SECTION II.

ENGINEERING AND SANITARY CONSTRUCTION

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The President of the Section, Robert Rawlinson, Esq., C.B., C.E., F.G.S., delivered the following address:—

Sanitary science may be said to be both old and young. It is so old that we know nothing of its commencement, simply because we know nothing definite of the origin of the human race. The cave inhabitants were skilled in art; but at how distant a period they lived, or in what other respects they were skilled, we have little means of knowing; of this, however, we may be certain, that they would suffer from disease and would use medicines and enchantments in some form to relieve their sufferings.[1] At whatever period of this earth's history intelligent man appeared, diseases would afflict him; and when remedial measures were invented and applied, then *sanitary science commenced.*

There are problems in natural history which can only be speculative; as, the origin and constitution of matter; the origin of life; the origin of disease. The human intellect is powerless to fathom these profound mysteries, and if revelation is rejected, there can be nothing but a blank impenetrable darkness. There is minuteness below the search of the best microscope, and a range in magnitude very far beyond the combining power of the best telescope. One law alone is clear and certain, namely, the universal law of motion, which is change—combination and disintegration. These never cease. That which we call life or death pervades the universe; and the life of a system—sun and planets—though extended to millions upon millions of years, is, in the roll of eternity, no more than the life of an emmet, which is born and dies in a summer's day. As old systems perish, new systems replace them, to run their appointed course from birth to maturity, and from maturity to decay. I have neither time nor inclination to attempt to summarise ancient and modern theories as to ultimate atoms, if, or if not, such exist; as, also, if or not, each atom is sen-

[1] There are dwellers in caves at this day in parts of Great Britain and Ireland, as, also, in other parts of the world—probably as many as ever in any age occupied such places for residence.

suous, and that, as a consequence, all bodies have developments of sensuousness in a degree—the combination of atoms in man developing sensuousness in the highest degree. Matter combined in living forms other than animal life develops properties very like consciousness, as plants shrink from poisons, and, with apparent avidity, seek wholesome food, in this respect showing an intelligence superior to many forms of animal life. I, individually, should like to believe that plants can think.

But to the purport of this paper,—'Old Lessons in Sanitary Science Revived, and New Lessons Considered.' The most reliable starting point I will take may be found in Leviticus xiv., beginning at the 33rd verse, where the plague of leprosy is described afflicting the house. Without extracting the whole, the sanitary engineer will recognise 'the walls with hollow strakes, greenish or reddish, which, in sight, are lower than the wall.' Here is vividly described a tainted subsoil, wet and rotten with saturated filth. The modern remedy would be, entire removal of the tainted subsoil, to be replaced by lime concrete, removal of the tainted walls, underpinning with new material, and the introduction of a damp-proof course. Leprosy (or the equivalent of leprosy) affects houses at this day in all parts of the world inhabited by man, from European palaces to the hut of the Esquimaux.[1] In this malarrangement the savage fares better than the civilised man, as nomad tribes can leave a tainted site, whilst dwellers in villages, towns, and cities remain fixed on sites filth-tainted to supersaturation. Seeds of disease ripen in the polluted huts and houses of India, China, and Europe, and the North American cities have not escaped this general contamination. Australia and New Zealand have already polluted the sites of their cities to a dangerous extent, so that the mortality returns are no better than those of the old country.

In England we have apparently banished plague, which, however, prevails in the East—Russia, Egypt, and the cities of Asia; but England has ripened the '*germs*' of cholera very recently, and typhus, typhoid, and other forms of fever commonly prevail. That these diseases can be prevented our model prisons bear witness, and modern sanitary works have also materially improved entire town communities.

I have used the word '*germ*' as applicable to disease, without in the least being enabled to explain satisfactorily what is meant by it. That types of disease can be introduced and spread will be readily admitted; but that the origin, in each case, is a *germ* is not so easy of

[1] It may not be strictly proper to use the word 'leprosy' as being common to houses; the meaning is, that houses are filth-tainted to an extent which causes rottenness capable of producing disease.

proof. It has been suggested that cholera must be conveyed to the human system in water; as, also, that tainted water and tainted milk produce typhoid and scarlet fevers; and some say that fluids are necessary to the introduction of these forms of disease into the human system, periods of time being fixed for incubation. There are, however, some facts against this theory being received in its entirety; as, for instance, troops and travellers on the march into a virgin country previously unoccupied by man, develop these forms of disease much beyond the assigned period of incubation, which, under the surrounding conditions, cannot be due to man-tainted earth, air, or water. So that the germ theory fails, unless we can imagine that germs of every form of disease which can afflict men or animals are as eternal as matter, and are dormant in matter until conditions for development are brought about. According to this idea, soil, water, and air, and every human body must contain germs of every disease, but dormant, until brought into contact with conditions favourable for development.

The cleanest looking places are not necessarily the safest.

A clean looking country house or village, surrounded by pure air free from coal smoke, may have hidden dangers worse than any in a town.

Visible dirt is not always the most dangerous, as the rain washes it, the wind blows over it, and the sun dries it.

The presence of rats, either in country or in town, is a certain indication of danger, as rats live on garbage. They are usually diseased, and can convey the seeds of disease.

It is not possible to predict, in all cases, as to what shall cause disease in excess in any given locality, as filth under peculiar and unknown modifications, or plus an unknown factor, may be sufficient to cause typhoid, without the so-called specific germ from a previous case.

A telluric influence, or an atmospheric influence, which we can neither control nor analyse, in combination with great elemental disturbances, may produce disease in excess.

It is difficult in all cases to prove contagion, and it may be as difficult in other cases to disprove it. In the East woollen garments are believed to be capable of conveying plague; but shoddy, which is waste woollen rags, collected and brought into Yorkshire from all parts, even where plague prevails, when manipulated by hand, never produces plague.

Great epidemics are not universal, but prevail over limited areas, for reasons similar to those which control and limit other excesses in nature. In meteorology excesses are always local, not universal, the areas affected being very much smaller than the areas unaffected.

The surface of the earth, the air, and the water, are modified by the elements, but not at one and the same time over the entire crust and circumference of the globe; but by sections at intervals, as in earthquake shocks, tornadoes, hurricanes, and deluges—these are always local, never universal. The seats of earthquakes change; all known active volcanoes having ruptured the tertiaries. But geology proves that earthquakes and volcanic eruptions disturbed the oldest rocks as now the newest.

Theories may be very harmful when wrongly set up and obstinately persisted in, because they lead the student from the true paths of research. A man with a theory which he is determined to establish, may be likened to a man digging himself into a well; the deeper he digs the less of the surrounding world he sees, but he nevertheless imagines that he is widening the range of his vision. To ascertain truth theories must be suspiciously examined, and facts alone when established be accepted. The world and its phenomena must be studied, and modern means and appliances show us that this is a very small world which we inhabit.

Science has artistically divided our world's history into geological periods, beginning with the lowest and, therefore, presumed to be the oldest semi-crystalline rocks, which at the time of their deposition were mud, and ending with the upper tertiary and alluvium. Ocean, earth, air, climate, and organised life (vegetable and animal) through the deposition of the older strata, are supposed to have been widely different to anything at present existing; but recent research has very much modified these crude notions, and it is now already perceived and proven, as far as proof is practicable, that there have been changes in the solid crust of the earth many times repeated, by land and ocean alternating, but only in such manner as we see at present. Ocean, air, wind, sunshine, frost, and rain, have been working mechanically and chemically in disintegrating the dry land; levelling mountain ranges and continents to fill ocean hollows, and thus again preparing for complete submersion of the old land, and by the heat of compression to bring forth a new birth.

The probability is that mountain ranges and ocean hollows, with continents, seas, islands, and rivers, existed in some such relative proportions as now, during the entire range of the water-deposited rocks, climate being modified by the relative position of ocean and land. Dry land teemed with vegetable and animal forms of life; ocean, seas, lakes, and rivers, swarmed with fish, many various and some strange, so that we must give up the chaos theory, and believe that the creating power through the preceding ages neither slumbered nor slept. These ages are in their entirety but as a lightning flash, a speck, a thought, eternity knowing nothing of time. We have no certain foundations upon which to build the structure of progressive development in geology; as we may say of fossil forms, that only those fitted to endure mechanical and chemical action through unknown ages have remained, and these are for the most part cast impressions and the solid bones and enamelled teeth of reptiles and fishes. Men are apt to draw general conclusions from limited periods and contracted areas. We assume history in periods, as for instance from the heptarchy to Queen Victoria, in a manner to lead a student to believe that the manners and customs of two thousand years ago have entirely passed away from the earth, when we may at this day travel into every phase of civilisation, and see every form of dwelling, from hut and tent of the nomad to cities such as London and Paris. So that a student, in place of relying entirely upon closet study, may, by travel, see man under almost every aspect known to research or described in history.

A closet study of history is however advisable, if only to learn how much error has prevailed and prevails; and it is to be hoped that study will modify egotism. Catalogues of huge convulsions, such as earthquakes, tornadoes, frosts, droughts, and floods, of plagues, famines, and pestilences, have been compiled which seemed to the affrighted inhabitants of the time so terrible and fatal, that they thought the entire family of man must perish from the face of the earth. Exceptional seasons, hot or cold, wet or dry, long continued, affected vegetation, then animals, then man; we witness this course of events in our own day, both at home and abroad. Exceptional seasons lead to famines, disease, and death. Here again we have not to go to history to learn the deadly records of famine and plague, as at this very time the freshly written records are before us:—famine in India, in China, in Asia, and in Ireland. If England can say that since 1665 plague has disappeared, typhus and typhoid fever remain.

The history of the great plague in London, 1665, is to be found recorded by Nathan Hodges, M.D., and John Quincey, M.D., and by an anonymous author in 'a collection of very valuable and scarce pieces relating to the last plague in the year 1665, and reflections on the weekly bills of mortality so far as they relate to all the plagues which happened in London from the year 1592 to the great plague in 1665, and in Naples 1656, of which there died in one day 20,000 persons.' There are other histories of the great plague of London, the picture by Defoe being considered more reliable than the histories. Plague raged about this time, not only in London, but in cities, towns, and villages generally. The plague-stones found in the suburbs of towns and villages attest the prevalence of the disease. These stones were cut to form a trough, which was filled with vinegar and water. They defined the boundary to which the people from the town or village might advance countrywards, and to which country residents might come townwards, bringing their produce, which the town inhabitants must fetch, leaving their money, the price of the food, immersed at the plague-stone, in the vinegar and water. Contamination was supposed to be prevented by these contrivances. Betwixt nations, quarantine was enforced, and is enforced up to this day. The quarantine enforced in London on houses during the prevalence of the great plague is terrible to think about. The blood-red cross and the awful text—'the Lord have mercy upon us'—on the house door, with a guard to hand food and medicine to the sick, and to restrain them from coming about until forty days after their recovery, must have contributed largely to the mortality. It is quaintly remarked, that 'the Lord Mayor's officers readily and effectually put these orders in execution, yet it was to no purpose, for the plague more and more increased; and the consternation of those who were thus separated from all society was inexpressible, and the dismal apprehensions it laid them under made them but an easier prey to the devouring enemy. . . . If a fresh person was seized in the same house one day before the completion of quarantine, it was to be performed over again, which sometimes caused the loss of the whole. But what greatly contributed to the loss of people thus shut up, was the wicked practices of the nurses, who would strangle their patients to rob them, and convey the taint from sores of the infected to those who were well.' Such is a very brief notice of the ravages of the great plague of London in 1665, when there were 97,306 funerals, 68,596 persons having died of the plague, besides many of whom no account was given by parish clerks, and who were privately buried.

The literature of plague, as written at the period, with all the vivid terrors of the disease described, is, for the most part, a record of gross superstition and romance. The plague was real, the filth was real, the terror was real, the sufferings were real, and the deaths were real; but the causes assigned were vague and wild, and the remedies recommended and medicines used do not in all their nastiness bear description. But even in this case we need not rely upon history, as now there is probably as much ignorance, superstition, negligence, and cruelty where plague and famine prevail, as was practised in England during the prevalence of the great plague.

We are frequently referred to China for an example of order and care in the conservancy of excreta for agricultural uses, but upon thorough examination, and a full knowledge of the details, we find that the Chinese example is one to be avoided rather than to be followed. What the state of China is may be inferred from the following remarks, descriptive of a visit to Canton, in the year 1878. The writer says: 'Without much delay we set off on our explorations, and a short walk over the green grass of the Shameen, brought us to a bridge which crosses the moat or canal that divides Canton proper from the foreign settlement. . . . We were astonished to note the marvellous change in the appearance of the surroundings, which the mere crossing of the bridge presented. We had gone from a broad, handsome suburb of a prosperous European community, into a veritable Chinese town, with narrow, irregular streets, full of people, and an atmosphere polluted with the most horrible smells. . . . Leaving this filthy spot, we went on to one even very much worse; namely, the city prison. . . . We went through a labyrinth of passages, and finally found ourselves in a square court, open to the sky, round which were ranged the dens or cells of prisoners, who were in most cases shackled by their feet. The moment we were seen, out they came upon us from their dens in all directions—filthy, horrible creatures, with hands outstretched, swarming around, and clamouring for money.' This description of one of the great cities of China, at this day, represents very graphically the condition of London, Paris, and the other European capitals and towns at the period of the great plague. Travellers do not always note the condition of the inhabitants of foreign countries when first visited. We may be told about beautiful scenery in lakes and mountains, imposing-looking buildings, fine museums, and fine picture-galleries, without one word as to the real state of the population. In the streets of every city in Europe there are indications of the real condition of the people, which an intelligent and practical sanitarian will at once note. The churches may be very noble in outline, and rich with carving, but if squalid, begging cripples surround the stranger, he will know by intuition that, not very distant, there are slums and dens—filthy, stinking, disease-smitten, and disease-producing. The probability will be that in one hour an observant sanitarian will learn and know more of the true condition of the city he is, for the first time, in, than thousands who have been born, brought up, and lived in the place all their lives. It will be a case of 'Eyes and No Eyes.' Sanitary science brings into play all the observing faculties of an educated man.

