HINTS

ON

DRAINS, TRAPS, CLOSETS,

Sewer Gas,

AND

SEWAGE DISPOSAL

BY

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As the knowledge of the public on this important subject is somewhat imperfect, I suggested to your Sanitary Authority the advisability of publishing some plain general hints and information on the subject. The conclusions of the Rivers' Pollution Commission represent the latest information on the subject, I therefore adopt them as the text. They are as follows :—

"That the scavenging, sewering, and cleansing of towns are necessary for comfort and health; and that in all cases these operations involve questions of how to remove the refuse of towns in the safest manner, and at the least expense to the ratepayer.

"That the retention for any lengthened period of refuse and excreta in privy-cesspits, or cesspools, or at stables, cow-sheds, slaughter-houses, or other places in the midst of towns must be utterly condemned; and that none of the (so-called) dry-earth or pail-systems or improved privies can be approved, other than as palliatives for cesspit-middens, because the excreta are likely to be a nuisance during the period of their retention and a cause of nuisance in their removal; and, moreover, when removed, leave the crude sewage, unless otherwise dealt with by filtration through land, to pollute any water course or river into which such sewage may flow. We have no desire, however, to condemn the dry earth or pail systems for detached houses or for public institutions in the country, or for villages, provided the system adopted is carefully carried out.

"That the sewering of towns and the draining of houses must be considered a prime necessity under all conditions and circumstances, so that the sub-soil water may be lowered in wet districts, and may be preserved from pollution, and that waste-water may be removed from houses without delay; and that the surface and channels of streets, yards, and courts may be preserved clean.

"That most rivers and streams are polluted by a discharge into them of crude-sewage, which practice is highly objectionable.

"That, as far as we have been able to ascertain, none of the existing modes of treating town sewage by deposition and chemicals in tanks appear to effect much change beyond the separation of the solids and the clarification of the liquid. That the treatment of sewage in this manner, however, effects a considerable improvement, and, when carried to its greatest perfection, may in some cases be accepted.

"That, so far as our examinations extend, none of the manufactured manures made by manipulating town's refuse, with or without chemicals, pay the contingent costs of such modes of treatment; neither has any mode of dealing separately with excreta so as to defray the cost of collection and preparation by a sale of the manure been brought under our notice.

"That town-sewage can best and most cheaply be disposed of and purified by the process of land irrigation for agricultural purposes, where local conditions are favourable to its application; but that the chemical value of sewage is greatly reduced to the farmer by the fact that it must be disposed of day-by-day throughout the entire year, and that its volume is generally greatest when it is of least service to the land.

"That land irrigation is not practicable in all cases, and therefore other modes of dealing with sewage must be allowed.

"That towns situated on the sea-coast, or on tidal estuaries, may be allowed to turn sewage into the sea or estuary, below the line of low-water, provided no nuisance is caused; and that such modes of getting rid of sewage may be allowed and justified on the score of economy."

In modern times we readily admit that in the darkness of the middle ages people poisoned themselves with their own filth, and therefore suffered terribly from the ravages of preventable disease, Hecker (*Epidemics of the Middle Ages*) estimating that in the first epidemic of the 14th century "the black death" swept away one quarter of the total population of Europe, other writers placing the mortality at a much higher figure; but all communities have been slow to believe that the more familiar diseases—scarlet fever and typhoid fever—which they have been in the habit of considering more or less inevitable, were, perhaps, not equally preventable with cholera and typhus, but still preventable to a very great degree; and it was with surprise that people not educated in medicine lately heard one of our highest authorities in sanitary science describe a large class of maladies as "filth diseases."—*Second Report of the Medical Officer of the Privy Council*, 1875.

Sanitary legislation resolves itself chiefly into the broad principle of attempting to provide clean air, clean water, clean food, clean soil, clean houses;—in furtherance of which "Sanitary Hints," general and special, on these points, have been freely distributed over the district.

It is not to be understood, however, that any *general* attention to cleanliness, in the ordinary acceptation of the word, will secure entire immunity from the preventable diseases. The special *kinds* of cleanliness necessary to avoid the different fevers, for instance, are quite different from one another, and cannot be fully practised without an intimate knowledge of the way in which each disease is propagated. A quarter of a century ago, preventive medicine consisted in trying by quarantine to keep out disease; now it consists chiefly in removing the conditions favourable to its existence and spread. Pettenkofer forcibly compares the outbreak of cholera to explosions from gunpowder. The sparks which set fire to the powder are the "germs" of the disease, which we cannot keep out by the most rigid quarantine; the powder is the combination of local circumstances in a town or city, without which the disease cannot get a foothold. He says that we "act more wisely in searching out and removing the powder itself than in running after and trying to extinguish each individual spark before one of them drops on a powder heap and causes an explosion which blows us into the air with our extinguishers in our hands."

We need not quote the opinion of various authorities on the effect of filth on health; that of Leibermeister (*Zur Aetiologie des Typhus*) seems to be gaining ground, that filth furnishes a favourable *nidus* in which disease finds favourable conditions for rapid development; it is moreover proved that the removal of filth lowers death rates, and that the general intelligence of any community may be safely inferred from the attention which they pay to removing all filth—(one link, at least, in the chain of disease which we can control)—completely away, beyond the possibility of doing harm.

"There is always an intimate connection between dirt and disease; the cleaner towns are kept the healthier they will necessarily become. The origin of typhoid fever is still under enquiry. Sir William Gull observes:—'There is no scientific theory, but there is a good working theory on the point. The origination of the disease is somehow or other connected with drainage; it has, therefore, been called the filth fever. Hence to get rid of the filth is to get rid of the fever.'"—(Dr. Hinckes-Bird. *A Preliminary Report on the Sanitary Condition of the Fylde District*, 1874.)

On referring to the 9th report of the Medical Officer of the Privy Council will be found an account of 25 towns examined by Dr. Buchanan, under the condition of properly-laid impervious sewers, well ventilated and sufficiently flushed, with a free outfall, and the connection of the houses with these sewers; it was found—1, The general death rate was lowered in almost every instance, in two cases as much as 32 per cent.; 2, the mortality of infants, always a good test of sanitary conditions, had decreased considerably; 3, the mortality from enteric (typhoid) fever was most remarkably diminished in almost all the cases examined. In ten towns the reduction was between one-third and one-half of the total number of deaths from this disease, in nine others it was over a half, being as much as 75 per cent. in one instance. In the three or four cases in which the reduction was very slight, or where there was an increase, it was found that the outfalls were not free, so that the sewage was backed up in the sewers, causing stagnation, and its results decomposition and sewer gas; 4, "the cholera epidemics appear to have been rendered practically harmless in the towns examined."

As, on the other hand, in many towns it has been found that the improper construction or ventilation of the sewers has been the probable cause of increasing the death-rate, by exposing people to the direct effects of the deleterious gases, we will briefly advert to the influence of sewer gas on health, and then consider the means for preventing it.

EFFECT OF SEWER GAS ON HEALTH.

At a late meeting of the Royal Society, Professor E. Frankland communicated a paper "On the transport of solid and liquid particles in sewer gases." He first referred to the large amount of suspended matter in the air, which consists of aqueous and other volatile particles that disappear by a gentle heat. There are other particles that consist partly of organic and partly of mineral matters, and the processes of fermentation, putrefaction, and decay afford abundant evidence that zymotic and other living germs are present among the organic portion. Of the zymotic matters, those which produce disease in man are obviously of the greatest importance, for there are well authenticated cases on record that disease has been comunicated by the germs being in suspension in air that has escaped from sewers. Professor Frankland has considered it important to investigate the conditions under which the germs pass from sewage into the air. Does the flow of sewage in a properly-constructed sewer produce sufficient agitation to disperse liquid particles through the air-space of the sewer? In this and in the other experiments mentioned below a solution of lithic chloride was used, Professor Frankland having previously ascertained by three separate tests that no lithic chloride is carried off at ordinary temperatures by aqueous vapour from a saturated solution of it. Some of the solution being placed in a glass jar it was agitated, and though this was done with greater violence than would ever happen to fluid in a sewer, it was proved that none of the lithic chloride was disengaged. It is, therefore, extremely improbable that the mere flow of foul liquid through sewers can impregnate the circumambient air with suspended particles. There is, however, another kind of agitation to which sewage is subject that may produce a very different result—viz., the development of gases during the processes of fermentation and putrefaction. When minute bubbles burst at the surface of an effervescing liquid little particles of it can be seen projected into the air some inches and then falling again. Professor Frankland experimented to test whether particles too small to be seen might not be also projected, and in consequence of the smallness of their masses in relation to their sectional areas, might continue suspended in the air for a long time. A strong solution of lithic chloride was acidulated by the addition of hydrochloric acid, some fragments of white marble were added, and this produced an effervescing liquid. A tube 3in. in diameter and 5ft. long was held over it, and there were distinct traces of lithium found during effervescence at the upper end. A second tube 3in. in diameter and 12ft. long was then held nearly at right angles at the top of the first, a slight draught through it being caused by external heating. At the further end of this tube, too, lithium was distinctly traced. The particles were also found to pass readily through two inches of of charcoal, and they passed even a layer five inches thick, though in greatly diminished numbers. Here, then, in the breaking up of minute gas bubbles is the cause of the suspension of particles in the air. If, therefore, through the stagnation of sewage or constructive defects which allow of the retention of excrementitious matters for several days in a sewer, putrefaction sets in, then gases are generated, and the dispersion into the air of zymotic matters is very probable. It is of the greatest importance that foul liquids should pass rapidly and freely through drain-pipes and sewers, so as to secure their discharge from the system before putrefaction sets in.

There should be, then, quick discharge of excreta and no sewers of deposit; if sewage is quickly got rid of there is little chance of gas developing. Some physiologists state that the excreta of human beings suffering from infectious diseases is not infectious until a few hours after discharge, or till fermentation takes place. Thus the importance that all communication between the house and the sewer, soil pipes of water-closets, as well as waste pipes of sinks, baths, &c., should be completely disconnected with the sewer.

With regard to the effects of sewer poison, its virulence is found to depend in some measure on the age, condition, habits, and employments of those exposed to it, and also upon the freshness of their exposure. Many facts tend to prove that an atmosphere may be tolerated in working hours which would produce serious disease if breathed when the system is in the non-resisting condition of sleep. In the same way when the system is robust, in active exercise, and well-nourished by abundant and suitable food, one may safely expose himself to a degree of contamination of the air which would be thoroughly unsafe if the various organs of the body were relaxed by sleep, fatigue, or even a posture of rest. In illustration of this a number of children in a workhouse were twice attacked with severe diarrhœa from exposure to emanations from a manure factory, while the workmen had good health; and at a school, twenty out of twenty-four boys were seized with violent vomiting, purging, prostration, and fever within three hours after exposure to foul sewage—emanations arising from a sewer the emptying of which they had been watching, while none of the workmen became ill; and in a case which lately came under my notice, a gentleman staying at a hotel had a most serious illness, with the above symptoms, from a cesspool being emptied under his open window in the night while he was asleep. It is undoubtedly the same with regard to sewage emanations in and near our dwellings. The strong, the active, the well, and those who spend a large time of the day away from their houses do not ordinarily suffer. In the 1853 epidemic of typhoid fever at Croydon, caused by sewer-gases in the houses, "we found servants chiefly attacked, and then children; the fathers were very seldom sick at all, because they were not much at home, while the others were usually at home."—*Evidence of Dr. W. Sunderland.* It is, then, from long-continued exposure or when some depression of the vital powers exists, that disease is caused by a sewer-poisoned atmosphere, unless the poison be very concentrated.

"When emanations from a sewer or cesspool enter a house, phenomena of disease, much more decided and acute than those described in the last section, are apt to be presented amongst the inmates. The researches of the late Dr. Herbert Barker, in which I had an opportunity of taking part, have taught the nature and quality of ordinary cesspool and sewer air, and the effect of such air on animal life. They have shown that cesspool emanations, when they are steadily inhaled, are poisonous; the symptoms of disease induced being those of intestinal derangement, followed by prostration, increased temperature of the body, distaste for food, and those general signs which mark the milder forms of continued fever common to the dirty, ill-ventilated houses of the lower classes of the community. Pursuing these researches into an analysis of the poisonous quality of sewer air, Barker discovered that the emanations were compounded of several gases, but that the true disease-producing agent was sulphuretted hydrogen gas. This gas diffused in breathing air in the proportion of 0·056 per cent.—in which dilution it is, after a time, indefinable by the sense of smell—was sufficient, even in such minute distribution, to induce diarrhœa, rapid pulse, heat of the surface of the body succeeded by coldness, tremors of the muscles, and all the worst symptoms that follow the inhalation of sewer air.

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"Sewer air may become the bearer of those poisons, of the spreading or communicable diseases, which are volatile and easily diffusable.

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"Typhus fever, scarlet fever, small pox, are dependent for their existence on poisons which are much more readily transmissable by suspension in sewer air, and are more liable to be introduced into the body by the breathing organs. With considerable reserve, I may express the opinion that I have known these diseases communicated by sewer air; but the disease, *par excellence*, derived from the sewer, is that continued fever which is induced by the natural atmosphere of the sewer, by the inorganic products of organic decomposition, of which sulphuretted hydrogen plays the leading part."—*Diseases of Modern Life*, by Dr. Richardson, F.R.S.

"Cases of asphyxia from sulphuretted hydrogen, sulphide of ammonium, carbonic acid, and nitrogen (or possibly rapid poisoning from organic vapours) occasionally occur both in sewers and from the opening of old cesspools. In a case at Clapham, the clearing out of a privy produced in twenty-three children violent vomiting and purging, headache, and great prostration, and convulsive twitchings of the muscles. Two died in twenty-four hours.—(*Health of Towns Report*, vol. i., p. 139.)

"These are instances of mephitic poisoning in an intense degree; but when men have breathed the air of a newly-opened drain in much smaller amounts, marked effects are sometimes produced; langour and loss of appetite are followed by vomiting, diarrhœa, colic, and prostration. The effluvia which have produced these symptoms are usually those arising from a drain which has been blocked for some time. When the air of sewers penetrates into houses, and especially into the bedrooms, it certainly causes a greatly impaired state of health, especially in children. They lose appetite, become pale and languid, and suffer from diarrhœa; older persons suffer from headaches, malaise, and feverishness; there is often some degree of anæmia, and it is clear that the process of aëration of the blood is not perfectly carried on.

"In some cases I have known decided febrile attacks lasting three or four days, and attended with great headache and anorexia. Houses into which there has been a continued escape of sewer air have been so notoriously unhealthy that no person would live in them, and this has not been only from the prevalence of fever, but from other diseases. Dr. Marston, R.A., in his excellent paper on the Fever of Malta, tells us that when typhoid fever broke out at the Fort of Lascaris, from the opening of a drain, other affections were simultaneously developed, viz., 'diarrhœa, dysentery, slight pyrexical disorders, and diseases of the primary assimilative organs.' A close examination and analysis of the affections produced by the inhalation of sewer air would probably much enlarge this list; and the class of affections resulting from this cause, to which it may be difficult to assign a nosological name, will be found, I believe, to be essentially connected with derangement of the digestive rather than with the pulmonary system.

"Dr. Herbert Barker has attempted to submit this question to experiment by conducting the air of a cesspool into a box where animals were confined. The analysis of the air showed the presence of carbonic acid, sulphuretted hydrogen, and ammonium sulphide. The reaction of the gas was usually neutral, sometimes alkaline. The gas was sometimes offensive, so that organic vapours were probably present; but no analysis appears to have been made on this point. Three dogs and a mouse were experimented on; the latter was let down over the cesspool, and died on the fifth day. The three dogs were confined in the box; they all suffered from vomiting, purging, and a febrile condition, which, Dr. Barker says, 'resembled the milder forms of continued fever common to the dirty and ill-ventilated homes of the lower classes of the community.' But the effects required some time, and much gas for their production. Dr. Barker attributes the results, not to the organic matter, but to the mixture of the three gases, carbonic acid, sulphuretted hydrogen, and sulphide of ammonium, and especially to the latter two."

"The air of sewers passing into houses aggravates most decidedly the severity of all the exanthemata—erysipelas, hospital gangrene, and puerperal fever (Rigby); and it has probably an injurious effect on all diseases.

"Two special diseases have been supposed to arise from the air of sewers and fæcal emanations, viz., diarrhœa and typhoid (enteric) fever.

"With regard to the production of diarrhœa from fæcal emanations, it would seem that the autumnal diarrhœa of this country is intimately connected with temperature, and usually commences when the thermometer is persistently above 60°, and when there is, at the time, a scarcity of rain-fall. It is worst in the badly-sewered districts, and is least in well-drained districts, and in wet years. It has been checked in London by a heavy fall of rain. All those points seem to connect it with fæcal emanations reaching a certain rapidity of evolution in consequence of high temperature, deficient rain, and perhaps relative dryness of the atmosphere. At the same time, there is a connection between this disease and impure water. It may own a double origin, and in a dry season both causes may be in operation.

"That enteric fever may arise from the effluvia from sewers is a doctrine very generally admitted in this country, and is supported by strong evidence. There are several cases on record in which this fever has constantly prevailed in houses exposed to sewage emanations, either from bad sewers or from want of them, and in which proper sewerage has completely removed the fever. Many of these cases occurred before the water-carriage of typhoid was recognised, but yet the connection between the sewage emanation and the fever seems undoubted.

"This evidence is supported by cases in which the opening of a drain has given rise to a decided typhoid fever, as well as to a very fatal disease (probably severe typhoid), in which coma is a marked symptom. So also in some instances (Windsor and Worthing) the spread of enteric fever has evidently been owing to the conveyance of effluvia into houses by the agency of unventilated sewers. In a case mentioned to me by a friend, an outbreak of enteric fever in a training school was localised in certain parts of the school (whereas the drinking water was common to all), and was traced to imperfection of traps in those parts of the house which were affected. In this case the drains led down to a large tank at some distance, and at a much lower level, and the smell of the effluvia was so slight that at first it was not believed that the drains could be out of order.

"These two classes of facts seem decidedly to show a causal connection between the effluvia from sewers and excreta and enteric fever, and they are supported by the statistical evidence which proves that the prevalence of typhoid fever stands in a close relation to the imperfection with which sewage matters are removed. The army statistics give excellent instances of this, and the evidence produced by Dr. Buchanan of the prevalence of typhoid fever before and after sewerage of a town is to the same effect."

"While numerous other instances are recorded of the evil effects of the air of sewers, cesspits, drains, &c., in producing temporary ailments, such as nausea, vomiting, diarrhœa, and headache, the great interest which attaches to this important subject rests on the development and spread of enteric fever. Dr. Murchison, in summing up his evidence with regard to the spontaneous origin of this disease, says, 'I readily admit that we cannot succeed in tracing every case of enteric fever to organic impurities. But if the disease can be traced to such causes, in a few undoubted instances, it is reasonable to infer that its causes are similar in all cases where it has a spontaneous origin. As already stated, the actual poison may, like the miasmata which gives rise to ague, be inappreciable to the senses, or by chemical research. During the last four years (1858-1862), however, I have met with few examples of enteric fever which, on investigation, I could not trace to defective drainage, the existence of which was occasionally unknown to the inhabitants of the infected locality.'

"More recent researches tend to show that enteric fever is perhaps seldom generated *de novo*, but that it is essentially a specific and infectious disease. No doubt, a great deal of the discrepancy of opinion which has hitherto existed, and still exists, concerning its etiology, is due to the difficulty of diagnosing the many different varieties of the disease. The point, however, which has especially to be borne in mind is this,—that sewers often become the real channels by which the contagium is propagated. The sewer-air, laden with the specific poison, readily finds its way into houses on account of its greater tension, and in consequence of badly-trapped or imperfectly-ventilated drains. It may be inappreciable to the senses, but its baneful effects make themselves felt none the less, and, as recent events have shown, may sometimes exhibit themselves in the most exalted stations of life. Indeed, it would appear that persons of the upper and middle ranks in towns are more liable to be attacked by enteric fever than the poorer classes, and for this reason—the houses of the former are more generally connected with sewers, and, either from structure or situation, are of higher elevation, so that the light sewer gases, in obedience to natural laws, are more apt to accumulate in the drains of such houses, and when the drains are not efficiently trapped or ventilated, to effect an entrance into the houses themselves. Thus it happens that a system of sanitary engineering which is intended to prevent, and does prevent, the development of disease, not unfrequently furnishes the readiest means for its propagation. All this, however, could be frustrated if sewers and drains were always properly ventilated.

"One other point connected with the propagation of enteric fever deserves notice:—It seems to be clearly established that the disease may be contracted by inhaling the effluvia from enteric stools previous to their being disposed of, and hence the necessity of disinfecting all such stools so soon as they are passed."—*A Manual of Practical Hygiene, by E. A. Parkes, M.D.*

"Amongst other serious consequences of fæcal emanations, the occasional spread of cholera, and the occurrence of autumnal diarrhœa, are specially to be noted. The outbreak of cholera in the City of London Workhouse, in July, 1866, was shown by Mr Radcliffe (*Ninth Report of Medical Officer of the Privy Council*) to have taken place, in all probability, in consequence of a sudden efflux of sewer-air from a drain containing choleraic evacuations. Autumnal diarrhœa, again, is found to prevail when the season is warm and dry, and more particularly in badly-sewered districts. In speaking of this subject, Dr. Murchison says, that 'circumscribed autumnal epidemics of enteric fever are often preceded by an increase of diarrhœa, and the diarrhœa reaches its acme long before the fever does.' After heavy falls of rain the sewers become well flushed, and the diarrhœa subsides."

Diphtheria is a disease peculiarly fatal to children, and owes its origin to the breathing an atmosphere tainted by putrefying sewage, or, as it is commonly called, sewer-gas. The Public Health Association of New York have come to the conclusion that it selects certain localities subject to 'certain conditions of soil, drainage, and sanitary wants of dwellings, which admit of preventive measures.' Mr. Oakeshott, the medical officer of health for Hornsey, has traced the cause to the escape of sewer-gas into houses. One case occurred at a small school held in a room ten feet square with a sink in it. The traps to this sink were defective, and the rush of sewer-gas into the room was from two to three cubic feet per minute. Again, on examining the National Schools at Fortis Green, where the disease had appeared, he found a pit in the rear full of foul soil, the stench being very bad. The married-quarters of the Royal Artillery on Woolwich Common, consisting of a row of badly-drained cottages, had to be cleared of their inhabitants in the spring of 1875, owing to the fatal prevalence of this disease.

"Danger may arise from the tampering of an ignorant workman with a system he does not understand; or stoppages may occur from various causes, which may produce evils that ought to be carefully guarded against, and such a system of safety-valves introduced as may obviate the chance of evil to the inhabitants. The pipe system of impermeable sewers is the best system, provided it is constructed on safe and really scientific principles, otherwise it is a delusion and a snare; like a watch or a steam-engine, it must be made and repaired by skilled workmen who really understand its management, and not the class of men usually employed, who are generally bricklayers' labourers—otherwise, the more perfect it is in theory, the greater will be the danger if it becomes imperfect or defective in practice. In all places a large number of new houses, as at present constructed, are not safe. They are like bell-glasses over the sewers; and in wet weather, when sewer gases are most developed—when it happens that every window is closed, and every care is ignorantly taken to keep out the healthy invigorating fresh air—the top rooms become receivers of a subtle poison, which, acting upon the sleeping inmates, sets up an attack of the disease called enteric or typhoid fever. The very impermeability of the pipes becomes, in the cases referred to, an additional danger. It is absolutely necessary that provision be made in every case against the possibility of such escapes; by no accident should the circulation of air be possible from a sewer into a house, and simple means may always be taken to avoid such a mischance.

"Not only may enteric fever be produced by sewer gases, but a long list of other maladies may be distinctly traced to the same cause,—the effect of such emanations varying according to the rapidity of their production; the character of the air as to moisture, heat, and electrical state; and the constitution of the individual, as well as the kind of gas evolved from the sewer. The complete removal of all local nuisances from our town, other than those produced by reason of imperfect house drains, has taken away a large number of causes of disease, which still exist in other places, and thus rendered causation less compound. So far as well-to-do people are concerned, the medical practitioner is enabled to put his finger upon the causation of disease, much more easily than can be with certainty effected in other places, which have not yet carried out a good drainage system, and introduced a pure water supply. It may happen that in a given case the evolutions continue long enough and are concentrated enough to produce typhoid fever. In my own family the exposure continued for three days, and struck down the two weakest persons in the house. In the case of a large school, upon one of the chalk hills a few miles to the south of the town, upwards of 50 cases occurred out of 120 inmates, after some weeks' exposure, but not simultaneously; and in the 20 fatal cases I personally enquired into, which occurred in October, 1865, the exposure lasted at anyrate for some days. In all these cases it may be noted that the smell was not great.

