it can no longer contain its rain. Shall we ever be able to influence the greater storms of the world, those, for instance, that come and sweep over the continent of Europe? There may be a place where, like other things, storms begin in infancy, and like other infants, they may have very tender lives, which, in their case, it would not be wicked to destroy.

One can scarcely avoid at this time pointing to geological phenomena as deeply affecting human life. In our own lifetime we have heard of violent changes in certain parts of the world, and only last month of some of the most frightful occurrences to which nature has ever subjected any known portion of land. Such changes must affect the health of those who survive the catastrophe, such as that in Java, because of the change of surface, and the destruction of the usual healthy condition of the soil, as well as the interruption to the usual supply of food.

But the condition of the surface of the ground and the influence of the violent phenomena are subjects of themselves too interesting to be spoken of in a fragmentary manner, although the second of these may happily have little interest for us who live in a country where the minutest vibrations only are observed in its foundations. The first of these, viz., the condition of the surface, is one that can never cease to deserve our attention, as its preservation, with its due amount of heat and of moisture, must always be to us of the greatest importance. (Much interesting matter on this subject will be found in Hecker's "Epidemics of the Middle Ages.") I shall finish by remarking only that we have still much to learn regarding the effect of surface on the air, and I hope that some papers will be read on this, bringing us up to the latest period, since a good deal of attention has been given to it, but I cannot here bring forward the work done in Germany and in America, having been compelled to go for a holiday at a time when in ordinary cases I would have been laboriously collecting from all sources matter for your instruction and entertainment. I have more matter in hand, but I trust that for the present I have brought forward subjects enough, although, in a fresher state of health, I might have attempted to press more on your attention.

There is, however, one subject on which I have promised to say something—it is smoke. I might have given all the time to it, but I shall only repeat what I have said in late reports, that the new modes of treating coal point to a time when the products will be so valuable that the heat may be considered as a waste product, and smoke absurdly extravagant. People take these ideas too slowly—men wait and wait; and they will consider how to save coal when it is done, and how to preserve health when they are dying. Even places to which you resort for health are defiled by the blackest smoke. Can you not show a preference for steamboats which have some care for appearance and comfort in this respect, if such steamboats are to be found. Perhaps the newest ideas are less applicable on sea, at any rate much may be done there; and on land I hope that manufacturers will not neglect new ideas, lest they find too late that trade has left them.

Sir James Watson proposed a vote of thanks to Dr. Smith for his interesting and important address. Dr. Smith, he said, had devoted a long lifetime to the elucidation of these important questions, and he had made very great discoveries in many of them—discoveries which had been of great importance to science. Much credit was due to him for what he had done in regard to the ventilation of mines. His information to the Home Secretary and the Local Board was of such a description that it was carried into effect, and had been the means of saving many valuable lives. He believed they were much indebted to Dr. Smith also for the knowledge that they had of the atmosphere, and its connection with health or disease. The lecturer had done much in the cause of science, and consequently the opinions which he had given them in the lecture that morning were of the very greatest importance, and deserved their most serious consideration. Dr. Smith's remarks upon oxidation in the prevention of disease and in the promotion of health were such as were worthy of being considered, and should be put into effect by every person. He thought they should all use their influence as much as possible to promote it among their friends and especially among the working classes. These observations were very valuable in a town like Glasgow, where there was a considerable amount of population who were not without the need of hints upon the subject. When he was connected with carrying out the Improvement Trust in Glasgow one difficulty he had to contend with was not only the closing of windows, but the objection of the people to go into better houses. There had been a very great improvement in Glasgow in this respect. He thought Dr. Smith's remarks in regard to the purification of rivers were well deserving of the attention of our local authorities. There would be great difficulty in meeting the enormous expenses which they would incur were they to follow out any of the proposals that had been made by the engineers hitherto. Probably a couple of millions would be required before it could be effected. Experiments were now, however, being carried on which he hoped would have the effect of showing them the mode which should be adopted. Dr. Smith's remarks upon smoke were most valuable. If he were correct that the value of smoke will be such as to induce every consumer to change their present mode and abolish open grates, he was sure it would be the greatest blessing which they could obtain. Every manufacturing town was polluted with it, and in Glasgow it was becoming every day more and more a subject of annoyance—to such an extent that the people in Glasgow were actually going to the outskirts of the town to avoid the smoke as well as the rates. Any improvement in this direction would be of the very greatest importance to Glasgow and every other manufacturing town throughout the kingdom.

Dr. Cameron, M.P., Glasgow, seconded the motion. He hoped that if Dr. Smith did take the smoke nuisance in hand he would not confine himself to Glasgow, but go into the surrounding districts, and apply his sensitive nose to the abominably fœtid smokes which were to be seen rising on every side from bins of burning shale and other refuse, and try if he could do something to render life in the country immediately surrounding Glasgow at least as tolerable as it was in the town. The address which had been read by Dr. Smith was particularly valuable at the present time, when the relations between chemistry and sanitation were undergoing a very considerable change. The purely chemical school of Liebig, which pointed out the importance of pure air and pure water as well as it possibly could be pointed out, had given way to a large extent to the zymotic and vital school of Pasteur. So long ago as 1848, Dr. Smith suspected that not to impure gases alone were they to attribute outbreaks of disease. He was glad to see that although in this country the vital philosophy, as regards disease and sanitation, of Pasteur had not made such great way as it had done on the other side of the Channel, yet very important contributions had been made to it by two men in this country. One of these contributions was that of Professor Tyndall, who had done most important service in the vital analysis of air; and the other service to which he referred was that of Dr. Angus Smith, who had invented a process for the vital analysis of water, which he thought they might look upon as a fresh starting point to sanitarians in their search for a test of pure water.

The Chairman, in conveying the vote of thanks to Dr. Smith, referred specially to what he had said as to the utilisation of sewage. He himself had for many years been interested in that subject. He had seen, and did see, the sewage of a population of 80,000 utilised with the best results. Land which before it was so utilised was worth 25s. per acre was now giving a much larger return. Land had been purchased by the Local Board under whom it was worked at a cost of £180,000. The interest upon that money was being paid. The land itself, which formerly would only bear one ox or half an ox per acre, was now bearing food for 3½ oxen per acre, and food was being provided for the people, and abundance of milk was being sent from the farm for the use of the people. Again, before the farm came into operation, there was only one person occupied for every 50 acres, whereas now occupation was provided for one person on every four or five acres. There was therefore abundance of employment, and a very large production of animal food for the people, and there was a large amount of money paid to the original owners, who had been made rich men, while the sewage of the district had been entirely utilised at very moderate expense to the district. He contended that a town had no right to discharge and to destroy that large amount of ammonia spoken of by the lecturer, and if it were so they were doing their country a very serious injury, for which they ought undoubtedly to be called to account. Until they took care to keep at home for their own purposes at least a large amount of the ammonia that had been referred to, they would not be doing their duty as citizens. On the part of the audience, and on his own, he had to convey to Dr. Angus Smith a hearty vote of thanks for the paper he had read.

Dr. ANGUS SMITH, in acknowledging the compliment, said he was afraid that Dr. Cameron, in his extreme courtesy, had given him credit for some things which must be referred to others. He certainly was working upon the analysis of water, and thought he had found some things which he believed were new; but he was afraid lest Dr. Koch should imagine that he (Dr. Smith) claimed the gelatine process, and, therefore, he was anxious to say that Dr. Koch had the entire credit of having begun the use of gelatine in this department.

On "*The comparative merits of Fine and Coarse Flour as articles of Food*," by WILLIAM WALLACE, Ph.D., F.R.S.E., F.C.S., F.I.C.

HAVING occasion to visit frequently one of the lowest quarters of this city, I have often been struck with the very large proportion of children in this locality who are "ricketty," or have their bones deformed from the absence of a sufficient proportion of phosphate of lime to give them stability; and although this is perhaps rather a medical than a chemical question, I venture to introduce it to the members of this Congress in the hope that some good may result, if not from the paper itself, at least from the discussion to which I trust it will give rise.

I am well aware that the disease popularly called rickets is not confined to any part of this city, nor to any particular city or town, altough it appears to be more prevalent in certain localities than in others. It is found wherever children are brought up on deficient diet; in crowded, ill-ventilated apartments; in streets in which the air is more or less tainted, and in which the sun is seldom seen, where there is no ground for exercise but the dirty street; in short, where all that is pure, all that is beautiful, all that is requisite for the healthy growth of the soul as well as the body is banished. It is a disease that is rarely met with in the children of the upper and middle classes, or those of the poor who are brought up under more favourable sanitary conditions than those I have mentioned.

The healthiest children, and the most robust men and women, are those living in agricultural districts, who, though eating the coarsest of food and enjoying the fewest of the luxuries of life, have a pure atmosphere to breathe, plenty of sunlight, and free exercise for their limbs from the moment they are able to crawl out of the open cottage door. Now I cannot for a moment doubt that the general insanitary conditions of life of the city child have a most powerful influence in bringing about the development of this melancholy disease, which always results in a greater or less degree of deformity of the lower limbs; yet I hold that the defective nutrition which is the direct cause of it depends, to some extent at least, on the deficiency in the food of those mineral constituents which are as essential as the flesh-formers and heat producers. Every article of diet, whether animal or vegetable, has its own mineral constituents, and these vary, not only in quantity, but very markedly in their nature and proportion. In some the leading ingredients are phosphoric acid and lime, or phosphoric acid and potash; while in others we find chiefly alkaline salts. In milk, the food specially provided for the young, not only is the saline matter excessive, constituting 5 or 6 per cent. of the entire dry substance, but there is a large proportion of phosphate of lime, the leading constituent of bone. Hence it is a fair inference that any food or mixed diet which does not provide this compound in sufficient quantity is unwholesome for the young, and is probably, although in a less degree, unsuitable for healthy adult life.

I may here quote an analysis by Marchand of the *femur* or thighbone of a ricketty child.

Cartilage	72·20
Fat	7·20
Phosphate of lime	14·78
Phosphate of magnesia	·80
Carbonate of lime	3·00
Sulphate of lime, Chloride of sodium, oxide of iron, and loss	2·02
	100·00

In contrast to this, the same bone in a subject free from this disease contains, instead of the 20·6 per cent. of earthy matter given above, 64 per cent. of ash, consisting of the same salts, and very nearly in the same proportions. In *rachitis*, therefore, the effect is due to the diminution in the *quantity* of the phosphate of lime and other salts, and not to the absence of any particular ingredient, or the abnormal introduction of any foreign constituent.

An attempt was made some years ago by some medical men and chemists to show that the hardness of water supplied in towns and cities had an important bearing on the subject we are discussing; and statistics, which, it has been well said, can be made to prove anything, were collected, in which it was apparently shown that the general health of the inhabitants of towns in which hard water was used, was better than those using soft water. More careful and general observation has, however, completely demolished the theory, while, on the other hand, it has been shown on evidence which has been considered satisfactory to physicians of the highest standing in their profession, that the constant use of certain very hard waters, and especially those containing an excessive proportion of sulphate of lime, gives rise to disorders of a somewhat serious description, particularly in old people. Now, in regard to the particular disease of which I have spoken, water, either hard or soft, unless contaminated by sewage, contains no phosphate of lime, or at most, only the most minute trace, which can be detected only by the most delicate chemical tests. Then, in regard to lime, which is at least one of the constituents of phosphate of lime, let us see how much of it there is in hard waters as compared with soft. Taking the whole of the lime as carbonate, hard water supplies contain 12 to 20 grains per gallon, soft waters 1 to 5 grains, and those of medium hardness 5 to 12. Now the quantity of water consumed in food or otherwise by an average human being may be taken at 40 ounces, or quarter of a gallon per day. This, I should explain, does not include milk, beer, wine or spirituous liquids, but only the water used for drinking, and that mixed with our food. It follows, then, that in a hard water town, such as London, where the hardness is about 16 degrees, the total quantity of lime taken as carbonate may amount to 4 grains per day, while in Glasgow it is little more than ¼ of a grain. In regard to children, who require relatively to their size much more mineral food than grown persons, there is comparatively little water used, while milk enters very largely into the diet. 20 ounces of milk per day is quite a moderate quantity for a growing child of four to eight years, and this quantity contains upwards of 50 grains of saline matter, a large proportion of which is phosphate of lime. Now as regards this particular ingredient, the quantity taken by a child in milk alone in one day will equal that introduced in the water, be it hard or soft, consumed by a grown person in about 10 years. But possibly the lime in water might be useful in making up the deficiency of that ingredient in certain articles of food; and

it is the fact that many substances of common consumption, such as bread, while they contain much phosphoric acid, have in their composition comparatively little lime. But even bread contains some lime; taking it as carbonate, as we did in the case of water, a pound of bread of an ordinary description contains about 4 grains, while other common articles of diet have a much larger proportion. I give here, in a tabulated form, a list of a few articles of diet, with the proportion of mineral matter, or ash in each, and also the proportion of lime and phosphoric acid in 100 parts of the ash:—

		In 100 parts of ash.	
	Ash per cent.	Lime.	Phosphoric Acid.
Flour	·8	3·4	50·7
Oatmeal	2·1	8·5	42·4
Barley	1·1	3·4	29·9
Rice	·5	7·2	60·2
Indian Corn	2·0	3·1	44·5
Peas	3·0		
Potatoes	1·1	1 to 4	15 to 20
Turnips	·8	7 to 35	3 to 8
Carrots	1·0	6 to 12	8 to 12
Beetroot	·9	4·8	2·8
Cabbage	1·2	11 to 23	10 to 20
Apples	·4		
Gooseberries	·5		
Grapes	·4		
Figs	2·3		
Dates	1·6		
Milk, Cow's	·7	17·3	28·4
" Woman's	·15	42	32·4
Cheese, Swiss	5·1	17·8	20·4
Eggs	1·3	10	33
Beef	5	5·1	39·3
Veal	4·5	2	48
Mutton	3·5		
Pork	1·5	7	42
Tea	5·5	8 to 11	8 to 17
Coffee	4·5	4 to 6	10 to 11
Cocoa	3·5	11	29·6

The estimated total amount of mineral matter consumed daily by a grown person is 170 grains, and I calculate that this quantity of ash of an average diet will contain lime equal to 33 grains of carbonate, so that the four grains taken in hard water would make no appreciable difference.

In all the articles of food I have mentioned phosphoric acid is a prominent ingredient, and in some it constitutes at least half the weight of the total mineral matter. But I have to point out that all the flesh-forming constituents of these alimentary substances contain phosphorus in organic combination, and this appears in the ash as phosphoric acid. In like manner, the urine, which contains the partially oxidized products of the wasted tissues of the body, has, as one of its leading components, phosphoric acid, existing partly as phosphate of lime, partly as phosphate of magnesia and ammonia, and partly in the free state. It is therefore natural that we should find in the ash of most articles of food phosphoric acid largely in excess of that proportion which would be required to combine with the lime that is present.

Of all the substances used for food by civilized nations none is so universally or so largely consumed as wheaten flour, and yet there are few which contain so small a proportion of mineral matter. If we take the dry substance in each article (for many vegetables and fruits, for example, contain 80 to 90 per cent. of water) I think there is none which contains so little ash as wheat, with the single exception of rice, and even it, as I shall presently show you, has more mineral matter than the finest flour. The dry substance of milk contains about 6 per cent. of ash, of eggs 5 per cent., of potatoes 4 per cent., of turnips 11 per cent., of carrots 9 per cent., and of cabbage 11 per cent. I think it is a fair inference that, as wheat contains naturally a comparatively small proportion of mineral matter, we should not use means to reduce it materially.