Past history has, for the most part, consisted of details of the birth, life, and death of kings—of their wars and conquests—with a very slight glimpse of the state of the people. In the future, true history will note and record the condition and doings of the people, as constituting the power of the state; but at present the world is very far from this condition.

When in this age of general improvement in arts, manufactures, and commerce, we find Europe in arms to a greater extent than at any former period, and the people under a load of expenditure the heaviest in the world's history, thoughtful men must pause, wonder, and look for some practicable solution. The taxes now being levied and expended on soldiers, armaments, arms, and ammunition, would more than serve to abolish every city slum and wretched town tenement, admit of the rearrangement of every city sewer, and pave every street, drain every house, provide a full supply of pure water at high pressure and constant service, and pay for daily scavenging. When history can detail these things as accomplished facts, it will be worth reading. Sanitary science is new, but it is not, as yet, popular. To remove filth, to promote health, and to prolong life, gain little of a statesman's notice in the battle of politics; the work has, however, commenced, and is being taken up, both at home and in our dependencies. The Americans are also becoming earnest sanitarians.

There are poverty, vice, and crime in Great Britain which, when contemplated in detail, are quite appalling; and these are the outcome of defective statesmanship—and this after years of political freedom and so-called enlightened government. We sanitarians, however, hold that statesmanship which leaves the largest numerical mass of the population in hopeless misery must be defective. This condition of society is not a sound one; and, consequently, is not a safe one. To see the results of despotism and neglect, in their most aggravated forms, we must, however, cast our mental vision over the empires of China and Russia, where millions of men know nothing of political and civil freedom; the results being civil commotions, rebellions, and civil slaughter, wholesale arrests, wholesale condemnations, wholesale transportations, and wholesale decapitations, which affect nothing worth the trouble, because the wretched people have no cessation to their persecution. They exist in misery, and have no hope.[1]

True sanitary science recognises the unit, man—looks at the individual, the single family, the single house, the village, the town,

[1] *A Bloodthirsty Mandarin.*—The following appears in the *China Mail*:—A tale of peculiar horror comes from the Swatow quarter. The military Mandarin for the Kit Yang district, Pung Tye-jen, who will be remembered as the Mandarin who gave the order for the compradore Ah Pae to lose his head, and was also intimately concerned in the Lee Lum Kwai affair, has been distinguishing himself in thoroughly Chinese fashion. Some small official, who held the position of tax-collector, had been murdered by the people, who, exasperated probably by his eternal and extensive squeezes, considered taking the law into their own hands to be the only way of getting rid of him. For this daring outrage against law and order, Pung Tye-jen undertook to inflict punishment upon the residents, and did so with a completeness we rarely see equalled. He first secured the services of a gunboat to protect or cover his retreat, the place where the inhabitants had done as we have stated being within reach of the guns of a man-of-war. The place was then besieged, and the soldiers killed something like 700, it is said, of the people who were supposed to have taken part in the uprising against authority and had caused the death of this petty official. The number of those destroyed by the avenging army of Pung Tye-jen is variously estimated from 400 to the figure above stated. Surely an ample satisfaction to even a mandarin of the bloodthirsty character which this man has acquired.

and the city, as these constitute nations, and as are the individuals, so must be family, town, and nation. If, therefore, there is ignorance, wretchedness, and vice amongst the lower orders of the people, the leaven pervades the entire nation.

These questions may be termed political, and it may be said that sanitarians have nothing to do with politics. Our reply, if questioned as to this, must be that to govern men is the prime duty of a statesman. But what are the definitions of the word 'govern'? To a despot there is only one definition, and that is, repression; which implies every form of cruelty which man ever devised and practised. To a British statesman I hope it means, to care for the whole people; to educate, and to protect them in all honest dealings; to repeal all laws which tend to the commission of crime, to abolish class legislation, and to know nothing of party if it leads to faction.

The domestic side of sanitary science deals with home comforts, and the unit in this case is the house, then the village, and the town. Houses must be planned, constructed, and regulated to afford means of health and morality to the occupants. Villages and towns must be so arranged, built, sewered, paved, and scavenged as to preserve the purity of the soil below and the air above for the benefit of the inhabitants. To secure such ends, there must be sewers, drains, pavements, scavenging, and a water supply. Sewering is ancient beyond written records; sewering scientifically is, however, modern, very modern, as some of those who presided at the birth of the modern system of town sewering are happily now living. Edwin Chadwick, C.B., though not a civil engineer, has, through the aid of engineers, done more to found and promote the true principles of town sewering than any other single individual in this generation.

There were sewers and drains in the cities of Asia, which are now heaps of ruins. As in these days, so then, where large areas were covered with buildings, and men were aggregated, there would be sewage; and this would be removed by open channels and covered conduits; necessity having been the mother of invention. These ancient cities were, however, not wholly sewered, but only partially. It is very easy to be positive on this point, namely, that sewers and drains were not general, as there are no remains beneath great areas covered by the common people, the ruins of which would have been found if sewer and drain-pipes had ever been laid.

Rome sewered and drained her cities, public buildings, baths, and palaces from a very early period of her history, and the ruins are there to this day. Pliny describes sewers in some of his letters to the Emperor Trajan. There were not only sewers, but there was also river pollution. The great Cloaca Maxima of Rome emptied sewage into the Tiber; and Pliny directs the attention of the emperor to a case in a provincial city, where certain banished men resided, apparently living in ease and idleness. There were sewers in the district, and a polluted stream flowed through it, which had become a great nuisance and was complained of by the inhabitants. Pliny, in this case, suggests that the idle easy-living banished men should be more fittingly punished by being made to cleanse the foul sewers, and for the future prevent river pollution. Trajan at once consents to so reasonable a proposition. These letters by Pliny are most interesting in showing how actively he performed his duties, and how minutely informed he kept the great emperor.

At Sinope, on the Black Sea, money had been advanced to the municipality for a theatre. A bad site was, however, chosen, a swamp, and the building became a ruin before completion, and the money was wasted. Subsequently a memorial was sent to Rome petitioning for money to construct waterworks. Pliny, in this case, cautions the emperor, and advises that, if the request is entertained favourably, an engineer be sent with the money, that the local authorities may not job it away, as in the case of the ruined theatre. I suppose the emperor did send an engineer, as, in 1855, I saw the ruins of the service reservoirs, which, but for man's destruction, would have been as entire as on the day of their completion;—the walls now remaining being sound and massive as when first constructed.

The making of earthenware vessels by means of the potter's wheel is of very ancient date; and the work of the potter has, amidst all the ruins of ancient cities, been the most enduring. The vast collections of bricks, tiles, tablets, pipes, and vases placed in European museums testify to this fact. At some early period earthenware pipes were thrown on the potter's wheel, having sockets for jointing similar to those now made in England. I saw samples in Asia Minor, in 1855, evidently new. They were about 13 inches in length, and 5 inches internal diameter, having a socket of about $1\frac{1}{2}$ inches in depth. They were being laid at Kulali, situate on the Bosphorus, to form a conduit to bring water to the barrack hospital. The natives were at work laying the pipes on a contour line, a considerable length of trench being open. I did not at first see any arrangements for ventilation and wash-outs, and was questioning the engineer officer upon these points, as to whether or not they had been provided for, making a rough diagram, and scratching on the ground with a stick to illustrate my questions. The engineer officer could give no information; but one of the native workmen, who had been listening to and watching us, touched me on the shoulder, and, with a sparkling countenance, said, 'bono-bono,' immediately taking me along the line of aqueduct, and pointing out the structural means I inquired about both for ventilation and for wash-out.

Aqueduct making is a very old Eastern practice, aqueducts, fountains, and wells being common all over the inhabited parts of Asia. Water, as one of the elements necessary to life, was, in a warm climate, sought for and stored carefully. A very meagre history of springs and wells would form a large book, and might be as interesting as the most vivid romance. There are holy wells throughout Asia, and there are also holy wells and fairy wells in Europe, novelists having with great effect availed themselves of these superstitions, and woven them into their descriptions of supernatural phenomena. There is, in fact, an enormous amount of superstition, romance, and poetry connected with springs. Magical virtues are attributed to many waters, a belief in which leads to incalculable injury.

There are shrines in India within which are reputedly sacred waters, to be washed with, and to be drunk by the pilgrims to secure eternal salvation. On certain days in the year thousands of the natives assemble and encamp round these sacred shrines. The approach to the holy water is by a flight of marble steps, down which perspiring natives, many of whom are crippled and diseased, throng to have a cupful of the fluid. The practice is to pour a cupful over the head of each native, to flow back to the tank, and this is repeated hundreds of times during the day, so that it ceases to be water and becomes a vile compound—the washings from the bodies and feet of natives, and this horrible decoction the priests in attendance administer to be drunk by the poor besotted votaries. Cholera usually breaks out amongst the pilgrims at these gatherings, and it would be contrary to the known laws of sanitary science if it did not do so.

Recently there has very properly been a rage for water analyses, many thousands having been made in Great Britain and in British India, and very startling conditions have been revealed. Water which has been considered pure by the inhabitants of English towns, has been found to contain a dangerous proportion of polluting matter, to the effects of which they appear to be stupidly apathetic; but the researches in India reveal a state of things almost too terrible to contemplate. The natives of India are expert diggers of wells and formers of tanks, to supply and store water for use; they are also careless of life, committing suicide with apparent avidity, death by drowning being common. It had been observed that at certain Indian stations British soldiers were liable to be afflicted with virulent types of disease—as cholera, fevers, and at Delhi carbuncles and sores, the Delhi sores having become a recognised affliction. Inspection was ordered, when it was found that within the province there had been about 1,700 carcases of human beings removed from tanks and wells, the water from which had been regularly used for human consumption. Some of the worst wells were ordered to be cleansed, when many human bones were removed from them. The tanks in use are open, and the surrounding ground slopes towards the water; over the surface human excrement is spread, and the natives both wash clothes and bathe in the water they use for cooking and drinking. High caste apparently affords no protection, but acts in a contrary direction. Calcutta is supplied with filtered water, but high class natives decline to use it. A native water carrier was observed filling his skin at a stand-pipe with filtered water, but when about three parts filled, he went to the nearest puddle, and with his hands proceeded to fill his vessel. An Englishman, observing him, asked what he was doing, when he replied, 'Making Ganges water for master.'[1]

Some medical men state that pure water is absolutely necessary to health; others send their patients to drink the most abominable compounds at English and foreign Spas. Pure water is a rarity in nature, and where it is found it must be protected with great care, as it is a powerful solvent and greedy of impurities. The solvent property of rain-water, which is the nearest approach in nature to pure water, is probably amongst all the elements the most powerful agent in moulding and disintegrating the solid earth. By way of illustration, the river Thames may be taken. The water of this river contains, in round numbers, about one ton of bicarbonate of lime in each million of gallons, when the water is clear, bright, and sparklingly transparent. The daily supply pumped into London is now about 135,000,000 of gallons, so that 135 tons of bicarbonate of lime are combined with the supply of each day's water, or upwards of 49,000 tons per annum. The average flow of water down the Thames may be taken as 1,000,000,000 gallons per day; so that about 365,000 tons of bicarbonate of lime are washed down per annum, from the Thames alone. About four-fifths of the dry land of the earth contain lime, or are limestone, upon which this dissolving action of rain-water is unceasing; so that the whole of the solid earth above sea-level may be silently washed and wasted down into the great salt ocean. Soft water, being so powerful a solvent, is economical for washing, but it is vapid for drinking, and is liable to produce diarrhœa when peat-tainted. It has not been proved that hard water (hard as Thames water) is injurious to health: it has, however, been demonstrated that it is a great protection to health, when it has to be brought into contact with metals—lead, zinc, and some other substances.

It is the duty of the sanitarian to obtain clean water, and to preserve it fresh, cool, and clean; but pure water—in the full sense of

[1] Great improvements have been made at stations throughout British India in improving and in guiding water supply sources, both tanks and wells. To prevent pollution these improvement works are now going on.

the word 'pure'—I do not believe to be necessary to health, since spring, stream, river, and well waters necessarily contain salts of the rocks they come into contact with. These are the waters, which are the most widely obtained in nature, and in by far the most cases can alone be obtained, and must therefore be accepted.

Contaminated water must be dangerous and should always be avoided. Contamination is not, however, the most dangerous when the water is most visibly polluted. The turbid waters of the Nile, in Egypt, and of the Ganges, in India, are taken for use in preference to all other water. These mighty rivers are, however, usually turbid, the suspended silt acting as a disinfectant.

The filthiest and most dangerous water to drink is well-water, tainted with human excreta, which water may be clear and sparkling. Surface-water flowing down brooks and rivers, though visibly polluted, does not appear to be as injurious as tainted well-water; earth and air being purifiers of surface-water. Water when enclosed and stagnant, as in wells, pipes, or small unventilated tanks, and especially when affected by liquid or gaseous impurities, becomes stinking and unwholesome.

In water-works the water to be impounded in reservoirs should be gathered from the cleanest possible sources, and should be preserved clean.

Sand-filters should be close to the service-reservoirs, which should be covered and fully ventilated.

The supply from the reservoir and the supply mains should be direct, and the mains should be so laid and connected as to produce continuous circulation, as water retained a long time dormant in "dead-ends" rapidly becomes deteriorated. The best water-supply will be one which secures the purest source, and by the works of storage and distribution preserves it the purest up to its delivery for use.

Bathing and washing are necessary to health, but there are many towns in Great Britain and Ireland without adequate means for bathing and washing; and, as a consequence, the people do not bathe and are not clean.