Sometimes a persistent diarrhœa arises and cannot be cured. The patient comes over and over again with the same symptoms, and often blames his medical attendant for not curing him, until at last the cause is suspected, and with its removal the disease is cured, or a change of air is recommended and is successful. This is especially the case with young children said to be teething: the upper rooms of the house in which they sleep act as receivers for the gas; the nurse possibly closes the register of the chimney, and fears to open the windows, and thus, towards the early morning, the air becoming loaded with the cause of diarrhœa, the disease begins afresh, and several actions occur before the morning is advanced enough for the windows to be opened. I am always suspicious of those cases in which the diarrhœa occurs in the early morning, abates throughout the day, and does not yield to medical treatment. The same cause (sewer gas) is sometimes the reason why convulsions frequently recur in teething children. If teething alone were sufficient, every child would be liable to them. Since my attention has been directed specially to the condition of the house drains, I have seldom had convulsions recurring in the same family more than once. In many cases it has happened to me to discover an imperfect or unventilated sewer, coexistent with convulsion, and the removal of the one has quite prevented the recurrence of the other. Obstinate indigestion is sometimes caused by sewer gas; and those terrible headaches, ending with sickness, from which females more frequently suffer than males, are often due to similar causes; and when persons who are so afflicted are not easily cured, their medical attendants would be well advised to look to the house drains. Palpitations, obstinate so-called nervous coughs, nightmares, and sleeplessness, may be entirely caused by such; and the difference between life and death in many acute diseases, may arise from the presence of some one of the various sewer gases which are at different times evolved.

"In one family, residing at a beautifully-built house, standing in its own grounds, entirely separated from any communication with other people's sewers, it happened that several of the children were ill, at the same time, with diarrhœa or frequent attacks of vomiting, and one child aged 16 months had convulsions. I drew the attention of the owner to the sewer, and all was supposed to be remedied by a trap which was placed upon the communication with the upstairs waste-pipe, from whence it was said that smells sometimes arose. Certainly the smell was removed, and the children were healthier; but two years afterwards a similar state of things arose,—another child had convulsions, a servant had mild fever, others had diarrhœa, and all the children had slight feverish attacks lasting a few days. In this case every precaution had been taken by one of the most eminent firms in London; everything was trapped, it was said most efficiently, but it was forgotten that gases cannot be sealed down by water. I examined into the case most thoroughly, being convinced that a serious error existed. The cesspool was found to be hermetically sealed and perfectly full, so that the sewers became simply elongated cesspools, and the highest points in the soil-pipes became the weakest points, and doubtless let the foul air escape into the house. The opening out of the cesspool removed the smell which had existed, and led to the introduction of proper safety valves, which will for the future render such mischief impossible.

"Another result of sewer poison is an eruption of furuncular spots or boils; carbuncles will also follow. I remember after the various epidemics of fever that I have witnessed, I have observed that some persons escaped the fever, but suffered from a succession of boils. Some members of a household had fever, with eruption of boils, as crises of disease; and similar boils have appeared in those not laid up by the epidemic. In the case of one school, every boy who did not have the fever had boils, some long after the fever had disappeared. It appears to me that the weaker constitution suffered from the fever; the stronger threw out the poison, through the medium of the cellular tissue. Probably many of those cases of recurring boils, which sometimes trouble medical men to cure, owe their continuance to the inhalation of sewer gas, in larger or smaller quantities, when the body is not strong enough to resist its influence, but strong enough to prevent a complete attack of fever."—*Hints on House Drainage, by Alfred Carpenter, M.D.*

Mr. Morley, surveyor of Carlisle, sent out circulars making inquiries as to population, acreage, length of main sewer, average distances between manholes, number of manholes, whether ventilated and how, general system of ventilation, whether tall chimneys and rain-water spouts are utilised for ventilation, average extent of daily supply of water per head, the number of water closets, private house drainage, method of flushing sewers, disposal of sewage, and velocity of travel of the sewage. Dr. Yeld, Sunderland, had stated that in that town there are 1,000 open ventilators placed forty yards apart, and that no inconvenience results from them. At Smethwick, near Birmingham, at Walsall, Lincoln, Tipton, Dudley, and many other places there is not yet any system of main drainage in operation; and that is the case even at Bradford, where the authorities are about to apply for borrowing powers. At Doncaster, with an estimated population of 20,000 and an acreage of 1,690 (rather more than that of Carlisle), the length of the main sewers is 9 miles, average distance between manholes about 100 yards, all manholes ventilated, no charcoal used in the cylinders, and in addition to the manholes there are metal shafts used for ventilators. There are very few water-closets compared with the size of the place. At Bilston the manholes are all ventilated in direct communication with the streets, and no effluvia rises. The same is done at Wolverhampton (population 72,000) where tall chimneys are not used for ventilation, where a hose is kept for flushing sewers when required, and where the water-supply is 18½ gallons per head per day. At Rochdale (population 70,000, length of main sewers 10 miles) a manhole is placed at every change of line or gradient and at every junction of streets. All the manholes now put in are ventilated, but some of the old ones are not. No charcoal boxes or side chambers are used, and no inconvenience is felt. All new private drains are ventilated. The rate at which sewage travelled there is 3 to 12 feet per second, and the water-supply is 13 gallons per head per day. At Kendal, with a population of 14,200, acreage 2,621, though the town proper only covers 450 acres, the main sewers are 7½ miles in length, and the average distance of manholes is 170 to 500 feet. All the manholes are ventilated, and side chambers but no charcoal used. Tall chimneys and rain-water spouts are not utilised. Velocity of the sewage 128 feet per second; water-supply 25 gallons per head per day. At Kidderminster the ventilation is by open gratings over the manholes in the centre of the streets. At Henley the same system has been adopted, with cans suspended to catch the rubbish that falls through instead of side chambers, which are thought to interfere with ventilation and certainly add to the cost. These are specimens of one class of replies received, but many contained no information of any value to the Carlisle authority, others had no sewer system, others a sewer system but no means of ventilation, others just beginning to ventilate by putting open girds on new manholes, and so on. A few reported that they ventilate by means of metal shafts run up above the gables of houses, a few use rain-water spouts where they do not come within a certain distance of windows. The supplies of water vary from about 13 gallons per head per day at Rochdale to 48 gallons at Salisbury and 50 at Wakefield. On this point Mr. Milburn suggested that probably a brook ran through each of the towns and the authorities reckoned the whole of that water as a supply. At Croydon, with a population of 63,000, 900 manholes about 150 yards apart, open grids without charcoal are used and no inconvenience arises. The water supply is 45 gallons, and the rate of mortality rarely exceeds 18 per 1,000 per annum. At Over Darwen only one manhole at the highest point is ventilated."

The whole subject is well-treated in *The Times*, September 22nd, 1876 :—

"We have expended enormous sums of money of late years on the efficient drainage of towns and the proper construction of public sewers, and, no doubt, our efforts have resulted in incalculable benefit to the community at large. But while we have been directing all our energies to the task of carrying off the refuse matter which reaches our sewers, and disposing of it in a harmless, if not in a profitable, manner, we have as yet taken little thought of the means whereby the matters we want to get rid of are to be conveyed innocuously from our houses to the sewers. It is much easier to reform town drains than house drains ; the former are made to be got at easily, and at the worst can always be reached at the cost of a temporary suspension of traffic. But house drains, especially in old houses, are to be found no one knows where, and even in new houses the perversity or ignorance of builders often places them where they are practically inaccessible. Out of sight out of mind is too often the easy-going maxim of builder and tenant alike, and it is frequently not till another sense is forcibly called to take cognizance of what the sight has neglected that the householder finds, to his cost, that the drains are out of order. Few builders can be trusted to make the connections between the house drains and the public sewers satisfactorily, and, unfortunately, it is a matter which most architects seem to think beneath their notice. But even if that particular matter has been thoroughly attended to, the danger is by no means at an end. *All house drains need to be ventilated*, and wherever it is possible their connection with the external sewer should be broken by a simple expedient, known to all builders, but, unhappily, adopted until quite recently by few or none, Thus in too many cases the improvement in public sewers has as yet been a bane as well as a benefit, because it has not been accompanied by corresponding attention to sanitary precautions within the house.

"It cannot be too strongly insisted on that the universal extension of a general and public system of drainage in large towns calls more imperatively than ever for vigilant attention to domestic sanitary arrangements. Formerly, when every house more or less disposed of its own drainage, though matters were bad enough, yet the extent of the mischief could generally be measured. Now, however, each house, unless specially protected, is exposed to the attacks of the sewage of the whole town, and yet, as a rule, no greater precautions are taken than heretofore to keep the enemy at bay. The evils to which the unwary householder is exposed are neither few nor easy to guard against. If his house is an old one, drains are hidden away in a manner which conclusively proves that malice is no match in ingenuity for ignorance. Some of them are sure to be found with all connections closed save that which furnishes them with a constant supply of noisome and fetid matter. Sometimes the outlet of the old cesspool is closed when the house is connected with the public sewers, but the builder has carelessly left open to the house all the old drains which formerly fed the cesspool; or the new drain is laid with a broken pipe or a defective joint, and fills the house with stench and poison. Indeed, where a house has exchanged the old system of drainage for the new, it needs an almost superhuman vigilance to guard against the various and subtle sources of future mischief; yet the task is generally left to a careless builder and to blundering workmen. In a new house the dangers are not, perhaps, so numerous nor so difficult of detection, but they are real and serious enough. The great object of builders seems to be to get the drainage out of the house in as closely sealed channels as possible. This is a good thing with proper precautions, but they forget or refuse to acknowledge that where water can pass gas can pass too, and that while the natural flow of water is downwards, *that of this particular gas is upwards. Consequently, the drains, unless ventilated as well as trapped, are so many channels whereby sewer gas is laid on to the interior of the house.* Now, sewer gas has a very bad character, and for all we know its character may be worse than it deserves; that, however, is not a question for us, and the connection of sewer gas with specific disease we are content to leave to professional experts. At any rate, all will admit that sewer gas is a very unpleasant companion in a house, more especially when a good deal of money has been paid to keep it out. Yet, with all our efforts at sanitary improvements, there are still very few houses in towns where it is not at least an occasional visitor. Builders will insist on the efficacy of water traps and cemented pipes, and, no doubt, such expedients are good so far as they go. But, of course, gas will pass through water under sufficient pressure, and, not to speak of the pressure which the unaided gas often exerts on the outside of the trap, it is often powerfully aided from within by the difference of temperature which exists between the house and the external drains. In fact, we not only lay on the gas from the large reservoirs we have constructed in every street, but we often turn our houses into ingenious pumps to suck it in. The remedy for this is not only to trap all drains, *but to ventilate them as well. If from below the trap a pipe rises to a convenient distance in the open air, the gas is forced through it whenever the pressure becomes excessive, and the trap, relieved from this pressure, becomes a protection, and not a snare.* This remedy is as simple as it is effective; yet it would be interesting to know the per centage of houses in any large town whose most noxious drain pipes are ventilated as well as trapped.

"Even if all new houses could be effectively drained, the danger would still beset us in our present habitations. We cordially sympathise, therefore, with the efforts of the Society of Arts, for nothing but benefit can come from a public discussion of the question, from the interest it will arouse, and from the knowledge it will diffuse."

As without a plentiful and constant supply of water the most scientific and complete system of sewerage is a nullity, so the experience of all large towns which enjoy this inestimable benefit indicates the water-closet system for the removal of fœcal matter, and the uniting with this of slop water and the refuse of kitchen sinks, for removal by water carriage through a system of drains and sewers to a destination suited to the locality, as best adapted to meet the wants of urban people. It is on the whole likely to be attended with less difficulty in its details, and more efficiency when applied to all sorts of houses and all classes of population, than any other system of removal yet devised. "Looking at the question in all its bearings, I am forced to the conclusion that the water-closet system will supersede all others, while I believe that I shall be able to show that, agriculturally speaking, it is the best and most profitable." —Menzies, *Treatise on the Sanitary Management and Utilization of Sewage*, page 8. "A good water-closet is the only appliance fit to be used within a house, for by it all matters are at once conveyed away, and cease to have the power of producing evil, so far as our houses are concerned."—Baldwin Latham, *Sanitary Engineering*, page 328.

"The advantages of the water-closet system, where it can be adopted, and will be properly worked, are, as regards the extremely important object of getting the refuse continuously and completely removed, too evident to require advocacy. Those advantages, however, may fail to be realized if the system be adopted without due circumspection; and the conditions which ought to be kept in view in order to avoid any such failure are, apparently, these three: First, that the closets will universally receive an unfailing sufficiency of water properly supplied them; secondly, that the comparatively large volume of sewage which the system produces can be, in all respects, satisfactorily disposed of; and, thirdly, that on all premises which the system brings into connection with the common sewers the construction and keeping of the closets and other drainage relations will be subject to skilled direction and control.'"—Simon: *Report of the Medical Officer of the Privy Council and Local Government Board*, 1874.

In the Report of the Local Government Board Committee on the Disposal of Town Sewage with respect to the use of the water-closet, the case may be thus stated. All parties admit that towns must be sewered, and that houses must be drained to remove surface-water and waste-water from dwelling-houses and factories; this being the case, these sewers and drains must be of cross-sectional dimensions sufficient to remove not less than 30 gallons per day, in dry weather, from each inhabitant, and the capacity ought not to be less than five times this to provide for occasional rain. All sewers and drains receive more or less of sediment, washed from roofs, yards, sinks, channels, stables, slaughter-houses, cow-sheds, and manufactories, and along sewers truly formed the entire contents pass day by day to the outlet, and where water-closets are used the entire excreta, solid and fluid, with the contents from the chamber utensils and slop pail, pass at once silently and imperceptibly with the sewage to the outlet, there to be dealt with under one set of operations, avoiding every form of secondary intervention involved in a use of dry-earth pan and pail. The entire of the excreta, in proportion to the sewage in dry weather being, by volume, as 1 of excreta to from 100 to 150 of sewage; and in wet weather, the proportion is of course much greater, consequently, in every portable form of dealing with excreta, by the dry-earth or tub and pail systems, the bulk and weight is formidable, and the removal costly, whilst in the water drainage system this bulk is unimportant, because it is only fractional. With respect to the supposed nuisance and danger arising from water-closets, proper construction and use render any atmospheric or other taint within the house absolutely impossible, and the sewage flowing daily in a fresh state from the closet-pans along fully ventilated sewers gives no injurious taint. There must, however, be no drains nor openings into drains within the houses. Sink-pipes must discharge over or into a drain outside, and water-closets must be against an external wall, connected with a soil-pipe, which is carried above the roof; the upper end to be fully open, and the water-closet rooms must have a daylight window, and fixed means for permanent ventilation to the external air at the ceiling. With such arrangements, and a good supply of water, one of the best water-closets will work with perfect safety, and may be, what such places should in all cases be—private. The mode of dealing with the sewage at the outlet, is in no way complicated nor rendered more difficult to deal with by the addition of the excreta from the water-closet; indeed, if the sewage is used in irrigation, it is dealt with to much better advantage, as the fluid is richer by so much manure. Bedford, Leamington, Croydon, and Cheltenham are cases in point, where the entire populations use water-closets, and the sewage is also used in irrigation for purposes of agriculture. That water-closets can be used on the greatest scale by an entire population, is further proved in the case of London, where, for 3,600,000 population, there is, on an average, one water-closet to each 5·5 of the inhabitants, or about 700,000 waterclosets are in use.* The excreta passed daily from London may be estimated at 4,000 tons, and to remove this in tubs or pails to a distance of five miles, would cost about £1,000 per diem, or £365,000 per annum. The daily volume of sewage and excreta of London weighs about 600,000 tons, and this flows along the drains and sewers to the outlet at no cost but that of pumping, which is about £36,000 per annum. In many towns this cost would not be necessary, as the sewage will flow to the outlet, but in every case of the dry-earth tub or pail systems there must be the cost of hand-removal and carting.†

The water-closet system has its weak points, however, and much remains to be done towards avoiding the dangers incident to its mismanagement, and towards perfecting its details, before reverting to which we purpose making some remarks on drains and traps.

DRAINS BETWEEN THE HOUSE AND SEWER OR OTHER RECEPTACLE.

The prime object of house drainage is the removal of the refuse with all possible speed; every device, therefore, by which

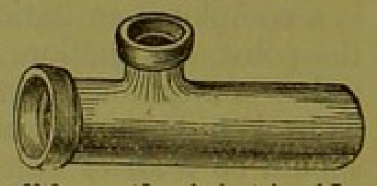
* With respect to water-closets, soil-pans, and urinals, no water-closets, soil-pan, nor urinal should be supplied with water through a screw-down cock, stool cock, or lever handle, direct from the water-main, but through a service-box or water-waste preventer.

† The late Dr. Parkes, F.R.S., made exhaustive experiments with disinfectants, and found that it would cost about threepence for the chemicals to disinfect one gallon of putrid excreta, so that the disinfection of 4,000 tons per day of London refuse would cost £11,200, or at a rate of £4,088,000 per annum, leaving the 600,000 tons of sewage per day (or 219,000,000 tons per annum) untreated. These figures only serve to show the extravagance of disinfectants: as, also, that the small doses of Condy's fluid, or of any other fluid or solid, passed down sinks, water-closets, drains, and sewers can practically have no beneficial effect. Foul drains and sewers can only be disinfected at a cost proportionate to the weight and volume of excreta and sewage in the drains and sewers, and this we see would be enormous; they must be flushed with water. Disinfectants may be used with advantage in hospitals, in sick-rooms, and in stables; they may also be used by butchers and by others, but they will be practically useless in cesspools, if only small doses are applied; and it is to this fact attention is intended to be directed. The vestries are only wasting parish rates when they send round carbolic acid to be poured down street gullies in tablespoonfuls. The foul gullies, drains, and main-sewers may require cleansing, and, if so, should be cleansed by flushing, as a use of chemicals for the purpose will be out of the question, on account of the enormous cost of such applications.

any part of it is hoarded or retarded in or about the premises is to be carefully avoided. Hence, cesspools are an abomination.

Connection of House-Pipes with the Drains.—It is a lamentable fact that thousands of houses are built every year, violating every law of sanitary science and the commonest rules of drainage. It is customary to commence the drains at the basement of the house, and the sink and closet pipes pass down inside the house and join on, a water-trap being placed at the junction. As the aspiratory power of the warm house is then constantly tending to draw air through the water-trap, and as the trap is liable to get out of order, it is most desirable to alter this plan. The drains should end outside the house, and, as far as possible, every house-pipe should pass outside, and not inside or between walls, to meet the drain. The object of this is that any imperfection in the pipe should not allow the pipe air to pass into the houses. At the junction of the house-pipe and drain there should not only be a good water-trap, but one of the plans proposed by engineers should be adopted, by means of which there is a complete ventilation and connection with the outside air at the point of junction. The rule, in fact, should be that the union of any house-pipe whatever with the outside drain should be broken both by water and by ventilation. In addition, it should be a strict rule that no drain-pipe of any kind should pass under a house; if there must be a pipe passing from front to back, or the reverse, it is much better to take it above the basement floor than underneath, and to have it exposed throughout its course. It is hardly possible to insist too much on the importance of this rule of disconnection between house-pipes and outside drains. Late events have shown what a risk the richer classes in this country now run, who not only bring the sewers into the houses, but multiply water-closets, and often put them close to bedrooms. The simple plan of disconnection, if properly done, would insure them against the otherwise certain danger of sewer air entering the house. Houses which have for years been a nuisance from persistent smells have been purified and become healthy by this means.

To secure a prompt and continuous flow, drain-pipes should be smooth inside, well laid, of proper size, and have sufficient fall to render them self-cleansing—whenever this is not practicable there should be provision for frequent flushing—they should be made of glazed stoneware, the joints well luted with hydraulic cement or proper clay, carefully bedded on concrete in all loose soils, and on well-worked puddled clay on clay soils; sometimes, in very loose soils, even piling for the depth of a foot must be used besides the concrete. When pipes are not laid on a good foundation leakage is sure to occur sooner or later, and the final expense is far more than the first outlay would have been. The spigot and socket pipes treated with a clay fillet often become loose, the filling at the top being sufficient to force out, by its weight, the clay at the bottom, leaving an aperture through which the sewage finds escape into the soil, thus percolating the subsoil and contaminating the basement of the house, the air from thence being insensibly drawn into the house by the suction of the fires, when the house is shut up in cold weather; a cement joint is by no means perfect; an elastic luting is the only satisfactory jointing. Doulton and Co. manufacture Stanford's Patent Joint for Pipes, which is made by casting, upon the spigot and in the socket of each pipe, rings of durable material, which, when put together, fit mechanically into each other, as in a bored and turned joint. This joint is absolutely watertight; needs no skilled labour in fixing; allows of slight settlement of the pipes without injury; and requires neither cement, clay, nor other extraneous material, the pipes containing a perfect joint within themselves. The connections or branches should never be at right angles (as the T or square junction, see Fig.) as this tends to produce an accumulation of solid matter, but the Y curve or oblique junction (see illustrations at end) should be used. The surplus



cement or joining matter should be wiped off from the joint inside, or a good drain may be entirely choked by sewage accumulating against burrs of cement inside the joints. If any drain pipes be laid inside the house—and in crescents and streets this is unavoidable—the pipes should be laid on a bed of concrete, and covered over with a few inches of the same material. When the drain-pipes pass through the walls a relieving arch should be turned over them, for if a settlement should take place in the building, the super-imposed weight will, in all likelihood, crack the pipes, and cause the drain to leak at a most dangerous place, perhaps breaking them, causing the greatest annoyance. A frequent mistake is often made in laying too large-sized pipes for drains, arising from the notion that small pipes are more likely to be choked; all increase of size above the requirements of capacity is detrimental by diminishing the scouring power of the current. If rain water is admitted from the roof-gutters either for convenience or flushing, a larger size is perhaps needed, but six inches is ample, even then, for any ordinary house-roof. Latham says that in order to be self-cleansing, the house drain should convey its contents at the rate of three feet per second. To attain this velocity a four-inch drain must have a fall of about 1 in 100, and a six-inch drain 1 in 140, even when half full; as such drains seldom run half full, they cannot be relied upon as self-cleansing, unless laid with nearly double the above rate of slope. When used for rain water this should govern its size, for the volume of sewage is quite insignificant compared with that of the rain water.

"1 in 48 is frequently given, or ¾-inch in every yard; a fall of 1 in 65 in drains of 6 inches diameter, and 1 in 87 in drains of 8 inches diameter, will give a velocity of 220 feet per minute."—Parkes, *op. cit.*, p. 344.

"Some authorities formerly recommended a quarter of an inch fall to each foot, but the best practice is to allow a fall of 2¾ inches or 3 inches to every 10 feet.—Eassie: *Sanitary Arrangements for Dwellings*, p. 23.

A large pipe should never deliver into a smaller pipe, or even into one of the same diameter. In laying down a system of drains to a house, &c., it will often prove beneficial and save much expense on some future occasion, if what is called a dummy be here and there laid in the course of the drain, the orifices of these junctions being stopped up with the disc-plugs sold for the purpose.

When there is a smell of drains in the house, and the presence of rats—proofs of defective drains—one is often asked the question, Who is to put defective drains to rights? If the tenant has a lease, most likely (without he has a philanthropic landlord) if he requires the drains made good, he must do so at his own expense,—but if he is only a yearly tenant and demands that the landlord shall make the drains good, most likely all the landlord will do is to block up the rat holes with lime and broken glass;—and if the tenant proposes to do it at his own expense, without he is on the spot to watch the British workman, it is likely to be scamped and improperly done. The Local Board of a town should be able to compel drainage to be thoroughly and perfectly finished.

Over and over again have our sanitary engineers recommended that proper plans of drains be made by the house-owner, and furnished to the tenant. The *Builder* returns to the charge, and suggests, through a correspondent, that it should be made compulsory on the landlord to attach to the lease a certified plan, showing the nature and direction of the drains. The tenant would by this means be saved much of the expense and inconvenience experienced at present, when, suspecting something wrong in his drains, he has to rip up half the flooring of his basement to find them, simply because the workmen have no guide by which they can be traced from the outside. It is already becoming a very common custom for sellers of houses to furnish the buyers with drain plans, and equally so for lessors to supply them, when they are in existence. We would go further than most people, and insist that a plan should be made a fixture upon the walls—framed, glazed, and varnished, and by this means yearly and even quarterly tenants would enjoy the advantage.