It will be useful here to give two analysis of wheat, which I made some time since. The first is of a sample of the finest Hungarian wheat, such as is used for producing the highest quality of Austrian or Hungarian flour; the second is a mixture of Scotch, American, and Baltic wheats, such as is used for making flour of ordinary quality in Glasgow.

ANALYSIS OF WHEAT.

	Hungarian.		Mixed Scotch, &c.
Albuminous compounds ...	12·29	......	11·17
Fat or oil........................	1·90	......	1·96
Starch, &c......................	70·50	......	70·97
Vegetable fibre	2·16	......	2·36
Ash or mineral matter	1·53	......	1·75
Water	11·62	......	11·79
	100·00	......	100·00
Phosphoric acid in the ash...	·70	......	·74

There is here a difference of one per cent. in the flesh-forming or albuminous compounds in favour of the Hungarian wheat, and about ·2 per cent. in the ash in favour of the mixed sample. The other ingredients do not differ materially.

I made, at the same time, analyses of the flour obtained from each of these wheats; the Hungarian being the finest and whitest flour obtainable by the Austrian system of grinding, while that from the mixed wheat was simply a good, white, Glasgow-made flour. The prices of these flours are at the present time, respectively 48s. and 35s. per 280 lbs., or per pound 2·06 pence and 1·5 pence. In round numbers the relative prices are 4 and 3. We should expect, therefore, to find the dearer flour much more nutritious than the other, or to have some other quality to recommend it.

Here are the chemical anaysis of the two samples:—

ANALYSIS OF FLOUR.

	Hungarian.		Mixed Scotch, &c.
Albuminous compounds......	10·62	......	10·04
Fat or oil........................	1·40	......	1·69
Starch, &c......................	75·35	......	73·92
Vegetable fibre	trace	......	trace
Ash	·38	......	·85
Water	12·25	......	13·50
	100·00	......	100·00
Phosphoric acid in the ash...	·14	......	·34

Let us compare these two analyses. In the Hungarian flour we have a larger proportion of albuminous compounds, to the extent of ·58 per cent.; while in the Glasgow-made flour we have a little more oil, and *more than double the proportion of ash.* This white Hungarian or Austrian flour has actually less mineral matter than rice, which contains ·5 per cent., and which is distinguished among vegetable productions for its very small proportion of this constituent. I may here say that some of the millers in the United States, having adopted the Austrian system of milling, are producing a similar quality of flour, and I found in a remarkably fine and white sample of American flour—

Albuminous compounds...........	10·62
Fat or oil.............................	1·14
Starch, &c............................	74·34
Ash	·34
Water	13·56
	100·00
Phosphoric acid in ash	·18

Wheat, as we have seen, contains from $1\frac{1}{2}$ to $1\frac{3}{4}$ per cent. of ash, but it is very unequally distributed in the grain. The outer part contains by far the larger proportion of mineral matter, and it is also more nutritious. In illustration, I quote some figures selected from researches made by Messrs. Lawes and Gilbert, the well-known agricultural chemists. I may say that the wheat was grown by themselves, and contained 1·9 per cent. of ash.

Mill Products.	Proportion for 100 of grain.	Ash per cent.	Albuminous Compounds.
1. Wire 1	51·2	·71	10·19
2. „ 2	24·8	·74	10·56
3. „ 3	1·7	·82	11·12
4. Tails	1·6	1·04	11·62
5. Fine sharps or middlings	3·3	2·19	13·81
6. Coarse sharps	3·3	3·93	16·12
7. Fine pollard	1·8	5·46	15·25
8. Coarse pollard	6·7	6·56	15·12
9. Long bran	5·0	7·14	15·00
	99·4		

I have ventured to introduce this subject to the Congress, because I think it is a most important one, and because we in Glasgow suffer especially, as I think, from the use of excessively fine and correspondingly dear flour. For my own part, I never eat white bread if I can get what is called household, or still better, whole-wheat bread; and I think a little education would incline the general taste in the same direction. But it is the fact, that the people of Glasgow, and particularly the working classes, eat nothing but the finest bread, rejecting the good, honest, and eminently wholesome bread made from home-made flour, as if it were unfit for human food. I have heard it said, that natural instinct, in this as in other matters, is an infallible guide, and that there must be something great and good in fine flour, although the chemist cannot discover it, which causes it to be so much prized. For my part I say it is not an instinct, but a mere fashion; and one as pernicious and absurd as tight lacing in our own country, or the compression of the feet of women in China.

It is greatly to be regretted that the use of oatmeal is gradually but surely being given up by the working classes in Scotland, especially in large towns; and there cannot be a doubt that the liberal use of porridge and milk, as contrasted with white bread and tea, would, in a great measure, prevent the development of the disease to which I referred at the commencement of this paper, and would improve the general health of the people. Can nothing be done to arrest the displacement of the wholesome and strengthening national food by articles which are radically defective?

Mr. T. H. Harrisson (Liverpool), remarked that the Bread Reform League were doing very good work in the direction indicated by Dr. Wallace.

Mr. G. W. Muir (Glasgow), said the reason why people preferred the fine wheat was that the brown loaf was charged at the same price as the fine loaf, and the people did not like to pay the same money for what they knew cost less. He himself never used anything but wheat and meal bannocks and oatmeal cakes.

Mr. J. J. Coleman, F.C.S., pointed out the danger of corn flour for children. That flour was deprived of its most essential constituents, and he had know cases where children were almost exclusively fed on it. The inevitable result had proved to be insufficient nutrition, and the consequences serious.

The Chairman said Dr. Wallace had called attention to the supply of hard and soft water as affecting the bone matter. He only wished to make one observation borrowed from the late Professor Clark, of Aberdeen. The professor had a very strong opinion in regard to the value of soft water, and he invented a process for the softening of it. When he was examined on the subject by a Committee of the House of Commons he was asked whether the loss of lime by using soft water would not prevent the growth of bone? To this the professor replied: "The water at Aberdeen is about the softest in the kingdom, and the people of Aberdeen are the largest boned of Her Majesty's subjects." The Chairman, speaking on the question of food, said he used oatmeal daily, but he feared they saw already indications of deterioration in fibre in large towns from the excessive use of tea and fine bread.

On "Disinfection by Heat, with Description of a New Disinfecting Chamber," by James Adams, M.D., L.R.C.S.E., F.F.P.S.G.

To Dr. W. Henry of Manchester is due the merit of conceiving and demonstrating by actual trials the fact that heat destroys or neutralises the morbific matter of certain communicable diseases. In 1832 (Phil. Mag., vols. x-xi) he published the results of experiments, showing that cow-pock matter becomes totally inert after an exposure *of some hours* to a temperature of 140° F., and that clothing designedly infected with scarlatina and typhus *contagium* was afterwards worn with no bad results by individuals likely to be susceptible, such clothing having previously been confined *for some hours* in a temperature of 200° to 206° F.

Since the time of Dr. Henry, various methods have been employed for practically utilising his richly suggestive conception, but in some instances without observance of his precautions, of which more hereafter. Meanwhile, a short reference to the nature and properties of the matter that transmits contagious disease will aid my description of a new Disinfecting Chamber professing to have some important distinctive features.

Of the constitution of morbid poisons we are as ignorant as of that of prussic acid or of strychnine, nor is it probable that the knowledge, if we possessed it, would throw any light on their mode of action, so far as relates to the essential morbific principle. We are well acquainted with their *chemical composition* without in any way understanding how they act so powerfully on the animal system; but we know they are capable of being decomposed by weak chemical agents, and rendered inert by temperatures of about 200° F., and therefore that their constitution is not stable, and that they are held together by very feeble affinities.

That contagion is connected with the diffusion of oganisms possessing vitality may now be assumed as an established axiom. This doctrine, known as the "Germ Theory," is usually ascribed to Pasteur, and it is undeniable that he is entitled to pre-eminence in enunciating the truths on which the doctrine is now so soundly based. But the notion was held as far back as 200 years ago, and originated with Kircher, who advanced the view that *animalculæ* or *acari* diffused through the atmosphere was the true originating cause of epidemic and contagious diseases. His opinion was endorsed by Linnæus, and advocated by other eminent men, but did not meet acceptance among physicians. On the contrary, it was by them, until a recent date, held that there existed a deleterious principle or medium, vaguely expressed by such terms as "fomites," "virus," "effluvium," &c., which became contagious or epidemic by some occult and mysterious influence, some "corruption of air," or some spontaneous change in inanimate matter. And it is illustrative of the general notions that long prevailed, and at same time interesting in the present connection to note, that Dr. Henry, who devoted much consideration to the problem, and whose name is so honourably associated with the subject of disinfection, was a strong disbeliever of Kircher's hypothesis, and characterised it as singularly

unsound—as having not a single valid analogy to confirm it—and as being at variance with all that is known of the diffusion of volatile contagion.

So late as 1860 the mysterious *something* that originated epidemic and contagious disease, was a matter of keen controversy, and was generally believed to have its most probable solution in establishing or disproving the doctrine of Spontaneous Generation, regarding which the views of the illustrious Liebig were held open to refutation by his no less illustrious contemporary, Pasteur.* The continuous and untiring researches of Pasteur, aided by others, and at a later date very materially by those of his able expositor, Tyndall, have clearly demonstrated not only the fact of the generation of certain communicable diseases by living organisms or "germs," but have gone far to make it very probable that it is through living organisms or germs that all zymotic diseases are propagated. According to this doctrine putrefaction and epidemic disease alike, arise, not from the air but from something contained in the air. This something is not a vapour, nor a gas, nor a molecule of any kind, but a *particle* or bit of liquid or solid matter formed by the aggregation of atoms or molecules. Tyndall has shown that the air is at all times, even when free from microscopically visible particles, beset with much smaller ultra-microscopical particles, and he alleges that air from which the particles have subsided—air which is "optically pure" as determined by the electric beam—is no longer capable of contaminating liquids, or of inducing fermentation or putrefaction. From such facts and from a review of the whole field traversed by other observers, he concludes that these particles are organisms, the germs of septic Bacteria. "The thing" he says, "which we vaguely call a 'virus' is to all intents and purposes a seed * * * as surely as a thistle rises from a thistle seed, as surely as the fig comes from the fig, the grape from the grape, the thorn from the thorn, so surely does the typhoid virus increase and multiply into typhoid fever, the scarlatina virus into scarlatina, the small-pox virus into small-pox."

This "virus," these particles or germs, are *volatile*—are shed freely from infected individuals and from their clothing, and are wafted to and fro by ærial currents. Hence all appliances which have for their object to limit the spread and ensure the destruction of these germs should be planned with special provision for this dangerous property of volatility in the germs of disease.

While the hypothesis of spontaneous generation was in de-

* See Addenda.

pendence and under anxious discussion throughout the scientific world, heat was the chief agent employed to determine the actual vitality of microscopic forms that are developed so abundantly in infusions of organic matter, and even in saline solutions. And while there was a general *consensus* to the effect that heat destroyed the evidence of vitality drawn from active movements, there was a great conflict as to the *degree* and *duration* of heat required. Moreover, there was a renewed generation of the same forms frequently observed in the liquids supposed to have been sterilised, which naturally gave rise to the belief in spontaneous generation. The first light thrown on this perplexing riddle was by Professor Cohn of Breslau, who showed that confusion and contradiction had arisen from having failed to distinguish *the growing germ* from its seed or spores. And it was reserved for Professor Tyndall to pulverise and destroy for ever the doctrine of spontaneous generation by an exhaustive series of brilliantly conceived and thoroughly conclusive experiments. He showed that the vitality of a germ or embryo organism and its disposition to development was a latent property dependent on different conditions of spores, age, dessication, exposure to air and light, &c., and that subject to these varying conditions there were required varying periods for germination: that in the operation of boiling that was usually adopted for their destruction, the broods or crops may overlap each other, the new brood making its appearance before the old brood died away, and that by repeated boilings at short intervals—and not by prolonged boilings—dealing with each successive crop as it springs into active life, there was effected ultimately a complete destruction. Finally he showed how all preceding observers had failed in their best intended efforts to procure a condition of the air absolutely or—as he phrases it—"optically pure"; and with this necessary condition of purity secured, he predicted with an accuracy that has not since been gainsaid, that there never would again occur an example of so-called spontaneous generation.

The distinction to be observed between the seed itself, and the developing organism, cannot therefore be too strongly impressed on the mind when dealing with methods of germicide. Notoriously the growing or adult organism can be easily destroyed. Not so the seed. The contrasted difficulty has been well expressed by our senior city member, Dr. Cameron, in his very instructive and in every respect excellent monograph on "Microbes." Dr. Cameron says "as to the spores which they [*i.e.* the developing or adult organisms] produce, and from which succeeding generations spring, there is almost no killing them. The more you dry them the better they resist destruction. Time is no object with them and they maintain their dormant vitality for an indefinite number of years. Absolute alcohol has no effect on them. As to oxygen they can stand that concentrated by the pressure of twenty atmospheres, and be none the worse. Two or three hours' boiling if they have been well dried beforehand, seems not to hurt them, and they have even been known to resist eight hours' of the process. *The only effective means for their immediate destruction that I am aware of is the flame of a spirit lamp.* To that their extreme minuteness renders them an easy prey."

But Pasteur never saw germs resist 230° F., or the adult organism from 122° to 140° F. *when in the moist state.* Chaveau, Calvert, Roberts, Tyndall, and many others, have shown that from 140° to 212° F. is a degree of heat that few developed germs can sustain. According to the very recent experiments of Koch, Wolffhügel, Gaffky, and Lœfleur, exposure to temperatures of 212° to 221° F. in dry heated air effects easily the destruction of Baccili and "adult" Bacteria, while *spores* of mould were not killed after being subjected for one and a half hours to air heated from 230° to 240° F., and *spores* of Baccili were destroyed only after being confined for three hours in an atmosphere of 284° F. On the other hand, these last-named observers have given very important evidence as to the difference in effect of heat according as it is dry or humid, for they found that spores of garden earth and of carbuncular disease lost all vitality by an exposure of only ten minutes in hot vapour registering 230° F., and they assume that this is the temperature to which ought to be heated any morbific principles of an unknown nature which can transmit disease. Their experiments show that in a practical point of view one cannot have absolute confidence in dry heat for the disinfection of all suspected objects. On the whole it may be affirmed that duration of heat and its degree are mutually complimentary both with dry and with moist heat, a long exposure to a low degree being equivalent to a shorter exposure to a high degree.

The natural inference from such experiences is that in seeking to disinfect by heat, that heat should be carried as high, and contined as long as is possible, or necessary, to ensure the destruction of infective matter; subject only to the limit that infected clothing or other articles operated upon, may not be injured or destroyed. And in determining the practical limit that is expedient, I have again to make honourable mention of Dr. W. Henry, who made practical trials 50 years ago on fabrics of clothing and other articles, which have left little save gleanings for subsequent observers. For the experiments of Ransom, Chaumont, Vallin, Koch, Wolffhügel, and others have added little beyond a confirmation of Dr. Henry's conclusions, and to these later observations I need not therefore refer in detail. They show in summary, that exposure in dry heated air to a temperature of 220° to 230° for one or two hours is sufficient for disinfecting purposes, and does not injure the integrity nor the appearance of ordinary clothing and bedding, but that a temperature of 250° is risky, may cause injury, and is therefore unnecessary.