Baths are common in better class houses, though by no means as common as they should be. The '*tub*' is, however, used as a substitute.

The poor cannot provide their own baths. These ought, therefore, to be provided for them by the Municipal Authorities in the best and cheapest form, and in the most convenient positions. With the baths should be wash-houses, where water, soap, and all the apparatus necessary for clean and rapid washing, drying, mangling, and ironing, should be made available at the least practicable cost. If sites are judiciously selected, and there is no extravagance in the construction and management, there must be no loss. But a small rate in aid, if required, will be a saving indirectly in promoting cleanliness, sobriety, and improved health.

The same writer I have before quoted remarks that in Japan bath-houses exist in great numbers in the towns, where warm water is provided at a small cost. These baths are for the benefit of the poorer classes, who use them in great numbers—as regularly as evening comes crowds of Japanese men and women go to bathe. There are ranges of box shelves where the clothes are placed, whilst the individual steps into the bath, emerges from it, well rubs the skin, dresses, and departs clean in person. In Great Britain, at this day, thousands upon thousands of the poor are never washed clean from their birth to their death, unless they go to prison, or to the workhouse. There is no bathing accommodation provided. At all schools there should be baths, and complete washing should be a part of education, as those who are accustomed to regular personal washing in youth will not subsequently abandon it.

Sanitary science has, during the last half century, probably made most progress in England; but then this island is a very small spot on the globe; and even England—free, rich, compact, and educated as it is—only progresses slowly. It may, however, be interesting to this meeting to learn that there is an Association of Municipal and Sanitary Engineers and Surveyors to the number of 205, and that 197 towns and districts are represented by the members. The extent of work executed might be indicated by the make of earthenware pipes and other sanitary articles, if a reliable return could be obtained. The Messrs. Doulton are making about 1,300 miles of drain-pipes per annum, besides many thousand soil-pans; and this may be about one-tenth of the entire English make of sanitary articles.

There is not time in a public address to deliver a closely reasoned essay, and a popular address is not, I assume, expected to be other than discursive.

The following remarks may interest the public, though they may not teach much to the educated engineer.

SEWERS AND DRAINS.

There are good and bad sewers and drains, and the public should know some of the reasons why this is so, and then they may refrain from condemning sanitary works in general.

Sewers and drains have been formed, which are so defective as to be a cause of serious nuisance; they are too large, have wide and flat bottoms, the materials are bad, and the construction worse.

It is possible to damage a town by defective works, and so bring discredit on sanitary science. I will attempt to describe how a town ought to be sewered, and how houses ought to be drained, to fully answer the purposes intended.

Correct plans and sections are required upon which to lay out the system of sewers and drains to be constructed; the depths of the cellars should be figured on the sites of houses; the relative levels of the streets may be indicated by contours, and on the sections the strata should be shown by colours.

A careful engineer will test the strata, by boring and trial holes.

Full details how to lay out sewers in right lines, both on plan and in gradient, are given in the 'Suggestions' published by the Local Government Board.

An engineer should settle at the commencement what duties the sewers will have to fulfil. If the town has manufactures consuming and polluting much water, the question may arise, if or not this polluted water is to be removed by the town sewers. There will also, in some cases, be a question of injurious fluids, such as tan-pit refuse and pickle-waste from brass founders, lacker manufacturers and tin-plate makers; there are also dye waters, and soap-waste from woollen manufactures. Some of these fluids can be treated on the premises so as to precipitate the solids and to disinfect and clarify the fluids, and, consequently, where there is no land available for sewage filtration, the manufacturers may reasonably be called upon to clarify their polluted liquids, and not pass them in their crude state to the sewers.

There are wet and dry subsoils. Sewage will, from good gradients, flow to any point required by gravity; in other cases there may be a flat area with a wet subsoil, and a swamp for an outlet, or this may be below the river or sea level. In such cases pumping may have to be resorted to, and then it is desirable to reduce sewage to a minimum. The subsoil should have independent drainage, and the sewers and drains should be water-tight,—surface water, including rainfall, being otherwise provided for.

To construct water-tight sewers and drains requires the best materials and the most careful workmanship, but these indeed are necessary under all conditions. In a wet subsoil land-water should be excluded, in a dry subsoil the sewage should be prevented from leaking out of the sewers. In the foregoing remarks extreme cases of wet and dry are contemplated. If sewage has to be pumped, and has to be clarified by irrigation, the volume to be dealt with should as nearly as practicable be a constant quantity. If, however, there is a free outlet by gravity, the sewers may be allowed to partially receive both subsoil and surface water; only, however, to some known and limited extent. It is an advantage to have a wet sewer rather than a dry one. Sewage flows intermittently, during portions of each day, when the inhabitants are using most water; if there is no subsoil water, the sewers at intervals may be comparatively dry, admitting of deposit. A steady continuous flow of water through sewers sufficient to maintain a regular current, and not more than a few inches in depth in the main sewers, will be an advantage.

Main sewers should ordinarily be laid at a depth sufficient to admit of the deepest cellar being effectively drained; the invert of the branch-drain being at the least twelve inches below the cellar floor, the fall of the house drain being not less than one in sixty, and entering the main-sewers not lower than half its diameter. These remarks are of course general, and cannot in all cases be acted upon, as many towns have low sites which cannot be effectively sewered and drained without special means (air valves) to prevent cellars being flooded by back-water from the sewers, or by special pumping.

House drains, as a rule, should be outside the basements of the houses. But where houses are built in streets, and the kitchens are at the back, the drain must cross the basement, unless back drainage is adopted, when no drain need enter the basement.

Much has been written and said both in favour of back-drainage and against it. I have had twenty years' experience of back-drainage, and know nothing but good of it. It has been said that it is an interference with the rights of private property; that the drains will choke, and then there must be trespass to find out the point of failure. My reply is that back-drains may be so laid that nothing but gross usage, amounting to wilful action, can choke them; and even in such a case they may be freed and cleansed without trespass, as manholes and flushing will enable them to be so cleansed.

To enable sound sewers and drains to be constructed, the trenching must be true, and the bottom to receive sewer or drain must be absolutely sound and solid. There must be no mistake here, or the work will soon be a nuisance and a ruin. Sewers and drains may become broken-backed; there will then be leaking joints, or saturated subsoil, and a choked sewer or drain will bring discredit upon sewering. If the bottom of a sewer or drain-trench is not sound, it may be made so by cement concrete, and in loose wet quicksandy ground sewers and drains should be covered with concrete.

Sewers and drains will work better, and be maintained in better order, if subjected to regular and properly graduated flushing at short intervals. It is possible to overflush, and so injure the sewers. As much water as will give a velocity of about six feet per second may be admitted; greater force, to give a quicker velocity, will be liable to injure brickwork, and blow or force open pipe joints.

Waterclosets and sinks should be against outer walls; should not have continuous flue-like connections with the sewers, but have a severed connection, and means for full external ventilation. Every public building, however large, and every house, however small, should be so drained as to afford no possibility of sewage gases entering, and they should stand absolutely free from the sewers, though perfectly connected with them. This may be a law without any exception. At present almost every public building and house in London is in direct communication, by the drains, with the sewers, so that sewage-gases pervade them. There are open sewer ventilators in the streets, which serve to dilute the sewage gases, and the enormous number of houses perform a similar purpose. It is this dilution which prevents the full amount of mischief from being experienced; but there is a danger in it, and this ought to be avoided. This is to be done by absolute isolation, and external ventilation above the roofs of the houses. In Leeds, for a population of 320,000, there are upwards of 20,000 openings from the sewers acting as ventilators, which have been in use more than seven years. This is an example other towns may follow with advantage.

Perfect sewering requires perfect street paving and perfect street cleansing. Scavenging must, in all cases, be a work of the municipality, or other local governing body. Contract work should be avoided. The work of scavenging should be paid by rate, and this rate should be general.

Waterworks should, in all cases, be in the hands of the local governing body. The service should be constant and at high-pressure, with fire-service provided for. Water should be laid on to every house and to every tenement; there should be no exception. The service-pipes may be of wrought iron, with screw joints, and all the taps should be 'screw-down.' If the services are taken within the houses and tenements, and the service is high-pressure and constant, there will not be much wilful wasting of water, and house-taps will not be stolen, as waste of water, when at high-pressure, will be very disagreeable within a house. Fix stand-pipes in streets and roads, as is done now, and the waste will continue to be unceasing, because it will not inconvenience any one, as when it is within doors. The poor cannot have a full and fair use of water if it is alone obtainable from external stand-pipes, as this involves carrying and storing within the tenement. It should also be remembered that one gallon of water weighs 10 lbs. and that fifty gallons weigh 500 lbs., and this will be only ten gallons per head for a family of five persons. The labour required to carry 500 lbs. of water each day, or 80 tons per annum, will be simply enormous, and ought not to be expected from the poor tenant. Serve the water within the house, have necessary supervision, and take charge of repairs; the inhabitants will then be properly supplied with water, and cannot easily waste it. Before closing these brief and imperfect remarks I may glance at a few works recently executed, or which are now in progress.

Calcutta has been partially sewered, Bombay is now in course of being sewered, and preparations are in progress for sewering and draining other Indian cities. Sewerage works at Berlin are also in progress, to be completed with sewage irrigation. Dantzig has been completed, with sewage irrigation added; and main sewerage plans are being prepared for other continental cities. At Warsaw, with a population of 350,000, the estimate for sewers is 600,000*l*. Buda Pesth, population 270,000, main sewering under consideration. St. Petersburg, population 670,000, estimate for sewers 3,000,000*l*., to include pumping and sewage purification. Munich, population 250,000, estimate for sewering 600,000*l*. Dusseldorf is to be sewered by Messrs. Lindley, of Frankfort. Messrs. Lindley have sewered Frankfort-on-the-Maine, population 125,000, cost 380,000*l*. Out of 6,800 houses, 5,200 have been completely drained, and in the town there are about 22,000 water-closets. At present, the sewage goes into the river Maine, but it is to be intercepted and clarified. The Prussian Government insists on sewage clarification, which, at present, is stopping sewering on the Rhine cities, where it is very much needed.

The water of the Rhine is, however, used for domestic purposes by the population on its banks, and it ought, therefore, to be preserved free from sewage.

French and Belgian towns remain with cesspools. Even Paris and Brussels, with their enormous and costly main intercepting sewers, are cities of cesspools, and I do not know of a single well-drained city in Italy. We are met here in this ancient city of Exeter to discuss sanitary science and preventive medicine, engineering and sanitary construction, meteorology and geology—to give information and to receive information on subjects which we consider to be of vital importance to each individual man, to each town, and to each nation; but when we read the current newspaper literature of the day, we seem as men beating the air. Statesmen pay very little attention to our subjects, but starve labour by conscription, impoverish populations by taxation, and, at enormous cost, provide the most refined and terrible weapons for human destruction. We are in the midst of a war furore, and sanitary works can have no solid and satisfactory progress under existing conditions. There is over the length and breadth of Europe a rampant military spirit; armies, armaments, ironclads, and 100-ton guns, attract most attention. The people are summoned from far to witness autumn manœuvres conducted by emperors, as if soldiers were the beginning and ending of human progress and civilisation. The Americans appear to be the only sane nation. The governments of the old world are drunk with military ambition.

Lord Fortescue proposed a vote of thanks to the President for his address. Mr. Rawlinson had spoken with much knowledge, and after long practical experience, of one of the most important sanitary subjects, in all its bearings, which could be considered for the benefit of the community.

Dr. Richardson seconded the motion, and said that those Sanitarians in London, who for the last thirty years had been most prominent in sanitary work, had always looked up to Mr. Rawlinson as in his way perfect, and as one whom they could trust in whatever he said. The solidity of sanitary development in the direction indicated by Mr. Rawlinson had been vastly owing to his skill and judgment, and, above all, to his truth.

The Mayor of Exeter said he should like to support the motion. The address was one of the most exhaustive he had ever listened to. It was most fortunate for the city that the Congress had come to Exeter, and still more fortunate that that section should be presided over by Mr. Rawlinson. The Mayor hoped before that gentleman left he would still further advise them on sanitary matters connected with the city. It was a matter of regret that the city was not yet sewered on modern principles, but the local authorities would now have the advantage of the advice of such gentlemen as Mr. Rawlinson to assist them. Mr. Rawlinson informed him that the city might be cheaply sewered. He was glad to hear that, as it had been to him, and many other gentlemen in the city, a matter of considerable anxiety, owing to the feeling that the expense would be enormous. He was, however, told by Mr. Rawlinson that the city could be even better sewered in a cheap than in an expensive manner. The visit of the Institute would well repay the citizens for the trouble they had taken and for the pleasure of entertaining its members.

Mr. Chadwick, C.B., in supporting the vote, said that in the many years Mr. Rawlinson had been engaged in advancing works of sanitary improvement he had displayed one great qualification—that in no instance had he exceeded the cost of his estimates.

The vote was then carried and acknowledged.

The Water Supply of the Louth Rural District.

At a period when the public attention has been directed to the great question of a national water-supply, a contribution on this subject may possess some interest. Louth Rural Sanitary District comprises eighty-nine parishes, somewhat unequally divided by the 'Wolds,' those on the east lying in proximity to the sea, the country being flat, and the soil, for the most part, being a rich loam, of the drift and post-tertiary formations, overlying a clay subsoil. On the west the country is hilly, dipping occasionally, with loose soil covering the upper and lower greensand formations, overlapping the calcareous strata in connection with the 'Wolds.' As in most chalk formations, the water-supply is ample; but boring to the depth of 100 yards in some localities is ineffectual in procuring water, whereas in most of the marsh villages overflowing springs and 'blow-wells' abound. This latter designation is applied to springs where the water flows to a considerable height, owing to the pressure exercised by the water-bearing strata in the hills.