Such things as unknown courses of drains, possible cesspools, etc., are the bane of old houses especially. In one house it was found "that the pipes used were the ordinary old porous pipes, and that the whole ground appeared to be permeated with the odour of drains." Such things ought not to be found under any Local Board, and the public should require of them not to be satisfied until it can be shown beyond a doubt on paper and by actual inspection that every closet and drain within the district is properly connected with the main drainage.

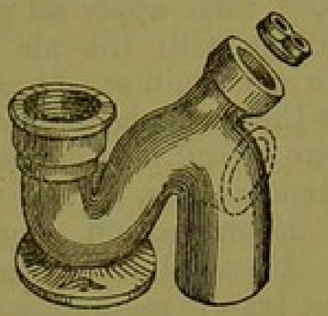
In the work entitled "Healthy Houses," by Mr. W. Eassie, which was published in 1872, we find the author going even a little beyond what we have lately noticed, and stating that the owner should not only receive from the architect plans with the direction and depth of the drains marked on, and that it should be compulsory for a landlord to furnish such plan, but—and here is a point to be looked at, we think—that it should be perhaps "made penal for the tenant—even on a building-lease —to divert or add to the drains without furnishing the landlord with a plan, showing the altered or added line of pipes, and that this plan should be certified as correct by both parties." Does it not often occur to surveyors in practice and others that, when they are handed over a drain plan, ostensibly correct at one time, they find it perfectly useless owing to the drainage having been diverted by a former tenant? The landlord knew nothing of this alteration; the house agent never insisted on a plan of it; and as for the tenant who ordered the work, and the builder who carried it out, they are dead or otherwise *non est.*

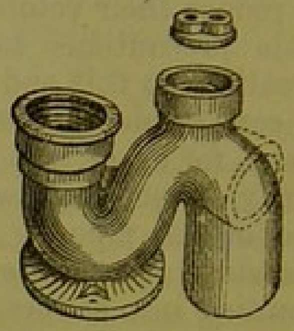
Drains, as we have frequently learnt from the reports of the Inspector of Nuisances, are too often abused and made the receptacles of bricks, broken crockery, grease, shavings, bottles, toys, chignons, linen, sponges, rags, india-rubber balls, shoes, and old tinned provision cases. Increasing the size of the drain is no remedy for such abuse, which would choke a street sewer, and is only to be met by the gradual education of the public in the value of Sanitary Science and Preventive Medicine.

Traps.—The smaller the drain, then, which will carry the largest flow with which it is likely to be taxed, the better is the scour, and the more likely it is to keep clean; any accumulation of sewage in the pipes will decompose and give rise to abundance of poisonous gas, which it is difficult to keep out of houses. It cannot be expected that the interior of sewers and drains should always be free from such gases, but it is by all means desirable to reduce their volume to a minimum, and then apply all possible precautions to prevent their mixing with the air we breathe; to this end traps are used. To a certain extent, and in certain places, they are essential; but there may be too many traps, for every trap in the line of a waste or soil pipe is necessarily a place for sewage to be arrested temporarily, and, if the use of the pipe be not very frequent, decomposition occurs, evolving gases deleterious to health. In all houses, then, draining into sewers, the place where the trap is most essential is outside the house walls, on the main house-drain, after it has collected all the branches which are tributary to it, and between this point and the sewer, and the importance of which has been previously adverted to.

The use of traps on every waste pipe inside of a house is a point upon which there is some difference of opinion. If the outside trap upon the main drain is well constructed and ventilated, there is somewhat less importance to be attached to those on each separate waste-pipe. Dr. O. Reynolds—*Sewer-gas, and how to keep it out of houses*—thinks they may in most cases be safely dispensed with. Every waste-pipe, however, becomes lined with a slimy film, which in hot weather decomposes, and gives off offensive effluvia. The difference of temperature in different parts of a house, and the impulse of the outside air, would always keep up draughts through waste-pipes if not trapped, passing down one orifice and up another, so that a dwelling-house can hardly be considered safe unless traps are provided at every waste somewhere within ten feet of its orifice. The chief objection to traps, except their cost, is that they delay or hinder, to a certain extent, the rapid efflux of the sewage, and keep a small quantity of it shut up to decompose within themselves. Moreover, there is always a column of air in a waste-pipe between any two traps in the same line of drainage. Care must therefore be taken to give this column a free connection or vent to the atmosphere, so that its tension may always be in equilibrium with the atmospheric pressure. Without this sytem of vents the traps are worse than useless, and deserve their name from the disappointment that would be be sure to follow their use.

The best form of trap is that which gives least obstruction to the flow of the sewage, and requires the least quantity of water to insure its seal. All square corners tend to promote an accumulation of sediment or slime, which should be avoided. No form of trap is so simple as the ordinary S-bend. Its calibre should be about as large as that of the pipe of which it forms a part, with continuous smooth lines. In Doulton's Improved Ventilating Closet Traps two small pipes are tapped into the





nozzles of the ventilating cap, and carried through an external wall, securing perfect and continuous ventilation. When a waste-pipe is expected to carry at times a full stream of water, as from slop-sinks, wash-trays, and bowls, there is risk of having the traps siphoned by the last water passing down, unless they be provided with a vent hole at the top and this must of course have a pipe to carry its effluvia to the top of the roof.

The position of traps is a matter of some importance. If close to the orifice, as in the common sink well-trap, a slight obstruction of sediment will soon serve as a nucleus for a complete dam; but if two or three feet below the orifice, and directly under it, such a slight obstruction would soon be swept away by accumulation of the two or three feet head of water above. The common bell trap used in sinks, and attached to the strainer, conforms to none of the above conditions, and is a mere subterfuge—" a delusion, a mockery, and a snare." Being close under the strainer no head of water can accumulate to flush it, and its large annular depression is a receptacle of rubbish. In fact, it is usually a mere obstacle to the drainage, so that most cooks lift the cover when they want the water to run off, losing the benefits of both strainer and trap together. I found this so often the case in my London house that I had the strainer, with holes of ample size, soldered down, and the pipe made to discharge in the open air, over a trapped grid; but such is the apathy of the public that even the trivial cost deters.

"There is an important point connected with cisterns: the manner in which the waste-pipe is made occasionally to pass into a sewer. This ought never to be permitted: it is true the waste-pipe may be trapped, but such traps are useless for the purpose intended, unless provision is made for a proper supply of water to the trap. The overflow should not go into the sewer at all, but directly out of the house as a spout, or else discharge itself upon a sink. No connection should be made with the sewer except for sewage purposes; and waste water from a bath or cistern cannot be regarded as such. I should advise every one, therefore, to have the overflow pipes of his cisterns examined, as well as the waste-pipes from all wash-hand basins and baths, now so generally introduced into first-class houses: they ought not, in any case, to communicate except indirectly with the sewer. They may remain unused for a time; the water in the trap evaporates, or is drawn off by the syphon action, and the communication is, to all intents and purposes untrapped; it is best to avoid the chance of such an accident, by turning the waste-pipe into an open receptacle outside the house. I have often cured a whole household of persistent diarrhœa and frequent attacks of sickness by discovering the faulty state of the cistern overflow and having it removed, especially in those cases where water is used for dietetic purposes, drawn from the cistern. The cistern is usually fixed in the water-closet, and even if the overflow is rightly placed, the surface of the water is a most powerful absorbent of the miasms of the closet, which thus find entrance into the blood, setting up various disturbing actions, according to the constitutional state of the recipient.

"The arrangement for the kitchen sink should be conducted on a principle similar to that recommended for waste or overflow pipes. The bilious headaches and sick attacks to which cooks and kitchen-maids are subject, are very frequently caused by foul air rising from the kitchen sink: they will remove the trap to allow the waste water to flow down more rapidly, or the trap itself gets choked up with grease, and they prefer to keep it off altogether, to poison the household as soon as the doors and windows are closed for the night, and the best ventilators, the fires, are out. This is especially liable to happen in the square houses, with kitchens under ground and sinks within the basement: the poison rises to the sleeping rooms like smoke. It unfortunately happens, also, that it is not the decided stink that is most dangerous; the results of putrefaction are not nearly so fatal as those faint animal odours that indicate organic matter in a state of change; a good stink rectifies itself by compelling ventillation. Even sulphuretted hydrogen will not produce fever: such gases are themselves probably the carriers of the fever poison, rather than the poison itself: some miasm capable of setting up a change in the human fluids, is presented to the breathing apparatus, and absorbed before such miasm has become decomposed into its simpler elements. How far the absence of an active oxidizing agent (viz. ozone) from the atmosphere may assist in this development, is more than I am able to determine; but the coincidence of the absence of ozone, and the rise of fever, is curious."—*Carpenter, op. cit.*

Richard Weaver, C.E., F.C.S., Sanitary Engineer, contributed the following paper to the Social Science Congress, Liverpool :—

"In the absence of provision for sewer ventilation, it is now tolerably well recognised that sewer air does, more or less, find an entrance into any building with which the drainage scheme is connected. Such every-day appliances as bell traps, D traps, syphons, &c., with which ninety-nine per cent. of houses are furnished, having any claim to drainage at all, readily permit of the discharge of gaseous sewage into the various offices of the building they are connected with, either by defective joints or materials, by simply forcing the water-seal, and blowing into the interior; or by the subtiler and more frequent mode of *conduction* through the water.

Where the sewer and drain are ventilated by rain water down spouts, or by the soil or other pipes conveying fluid refuse, by apertures at the upper ends, it is not so widely known that injurious results often follow—nay, amongst jobbing builders and their staff, to whom is generally left the care of the house, it is a standing article of belief that a sewer ventilating into the street, and the drain by an upright pipe, mal-odours cannot exist in a house from this source. A considerable improvement is to ventilate the sewer by one channel, then outside the house wall to introduce a syphon trap, so as to obstruct aerial connection between the house and sewer, leaving, as before, the upper orifices of house pipes open to the outer air. Even this course is not always satisfactory, because air currents within the pipes are often downwards, and the vaporous emissions from foul pipes, and that which passes the syphon by *conduction*, are blown into the house. On this subject the general opinion would seem to be, that given a tube open at its summit, discharging effete matter, there is an upward aerial flow. This, however, is by no means so universally. Charge a pipe with visible and nearly imponderable matter, as smoke for example, when it is observed that the current is as likely as not, downward as ascendant; sometimes it is intermittent, the puffs oscillating up and down alternately. Not unfrequently, it may be noted, the course is fairly uniform in one direction; now again it is in the opposite. With the same pipe under observation, these alternations of aerial currents inside the tube are witnessed; and when a number of pipes connected with different buildings are under experiment, it may be noted that equally confusing results ensue; when the conditions of working are apparently alike, the currents are again dissimilar and erratic. With a wind of moderate pressure, a strong blast descends the ventilator, and blows through, not alone defective joints, but water seals also. I have known houses rendered uninhabitable by this descendant motion of wind rattling down water spouts and soil pipes, up through the closet pans, and sink traps, sucking the sewer air from the lower pipes, and carried forward into the interior of the dwelling. Now, observation has led to the fact that where a proper opening connected with the external air exists near the base of pipes delivering from the house—at a point, however, above the water trap placed beyond the building, which no house ought safely to be without, but which few possess—that no tainted air passes into the interior of that building. There is at all times a current flowing in one direction or the other, which, in calm cold weather, with steady barometer, is barely perceptible. In a hot, calm season, there is a quickened upward flow, whilst with a strong wind, a sharp blast passes either up or downwards. If the breeze blows squarely and steadily across the orifice of ascendant pipe, the blast is upwards, caused by a reduction of pressure within the pipe by rapid passage of a gaseous body over the mouth—as is witnessed in the toy spray disperser. If, however, wind deflections are created by projecting bodies, as gables and chimney stacks, the motion of the air is downwards.

These and other observations, noted years ago in the course of professional practice as a sanitary adviser, led me to provide an opening in the lower exit drain pipes just outside the house to facilitate the passage of air through them, thus cutting off aerial communication with the sewer, except such sewer gas as effects a passage by *conduction* through the water seal of syphon, by means of a trap at a lower point, and reducing the stagnant foul air of the pipes within the house to approximately the same quality as the external atmosphere. This result I always arranged by local materials, and obtained the object in various ways, according to the position and circumstances of the particular house or other building to be treated. In one the end would be achieved by inserting a small inverted syphon, tapped into the soil or other down pipe, externally fixed, with its mouth uppermost, into which a current of air passed. In another the desired result was attained by delivering the sewage over a D or other trap, with the grate removed to the ground line to carry away surface water, and provide for the passage of fresh air into the house pipes. An effective mode is by removing the upper half of a sewer, or drain pipe, building up the sides vertically to the ground, and inserting a grid. At a lower point fixing a syphon, or dished channel of cement, with a lip dipping a few inches into the water.

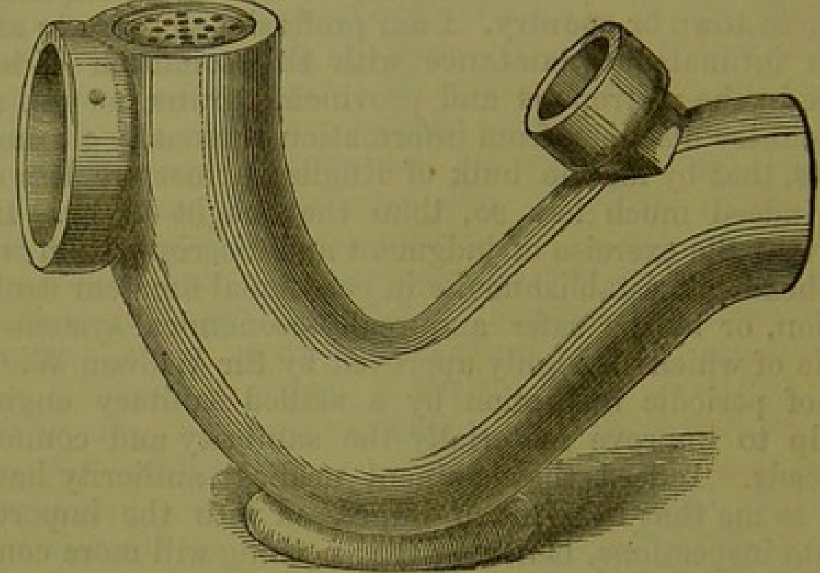
Some three or four years since several of these methods were advised by me at H.M.'s Convict Prison, at Chatham, for excluding sewage gas from the various inhabited buildings there. Owing to peculiarities of site and tidal influences, the sewer emissions in that place were voluminous in quantity, and strong of scent; but the means devised of cutting off direct contact with the sewers, and the circulatory system of ventilating drains by introducing air at the lower points above the outer traps, finally prevented contamination to the internal air of the rooms. Extemporaneous ways of the sorts here sketched are equally sure, if carried out under skilled direction, in ventilating house drains and sewers when the vertical pipes are open above; and are tolerably certain in severing gaseous connection between the sewer and the house through the drains. There is, however, a numerous class of persons, very worthy folks, no doubt, and possibly actuated by honest intentions, but whose action, I fear, is oftener more obstructive than beneficial. With these gentlemen the effects of makeshift expedients of the kind described may be the reverse of satisfactory, and constitute all the difference between a healthy and unhealthy home. Having in view the requirements of a large section of householders, and experiencing the difficulty of obtaining a satisfactory sewer gas trap, which is at once economical in cost and effective in action, I have registered a design something similar to the plan and section now exhibited, which in one piece secures the combined advantages just referred to. Conceive, if you please, an ordinary six-inch syphon pipe, with a 3-inch junction attached at the spigot end, with a square slice, about 4″ × 4″ cut out of the upper surface of pipe at the socket end, into which a grate is dropped, and that is what I present, as a cheap, simple, and thoroughly effective house drain trap.

Sewer gas is prevented passing the water seal by force, for it is conveyed away to a convenient outlet through the small junction. Any foul matters—partly gaseous, partly vapourous —the volatile products of organic decomposition within the sewers, effecting a silent passage through the water seal of the syphon by the process I have termed *conduction*, are immediately diluted with a large volume of air fresh from the atmosphere and swept outwards. With the equilibrium of pressure established between each side of the trap, secured by the junction pipe delivering the aerial sewage into the outer air, there is a reduced tendency to absorption of matter by the surface water of syphon on the sewer side; consequently less mephitic air passes the trap upon saturation to be given off again on the house side; but such small quantity as stated is at once mingled with the fresh air, copiously pouring in through the grid, and ultimately discharged into the atmosphere above the house top after flowing through the system of house drains and internal pipes, which are so maintained in a comparative sweet condition.

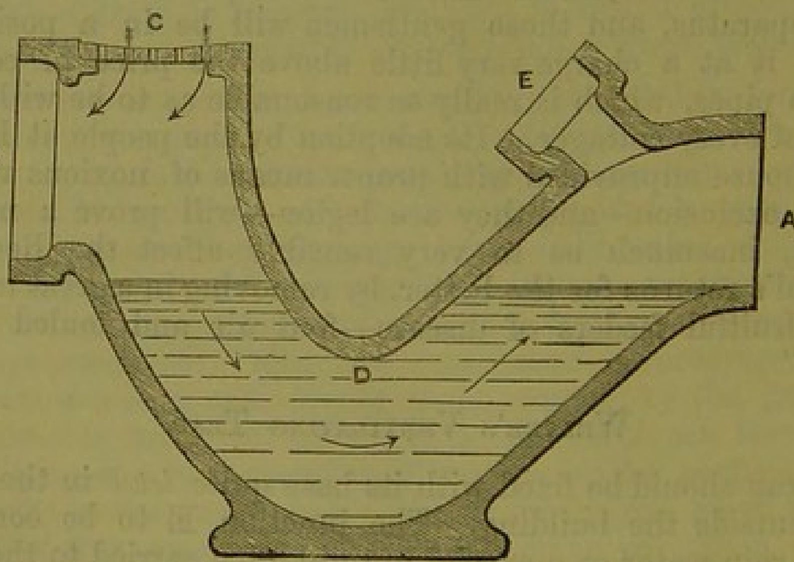
It is a compact convenient form of syphon ventilator suitable for house and sewer purposes, which for efficiency, simplicity of form, economy of space, certainty of action, non-liability to derangement, or stoppage by silting or floating materials, for which the lines and curves are especially designed to avoid, will, it is hoped, meet a universal want amongst householders, whether tenants or landlords, adapted to all descriptions of drainage in town or country. I am professionally able to affirm from an intimate acquaintance with the condition of house drainage in the metropolis and provincial towns, as well as of many country districts, from information personally gleaned on the spots, that by far the bulk of English homes are less salubrious, indeed much less so, than they ought to be. But I believe that the exercise of judgment and discrimination on the part of heads of establishments in occasional amateur sanitary inspection, or by the safer and really economical system—the principle of which is highly approved by Sir William W. Gull, Bart.—of periodic inspection by a skilled sanitary engineer, will help to improve materially the salubrity and comfort of homesteads. Indeed that eminent medical authority has expressed to me that he is much impressed with the importance of private inspections, believing that nothing will more conduce to the health of the community. A large majority of houses are unhealthy through sewer exhalation penetrating into them, but most of them may be improved by using the inexpensive contrivance I have now submitted to you. Messrs. Stiff, of the London Potteries, Lambeth, will take up the manufacture of the apparatus, and those gentlemen will be in a position to supply it at a charge very little above the price of common syphon pipes, which is really so reasonable as to be within the reach of every cottager. Its adoption by the people at large in every house unprovided with proper means of noxious vapoury sewage exclusion—and they are legion—will prove a national benefit, inasmuch as to very sensibly affect the Registrar-General's returns for the better, by removing in a great measure those fruitful feeders of disease—foul air and fouled cistern water."

Weaver's Ventilating Trap.

The Trap should be fixed with its base quite *level* in the line of pipes outside the building. The junction E to be connected with a rain water or a special upright pipe carried to the house top clear of windows and chimneys. The air inlet C must communicate with the atmosphere by pipes brought to the surface of the area or yard, where the grid may be placed to carry off water. If more convenient a pipe may be attached to a wall and carried up a few feet. All soil, bath, and slop pipes must communicate with the air outside the house by short pieces of pipe with open ends pushed through the walls. The lines of the Trap are designed to convey floating and sedimentary matters without obstruction, but if stoppage occurs it is removed by the fresh air inlet C.



EXTERNAL VIEW.

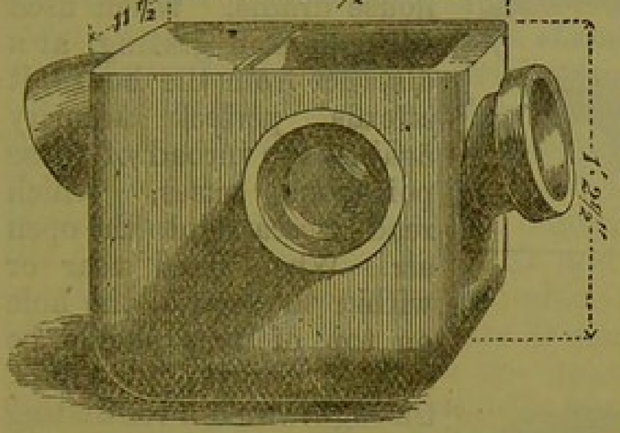


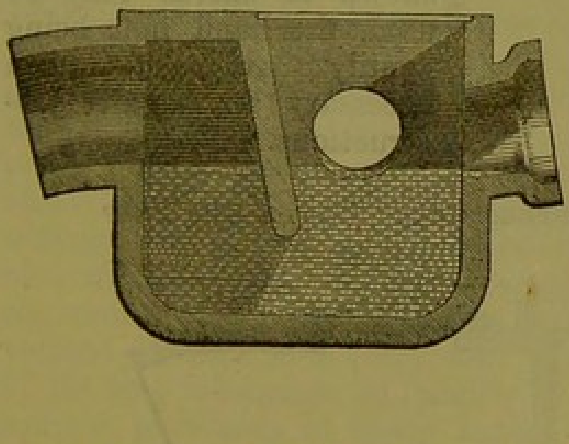
SECTION

A Outlet to Sewer. B Inlet from House. C Fresh Air Inlet
D Dip of Trap, 3½ inches. E Junction to Ventilate Sewer.

Bavin's Dip Traps.

These simple and effective traps can be seen in perfect working order in the areas of two large buildings recently erected on the Bridewell Estate, Blackfriars. They were introduced to prevent the entrance of poisonous gases into houses, &c., from the sewers and general soil drainage. To ensure this, the overflow or waste pipes of all cisterns, lavatories, baths, and sinks, as also the rain water pipes, should be connected with the three 4-inch inlets provided in each of the traps. They are not adapted to receive the drainage from water closets, which should be ventilated by continuing the soil pipe into the open air above the roof. When used externally in areas and yards, they should be provided with a cast iron grating, ten inches square by one inch thick, which can be easily moved when necessary for cleansing or inspection. The grating should be kept about an inch below the paving level, so as to drain off the surface water. When used internally the traps should be kept well out from the footings, and covered with a ringstone, by the removal of which the drains may be occasionally flushed, and the necessity for taking up floors, &c., prevented. If all the inlets are not required, those unused should be carefully closed with disc plates. The trap is formed by the deep diaphragm in the centre of the chamber, which dipping three inches below the water line, forms so strong a seal, that the sewer air, often charged with the germs of typhoid fever, is effectually checked.

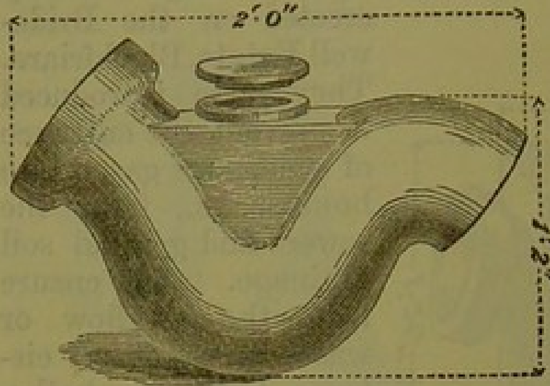


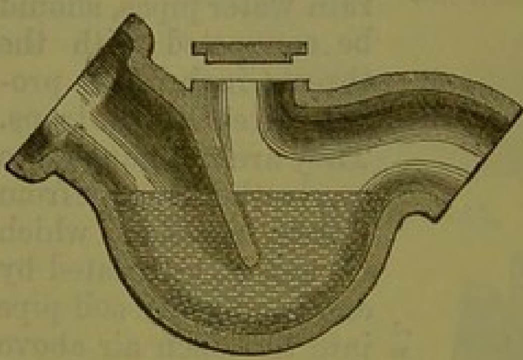


Section of Fig 1.