In considering the practical application of heat to infective matter for disinfecting purposes, we need not take into account the exceptional laboratory experiences of various observers who have recorded extraordinary degrees of heat withstood by some germs. These are little likely to be noticed in future now that Tyndall has specified so clearly the conditions under which they are likely to have occurred. These rare instances are matters of curious interest more for the naturalist than for the sanitary physician. The general evidence now accumulated, is abundantly sufficient to warrant the conclusions recently laid down by Pasteur and Leon Colin in their Report on Disinfecting Stoves, made in 1880 to the Council of Health of Paris and the Seine. These are to the effect that while humid heat of 212° F. will certainly destroy all life in morbid germs and all dangerous condition in virulent matter, a temperature between 212° and 230° F., whether dry or humid, may be fixed as sufficient for all practical purposes. A higher temperature is unnecessary.*

When selecting an apparatus for disinfecting by heat, there is a somewhat embarrassing choice between those which are more or less portable, and sold in the ordinary course of commercial manufacture, and those which are erected on an extensive scale to special designs and for the needs of a large population —between those which are employed for occasional use, and those where the process of disinfection may be a matter of daily or hourly requirement. In a description of my own apparatus I will, therefore, best indicate the points wherein others in frequent use seem defective, and wherein my own contrivance seems to supply a desideratum. I say so much because I was led to realise my conception on the request of Major-General Collinson, Architect to the Prisons' Commission for Scotland, who did not find in existing apparatus the economy and convenience or efficiency that were desirable, and in his view attainable. He sought a portable appliance that could be easily fitted up in an ordinary appartment of a gaol, and be quickly brought into use for the few hours during which disinfection of clothing, &c., was occasionlly required. Dr. Littlejohn, with whom I also freely

* See Addenda anent high temperature.

discussed my plan, and to whom, as well as to General Collinson, I exhibited a small model, was clearly of opinion that the apparatus was peculiarly suitable for the service of gaols, workhouses, small hospitals, small country towns and various localities where the use of disinfecting chambers were practically excluded, because of first cost usually was then doubled by the conjoined expense of a special building, and subsequent considerable cost of working, irrespective of their shortcomings in real sanitary efficiency. Several medical officers of health with whom I have since exchanged views, have added their cordial concurrence in this opinion.

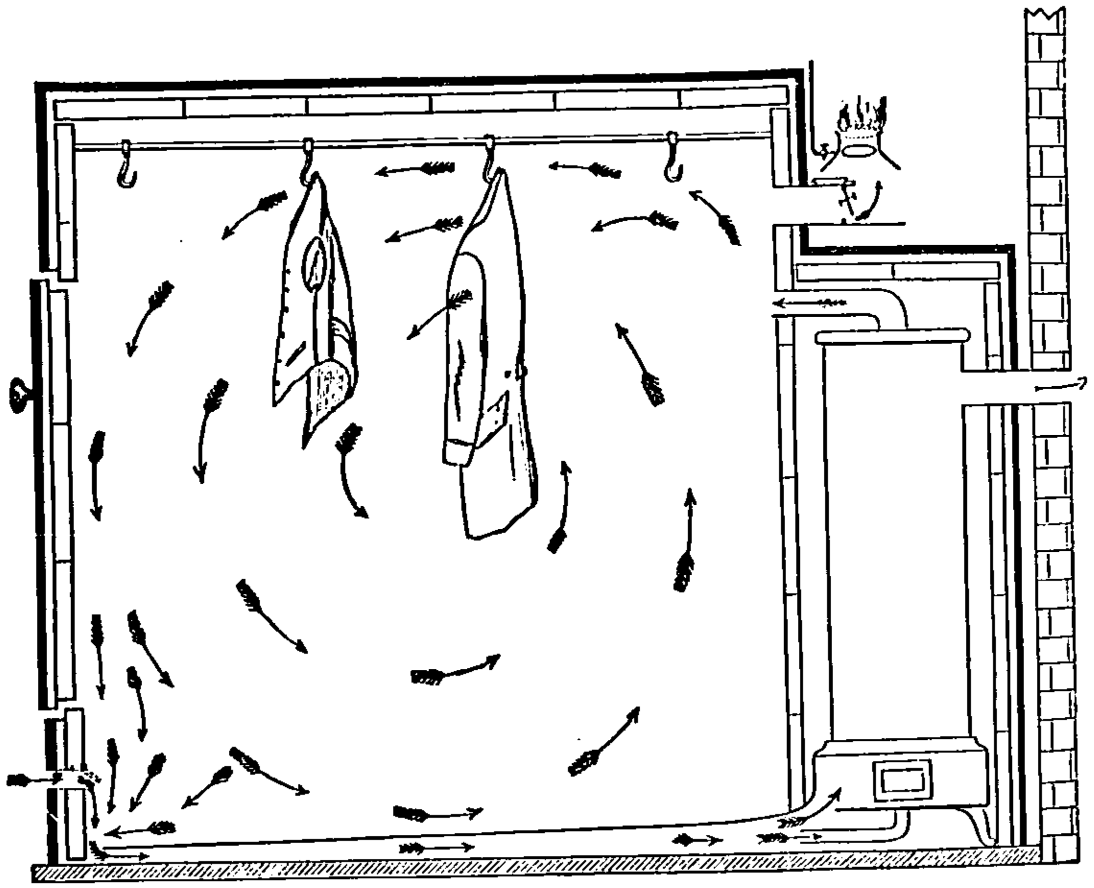
The "principles" on which my chamber is planned have reference to the following points. 1. Portability, cheapness of construction, and economy in use.* 2. Improved method of causing heat and of preventing subsequent waste of fuel. 3. Equality of heat throughout the chamber. 4. A maximum or any desired temperature maintained by a simple contrivance acting automatically. 5. Germs or other infective matter disengaged from infected objects, not permitted to escape into general atmosphere. 6. Infected objects not exposed to products of gas combustion, but only to pure air, conjoined with moisture when desired. 7. Gas consumption regulated by automatic governor to an efficient average quantity.

These points I will now comment upon.

The sides, top, and bottom of the chamber form so many complete pieces, prepared, adapted, and numbered in the workshop so that they can be easily put together by any ordinary workman. The interior is furnished with the usual rods and hooks for supporting articles that are being disinfected. A powerful gas stove of peculiar construction, exposing a large heating surface in its interior traversed by pure air, is connected inside or outside of the chamber, preferably on the outer side. It is then only necessary to attach the gas supply and lead the stove flue into the chimney of the apartment in which the chamber is placed. The walls of the chamber consist of double casings made of thin plates of sheet iron, one-and-a-half inches apart, air tight, and containing only confined air. Each casing is farther subdivided by partitions to prevent heated air accumulating in the higher compartments. Confined air is the best non-conducting medium and renders unnecessary the packing material that is usually employed. Such packing in the degree in which the material is solid, necessarily absorbs heat at

* The company that manufactured the workshop model shewn at the Sanitary Exhibition at Glasgow has, with my permission, taken out a Patent, and I am informed that the selling price of a chamber of 130 cubic feet inside capacity will be about £40.

the beginning of an operation and prolongs the time requisite for getting up the desired temperature. Such packing—the most useful of which is boiler felt—may, however be applied to my chamber with good effect when it is intended to be kept in use for many hours or days at a stretch; otherwise it is unnecessary. A case of wood lining outside, with an inch space between it, and the sheet iron forms a second air jacket, and the wood, by its slow conducting and radiating properties, conserves the heat still farther.



The bottom of the chamber is double, having about six inches deep of an under space communicating by openings at one end with the general interior. The heating stove, whether placed within or connected outside, draws air from the under floor space through two separate pipes, one leading to the furnace, the second admitting air to the pure air caliducts of the stove. The under floor space, therefore, communicates at one end with the general interior of the chamber and at the other end with the stove, and the air drawn from the under floor space divides into two currents, one of which passes through the furnace and ultimately escapes into the chimney of the apartment. The

other and much larger current follows a separate course through the stove where it becomes highly heated, and is discharged in a pure state into the chamber. It is not then permitted to escape outside, but is drawn down through openings into the under floor space, and again led into the stove highly heated, and again discharged into the chamber, with each circulation gaining increased heat until the maximum temperature desirable is attained. And so the circulating current goes on traversing and retraversing the general chamber from end to end and from top to bottom in brisk movement as long as the stove continues lighted. The "principle" of action is analogous to that of heating by hot water pipes. This automatic movement of hot air in a circle ensures a nearly equal temperature throughout the chamber. The briskly moving current passes through the suspended clothing more effectively than a stagnant atmosphere can penetrate. It plays in the manner of a light breeze, rustling the garments, disengaging and floating off infective matter, while the rapidly successive impact of heated air molecules must oxidise more effectively than a still atmosphere.

The volume of air drawn through the stove furnace would suffice to fill the chamber more than twice every hour. That quantity is replaced by fresh air continuously admitted from the exterior through a simple valve that prevents reflux. The much greater body of air that moves through the chamber in an automatic circuit would suffice to fill and empty it about fifteen times within an hour, giving a complete revolution and replacement about once every four minutes. All infective matter volatilised and floating in the larger current is therefore being continuously heated and re-heated within the pure air caliducts of the stove, while any matter floating in the smaller current that is being continuously drawn through the stove furnace and burned gases caliducts, is thoroughty carbonised and conclusively dealt with. At the expiry of the time given to the operation, an aperture in the upper part of the chamber is opened to permit the escape of the confined air, which passes through a pipe that has its point of discharge underneath a solid gas flame, so that any infective matter still suspended in the air must pass through this flame. *Thus, from beginning till the end of the operation, all volatilised matter liberated in the chamber must pass through flame.*

I place much stress, and not unduly, on the paramount importance of imprisoning volatile infective matter throughout the entire period given to a disinfecting operation. There is otherwise a very fallacious security. The quantity of epidermic scales shed from the skin of patients affected with typhus, scarlatina, smallpox, and other eruptive fevers throughout the desquamative or convalescent period is very great, and these together with the more subtle, or less visible emanations exhaled by the skin or breath, or the grosser discharges from typhoid or diptheritic patients, contain the matter that makes those diseases communicable. I have seen the shirts and other clothing of such patients when held up and briskly shaken, discharge clouds of contagious dust, similar to what takes place in shaking a flour bag. Now this infective matter may be dried and exposed to the air for weeks together, and yet lose little or nothing of its virulance, and this dust constitutes the infective particles or germs that we dread should float from a sick room into the adjoining apartment of a dairy or farm-house where it may settle in the milk vessels—that we apprehend from the association of our children with school mates recently convalescent, or coming from an infected house—that we fear may be suspended in the atmosphere of a cab that has conveyed an infected patient. How evidently necessary it, therefore, is that in a disinfecting operation there should be provision made for following up to utter extinction such contagious matter. The facts that have within so recent a period been adduced, and that since are daily illustrating the vital importance of the "Germ Theory" were not in the prevision of those who designed the gas disinfecting chambers at present in frequent use throughout the country. There is not in many of them any provision for such heroic treatment as I am advocating. In some the infected clothing is merely hung up in a chamber traversed by a current of hot products of gas combustion that enters at the bottom, and passes instantly out at the top. The shirt or blanket may be detained for a conventional period of two hours or thereby, but any volatile matter that is disengaged, is instantly swept off into the general atmosphere. The shirt or blanket is itself disinfected and may afterwards be worn with impunity, but where do the infective "particles" alight? They have not been detained for two hours nor for as many minutes. They have not been subjected to the necessary temperature during the necessary period of time, nor for any notable period of time. They cannot under a momentary exposure to heat of 230° or 250° have been rendered inert. They have simply been blown away to join the idle wind that wanders where it listeth; and we never can know what becomes of them during the weeks, or it may be years, that they retain their deadly properties, although we may conjecture when we meet epidemic and contagious disease springing up in some locality under inexplicable conditions. Dr. Henry detained his cow-pock, scarlatina, and typhus matter within his

heated laboratory oven for *hours*, proving as he cautiously proceeded that time was an all important condition in disinfecting by heat—that sometimes a duration of exposure for one hour, sometimes for two hours was insufficient, and that where he stopped short the contagious matter retained its potency. All subsequent observers have followed in the same lines, and confirmed substantially his conclusions.* When Pasteur, Tyndall, and others, boiled the germs on which they operated, they found at one time one hour, at another time three hours too little. But we now know through the teachings of Tyndall that at the beginning of a heating operation there may be germs in such an embryo state that heat of a certain duration only stimulates their growth a stage, and if at this stage the exposure to heat be discontinued, the germs retain their vitality, although—as shown by Pasteur—in a frequently attenuated condition that impairs their subsequent activity or virulence. Heat must therefore be long continued, or it must be renewed more than once, or it must be applied in the form of actual flame, a verification of the old adage "fire purifies all." Less capable observers than Pasteur and Tyndall stopped short in their process of boiling the liquids they assumed to have been sterilised by one boiling operation, and when afterwards vital organisms appeared in the liquids, these were assumed to be examples of "spontaneous generation." Let it be assumed that in the experiments of Pasteur and Tyndall, there had been permitted to boil over from their flasks a number of germs not yet sterilised, these would have dried up, and afterwards have become capable of being developed through ever active agencies. What did occur in the fallacious observations referred to, and what might occur, are conditions analogous with those which obtain in a chamber, where volatilised *contagia* are floated from off the surfaces of infected clothing and wafted into the general atmosphere on a strong up-rushing current of burned gases. The best known of these chambers is in its mechanism fashioned with an ingenuity that reflects credit on its inventor, and from its commercial success has been honoured with imitations, but that chamber was in its "principles of action" designed eighteen years ago, and consequently before the "germ theory" had become an accepted fact. In the light of our present knowledge that chamber and all others of like "principle" are behind the time.

It is not that products of gas combustion have, or are alleged to have, any destructive effect on germs, or any effect whatever apart from their heated condition that differs from pure air, or

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* See Addenda.

a mixture of air and watery vapour. It is, on the contrary, open to surmise that certain products of gas combustion—certain tar products—may actually have a temporary conservative effect of the kind that Dr. Dougall, of this city, showed to be produced by the vapour of carbolic acid on vaccine lymph. The variations in the products of coal gas combustion, according as that is more or less perfect, and the variability in the composition of coal gas, its impurities and the like, make this surmise a point worth consideration. Dr. Dougall, whose researches on chemical disinfectants are, in extent and original conception, second to none, is of opinion with me that the influence of burned gases is not only probably, but very likely, of the nature I have suggested. But assuming that they have no influence either for good or for evil, so far as destructive action on germs is concerned, it still seems to me that to avoid pure air and to make choice of an atmosphere contaminated with the products of gas combustion, is something equivalent to a preference for dirty water before clean water for washing purposes. It might be tolerated if no other method of applying heat was available, and it is an extenuation if used in the belief that exposure to the burned gases of gas coal will do no harm. But on this latter point I have grave doubts, and if compelled to give over my property for disinfection, I would be very fearful of the results of exposing a piece of fine lace, a delicate coloured silk fabric, the valued photograph of a deceased friend, a precious letter, or an important law document to be played upon for a couple of hours by a strong current and heavy atmosphere of burned coal gas.

Setting this point aside, it is deserving of note—although the least of probable evils belong to the use of such chambers—that the waste of heat, and consequently of fuel is so great, that the hot products of combustion escape in enormous quantities, carrying off heat that has been only partly utilised, and this waste of heat is aggravated by the method of burning, in which the rush of inflamed gas is accompanied by a practically unlimited quantity of unnecessary cold air that mixes with the hot gases, dilutes and cools down their temperature, and renders one-half or two-thirds of the heat ineffective. Instead of the gas being burned with about ten volumes of air to one of gas, the theoretic proportion, or even twenty volumes, which is the practical limit aimed at by all who have studied the laws of gas and coal combustion, I have estimated that from 150 to 300 volumes of air are admitted into such chambers for each volume of gas. But so little consciousness does there seem to be of extravagant waste on the part of the makers, that I have seen a letter written from one who refers to 50 or 100 cubic feet of gas per hour as the required quantity for his apparatus, and as a quantity "not worth consideration." And yet a chamber of equal capacity can be equally heated with pure air by the use of 20 cubic feet of gas properly burned and properly applied. Before leaving this question of *pure air* versus air contaminated with burned gases, I may plead that while pure air can have no hurtful action on clothing or other infected objects, it has on the other hand assuredly an oxidising and distinctive action on infective matter. Still farther let me urge that there can exist no valid reason why the same chamberful of air when once heated, should not economically be made to do duty again and again in the manner of hot water warming apparatus, more especially when the heat can be kept up to give all the effect that heat can give by the use of one-third or one-fourth of the gas fuel that in contrasted arrangements is *avoidably* wasted.