Having thus given a general outline of the sources of water-supply, I propose to describe the distribution of it as regards meeting the wants of the population; and, before doing so, I must observe that no water can be considered reliable which is not obtained from a rock source. In many villages near the coast, such wells are scarce, as the surface water obtained from the gravel overlying the clay is much more accessible, but of course objectionable, being liable to pollution.

In approaching the coast, the difficulty of reaching the underlying rock is, of course, increased, especially at Mablethorpe, where the water is generally brackish, and it is only in certain districts that deep boring is attended with success. It has been a source of anxiety to meet the wants of this favourite seaside resort. All the springs are affected by the tide; and an analysis of a sample of water from this place by Professor F. de Chaumont, F.R.S., indicated 92 grains of solid matter per gallon, while the hardness showed 59 degrees of Clark's scale. These facts are doubtless discouraging; yet an enterprising proprietor, at the suggestion of Professor Frankland, has adopted the softening process, by means of quicklime, with very good results; and, after filtration, he has succeeded in producing a wholesome and potable water. This, however, is an individual case; but the problem of supplying the inhabitants generally is not yet solved, and should the place become populous, some other plan must be devised.

The town of Louth, containing 10,750 inhabitants is mainly supplied by a company, which has utilised the 'Silver Spring' lying adjacent in the Wold Hills, though many houses have wells on the premises more or less impure. Many of the latter class have, however, been improved of late years, and the zymotic death-rate of Louth for 1879 was 1·9 per 1,000, which speaks well for the general salubrity of the town. The rural district death-rate for the same period was 1·29 per 1,000. Preventable disease has not been rife. Typhoid fever scarcely exists in our midst; and out of a population of 24,750 only one death occurred from it in 1879. The autumnal diarrhœa contributed the largest number of deaths under the zymotic class, and did not appear to be influenced by the water-supply. These results have been mainly brought about by close attention to the wells of the district under the powers given by the recent Act of Parliament, and many new ones have been sunk.

In some of the large farmsteads, rams have been constructed; and in others, where well-boring was impracticable or difficult, brick tanks, cemented inside, have been constructed, to hold 1,500 gallons, at a cost of 20*l.*, to supply double cottages. Iron tanks are in use, but are not generally approved of. Believing as I do, that a wholesome water-supply is the great factor in promoting the public health, I have offered these remarks in the hope that attention may be drawn to a district purely agricultural, where much has been achieved, even in these depressed times, by a vigilant attention to the water-supply, without embarking in any ambitious schemes, and relying solely upon the proprietors giving a loyal support to the intentions of the Legislature, under the guidance of the sanitary authorities; for we have to look for improvement in sanitation, not only to the co-operation of capital and labour in the initiation of schemes for an improved water-supply, but also to the patient investigation of the evils which lurk in many a domestic household, and only to be removed by the exercise of the powers we possess for their mitigation and removal.

In conclusion, let me review some of the suggestions which have been put forward on this topic, and consider which are applicable to the district which I represent. It has been proposed to supply villages by pipes from distant sources—say the Wold Hills in the Louth district. This plan is clearly too expensive, and must be dismissed, except perhaps in the instance of Mablethorpe, on the coast, and the villages intervening between it and the proposed source, ten miles distant. The river-catchment system, as advocated by the Royal Commission in 1869, by which each should supply, as far as possible, its own population, is inapplicable here, except in a limited form, owing to the pollution of the principal streams by sewage. Artesian wells might be resorted to with advantage, superseding gradually the surface-water too frequently in use; and, lastly, the rainfall should be utilised for individual houses and farmsteads. It would be foreign to my purpose to dwell upon the system of main drains and dykes, under the supervision of the Commissioners of Sewers, for watering cattle, &c., as this source is condemned by sanitarians as impure for domestic use. My object in bringing forward this subject will have been attained if I am able to elicit in the course of a discussion any suggestions for the improvement of the water-supply of my district.

RICHARD DOMENICHETTI.

Water-Closet Construction.

GREAT importance must necessarily attach to the deliberations of an Institute like this, which aims at disseminating information, and guiding public opinion on sanitary matters. It may, however, be questioned whether the real importance of a given subject is not shown less by the amount of talk to which it may give rise, than by the amount spent upon it in the production of an article the best fitted to meet advancing requirements.

The amount of brain-power and hand-labour expended for many years past in invention and experiment for the production of a perfect water-waste preventer and regulator, and an unexceptionable water-closet apparatus, is alone sufficient to testify to the paramount importance of investigation into the proper principles to be followed in their construction, with the view of arriving at some intelligible lines within which they should be restrained.

To all who have taken an active interest in sanitary matters, nothing can have been more evident than the dangers attending the old system of pans and valves, with D traps fixed out of sight, inside the house. At the annual meeting of the Parkes Museum, Sir William Jenner spoke of these last in no polite or measured terms. And truly the terms used by him were not exaggerated. But the difficulties attending the amendment of an established state of things with the British citizen are almost insurmountable, especially if it be such as to touch his inner man, whether through the pocket, or (if there be such) some equally tender point. Unquestionably there are vast commercial interests which stand in the way. So far as can be judged by outward appearances, under the present state o. things, even the value of the great bulk of house property is but little affected by the presence of sanitary or unsanitary arrangement in these respects. On a recent occasion in a house in which I have sojourned, and in which there has been constant ailment with one or more of the inmates—to say nothing of several cases of blood-poisoning attributed by the medical attendant to sewer gas—I have endeavoured in vain to induce the landlord to provide a water service for domestic purposes, apart from the only one which is supplied from a cistern over the water-closet; this closet being served by the customary spindle valve, with water-box, which inevitably releases the bad air from beneath into the water at the bottom of the cistern. I appealed to him, further, to remove, and to ventilate, the decayed and constantly leaking lead soil-pipe (occasionally eaten through by rats from the drain), which runs down inside the house, adjoining one of the sitting rooms, leaving it in an almost chronic state of stench. And, more than this, I appealed to the sanitary inspector, but could get no redress in these matters. This landlord, being also the agent of an enormous house property, was imperturbable alike under threats of quitting and under appeals to authority. There is every reason to fear that such is no uncommon case. In the great mass of speculative building hitherto, a few pounds per house of additional outlay, in these respects, has not been considered remunerative by way of investment. The houses must be had, and are often occupied almost before they are properly completed, irrespectively of these trivial considerations, about which it is said meddling people make so much fuss. People have become habituated to it. No death in *their* families has been traced to such causes. Almost all houses are alike in these respects. There is but little choice, and other occupants have lived on without complaining. Surely there cannot be so very much the matter, or we should hear more about it, and we can only go on as others do, and if we tried to examine into the matter ourselves, we should be no wiser. We must take what we can get, and either grumble or be thankful as the case may be. This, I venture to say, without exaggeration, is the prevailing state of feeling, and mode of action, or rather of inaction, in these matters.

The remedies usually proposed for this state of things are, first, legislation for the enforcement of sanitary conditions; secondly, the

education of the masses to understand and appreciate their own true interests, and to insist upon these being respected. Excellent remedies in their way, and they will doubtless effect much. But the difficulty of a general application of them meets us at every point. The great precedent remedy must be looked for mainly in the production of satisfactory sanitary apparatus and appliances, of the greatest simplicity, and at the most moderate cost; and then at imparting information respecting their principle, and their practical application, to the more educated classes of persons, and to those through whom such appliances are brought into use; rather than in any amount of crusade against mere recklessness, ignorance, or prejudice.

Let me now endeavour to give effect to the foregoing remarks, by a few practical considerations as to water-closet construction. I would, in the first place, deprecate the use of all closets by which, on the pulling up a handle, the contents are dropped down by means of the withdrawal of a plug, valve, or pan, whether into a trap, or directly into the soil-pipe and drain itself. Apart from valves and plugs being liable to derangement, it is evidently possible, and in many instances of accidental deficiency of water extremely probable, that they may be used without water, to the great danger of corroding the pipes and choking the drains. Secondly, I would eschew everything but some description of hopper-basin or flushing-pan. The contents of these *cannot* be let down, to the great danger of soil-pipes and drains. In case of the water service failing, or being frozen up, or otherwise deranged, a pail of water poured down will carry everything away safely. Thirdly, I would have the best possible flush of water which can be obtained by a regulator, or waste preventer, constructed without any valve except only the ball-valve which supplies the 'feed' or serving cistern. Fourthly, I would in all cases insist upon the use of this feed cistern, or other intermediate receptacle, for cutting off completely all contact between the closet and the main service, or house cistern, which may then be placed at any convenient distance from the closet, whilst affording the opportunity of regulating, accurately, the amount of water to be used for each discharge. Fifthly, I would avoid all traps except the one which is formed in the construction of the hopper-basin; this being made to flow out into a ventilated or open soil-pipe, which again may be carried up within an external ventilated flue for protection from frost, or for carrying off the foul air more effectually. There have been several inventions which I cannot regard as wholly satisfactory, with a system of flushing which merely washes out the contents of the basin into the trap below; in which the contents commonly are only partially concealed, and which does not clear itself properly with any ordinary flush of water which can be let in upon it. They are, however, a wonderful improvement upon previous descriptions of hopper-basins, and of still greater value as aiding in the superseding of closet valves and pans. The old hopper-basin has in the main worked far better than these, but the small stream of water, through an insufficient nozzle, has been quite ineffectual for its proper cleansing. The 'Shrewsbury' patent basin made by F. Peirce and Co. is calculated to meet most of these objections. But invention has been rife in the direction of valveless waste-preventers for the flushing of closets in the manner which I have indicated. Of these Hailstone's patent, and Brathwaite's patent, appear to be excellent, if the stream discharged is sufficient. The water is discharged through a syphon which is set going, in the one case by immersing a block of terra cotta to raise the water to a sufficient height to fill the syphon; in the other by raising a small quantity of the water in a cylinder. By the 'Shrewsbury' patent the result is produced by the mere process of lifting out of the regulator, or feed-cistern, the requisite quantity of water in a pan or tray, and so tipping it into a funnel, thus securing the sudden and effectual flush which is required for the specially formed basin or pan.

It surely is to the fulfilment of such conditions as these that all our efforts must be turned, and the stream of invention directed; as indeed, latterly, it has been to a great extent. If there are principles in closet construction radically wrong and bad, and there are others which are essentially true and good, it is only by thoroughly sifting the one and the other that just conclusions can be arrived at, and advancement made. I have not been advancing theories without giving, as I conceive, good and sufficient reasons for the general principles which ought invariably to be followed. Let them be well weighed, and if they cannot be defended, let them be amended. Whether they be accepted as good and true or not, I cannot, I am sorry to say, conceal from myself the fact that they are not likely to be generally carried out, at all events for a long time to come, even with the most strenuous efforts of sanitarians to enforce them, either by precept or by law. The present state of things has too firm a hold on the people at large; and there are commercial principles at stake, which will greatly stand in the way of such a general improvement.

I am not one to advocate interference with personal rights or vested interests, and I may therefore state freely what I believe to be the almost insurmountable difficulty attending it, even supposing a general agreement as to this system being the best. The best and largest firms necessarily live by advertising. And enormous is the good which they have effected by spreading the knowledge of improvements. Advertising is the only means by which such things can be brought before the public; and that which will pay, and will meet the public requirement, howsoever bad in principle it may be shown to be, must not be omitted from the catalogue of the useful articles supplied. The good and the bad are *equally set forth, side by side.* The generality of people take the recommendation of a thing in this manner, and are only too glad to take what is thus brought before them without further trouble or question. And so long as great variety of opinion upon these matters exists amongst those who are supposed to be well informed, it is not to be wondered at that so little real result should be obtained. With all this, however, we are far in advance of our continental neighbours. At Berlin, and at Rotterdam, they rest content, as it was described to me a few weeks since by well-informed persons, with merely a pan and a tap; and nothing could be more simple. At Dresden, Hanover, Bremen, and Hamburg, much more attention is now being paid to these mundane things; but one's reminiscences of continental sanitation are by no means pleasant. I am not at all sure that the same remarks might not be made by a casual observer, as to the state of the case in our own country; for as yet, I fear, we are after all but little in advance of them, and that typhoid fever, certain skin diseases, and much general debility and ill health, will continue to be, as now, but too common; for up to the present time all that has been written and said by our most eminent physicians and sanitarians seems to have made but little practical impression on the educated, the heads of families, and house-owners generally.

WILLIAM WHITE, F.S.A.

MR. MARTIN, C.E., said that he agreed with what had been said as to the defects in the D-traps, which he had experienced in his own house. He believed that there was nothing so efficient as a syphon-trap.

MR. ROBINS and MR. CHADWICK spoke in similar terms.

MR. TOWLE repeated that the whole present system of closets was bad; the sewerage should be taken away direct and sent over the land.

MR. CHADWICK said that he had often observed that the most healthy of all buildings was a prison, and in every cell there was a pan. According to Mr. Towle's theory prisons would be a source of poison, whereas they were the healthiest places in the community.

THE PRESIDENT, in proposing a vote of thanks, observed that where there was a connection between the sewer and mains and the soil pan, it should be immediately severed, and the supply should be either by hand or through a sewer-box.

The vote was seconded, carried, and acknowledged.

The Plan adopted by the Local Board of Health for the Urban District of St. Thomas the Apostle, in the County of Devon, for Disinfecting the Sewage of the District.

THE subject chosen for this paper, being a history of the introduction and carrying out of a system commenced at the end of the year 1860, and continued to the present time, with no alteration in its principle, is intended to be a narrative of facts and not a challenge to other systems which may have been adopted with equal success in other places.

Suffice it to say that from the low lying level of our Sanitary District we have laboured under many difficulties which do not present themselves in other more favoured localities.

I cannot do better than quote from the minutes of the first meeting at which the present system was suggested as a remedy for the evil arising from sewage not disinfected.