The Red Hill Trap

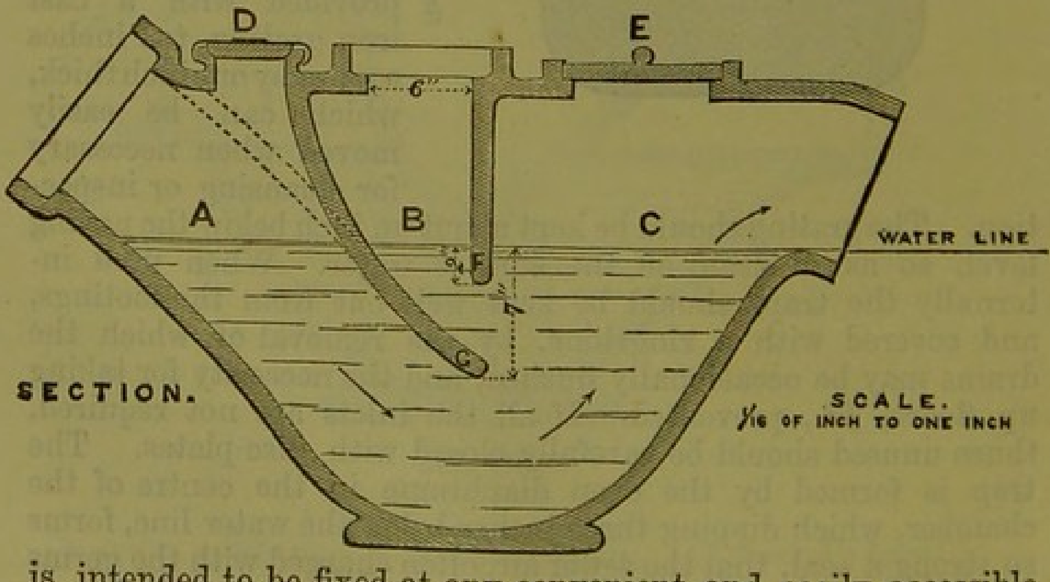
is a very efficient sewer trap, of a simpler kind. It surpasses those commonly made, in the greater depth of the diaphragm below the water line, and the consequently increased protection against the entrance of sewer air into the house drains. When used with an iron grating, at a distance from the house, it affords perfect security against the inroad of these poisonous gases, which readily escape into the open air. When fixed near or within the house, the hole on top of trap should be covered with a stone, through which a ventilating pipe should be conducted above the roof. In all ordinary cases, the solid cover shown in sketch may be used, the hand hole being readily available when necessary to remove obstructions.





Section N of Fig. 2.

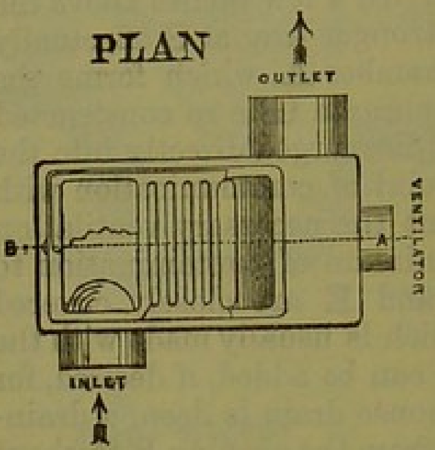
The Registered "Intercepter" Sewer-Air Trap

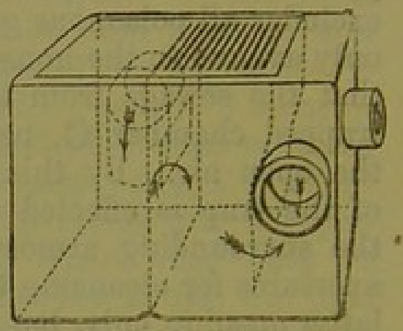


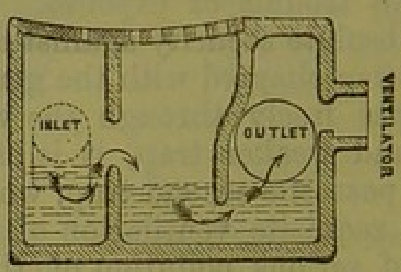
is intended to be fixed at any convenient and easily accessible point between the house and the street sewer. The mephitic air from the sewer is effectually intercepted by means of the two water seals F and G (the latter being much the stronger), with intermediate ventilation. Under ordinary circumstances the foul air will be confined to chamber C, but should the pressure be strong enough to force the trap at F, the sewer gas will at once escape into the open air through chamber B, from which a ventilating pipe must be carried a few inches above the ground level. A second and much stronger trap at G effectually excludes all poisonous gases from chamber A, which forms the only avenue to the house. The diaphragm G is so constructed that the sewage from the house is discharged directly into the trapped chamber C, beyond the point of communication with the open air. By this arrangement the necessary ventilation of the trap is effected with the minimum of contamination to the surrounding atmosphere. D and E are closely covered apertures for cleansing the trap, which is usually made with the latter opening only, but aperture D can be added, if desired, for a small extra charge. When the house drain is deep, a drain-pipe should be conducted vertically from the opening E to about nine inches below the ground level, then carefully closed with the disc plate and covered with earth. By means of a long-handled ladle any subsequent obstruction in the trap may soon be removed without trouble or expense. It has the following advantages:—1, Absolute security against the inroad of sewer-air, which is so often charged with the germs of fever; as the mephitic air escapes freely through the ventilator, by simply forcing the first and weaker trap, it is of course utterly impossible for it to pass the second trap, which is of far greater strength. 2, The requisite ventilation of the trap is secured without the risk of serious pollution of the atmosphere, and also without the necessity of carrying ventilating pipes above the roof of the house. 3, The trap may be fixed at any convenient distance from the house. 4, The interior configuration of the trap minimizes its liability to obstruction (there being no upright partitions or sharp angles to impede the sewage current), but full provision is made for inspection and cleansing whenever necessary. 5, Being made of glazed stoneware the trap is exceedingly strong and non-corrosive, and having a broad flat base, it is almost impossible to set it out of the proper working level. All these are made and supplied by James Stiff and Sons, Lambeth.

Mansergh's Trap,

made by Doulton, of Lambeth, which is adopted at the Sanatorium at Blackpool, consists of a doubly trapped gully (provided with a ventilator), into, not upon, which the various pipes are conducted, and their contents thus transmitted on to the sewer. By the threefold means of the double trap, the ventilator, and the open gully, all connection between the sewer and the house is severed, and any backflow of gas, from suction or any other cause, into the house is entirely precluded.







This trap is intended to prevent the ingress of sewer gas into the house through waste and overflow pipes, from cisterns, baths, lavatories, sinks, &c., and is always to be placed outside the house. The opening grating admits of its serving as a yard gully, and by attaching a ventilating pipe to the opening indicated on the woodcut, the entrance of sewer gas into the house is rendered impossible. The trap may also be used without the ventilator if necessary.

"*Efficiency of Traps.*—Supposing, of course, they are properly laid, a trap is efficient if water stands in it to the height of $\frac{3}{4}$ inch above openings, if water passes through it sufficiently often, and with force enough to clear out the receptacle and renew the water in it. But traps are often ineffective—1st, From bad laying, which is a very common fault. 2nd, From the water getting thoroughly impregnated with sewer effluvia, so that there is escape of effluvia from the water on the house side. 3rd, From the water passing too seldom along the pipe, so that the trap is either dry or clogged. 4th, From the pipe being too small (2 to 3 inches only) and "running full," which will sometimes suck the water out of the trap; it usually occurs in this way, as frequently seen in sink traps: the pipe beyond the trap has perhaps a very great and sudden fall, and when it is full of water it acts like a syphon and sucks all the water out of the trap; to avoid this, the pipe should be large enough to prevent its running full, or the trap should be of larger calibre than the rest of the pipe. 5th, Traps may perhaps be inefficient from the pressure of the sewer air, combined with the aspirating force of the house displacing the water and allowing the air uninterrupted communication between the sewer and the house. The extent of the last danger cannot be precisely stated. In a long house-drain which got clogged, and in which much development of gaseous effluvia occurred, there might possibly be for a time a much greater pressure, but whether it would be enough to force the water back, with or without the house suction, has not been yet experimentally determined. But the reasons already given show that we ought not to place dependence solely on traps, though they are useful adjuncts."

WATER CLOSETS.

The use of water closets, though generally considered a modern device, really dates from a very remote period. The summer chamber of Eglon, King of Moab (Judges iii., 20-25) is supposed to have been one. They were introduced into Rome during the Republic. Those constructed in the palace of the Cæsars were adorned with marbles, arabesques, and mosaics. At the back of one still extant, there is a cistern, the water of which is distributed by taps to different seats. Their general use in private houses, however, dates from a very recent period. "Nothing can be more satisfactory than a good water-closet apparatus, properly connected with a well-ventilated sewer. It is cleanly to a degree, and at once allows the removal of all objectionable matter to a place where it can be utilised in a wholesale manner."—Eassie, *Sanitary Arrangements for Dwellings*, page 59. By the water-carriage system properly carried out we have the refuse matters immediately removed from the houses, and one of the most important of the sanitary laws thus obeyed; the wells, where there are any, are no longer polluted, as the sewers are impervious, and the sewer air, of which there is very little indeed in sewers of sufficient gradient, escapes into the atmosphere, and is dissipated, where it is of no consequence whatever in comparison with the foul effluvia given off in enormous quantities from the collections of filth made under a conservancy system. But it is to be regretted that among the hundreds of patented inventions, lately brought before the public, one of the most defective and dangerous of them should have got into such general use, the ordinary "pan-closet."—Baldwin Latham (*op. cit.*, p. 329) speaks of them as "cumbrous appliances, which cannot be introduced into a house without creating a nuisance." Thousands having already fitted their dwellings with them, at a considerable cost, it becomes important to remedy their defects, as far as possible, where already in use; the most important of these is making a vent in the soil pipes, to relieve compression or tension of the contained air from the following causes acting together or separately:—changes of temperature either from that of the surrounding air, or by pouring hot water into the pipe; blowing of air into the soil pipe from ill-ventilated sewers,—the disconnecting trap being disabled from some accident; the influx of a considerable quantity of water into the column from above forcibly displacing an equivalent volume of air. When compressed from any of the above causes the foul air is blown out into the house at the orifice of some waste pipe in connection, in spite of its trap. Tension may occur from the reduction of temperature, or from the efflux of water as it leaves the confined column through the outside trap. In either case the vacuum is supplied by sucking the water out of some of the connecting traps, leaving their waste pipes unsealed, the simple remedy for which is to carry the soil pipe, in its whole size, or nearly so, up through the roof, with an open end, to connect the interior with the open air. If the sewers are ever tide-locked, a heavy rain at such times displaces an immense volume of air, which is forced into the house-drains, causing these vents to be fully taxed.

When several water closets are placed one above another, on different storeys, drained by a perpendicular soil pipe, as often occurs, it is not enough to extend the soil up pipe through the roof. The trap on each of the closets below the upper one, except perhaps the very lowest—if this be at the bottom of the column—must have its own separate vent, otherwise the rush of water down the column from the upper storey, or from any of the closets above the lower one, will be likely to siphon the water out of the intermediate traps in passing, or the trap itself which is used. The vents for this purpose should be at least two inches in diameter, and may all branch into each other, and into the soil pipe above the upper closet.

When the bath waste-pipe runs full bore—as it will do on emptying a bath,—it will work as a syphon; the shorter leg of which extends to the bottom of the water-trap only. As a syphon will empty a vessel of its contents, *and* its shorter leg, so in this case will the "bend" be emptied and the "trap" rendered of no avail. To obviate this and maintain the trap, a small pipe should be inserted into the top of the long leg of this syphon; of such a length as to reach above the level of the water-bath. This will prevent the syphon action; or after the waste water has been run off, a sufficiency of water should be poured into the bend to form the water seal;—the first, as being structural, is the safer remedy.—*Sanitary Record*, vol. vi., p. 127.

It has been usual with many plumbers of late to recommend the flushing of water-closets of the common "pan," or "hopper" style, by a valve, to be opened in a branch of the main water supply of the house, from which drinking-water is drawn through another faucet. But the only safe way is to break this connection by providing a small tank and service-box for the closet. With the valve furnishing water direct from the main the following risk is incurred:—The water supply, even though nominally "constant," is sometimes shut off temporarily for repairs in the street, and if at such time the water-closet valve should be opened, the air is drawn rapidly into the water-pipes from the interior of the closet, which is filled with sewer gas, and perhaps with actual contagiun from disease. The water is soon let into the pipes again, mixing with this air and dissolving a portion, thereby becoming contaminated, and unfit for drinking. In the supplementary report of the Medical Officer of the Privy Council, for 1874, there is an interesting report from Dr. Buchanan, upon an outbreak of enteric fever in Caius College, Cambridge, when fifteen students were attacked while living in the newly-erected buildings, which were supposed to be provided with the most perfectly arranged sanitary appliances. After a most painstaking investigation the fever was traced, by convincing evidence, to the use of a water-closet with direct supply from the mains, which had poisoned the water used for drinking in precisely the manner indicated above, and the outbreaks of typhoid fever at Croydon and Lewes are instances of the great danger resulting from intermittent water supply.

In an outbreak of typhoid fever recently investigated in Tideswell, all the early cases occurred in houses near to that of the person who first suffered from the fever, and in all there were special reasons for believing the disease to have been caused by air or water pollution, as the houses were supplied with water from a small main which was connected with three houses in which the pipes opened directly into the pans of the closets. On examining these it was found that the water was not running into the pan, and on applying a lighted taper a strong draught was noticed from the pan into the pipe, so that the water in the supply-pipe and small main must almost necessarily have been fouled with the excrementitious matter of the fever patients. "Such an occurrence was in itself sufficient to explain mainly the whole spread of the disease in Tideswell subsequent to the occurrence of these two cases." There were also sinks in the houses, which were connected with the sewer;

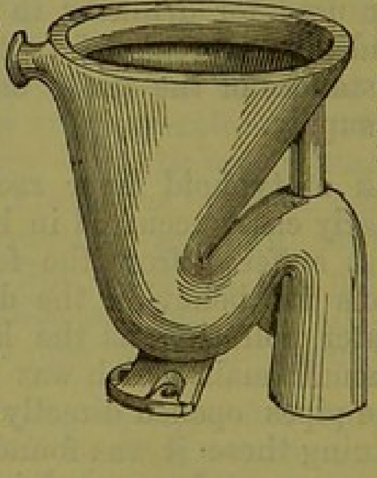
and they, as well as the water closets, were imperfectly trapped. A better water supply, improved paving and means of drainage were recommended, and especially that there should be no direct communication between the interior of the houses and the sewers.

"Rain-water pipes are sometimes used to ventilate drains, but independent of their small size, which often leads to blockage, they are often full of rain, and cannot act at the time when ventilation is most required."

"The ventilation of the soil pipe is a matter of importance, as the water from the pan suddenly displaces a large body of foul air, which rises through the syphon as the water flows."—*Parkes, op. cit.*

"Generally speaking, those closets are the best which provide for good flushing and rapid and complete removal of the excreta, without permitting reflux of foul air. The pan should be roomy and made of white glazed earthenware, the machinery should work easily and not be apt to get out of gear, and the seat should be so framed as to come asunder readily to permit of inspection."—*Handbook of Hygiene, by George Wilson, M.D.*

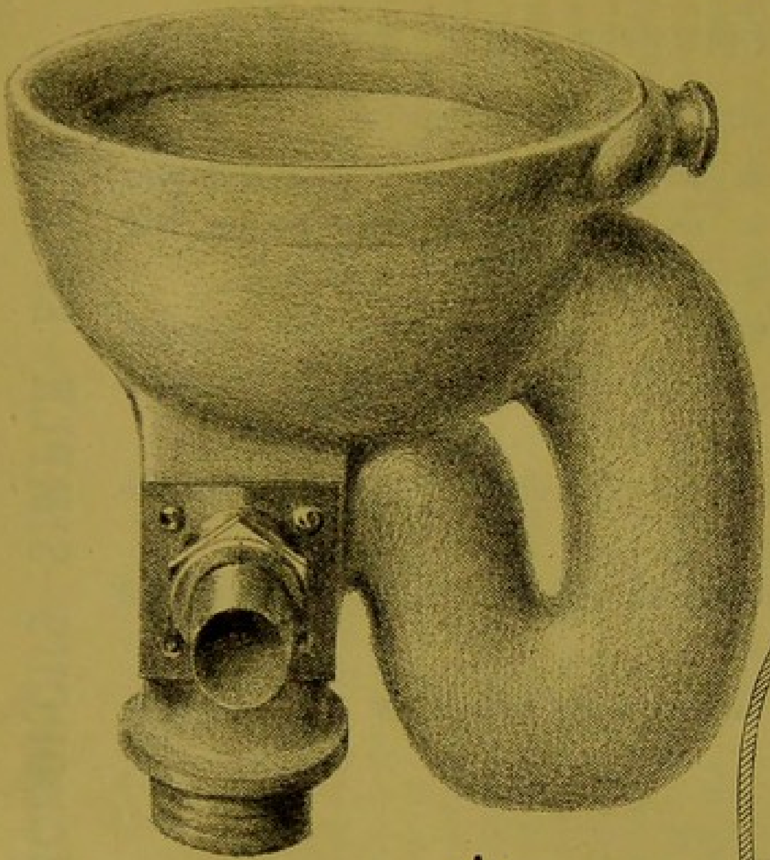
In Blackpool it has been my aim to discover and fill up all cesspools and remove cesspit-middens by converting them into wash-away closets. These are built of brick and cement, hopper shaped, and might be replaced by pans quite as cheap, and more easily kept clean (see Figure). These are provided with a trap at the bottom of the receptacle. Above the trap the slop-stone pipe enters, to this also the rain-water pipe is joined; not inadmissable, provided its upper end is not near a window. In dry weather they can be kept clean by flushing with a bucket or two of water every day.



Amongst the varied and numerous water-closets of later construction I was much struck with one at the Sanitary Exhibition, in connection with the Social Science Congress, at Liverpool, 1876, described and figured in the next page. Finding on my visit to London that one of the old fashioned pans was out of order, I ordered the one of the simpler construction, upon the action of which I am able to report most favourably.

DODD'S
PATENT VENTILATED WATER CLOSET

WITH PATENT



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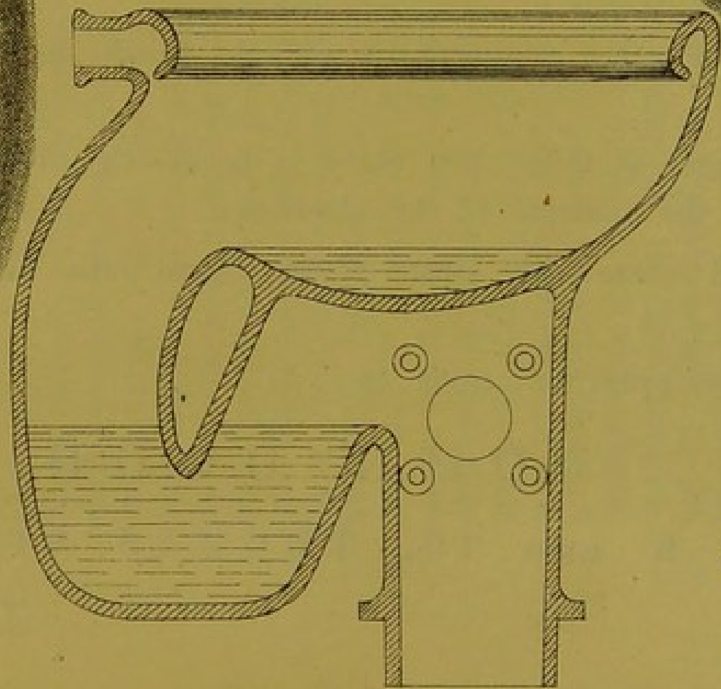
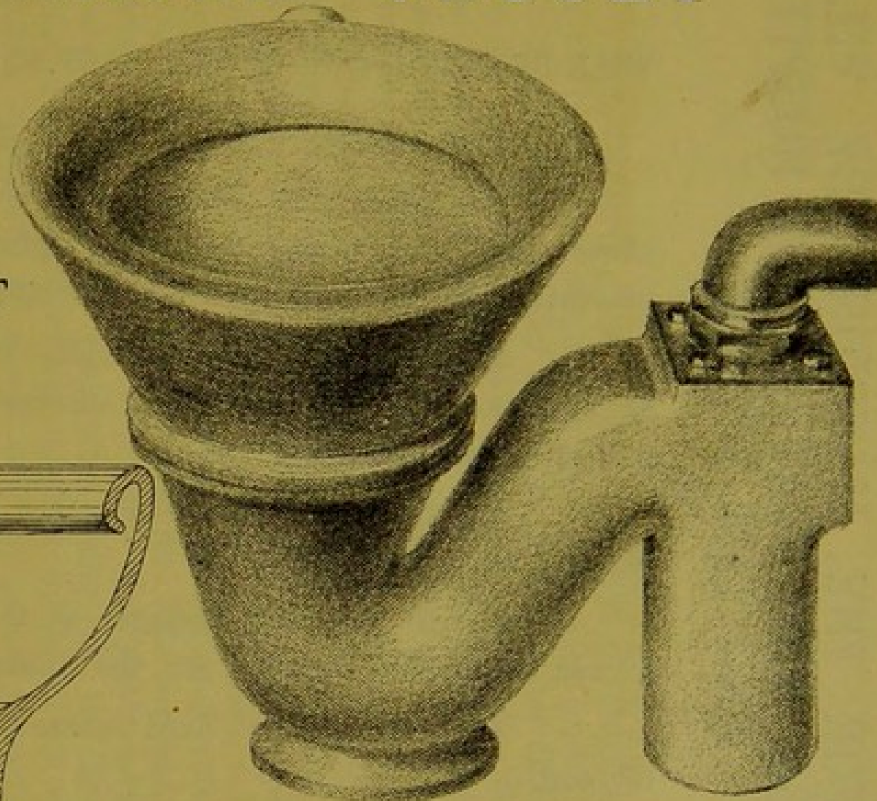




B

IMPROVED SPREADER,

P.T.O.