I turn to a description of the means I employ for maintaining a desired maximum temperature. A thermometer fixed inside the chamber, but visible outside, indicates the heat. A single Arnott chimney valve, specially balanced and regulated, supplies every other necessary requirement. This valve consists of a thin leaf of metal resting with a fine edge upon a delicate balance socket. A rod with a screw turned upon it, and having a weight at its extremity is attached to this balanced leaf, and by rotating the screw the weight is shortened or lengthened from its fulcrum. The principle of the valve is that of a balance having at one end the elastic force and pressure of air confined at 250° F. (or any other temperature that the valve is weighted to withstand the elastic force of) and at the other end the equivalent force or counterpoising weight of metal attached to the valve. When the air becomes heated above 250° F., the elastic force and pressure upon the valve is increased, the valve yields and the heated air escapes until once more the pressure of the air and the weight of the valve become equal. The adjustment of the valve is made when the thermometer reaches 250° F. (the temperature at present assumed for illustration) and it is effected by simply turning the milled head, which, for convenient manipulation, is attached to the screw rod. When the valve is perfectly vertical at 250° F., preventing all escape of heated air, but yielding at 255° F. or thereby, the adjustment is practically perfect, and requires no further attention for that temperature. By this contrivance I dispense with costly arrangements easily deranged, and in practice not admitting of ready adaptation to varied standards of temperature that may be desired, while other automatic arrangements when out of order can only be repaired by specially skilled workman.

To meet the requirement that has arisen from recent observations, showing that moist heat is more effective than dry heat, I employ a simple provision whereby the chamber is charged with watery vapour, subject to the same control as regards temperature, as in the case of dry air. A shallow vessel containing a quantity of water, about 16 oz., is placed in the line of the entering hot air. The water evaporates, and the moisture condenses on the colder clothing, ultimately becoming steam of the elastic force, proper to a mixture of air and moisture at 250° F. Should the temperature exceed 250° F., the valve moves precisely as in the case of dry air alone; for in all cases the sum of the elastic forces of a mixture of moisture and of air is equal to the weight of the atmospheric pressure, which has its equivalent in the weighted balanced valve, the vapour taking always the force due to its temperature, and the air making up the complement. The arrangement is entirely free from the cost, difficulty of management, and dangers attendant on the great elastic force of steam generated in and delivered from a high pressure boiler.

In the application of moist heat it is desirable that the watery vapour should be generated at the early part of the disinfecting operation, and while the clothing or other infected objects are at a relatively low temperature, so that the moisture may become condensed upon them, and afterwards it is only necessary that the temperature of the vapour does not descend below 212° F. Instead of a water vessel, the object may be very well effected by suspending a piece of woollen blanket of about half-a-pound weight, wrung out of water, of which it will retain about 1lb. And it may be still better effected by simply sprinkling the infected articles pretty liberally with water, and directing that they are not to be removed from the chamber until quite dry. Under all circumstances, it will detract from the efficiency of the moisture, if that moisture is delivered at first of a high temperature, say 220° and upwards, because at these temperatures it approaches the condition of a perfect gas and will only act as dry heat.

After the strictures I have passed on any mode of disinfection by heat that permits the escape of volatile *contagium* into the atmosphere, it is only due that I should state that disinfecting by heat in a chamber which confines all volatile matter until the close of the operation, is carried out in various apparatus in frequent use. Dr. Esse of Berlin, who has given much attention to the subject, makes this the principle of several chambers constructed under his direction at the Hospital, St. Moabit. In one arrangement the infected articles are placed within a cylinder, which is itself contained within a larger cylinder, the space between being filled with steam, and thus the inner cylinder is heated. There is no communication between the outer and inner cylinder, and the latter contains dry heat only. This is precisely the arrangement on a larger scale devised by Dr. Henry in his small laboratory apparatus 50 years ago. In another form Dr. Esse's chamber is lined or traversed with steam pipes. M. Vallin, in his comprehensive treatise on disinfection, objects to Dr. Esse's chamber that the air is stagnant and cannot have the heat penetrating property of hot air in motion. He suggests—and the suggestion is applicable to other apparatus—that at a stage of the operation a stop cock should be opened, admitting a jet of vapour for 15 to 45 minutes, having a temperature of about 212° F.; this vapour to be afterwards got rid of by ventilating openings, and the operation completed by dry heated air, so as to thoroughly dry the infected articles. He believes such an arrangement to be perfect. I think it will be evident that in my chamber, the process that M. Vallin recommends is practically ensured with this superadded advantage,—that ultimately all air or vapour that has been in contact with the infected matter is made to pass through a furnace.

Mr. W. Lyon, a London manufacturer, supplies a machine that confines all volatile *contagium* till the close of a disinfecting process, and also aims at carrying out the "principle" of moist heat; and as it professes likewise to introduce an entirely novel "principle" of action peculiar to itself, of which moist heat is the characteristic, that claim requires the detailed examination I give in an addendum, because of its novelty and, as I believe, of its fallacy.

In conclusion, and on a careful consideration of the entire subject of disinfection by heat, I feel warranted in laying down the following axioms, of which the first is a truism:—

1. That as contagious matter volatilised and diffused in the atmosphere is the chief condition that propagates contagious disease, it follows that the best preventative consists in excluding the entrance into the atmosphere of such contagious matter.

2. That any apparatus for disinfecting by heat is insufficient that does not make provision for detaining volatile contagious matter, and subjecting it to the same degree of heat, at least, and the same duration of exposure that is found practically necessary in dealing with infected clothing, bedding, and other objects.

3. That the alternate use of moist and of dry heat, or of both conjoined, is preferable to the use of dry heat exclusively.

4. That in disinfection by heat, the immediate and certain destruction of volatile contagious matter can only be ensured by passing such matter through the flames of a furnace.

ADDENDA.

In 1860 it was announced as a discovery by Schröder that "the atmosphere contains an active substance which induces the phenomena of fermentation and putrefaction, and which is decomposed by heat and arrested by filtration," although why muscle, yolk of hen's egg, and milk should occasionally putrefy in spite of filtered air alone being permitted to come in contact with them was a point most difficult to explain, and one which Schröder admitted was not in perfect accord with his theory. Pouchet about the same time cited several experiments which he considered crucial, and which he performed with the special object of settling the question of spontaneous generation, and he affirmed that the results of the experiments were perfectly conclusive as to the spontaneous origin of animal organisms. To test this doctrine Pasteur made very extensive investigations (published 1860) which resulted in establishing the fact that the air at all times contains microscopic organised corpuscles, which may be collected by filtering it through gun cotton, dissolving the cotton in ether, and allowing the ether to evaporate spontaneously. Pursuing his investigations into the origin of ferments and putrefaction, he in 1863 announced that his previous experiments had entirely disposed of the hypothesis that fermentation can be effected by the influence of decomposing albuminous substances, and affirmed conclusively that the sole agents in the process are animalcules or their germs, termed by him "vibrios," of which fact he adduced examples. From this date the "germ theory" made rapid progress, although strenuously resisted up to a very recent period by Bennett, Bastian, and other very able observers.

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Up till a comparatively recent date, the highest temperature short of actual injury to infected clothing, &c., have been employed or thought desirable, while by tradesmen who vend disinfecting apparatus, a minimum standard of 230° to 250° F., or even higher has been assumed and taught as necessary, and the power of producing temperatures of even 300° or 450° F. has been vaunted as a claim to recommendation. It should, however, be very obvious that in *all* gas heated chambers the *degree* of heat that can be reached above the highest heat that is necessary, *viz.*, 230° F., is a mere matter of so many extra feet of gas, and therefore implies no superiority in the apparatus, because an equal degree is attainable in *any* gas heated chamber. But the point that deserves consideration in this relation is the expenditure of gas at which any temperature that is desired can be attained and maintained.

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The important distinction that obtains between the vitality of the spore, or germ, or particles, and the organism which is developed from the spore, is all in all in considering the practical application of heat in the process of disinfection. For the quality, degree, or duration of the heat which destroys the vitality of Bacteria, Torula cells, spiral fibres, and fungi, fails to destroy the spore of the Bacterium. We have quite a cloud of witnesses as to the effects of heat on germs and their offspring, for the long contention on the doctrine of spontaneous generation that has so very recently received its quietus, brought into the field of practical investigation a host of observers. A very favourite method of experimentation consisted in heating or boiling infusions of vegetable or animal material, in which Baccili, Bacteria, and Vibrios are so readily and so abundantly developed. On the point merely of the degree of heat that will destroy Bacteria, there is a pretty general concurrence of experience, and Pasteur, Chaveau, Calvert, Roberts, Tyndall, and many others have shown that from 140° to 212° F. is a degree of temperature that few developed organisms can sustain. Haizings agrees with Cohn that Bacteria are killed by 10 minutes boiling, but against this general assertion Roberts has shown that the length of time varies greatly, according to the nature of the matter that develops the Bacteria, one kind requiring 20 minutes, another 40 minutes boiling. If, however, the infusion is rendered alkaline, Roberts alleges that it is not sterilised until one, or two, or even three hours boiling. Mr. Dallinger and Dr. Drysdale report that while certain living septic monads were killed by a heat of 140° F., there were spores of one variety that germinated after exposure for 10 minutes to 200° F. Instances are recorded of certain spores resisting for hours a temperature of 400° F. The resistance to destructive agents of certain spores is very extraordinary. Koch relates that the spores of splenic fever—a disease of cattle that occasionally affects, and it may be in a fatal form, the human subject—retained their infective vitality for an indefinite period in spite of all kinds of mal-treatment. They could be reduced to dust, wetted and dried repeatedly, kept in putrefying liquid for weeks, and, nevertheless, at the end of 4 years they still displayed an undiminished virulence. Such experiences give point to the principle for which I am contending, *viz.*, that in disinfecting by heat, the only effective application for the immediate destruction of infective matter suspended in the air is to subject it to the action of the flame.

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I am not aware of any experiments exactly similar or so direct as those which Dr. Henry made with infective matter of cow-pock, scarlatina, and typhus. Those with cow-pock matter have been repeated, but the others have not. He dealt with what he recognised only as infective matter in the gross, and without thought or reference to germs. Our conclusions, therefore, regarding disease germs are drawn from a different class of observations, and mainly from the known analogies that link together the entire animal and vegetable kingdom. The number of species and the number of individual varieties of germs are very great, and a distracting multiplicity of names have been invented, and are being continually manufactured and applied by different observers in the field of investigation that is covered by the germ theory. And it is perplexing, even to a well-informed student of modern scientific literature, to track out the intended meaning of some writers who, within half a page, will make reference to half-a-dozen names all with little apparent discrimination, and often with little knowledge that they are dealing occasionally with mere synonyms. I give here a cluster of these ingeniously varied descriptions of minute organisms: cells, monads, germs, seeds, spores, sporules, torula, spirilla, vibrios, bacteria, baçcili, zooglea, micrococci, microzymes, microphyptes, microbes, microzoaires, entophytes, saprophytes, infusores, contagium corpuscles, particles, &c., &c.

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Washington Lyon's disinfecting apparatus is substantially the same as Dr. Esse's, but the cylinders communicate through a stop-cock. The outer cylinder is first heated by the admission of *saturated* steam with the effect of heating at the same time the inner chamber. The objects to be disinfected are then placed within the chamber and the cover tightly closed by a number of screws, an operation requiring about ten minutes, during which the imprisoned air and the infected objects are getting heated. The stop-cock of communication is now opened and steam of about 260° F. is admitted. If any condensation occurs, provision is made for that being immediately carried off

by drainage pipes. But it is stated that "*the great object of the casing* [*i.e.*, the heated outer cylinder] *is to prevent condensation* of the steam within the chamber, for if such a condition were to arise the object would become wetted." Nevertheless the theory of the maker is that "the steam on coming into contact with the colder infected objects *instantly condenses* upon them until *all are damped and moist*, and when the pressure is removed the *water*, no longer restrained, evaporates, and the objects remain *in an almost dry condition*." M. Vallin, when commenting on this phenomena, says "this is what we do not very well understand," and his difficulty claims sympathy. An eye-witness to the process whose evidence is adduced by the maker says "on opening the door the several articles above named [*i.e.*, various fabrics and a letter in coloured ink] were *to our surprise and satisfaction perfectly dry!*" Now there is here a blowing of hot and of cold, a condensing, a wetting, and a damping conjoined with a provision against condensing, or wetting that needs to be reconciled. My explanation is that the maker's theory—a very pretty one by the way—is altogether based on a fallacy. I feel assured that no condensation of steam can take place unless slight and momentarily at the close of the process when the articles are being removed from the chamber. At the instant when the cover is swung aside there will take place a rush of cold air, a portion of steam will be condensed, and the remainder dissipated. For steam so far from being a moist fluid is *perfectly dry* as long as it retains the elastic force due to its temperature—that is, so long as the temperature does not fall; and in this case the temperature is kept up by the hot outer casing and the continuous supply of hot steam, from beginning till the end of the process. It has been pointed out by a great authority that "steam is of so drying a nature that it cannot be contained in wooden vessels (however well seasoned they may be) without drying them and making them shrink till they crack and fall to pieces. Steam is never moist." When steam is *condensed* it becomes water itself, and the mere removal of pressure will not evaporate water, although it will permit the dispersion of steam when liberated from pressure. If the articles placed in the disinfector under consideration are ever penetrated with steam that has *condensed*, then assuredly they are wetted with water as effectively as if cold water had been poured upon them, and that water will only evaporate under a separate drying operation. If the chamber had been filled only with saturated steam, and if that steam had been isolated from water in a space of fixed dimension, and if the temperature had been permitted to fall, instead of being steadily maintained, there would then have been a certain amount of condensation, although very trivial because of the little margin of fall that could be possible under the conditions. But the chamber is not filled with saturated steam, but with a mixture of hot air that previously filled the chamber, conjoined with as much moisture from the steam as the air can absorb, viz., about five-eighths of the gross weight of the mixture. The weak points in the theoretical "principle" of this apparatus consists in overlooking the *perfectly dry gaseous nature of steam* while retaining the elastic force due to its temperature, and in applying to a mixture of air and moisture the physical laws applicable to saturated steam.

It must not be supposed that I am disparaging the real efficiency of the apparatus *quantum valeat*—that is as a *dry heat* apparatus. I think it an improvement on those of Dr. Esse's and Dr. Henry, but the quality and action of the heat is precisely the same as in these or any other dry heat appliance where dry heat alone is employed. The penetration of heat will be quicker, because of the pressure, and that is all. But it will lead to a fallacious security if the alleged property of *moist* heat is made the ground for materially shortening the process. I say so much because I am told by an official having charge of the erection and experience of the working of one of these machines, that half-an-hour was a customary period to give to one operation, but that ten minutes would really suffice. Against that belief, and against operations conducted under that belief, I enter a protest and give warning. The duration of exposure should be nearly the same as in any dry air apparatus of the same temperature. Dr. P. Bate, of London, thinks well of this machine after having seen it in action, admitting that "it has the drawback of being more costly than others, together with the necessity of requiring an able and experienced attendant," but he adds, "the rapidity and certainty of a sufficient heat are a sufficient compensation." With regard to the "rapidity," I must lodge this caveat that a furnace must be got into action and a steam boiler be in full delivery before the disinfecting process can be commenced. I had it in view to make an *experimentum crucis* to settle beyond any cavil all question as to the alleged moisture of the heat under which it operates, and with that object I have on two occasions made visits to Belvidere Hospital, in the suburbs, where one of these machines is in course of erection, but it is not yet in readiness, and my intended experiment is delayed.