For access to these most valuable and ancient minutes, I have to thank Mr. J. Champion, now the clerk to our Local Board of Health, who most courteously placed them at my disposal, and to whom I am indebted for much valuable information.

'At a monthly meeting of the Local Board of Health for the district of St. Thomas, held on the 3rd Dec., 1860,

'James Wentworth Buller, Esq., M.P. in the chair, Mr. R. T. Pince called the attention of the Board to Mr. McDougall's scheme for disinfecting and dealing with the sewage at Carlisle, and produced a correspondence respecting it recently published in the "Times" newspaper. After the matter had been well considered, the Clerk was directed to write to the Town Clerk of Carlisle, and to Mr. McDougall at Manchester, soliciting information on the subject, and to call a special meeting of the Board when the answers were received.'

On the 21st December of the same year, 1860, Mr. Ellis, the Surveyor, was requested to go to Carlisle to inspect their system, and to meet Mr. McDougall there, together with the Town Clerk of Carlisle. He also visited Rugby, and the result was that on Mr. Pince's proposition, which was unanimously agreed to by the rest of the Board, the disinfecting process there adopted was tried at St. Thomas for three months. After this time there are reportsas to its satisfactory working.

The system was, after this, further extended, and satisfactory experiments were tried as to the fertilising properties of the disinfected sewage. (2nd September, 1861).

After this, at a monthly meeting on the 4th August, 1862, J. W. Buller, Esq., M.P., in the chair, Mr. Northmore submitted the draft of a letter he proposed to send to the authorities of the city of Exeter on the subject, and on the advantages that would accrue if Exeter would join St. Thomas in carrying out the scheme. At the same meeting it was proposed to exchange the old basket-work screens for perforated cast-iron panels, $\frac{3}{8}$ths of an inch in thickness, for filtering the sewage.

Then we find details of the sale of the solid sewage.

In the beginning of 1863 we find the Board considering the practicability of using the valuable liquid portion containing the soluble salts of the disinfected sewage for the purpose of irrigation. For this purpose, owing to the low-lying level of the works, it was deemed necessary to have a pumping engine to raise the sewage, but this was not carried out.

This disinfected fluid still continues to flow a considerable distance, until near Countess Weir it passes into the river, being thus lost to agriculture; and I may here observe that having been treated with carbolate of lime it would, if allowed to flow over the level lands adjacent to its channel, produce a good effect on the pasture, and not be open to the objection which attaches to all other sewage water, carbolic acid being a wholesome detergent, and even in its greatly diluted form curative in its effects and antiseptic. It is therefore helpful against 'footrot' or 'flukes,' as it would destroy slugs, especially when combined with lime; and though perhaps not sufficiently strong to cure footrot, it certainly would have a beneficial influence on sheep so affected.

This history would be incomplete were I not to quote here an admirable article from the facile pen of a gentleman who was on the staff of the 'Exeter and Plymouth Gazette.' The paper bears date September 20th, 1867, and I must tender my thanks to Mr. Donisthorpe, the present editor, for his great courtesy in furnishing me with it. It is headed 'Our City,' and contains an excellent account of the sewage operations in the parish of St. Thomas, and the formation of a new water supply for that district.

OUR CITY.

There is not much distinction to be drawn between a citizen of Exeter and an inhabitant of the parish of St. Thomas. Both hail from Exeter, and each has the same pride in the old city. In local government, however, there is a difference between the management on one side of the river and that on the other. Invidious comparison ought not to be drawn between the two. The circumstances of the single parish and those of the great city are very different, and the authorities of the smaller place are in the better position to make experiments. Still the St. Thomas Local Board of Health have acted with great spirit in the important matter of the sewerage and the water supply, and now that they are preferring certain charges against the city authorities, it seems an opportune moment, on the part of our city, to endeavour to ascertain exactly what the parochial Local Board are doing, and what actual grounds of complaint they have against us, and against the Water Company of the city, which has hitherto supplied both Exeter proper and the transpontine district with water.

While the whole country has been agitated with the question as to what shall be done with the sewage of towns, and every new system adopted has been discussed with the greatest interest in a hundred other towns, anxiously waiting to have a method propounded to them to relieve them of the difficulty in which they are placed, the parish of St. Thomas disposes of its sewage in a simple and comparatively inexpensive manner, and avoids the objections which have been raised against almost every other suggestion that has been made in the shape of a solution of the question, for it neither pollutes the river, infects the atmosphere, nor destroys the manure. The St. Thomas's sewage system, which has been inspected by deputations from a large number of towns, and from scientific and other societies, must be familiar to a large number of persons in Exeter; but since the Local Board have very recently completed the works so as to apply to all the dwellings in the parish, and that completion has a particular bearing on the application recently made to the local authority of the city, we will briefly explain the plan which has been found so satisfactory in that parish.

Some ten years ago, about 1857, the authorities of St. Thomas made an attempt to adopt Mr. Herepath's patent system of deodorisation, by means of which the solid matter was to be preserved for agricultural purposes, and the liquid to flow off in an inoffensive and harmless manner.

That method failed entirely. It was too expensive, it did not produce the expected results as to purification, and the manure did not answer. The Local Board, therefore, found themselves in the possession of two large tanks and a channel for carrying off the liquid portion of the sewage, which promised to be useless, and the whole scheme was at a dead-lock. They were in that position when the South Devon Railway Company indicted them for the nuisance caused by their open sewer, which ran parallel with their line for a certain distance and then crossed it, emptying itself at a point down the river just below Countess Weir. To have covered in that long channel would have added immensely to the original cost of the works, and have been a very serious burden to the ratepayers. At that time the merits of McDougall's patent disinfecting fluid, carbolic acid, were much discussed, and it was said to have been used with great success in the sewerage system at Carlisle. The Local Board therefore sent their Surveyor (Mr. Ellis) to Carlisle to inspect the method adopted there.

He found the disinfectant acting satisfactorily, and saw that, with certain modifications, it could be made to apply to the existing machinery at St. Thomas. His report was at once acted upon, and by dint of much ingenuity and contrivance a system was got to work, differing in many respects from that at Carlisle, and a great improvement upon it in point of economy.

The tanks, which were constructed to carry out Herepath's system, were still made available as receptacles for the sewerage of the parish, which was conducted to that point, about a quarter of a mile from the streets, by the same covered main sewer; but within a few feet of the outfall of the tanks the disinfecting apparatus was constructed. This was very simple and economical. It consisted of a common pump, a pail, a vat holding from ten to fifteen gallons, and a little cask of carbolic acid. The pump supplied the pail with water, which was mixed with a small portion of lime, and the lime-water fell by a regulated flow into the vat, into which also the colourless acid from the little cask dripped in the proportion of 1 of acid to 250 of lime-water, forming a brown transparent liquid called carbolate of lime.

In endeavouring to carry on the mixing process on a more economical plan than that adopted at Carlisle, Mr. Ellis met with a difficulty in mixing the lime with the water. The lime had a tendency to remain in the form of a sediment at the bottom of the pail, while the water ran off clear. He, however, after some small experiments, overcame the obstacle by a simple and ingenious contrivance. He pumps the water into the pail by a tube which descends to the bottom of the vessel and forms a coil perforated horizontally towards the centre, and the force with which the water is ejected through the perforations disturbs the sediment of lime (of which only a few lumps are dropped daily into the pail) and keeps the lime and water well mixed. The carbolate of lime formed in this cheap fashion is conveyed, by a small pipe about two feet from the little shed in which the vessels are kept, and drips into the main sewer, which at that point, near the fall into the tank, is furnished with a contrivance similar to a weir, causing a commotion at the fall of the sewage, effectually mixing it with the disinfecting fluid. The

two great tanks, which receive now the whole of the sewage of St. Thomas in its disinfected state, are each about twelve feet square, and six feet deep. Their sides are perforated from the bottom to the height of about four feet, letting out the fluid and retaining the solid matter. The fluid is simply dirty water, not at all offensive, and it flows by the same open channel, which was once indicted as a nuisance by the South Devon Railway Company, down to the outlet into the Exe *below* Countess Weir. The sediment in the tanks is removed at short intervals and placed, partly in an adjoining shed and partly in the open air, to dry, and in that form it is sold to farmers, about forty cartloads being taken away every two months.

It is considered to be very efficacious manure, and is purchased by the same farmers who took it in the first instance. The carbolate of lime is said to fix the ammonia, preventing decomposition without rendering the substance insoluble in the soil. A portion of the manuring properties, however, escapes with the liquid that runs away by the open channel to the river, for on a piece of land adjoining the works, watered by this fluid, and consisting of very poor gravel, a remarkably fine crop of beet and turnips is now growing, and the Local Board hope to utilise the liquid manure at some future day by running it upon land adjoining the current of the channel by which it is conveyed to the river.

One man is sufficient to superintend all the operations at these tanks, and the cost of the carbolic acid is not more than 15*l.* per annum. The man in charge also finds time to go round the parish three times a week, and apply the disinfecting fluid wherever he finds any accumulation of impure matter. The fluid is also freely given away to the poor, who frequently avail themselves of the privilege to purify their dwellings, especially during the prevalence of epidemics.

The complaint which the St. Thomas's Local Board have, from time to time, made to the authorities of the City, refers to the state of the river immediately below the Exe Bridge, upon the St. Thomas side. '*The whole sewerage of Exeter is emptied into the river*, a large portion of it being received into the mill-leat, which runs between Commercial Road and the Exe; and the allegation is that at the particular point of the river in question, where the water is almost stagnant from being out of the current, there is an accumulation of impure matter washed and floated there by the eddy. To this complaint there was, no doubt, for a time a good reply; for the sewerage system of St. Thomas was not complete. About 120 houses on the north side of Alphington Street and Okehampton Street still continued to be drained into the Exe, and the city authorities charged the people of St. Thomas with themselves causing the nuisance of which they complained. The Local Board of that parish, therefore, resolved to remove that evil, and, at considerable cost, they laid intercepting sewers down Alphington Street and Okehampton Street; and now having *stopped every house in the parish from emptying its sewage into the river*, they turn to the Exeter Local Board, and say, 'We no longer pollute the stream, but yet it is as bad as ever.'

The water and the bed of the river are certainly in a very unwholesome state along the shore next the south-east corner of the bridge, and the place is only kept from emitting a foul stench by the application, two or three times a week, of the disinfectant. The inhabitants at that spot complain loudly of the foul state of the river; and at the workshops adjoining, it is said they are compelled to keep the windows closed at times, and the men are often ill from the effects of the impurity.

The plan suggested by the St. Thomas Local Board is to build a low wall and reclaim the piece of land where this stagnation takes place; and it is said that persons in the neighbourhood would be willing to pay the cost for the sake of a lease of the reclamation. On the other hand, it is contended that to narrow the stream at that point would throw too much swell on the opposite point, and the authorities of the city still allege that the nuisance is caused by the inhabitants of the St. Thomas's side. The question has been referred to the Streets Committee and the Surveyor to the Exeter Local Board; but we understand that it is not proposed to take steps for the permanent alteration of the river as suggested by the St. Thomas's Local Board.

That parish has, however, now placed itself in such a position that, if the foulness is not permanently remedied, they will be able to charge the city authorities with causing the nuisance.

While the Local Board of St. Thomas were engaged with much determination and good sense in relieving themselves of the great and serious difficulties connected with the sewage question, another trouble arose. They had been supplied with water by the Exeter Water Company constantly for sixteen hours every day; but when the agreement ran out a few months ago, the Company, in accordance with a previous notice, declined to furnish any longer a continuous supply. They gave, some months before, an intimation that for the future all houses to be furnished with their water must be fitted with cisterns to be filled only on certain days in the week, on the peculiarly objectionable and unsatisfactory plan of the water supplying the city. The Local Board of Health spiritedly refused to accede to that proposal. The stinted supply of water was calculated to upset all their plans for promoting the health of the parish, and in particular it would tend to interfere with the working of their sewerage system. Much discussion ensued, deputations waited upon the Water Company. The Local Board sought to make compromises, offering to be content with ten hours' and even eight hours' supply per day; but the Company would not yield, and the inhabitants unanimously supported the Board in their determination not to accept the Company's terms. The result is that the Board have decided to erect waterworks and supply the parish; and, with characteristic promptitude, they have already sunk a huge well, in a field near the Okehampton Road, into which pure water, filtered through the earth, flows in abundance at the rate of 100,000 gallons in 24 hours. The well is 12 feet in diameter, and will be made 20 feet deep. From this the water will be pumped to a reservoir from which the whole parish will be supplied constantly.

(This has since been carried out, and is still in active use with a fair supply.)

From these specimens of the courage and public spirit of the St.

Thomas's Local Board, it would seem that the parish deserves the respect and consideration of her elder sister on this side of the river, and such complaints as she makes have a claim upon the attention of the authorities of the city. The parish of St. Thomas is poor and contains a large number of inhabitants, and the credit due to them is so much the greater for what has been done for the health and comfort of the population.

The Local Board, under the excellent chairmanship of Mr. Pince, have watched over the interests of the parish with such zeal and method during the last few years that fevers and epidemics are almost unknown. With a good water supply and an efficient sewerage system, more than half the conditions necessary for health, even under unfavourable circumstances, are secured. The sewerage question is still in an unsettled state, and, except in places like London, where the emergency is very great, it is not wise to enter upon works of great cost and magnitude; but until scientific and practical men have decided upon a really effectual method of preserving at once the health of the people and the whole fertilising properties of the manure, we know no plan so well calculated as that adopted at St. Thomas to give safety to the public at so trifling an expense, with the least loss to agriculture and breathing time to the philosophers.