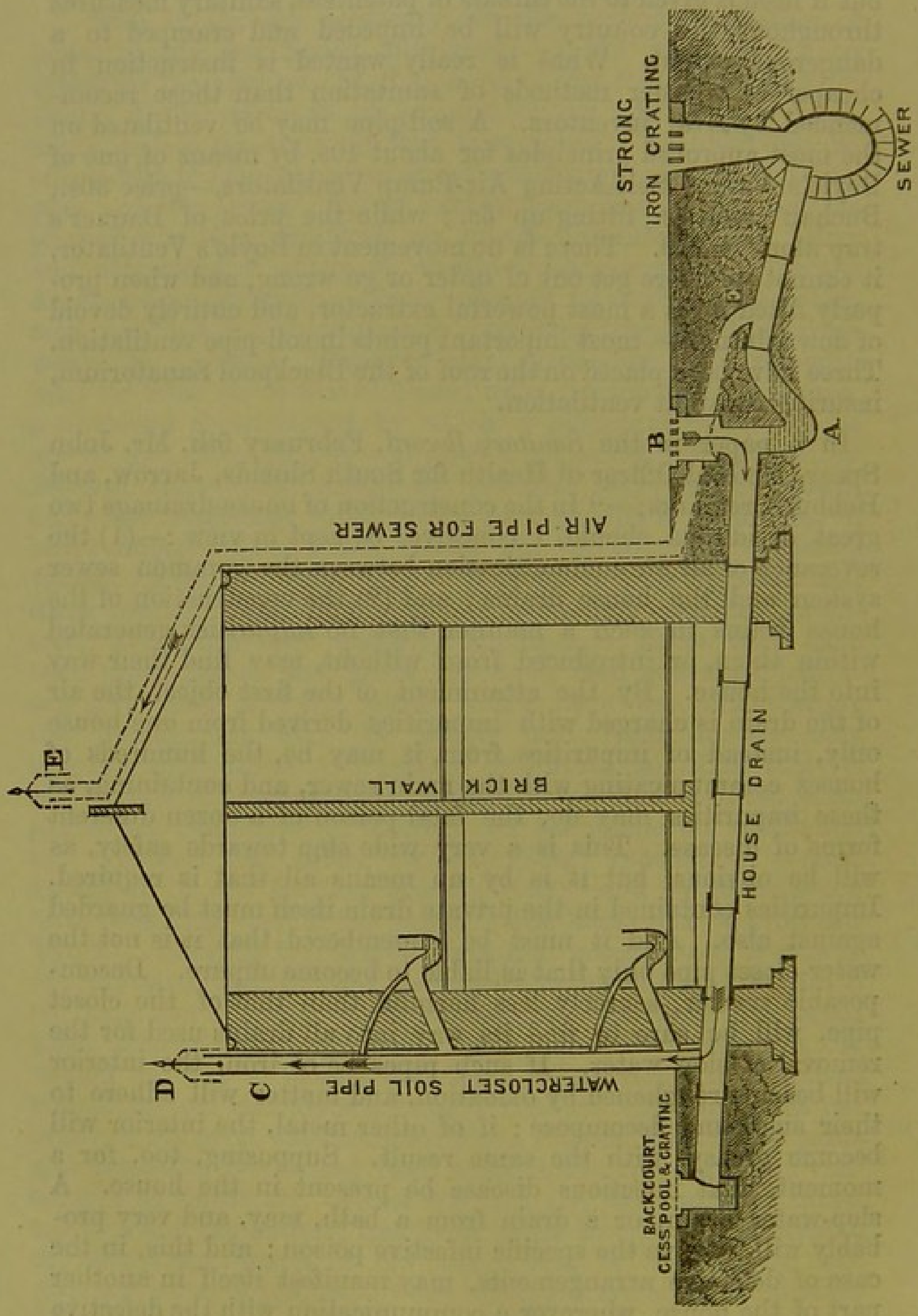
Dr. Cameron, the medical analyst of Dublin, records a highly instructive instance, representing what undoubtedly takes place in a great number of houses of the better class, in which a case in which pipe-water, originally perfectly pure, became locally highly contaminated, and with fatal results, came recently under his notice. "In the suburban dwelling of a well-known and popular clergyman, no fewer than seven cases of typhoid fever occurred within a month. We were asked to make a sanitary inspection of the house, which we did, with the following result. We found that the sewerage arrangements were good, but we traced the over-flow pipe from a water-closet cistern to a second cistern, which was supposed to furnish water only for a bath. We found, however, that the water from this cistern was often used to supply the water-carafes in the bed-rooms. In this case pure water, in the first instance, entered the cistern which supplied liquid to the water closet. When water was let down into the pan of the water-closet, a certain amount of foul air ascended into the water, and to a great extent dissolved therein. As the over-flow pipe from the cistern passed into the soil-pipe, the foul gases in the latter must occasionally have passed up into the space over the water-cistern, and have become absorbed by the water. In this case the water was highly and even obviously polluted. This was one of those sudden and localised outbreaks of typhoid which, according to the late Professor Parkes, are occasioned by contaminated water. Had the inmates of the house not used this polluted water, the fever would probably have been confined to the first individual who contracted it, and whose dejections, without doubt, contaminated the water in the cistern in the way which we have explained. It is a fact, but one not generally known, that air is often sucked into pipes through which high pressure water is flowing. If in such a pipe there are small holes (as sometimes happens), the water will pass out through them in the form of jets, which will diminish in size if a tap be opened close to them. Now, when by the opening of a tap near where there is a hole in a water-pipe, the jet from the latter is diminished in size and force, then air is liable to be sucked into the pipe. As leaky taps may be regarded as equal to holes, it is not safe to have taps over sinks or other places from which foul air is likely to issue. It is for this reason that it is improper to flush the pan of a water-closet by discharging water directly into it from a tap, as we know is often done; if whilst such a tap was open the pressure of water was diminished in the main, an insuction of foul air into the pipe would certainly occur."

VENTILATION OF HOUSE DRAINS AND HOUSE SOIL PIPES.

Two things are necessary for the perfect ventilation of house drains and house soil pipes:—1, the provision for an outlet for the removal of the more or less foul drain air from them; 2, the provision of an inlet for the admission of fresh air to replace the drain air that is removed. This can only be effected by the severance of direct connection between the soil-pipe and the sewer. These twenty years have I adopted the plan of admitting the fresh air into a ventilating shaft below and extracting it above by an air-withdrawing cowl,—on the Archimedean principle,—since patented by several rival patentees, and little I thought that the banner of threatened penalties would be unfurled. Banners' plan, consisting of a trap with inlet for fresh air at foot and cowl upon the top of the soil-pipe, a combined arrangement by which a perpetual movement of air in and through the soil-pipe is patented, but claimed by Buchan, and several others, the gauntlet being thrown down, and some hesitation being shown as to picking it up for fear of burnt fingers. (See *Public Health*, pp. 70, 104, 123; *Sanitary Record*, pp. 63, 78, 111, 1877.) It is much to be regretted that these sanitary times have generated a herd of rapacious patentees, who, with cool audacity appropriate ideas that have been promulgated and plans that have been practised half-a-century, and, if they could, would have the public enjoy the blessed air and the gentle rain from heaven only through their mean and greedy specifications. This truly is not the age of disinterested philanthropy. Half-a-dozen companies are established to take toll on the public for ventilation by syphons and tubes, by "Costless Ventilation"—(first described in the *Builder*, March, 1862)—and by plans which have been years before the public. The latest idea of Professor Tyndall, filtering through canvass, and cotton wool, is calmly appropriated, and we are threatened by penalties, forsooth, if we make use of an air withdrawing cowl, combined with an air inlet, unless royalties are paid—a plan anticipated years ago. It should be that to patent the action of common air is indeed "wasteful and ridiculous excess." That we may enjoy the use of air in the good old-fashioned ways without the fear of pains and penalties, Boyle and Son, whose self-acting air pump ventilators so effectually extract the foul air, have no mechanical motion, and are entirely free from down draught,—"undertake to defend any action at law which may be brought by evil-disposed persons against any one using our system of ventilation for soil pipes, &c." The invention of a really genuine original sanitary success should meet with honourable recognition and substantial reward. Drain pipes, stoves, ventilators, cowls, filters, disinfectants, traps, and even systems of sanitation, are now all to be protected, of course, by "Royal Letters Patent;" but if heed is given to the threats of patentees, sanitary measures throughout the country will be impeded and cramped to a dangerous extent. What is really wanted is instruction in cheaper and easier methods of sanitation than those recommended by rival inventors. A soil-pipe may be ventilated on the most approved principles for about 40s. by means of one of Boyle's Patent Self-Acting Air-Pump Ventilators,—price 30s., Buchan's trap 5s., fitting up 5s.; while the price of Banner's trap alone is £10. There is no movement in Boyle's Ventilator, it cannot therefore get out of order or go wrong, and when properly fitted up is a most powerful extractor, and entirely devoid of down draught—most important points in soil-pipe ventilation. Three have been placed on the roof of the Blackpool Sanatorium, insuring constant ventilation.

In a paper in the *Sanitary Record*, February 9th, Mr. John Spear, Medical Officer of Health for South Shields, Jarrow, and Hebburn, remarks:—" In the construction of house-drainage two great desiderata should, I conceive, be kept in view:—(1) the severance of all air communication between the common sewer system and the house drains; and (2) the construction of the house drains in such a manner that no impurities generated within them, or introduced from without, may find their way into the house. By the attainment of the first object, the air of the drain is charged with impurities derived from one house only, instead of impurities from, it may be, the hundreds of houses communicating with the main sewer, and containing, as these impurities may do, the fatal poison of a dozen different forms of disease. This is a very wide step towards safety, as will be obvious, but it is by no means all that is required. Impurities contained in the private drain itself must be guarded against also. And it must be remembered that it is not the water-closet pipe only that is liable to become impure. Decomposable matter, scarcely less harmful than that of the closet pipe, will be sure to find its way into all drains used for the removal of slop water. If such pipes be of iron, the interior will become roughened by oxidation, and matter will adhere to their sides and decompose; if of other metal, the interior will become greasy, with the same result. Supposing, too, for a moment, that infectious disease be present in the house. A slop-water drain, or a drain from a bath, may, and very probably will, receive the specific infective poison; and this, in the case of defective arrangements, may manifest itself in another part of the house, wherever a communication with the defective drain exists, or perhaps sometime afterwards."

The accompanying woodcut illustrates Buchan's method of ventilating house drains, especially when obliged to pass under the house, which should be avoided if possible :—



Dr. Buchanan, in his recent official report on the epidemic fever at Croydon (1875), not only advises that the ventilating shafts to the sewers opening in the public thoroughfares should be multiplied, but recommends and gives a diagram of an opening to the soil drain between the sewer and the house, terminating on the level of the ground, and states that he can speak from experience of its advantage. Open ventilation of sewers at the level of the street is the almost universal practice in London, and is generally quoted with approval by engineers. It has lately been adopted at Carlisle, and has been long since suggested for Blackpool, Lytham, and Fleetwood. As Dr. Buchanan, in his above-mentioned report remarks, "the air of the sewer is, as it were, laid on to houses; it is arranged that every house-drain and every house soil-pipe shall contain, up to the very wall of the house and the very trap of the water-closet, the common air of the Croydon sewers, not simply charged with impurities it may receive from the particular house, but charged also with any dangerous quality it may have brought from other houses, for hardly anywhere in Croydon can their be found an arrangement for severing the sewer air from the air of the house-drain." The complete severance, therefore, of the sewer of the whole of the house-drains without exception, soil-drains as well as slop-drains, should be the primary principle underlying all sanitary drainage. Every leak is the source of great risk, contaminating the soil in its vicinity to an extent dependent upon its permeability. In fact, no workmanship can be too good to be employed in laying house-drains, which should be done under *bonâ fide* supervision. In Leeds Infirmary, which, as one of the latest constructed, should have been a model, several cases of unanticipated illness having occurred, the drain pipes were examined, and many deficiencies were found from "iniquitous workmanship;" a regular cesspool was discovered near the residence of the medical officers, some of whom were ill. "Out of sight, out of mind," is too often the workman's soliloquy, and the defect may not be detected for months or years, during which time the soil may have become polluted to an incredible extent, rendering a home a mere pest-house, which might otherwise have been healthy, and with the increased use of water in dwellings, raising the standard of cleanliness among the poor, and in contributing to the comfort and luxury of the more wealthy, the laying of house-drains demands the more careful attention. Private drains are but a continuation of the main sewers into the very places where defective planning and workmanship are sure to work much havoc, and in the same way that the strength of a chain is determined by that of its weakest link, so the efficiency of a sewerage system can only be measured by the standard of its most defective portion, which is, in nearly all cases, the house drainage. Sewer gas, as already shown, is one of the most powerful labourers in the harvest of death. In winter the temperature of our rooms both night and day is much increased, and the doors and windows being all the more carefully closed, our houses become exhausted receivers, planted over the prolongations of the sewers, for such every soil-pipe and disconnected waste pipe really is. With the forces thus set up, and which tend to suck the sewer-gas into the house, the ordinary water traps are utterly powerless to cope. The water trap is a useful auxilliary and nothing more. This has been well shown by the experiments of Dr. Fergus, of Glasgow.

It has been asserted that an increase of diarrhœa is due to the adoption of the water-carriage system; but a careful examination of the returns of the Registrar-General shows the fact that, with the constantly increasing density of population, such diseases have increased in Lancashire where the old system of removing excrement by hand is the rule, but that they have remained stationary or decreased where water-closets have been largely introduced, the less favourable condition in the former case overbalancing the improvement in the latter.

About three years after the completion of works of water-supply and drainage in consequence under bad management, of allowing filth to accumulate, and for the poison in the air and water to become sufficiently concentrated to cause illness, it has been found that a considerable amount of disease has arisen with a consequent augmented death-rate, as in Glasgow and Edinburgh, and hence typhoid fever in the houses of the better class and on high land,—attributable to sewer-gases from ill-ventilated sewers, ill-ventilated and improperly constructed water-closets. Menzies says (*op. cit.* p. 13) :—" The gas which arises in foul drains is of a singularly light character, and has a tendency to ascend or draw towards any heated part of a house. Hence, it often arises that houses in towns situated on the highest ground are more unhealthy than those in the valleys ; the foul air rises to them through the drains, as during the greater part of the year the internal temperature of an inhabited dwelling, and especially of some parts of it, is much higher than the surrounding atmosphere, it is obvious that the gas naturally ascends to the living-rooms, especially if during the winter and autumn they are warm and comfortable. These water-closets are also generally on the bedroom floor, and it is more injurious to health to sleep in foul air than to be in it during the day-time." Experience has fully shown that the dangers to health are least under the water-carriage system if properly managed, and the common sense of the community has declared it the most decent and the most convenient. "If one of two evils were unavoidable, it would be better that the rivers should be polluted than that the atmosphere in which we live should be subject to constant deterioration; but this is not really the question. Both evils may be avoided. But it is strikingly shown in this district (Lancashire) that, notwithstanding the purity of the air of the town is sacrificed by a retention of its fœcal matter, the rivers are at the same time so polluted by the discharge of town-refuse of various kinds as to call imperatively for remedial measures."

Ash-closets are much used in Lancashire, and their use appears to be extending. In Manchester, with a population of 360,000, they number more than 15,000. The daily scavenging in that city costs £30,000 a year; net cost of disposing of nightsoil in 1875, after deducting receipts, £22,839 2s. 7d., scavenging £22,151 7s. 11d.:—£31,925 10s. 1d.; and £18,417 15s. in 1876; whereas all their privies and cesspools might be abolished, and drains provided at a cost of say £100,000, of which the yearly interest would be about £3,500, in place of the £30,000 now spent. The estimated number of water-closets in use is 10,000, for 50,000 inhabitants, including those of hotels, and the contents are discharged into the river. The better classes live for the most part outside of the city limits; but, whether within or without, they insist upon having water-closets in their houses. This expensive and disagreeable method of removing the "filthy stuff, too poor for use as manure" (its value is less than 1s. a ton; the result of the secret manufacture is not published, but is likely to prove a costly experiment), is adopted, under the conviction that in this way their sewage may be kept inoffensive enough to be discharged into the river Irwell without purification. Kirkham, and many other towns are examples of the same pernicious plan on a smaller scale; there is no system, or indeed any arrangement for the removal of night soil; farmers will not have it at a gift, even if paid to take it; there is no regular scavenging; as a result overflowing privies pollute all around—

> "Rank corruption, mining all within,
> Infects unseen"—

while the sewage is discharged, pure and simple—though so-called settling tanks have been constructed—into a brook, but which pollution will have to be remedied forthwith.

Fleetwood has allowed its once uncontaminated subsoil to be irretrievably excrement sodden,—and of the importance of maintaining the sanitary reputation of a health resort, we may refer to the case of an opposite neighbour, and some other watering-places we could mention, where the once virgin subsoil is polluted to the extreme, sanitary arrangements not having kept pace with building operations—so that typhoid fever is domiciled, and epidemics of infectious diseases assume a virulence of type and persistence with results disastrous and semi-ruination to the town. Too late extensive drainage and sewerage works are to be constructed;—the confidence of the public once lost is not so easily regained;—it is a plant of slow growth.

The investigations of the Rivers Pollution Commission demonstrate conclusively that the sewage contains nearly as great a proportion of putrescible matter in this form as when collected by the water-closet system, as the table from Hoffman and Witt shows. The results are given in parts per 100,000 :—

	Average of 54 specimens from 18 cities and towns where water-closets are used.	Average of 37 specimens from 15 cities and towns where water closets are not used.
Total of solid matters in solution ..	72·200	82·400
Organic carbon	4·696	4·181
Organic nitrogen..................	2·205	1·975
Ammonia..........................	6·703	5·435
Nitrogen, as nitrates and nitrites....	·003	0·000
Total combined nitrogen	7·728	6·451
Chlorine	10·660	11·540
Suspended matter— Mineral	24·180	17·810
Suspended matter— Organic	20·510	21·300
Suspended matter— Total....	44·690	39·110

The amount of sewage corresponding to 1,066 persons where water-closets are used is the same as that from 1,154 under the other system. When, however, from any reasons sewers are not to be had, the dry closet, ash or otherwise, is much to be preferred to cesspools, privies, &c. At a late meeting of the Manchester Scientific and Mechanical Society on the treatment of town sewage, it was remarked that Manchester, by setting her face against water-closets, had caused the nuisance of the Collyhurst "tip," and the fever-haunted streets of Moss Side and neighbourhood showed conclusively the evil of depositing sewage on the ground without previous manipulation.

The heterogeneous contents of the dust-bin in large towns will always be a source of expense and nuisance until the mind of the domestic servant is sufficiently educated and sufficiently interested in the welfare of the house to convert into fuel at least two-thirds of what in the shape of vegetable refuse, paper, cinders, &c., is wastefully thrown away. Not long since, contractors used to pay the vestries a handsome sum for the removal of the contents of dust-bins,—now they expect to be paid, and some of the vestries undertake it themselves at considerable cost to the ratepayers. It appears that the contents of the carts, valued from 5s. in winter, are valueless in summer.

The disadvantages therefore to be urged against the midden and dry systems are,—the imperfect character of the various kinds of apparatus used; the likelihood of a nuisance arising from smell; the probability of propagating disease from the retention of quantities of putrescible filth in the immediate vicinity of our dwellings; the pollution of the ground; the amount of manual labour entailed in cleaning out the closets; and, finally, after all, the fact that a grossly polluted sewage still remains to be disposed of.

A correspondent of the *Times* (signing himself M.D.) says:—"The soil-pipe of a water-closet, like the house drain, should always be ventilated—*i.e.*, an open pipe should pass from the soil-pipe out to an elevated spot, that is to say, at some distance from all openings leading into the house. If the soil-pipe of the water-closet be not ventilated, then, whenever the closet is used, should there be the least defect from wear or accident in the trap a certain amount of sewer gas will be forced upwards into the house from the soil-pipe."

Mention is here made of the soil-pipe, and it may not be undesirable to state, for the benefit of the public in general, what is well known to plumbers and other practical men—that the soil-pipe is even worse than the sewer, while worst of all is the trunk of the closet. The power for evil of the animal matter collected in the sewers is lessened, if not removed, by the constant flow of water through them. In the soil-pipe there is no such constant flow of water. On the contrary, water is only run through it for a second or two so many times a day. And in what condition does it leave the pipe? It is well known that water insists on parting with animal matter, and leaving it attached to the lead or iron. The effect on the metal is soon shown, and plumbers will tell those who are not aware of it from their own experience that pipes used for such purposes become in the course of a few years perfectly rotten from the action on them of animal and aciduous matter. As for the trunk of the closet, it—not occasionally, but invariably—becomes a medium for the generation of noxious gases; and plumbers have often to put it bodily into a furnace before they can render it even tolerably clean.

Again, Dr. Francis T. Bond, Medical Officer of Health to the Gloucestershire Combined Sanitary District, in a paper in *Public Health*, Jan. 7, 1875, on the danger arising from leakage

of sewer gas through water closets, and on its remedy, says :—
"One of the most fertile sources of danger to health in ordinary houses arises from the facility with which sewer gas finds its way into them through water-closet pipes. Not only is typhoid fever frequently traceable to this cause, as in the well-known case of the Prince of Wales' attack a few years ago, but even where this does not occur a generally low state of health and a predisposition to disease may exist amongst the inmates of the house, which is only attributable to the continual impregnation of its atmosphere by sewer gases. The primary remedy for this evil, where it is practicable, is undoubtedly the ventilation of the sewer pipe at the highest point, viz., just below the water-trap; or in the pan itself, if the latter can be protected by an air-tight cover when it is not in use. . . . Even where the trap of the closet-pan is sufficiently well made to withstand the pressure of the gases in the pipe to which it is thus exposed, the danger of penetration is not avoided, for the water in the trap and pan greedily absorbs the gases by the surface which is exposed in the pipe and gives them off by that which is exposed in the closet. In this way even in an ordinarily well-constructed closet a diffusion of sewer gas may be constantly going on, of which any one may readily satisfy himself by smelling the water which has remained for a short time in the pan of such a closet, and no amount of ventilation of the pipe can entirely prevent it. Where the closet is so placed that it has no external window, as is often the case, or where the window is kept systematically closed, not only is the atmosphere of the closet persistently foul, but it is liable to find its way into other parts of the house. Such houses can be at once recognised by any person who enters them, by the close, if not offensive, odour which always hangs about them, and there is little need for surprise if the doctor is a frequent visitor to them."

In conclusion, then, it appears that the function of a water-closet is to receive and get rid of excrementitious matter, for which the following conditions are necessary :—

1st. Absolute protection from invasion by the vapours and gases which result from the decomposition of excrementitious matters, and this of course involves their rapid removal.

2nd. That the sense of smell should not be offended,—so that if the first condition is obtained this second one follows as a natural consequence.

3rd. That sanitary æsthetics should not be overlooked, and that the eye should be consulted as well as the other senses.

4th, That the appliances used should be such as seldom to require repair, so that the function of the closet may be exercised without interruption; automatic disinfectors should not be added.

5th. That the arrangement should include ready ventilation of the soil pipe, so as to prevent the entrance of sewer gas into the closet.

The closet previously described and illustrated appears to fulfil all these requisitions.

DISPOSAL OF SEWAGE.

I am quite willing to admit that up to the present time sewage farms, as a rule, have not been a financial success. Profiting by the experience and experiments of other sewage farms, supposing suitable land could be obtained at a moderate price, it is worthy of the consideration of the Blackpool Sanitary Authority whether it would not be advisable to turn the sewage landwards, keeping the present outfall for storm overflow and for those periods of continued wet weather when the application of sewage to land is not advisable. We should then avoid the retention and backing-up of the sewage in the sewers at high tide, the contamination of the foreshore and the loss of that value in sewage—which certainly must exist, but which up to the present time it has been so difficult to realise.

The manipulation of the fœcal matter of tubs, pails, and dry closets, is a greater or less abomination; the carriage of the material, which must take place in the day time, a huge nuisance; and the manufacture, if I may judge by what I witnessed at the works of the Carbon Fertilizer Company at Oldham, besides the stench, truly one of the plagues of Egypt—"the land was corrupted by reason of the swarm of flies," themselves very likely carriers of contagion.

In a report of a committee appointed by the President of the Local Government Board to inquire into the several modes of treating town sewage (London: Eyre and Spottiswoode, 1876), signed by Robert Rawlinson, C.B., C.E., and Clare Sewell Read, M.P., and by S. J. Smith, Assistant—while full of excellent matter, no clue is given to the best practicable and available means. They evidently lean to irrigation, at the same time the inconveniences and expenses attendant upon it are stated. "It may be quite true," say the Commissioners, "that town sewage contains all the manure that most plants require, but these elements of fertility are dispersed through a volume of water many times greater than any crop can absorb." Again they admit, "No growing crop, save natural grass, should be sewaged during the depth of winter;" and that "Very few crops are actually benefited by the direct application of sewage upon a stiff and retentive soil; indeed, Italian rye grass, cabbage, and mangold-wurtzel, seem to be the *only* farm crops that persistently flourish upon any soils, heavy or light, under continual doses of town sewage;" and that they have been "assured by a gentleman of vast experience, that the long-continued application of sewage to the same land fails to produce the like beneficial effect as when it was first used."

"The chief produce of a large sewage farm," we are further informed, "*must be* Italian rye grass, because it is a plant which luxuriates in moisture, and feeds with singular avidity upon all kinds of liquid manure." Rye-grass, when grown, however, is not always saleable; "the demand for cut grass is so variable, that its disposal is not a very easy task. Rye-grass, even when heavily sewaged, grows most rapidly in wet weather: consequently when there is much rain a greater crop is produced, when it is most difficult to deal with; and, as there is at such times a more plentiful supply of similar green food on other farms in the district, the demand for the rye-grass of the sewage farm is not so extensive. In a damp season it is next to impossible to make sewage-grown grass into hay, as the soil is sodden with rain-water and sewage, and the young undergrowth of grass so soon springs up that the land must be cleared of the cut grass to enable the next crop to grow."

In order to grow this rye-grass with cabbages and mangold-wurtzel, "more than double the amount of manual labour which is usually employed upon arable land" is required, "and more horses must be kept than upon an ordinary farm. The amount of capital, even where the produce is sold off as soon as grown, must be greatly in excess of that required for the general ordinary cultivation of the soil; while to properly stock and work a sewage-farm upon which the main produce is consumed" in cattle rearing, "quite five times the usual amount of money will be needed. One of the greatest difficulties is to keep the sewaged land clean, as not only does every seed and the minutest portion of a root-weed grow, but sewage itself often contains the seeds of numerous weeds which have been washed down from the fodder and straw of stables and cowhouses."

Lastly, it is said, "Farms to which town-sewage is applied have invariably many unfavourable circumstances to contend with. The rent, except where the local authority has land of its own, is certain to be extravagant; the application of sewage is often too costly; the management is frequently changeable and faulty, and the prejudice against the produce of the farm is, in some districts, obstinate and wide-spread."