Dr. Cameron, M.P., Glasgow, remarked that as Dr. Adams had made reference to a paper of his on this subject he might be permitted to say a very few words on it. He thought there could be nothing more important than the recognition of the superiority of disinfection by heat over disinfection by disinfectants; the mode of application of the latter being empirical, and the knowledge of their action very rough and ready. He believed that in many cases much more harm than good was done, because the use of disinfectants engendered a confidence they had no right to give. Dr. Adams would have done great service if he had succeeded in making the process of disinfection by heat thoroughly efficacious. Judging, as they must all judge, very crudely by what they heard without illustration, it would seem that he had succeeded in what he had attempted. He had succeeded apparently in burning the germs of disease that might have been removed in clothing and been discharged into the open air. The importance of that might be judged from a circumstance to which great public attention had been directed in London. The spread of smallpox in the neighbourhood of smallpox hospitals could be accounted for in no other way than the dissemination of the smallpox germs in the area surrounding those hospitals. There was just one weak point in this hot air arrangement—that it was impossible entirely by means even of the current of hot air to drive off the spores of the organism of disease which might be harboured in the articles they wished to disinfect. Some interesting experiments, however, had lately been made by M. Chauveau and others on the attenuating power exerted by heat on the microbic organisms of disease which appeared to him to throw considerable light on the practical nature of disinfection by heat. These experiments explained the fact that although spores might still rest on the clothing exposed in the disinfecting chamber, and not altogether deprive them of vitality, still after they had been submitted to the attenuating action of heat they were rendered of no consequence. That, he thought, explained the fact that articles disinfected in those hot chambers were free from all danger of producing disease.

Mr. G. W. Muir, Glasgow, asked Dr. Cameron to explain whether the destruction of germs by flame was superior to the disinfectant that Professor Lister had been so successful with. He could not see how the flame power was to be applied in surgical operations.

Dr. Cameron said no one recognised more fully the ability of Professor Lister than he did, and no one had spoken more unreservedly in acknowledgment of the great merit of his discovery, but it would take too long to explain the question asked. The cases were entirely different, and he would merely recommend Mr. Muir to read Professor Tyndall's paper on "Floating matter in the Air."

Dr. Sutherland quite agreed with Dr. Adams that his disinfecting chamber was capable of destroying the skindrift of infectious diseases and the germs in the clothing and bedding; but he wanted to know whether a heat of 300 degrees was capable of destroying the ova of vermin, which was a great source of trouble in reformatories, poorhouses, and other public institutions. How to thoroughly destroy these was not yet known. The capsule was very tenacious, and he was not at all sure that a heat of 250° F., would kill the ova—in fact he was afraid that it would so far mature them that contact with the human body would complete the dehiscence of the capsule and the escape of the parasite.

Dr. ADAMS said that had been clearly demonstrated. It had been shown that if the air was a little moist then a heat of 212 degrees was abundantly sufficient for destroying the ova.

Mr. W. R. MAGUIRE, Dublin, said he was an Irishman, but he supposed they would listen to him, even in Glasgow. He had a great deal of experience of disinfecting chambers of this kind, and he would criticise Dr. Adams' chamber in regard to his arrangement for non-conducting. Although Dr. Adams said he relied on air as a better non-conductor than felt, he employed iron back and front plates, and he was therefore obliged to use iron connecting strips, as shown on his plan, to join the inner and outer iron plates rigidly, else these plates would buckle or warp from the heat, and the result was that necessarily these connecting iron strips rapidly conducted heat away from the chamber. Iron was here used with air enclosed: but wool and timber non-conductors would be far better. He was very well acquainted with Dr. Scott's self-regulating disinfecting chambers, which received the Award of Merit from the Sanitary Institute, and are extensively used in England and Ireland. In them the entire heat produced was utilized, while two-thirds was evidently wasted by Dr. Adams' chamber. A patent self-regulator was also attached to Dr. Scott's chamber, which marvellously economised consumption by automatically shutting off the gas as the temperature reached the desired point. The foul infected air was also passed through flame, and all organisms therein utterly destroyed before it escaped. And, finally, Dr. Scott's chambers were made either for coal or gas fuel, so that where there was no gas these chambers were still available. There does not appear, therefore, to be much of desirable novelty in Dr. Adams' chambers; and they will be found to consume much more gas than Dr. Scott's, bulk for bulk; and as to price, of which they had not been informed, as a practical man, he could say that Dr. Scott's chamber would be made for less money.

On "River Pollution," by HENRY ROBINSON, M.Inst.C.E.

WHEN the Rivers Pollution Prevention Act was passed in 1876, hopes were entertained that it would result in stopping the pollution of our rivers. If, however, the working of the Act up to the present time is considered, it must be admitted that it is practically inoperative, and the results that have accrued are

utterly incommensurate with the evils which had to be grappled with.

I consider that no more fitting time or place could be chosen for discussing the working of this Act than at a Congress of the Sanitary Institute of Great Britain held in Glasgow, a city having deep interests at stake in the matter, whether regarded from a manufacturing and commercial, or from a sanitary point of view. The inquiries that have been held with reference to the state of the River Clyde are evidence of the keen interest that exists. The Reports of Messrs. Bateman and Bazalgette in 1868; the Report on the River Clyde pollution dated 1872–1874; the Report of Sir John Hawkshaw in 1876; the more recent Report by the deputation appointed by the Town Council and Board of Police of Glasgow to inquire into the methods of disposing of sewage adopted in various towns in England; and lastly, though equally deserving of acknowledgment, the valuable data collected by Dr. William Wallace, the City Analyst of Glasgow, all furnish information for the guidance both of those who have to decide as to how this town and this river are to be dealt with, as well as of those who are interested in the general question. The Association for Preserving the Rivers and Lochs of Scotland from pollution rendered good service in forming public opinion and in accelerating legislation.

The Rivers Pollution Prevention Act was passed to meet the well founded demand for such legislation as would prevent the injury and pollution of rivers by the discharge into them of refuse, putrid solid matter, or other waste or noxious or polluting liquid or solid sewage matter. The Act deals with the evils under three heads—1. Solid matters. 2. Sewage pollution. 3. Manufacturing and mining pollution. The prohibition as to putting solid matters into rivers is absolute. The prohibition as to the discharge of sewage or poisonous noxious polluting liquids from manufactories or mines into rivers, is accompanied by the proviso, that no offence shall be deemed to have been committed where the fluid is conveyed by a channel used, constructed, or in process of construction at the passing of the Act, if the best practicable and available (or reasonably available) means has been used to render harmless the sewage matter or polluting liquids so passing into the river.

Power is given to the Local Government Board to grant further time for a local authority to adopt the best practicable and available means, and to grant Certificates where these means have been adopted.

To put into operation this Act a sanitary authority may (the Act, be it observed, is permissive, and not compulsory) take proceedings against an offending mine owner or manufacturer, for discharging liquid pollution or solid refuse, or an aggrieved person may compel a sanitary authority to move in the matter, by application to the Local Government Board. An aggrieved person can also put in motion the Act against a local authority for discharging sewage into a river. The County Court of the district in which the offence is committed is the tribunal before which the case is taken in the first instance.

In August, 1877 (when the Act came into operation) the Local Government Board issued a circular to the Sanitary Authorities throughout the country, bringing to their notice in very clear terms the provisions of the Act, with the view to their being put into operation.

It cannot be said that this Act was in advance of public opinion, inasmuch as there was a universal agreement as to the necessity for legislation on the subject. Neither can it be said that the Act was too stringent. Indeed, criticism was rather in the direction of its being too lenient, but it would have been undesirable for any legislation to have erred on the side of excessive stringency, as this would have led to its being defied as unreasonable, or, to its being disregarded, as incapable of being enforced.

Now this Act, mild as its provisions undoubtedly are, has been in operation long enough to enable an opinion to be pronounced as to whether or not it has accomplished, or is likely to accomplish, that which was anticipated. I am of opinion that it has not, and that practically it is a dead letter, and that unless it is amended it will remain inoperative. I do not go so far as to say that it has been a useless piece of legislation. It served for a time as a rod to be held over individuals and local authorities who were offenders, and to some small extent it caused enquiry and action where indifference had previously existed. The total effect, however, is inappreciable. The rivers continue as before to receive the pollutions which were sought to be abated. Not one certificate has been given to a town that the best practicable method has been employed to remove polluting sewage matter, although there are hundreds of towns offending against the Act which could be prevented from offending by adopting well recognized methods of dealing with their sewage were they stimulated to do so.

Although my own professional experience lies more in the direction of the operations of the Act in regard to sewage pollution, I believe it is a fact that the Act is inoperative in regard to pollution from mining and manufacturing refuse.

The exact amount of good which has resulted will shortly be

ascertained when the returns which were moved for by the Duke of Northumberland last session are issued.

As the prevention of the pollution of our rivers was considered (and very properly so) sufficiently important in 1876 to secure special legislation, and as that legislation is not producing the anticipated results, it is most desirable to consider the causes of this failure, and of eliciting opinions with the view of arriving at what alterations are necessary to ensure the attainment of the objects contemplated.

One difficulty which existed at the time this Act was being shaped has disappeared, inasmuch as the methods of dealing with sewage are now well understood, and have ceased to be the bone of contention amongst interested patentees of chemical systems or of enthusiasts who looked to realizing fortunes by irrigation. Therefore, in interpreting the expression, "the best practicable and available means," I am confident that an impartial expert in sewage disposal would now be able to advise without any difficulty as to the proper and suitable system and works for each case.

The interpretation of this important expression might advantageously be explained in any future Act, so as to indicate the standard of purity which will be admissable, and to prevent its being considered that it is intended to require a uniform standard in all cases which would be both undesirable and impracticable to enforce, as any attempt to compel the adoption of an equally high standard in all cases would lead to failure. It would be unreasonable to require the effluent from sewage disposal works which discharge into a tidal river, or into a river like the Thames below the water companies' intakes to be as pure as should be required where the effluent passes into a small rivulet, or into a river above intakes of water works.

It appears to me that one serious defect in the Act which has contributed as much as anything else to its being inoperative is this:—The onus of initiating proceedings against offending persons or authorities is largely cast upon the individual riparian, or other, owner, which involves the assumption that such individual is able and willing to undertake the duty of enforcing the Act, or where the sanitary authority is relied on to enforce the Act, it presupposes that it will move in the matter, whereas in regard to sewage pollution, the authority itself is the offender. I may illustrate this by referring to a recent case, which is one of the few that have been tried under this Act, and as I was personally engaged in enforcing the Act against the Local Board, I am familiar with the facts. The sanitary authority of a town had, in a fitful way, and for years considered whether or no their town should be properly sewered, and the sewage properly disposed of instead of its continuing, as it did, to pollute the beautiful river which passed through the town, by discharging sewage matter into it from several old ditches and drains. This state of things would have continued but for the action of a powerful riparian owner who had both the will and the means to fight this Board, and who determined to put in motion this Act. He succeeded in these proceedings, and obtained a decision against the authority, which will result eventually in the pollution of the river being stopped.

This was not a very flagrant case inasmuch as the whole sewage of the town was not passing into the stream. Yet it constitutes one of the very few cases where a riparian owner has moved in the matter.

I think that the burthen of enforcing the Act should not lie with individuals or local authorities alone, as if the question were purely local. It is a public grievance which was sought to be removed by the Act, and requires to be treated in a broader manner than has been done. Individuals taking the initiative (as in the case I have referred to) are placed in a false and invidious position, as their action may prejudice them in the eyes of their neighbours who may fail to appreciate the motives actuating them. I am quite satisfied that the machinery devised by the Act will continue to be incapable of overcoming its own *vis inertia.*

In my opinion an alteration in the Act is imperatively called for, and I suggest as a necessary change that the initiation of proceedings under the Act should be entrusted (in addition to the authorities and individuals) to public inspectors who should be entirely independent of local authorities, and who should be responsible to a Department of State. These officers should have power to enter premises to examine into cases of pollution and to report to head quarters. The Department, after considering the facts stated in the report, could take action or not. The establishment of such a *modus vivendi* would secure the co-operation of the public, and the existence of causes of pollution would soon be made known voluntarily by residents and others who would be unable or unwilling to enter upon the tedious, costly, and uncertain course of procedure under the Rivers Pollution Prevention Act.

Professor Robinson wished to say before the discussion was entered upon that he was very much tempted when he wrote the paper to make some reference to the question of the purification of the Clyde. But his object was to procure consideration of the Rivers Pollution Prevention Act. Whilst the question of the Clyde was a large one, he felt he would be following the wisest course and meeting the wishes of the Institute if he treated the matter generally. Besides, without data, his opinion on the subject would be without value. As the question of sewage disposal was referred to by the president and Dr. Carpenter, in connection with a previous paper, he wished to say that the suggestion made by the latter, that sewage should be disposed upon land, was one which required consideration as to the area of land that could be obtained. The disposal of the sewage of Glasgow upon land was impracticable, owing to the enormous area which would be required.

The discussion was opened by—

Mr. W. C. Sillar (London), who said they were all much indebted to Professor Robinson for calling the attention of the Congress to so decided a defect in the legislation intended to put a stop to river pollution. And the task could not have been entrusted to abler hands, for Prof. Robinson, as an engineer, was thoroughly acquainted with the subject in all its branches, and must be considered an expert in the matter of remedying the evil on account of the long and earnest study he had given to the subject, and the experience inseparable from such a study. Prof. Robinson did not propose more legislation, and in that all sensible people must think him right. What he wished to remove now was not the pollution of the rivers, but the inaction or inactivity of those persons who alone possessed the power of putting the legislative Acts in force, and he was right in attributing the existence of this inaction to the unwillingness of riparian owners to incur the unpopularity of originating a movement which was to affect the purse-strings of the ratepayers. Now, it surely was patent to everybody that, whatever odium or unpopularity might attach to an independent riparian owner who was in no way answerable to the ratepayers, but, on the contrary, was one himself, an immeasurably greater amount of it would rest upon any member of a corporate body who imposed an additional burden upon the men who elected him, and that voluntarily and without any outside pressure. Therefore the pressure proposed to be put upon town authorities was one to which they could not reasonably object, for it furnished their justification for increasing the rates. He (Mr. Sillar) spoke from a standpoint by no means disinterested, for he had laboured long and earnestly to perfect a system of water purification, and though it did not become him to declare it to be the best practical method, he conscientiously believed it to be so. On many former occasions he had had the privilege of explaining before that and other Congresses the principles of the system so successful at Aylesbury, but upon the present occasion he had the greater privilege of speaking of facts accomplished instead of excellences expected. For seven or eight years the Native Guano Company had received from the authorities of Aylesbury a unanimous and annual expression of perfect satisfaction with the system. The Congress heard the day before yesterday a sad account of the deficiencies of Southport. It could not be otherwise. Sewage *per se* was not intolerably offensive until it had been decomposed. So there was an evident advantage in the treatment of it being as speedy as possible. The necessity of long and expensive sewers only existed for the purpose of removing from the neighbourhood of dwellings the offensive sewage works. But as the Aylesbury process was not offensive that necessity did not exist. That the process was not offensive might, he thought, be fairly inferred from the fact that a working model upon real sewage had been exhibited in constant operation at the International Fisheries Exhibition for some months, where any offence would not for a moment be tolerated. It had been visited by thousands, including His Royal Highness the Prince of Wales, who personally expressed his approbation of the process, and who had sanctioned it adoption at Wellington College, of which he was the president. It was not his (Mr. Sillar's) intention of unduly occupying the attention of this Congress in saying what had been often said before. Let it suffice to say that the A B C process had for years effected a sufficient, and more than sufficient, purification. Secondly, the operation required little space, and caused no offence; and thirdly, the manurial wealth was preserved for agriculture, and was so fully recognised as valuable that the farmers bought it, and would buy more if they had more to sell. Dr. Carpenter, whose account of the Croydon farm they had heard, would excuse him if he said that such wealth as existed in sewage was more economically applied to the general agriculture of the country than confined to the limited area of a sewage farm.