For the last twenty years the Local Board of St. Thomas has used carbolic acid as a disinfectant, and this paper has already treated of the first seven years of that period, during which negotiations were opened with the authorities of the adjoining city of Exeter, committees were appointed, deputations 'waited,' and every effort was made to secure their co-operation. This state of things continued for some time, but finally fell through, and the city continues to this day to pour all its sewage and waste water into the River Exe, which thus becomes a *gigantic cesspool*, the *slush* being kept from flowing away by a series of weirs.

The remaining thirteen years of the twenty have now to be accounted for. During this period the number of houses has been steadily increasing, and we have found our system as good as ever; we have added to the number of tanks as our need has increased, and during the last twelve months we have considerably obviated a difficulty we before experienced in saponifying, or rendering sufficiently miscible, the carbolic acid, which from its oily nature had a strong tendency to float in considerable quantity on the surface of the fluid in the catch-pits, thus causing a waste of the disinfectant, and occasionally impairing its efficiency.

The addition is both simple and inexpensive, and its quantity too insignificant when compared with the bulk of the sewage to influence its quality to any great extent. It is the simple addition of a little common salt to the lime with which the carbolic acid is blended.

We find the daily allowance which is sufficient for all ordinary occasions costs about 1*s*. 3*d*., and consists of

		d.
35 lbs. of white lime	. .	say $4\frac{1}{2}$
12 lbs. of common salt	. .	„ $1\frac{1}{2}$
3 pts. of carbolic acid	. .	„ 9

These are thoroughly mixed together in a suitable vessel with water; this is conveyed in a carefully graduated stream into the main sewer at a point a short distance from its opening into the catch-pit, and is so regulated as to continue flowing for the twenty-four hours.

The population of the district sewered is about 4,500.

The sewering is divided into two sections, the older portion of the parish consisting of 3,687 yards of glazed piping from 9 to 18 inches in diameter, with an ordinary delivery of 314 cubic feet, or 1,965 gallons per minute. The newer portion of the parish is sewered with 2,533 yards of glazed piping from 9 to 15 inches in diameter, with an ordinary delivery of 157 cubic feet or 981 gallons per minute, without storm water. The average inclination is about 1 in 450.

Our present chairman, Mr. Mark Farrant, is also fortunately our medical officer of health, thus enabling us to keep pace with the health requirements of the district in our sanitary work, and keeping us informed of many important details which would probably otherwise be never brought under our notice. We have an excellent surveyor, Mr. Samuel Churchward, appointed in February 1874, and who has since that time been most energetic in carrying out the great work of sanitation.

The health of the district has been steadily improving, and we have every reason to be satisfied with the present system as far as we have carried it.

Our low-lying level prevents our filtering the sewage as effectually as it might be done in a different situation, and we have hesitated at incurring the expense of another engine in the parish, which, if placed at our sewage works, would get us over all our difficulties in the way of raising the bulk of the sewage to a higher level, and enable us to filter thoroughly the solid portion, as well as, if required, to distribute the fluid which contains so many valuable fertilising salts in solution. We have already done much good work in our parish, and must for a time be content to rest from our labours and await the course of events and the further development of science, always bearing in mind that much wealth is being daily lost to our country from the want of knowing how to utilise those products which both nature and common sense teach us are the true and only source of agricultural prosperity.

WILLIAM ROBERT WOODMAN, M.D.,
Ford House (St. Thomas), Exeter,
Member of the Local Board of
Health of St. Thomas.

Mr. CHADWICK, on the incidental question of disinfection, said that the subject had been very carefully examined in Paris, Berlin, and other places, and the unanimous conclusion was that the cheapest, best, and most effectual way was the direct application of the sewage to the land, without any intervention whatever. At Croydon, as Dr. Carpenter could testify, it was effectual, provided it was done in a proper manner. There was a distinction not yet understood—that between fresh and putrid sewage. What was smelt in towns was

putrid sewage. The direct application of fresh sewage was the least expensive and most efficient system, and the one that should be adopted.

In reply to the President, Dr. Woodman said he himself used the sewage on his farm, paying by tender 15*l.* a year for it.

The PRESIDENT said it must be quite clear that, as a profitable speculation, it did not pay the parish of St. Thomas to utilise the sewage; and it was curious that they should go to Carlisle for an example, when at Carlisle Mr. McDougall never did anything of the kind that Dr. Woodman had been speaking of. Mr. McDougall never made a profitable manure; he was not aware that Mr. McDougall ever made 1*l.* by any portion of the solid matter. He supposed that there was no complaint at St. Thomas because the sewage went into a very large body of water, itself impure from other sources. If they wanted to get the greatest amount out of the sewage they must not disinfect the crude sewage at all. It was not in every town that they could find land on which to pump the sewage. But at Doncaster and Leamington, from Christmas to Christmas, the crude sewage was pumped on to the land, and it produced very good crops when the season permitted it. He would say advisedly to the Exeter authorities that it was the duty of the Municipality to get rid of the sewage in the cheapest way; but if it cost a rate in aid, it was the duty of the Municipality to do it, and pay without grumbling. A gentleman present had taken a poetical license when he said that the sewage of Glasgow could be pumped over the mountain tops. No local authority was justified in paying 30*s.* for a sovereign.

Mr. BOULNOIS said that of course there were two sides to every question, and the works just described had somewhat of a notoriety, not from their immense size, for they heard that they only professed to treat with the sewage of 4,500 persons, but from the fact that they were sometimes complained of as a nuisance. Persons who travelled on the South Devon Railway were often made painfully aware of their proximity to the spot where the refuse of St. Thomas was emptied out. The process adopted at St. Thomas was similar to that of Taunton, but at the latter place they found it necessary to mix the carbolic acid, lime, and salt together by machinery, and also to mix this compound with the sewage in a similar manner. At St. Thomas one old man was found to be sufficient, and, he believed he had also many other duties to perform. The effluent water from these works was allowed to enter a brook in the neighbourhood, and it was not quite so clean and free from impurities as would be considered to come up to the standard of the Rivers' Pollution Act. (A bottle of the effluent water was produced by the speaker, and looked very like thick ale.) Dr. Woodman's paper seemed to him to be almost an attack upon Exeter; and the introduction of the subject of the water-supply of St. Thomas, which surely could have nothing to do with the treatment of sewage, strengthened his suspicions, now, with reference to the water-supply. It was an absolute fact that at this present moment there were many persons who declined to take the magnificent supply offered them by the St. Thomas Local Board, but preferred to take the Exeter water. He would not then tell them of the excellent quality of the Exeter water—as that subject was reserved for discussion; but he wished to disclaim entirely a misrepresentation in the paper just read, to the effect that St. Thomas was not supplied with water by Exeter. It was supplied to many customers who paid for it; and, he regretted to say, also to many customers who were so infinitely fond of it in preference to the St. Thomas supply that they stole it. Nor could they wonder when they heard in the paper just read of wells 20 feet deep, supplying 100,000 gallons per diem; and that the wells were sunk in a gravelly soil, close to the fearfully polluted River Exe, to which their attention had just been drawn. It would be observed that Dr. Woodman produced no analysis of the water so bountifully bestowed on the inhabitants of St. Thomas. He did not wish to deny that the whole of the sewage of Exeter did reach the river, but it must be remembered that within a mile of Exeter the river became tidal. The Town Council had not been idle either. Four years ago, just after his appointment as their Surveyor, he presented them with a report on the sewerage question, and laid a scheme before them for disposing of the sewage, by carrying it in pipes along the raised banks of the Ship Canal, and irrigating some 700 acres with it at will on both sides. This plan was to cost 30,000*l*. Last year he presented them with another report, proposing to deal with the sewage on some fields known as Duck's Marsh. A plan of this was hung in the Exhibition in connection with the Congress. The cost of this scheme would have been 13,000*l*, exclusive of land or compensation. Exeter, he believed, was quite willing to do that which was expedient when the right time came, but he regretted to be compelled to state that it would not be to the St. Thomas sewerage works that they would turn for a lesson. In many of these precipitation sewerage works the addition of the precipitant or disinfectant was intermittent, and often only added when an inspection was expected. He should not be surprised if the St. Thomas works were no exception to this rule. His duties as engineer often took him to the Ship Canal and along its banks, and he was often struck with the sights and smells of the stream into which the effluent flowed, some two or more miles below the works, where it joined another brook, and passing under the Canal, reached the tidal portion of the river.

Mr. Bodley asserted that the depth of the wells in St. Thomas was 30 feet, not 20 feet.

Mr. Sillar demonstrated that at Aylesbury sewage was deodorised by the A B C process without its fertilising powers being destroyed.

Mr. J. Daw observed that at Trew's Weir the water was impounded, and thrown back upon fifty acres of land.

Dr. Woodman desired to revert to Mr. McDougall's operations at Carlisle.

The President said that when Mr. McDougall's lease was out it was not renewed; and now the inhabitants, having an injunction filed against them, were devising means to get rid of the sewage without polluting the river Eden. In point of fact, Mr. McDougall worked his process at Carlisle to enable him to bring into notice his carbolic acid, and for no other beneficial purpose whatever.

Dr. Woodman, in his reply, said that in some places both banks of the Exe belonged to St. Thomas, and its inhabitants did not like to see the river polluted by the sewage of Exeter. The 'effluent' produced by Mr. Boulnois was not drinking water; but the decanter of fluid on the President's table was represented to be Exeter drinking water. His object was to prevent the pouring of sewage into the river by the Exeter people.

The President added that the Public Health Act prohibited anyone from discharging crude sewage into the river. It only required some person to put the law in motion, and an injunction might be obtained to restrain this action by the towns on the Exe.

Sewer Gas Annihilation.

The author of this paper has recently published a pamphlet on the subject of the ventilation of sewers, in which he has described in detail the several methods which have been introduced for the purpose of disposing of the noxious gases generated in sewers and drains. He will not therefore recapitulate these systems, but will content himself with a few observations on the 'open shaft' ventilation system, which has hitherto found most favour with sanitary engineers and others who have dealt with this all-important question.

It is unnecessary to describe all the various forms of the 'open shaft' system, as they are probably well known to most of the hearers of this paper; and whether open gratings in the centres of the streets are employed, or shafts carried up the sides of buildings, or the gully-pits left untrapped, they are one and all modifications of the same principle, which is to allow the escape of the foul gases of a sewer into the neighbouring atmosphere.

Now let us as sanitary exponents ask ourselves at once, is this a truly sanitary and wholesome measure; to allow these offensive and perhaps pestilential gases, which are generated in our public sewers, to pass into the air we breathe, and thus to pollute and poison it?

Is the principle a scientific one? Has any advancement been made over the old systems, when open ditches and brooks received the contents of the house-drains and of the sewers; when, be it remembered, such brooks and ditches had these advantages over our present well-constructed sewers: the surrounding earth deodorised and absorbed a portion of the sewage, and the whole length of the ditch being open, the foul gases that were generated did not concentrate at any one point, as at a ventilating shaft in the present system. And again, no doubt the banks of the brooks and ditches were fringed with a luxurious growth of watercresses or other aquatic plants, which helped to destroy many of the offensive components of the sewage flowing past, and it was only when the sewage overpowered nature, and the senses of sight and smell were overcome, that our predecessors, in order to avoid these evils, covered over the ditches and brooks, and in some cases gave them paved inverts. Foul gases, however, of sewage decomposition were still rapidly formed, and the advocates of open ventilation at once said: 'We find these gases are generated, however well our sewers are constructed, and however quickly their contents are made to flow, and we further find that unless we allow these gases to pass out readily through openings into the surrounding atmosphere, that they pass through the house-drains, into the confined spaces of the dwelling-houses, and poison the inhabitants.' It is also contended that open ventilation introduces fresh air into the sewers, and that by so doing the foul gases are disseminated and destroyed, and are so diluted as to be rendered quite harmless.

These arguments are perfectly true and consistent, and it is without doubt absolutely necessary that these dangerous and offensive gases should be kept out of the interior of our dwelling-houses. But the author goes even further than this, and says that this impure gas should not only be kept out of our dwelling-houses, but that it should be kept out entirely from the air we breathe, and not be suffered to pollute the atmosphere of our crowded courts and narrow streets, nor be breathed in its concentrated form by persons unsuspectingly passing by or standing over a ventilating grating or shaft.

And with respect to the introduction of fresh air into the sewers, although the author does not wish to absolutely condemn this practice, he wishes to point out the scientific fact that the action of the atmospheric air upon the organic matter contained in the sewage, produces and feeds decomposition or putrefaction, and that if it were practicable to make a sewer perfectly airtight, or in other words to hermetically seal it, no decomposition could take place.

In practice, however, this would be found to be impracticable, and sewers unprovided with any outlets or safety valves for the escape of the vapour or gas generated in them are frequently found to be dangerous to the locality in which they are situated, and so it has come to pass that open sewer ventilation has been introduced, and that up to the present time no better means for the disposal of the foul gases have been discovered.

It is true that the charcoal tray or basket system was introduced some years ago. The author will not waste time by describing this system, as it is so well known, but will content himself by observing that it has not found much favour with engineers; for, irrespective of its first cost, admirable as the system is, it is found in practice to be rather complicated, and the charcoal is apt to clog and become inoperative after a short time by reason of the wet affecting it and the vibration of the traffic. It is consequently necessary to give it a great deal of attention, and the first cost is not the only one involved. It was therefore with a view to discover some other simple, inexpensive, and certain method to deal with this vexed question of sewer ventilation that the author gave the subject some considerable attention, and in the course of making some investigations on the subject, he found that in some of the old ill-constructed sewers he inspected that there was a remarkable absence of smell or foul gas, although from the conformation of the sewer the contrary might have been expected.

On searching for the cause of this, the author noticed that the brickwork of which the sides and crown of the sewer were composed was very defective, and that holes and openings were thus caused through which the air in the sewer passed and became absorbed in the surrounding and superincumbent soil.