These testimonies are delivered by Commissioners who nevertheless "recommend the application of town-sewage to land," and who give as their conclusion, "That town sewage can best and most cheaply be disposed of and purified by the process of land irrigation for agricultural purposes, where local conditions are favourable to its application, but that the chemical value of sewage is greatly reduced to the farmer by the fact that it must be disposed of day-by-day throughout the entire year, and that its volume is generally greatest when it is of the least service to the land;" wherefore, they allow, "That land irrigation is not practicable in all cases, and, therefore, other modes of dealing with sewage must be allowed."

The evidence produced to bear out this modified judgment in favour of irrigation is chiefly derived from places like Doncaster, Bedford, Wrexham, and Aldershot, where soil and sewage are about equally mated; but, even with all conditions propitious, irrigation is conducted at a loss. Indeed the Commissioners confess that "the only instance in which town-sewage irrigation is a decided financial success is that of the Craigentinny Meadows at Edinburgh." These famous Meadows (which have been the *ignis fatuus*, the slough of despond, to thousands) consist of about 250 acres on the sandy shores of the Firth of Forth, to which the sewage of a portion of Edinburgh flows in an open stream, with a stench at times overpowering. "I assure you," wrote Dr. Letheby, "the odour is so offensive that I have hardly been able to walk on the ground." The owner of the Meadows draws copiously from the stream, "often as much as ten or fifteen tons per acre during the growing season, besides an indefinite quantity during winter," leaving the residue to flow to the sea. The crop grown is rye-grass, sold to cow-keepers, and realising from £24 to £36 an acre annually. At certain periods the Meadows are little but a stinking morass, which but for the sea breeze would be unendurable, whilst the sewage leaves the grass-land filthy and offensive. Moreover, the application of the sewage does not extend, for two reasons, namely, absence of demand for a larger quantity of the rank grass grown, and absence of suitable soil for other crops.

The evidence from Craigentinny Meadows therefore proves no more than this (which no one ever doubted), that the growth of rye-grass may be promoted to extreme luxuriance by the free application of sewage. But the Meadows do not exhaust the stream of sewage that runs by, but only so much of it as suits the owner's convenience at certain seasons. The success with irrigation of real value would be the utilisation of the entire volume of sewage on the land at all seasons, accompanied with drainage void of offence. Tested by this standard, the Craigentinny experiment is a conspicuous failure, and its production as evidence in favour of irrigation only demonstrates the muddled condition of mind into which we have lapsed on the sewage question.

Without doubt town sewage is a most useful fertiliser for root crops, especially for mangolds, provided it be applied to the land at the right time and in proper quantities. Town sewage may be employed with great advantage repeatedly in large doses during the first two or three months of the growth of the root crops. In dry springs especially the liberal application of sewage cannot fail to be of the utmost utility to farmers who can command a supply of this liquid fertiliser. It then encourages an early, luxuriant, and healthy development of leaves, by which sugar is afterwards elaborated from atmospheric food and stored up in the roots. Almost any quantity of town sewage may be applied to root crops during the first two months of their growth; but subsequently, and more especially, when the bulbs have reached a considerable size, sewage should be withheld, or otherwise the crop will not properly ripen and will not be worth much for feeding purposes.

It is important to bear in mind that the more completely the supply of soil-food is withheld during the late summer months, the more fully the roots will ripen, and the richer they will become in sugar in consequence. Town sewage is held in bad repute by not a few farmers, whose experience leads them to suspect there is something or other in sewage prejudicial to the production of sound roots of good feeding qualities. I believe this is a mistake, for sewage contains nothing inimical to the healthy growth and development of roots; and the examination of mangolds and sugar-beets has shown me that perfectly sound and nutritious roots can be grown with town sewage. At the same time I may state that some of the worst and least nutritious mangolds which have ever been analysed by me were grown with sewage; and I have therefore come to the conclusion that ill success with sewage as a manure for mangolds in most cases is due to its injudicious use, and not to any inherent bad qualities which it has been supposed to possess.—*Root Crops as affected by Soil, Manure, and Climate*, a Lecture by Dr. Voelcker to Central Farmers' Club.

The Commissioners whilst recommending the application of sewage to land "wish to guard against some extravagant expectations of the agricultural benefits it will confer, which are held and advocated by a few zealous and enthusiastic theorists;" and the warning equally applies to those who have set Precipitation against Irrigation, and have claimed for the precipitate the value of first-class manure, and for the effluent a purity approaching that of rain-water.

As for the precipitate or sludge, it is at last confessed on all sides that it has been over-valued as manure—whilst now it is probably under-valued. And this sludge is converted into a steady-going objection to all methods of precipitation—"it is an enormous mass, swollen with from 80 to 90 per cent. of water; it cannot be handled nor dried at a profit; and what is to be done with it?" A Precipitationist might fairly reply, that by the adoption of irrigation, sludge is not got rid of. Under some circumstances it may be possible to throw the entire contents of the sewers upon the soil, but in most cases it is necessary to receive the sewage in tanks where matters in suspension are allowed to settle, and the problem of dealing with the resulting sludge therefore remains. In Birmingham this sludge, containing the detritus washed from streets and other surfaces, amounts to about 300 tons a day, and has to be dealt with under whatever system. Of course, if precipitation be adopted the volume of sludge is more or less magnified; but the point to be observed is, that the existence of sludge is not evaded under irrigation; and it is scarcely ingenuous to use it persistently as a sort of conclusive objection to any process of precipitation.

It is, however, in the attempt to deal with sludge, to dry it rapidly, and to vend it as manure, that Precipitationists have incurred their chief loss and worst discredit. At Coventry, for instance, 2,000,000 gallons of sewage are treated daily with lime and sulphate of aluminum, and "a clear and inodorous effluent," according to the Commissioners, is turned into the river. The process is satisfactory, though susceptible of improvement alike in efficiency and economy; but the essential error begins in dealing with the sludge, which is ingeniously strained and then dried in Milward's mud-drying machines. The folly of the operation is manifest when it is stated, that the outcome of the cookery is a manure worth 16s. 9½d. per ton by analysis. Sewage sludge is best "left alone," and the result in process of time is a firm, inodorous mass, which cuts with a spade like peat or garden mould.

The Commissioners condemn without reserve "the retention for any lengthened period of refuse and excreta in privy-cesspits, or in cesspools, or at stables, cowsheds, slaughter-houses, or other places in the midst of towns;" adding "that none of the (so-called) dry-earth or pail-systems, or improved privies can be approved other than as palliatives for cesspit-middens, because the excreta is liable to be a nuisance during the time of its retention, and a cause of nuisance in its removal."

This judgment acquires its special force when it is understood how small is the portion of sewage which water-closets contribute to the general sewage of a town—the proportion is calculated as 1 to 100. Hence as town sites must be sewered, if only to remove sub-soil water, surface water, and waste-water from dwelling-houses, the addition of water-closets, whilst affording most desirable convenience, does very little to aggravate the sewage difficulty. On the other hand, the pail system, as practised at Rochdale and elsewhere, is an indescribable nuisance, and the manure, for which it is worked, does not repay the cost of preparation—a satisfactory result in the case of such a nasty business. It is at the same time a comforting conclusion that the existence of the water-closet is vindicated on the score of economy as well as of convenience. There are of course situations where water-closets are ineligible, and, therefore the Commissioners say, "We have no desire to condemn the dry earth or pail systems for detached houses, or for public institutions in the country, or for villages, provided the system adopted is carefully carried out."

On profitable sewage farming, the *Agricultural Gazette* says:—The difficulty of dealing with town sewage, so as at once to abate the nuisance which it creates, and cancel the dangers which are incurred by it, has been lately discussed at great length, and with an almost Ishmaelitish vivacity, before the Institute of Civil Engineers. Mr. Norman Bazalgette seems to have set to himself the task of proving the failure of all the remedies which have hitherto been offered, in order that the conclusion may be inevitable which we once heard Mr. Lawes enunciate—"Off with it to the German Ocean." And no doubt this is the policy which towns upon our Eastern shores may be well advised to adopt, leaving the utilisation of this wasted manure to some future time, when farmers may have learned how to convert it profitably into agricultural produce. But, unfortunately for all our large inland towns, this cutting off the knot of their difficulty is impracticable; and it is in the interest of agricultural economy, and no less than in that of health and decency, that some remedy be discovered and applied. Mr. Norman Bazalgette says that none exists. Subsidence, precipitation, filtration, are alike a failure, and the agricultural remedy is only rarely possible. In no case can a profitable result be looked for. We are happily able to assure him that a profitable result has been actually achieved during the past year in one very noteworthy example. Lord Warwick's farm, which pays £450 a year for the sewage of Leamington, has produced enough to pay farm rent and sewage rent, and improvement rent charges and all expenses, and leave a handsome profit; so that the story of uniform disaster which sewage farms have generally told is, at any rate, not without exception. And if to good farm management there were added inexpensive engineering, the exception would become the rule. Ordinary rents can be borne without difficulty by good ordinary farming; and accommodation rents, such as befall the town or corporation which hires land for a sewage farm, can be borne by good sewage farming; but when, in addition to this, there comes the enormous rent-charge which is oftentimes created by the expenditure of the lawyer and the engineer, the prospect becomes hopeless. Inexpensive methods of distribution must be adopted —and, let us add, that they may be safely adopted. Exact distribution is not necessary, nor is it possible; even with such an enormous expenditure as has been incurred in the endeavour to ensure it ât Merthyr and Kendal. The astonishing power of aërated and porus soil and subsoil (our knowledge of which we owe to Dr. Frankland) may be trusted a great deal more than engineers appear to trust it. Mr. Norman Bazalgette laboured hard the other evening to prove that the Merthyr filter-beds had done nothing like the work which Dr. Frankland had declared them capable of doing. But the answer to his criticism which was given in the subsequent discussion seemed to us complete; and as upon it rests the safety of the cheaper method which, in the agricultural interest, we recommend, we reproduce it here. At the close of his clear and conclusive argument on this subject, Dr. Frankland put the matter thus:—"I have analysed the effluent water from the Merthyr filter-beds when only 239 people drained on to them per acre, and again when 500, and when 1,250 people were draining on to them per acre. And deducting and discounting the dilution by the subsoil water, in the first case it was thirty times as clean and pure as it needed to be; in the second case it was purified seventeen times more than enough, and in the last case it was still three or four times purer than was necessary. Is it unreasonable, then, to believe that those filter-beds could have cleansed sufficiently, or even more than enough, the sewage of three or four times as many as the greatest of these numbers if only the work had been given them to do." Now, we contend that the work was given them to do, and that they did it. For it is plain that when Mr. Norman Bazalgette limited the performance of those filter-beds to the defecation of the sewage of only 1,000 people per acre, he forgot the very important fact that large potions had four or five times as much work to do as the rest. If it had been possible so to have distributed the sewage of Merthyr over the area of these beds that every square and cubic yard should have had just its aliquot share of the sewage to deal with daily, then undoubtedly it would have been perfectly correct to quote their performance as not representing one-third of the duty which Dr.

Frankland had declared them capable of doing. But the distribution was not and could not be anything like so uniform as that. It was not every square yard, but only every acre, or thereabout, that received its equal and aliquot allotment of the sewage. By a series of carefully-calculated and accurately-gauged water-ways, Mr. Bailey Denton ensured that when the water poured on five acres at a time, it divided itself into six equal spaces, each of which went to its own plot, about five-sixths of an acre in extent, and this was fed from a carrier along its side. But it is impossible so to water a sieve that every mesh shall have its equal share of work, by just setting it slightly a-tilt and pouring the water on along its upper edge. The quarter of the plot which was next the carrier had its full work to do from the first till the last of its six hours' period, but it often was not till two or three hours had elapsed that the quarter farthest from the feeder was even fairly wetted. And thus it was that, while it may be true enough that it was only the sewage of 20,000 people that was dealt with by the 20 acres of filter-bed at Trœdyrhiew—being at the rate of 1,000 people per acre—yet at least one-half, probably much more than one-half of that beautifully-purified effluent water must have come from the areas of the filter-bed which were being watered at the rate of 2,000, 3,000, or 4,000 people per acre. And that, we submit, is a consideration which well deserves the attention, and ought to influence the judgment of those who may study the action of the filter-beds below Merthyr, and even the Blue Books relating to them, not for the purpose of sustaining a foregone conclusion, but to seek, and as we believe to find, a remedy for the great difficulty which we all acknowledge, and from which such large populations in this country are actually suffering. As to the agricultural aspect of the question, that must not be looked for on filter-beds costing £200 an acre, but on those other filter-beds which may be prepared at a cost of £10 an acre, existing as they do wherever suitable fields have been properly drained and laid out in lands for the reception of the sewage.

Lord Alfred S. Churchill, in his address at the opening of the current session of the Society of Arts, summed up the situation very accurately in these words:—" The sewage question still remains a problem for solution, notwithstanding all that has been done for nearly a quarter of a century. How to deal with our sewage, and how to get rid of the nuisance at the smallest possible cost, and with the greatest advantage to health, is a difficulty which still confronts us. Exaggerated notions at one time prevailed as to the fertilising value of the sewage, and there was a popular belief that, in lieu of a burden on the rate-payer, it would become a source of wealth to each town. Scheme after scheme was propounded on this supposition, but only disappointment followed. Chemical analysis showed certain valuable fertilising constituents and fostered delusion, no account being taken of the cost at which they could be secured, even if any process had been discovered by which they could be made available. Experience, however, has led to the entertainment of more sober views, and the public are now beginning to learn that profit must not be looked for. Our health and comfort demand that the nuisance must be got rid of in some way or other, and at any reasonable cost; and if by some method of treatment a return can be obtained to diminish this cost, so much the better. We are no longer permitted to pollute our streams with it, and other means must be adopted for the removal of, and dealing with, our sewage. Experience would seem to show that perhaps a profitable, as well as healthful way of dealing with sewage, is to apply it to the land; but, unfortunately, it is not every locality that can supply, at a reasonable price, land suited for the purpose, either in soil or position. There are, doubtless, various processes for treatment of the sewage, chemically and by precipitation, which result in the production of a good effluent, generally sufficient to meet the requirements of the Rivers Pollution Act, passed last session, but the precipitant, sludge or solid matter, produced is of little value, and must not be reckoned upon as giving a return in money covering the outlay for works and cost of carrying on the process. At Leeds, I understand, where, probably, a larger amount of practical experience has been obtained on an extended large scale than in any other town, the difficulty has been to get rid of this sludge or solid matter; and it is only within the last few weeks that arrangements have been made with the contractor to purchase it and take it away at 12s. per ton, a sum totally inadequate to defray the cost of treatment. All that can be looked for in any case, wherever the water-carried sewage is applied to land, or treated by any known process, is that, under the most favourable conditions, some small return may be obtained in diminution of the necessary cost of getting rid of the nuisance."

At a meeting of the Institution of Civil Engineers, Mr. C. Norman Bazalgette read a paper "On the Sewage Question." It was stated that the object of the communication was, first, to limit and define the proper application of the various systems which had from time to time been devised; and, secondly, to direct attention to certain subordinate questions arising upon the practical operation of such systems. For the purposes of the paper the following classification had been adopted:—1. Treatment with chemicals. 2. Application of sewage to land. including irrigation and intermittent downward filtration. 3.

The dry earth system. 4. The Liernur or pneumatic system; and 5. Sea-board and tidal outfalls. After very long and elaborate arguments under these several heads, the author arrived at the following conclusions:—1. That no chemical process could efficiently deal single-handed with sewage, but must be assisted by subsequent natural or artificial filtration of the treated sewage, and that therefore no chemical process *per se* should be adopted for the purification of town sewage. 2. That where land could be acquired at a reasonable rate, irrigation was the best and most satisfactory known system for the disposal of sewage, but no profit must be expected from the cultivation of crops, and no definite standard could be laid down as to the proportion population should bear to acreage. That intermittent downward filtration might be practised where irrigation could not reasonably be adopted, but experience showed that the permanent proportion of population to acreage, where land was drained six feet deep, should in no case exceed 500 or 600 persons to an acre. That the term "intermittent downward filtration" meant no more than the production by deep drainage of a state of things frequently found in irrigation, and that irrigation could in some cases accommodate a larger proportion of population to acreage than intermittent downward filtration. That intermittent downward filtration, as expounded and explained by the Rivers' Pollution Commissioners, had never had and never could have any practical existence. 3. That the dry earth system could never be adopted for the purpose of dealing with town sewage, but might be occasionally used with advantage in small hamlets or detached buildings and institutions. 4. That the Liernur system was of such a character that it should never be imported into an English town. 5. That towns situated upon the sea coast, or within the tidal range of rivers, should avail themselves of the means of outfall thus presented, as affording the most economical and efficient means of dealing with their sewage, careful regard being always had to the position of the outfall, proper precautions being observed for the purpose of excluding silt from the sewers, and care being taken, in the selection of outfalls upon the banks of tidal rivers, that there was no reasonable danger of the silting up of the navigable channel.

At a public meeting lately held at the Society of Arts, allusion was made to the report recently presented to the Local Government Board. Sir J. Bazalgette, in his opening remarks, pointed out that the conditions essential to the health of towns are pure air, pure and abundant water, and the rapid removal of contaminated water, rainfall, and subsoil percolations, and of excreta, in the best possible manner. The report of the Committee of the Local Government Board recorded what had been done and the failures, and it concluded by urging the necessity for scavenging, sewering, and cleansing; by condemning the retention of excreta in cesspools, dry earth, or pails; and by affirming the sewering of towns and the draining of houses and the subsoil to be a prime necessity. As regarded the cost of precipitation and the value of sewage manure, the Committee said that no chemical or other treatment of town sewage with which they were acquainted was a commercial success. At Birmingham it appeared there was now no serious attempt to sell the sewage sludge; and at Leeds, Bradford, Bolton, and Coventry thousands of tons of extracted sewage sludge remained to cumber the works. In London, to produce 700 tons of wet sludge cost 25s. per ton, and when that quantity was dried to 142 tons the cost was £6 6s. 4d. per ton. Such a system was, Sir Joseph contended, only to be adopted in exceptional cases. Speaking of towns situated near the sea, he maintained that the wisest course to adopt was to let the sewage be carried out with the tidal waters. As to the objection on the ground of waste, it could not, he remarked, be wasteful to lose what was worth £1,000,000 if it would cost £2,000,000 to retain it. He then drew a comparison of the relative cost of the sewage systems of London and Paris, showing that whereas that of London amounted to 1s. per head of the population, that of Paris, with only half the population of London, amounted to 6d. per head, in addition to which 600,521 cubic metres of soil were removed from Paris in 1869 by carts, at a cost of 2s. 3½d. per head, which, if applied to London, would add £457,000 per annum to the present expenditure. The general conclusions which he drew from all the facts before him were that cesspools, middens, and dry systems are objectionable in towns; that purification by chemicals is costly and unsatisfactory, and only to be regarded as palliatives in exceptional cases; and that tidal outfalls are the cheapest, involve the least waste, and are in nine cases out of ten the most satisfactory mode of dealing with the sewage of towns in cases in which they can be used.—In the discussion which followed the opinions were very varied and conflicting, and the insurmountable difficulty of inland towns carrying out the sewage to tidal waters was apparently not alluded to.

As regards, then, the great problem of the day, which neither the report of the Commission, nor the results of the above meetings, solve,—and the solution of which seems so beset with difficulties,—sewage should be treated at its outfall by a combined plan of clarification, precipitation, and filtration, with or without its application to land. No one plan will suit every place, no universal rule can be made, but that should be adopted which on careful consideration is most to be recommended by position, soil, population, manufactories, &c. The impossibilities of getting land in some cases, and the exorbitant rents demanded for it in others, have driven towns to processes which do not find favour with them, and which can only be carried out in small areas. Instead of one main sewer, Mr. G. Henry Roberts, C.E., Preston, proposes to divide the town into sections, and convey the sewage to several outlets in the outskirts of the town. As regards cost, Mr. Roberts holds that he would construct the necessary works for a sum of £2,000, whereas with a long main sewer and one large outlet the sum expended would likely reach £10,000, or even more. With regard to chemical treatment, "it may be considered as still in its infancy, and presents a fine field to chemists for investigation and research. From the rapid advance which chemical science is now making, I have little doubt that sewage will eventually come much more completely under chemical control than it is at present, but as far as we have yet gone, I think, there can be no doubt that nature's laboratory and mother earth have done more for the satisfactory purification and utilization of sewage than any method of artificial treatment."—(*Sanitary Papers*, by Allen Carter, C.E., 1877, p. 11.) I am perfectly satisfied from carefully conducted experiments that the disposal of sewage can be thoroughly accomplished without the enormous expense to which various communities have been put, and that the economical, if not profitable, riddance of this universal nuisance can be successfully accomplished. As water-carriage of excreta must eventually be the plan adopted by every large town presuming to advanced civilization, the disposal of sewage becomes the question and problem of the day, the outcome of the adoption of what has been above recommended—the water-carriage system in preference to conservancy plans. In the new Act for making further provision for the prevention of the Pollution of Rivers (39 and 40 Vic. cap. 75), the principal object of the statute, as declared by the preamble, is "to prevent the establishment of new sources of pollution," and certificates are to be given to the effect that the means used for rendering harmless any sewage matter,—"good stuff in the wrong place,"—or poisonous, noxious, or polluting, solid or liquid matter, carried into any stream, are the best and only practicable and available means under the circumstances of the particular case, but what the best means are the above reports have not decided;—he who solves the difficulty should undoubtedly be amongst the worthies entitled to a place in the Elysian fields—

"Inventas aut qui vitam excoluere per artes" (*Virgil*)—

paraphrased rather than translated by Dryden,—

"And searching wits, of mere mechanic parts
Who grace their age with new invented arts."

CONCLUSIONS.

The conclusions as to sewerage and drainage are best summed up by extracts from a publication, entitled *Suggestions as to the Preparation of Plans as to Main Sewerage and Drainage, and as to Water Supply*, which were prepared by Mr. R. Rawlinson, C.E., C.B., and issued by the Local Government Act Office.

MAIN SEWERAGE AND DRAINAGE.

Before a scheme of sewerage is devised, the district should be fully examined so as to obtain a correct idea of the drainage area, or the several drainage areas; enquiry should then be made to ascertain how surface water has passed off up to the time of such examination, and with what effects. Main sewers and drains should be adapted to the town area, length of streets, number of houses, surface area of house-yards and roofs, number of street-gullies, and volume of water supply.

Sewers and drains, in wet subsoil, should be made to act as land drains.

The following rules are general. Each surveyor must, however, use his own judgment, and make the best arrangements possible, having regard to the circumstances of each special area, and the materials at command.

Natural streams should not be arched over to form main sewers.

Valley lines and natural streams may be improved, so as to remove more readily surface water and extreme falls of rain.

Main sewers need not be of capacity to contain flood-water of the area drained; such flood-water may be passed over the surface, in most cases without causing injury.

Main sewers should be laid out in straight lines and true gradients, from point to point, with side entrances, or with manholes and flushing and ventilating arrangements at each principal change of line and gradient. All manholes should be brought up to the surface of the road or street to allow of inspection, and should be finished with a cover easily removable.

Duplicate systems of sewers are not required. Drains to natural streams in valley lines for storm waters may be retained, and may be improved, or, if necessary, enlarged.

Earthenware pipes make good sewers and drains up to their capacity. Pipes must be truly laid, and securely jointed. In ordinary ground they may be jointed with clay. In sandy ground, special means must be used to prevent sand washing in at the joints. House drains should, in all cases, be laid in a water-tight trench. If the subsoil is porous, the trench should be lined with clay-puddle. Special care should be taken to prevent any contamination of wells, by sewage from main sewer or from house drain, the water from which wells is to be used for domestic purposes.

Brick sewers ought to be formed with bricks moulded to the radii.

Brick sewers should, in all cases, be set in "hydraulic mortar," or in cement. In no case should any sewer be formed with bricks set dry, to be subsequently grouted.

Main sewers may have flood-water overflows, wherever practicable, to prevent such sewers being choked during thunderstorms or heavy rains.

Sewers should not join at right angles. Tributary sewers should deliver sewage in the direction of the main-flow.

Sewers and drains, at junctions and curves, should have extra fall to compensate for friction.

Sewers of unequal sectional diameters should not join with level inverts, but the lesser or tributary sewer should have a fall into the main, at least equal to the difference in the sectional diameter.

Earthenware pipes of equal diameters should not be laid as branches or tributaries, that is, 9-inch leading into 9-inch, or 6-inch into 6-inch, but a lesser pipe should be joined on to the greater, as 12-inch to 15-inch, 9-inch to 12-inch, 6-inch to 9-inch, and so on.