Mr. G. J. Symons, F.R.S., pointed out that if they insisted upon the Act in its integrity our manufacturers might be worsted in their competition with foreign manufacturers. If it could be shown that a river could be kept absolutely sweet and pure without crippling the manufacturers, then let it be made as sweet as possible. But rivers would require to be treated differently. The Irwell would require to be treated in a way different from the Tay. The former was black as ink, but the latter contained tens of thousands of salmon. On the other hand, the Thames and Clyde would require intermediate treatment, for they were used for both pleasure and commerce. No one would go upon the Irwell for pleasure. In all these matters there should be as much amelioration as possible. The Institute must not aim too high in this matter. They must not aim at a point where the great bulk of the common-sense of the country would not go with them. What they must do was to go as fast as, and perhaps just a little ahead of, the ordinary common-sense of the country, but they must not aim at theoretical perfection. He was glad that the President of the Institute (the Duke of Northumberland) had taken a step in the matter. As it was, the "Local Authority" was often the people who ought to proceed against themselves—which was the last thing they would do. The responsibility of stopping a nuisance was sometimes thrown upon the individual. Now an individual did not like to come forward and annoy all his neighbours. He thought it would be better, as had been suggested, that inspectors should be appointed entirely independent of local influence.

Dr. W. Wallace, Glasgow, thought it would be a great benefit if there was a system of inspection with regard to rivers pollution such as there was for Alkali works. These works at one time annoyed the inhabitants and destroyed vegetation, but legislation had been brought to bear upon them and a great improvement effected. Besides, the owners had been able in consequence to utilise some of the refuse which was at one time offensive. Now, if legislation were applied more sharply than at present in respect of river pollution, a similar improvement would be effected. In Glasgow a great deal of attention had been devoted to the subject of river pollution, and although they had not yet done anything in regard to the Clyde, still they were in a position that when they were forced to do something they would be enabled to go into a satisfactory scheme. The position they took up was this, that in the first place, as regards manufacturers' refuse, no solid matter of any kind should be allowed to go into the sewer from the factory, and in the second place, that no acid should be allowed to enter it. They held that manufacturers should treat their acid refuse in such a way as to run it off in a clear state and slightly alkaline, or at least, free from acidity. Then it would do no harm to the sewage. No scheme of precipitation had yet been fixed upon; but they thought that precipitation was the most likely thing to adopt for Glasgow. They could not adopt a system of irrigation. He knew the sewage farm at Croydon, and he considered it a great success. But that success depended upon peculiar circumstances whice did not exist in Glasgow. In the first place, they had not got the quantity of land required, nor the kind of land. If they treated their sewage by irrigation, they would require ten square miles. Now they could not get that, indeed he did not think there were 100 acres suitable for the purpose. As regards the schemes of precipitation, these also depended upon the situation. He had seen the A B C process to which reference had been made, and he considered it very suitable for Aylesbury, but it would be absurd to adopt it for Glasgow. For a small town it was an excellent process, but other processes were more suitable for larger towns. If Glasgow adopted a scheme by precipitation, it would in the first instance try lime simply.

Mr. G. W. Muir said that he had some experience of Government inspection lately, and he did not like it. He would rather that it should be a local inspector, who should be placed above the influences of the Local Board. But when he was deemed entitled to an advance of salary he should apply for it not to the Local Board but to the Government Board in London or Edinburgh. He also objected to Prof. Robinson's proposal to treat different streams in different ways. All the difficulty would be removed if they said, "We will not allow anyone to pollute a stream at all." They had a scheme for the purification of the Clyde four years ago; but he had reason to believe they had now a better scheme. The great mischief in Glasgow was that, being a large city, they would require immense works. But they could have the works within Glasgow itself, and there would be no necessity for gigantic sewers. He believed that sewage works could be carried on in any town without offence to the sight or smell. In Bradford the sewage works were in the best part of the town. Therefore the way was easy if the Local Boards would make up their minds to do their duty. If they did not do it, the Government should.

Mr. W. R. W. SMITH, said the question for the Congress to discuss was whether they should seek so to alter the Act as to benefit riparian landowners purely at the expense of the community. If Prof. Robinson had suggested in his paper that every riparian owner who was benefited by the purification of the river which passed his property should pay a large part of the cost of that work, then and then only would he have said there would be some justice in seeking further legislation. While he would like to see their rivers purified, he was afraid that it would be a long, long time before the general provisions were carried out, whereby the various Local Authorities should be compelled, at the public expense, to purify the rivers, unless landowners were obliged to pay a certain amount for the benefit which would thus be conferred upon them. He said, "I considered rivers were common property, being the arterial drains of the country." Mr. Smith further pointed out that it had yet to be proved, so far as the Clyde was concerned, that the public had derived any bad health from its foul condition. Besides, while they were badly off in Glasgow as regards the condition of their river, they were nothing like so badly off as the people residing on the banks of some of the rivers in Yorkshire. About a river in Yorkshire it was said that a petition sent up for its purification was written with water from the river itself.

Ex-Bailie SALMON, ARCHITECT, Glasgow, argued as long as the present mistaken water-closet system existed, no ingenuity—every scheme in that direction having been exhausted—can prevent the pollution of the running waters of the kingdom from the rivulets to the rivers. What he would like to impress upon the nation was that we are by this system bartering the health, wealth, beauty, and water carriage necessities of the kingdom for an unattainable chimera. To undertake the task of providing water-closets that will poison neither the water nor the air we must begin by conquering the laws of nature. The present water-closet system, while dangerous to every householder, is peculiarly so to the industrial classes, numbering at least 20,000,000 of the population. The water-closets introduced into these houses are in themselves cheap and imperfect, and made still more injurious by ignorance or carelessness of the householders until not unfrequently even their habitations become traps for disease. With regard again to the serious interruption and expenditure with which the system burdens the upholders of our navigable river, we have only to obtain information from the respective authorities to learn that thousands and thousands are expended from year to year to remove part of the poisonous sludge from the river so as to keep navigation open. The speaker at the same time, after a very long experience, asserts that there is no difficulty in providing closet accommodation suitable for every rank of life, and on such a principle as to keep the rivers in the hands of nature and our towns and cities undefiled. And in reference to the agriculture of the kingdom, the late Mr. Mechi, acknowleged to be our highest authority in such matters, in a letter to the *Times*, declared that if the misapplied manure which is at present producing so much evil throughout the nation was carried to the agricultural districts, the food production for the people would be doubled. In that same letter Mr. Mechi expressed in strong terms his wonder that neither Architects nor Engineers had overcome the difficulty, if there was one. But the difficulty is overcome and only waits the dictum of our Rulers to make its observance imperative.

Dr. DUNCAN, Crosshill, urged that there should be a distinction drawn between tidal parts of rivers from which no one thought of taking a water supply, and the rivers or parts of rivers which might supply the communities living on their banks with drinking water. He further urged that the entrance of sewage matter into rivers which provided water supply to the people should be summarily put a stop to, and stated that in the present state of the law persons might pollute any public river in Scotland with sewage matter with perfect impunity. There must therefore be a change in the law of Scotland. In such cases as cholera and typhoid fever they found that the excreta of these diseases might pass for considerable distances along water-courses and yet not be robbed of their terror. He could point to hundreds of instances in which one or two typhoid stools entering a small stream had produced great epidemics at considerable distances from the point at which they entered the stream. Consequently such views as had been advocated by some, that the mere fact of the excreta passing through the current of the river and being exposed to oxygen robbed them of their danger, were entirely at variance with the facts of medical science. As far as they knew at the present moment the germs which produced these diseases were solid, and probably living particles, and they did not know that any system of precipitation applied to sewage prevented them from exercising their noxious influence. The only system as far as he was aware that had yet been proposed which prevented such materials as typhoid and cholera excreta from exercising their dangerous influence, was the system of the Messrs. Fryer of Nottingham, which subjected them to a high temperature. There was no doubt whatever that it would be a very important thing if all the sewage of the community could be returned to the soil; but if the sewage were to be returned to the soil at the expense of poisoning the inhabitants all round the district in which it was placed, it would be a very serious matter indeed, and would require a great deal more consideration than had up to the present time been given to it. If the sewage was to be returned to the soil, it should be spread over lands which were not in the neighbourhood of districts which supplied the community with water. In Glasgow the sewage precipitation which had been suggested by the authorities was, in his opinion, the best scheme for the public, because the River Clyde at Glasgow is a tidal river and is not used as a water supply for the inhabitants on its banks.

The President (Dr. Angus Smith) said it was a little alarming to hear that the Rivers Pollution Prevention Act, which had cost him considerable labour had been of no use at all. He thought they had made a fair beginning. The inspectors had no power to initiate a prosecution; they could not go to any river or brook and say to any individual, "You shall not pollute," but the initiative must be taken either by the local boards or by individuals, or, in other words, by the public. If little had been done, it was the fault of the public, and although the Act had not done a great deal, it had not been inoperative. There had been several trials consequent upon complaints, and more or less action had been taken. Professor Robinson had said that not one certificate had been given under the Act.

Professor Robinson: The sewage part of the Act.

The President (Dr. Angus Smith) said he would use the words "under the whole Act." Applications had been made for a certificate, but he had uniformly refused to give any, the reason being that the Act demanded the best method. Now, he could not say that in any case the best method had been put before him. Professor Robinson considered there could be no doubt as to what was the best method, and that a law might be readily framed; but as soon as he had said that, three, four, or five gentlemen rose up, and each had a different method. Now, which would be the best? He still felt justified in doing what he had done. He would still refuse any certificate unless the words of the Act were somewhat altered. That was the only thing he objected to in the Act; it was too stringent in the use of these words. At the same time, it was exceedingly difficult to alter the words without bringing in some considerable objection. A distinguished sanitarian had said it would be impossible to purify the rivers unless we used the whole army of Great Britain. We might almost agree to this. But he differed very much from those gentlemen who supposed this must be done by legislation alone. He considered what was wanted was invention more than legislation. The Rivers Pollution Prevention Act brought to bear a slight pressure upon the community, and this pressure was causing manufacturers and others to promote invention and avoid pouring refuse into the rivers. Although no invention had been made compulsory, manufacturers had been quietly moving in various parts of the country, and what had taken place at Galasheils was a most important proof, so far as Scotland was concerned; for, had it not been for the Act, the improvement in that district would not have been carried out. The same thing might be applied to other places. He considered, therefore, that the value of the Act had been by a slight pressure, not a violent one, to cause improvement in the direction of invention, which, so far, had been successful.

Professor Robinson replied that he quite agreed with what the President had just said as to the inspectors having no power of initiation; in fact it was the very thing that he thought required dealing with. He could not, however, agree with what the President said that the action which had been taken could be regarded as a fair beginning. It was so trifling in its degree that it ought to be characterized as inappreciable. With respect to what had fallen from other speakers he considered that useful opinions had been elicited. He would reply to the speaker who objected to riparian owners having the streams purified without paying for it that it was quite reasonable to deal with the question of cost on an equitable basis, so that all classes should contribute. He did not propose to meet the suggestion to discard the water closet system or several other points which were touched on, but which time did not admit of dealing with. As regards Mr. Sillar's remarks, he would observe that although the A B C system produced a successful sanitary result at Aylesbury he was not prepared to recommend it for Glasgow. He said this with a full appreciation of the labours of Mr. Sillar and his fellow workers. Parliament had clearly intended that a certain end should be attained by passing the Rivers Pollution Prevention Act. This end, however, not having been attained, and the condition of things remaining which called for, and resulted in, legislative interference, he was fully persuaded that an impetus should be given by which so unsatisfactory a state of affairs would be removed. In conclusion Prof. Robinson thanked those who had spoken, and also the President, for having contributed to the discussion.

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

In the presidential address of Captain Douglas Galton at the Congress held last year at Newcastle-on-Tyne, he reviewed in detail the influences of town atmosphere on health, and proved by carefully prepared statements that in twenty-three towns selected for their smokiness, the mortality from diseases of the respiratory organs was largely in excess of the average, and from diseases of the zymotic class, the mortality was more than double that of the rural districts. At the same meeting the suggestive papers of Mr. Ralph Carr Ellison and Dr. B. W.

Richardson treated of those social evils directly begotten of a darkened and polluted atmosphere, say lowered tastes and moral tone, craving for stimulants induced by lowered vitality, debasement of the poorer classes, especially, from the influences of unavoidably dirty homes and persons.

The efforts thus put forth at Newcastle-on-Tyne by the Sanitary Institute are noteworthy, for they have met with sound and promising success. Not only have various private individuals and commercial firms been stimulated to lessen the production of smoke in their particular cases by adopting improved heating apparatus, but the town authorities have been so influenced by public opinion and personal conviction that within the past fortnight it is reported that they have completed the substitution of improved furnaces to abate smoke at some of the Corporation works, which formerly produced a great deal of smoke, and simultaneously with setting so good a public example, they have decided to issue a circular calling upon owners of steam vessels on the Tyne and all manufacturers to abate smoke to the lowest possible point. But though it has thus chanced that the Sanitary Institute have so far moved in other centres than this in the cause of smoke abatement, it is at the present Congress in the great city of Glasgow that the Council have authorized the *first* paper on smoke abatement to be submitted for consideration as a separate branch or department of sanitary science.

Nothing, I venture to think, can be sounder in policy than this decision on the part of the Institute, for the magnitude of the evil, as well as its peculiar character, alike mark it out for separate recognition and distinct treatment at the hands of the legislature, local authorities, sanitary, medical, scientific and other professional and non-professional classes of the community. As a separate sanitary work none can transcend that which aims at, and is capable of, securing for the inhabitants of towns more of those vital and vitalising elements—sunlight and respirable air —than they now possess; and while thus occupying an unique and defined position in the department of sanitary science, and standing as an indispensable ally to that science as well as to every other effort aiming at amelioration of the physical and moral conditions of town life, the smoke abatement cause has other, yet wider and special claims of a social and economical character upon the attention of public bodies and private individuals.

It seems unnecessary to deal *separately* with either the sanitary or the social aspect of the smoke question at this time. The sanitary side of the subject has already been treated in detail by Captain Douglas Galton in the address I have alluded to; and others (among whom I may mention Mr. Ernest Hart) have statistically shown the largely increased mortality to be fairly ascribed to a smoky atmosphere. Medical opinion is virtually unanimous on the subject. Sir William Gull, Dr. Andrew Clark, Dr. Alfred Carpenter, Sir Spencer Wells, and other eminent private practitioners, have publicly expressed their warm support; while from the other branch of the medical profession—the Medical Officers of Health—equally strong sympathy has been evinced. Dr. Tripe and Dr. Wynter Blyth were among the earliest members of the Smoke Abatement Committee, and from that time, and the earliest reports of Dr. Sedgwick Saunders to the Corporation of the City of London, down to the recently published report of Dr. Leigh of Manchester, the support of the Medical Officers of Health has been strongly expressed in favour of smoke abatement. Sir Henry Thompson has stated that "the influences of sunlight, imperceptible as they may seem to us, are almost as necessary as the food we eat."