The outcome of these observations and investigations has been the invention by the author of what he has designated the 'sewer gas annihilator,' the principle of which is based on the well-known fact that earth has a powerful action in deodorising and rendering innocuous fæcal and other matters undergoing decomposition, and in absorbing the noxious gases and emanations from such matters.

There are of course many modifications of this principle, but the author will proceed to describe a few of the best methods, which he has patented.

For a brick sewer where no spring or subsoil water is present, a perforated earthenware segment is built at intervals in the crown of the sewer. In a pipe sewer a portion of the upper periphery is perforated in a similar manner. These perforations in each case are surrounded by broken stones, then gravel, and lastly dry earth, the whole being built up with sloping sides, and isolated if thought necessary from the surrounding ground by either panning the sides, or coating them with fine concrete or asphalte.

Where any manhole or ventilating or lamp shafts already exist, they can be treated in the following manner, or, in their absence, shafts can be specially built. These are covered with a perforated cover or hood of various shapes, which are then surrounded by broken stones, gravel, and earth as before, which are then placed in the form of an inverted cone and are isolated as in the previous case.

The diagrams accompanying this paper show the arrangements alluded to, which are extremely simple, very easily constructed, and kept in working order by the most unskilful workman, the expense of their construction being almost nominal: and the author will now proceed to point out some of the advantages of the system which he advocates:—

Sewer gas, or 'fœtid sewer organic vapour,' is frequently generated in the sewers of the best and most modern construction, partly on account of temporary obstructions in the sewer, partly because of the so-called low and high watermark in a sewer, which allows an accumulation of slime, and is constantly manufacturing the gases of decomposition.

Now these gases of decomposition have over and over again been proved to be highly poisonous and even dangerous to human life, and although it is affirmed that, diluted with atmospheric air they become harmless, the author does not recollect that such has ever been proved to be the case. On the contrary, it has been shown more than once that this sewer vapour contains solid flakes or atoms of organic matter floating about in it, and also contains germs of disease which all the atmospheric air surrounding our globe is powerless to destroy. Woe betide any unfortunate child or adult into whose body these germs are carried by the air wafted from an open sewer ventilator, often the chosen favourite play place for the children from the adjacent Board School, who should have been at all events warned against the danger thus incurred, however little else of sanitary or practical knowledge they may have been taught.

In the author's system none of this deadly poison is allowed to escape into the air we breathe. It is on the contrary 'cabined, cribbed, confined;' it is absorbed into the earth and there rendered harmless and safe by nature's own great laboratory, and the sewer which is so carefully buried out of our sight in the ground beneath us, is really, *not* nominally, separated and cut off from our daily life.

The intermittent flow of the sewage constitutes the force which, slowly but firmly, forces the foul air through the apertures over the stones and gravel into the earth.

Experiment and observations only can prove what area of earth is necessary in any sewer to overcome the gas, as this must vary in every town in England, and almost in every street; but there is no difficulty and but little expense to be incurred in expanding this area to any reasonable and required limits, and should the earth forming the annihilator become overcharged and sodden with the gases it has absorbed, it can easily be removed, sold as a valuable manure at a large profit, and fresh earth substituted. In fact, this is an application of the principles of the dry earth system for the disposal of sewage to the water carriage system, which has hitherto been found the most convenient, clean and inexpensive:—water to carry off the refuse of our houses, earth to disinfect the impure gases, and to prevent the air we breathe from being poisoned.

Some hearers may argue that the earth composing an 'annihilator' might be washed or find its way into the sewer below, and thus cause an obstruction in it, besides injuring the good effects of the 'annihilator.' But this could easily be prevented were even such a contingency likely to occur, for in no case need the 'annihilator' be placed at a less depth than 12 inches from the surface of the ground, and in ordinary soil the rain seldom reaches such a depth. Besides this, the annihilators would in nearly all cases be placed under roadways or streets, the surface of which, if even composed of macadam only, would effectually prevent any washing taking place.

In completely closing up a sewer in the manner suggested by the author, and in doing away with all open communication with the external air, there is of course the risk to be run of unsealing the traps of the street gully gratings or of house-drains, when the air contained in a sewer is put under an abnormal pressure by reason of its liquid contents being suddenly largely increased by a heavy rainfall or by an artificial flush of water.

It is however a fact, that there are many cities and towns in England where no provision whatever is made in the sewers for the escape of the air when under such pressure, and, so far as the author is aware, no evil results have followed in consequence.

In the system which he advocates, he is of opinion that the ordinary rise of the level of the sewage in a sewer, and consequent increase of pressure in the air therein, will certainly not be sufficient to unseal either an ordinary 'mason's' or 'syphon' trap, but that the effect will be simply to compress the air (which is well known to be extremely elastic) into a smaller space, and to force it more rapidly into its 'annihilator,' which acting like a sponge, will absorb and cleanse the air thus driven into it, the latter returning when the pressure is withdrawn, purified by its contact with the earth.

In the case of a heavy fall of rain extending over a short period of time, when the sewers and drains of a town are running full almost to bursting point, the effect no doubt will be to unseal all the traps of the gully gratings and thus liberate the air. This result will not be concentrated at any one point. It will be scattered all over the city, and the sudden liberations, or almost explosions of the air through the traps, will be intermittent and at varying times. In fact, it would be merely a transfer of outlet for the air, which outlet at present is the grating in the centre of the street or the shaft at the side of the house; in the author's system it is the gully grating at the side of the road. The effect would not be noticeable, and when the storm was over, the gully pits could be cleared of the detritus with which most of them would be filled by the sudden storm, the exceptional derangement of the system would be rectified, and all would again be well perhaps for many years.

With regard to the house-drains, and the possibility under these exceptional pressures of the sewer gas being driven into the dwelling houses through them, the author is of opinion that all house-drains should be pneumatically separated from the main sewers, so that under no circumstances whatever could the air from a public or main sewer find its way into a dwelling house.

Of course, to effect this would be enormously costly to any community. As the system is not now in use, and in fact, on the contrary, many of our houses are in direct untrapped communication with the sewers, the author is of opinion that his system is superior to the open shaft system, for the reasons he has given, and also from the fact that, except in cases of heavy and unnatural rainfall, the pressure of air in the sewer would not be subject to the variations now effected in it by the external air being often blown, sometimes fiercely, *down* an open-air shaft, unsealing all the traps in the vicinity, and forcing the foul gases into the houses.

The author has not at present been able to give his system a full trial, but he has been able to give it a rough test, with very satisfactory results. A few years ago, acting under instructions from the Town Council of Exeter, he constructed about $1\frac{1}{3}$ miles of stoneware socket-pipe sewers, in a district of Exeter known as St. Leonards. These drainage works were constructed on the approved method of straight lengths with circular manholes at every change of direction or gradient. As open ventilation by means of grids in the centre of the roads was objected to, these manholes were each covered by a solid cast-iron plate, placed about 12 inches below the surface of the ground. After the drainage works were completed and the contract finished, the roads throughout the district were reformed and reconstructed under the directions of the author; and it was then found necessary to raise these manholes, in order to bring their tops to within a convenient distance of the surface of the roadway.

Previous to this, many complaints had reached the author of the bad smells arising from the gully gratings in the neighbourhood of the new sewage works, which, on investigation, were found to be correct, and they were temporarily rectified.

When the manholes were raised, the author treated them in the following manner: he caused every other radial brick in the upper course of the brickwork to be omitted, the plate replaced, and the ground made good; the cost of this being less actually, on account of the saving of bricks, cement, and labour, than it would have been had the brickwork been constructed solid as before.

These manholes thus became rough and ready 'annihilators'; and, as a proof of their beneficial results, no complaints of smells from the gully gratings in their vicinity have ever since been made although the summer having been exceptionally dry they were frequently, and for long periods, perfectly free from water, and were consequently unsealed.

This, therefore, has been as thorough a trial as could be made under the circumstances, and has proved entirely satisfactory.

If, however, the author had had sufficient time at his disposal to have carried out his system in its entirety, he would have been quite able to refute any objections that could be raised, and he would also have been able to lay before you some more scientific and elaborated evidence of the beneficial results that he confidently believes will follow the adoption of his system.

H. Percy Boulnois, M.Inst.C.E.,
City Surveyor of Exeter.

Mr. Chadwick said, as the writer of the paper asserted that, however well sewers were constructed, gases would arise, he could not have visited towns where that phenomenon did not take place. At Croydon, some of the drain-pipes were only connected with clay, which disappeared, and the nuisance occurred, but elsewhere in the town where the sewers had been properly made, there had been no disease arising from this evil. At Carlisle, so well sewered by Mr. Rawlinson, there had been an escape of sewer gas, and fever; but this arose from the ill-construction of a section of the sewerage. At Carlisle the fault was that the putrid sewage and gases remained in a portion of the sewers for a year or more. There ought to be no smell, and there would not be if there were self-cleansing house-drains, and if the sewerage were properly constructed.

Mr. Robins said that the difficulty in Mr. Boulnois's plan would be to get the air to pass through such solid substances. There might be furnaces at the end of some of the long sewers, in combination with Mr. Eassie's plan of cremation.

The President could not encourage Mr. Boulnois to continue his experiment. He would not himself adopt it, and could not advise others to do so. If there was a bad smell, it was because the drains were closed. It was of the utmost importance that the sewage gas should go into the open air rather than into the dwelling-houses. It might be offensive if it came into the street, but it was infinitely better in the street than within the four walls of a dwelling. He could not regard Mr. Boulnois's plan with the slightest degree of satisfaction. If we stopped the ventilation of a sewer, we should soon have the whole population down with typhoid.

Mr. Square (Plymouth) believed it would be an advantage if all the street gullies were untrapped.

Mr. Boulnois, replying upon the discussion, said that as his plan was a novelty, he expected to meet with opposition just as the President had met with opposition from the Institution of Engineers, when he first suggested small-sized sewers on the Memphis model.

Suggestions for the Cleansing of Sewers.

The water-carriage system, with its many and great advantages, exposes a community employing it to serious dangers. These arise, in most cases from preventable causes; but as ignorance, apathy, and the scamping of work cannot be completely eradicated from human beings, it behoves those who may suffer from the consequences of these shortcomings to take all possible precautions against them. If the sewage of a town could at once and completely be removed from the neighbourhood, and be taken to a point sufficiently distant, its inhabitants might escape harmless, whatever might be the annoyance to its neighbours between them and the sea: but this is not often the case. When Dr. Johnson threw the snails from his own garden into that of his next door neighbour, the relief was, probably, temporary only. They increased and multiplied in their new resting-place, and without doubt many of their offspring found their way back again to the garden of the great philosopher. So also, whilst we are passing our sewage on to the next parish, enough of it lodges on the bottom of the sewers to produce by its putrefaction the germs of those diseases which so often ravage our towns. We might say, indeed, of a particle of sewage which we cast into a badly constructed sewer, 'Then goeth he, and taketh to him seven other spirits more wicked than himself, and returns to the house whence he set out, and the last state of that house is worse even than the first.' It was better off when it emptied its uncleanness into a cesspool. Sewage matters, when mixed with water, undergo rapid decomposition, and being of a slimy, glutinous nature, adhere tenaciously even to the comparatively smooth surfaces of drain pipes, and much more so to the porous surfaces of bricks; and when to this cause of uncleanliness in drains and sewers is added the evils too common in every town, of '*main drains which, from ignorant construction as to the levels, do not perform their office, and do accumulate pestilential refuse; and others which have proper levels, but from the want of proper supplies of water do not act,*' we can hardly be surprised that our noses are often offended when passing sewer gratings in the streets, or, if we have not broken the uninterrupted communication between our house drains and the street sewer, that our families are visited by typhoid and diphtheria.

Too often 'each drain acts' (as was stated in the First Report of the Commissioners for Improving the Health of Towns, from which the above extracts are made) 'like the neck of a large retort, and serves to introduce into the houses the subtle gas which spreads disease from the accumulation in the sewers.' The well-directed labours of Mr. Field, Mr. Griffith, and others are effecting much to prevent this in the houses of the wealthy, but without special administrative arrangements no relief will be given to the classes who cannot afford to employ a skilful engineer, and, indeed, cannot perceive the paramount importance of doing so.

The expedients which can be adopted to remedy the evils arising from the adhesive nature of sewage matters and from their deposition in flat drains, or arising from an insufficient quantity of water, are first to break up the slimy, glutinous condition of the sewage as soon as possible; secondly, to absorb the gases which arise from the decomposition of the sewage, and which, by the increased pressure, exerted by them, force sewage gas into our streets and houses; and thirdly, to flush the sewers copiously.

The two first objects can be attained by introducing lime into the sewers at their summit levels. The gases which chiefly result from the decomposition of the organic matters of the sewage are carbonic acid and sulphuretted hydrogen, the first being evolved in by far the largest quantity. When lime is introduced into sewage-water, the carbonic acid is removed from solution, and can no longer add to the pressure of the air in the sewers. The sulphuretted hydrogen is also for the time rendered comparatively inoffensive, being converted into sulphide of calcium. At the same time the glutinous nature of the sewage is destroyed by the coagulation produced, and then, with a degree of flushing, proportional to the flatness of the sewers, all deposits can be readily removed. The sewage no longer acts as a cement to bind together the particles of detritus washed from the roads.

In the year 1872, I had the opportunity of carrying out an experiment at Ealing, which I find described in an old paper of mine in the following words:—

'*In lieu of introducing the precipitating materials at the outfall, as hitherto practised, they have been introduced into the sewer itself at a point nearly 1½ miles from the depositing tank, and near the head of the village . . . and the experiment was attended with the happiest results. All the slimy and sticky, black decomposing filth which usually furs the bottom and sides of drains disappeared; the main sewer was perfectly freed from stinking sewer gases, no deposit of any sort was left behind, and, owing to the thorough admixture of the chemicals with the sewage, the deodorisation and precipitation were more perfect than when the precipitants were introduced at the outfall. As the main sewer alone was treated, and the branch drains to the side streets and houses were comparatively unaffected, still, inasmuch as the great volume of the sewer gases was disposed of, much benefit resulted.*

The Surveyor of Ealing, Mr. Charles Jones, visited a portion of the sewers with my brother, and found the results above described; and so much impressed is Mr. Jones with the value of the cleansing effect of the lime on the sewers, and of having the liming operation under his own eye, that he has prepared a chamber within the premises of the Local Board from which the lime can be introduced at the head of the main sewer.