House drains should not pass direct from sewers to the inside of houses, but all drains should end at an outside wall. House-drains, sink-pipes, and soil-pipes should have ample means of external ventilation.

Sinks and water-closets should be against external walls, so that the refuse-water, or soil, may be discharged into a drain outside the main wall. Down-spouts may be used for ventilation, care being taken that the head of such spout is not near a window. Water-closets fixed within houses, and having no means of direct day-light and external air ventilation, are liable to become nuisances, and may be injurious to health.

Inlets to all pipe drains should be properly protected.

Side junctions should be provided in all new sewers and drains. The position should be sketched, and indicated by figures in a book or on a plan. Side junctions not used at once should be carefully closed for subsequent use.

A record should be kept by the surveyor of the character of the subsoil opened out in each street as it is being sewered or drained.

Sewers and drains should be set out true in line and in gradient. All the material used should be sound, and the workmanship should be carefully attended to.

"Sight-rails" should be put up in each street before the ground is opened out, showing the centre line of each sewer and depth to the invert.

Sewers having steep gradients should have full means for ventilation at the highest points.

Tall chimneys may be used, with advantage, for sewer and drain ventilation, if the owners will allow a connection to be made.

Sewer out-let works should be simple in form, cheap in construction, and so arranged as to remove all solids, sediment, and flocculent matter from the sewage.

General Remarks.

In executing town sewers and drains danger may be anticipated from several conditions; as where a street or place is narrow, with buildings on both sides, and where the trench is deep; where the substrata is clay or marl, made ground, loose earth, bog and silt, quicksand, or any combination of such strata.

Quicksand is most difficult to deal with, and, as a rule, such ground should only be opened in short lengths; this ground may require to be close-timbered, and in such case, stable litter and ashes will be found useful to pack behind and betwixt the "polling" boards.

Sound-looking clay or marl may require a careful timbering to prevent heavy breakings from the sides of the trench. When such ground "sets" heavily, the sewer, if of bricks, may be seriously injured; if of earthenware pipes, it may be ruined by cracking or by crushing and distorting the line of sewer or drain-pipes.

As a rule all sewer and drain trenches in towns should be carefully timbered, and such timbering must either be left in or must be carefully removed as the trench is filled.

The houses and buildings in narrow streets may require to be propped and stayed; if so, such props and stays ought not to be removed until the sewer or drain has been completed, and the ground become perfectly consolidated.

In many cases it will be cheaper, because safer, to leave timbering in deep trenches, and where there is special danger the trench may be filled with concrete.

A foreman in charge of sewer-works is expected to be on the watch to see that the men execute the works safely. The local surveyor must see that timber sufficient in quantity and in quality is supplied to secure all open trenches, and the buildings on either side.

Where ground is known to be specially dangerous, all available precautions must be taken to prevent accidents.

It is of the utmost importance to impress upon local surveyors the necessity of care in setting out main-sewerage works and house-drains with accuracy, in choosing sound materials, and in properly superintending the works during their progress. House-drains should be so arranged as to be capable of removing all water, soil, and fluid refuse from yards, roofs, and interiors of houses to the sewers, without any risk of gaseous contamination to such houses.

Street sewers should be capable of conveying all sewage to some common outlet, without retaining sediment in them. All sewers and drains should have arrangements for full ventilation, at such points and in such manner as not to cause any nuisance. Charcoal (as proposed by Dr. John Stenhouse) may be used to filter and disinfect sewage gases, at manholes, and other ventilators.

(With properly constructed sewers there should be no necessity for resorting to charcoal, for although, theoretically, charcoal possesses a wonderful deodorising power, still practically,—as it soon gets damp and covered with grit,—it acts as an obstruction, thus tending to check free ventilation and doing more harm than good.)

If the fluid sewage can be applied to land for agricultural uses, means should be provided for effecting this purpose.

Water-closets should have a day-light window (not a "borrowed light"), and fixed means of ventilation, which can neither be seen nor tampered with. Permanent openings, equal to a slit 12 inches in length and 1 inch wide, should be provided. The cover, or lid of the seat, should be made to close and leave the valve handle free, so that the contents of the closet may be discharged with the lid closed down. At all times when a water-closet is not in use the lid or cover should be closed.

Manholes should have moveable covers at the surface of the ground. There should be a side chamber for ventilation, "step irons" to give access to the invert, and a groove to allow of a flushing board being inserted at will for flushing purposes. The side chamber should be arranged for a charcoal screen or filter.

Main Sewer Ventilation.

Towns situate on land rising considerably will best be sewered in zones; that is, by intercepting lines of sewers contouring the site, as such intercepting sewers will prevent gorging the low-level districts, as, also, prevent the rush of sewage direct down steep gradients at high velocities, which in times of heavy rain may burst the low level sewers at the steep gradient junctions. By intercepting lines of sewers, sewage may also in some cases be retained at such an elevation as to deliver it in the country by gravity, on to and over land for agricultural uses. Sewers with steep gradients, if the flow of sewage is unbroken, get up a velocity in the sewage which is liable to be very injurious in its wearing action on the sewers. Sewage should not be allowed to acquire a greater velocity at any state or time of more that 4 (four) feet per second, which is nearly 3 (three) miles in the hour. Six feet velocity per second will take any grit, or other solids, along the sewer invert with a cutting and disintegrating action rapidly destructive to the material of the sewer.

Main sewers are underground conduits for sewage to flow down, and if they are not fully ventilated at regular intervals along the crown by fixed openings communicating with the external air, they become flues up which sewage gases will rise and pass through the drains to the connected houses.

Sewers formed along steep gradients therefore require to have more care bestowed on the means for ventilation than other sewers laid along flat districts, to prevent dangerous accumulations of sewage gases in the upper districts of towns. Sewers rising from lower and flatter districts should therefore have manhole or "*side entrance*," tumbling-bay, and double ventilating arrangements. This form of tumbling-bay should be repeated on the steep gradient at intervals of not less than 300 yards.

Ordinary main sewer ventilation should be provided for on all sewers at intervals not greater than *one hundred yards*, or not fewer than 18 fixed openings for ventilation should exist on each mile of main sewer.

The upper or "*dead ends*" of all sewers and drains should have means provided for full ventilation continued beyond the junction of the last house drain.

Provision should be made for the use of charcoal screens on all manholes. Charcoal will not, however, be required in all cases, and should only be exceptionally used, as it retards ventilation.

Steam-boiler or other furnaces and tall chimneys may be used for sewer ventilation where the owners of factories and of steam engines will permit of such use, but the ordinary means for sewer ventilation must not on this account be dispensed with, as the ventilating effect of a furnace or tall chimney will be limited to a comparatively short length of the sewer, by the number of openings into the main sewers, such as house drains, street gulleys, &c.

Separate costly tall shafts or furnaces for main sewer and house drain ventilation are not required, and should not be provided, because such works cannot be of use in proportion to their cost. Sewers cannot be ventilated as tunnels and coal mines are in which close airways have to be provided and also kept under control.

Sewers liable to be affected by the rise of tides or land floods, as on the sea shore, or on a river, must be so arranged that any backing of the sewage shall not injuriously affect the sewers and drains within the town. The lower portion of any system of sewers below the level of high water of the sea, or land floods of an inland river, must therefore be cut off from the upper portions, and must be so abundantly ventilated that any sewage gases may be forced out at points specially provided for the purpose, and not be driven inwards and up the steeper sewers of the town through the drains and into the houses.

The ends of all sewers and drains at the lowest outlets must be so protected that the wind cannot blow in and force any sewage gases back to the streets and houses. Flap-valves, or other contrivance, may be provided to cover and protect outlet ends of sewers and drains, and so prevent the wind blowing in.

Means for full and permanent ventilation of town sewers and house drains are required to prevent stagnation or concentration of sewage gases within sewers and drains, and with numerous openings from the sewers to the external air, as described, there will be unceasing motion and interchange betwixt the outer air and the inner sewer air which will bring about and maintain extreme dilution and dispersion of any sewage gas so soon as generated. It has been found by experiment that in unventilated sewers the gas concentrates and so becomes deadly,* whilst in fully ventilated sewers the sewer air is purer than that of stables, or even than in a public room when occupied. The air from well ventilated sewers is not offensive to the sense of smell. If, however, sewer air at any sewer ventilator, or at any other point, should be offensive,

* Men have lost their lives by entering unventilated sewers on many occasions in London, as also in other places.

additional means for ventilation on this sewer or at this point are required and should, as soon as possible, be supplied. Trapping should not be resorted to in such case.

If cesspools are required for any purposes, they should be made watertight, and placed as far from wells and dwelling-houses as possible, and should be abundantly ventilated.

Dust-bins should also be fully ventilated.

Ventilation cannot be fully accomplished through single tubes or openings. There should never be less than two passages, or any tube or pipe must be divided by a diaphragm.

Where charcoal is used in sewer ventilation, it must be understood to retard motion, and provision should be made to meet this. Charcoal trays, or boxes, for sewer ventilation should never have less than 1,000 square inches of surface exposed for the passage of sewage gas to each 50 square inches of free opening to the outer air. The meshes of a charcoal tray may be about $\frac{1}{8}$ of an inch. The charcoal (wood) may be about the size of coffee beans, clean sifted, and placed in a layer of two or three inches. Charcoal in a dry state acts best; but its disinfecting property is only diminished by damp, it is not entirely destroyed. The length of the intervals betwixt the renewals of the charcoal will depend upon the dryness of the situation where the material is placed, and the volume and strength of the gas to be acted upon. In some cases two or more charcoal trays may be used apart, one above the other, so that the gas to be acted upon may have to permeate and pass through the whole of the trays. The charcoal may require in some places to be renewed at intervals of six months.

For detached houses, villa residences, or larger establishments, drains should never end at the house to be drained, but should be continued beyond and above to some higher point or ventilating shaft where means for full and permanent ventilation can be provided so as effectively to relieve the house from any chance of sewage gas contamination.

Drains should never traverse the basement of a house, but should be external; if there are drains within a basement, and crossing it, such drains should be absolutely air-and-water-tight within such basement and have full means for permanent ventilation provided outside at both sides of the basement. Pipes of earthenware may be bedded in concrete; in some cases pipes of cast-iron may be used within house basements.

All drains should lie their full diameters below the surface of the subsoil of any basement, and have a fall of not less than 1 in 60 towards the sewer. The full half-diameter of the sewer (at least) should be below the junction of the house drain.

Wherever a trap is placed on a sewer or drain, there should means for sewer and drain ventilation be placed also. Traps are only safe and useful in conjunction with full and permanent means for sewer ventilation.

It has been suggested that sewer and drain ventilation will so taint the atmosphere within and over a town as to cause houses at a lower level to pollute those situate at higher levels. This result need not be feared, as, with the abundant means for ventilation suggested the air within the sewers will be comparatively pure, so pure in fact that the most delicate test will be required to find the presence of sewage gas at the immediate outlet of any ventilator, and out of the ventilator further dilution and dispersion will dissipate every trace of taint and danger.

Flushing Sewers and Drains.

On a system of sewers every manhole should be a flushing-chamber, so managed as to be charged with water for flushing purposes. There should also be a flushing-chamber at the head of each sewer and drain. Where there is a public supply of water, the flushing chambers may be filled from the mains; where there is no such public supply, they may be filled by water-cart. Flushing a sewer means accumulating water sufficient to pass down and along the sewer below with a rush when suddenly liberated, which water shall loosen and carry away all sediment. Leaving house-traps open and propping the handles of water-closets will not flush drains and sewers, but will only waste water. It is possible to injure sewers by overflushing them, and it is therefore the duty of a local surveyor to understand this, and to avoid it.

With sewers in right lines, and even gradients, from manhole to manhole (as directed to be made), the surveyor can first float a light cord from one manhole to the other below, then draw along a stronger rope to which scrubbers may be attached to cleanse effectually such sewers as have very little fall, and are consequently liable to accumulate deposit.

An ordinary amount of subsoil water may be admitted into the sewers with advantage, as the regular flow will tend to prevent any silty deposit, and the dilution will tend to lessen the putridity of the sewage. Sewers formed in and along a naturally dry subsoil are liable to accumulate deposit by allowing the fluids to filter into the subsoil. The trench should therefore be made water-tight before the invert of the sewer is laid in it.

Springs of water, if of considerable volume, may require to be removed from a sewer trench independently of the sewer, to prevent this surplus water usurping the place of sewage.

Springs of water, and the water from canals, reservoirs, rivers, and streams, may occasionally be so near as to be easily made available for purposes of sewer-flushing. Where this is the case, it will be of great advantage to the local surveyors to arrange for such flushing power being made available.

Sewers and drains perform good service when they permanently lower the subsoil water within a town or near houses, and if this draining of the subsoil lays adjoining springs, wells, and pumps dry, no action at law will lay against the local authority. There is no private ownership in underground water which is capable of being removed by sewering and draining.

"1. Be not content until you have *seen* that every waste pipe and overflow pipe is cut off from the access of sewer gas, that the soil pipe of your water-closet is sound and adequately ventilated, and that there is no leakage at its junction with the drain.

"2. If there is a smell of drains in your house, or a damp place in a wall near which a waste pipe or a soil pipe runs, or a damp place in the cellar or kitchen floor near a drain or a tank let no time be lost in laying bare the pipes or drains until the fault be detected.

"3. If you are tenants, and your landlord refuses to remedy the evil, *do it at your own cost rather than allow your family to be ill.*

"4. If you are about to buy or to rent a house, be it new, or be it old, take care *before you complete your bargain* to ascertain the soundness of its sanitary arrangements with no less care and anxiety than you would exercise in testing the soundness of a horse before you purchase it.

"5. If you are building a house, or if you can achieve it in an old one, let *no drain be under* any part of your house, *disconnect* all waste pipes and overflow pipes from the drains, and place the soil pipe of the w.c. *outside* the house, and ventilate it.

"6. If, having bought a house with bad drainage, it costs you £100 more than you expected to put it right, so much the worse for your bargain.

"7. If you are a tenant, and your investigation compels the landlord to spend a large sum in rendering the house free from sanitary dangers, you may fairly pay a higher rent for the greater safety, and for the greater immunity from illness and all the expenses it entails.

"8. A landlord may reasonably look for interest on money which he spends for the benefit of his tenant; but he is committing little short of manslaughter if, by refusing to rectify sanitary defect in his property, *he saves his own pocket at the expense of the health and lives of his tenants.*

"9. Many a man who would be aghast at the idea of putting small quantities of arsenic into every sack of flour, and so by degrees killing himself and family, does not hesitate to allow sewer gas to poison the inmates of his house, even in the face of the strongest remonstrances of his medical adviser.

"10. If a rat appears through the floor of your kitchen or cellar, feel sure that something is wrong with the drain.

"11. When you leave a house because of its unhealthiness, don't let others go into it unwarned, or at any rate let the landlord know the reason of your leaving, and throw upon him the responsibility of the health of the future tenant.

"12. If you be a landlord, don't intimidate your tenants or threaten to give them notice to quit if they complain of defective drainage or sewer gas in the house. I just touch on this point and say no more, but it is a caution which, I believe, is needed.

"13. If any one should be spurred up to the investigation of the sanitary condition of his own house, let me urge him to go round with the person whom he consults and see for himself every pipe and trap, and if possible every drain investigated, and let him not shrink from the man-hole in the roof. It will be a valuable lesson, and may help him to detect faults on a future occasion, or perhaps in a friend's house.

"14. When illness of a zymotic type breaks out in a house from poison within the house, what ought to be done? Theoretically, no doubt, the patient ought to be removed, so as to secure an untainted atmosphere. Practically this is often out of the question. What is the next best thing to do? To make the atmosphere of the room independent of the atmosphere of the house, acting on the principles so ably advocated and forced upon the attention of the country by Mr. Tobin. This may readily be done as a temporary measure, by opening the bottom sash of the window just to the extent which allows the flame of a candle held at the key-hole to burn steadily. In other words, admit through the window just the amount of air that will feed the chimney without drawing upon the air of the house. The next step is to convert this horizontal current into a vertical one, by fixing a board six or eight inches in height against the lower part of the window, and one and a half or two inches distant from it. Then the current will set upwards towards the ceiling, and slowly diffuse itself without producing a draught." The same idea was suggested in the year 1862, by Mr. P. Hinckes Bird, F.R.C.S., in a paper in the *Builder*, on "Costless Ventilation," which contains most valuable hints.—T. P. Teale, *Dangers to Health in our own Houses*, pp. 18—20.

The resolutions adopted by the Croydon Local Board of Health were to the effect that—

1. After the date of approval, no new house should be passed as fit for occupation that did not have a cistern fitted to the w.c. on self-flushing principles. That water from such cistern should not be used for dietetic purposes.
2. That every branch of drain going into the public sewer should be properly ventilated by an extension of the soil-pipe of the w.c. upwards and outwards.
3. If the drain is not intended for a w.c., then by a ventilating pipe inserted between the trap and the sewer, and as close to the trap as possible.
4. That all rain-water pipes be untrapped.
5. That all overflow pipes from cisterns, baths, and waste-water sinks or closets, be cut off from direct communication with the sewer.
6. That no communication with the public sewer, or any sewer-pipe, be covered up until it has been inspected by the proper officer of the Local Board.

A most important and necessary rule, that all such communication be laid upon concrete, was rejected by the Local Board. —Carpenter, *op. cit.*, p. 3.

In a special report on sewer ventilation in Salford, Dr. Tatham advises the committee "that in all cases where there is not sufficient space for the immediate dilution and destruction of noxious effluvia, they recommend the council—either, (*a*) To cause ventilating shafts to be erected at frequent intervals, in connection with the sewers, of a sufficient diameter, and of such a height as to safely discharge the foul air above the roofs of the houses ; or (*b*) In case the present street grids are retained, to use every diligence in purifying the sewer air, by means of charcoal, before permitting its escape into the street. The first plan, viz., that by ventilation above the roofs, seems to me the better one, inasmuch as all obstruction to a free circulation of air in the branch sewers being removed, there is less fear of that dangerous pressure at the distal, or house end of the drainage system, which so frequently forces pestiferous gases through the water-traps of our dwelling-houses."

The following are the conclusions from the first and second reports of the Select Committee on the sewage of towns, dated 10th April, 1862 :—

Analysis of Evidence.

1. The evidence proves that sewage contains the elements of every crop which is grown.

2. That as compared with solid manure there are advantages in the application of sewage manure to land.

3. The evidence proves that town sewage contains a large amount of heat, which in itself is beneficial in stimulating vegetation.

4. The evidence also proves that the water alone of sewage is of great benefit for agricultural purposes.

5. The evidence further proves that one ton (224 gallons) of average town sewage contains an amount of manure which, if extracted and dried, would be worth a little over 2d., taking Peruvian guano (at £11 per ton) as the standard.

6. A judicious use of town sewage permanently improves land.

7. Sewage may be applied to common grass, Italian rye-grass, and also to roots and grain crops, with great advantage, dressings with sewage hastening vegetation.

8. Sewage-grown grass has a great effect in increasing the quantity and richness of the milk of cows, as well as improving the condition of the cattle, which prefer sewaged-grass to all others.

9. The earth possesses the power of absorbing from sewage all the manure which it contains, if the dressings in volume are proportioned to the depth and quality of the soil.

10. Those who use sewage should have full control over it, that they may apply it when and in what quantities they may require it.

11. Heavy dressings of sewage (8,000 to 9,000 tons per acre) are wasteful; less dressings (500 to 2,000 tons per acre) when more carefully applied, produce better results. The enormous dressings recommended by some witnesses would be agriculturally useless, as the sewage would flow over and off the surface unchanged.

12. When the sewage of our cities, towns, and villages is utilized to the best advantage over suitable areas, little or no imported or manufactured manures would be required in such districts.

13. Sewage may be applied with advantage to every description of soil which is naturally or artificially drained.

14. The most profitable returns, as in the case of all other manures, will be obtained when sewage is judiciously applied to the best class of soils.

15. Sewage may be advantageously applied to land throughout the year.

16. Some matters used in manufactures which enter town sewers, such as waste acids, would be in themselves injurious if applied to vegetation; but bearing as they do so small a

proportion to the entire volume of sewage into which they are turned, they are rendered harmless.

17. Fresh sewage at the outfall of the sewers, even in the hottest weather, is very slightly offensive; and if applied to the land in this state, in such dressings as can at once be absorbed by the earth, fear of nuisance need not be felt, as the soil possesses the power to deodorize and separate from liquids all the manure which they contain.

18. Large dressings and an over-taxed soil may pollute surface streams, subsoils, and shallow wells.

19. Solid manure cannot be manufactured from town sewage with commercially profitable results.

In the report on the results of the Society of Arts Conference on health and sewage of towns, June 1876, the following conclusions are deduced:—

The Chairman of the Conference and the Executive Committee, after having carefully considered the information furnished from the various localities, as well as the facts brought forward during the Conference, have to submit the following as the conclusions to which such information appears to lead:—

1. In certain localities where land at a reasonable price can be procured with favourable natural gradients, with soil of a suitable quality and in sufficient quantity, a sewage farm, if properly conducted, is apparently the best method of disposing of water-carried sewage. It is essential, however, to bear in mind that a profit should not be looked for by the locality establishing the sewage farm, and only a moderate one by the farmer.

2. With regard to the various processes based upon subsidence, precipitation, or filtration, it is evident that by some of them a sufficiently purified effluent can be produced for discharge without injurious result into water-courses and rivers of sufficient magnitude for its considerable dilution; and that for many towns where land is not readily obtained at a moderate price those particular processes afford the most suitable means of disposing of water-carried sewage. It appears, further, that the sludge, in a manurial point of view, is of low and uncertain commercial value, that the cost of its conversion into a valuable manure will preclude the attainment of any adequate return on the outlay and working expenses connected therewith, and that means must therefore be used for getting rid of it without reference to possible profit.

3. In towns where a water-carried system is employed, a rapid flow, thorough ventilation, a proper connection of the house drains and pipes with the sewers, and their arrangement and maintenance in an efficient condition, are absolutely essential as regards health; hitherto sufficient precautions have rarely been taken for efficiently ensuring all the foregoing conditions.
4. With regard to the various dry systems where collection at short intervals is properly carried out, the result appears to be satisfactory, but no really profitable application of any one of them appears as yet to have been accomplished.
5. The old midden or privy system, in populous districts, should be discontinued, and prohibited by law.
6. Sufficient information was not brought forward at the Conference to enable the Committee to express an opinion in regard to any of the foreign systems.
7. It is conclusively shown that no one system for disposing of sewage could be adopted for universal use; that different localities require different methods to suit their special peculiarities, and also that, as a rule, no profit can be derived at present from sewage utilization.
8. For health's sake, without consideration of commercial profit, sewage and excreta must be got rid of at any cost.

The Executive Committee, whilst abstaining from submitting any extensive measures, have no hesitation in recommending that the prevention of dangerous effects from sewage gases should receive the immediate attention of the Legislature, and they submit the following resolutions as the basis of petitions to Parliament :—

1. That the protection of public health from typhoid and other diseases demands that an amending Act of Parliament be passed, as soon as possible, to secure that all house drains connected with public sewers in the metropolis and towns having an urban authority should be placed under the inspection and control of local sanitary authorities, who shall be bound to see to the effective construction and due maintenance of all such house drains, pipes, and connections. Provisions having this object in view already exist in the Act constituting the Commissioners of Sewers in the City of London, in the Metropolis Local Management Act, 1855, and in the Public Health Act, 1875, but practically they seem scarcely sufficient for the purpose.

2. That plans of such drains and connections be deposited in the charge of the respective local authorities, who shall be bound to exhibit them and supply copies of them to the public on payment of a moderate fee.
3. That the owners of houses be compelled by law to send to the respective local authorities, within a specified time after the passing of the Act, plans of all house drains on an appointed scale.

Signed by—

Members of the Executive Committee.	The Right Hon. JAMES STANFIELD, M.P., Chairman of the Conference. Lord ALFRED S. CHURCHILL, Chairman of the Council. F. A. ABEL, F.R.S., President of the Chemical Society. Sir HENRY COLE, K.C.B. Captain DOUGLAS GALTON, R.E., C.B., F.R.S. Lieut.-Colonel E. F. DU-CANE, R.E., C.B., Surveyor-General of Prisons."