The Sanitary Institute, the National Health Society, and other Sanitary bodies, strongly urge the necessity for smoke abatement. Thus the evidence on this side of the case seems practically as strong as it can be; while on the question of there being *moral* reasons for purifying the atmosphere, I don't think stronger evidence need be adduced than that given by Mr. Ellison and Dr. Richardson in the papers to which I have referred. I may perhaps mention a practical consideration advanced by Mr. T. C. Horsfall, of Manchester, namely, that one great evil of smoke is that it drives many of the upper and middle classes who can do so, to live out of town, and thus cut off their association with town affairs, and their influence for good upon the poorer members of the community.

In view of these separate branches of the subject being thus so well authenticated and generally understood, it seems desirable to consider *other* general features of the case, and more particularly the actual *cause of the evil*, and the *probability of its abatement*.

As smoke is but the expression of defective heating processes, by its production these processes stand condemned. They must be improved. We must face the true issue. The production and application of heat must become raised to the level of a recognised and rewarded art and industry, before the ultimate success of the smoke abatement cause can ensue. The very term "Smoke abatement," is, in a sense misleading, for it points but to an *expression* of evil—not to its *cause*. "Heat cultivation" would more correctly indicate the underlying and governing principle on which thought and action must be based if we would intelligently address ourselves to rid the atmosphere of smoke and secure the advantages attaching to that great object. When we remember that heat agency lies at the root, and more or less intimately affects almost every civilized art, we see how large is the field for useful reform which opens before us.

In a broad sense it has hitherto been, and still is, the practice to obtain heat merely by heaping crude coal on a fire, regarding little the true character of the fuel, the apparatus in which it burns, or the duty actually required. So long as there is heat enough for the purpose in view that is deemed sufficient; the strictly exact and beautiful natural process called "combustion" will not submit to such usage, and it punishes man in purse and in person to teach him to use his intelligence and amend his ways. These are but elementary truths, and trite ones to many, but this Congress cannot, I think, ignore them while it remains an urgent and essential necessity to sanitary progress that public attention should be thus directed to consider "first principles," in order to judge aright the true cause of, and true remedy for, the ills now suffered. Hitherto, as we know the smoke question has been treated either slightingly or in a desponding or impatient spirit, perhaps the term "nuisance" has had much to do with this. It does not suggest the true idea that smoke production, in the sense we know it, is a grave national calamity, calling for the voice and effort of the nation to contend against. The word "nuisance" conveys, or has grown to convey, something of the kind known as "annoyance," something which must either be borne as inevitable, or be avoided by forcible measures. In this case, the force of sharp legislation has been tried both in modern and ancient times. In 1306, Edward I. decreed, by royal proclamation, that the buildings from which smoke issued should be pulled down! In 1855, Lord Palmerston, then prime minister, proposed the more practical, but still inadequate measure, that "a thumping fine," as he is reported to have expressed it, should be inflicted; and the law was amended. But although the legislation has undoubtedly effected considerable good by forcing a certain number of persons to yield to public necessity and abate smoke, still it is obvious that legislation has failed, and must fail, of its ultimate object so long as it is limited to its present scope and application. Beyond all, however, legislation far in advance of general public opinion cannot, as we know, be practically operative, however really beneficial its character may be. Although it may be expedient to hold public enquiry into the smoke abatement question by a Royal Commission as has been proposed, to consider immediate extension and amendments of existing laws for the suppression of smoke in view of the various changes

which have occurred since their enactment, still it seems to me that the great aim of those who seek to advance the cause of smoke abatement should be much more directed to awakening and stimulating general public interest on the grounds I have alluded to than to discussing legislative remedies or particular methods of smoke prevention.

It is frequently urged that local authorities are at fault in not enforcing laws in restraint of smoke. Doubtless there is some foundation for this charge, and also force in the complaint so frequently made that those who are called on to administer the law are themselves offenders against it. But these complaints often take the place of the practical consideration of how the state of things is to be improved. It seems overlooked that those who administer the laws are not likely, as a rule, at any rate, to see the smoke question in a different light to that in which the general public view it. Their minds, like those of others, must be opened to the desirability and practicability of reform; but perhaps of all things pertaining to legislative reform, the greatest barrier to its advancement is the manifestly unfair basis on which smoke law has hitherto always stood, namely—that it has been levelled against *certain* trading classes of the community only! Besides this unfairness, there is, too, an impractibility about such legislation which must strike everyone who considers it—How can it be reasonably expected that masters or men who are accustomed to unlimited production of smoke in their own and neighbours' houses and elsewhere, should be imbued with any special views as to the necessity for absolutely preventing smoke in their works? As a rule they look upon the smoke laws as an irksome and unfair restriction on trade; and so long as they can by any means avoid penalties, they practically do no more to advance the object of the legislation.

It seems to have been generally accepted in the past and to remain now a fixed idea, that the smoke from Domestic chimneys cannot be checked or dealt with at all by legislation. Must this view be held as absolutely correct now—and to apply as well to all future time? It would be wholly unreasonable to consider even the possibility of passing an immediate law to absolutely restrain smoke from private houses now existing. Were it even to be passed it manifestly could not be administered. For, as the late Home Secretary (now Lord Aberdare), said in a speech on the subject, "It would be impossible to draw an indictment against a whole people;" but as he went on to say, "Supposing it can be shown that grates as cheap or cheaper than the present ones have been invented and could be applied, and that the result of using them would be an economy of fuel, we have then to consider whether the foundation has not been laid for the gradual application of compulsion." Surely these words of his are worthy of consideration. In the case of *new* houses, at any rate, a great check might readily be imposed by the united forces of public opinion and suitably restrictive legislation.

The Government have set the example in the abatement of smoke by announcing that tenders for the new Admiralty and War Offices must provide for most improved heating arrangements.

I do not know the annual rate of increase of new houses in Glasgow, but in London, in 1881, it was 26,170, or at the rate of about three new houses an *hour* for every hour of the year! In some other cities it has been proportionately as great. When we realize this enormous extension of new buildings, all with more or less defective heating apparatus, and what they are constantly doing to *increase* the smokiness of the atmosphere and swell the attendant evils of the vicious system which the smoke indicates, is it not our national duty, as well as our individual interest, to join the cause of smoke abatement? Unlike other great sanitary and social reforms, the desired relief will not have to be purchased by the expenditure of large sums of public money involving increased taxation; on the contrary, this reform may be wrought out gradually as, in the strictest sense, one of economical advantage to the present as well as to future generations.

Regarding the possibility of carrying out the reform in a thorough and practical way, we may be encouraged by the success which has already followed the efforts put forth. It would not be practicable to enter into details here nor expedient to refer to particular instances, but it may be accepted as a fact, that the attention which has been directed to the subject has resulted in a large extension of knowledge and marked improvements in all classes of heating apparatus. It is generally admitted that our heating processes are, for the most part, primitive and unsatisfactory, and that cheaper, less cumbersome, and more readily manipulated methods of applying heat are becoming more and more essential in all domestic and industrial operations.

The Official Reports of the Smoke Abatement Committees of London and Manchester are highly instructive and suggestive. They afford a comprehensive view of the character and efficiency of the best kinds of heating apparatus now available, and show the margin for improvements. For instance, it is shown that some domestic grates burn three times as much coal as others do, and produce six times more smoke; that some gas stoves burn nearly three times more gas than other stoves, and that some steam boiler furnaces burn more than twice as much coal as others for equal work; and that while some produce a great deal of smoke, others are practically smokeless. It is very important to notice that all the tests made were conducted under the superintendence of persons interested in the success of their particular apparatus, and therefore the results recorded by the Committees would undoubtedly show a higher range of efficiency than would be obtained in ordinary use by the public.

Mr. D. K. Clark, M.Inst.C.E., formerly of Glasgow, and well known for his elaboration of the works of the late Mr. Charles Wye Williams and his own, on "Fuel Economy," states, in his report to the Committee, that the tests of open grates showed that only 42 per cent. on the average of the heating power of the coal consumed was utilized in warming the room. Professor W. Chandler Roberts, F.R.S., made a series of valuable and novel experiments to determine the composition of the gases or "smoke" given off from the chimneys, and ascertained that for one part of solid carbon, the blackening constituent of smoke, five parts of invisible but combustible gases (hydro carbons and carbonic oxide) are discharged into the air. By the aid of these reports, the economic as well as the sanitary bearing of the smoke question is presented to our minds with some definiteness—a basis is thus established for future investigations and action.

Hitherto there has been no *general* treatment of the smoke question, nor any point to which interest in it might converge. A general complaint has been made against smoke, but no organized effort has been made to advance general knowledge on the subject, and ally public sympathy and public efforts together to abate the evil in the common interest.

The future progress of the cause must, of course, depend mainly on the *extent* to which the public interest is awakened to recognition of the necessity and desirability of change, and to the *time* at which this influence is brought to bear. If the public support is favourable and prompt to extend the movement now in active existence, scientific minds and commercial interests will naturally be stimulated to continue efforts in an increasing ratio to supply public demand.

As one practical illustration of the speed and soundness with which these forces operate in the present day, I may mention that in connection with an important series of competitive tests of gas cooking and heating stoves, now being carried on in London under the auspices of the Smoke Abatement Institution, it has been found that the character of the apparatus has actually been improved in several instances since the testing was commenced in the spring of the year. Improvements have been suggested to the minds of designers and manufacturers, and they have actually brought forward modifications of their own original apparatus for competitive tests. That considerable improvement has taken place in gas apparatus has been specially noticed in a recent Report by the Smoke Abatement Institution, and it has been stated at some of the meetings of the Gas Companies that a very large increase in the demand for gas for heating purposes has arisen. So far as the use of gas can be made available for reduction of smoke at Glasgow there is an encouraging prospect, for the name of Mr. Foulis stands high in the gas world as an admirable manager of gas works; and under his scientific development of gas manufacture, the well known system of Heating the Retorts, invented by Sir William Siemens, has been introduced on a larger scale than at any gas works in the kingdom. Moreover, the coal of the country is suited to gas making, and the manufacturers of gas apparatus in Glasgow are among the largest—if not actually the largest—in the kingdom.

I find I have already extended this paper beyond the prescribed limits, and must somewhat hastily conclude it. I may, however, be permitted to mention that the review of heating systems has already led to the discovery or recognition of various collateral advantages being associated with changes tending to the prevention of smoke. Among them may be mentioned that, in the manufacture of coke, a saving of several millions sterling could be effected by the collection and condensation of the volatile constituents of coal, now poured into the atmosphere in the form of smoke; the development of furnaces suited to utilizing inferior coal and gaseous fuel, and the introduction of appliances for labour saving. The important bearings of these several things on the commercial as well as social interests of the country are obvious, and at the present meeting of this Congress it is not too much to hope that they will find appropriate recognition and development, and that the work of this Section, presided over by Dr. Angus Smith, will, by introducing the subject of smoke abatement, have aided, in some degree, to fulfil the hopes with which he wrote his well-known "Contributions to the Beginnings of a Chemical Climatology," and that the atmosphere of Glasgow may became purer, and its inhabitants richer, by abating smoke which, as Sir William Siemens has expressed it, "always indicates waste."

Mr. C. J. Henderson (Edinburgh) described his new patent stove, which being covered, within a few inches, with sheet tin, induced a current of outside air to pass in between the metals by openings

in front, the temperature of which would be 8 to 10 times increased on issuing by carrying off the molecules of heat as they came to the surface of the iron.

Mr. G. W. Muir (Glasgow) contended that, in the desire to abate the smoke nuisance from furnaces, the public had relied upon inventions when dimensions were of greater importance. No furnace used for steam raising should emit smoke if the draft was strong enough to raise steam without forcing the fire.

Dr. Carpenter agreed with the statement that there was no reason why the chimneys of manufactories should send out smoke. It was a matter which the people themselves could settle. He was glad to see from the newspapers that the authorities of Glasgow had commenced to take proceedings against the offenders. In London no manufacturer would dare to send out smoke, because he would be pounced upon at once by the police and prosecuted. Indeed, he never saw a chimney in London sending out smoke in the way he had seen them doing in Glasgow; but the police of Glasgow were the servants of the offenders. With regard to domestic chimneys, there was a difference of opinion. It was quite certain that a local authority could not indict the whole people, and therefore he would press on the Congress a point that he pressed on the Society of Arts three years ago, but which did not meet with much favour. Still, he considered it was the right one. The large proportion of smoke in large towns—and this interested not Glasgow alone, but also all large towns as well as London, which, from its large extent, was becoming a forest of houses, or, as one gentleman had called it, a desert of houses—tended to produce fogs, and he believed these were sometimes even more dense in London than they were in Glasgow. How was that dangerous result to be done away with? His impression was that if the Legislature gave the Local Authority power to license chimneys to discharge smoke into the atmosphere, and let the produce of the licenses be collected by the Local Authority for the purpose of reducing the cost of sanitary operation in the district, he thought they would soon find the smoke nuisance would be very materially abated, the cost of the license being considerable. They would also find that the appliances which science had brought out, such as stoves and warming apparatus, would, by their increased use, soon get rid of a very large amount, say four-fifths, of the smoke that arose from the domestic chimneys. They would also provide a source of profit to the Local Authority from those who liked to have their open fire, and have the privilege of poking it. That to some extent was one of the reasons for the continuance of smoke. It would be more beneficial and less costly to the owners of poor property to have smoke-consuming fireplaces, or that cooking should be carried on by gas. They would then have a very large amount of that smoke removed from the atmosphere without any of those various changes which had been suggested—that of laying on very heavy penalties against the offenders and preventing people having a fire to look at if they liked. He thought the plan he had suggested would be found in the end to abolish the smoke nuisance more effectually than any others they could think of.

Mr. COLES said the main consideration was to avoid the production of smoke, and he contended that while it was possible under certain conditions to consume the first products of distillation arising from a fire after fresh coaling, it was not practicable in a broad sense to consume smoke. It should be prevented.

The PRESIDENT, in conveying a vote of thanks to Mr. Coles for his paper, said that that gentleman had, in conjunction with Dr. Lyon Playfair, been instrumental in forming the Smoke Abatement Association. It was of considerable importance that such institutions should exist in the country, because by making experiments they kept the matter continually before us. Even Royal Commissions confined themselves to acquiring information which existed among the people, and then giving it out in reports. What they desired most in nearly all the branches of sanitary inquiry was a proper series of experiments, and such, he believed, were carried out for small fire-places by the Smoke Abatement Association. Larger experiments, which were very expensive, could, perhaps, only be made by those who had large works, and were able to spend a considerable amount of money upon them. He alluded to the new methods of using coal, for example, the Simon-Carvés and Jameson furnaces. He also wished to call attention to the latest development of the Jameson furnace, which he found in action near Glasgow, although, so far as he knew, it was not in use anywhere else in the kingdom. He happened to go out on the Great Western Road this week, and there he saw a considerable number of large heaps of waste coal, and he was told that in one of these a method was being employed to make use of the smoke. He found that tubes had been inserted to a considerable depth into the mass, and a fan was drawing out the air and gases from the centre, and from under the surface of these heaps—the air going in by the surface, the smoke and some air of course being drawn out through the tubes. This smoke so carried off was converted into a constant flow of liquid, which contained ammonia and oil. The smoke had ceased from that part of the heap where these tubes were inserted, so that this process of Jameson's had made it possible to burn these enormous heaps, whose destruction was very important, and without being in any way offensive to the neighbours, and that, he believed, if not at a loss, at least without very great expense. Then there were different kinds of smoke—black and grey smoke—and as the colour was different the composition was different. In house fires the combustion was not sufficiently strong, the oleaginous matters were not sufficiently heated, and a greyish smoke appeared; with more heat smoke of a black colour was produced. Any method which increased the heat of combustion still more, and with sufficient air, would enable them to get rid of this black smoke. Mr. Muir's statement was that smoke could be consumed by proper apparatus, but Dr. Smith was looking forward to an improved use of coal, which would not depend on those mechanical agencies which Mr. Muir alluded to. He found that in most towns those who were entrusted with the duty of putting down smoke were smoke consumers themselves, and it was, therefore, difficult to get these Acts put into operation. He looked more, however, to invention and to the spread of knowledge amongst the people than to legislation for improvement in this matter.

On "*The Treatment and Utilization of Town Refuse*," *by* JOHN COLLINS, F.C.S., F.G.S., &c.

THE writer has little apology to offer in submitting this paper to the Congress of the Sanitary Institute save that of its importance and the little scientific attention which has been paid to the subject of it hitherto.

There can be no doubt that the disposal and utilization of effete and offensive town matters, as derived from middens, cesspools, &c., forms one of the most difficult as one of the most important problems with which we have at present to deal. For, while the modes of treatment and of disposal may not be too technical or too expensive, the work must be thoroughly done, and in such way, too, as to cause no nuisance or damage.

In large manufacturing towns, where action is most needed, the problem is necessarily most difficult.

It is not proposed by the writer to deal, in any way with sewage, properly so called, but with such towns' refuse as is commonly found in the endless variety of substances in cesspools, midden heaps, excretal refuse, market, and other garbage.

The depôt, or works, for dealing with these should be as central as may be, and must have the necessary aids to cheap and rapid transport offered by rail or canal, or both. The arrangement of plant, &c., must be simple and not liable easily to get out of order or to suffer from indifference or mismanagement. The process of utilization must also be rapid, in the disposal of what are really offensively disgusting, and, in many cases, dangerous matters. The means of transport must provide an outlet into an agricultural district which shall be handy for application and consumption at low rates.

Without going into the means adopted to secure these ends in other places, the town in which the writer practices affords, as he believes, an illustration—as advanced as may be found—of a mode of cheap and thorough disposal of efféte town refuse; and it is the main purpose of this paper to lay before the Congress the means whereby this is effected and to what extent.

The population of Bolton is about 106,000. The midden and open cesspool prevails, although there are a few water closets, and a considerable part of the newer cottage property is provided with "pails."

The collection and scavenging of these is mainly effected in the night, and by means of *closed* carts of excellent design. These matters are roughly assorted on loading. Dry ashes from fires and furnaces only are taken and "tipped" outside the town. All other matters are carted to the works, and are again sorted on their arrival. When needed they are deodorized. They are all immediately dealt with, and no accumulation is permitted. The drains and sewers therein are all disconnected with the town system, and their contents are dealt with in the works.

The material brought to the yard works may be described generally as domestic and market refuse and street sweepings. It contains cinders, coal, ashes, brickbats, glass, crockery, mortar, old carpets and shoes, paper, rags, bones, cabbage stalks and other vegetable refuse, sound and unsound, entrails of birds and fish, manure and fæcal matters, oyster shells, dead kittens, old meat tins and pails, bottles and jars in earthenware and in glass, old iron, &c., &c.

On arrival, this is variously dealt with. The comparatively dry ashpit refuse is assorted, and part is ground with fæcal and other effete matters into a manure of a dark grey colour, inodorous and pulverulent, and having little about it to suggest its origin. This manure is at once sold to the farmers, or it is stacked in the staiths specially provided for it, until the season arrives when it is required.

No nuisance, nor even smell, is due to, or is caused by this stacking.

Another part is charged to the "Destructors" (Fry's), where it is burnt, leaving only a residuum of "clinker" and of ash, which is, in its turn, used for making a capital mortar and cement, and for road making.

In this way the whole of the "refuse" is daily dealt with immediately on its arrival, and it is in no case permitted to remain to become the nuisance and danger to health it would otherwise surely become.

Were the burning carried on in open heaps, or in openly constructed furnaces, it would pobably be found to constitute a very serious and dangerous nuisance. But, here, the furnace is specially designed, and no such result can arise.

It is self-sealing, and is connected with a chimney shaft 180 feet high, with a mean sectional area of 49 square feet, and a mean draft of 107,800 cubic feet per minute.

Traces of the gases passing away by this chimney have been sought for in the atmosphere as a pollution, through an area

having a radius of 2,600 yards as the crow flies. The tables appended will show how far this was successful. The quantity of "smoke" is very small, and has the faintest diagreeable odour. It is mainly watery vapour.

A fine dust (Table 3) is one of the results of this "destruction." It is lightish grey, caustic, and absorbent. It is inodorous, and not in any way more offensive than is ordinary flue dust.

The "clinker" and ash (Table 3) is absolutely inodorous and inoffensive.

The samples of air (Tables 1 and 3) were taken under the following conditions:—

No. 1.	Wind	S.W. ...	Temp.	65° F....	Showery.
2.	"	" ...	"	68° " ...	"
3.	"	" ...	"	68° " ...	"
3*a*.	"	W. ...	"	76° " ...	Fine.
4.	"	" ...	"	70° " ...	"
4*a*.	"	" ...	"	70° " ...	"
4*b*.	"	" ...	"	68° " ...	Heavy showers
4*c*.	"	W. & S.W...	"	70° " ...	"
4*d*.	"	W. ...	"	78° " ...	Fine.
5.	"	S.E. & E. ...	"	76° " ...	"
6.	"	" ...	"	76° " ...	"
7.	"	" ...	"	76° " ...	"
7*a*.	"	S.W. & S....	"	70° " ...	Showers.
7*b*.	"	" ...	"	70° " ...	"
7*c*.	"	W. & S.W....	"	72° " ...	Heavy showers.
7*d*.	"	" ...	"	72° " ...	"
7*e*.	"	" ...	"	72° " ...	"

It should be suggested here that the yard and works are immediately to the W. and S.W. of the town and adjacent thereto.

1. Heaton Cemetery lies to the W. of the town and outside it.
2. Junction of St. George's Road and Bridge Street lies N.E. and E.
3. Wellington Street lies immediately to the S.
4. Wellington Yard is the depôt and works.
5. Gas Street lies to the E., and contains Corporation Gas Works.
6. Back Milton Street lies immediately to S.W.
7. Black Horse Street lies E.

And the air analyses show this order as affected by polluting gases.

There is necessarily an occasional smell of fæcal matters in the works, but this is not more than would and does occur in the daily use of, and in the occasional emptying of the old privy provided in the back yard of each cottage, and it cannot be said to constitute an injurious nuisance.

The albumenoid ammonia supplies a measure of the nitrogenous organic bodies and putrescible matters, or of the sewage contamination of the atmosphere. It is always an ingredient in bad air, and it is rarely, if ever, absent in the air of all town dwellings. It is not there in sufficient quantity [see tables], to be noxious and injurious.

When manufactured and stacked, the manure has been carefully watched, to ascertain if any "heating" from storage or further decomposition occurred. But the stock is almost inodorous, and is certainly not offensive, for it cannot be detected at a distance of twenty yards. It will be seen that, after intimately dividing and mixing the ingredients, decomposition is stayed, and the gases are fixed, to be liberated only by the growing plant when applied in agriculture. The ammonia and other nitrogenous matters are intimately combined and admixed with carbon and other finely-ground absorbents, and hence no offensively-smelling gases are evolved. A sample of this manure has been in the writer's laboratory open and under ordinary conditions for over twelve months, and is now free from smell.

The temperature of the stock is very steady, at about 60°—61° F. Hence no decomposition is going on in the mass. for this would produce heating [Table 4].

The moisture in the ashpit refuse is usually about 10 per cent., and the whole of this water is vaporized in the "Destructor."

It is not within the province of the present writer to give the costs of this mode of disposing of town refuse; but it will be seen that it must be economical, as it is effectual. No attempt is made to "manufacture" a high class "guano" or other manure. The first object aimed at is the getting rid of an evil. The next, how to do this cheaply and effectually. It is believed this is done in the case here described: for the ordinary means for collection and removal are sufficient and ample. The plant for dealing with the matters is simple and economical, and the results are merchantable and find ready sale. Much is disposed of as made, and of the remainder the stock disappears in a few days when the season for its application arrives. It does not pay expenses, of course, but it costs less, it is believed, than any other plan in operation on a similar scale.

The superintendence and laying out of the works and plant, and the general success of the process adopted, owes much to the close attention and the indefatigable oversight of his worship the Mayor of Bolton, E. G. Harwood, Esq., and only in a less degree to the committee over which he presided, and which had charge of this department.

TABLE 1.—AIR ANALYSES.

Date of Sampling.	Place and nature of Sample taken.	Oxygen.	Nitrogen.	Carbonic Acid.	Ammonia, parts per Mill. Free.	Ammonia, parts per Mill. Albuminoid.	Index No.
		Per cent.	Per cent.	Per cent.			
15th July, 1882, 10.30 a.m.	Heaton Cemetery	20·98	78·7	0·034	0·042	0·082	1
19th June, 1882, 2.30 p.m.	Back Milton Street	20·74	..	0·054	0·068	0·086	2
" " 3.30 p.m.	Wellington Street	20·88	..	0·040	0·046	0·085	3
29th June, 1882, 11 a.m.	"	20·91	..	0·043	0·049	0·069	3a
20th June, 1882, 10.30 a.m.	In Works	20·89	..	0·044	0·055	0·083	4
" " 3.30 p.m.	"	20·87	..	0·038	0·047	0·068	4a
21st June, 1882, 11.15 a.m.	"	20·91	..	0·036	0·046	0·083	4b
22nd June, 1882, 10 a.m.	"	20·94	..	0·035	0·044	0·083	4c
28th June, 1882, 4.10 p.m.	"	20·95	..	0·038	0·051	0·085	4d
23rd June, 1882, 10, 12, and [2 p.m.	In Blackhorse Street	20·73	..	0·054	0·071	0·088	5
15th July, 1882, 5 p.m.	In Gas Street	20·78	..	0·041	0·083	0·085	6
26th June, 1882, 10.30 a.m.	At junction of S. George's Road, with Bridge Street	20·94	..	0·038	0·043	0·083	7
" " 3 p.m.	"	20·92	..	0·035	0·043	0·082	7a
" " 5 p.m.	"	20·92	..	0·035	0·044	0·083	7b
22nd June, 1882, 10.10 a.m.	"	20·94	..	0·036	0·044	0·084	7c
" " 3 p.m.	"	20·95	..	0·035	0·043	0·085	7d
" " 5 p.m.	"	20·95	..	0·036	0·045	0·085	7e

TABLE 2.—ANALYSIS OF CHIMNEY GASES.

Date of Sampling.	By whom Sampled.	Oxygen.	Nitrogen.	Carbonic Acid.	Carbonic Oxide.	Index No.
		Per cent.	Per cent.	Per cent.	Per cent.	
10th July, 1882, 11 a.m. ..	Self and W. H. Collins....	17·25	77·51	3·89	1·35	8
" " " ..	" "	11·33	77·94	4·34	6·39	8*a*
" " " ..	" "	2·46	68·61	20·58	8·35	8*b*
" " " ..	" "	1·14	67·10	25·95	5·81	8*c*
" " " ..	" "	13·95	79·84	6·09	0·12	9

These gases are the products of combustion from "destructors," and are tapped from the chimney.

They represent three distinct conditions of the destructor, viz.:—

8, 9. Shortly after firing and when heat in destructor is low—white vapour and smoke.

8*a*. When strongly fired " " " dull red, empyreumatic smell, very strong.

8*bc*. When more fired " " " bright, little moisture, whitish deposit.

They are mixed with traces of Sulphurous Acid, Sulphuretted Hydrogen, Ammonia, Cyanides of Sodium and Ammonium, and empyreumatic and other vapours—non offensive, non injurious.

TABLE 3.

A.—*Analysis of the grey or whitish flue or vapour deposit from Chimney Gases*—

	Per cent.
Loss on ignition at white heat	14·06
Lime Sulphate	15·09
Potash "	19·30
Soda "	2·64
Sodium Chloride	1·96
Ignited residuum: insoluble in water	46·95
	100·00

B.—*Analysis of Ash and Clinker (average) from "destructor"*—

	Per cent.
Silicate of Alumina	38·46
Lime	4·01
Magnesia	0·63
Iron	11·02
Carbon	30·16
Salts of Sodium and Potassium	1·51
Insoluable matter and loss	14·21
	100·00

TABLE 4.—AIR ANALYSES.

	Oxygen.	Carbonic Acid.	Ammonia, parts per Mill.		Index No.
			Free.	Albuminoid.	
	Per cent.	Per cent.			
9th Aug., 1882, 10.35 a.m. In Wellington Yard	20·94	0·035	0·046	0·075	25
" 10.42 a.m. In Wellington Street..	20·91	0·038	0·046	0·070	26
" 10.48 a.m. In Back Wellington Street	20·86	0·041	0·058	0·081	27
" 11.5 a.m. In Back Milton Street	20·89	0·040	0·063	0·086	28
" 11.18 a.m.	20·91	0·039	0·051	0·073	29

TABLE 4a.

Observations and Experiments on Temperature of Air and of Stock Manure—

	Temp. of air in shade.	Temp. manure at depth of 12ft.	In stock averages at depth of 7ft. 6ins.
11th August, 1882, 11.30 a.m.	72°·0 F.	61°·0 F.	63°·0 F.
14th " " 11.10 a.m.	75°·0 F.	61°·0 F.	63°·0 F.

The average temperature manure is 11° F. *below* that of atmosphere as shown above.

"FELICITY AS A SANITARY RESEARCH."

LECTURE TO THE CONGRESS.

By BENJAMIN WARD RICHARDSON, M.D., F.R.S.

OUR Congress this year has been ringing peals of congratulations, and the peals are deserved. Sanitary science, in some simple directions, has won triumphs such as have never been won before, and its advocates, once called enthusiasts, dreamers, visionaries, and other poetical names, are now, in respect to enthusiasms, dreams, visions, looked upon as common-place observers. The miracles they declared posssible are performed so regularly that wonder and doubt have ceased.

We sanitarians declared that it would be a comparatively easy task to find out the courses and, at least, the proximate causes of the great pestilences, and that, with a fair knowledge on these subjects, combined with a comparative ready assistance by the public, we could control both the courses and the causes. The work has not been done so thoroughly as we could have wished, because the public has not come up, as yet, to our views; but the work is progressing, and sufficient is already done to prove the truth of our position.

We said that the once current rates of mortality were deathly of deathly; that they represented a low civilization; that they might, in these countries, be reduced generally to a mean of fifteen in the thousand per annum, and, in favoured localities, to a lower figure still. We were taunted with the rejoinder, that if such were accomplished men and women would live a hundred and fifty years. We replied, Let them live two hundred years if they like, but let us, any way, reduce the huge mortalities which are considered natural.

The result of our work is that there are towns where the average mortality is actually lower than fifteen in the thousand. Strangely too the popular cry is not now against us as enthusiasts but against towns which do not follow up our enthusiasm. Towns, therefore, in this day, compete with towns for a low