Postscriptally I may add as an instance of the inordinate prices which have been paid for land, arbitration, law charges, &c., &c., &c., the case of Blackburn, in which they amounted to £30,000—a heavy burden to the ratepayers, and such as quite to militate against a sewage farm being profitable ; and in the *Echo* of April 14th, we read that the ratepayers of Barnsley, in Yorkshire, " are almost at boiling point now," so says Mr. Blackburn, a councillor of the town. The cause is this—the costs incurred in a recent case of arbitration between the Corporation and a Colonel Wombwell with respect to land required for sewerage purposes at Benton Grange, near Barnsley. The total costs came to £4,339, and Alderman Brady said, in bringing the matter before the notice of the Council, included some curious items. Among other charges there was one for a dinner at Greenwich, some of the witnesses refusing to be content with the fare to be had at various noted London houses. Before the Council could get the award in the first instance, they had to pay £622, of which sum about £170 was claimed by each arbitrator, and £271 by the umpire. The cost of fees to witnesses on the Corporation's side was £935, and on Colonel Wombwell's side £948. It is said that some of the witnesses examined were of European celebrity, and these sent in moderate bills ; while men who had never been heard of till the arbitration had charged in an inconsistent and reckless manner. In addition to the costs of witnesses, the Council had had to pay the legal expenses imposed by Colonel Wombwell. The bill sent in by

Messrs. Newman and Sons, his solicitors, amounted to £884, of which £357 was for professional services rendered, and the remainder "money out of pocket," whatever that may mean. The Council's own legal adviser, the Town Clerk, had sent in a bill for £866, which included £357 for professional services, and the remainder for "money out of pocket." Alderman Brady questioned the right of the Town Clerk to charge for professional services, when he was the servant of the Corporation. For refreshments at the King's Head Hotel, Barnsley, the Council had been charged £61 12s.; for paying a counsel his fee, £2 2s.; for making minutes of evidence, £8 7s. 10d.; and for handing the same to the counsel, £1 13s. 4d. The crowning point, however, was considered to be Messrs. Newman and Sons charging £8 10s. for making out their own bill; and the Town Clerk had charged £4 10s. for going through the same interesting occupation in the case of his own bill! No wonder that the ratepayers of Barnsley "are almost at boiling point now," and the Council thinking of taxing the costs. They have got, indeed, a nice little bill to deal with.

I attended the meeting held at the Society of Arts, on April 11th, to consider the uses to which town sewage could be applied. The meeting was in the form of a conference of gentlemen who had paid great attention to the subject. Dr. Bartlett, the well-known analyst, gave the result of his analyses, and stated that whatever material value was contained in town sewage, three-fourths of that value arose from the salts in the liquid. He also pointed out that ammonical fermentation would scatter broadcast the germs of disease, such as had been forcibly shown in late lectures by Professor Tyndal, and the speaker stated that he could add another link in the chain of evidence which immediately connected the fermentative growths of zymotic disease with the fluids from typhoid patients. Dr. Drury said that when he was appointed Medical Officer of Health for a populous borough (Walsall) he wished to have traps to the houses. The surveyor said that the men would not go then into the sewers as they would be suffocated, so that in point of fact without traps the sewers were ventilated into the houses.

It is to be hoped that the Annual Conference on Health and Sewage of Towns, to be held on the 3rd and 4th of May next, will furnish us with some more definite and decided views on this vexed question than have yet obtained.

1, Norfolk Square, W., London, and Lytham, Lancashire,
May, 1877.

JOHN GRIME, GENERAL PRINTER, "GAZETTE" OFFICE, BLACKPOOL.

HEALTH AND SEWAGE OF TOWNS.

Some unexpected delay in preparing the sheet of illustrations has afforded the opportunity of referring to the result of the May meeting on the "Health and Sewage of Towns," as reported in the *Sanitary Record* and *Public Health* :—

The Chairman (the Right Hon. J. Stansfeld), in the course of his introductory remarks, said that in his opening address of last year he had alluded specially to the question of the escape of sewage gas into dwellings, and that subject deserved their careful consideration at the present time. Since their last meeting he had received several communications with regard to this new source of nuisance and danger, arising out of the modern systems of water-carriage sewage, which led him to the inference that the attention of sanitary engineers and others had been very much addressed to the subject, and that it had not yet been avoided, but that it was possible to prevent it. He believed that the difficulty of preventing the ingress of this dangerous gas into houses could be surmounted, and trusted that the discussions at this conference would help towards the solution of the problem. He still felt that in the case of large and dense populations there was much to recommend the water-carriage system of sewage; it was certainly the most cleanly and decent in action, but, on the other hand, it was a system which involved very considerable outlay. After cautioning local sanitary authorities against rashly embarking, in the present state of knowledge on the subject, in large schemes for the disposal of sewage, the Chairman said that one or two dry systems had certain advantages. They involved less capital outlay, and might be a nuisance, but they were not subject to the objection of being dangerous in the direction of the production of sewer gas. He asked to be supported by the members of the conference in carrying out the rule forbidding the introduction and discussion of untried schemes; he was desirous that the proceedings should be practical in character. The conclusions at which they arrived at last year's conference, and to which they must direct their attention, were, in the first place, that under certain favourable conditions, a sewage farm, if properly conducted, was apparently the best method of disposing of the water-carriage sewage; the second proposition was that there were various methods of dealing with sewage outfall, by subsidence, by precipitation, or by filtration; the third conclusion was, that in towns where the water-carriage system was applied, a rapid flow, thorough ventilation, proper connection between the house, drains, pipes, and sewers, and their maintenance in a proper condition, were absolutely necessary with regard to health; fourth, that with regard to the various dry systems, the result, if properly carried out, appeared to be very often satisfactory; and the fifth and last conclusion was to the effect that the old privy system should be prohibited by law, and that it was evident that no one system of sewage could be adopted for universal application, inasmuch as different localities required different methods. They further arrived at the conclusion that, whether it was water-carriage sewage or a dry system, they had no evidence before them showing that any one system had been conducted at a profit. That conclusion had induced them to advise local authorities to be careful before they entered into large and costly schemes, in the hope that by the outlay of capital they might render a scheme efficient and profitable. He desired the delegates to ask themselves, What is the implied contract entered into between the community and the individual, when a water-carriage system was established? The community made a sewer, and the individual was, or ought to be, compelled to drain into it; the community undertook to convey it away, so as neither to be a nuisance nor danger to the health of himself or the community. But had the community a moral right to propose such a contract when, under the existing law, it had no reliable means of preventing the escape of gaseous matter at the point of juncture between the householders' drain and its system of sewers? Should they now carry the community's responsibility a step higher, and say that its duties of removal should commence at the outside wall of the house? (Expressions of approval and dissent from delegates.) He would leave the subject in the hands of the meeting, suggesting two inquiries—First, whether it was not a part of the implied contract of each local community so to deal with the sewage as to prevent it from being a nuisance or a danger to the health of the householder or the community? And, secondly, under what conditions can the contract of removal best be carried out?

Dry, or so-called dry, systems of conservancy came first for discussion, and here the Goux system was highly approved. A good number of gentlemen who were thoroughly and practically acquainted with its working details were singularly unanimous in awarding it the palm. The absence of all machinery and the cleanly decency afforded by the bird's-nest-like lining were strongly insisted upon. This testimony was all the more valuable as coming from the chairman and other members of the Halifax Health Committee, as well as from Mr. Haviland and Drs. Ainley, Syson, and other professional sanitarians. Mr. Alderman Taylor's Rochdale system also attracted a large amount of attention. The admirable mechanism with which the Rochdale system is carried out was admitted on all sides, the after manufacture and its results, chemical and economical, being chiefly criticised and debated. The Goux and the Rochdale systems, so far as size and construction of closets and tubs, and mode of collection, are practically identical. In fact the Goux is father of the Rochdale system, save that at Rochdale the absorbent lining has been discarded and a liquid disinfectant used in its stead.

In discussing the various manufacturing processes, on the one side it was maintained that no known or tried process of manufacture could possibly pay, while on the other it was asserted that several did actually pay a fair trade profit. Professor Way most strongly insisted that excrement manures were generally too poor to pay for carriage, and that all attempts to concentrate were attended by loss of money or chemical value, or both. Professor Way, in the course of what may be termed his cross-examination, stated that the chemical value of urine was much greater than that of fæces, and that the moment fæces were added to the urine its value was proportionately decreased. He was then asked how he reconciled this statement with his analyses quoted, evidently with approval, by Dr. Voelcker in the papers he had prepared at the request of the Society of Arts. In these analyses the Professor states that fresh fæces contain per 100 parts, water 75·00, organic matter (containing ammonia 1·82) 22·13, and phosphoric acid 1·07. Fresh urine, on the other hand, is stated only to contain 2·026 organic matter (ammonia ·71), and phosphoric acid ·040, while the water is 97·00. Professor Way said he referred to the direct results, and also referred to the relative quantities of each. Neither of these explanations really at all touch the questions. It is quite clear that if Professor Way's analyses are correct and correctly quoted, urine is less valuable by one half than fæces weight for weight, and, if so, not only Professor Way, but Mr. Gilbert R. Redgrave, will have, in sporting parlance, to hark back a little.

House drainage and ventilation naturally excited a good deal of attention, and Mr. Rogers Field opened the ball by explaining his ideas as to the best means of excluding sewer gas from dwellings. His method is a compound of Professor Reynolds' ideas of 1872 with the inlet claimed by Mr. Banner, but although Mr. Rogers Field was evidently indebted to both these gentlemen, he was not disposed to acknowledge their labours. The omission was supplied by Dr. Vacher and other speakers, who insisted on the simplicity and economy of the Reynolds' method, and the benefits of the constant through currents of fresh air maintained by the Banner exhaust cowl.

Some rather curious notions as to pneumatical laws were expressed by Dr. Thorne, of the Local Government Board.

Mr. Baldwin Latham gave some interesting details of a town he had just sewered on a new plan, and in which the first flush of storm-water only flows into the sewage culverts. Mr. Baldwin Latham endeavoured to controvert the prevalent idea that typhoid fever was essentially a drain fever, and Dr. Vacher, in controverting Mr. Latham's ideas, gave the results of his researches on the origin of fever poisons, or germs. Dr. Vacher's remarks were a little misunderstood by many of the audience, who understood him to argue that sewer-gas was innocuous.

Taken altogether the results or conclusions of the conference may be summed up as follows :—

1. Dry systems of conservancy may be looked to as great helps in assisting to minimise the sewage difficulty.

2. What is known as the "separate system" is the system which should be adopted wherever new sewers are constructed.

3. Existing water-closets as a rule—together with house-drains in general—are, from their faulty construction, the means of introducing sewer-gas into dwellings.

4. All house and closet drains should be well ventilated and cut off from direct communication with the sewer.

5. That this disconnection and severance can be well effected at a comparatively small cost.

6. That to ensure thorough ventilation a constant through draught is required, *i.e.*, a cowl-extractor and a fresh-air inlet.

The Chairman, in the concluding address, was of opinion that the Conference had been at least as instructive and satisfactory as that of the previous year. The discussions had been eminently practical, and had centered round two or three points. The dry systems has been exhaustively treated, and the subsequent discussion on the drying of sewage, although incidental, would probably set some members thinking on the subject. At the same time the demonstrators of water-carriage systems would be put on their mettle to discover an efficient means of keeping sewer-gas out of dwellings. They had just been told that the evil to be dreaded was not sewer "gas," but certain albuminoid particles conveyed in the air of the sewers ; but in any case, whether the air, or what were borne on it, were the germs of typhoid or any specific poisons, all would agree that foul air showed itself deleterious to health, and that it was the duty of local authorities adopting water-carriage to keep this offensive gas out of the houses sewered. If perfect safety could not be attained, the aim of the engineer must be the multiplication of simple appliances to prevent sewer-air from effecting an entry into dwellings. They were agreed, he understood, that sewers ought to be flushed, and that at frequent intervals, and that they should be ventilated; and he gathered, from the tone of the discussion, that the simpler the access to the open air the better. Several schemes for this purpose had been suggested; Stott's process of connecting the main sewers with furnaces might be some advantage to manufacturing towns, and Mr. Field had shown some plans for disconnecting the house-drain from the sewer, in which decency was met by a grated surface, even in his most thorough method—that of disconnection by an open channel beneath a man-hole. They had been reminded that in any case they must have a dual system of refuse-disposal, while, in addition to any dry system, drains must be provided for surface and slop-water; where water-carriage was adopted, scavenging was as necessary as before; and therefore no one system presented unmixed advantages. With regard to the subject which should occupy their attention next year, it had been suggested that they should take up the branch of sanitary legislation. If so, it was most desirable that they should limit their inquiries, as, otherwise, it would be easy to talk for two days without effecting much practical result. He would suggest to members that they might, in the meantime, with advantage master and abstract the present laws relating to public health, to ascertain if for evils which might be felt an immediate remedy was not at hand in an existing Act. The sanitary question was entirely one of education: they could not hope to introduce bye-laws for the promotion of health, with any success, unless they possessed the goodwill of the community. Medical and scientific men were very desirous to make all laws compulsory; but people would not be controlled by laws of the necessity for which they were not convinced.

In commenting upon this Conference *Public Health* says:—
We cannot assert that the Conference held at the Society of Arts has been fruitful of any new ideas or great results. The same questions relating to the dry systems and the water-carried systems were considered that were discussed two years ago at the previous Conference; new facts and fresh data have been brought before the members present; but the general conclusions may be summed up in a few words—namely, that the dry systems are practicable and available only to a limited extent in inland localities, where facilities for irrigation or precipitation do not exist; and that the water-carried system is still the only general system that can be universally adopted in all large towns with admitted safety to public health. It may also be conceded that sewage-farming has the preponderance of evidence in its favour. This subject, opened by Mr. Rogers

Field's paper, is not new. As our readers are well aware, the theory has been introduced into these pages on several occasions; and the whole secret of the principle is expressed in one word—"disconnection." At present every one at all conversant with sanitary arrangements knows that the sewers are in direct communication with the drains of our houses, while these enter at several places and terminate in cisterns, water-closets, sinks, lavatories, and the like. In fact, an ordinary well-appointed house in any of our West-end streets or suburbs has the gas of the sewers "laid on" at all those appliances of the house as securely as if the tenant paid the Metropolitan Board of Works for "laying it on." Yet, singular to say, there are some sceptical enough to doubt the existence of the danger; who believe a trap a safeguard against the intrusion of the deadly enemy. Mr. Field's and Mr. Weaver's papers dealt with the question in a comprehensive manner, though the appliances illustrated were not the most effective that have been contrived. Treating of the disconnecting appliances, the trapped gully was mentioned as one of the simplest forms. Who can say how large a percentage of deaths would be averted if every house in our large towns had this very simple means of cutting off the connection with the sewers applied to the waste-pipes from sinks, cisterns, and baths? It is only just to say, Professor Reynolds, in 1872, was the first to introduce an improvement. His ventilating-trap was an ordinary trap with an upright ventilating pipe above it; and, by the adoption of this plan, all common traps could be dispensed with. Speaking of soil-pipe ventilation, Mr. Field fairly said that the ordinary small ventilating-pipe carried up from the bend of the soil-pipe only prevents undue pressure, but will not clear the soil-pipe of sewer air—as any air removed by the ventilating-pipe must at once give place to sewer-air. Besides this, it is evident the evil of connection of the house-drain with the sewer remains; and the friction of the pipe and its smallness do not facilitate the escape of sewer-gas. But one point overlooked by most of those who took part in this discussion was the harmless nature of the air escaping from drains under the system of disconnection. As one speaker intimated, the gas is liberated as soon as it is generated in the drain, and all danger is obviated. A very specious objection urged by many against the disconnecting or ventilating gully system is, that a smell escapes from the opening, or trap. This idea will not bear examination. Experience shows that a constant escape for any foul gas renders it powerless, by the fact that it has no time to accumulate. To this end, we believe if our road-gullies were all untrapped, we should get perfect immunity from sewer-gas. Again, as Mr. Field observes, any unpleasant smell from the opening is an index to the condition of the internal drains of the house. Thus if the apparatus of the closets is of imperfect design, and foul matter is retained in them, and in the traps, such as the D traps, gases will be given off. The old "pan-closets" are particularly open to this danger; and we advise their substitution by syphon-traps.

Another point of interest referred to the other day—and one bearing upon the subject of ventilation intimately—is the motion of the current of air through ventilating-pipes. Some assert that the current is downward through the surface ventilator or gully trap, and upwards through the soil-pipe; while others assert the action to be the reverse. What appears more necessary is that, whichever way the current acts there should be a free vent. An extracting cowl, such as Banner's or Boyle's, would insure an upward current in the soil-pipe shaft, and a downward at the surface-gratings, and this is unquestionably the normal direction of current; but we believe it to be quite an immaterial point if free inlet and outlet are provided, or if every system of house-drains is open to the air at both ends, so that a current of air can pass through them without entering the house-traps. One speaker proposed that a second ventilating-pipe should be placed on the drain so that a downward current in the soil-pipe should be established and so upwards at the second pipe and escape. This would not interfere with the closet-traps. Nothing can be worse than an inner soil-pipe taken through the house and unventilated; it is constantly leaking in dangerous and concentrated streams of insidious gas; but make an outlet above the trap, and an inlet below, outside the house, and the same pipe can never become charged with deleterious air. It is, indeed, the very "irony of fate," as one medical officer observed, for engineers who were once so persistent in constructing airtight drains, and laying on the poisonous gas to our houses, to now tell us to lay it off. Yet there are a few, as we have said, sceptical enough to disbelieve in the efficacy of the disconnecting plan. So experienced a sanitary authority as Mr. Baldwin Latham actually maintained that enteric fever is not the result of sewer-air; and one speaker, the other day, boldly made the same assertion, in spite of actually established statistics. Mr. Latham said that sewer-air alone will not promote fever, but that we must trace enteric poison to other sources, such as water. As Dr. Wilson, of Rochdale, said, the idea that a diluted sewer-gas is harmless is absurd; and his own experiments have convinced him that a certain degree of dilution with pure air renders the danger of sewer-air of greater effect; and that enteric fever is not necessarily nor exclusively engendered through water or food taken inwardly. We shall always have a few obstinate adherents of well-jointed pipes and plumbers' traps as the panacea for all wrong in our drainage systems. There are a few now who would seriously think of placing charcoal boxes in our sewer openings; but it is satisfactory to find common-sense in these matters has, at last, broken through a crust of conventional ignorance and prejudice.

Let us hope the Executive Committee of the Conference, who number some eminent sanitarians, will apply themselves to the task of collecting the evidence brought before them upon this vital question, and publish in a simple form a series of rules and regulations for builders as the basis of the Local Government Board operations. If that Board would issue a set of by-laws for sanitary authorities, much good would follow. These should insist on disconnecting the sewers from the house-drains, the use of proper traps, and should provide for certain emergencies and exceptional cases. Mr. Field mentioned the Uppingham Sanitary Authority by-laws as embodying all the most important precautions; and he also hinted the value of preparing diagrams to accompany such by-laws, to render the system intelligible to the illiterate. No doubt, in the case of old houses and connections, the difficulty of enforcing rules would be formidable, and they must be more or less discretionary; but, for new houses, a standard series of by-laws of a compulsory character is necessary.

"No sanitary improvement worth the name," said Lord Derby, at Liverpool, "will be effected, whatever Acts you pass, or whatever powers you confer on public officers, unless you can create a real and intelligent interest in the matter among the people at large." . . . "Whatever administrative measures can do for public health—and they can do a great deal—they can never supersede the necessity for personal and private care." . . . "The State may issue directions, municipal authorities may execute them to the best of their power, inspectors may travel about, medical authorities may draw up reports, but you can't make a population cleanly or healthy against their will, or without their intelligent co-operation. The opportunity may be furnished by others, but the work must be done by themselves. This is why, of the two, sanitary instruction is even more essential than sanitary legislation."

SEWER AIR

AND

HOUSE DRAIN VENTILATION.

The following has been circulated in handbill form by the Blackpool and Lytham Urban Sanitary Authorities :—

"The Sanitary Authority wish to call the serious attention of the inhabitants of Blackpool to the great importance of House Drain Ventilation. This is recommended by the Government and all Sanitary Authorities as the only means (when coupled with effective trapping) of entirely keeping out of houses dangerous sewer gases. These gases, which are harmless when they escape freely into the open air, are known to be the frequent cause of serious and often fatal illness when they find their way into the interior of dwelling-houses.

"The soil-pipe of every water closet should be ventilated by means of a straight pipe, at least three inches in diameter, which should be inserted into the uppermost portion of the soil-pipe, between the trap and the sewer, and from it carried upwards outside the house until it is clear of the eaves ;—if possible it should pass through the roof.

"All sink pipes and waste pipes from basins and baths can be ventilated in the same way, but in these cases a still better and cheaper plan of keeping out sewer gas is usually possible. This is to sever the pipes outside the house, and to place a trap below the point of severance. On the same principle, it is an exceedingly good plan to have a trap at the junction of the main house drain with the sewer, and an opening to the outer air from the house drain immediately behind this trap. No offence need be apprehended from this opening, as it will, when the drains are in good order, act as an inlet to air, and if there should be smell from it, a reason is given for examination of the house drains, so that entry of sewer air into the house may be prevented and disease be avoided. Overflow pipes from cisterns and baths should never enter the sewer, but should always end in the open air. All waste pipes, either led into the drain direct (whether trapped or not) or branched into the soil-pipe, or led underneath the floor of any portion of the house, should be altered at once. There is no security, where these defects exist, against fever, diphtheria, or diarrhœa in any house, however otherwise airy or commodious, and they should therefore be remedied immediately.

"Where it can possibly be avoided, no pipe issuing from the house (except the closet soil-pipe, and that ought to have a trap and ventilator as above) should pass into the sewer without a break. Rain water pipes should never be used for the purpose of ventilating drains, except when distant from windows.

"Cellar washhouses are objectionable, as it is difficult to trap the drains so as to preclude the possibility of the escape of sewer gas into the house above.

"Fresh sewage is not dangerous if kept in motion, and sewer gas is comparatively harmless if it escapes freely into the open air. Dilution of sewage by means of constant water supply;—dilution of air by its admission at every junction of a branch with the main sewer, by frequent manholes in the crown of the arch, and exits at the top of every soil-pipe, will prevent the production of sewer gas.

"House Drain Ventilation can be carried out at a moderate cost. Further information can be obtained at the Town's Offices. Reference is also recommended to the work, 'Hints on Drains, Traps, Closets, Sewer Gas, and Sewage Disposal,' published at the *Gazette* Office, Blackpool: by post 2s. 6d.

P. HINCKES BIRD,

Medical Officer of Health."

May, 1877.

JOHN GRIME, "GAZETTE" GENERAL PRINTING WORKS, BLACKPOOL.

RECHERCHES

SUR

L'HYMEN ET L'ORIFICE VAGINAL

OUVRAGES DU MÊME AUTEUR :

De la tête du fœtus au point de vue de l'obstétrique. Recherches cliniques et expérimentales. Thèse de doctorat, 1876.

Recherches physiologiques et cliniques sur les accouchements. A quel moment doit-on opérer la ligature du cordon ombilical ?
Nouveau moyen qui permet de constater la mobilité de la symphyse pubienne pendant la grossesse, etc. Le *Progrès médical*, 1875, et tirage à part.

De certains cas dans lesquels la docimasie pulmonaire hydrostatique est impuissante à donner la preuve de la respiration. Société de médecine légale, 1872.

Recherches cliniques et expérimentales sur l'état de la pupille pendant l'anesthésie chirurgicale produite par le chloroforme. (En collaboration avec M. P. Coyne.) Archives de physiologie, 1875.

Sur le mécanisme de l'accouchement normal et pathologique, par J. Matthews Duncan. Traduction française. 1 vol. 500 p.

Des lésions traumatiques chez la femme dans les accouchements artificiels. Thèse d'agrégation, 1878.

L'inventeur du forceps à double courbure. Le *Progrès médical*, 1876, p. 779.

Note sur un cas de rotation spontanée et très étendue de la tête pendant l'accouchement, rotation non suivie d'un mouvement semblable du tronc. Le *Progrès médical*, 1877, p. 45.

Note sur un signe permettant de reconnaître une hémorrhagie des parois du vagin après l'accouchement. Le *Progrès médical*, 1877.

Extensibilité des membranes de l'œuf. Formation de la bosse séro-sanguine avant la rupture de la poche des eaux. Le *Progrès médical*, 1878, p. 58.

Les dernières expériences sur la compression cérébrale envisagées au point de vue de l'obstétrique. Le *Progrès médical*, 1878, p. 198.

De la douleur ovarique chez les femmes enceintes. Le *Progrès médical*, 1879.

Rapport à M. le Ministre de l'Instruction publique sur l'enseignement de l'obstétrique à l'étranger. *Journal officiel*, 10 avril 1879.

Recherches sur les dimensions de la tête du fœtus. (En collaboration avec M. A. Ribemont.) *Archives de tocologie*, 1879, etc., etc.