It may be objected, perhaps, the the action of the lime would also be to set free the ammonia, and as this is a great carrier of noxious vapours, a counterbalancing evil to the advantages named might be reckoned upon; but I submit that the quantity of ammoniacal salts existing in the sewage is too minute to allow appreciable volumes to escape from the liquid, more especially as I would propose to add the lime at the moment when the flushings take place, and so contrive the flushings, by means of the sewage water itself, that they may take place at short intervals of time. In so far as the solid organic matter is concerned, as long as any free lime is mingled with it, putrefactive decomposition does not go on, and when the lime becomes carbonated it loses the property of expelling ammonia from liquids. By the use of salts of iron with the lime the sulphuretted hydrogen may be permanently, instead of temporarily, fixed, but the cost of the process is increased. Lime is recommended on account of its small cost, but many other precipitants will serve the purpose. These, then, are the means which I would suggest for deodorising the sewage, for reducing the tendency of the gases formed from it to escape into our streets and houses, and to enable the deposit to be washed from the bottom and sides of the sewers with facility.

For flushing purposes I would suggest the use of the beautiful invention of our colleague Mr. Rogers Field, which is exhibited by Messrs. Bowes Scott and Read at the Exhibition now being held at the new Abattoirs in this city. The flushing tank of Mr. Field allows of the sewage itself being employed to work it, so that the process of washing out the sewers can be effected without material cost. It also admits of the use of power obtained from the falling water from the tank to discharge from a hopper the required doses of quick lime. Of course, when lime is applied at the summit levels of the different branches of a sewerage system, precipitation at the outfall tanks may be dispensed with.

H. Y. D. Scott, Maj.-Gen., C.B., F.R.S.

Sewage.

In former days, when population was less dense, and towns depended upon wells and rain-water butts, before a regular water-supply had been introduced, cesspools and drains satisfied the requirements of the inhabitants for the storage and removal of foul liquids, as well as surface and subsoil water; but when once a regular water-supply introduced water-closets and a generally increased consumption of water in a town, there arose an imperious demand for better sewerage or drainage.

Engineers who had scientifically planned and constructed a water-supply system, with pipes carefully graduated to meet the wants of every street and house, seem to have exhausted all their science and energy in the effort to provide the water, and when called upon to secure its removal, after it had been fouled by use in the town, they could think of nothing better than to let it soak away into subsoil, or run downhill in old or new drains together with the rain-water. When the need of sewerage was first recognised, it was thought that settlement in a tank before discharge into the nearest natural water-course was all that was necessary, and accordingly the sewerage system was contrived to bring everything—sewage, rainfall, and all—to some low-level tank outside the town, and as close as possible to the natural watercourse.

Science seems to have departed directly the water was let loose from its supply-pipes, and, although every engineer's pocket-book bristled with formulæ and tables showing the volume and velocity of water running through pipes of given diameter and gradient when full or half-full, &c.—in practice it was considered that cost was the only limiting consideration, and that the larger the pipe the better the sewer.

Millions of money have been expended upon no better system than this haphazard one, and when our rivers became foul, and chemists began to calculate the theoretical value of excreta per head of population, inventors crowded in to discover short cuts for the recovery of the manurial matter which was being thus unscientifically cast away.

Success, however, is rarely reached by short cuts, or by acquiescence in the neglect of natural laws, and most of these inventors have at last found their level after years of not very honest toil, seeing that they always vaunted their success in purifying the sewage of a town of such and such a population without referring to the fact that, whenever rain fell upon the sewered area, a volume of foul liquid, ranging from double to ten times that which they professed to purify, was always suffered to escape by 'storm-water overflows' without treatment of any kind.

The great Duke of Wellington, commenting on the want of practice in the movement of large bodies of troops within the reach of officers in his latter days, is said to have remarked that if an army of 50,000 men was assembled in Hyde Park, there were not two generals who could move it out again without getting the men mixed up with the London rabble, which would destroy its efficiency as an army. And this is exactly what our civil engineers have done with regard to the water-supply of nearly every town in Europe and America, *i.e.* they have brought it scientifically into the town and left it to find its own way out, mixed up with a variable quantity of rain-water, which destroys its value as sewage.

Nor is this loss of value the only bad result of such a want of system, for in a sanitary point of view the large sewer must in dry weather generally become a gas-generating cesspool, instead of the self-cleansing conduit always contended for by Mr. Chadwick, Mr. Rawlinson, and the other prime movers in the demand for better sewerage from the year 1848 up to the present time.

These great men pointed out the need of such self-cleansing sewers, but the executive engineers thought that the rain-water of our humid climate would cover any want of calculation and consideration which it was inconvenient to them to apply to their work, so they made every sewer as large as they could, and trusted to Providence.

At a meeting of the Society of Arts in the year 1876, I referred to this arrest of scientific treatment at the point when water issues from the supply pipes, and the idea was taken up and has been fully and satisfactorily worked out by Mr. Isaac Shone, a mining and civil engineer of Wrexham, who read a Paper at the Annual Congress of this Institute at Leamington in 1878. I then remarked that probably, in future years, that meeting would be especially noted for its introduction of the sewerage system of the future, and after two years' observation and experience of its excellence, I agree with the following quotation from a letter lately received from Mr. J. J. Mechi of Tiptree Hall, Essex, who says: 'Nothing can change my conviction of the practical utility of Mr. Shone's admirable and simple invention, and I feel sure that, ultimately, it must be generally adopted.'

At the time of writing this paper I have no pecuniary interest whatever in Mr. Shone's patents, and it would doubtless be more prudent for me to stand by, as so many other engineers are doing, to see whether the inventor will sink or swim by his own exertions to get a town to try his system. That is really the point, as all who have studied the question admit, *que ce n'est que le premier pas qui coûte*, and if one town or a part of it once experienced the sanitary and economical advantages which the adoption of this system would secure to it, the revolution in sanitary engineering would be accomplished. But as a member of the Council of the Sanitary Institute of Great Britain, I desire to contribute my mite to the common stock of knowledge in sanitary matters which it is the mission of this institution to collect and proclaim.

The system in question has been before the world for two years, and has met only with praise from those who have studied it. Among that number not an objection has been made which could not be readily answered. I will not weary the meeting by entering into details which are to be found in numerous circulars and pamphlets supplied by Mr. Shone, but should like to state that I am fully satisfied with the trial which has been made at my farm during the last year and a half, not, be it understood, for any purpose or advantage of mine in irrigating the land, but simply as an exhibition to numerous visitors of the inventor's method of lifting liquid from a low to a high level by the power of a steam engine, or water power, at long distances from the point at which the lift is required.

Now every engineer who has ever planned the sewerage of a town must recognise the advantage accruing from the facility of giving good falls to the collecting sewers towards certain man-holes under the streets, wherein, by a simple automatic apparatus, their contents can be made to mount with unerring certainty some 10, 20, 50, or 100 feet, and then begin their gravitating course towards the outfall, or be pushed on by the same power along a level or rising main in any required direction.

Formerly such a plan would have required a regular pump and motor with attendance on the spot, the expense and inconvenience of which led the engineer to make such lifting-stations only on a large scale, and as quite exceptional aids to gravity.

He was thus tempted to be content with flatter gradients than it was desirable or safe to adopt, but as there is no reason why Shone ejectors cannot be placed out of sight under any street or square without interference with traffic, and actuated by power generated by steam or water at any convenient place several miles distant, if necessary, from the several ejectors, the engineer is now free to choose the most favourable localities towards which, as centres, he can give an artificial fall for the collecting sewers of each district where a natural fall is not available. Plans and estimates have been prepared for the sewerage of several towns on this system, which show very considerable economy as compared with the unscientific system of the past. So there is no objection on that score to detract from the weight of the sanitary argument for its universal adoption, and I have no doubt that an absolute revenue will be gained by the delivery of sewage proper to the land in a more marketable condition than it has yet been offered to the farmer.

Passing from the pneumatic ejector above referred to, I will introduce to your notice another valuable improvement combining the most perfect sewer gas-trap with automatic flushing for house-drain or public sewer, which we owe to the same inventor, who, recognising its analogy with his pneumatic ejector, has called it the hydraulic ejector.

Both the pneumatic and the hydraulic ejectors are intermittent in action, collecting and storing for a few seconds, or a longer period of time, whatever sewage is led into them, and ejecting their contents automatically, and with perfect certainty, the moment they become full.

The only limit of height to which the *pneumatic* ejector can project its contents is the air-pressure, which it is economical to apply; but the *hydraulic* ejector, as its name implies, is limited by the total fall or head of sewage, and of course it is not pretended that it will do more than discharge in one gush what would, if it had been clean water, have flowed down a pipe which had the same fall distributed evenly over its whole length.

With dirty water or sewage, however, the advantage of storing up and discharging in gushes by syphon action has long been recognised and applied by Mr. Rogers Field, C.E., in his well-known flush tanks. In circulars describing the original flush-tank of this inventor, its two defects were very candidly intimated by the recommendations (1) to throw a jug of water in suddenly to start the syphon action, if the tank at any time failed to discharge itself automatically; and (2) to remove the cover and clean out sediment from the tank occasionally.

Now, servants and others are not always very attentive to the directions of those interested in the regular working of any contrivance; and I think Mr. Shone has taken the very simplest and most practical means for dispensing with the necessity for issuing any directions for insuring the perfect working of his *hydraulic* ejector by pivoting over it a tumbling-box or basin, which, when filled by a small pipe—say from a sink or any other convenient source—will automatically topple over and right itself. It is thus evident that when the tank has been filled by the other discharges of the house or the sewers led into it, the next succeeding overturn of the basin must inevitably start the syphon action, which will empty the tank as effectually as Mr. Rogers Field's jug of water poured in by hand.

The second precaution suggested by Mr. Rogers Field has been obviated in an equally simple manner by starting the syphon from the very bottom of the tank which shelves down to that point; so that any sediment accumulating there is subjected to the full force of the discharge, and must go out in front of the lighter contents of the tank.

Mr. J. C. Edwards, of Ruabon, manufactures these ejectors in the simplest possible manner, by making a fire-clay bottom and cover to fit one of the ordinary 2′ sanitary pipes, set vertically to form the body of the tank, the syphon being composed of ordinary 4″ sanitary pipes, cemented together as usual. I should here mention that Mr. Rogers Field has introduced a very ingenious improvement upon his old form of tank, to which alone I have alluded above. This is called the annular syphon, and doubtless works well with clean water or *screened* sewage in tanks of large dimensions; but, owing to the cubic space occupied by this annular syphon, which must necessarily be deducted from the total internal measurement of the tank, as rendered non-effective for flushing purposes, it cannot, I think, be so economically applied on a small scale; and it is highly probable that the rags and miscellaneous articles always found in *unscreened* sewage would lodge on the sharp edges presented to the outflow of the sewage, even if the annular space were as favourable for that purpose as the simple pipe usually employed.

ALFRED E. JONES.

On the Self-providing Sanitary Capabilities of Isolated Middle-Class Dwellings.

DWELLINGS possessing the qualifications of being healthy and comfortable, combining sound sanitary arrangements and construction with suitable and appropriate design, are what every one professes to set a high value upon. To attain these desirabilities it is essential that the house should be properly arranged, drained and ventilated, and provided with a sufficient supply of pure water; and the main object of this paper is to show briefly and concisely to what extent this is capable of being carried out in comparatively isolated cases, whereby the house is made self-sustaining or providing, relying on no exterior influences, but containing in itself an abundant and sufficient means for its own water supply and sewage disposal. In cases where premises are in an urban district and the house drains empty into the public sewer, whilst a constant and never failing supply of water is derived from the Company's mains, the questions respecting these two important items become comparatively easy of solution. The dwellings that I refer to are houses which do not possess these advantages—houses and premises in out-lying districts, houses of about 35*l.* to 40*l.* yearly rental, with perhaps a trifle more than half an acre of land attached, numbers of which are scattered about in villages and at short distances from the outskirts of towns. These are the places frequently to be met with where visitors sometimes resort to for change of air and the benefit of their health, under the impression that the atmosphere being normally pure the air of the country house is free from pollution. At the same time, could they only be aware of the general unsanitary condition of the house and its surroundings, they would fly the place. They never trouble themselves concerning the arrangements and state of the W.C., the domestic offices, the cisterns and tanks from which the water for dietetic and household purposes is continually being drawn, the condition of the well and the ground adjacent to the dwelling. On the assumption in the present instance that the arrangements of the house in question have been duly considered as regards convenience and design, we will proceed to discuss the important questions of ventilation, water supply, drainage and sewage disposal, which devolve directly upon the sanitary engineer.

1*st. Ventilation.*—Proper ventilation is one of the most important requirements for the maintenance of public health, being the agent for the thorough distribution and circulation of fresh air, that element which everybody prizes so highly and which is so essential to existence. According to Dr. Angus Smith, a fairly attainable standard of pure air may be taken to contain of nitrogen 79·00, of oxygen 20·96, and of carbonic acid ·04 per cent. Air with a loss of only ·21 of oxygen, and the substitution of a similar amount of carbonic acid becomes perceptibly deteriorated, so that the result when it is vitiated to the extent of 1 per cent. must necessarily be considerably worse. It is calculated that in 12 hours an individual body would vitiate 900 cubic feet of normally pure air to the extent of 1 per cent.; and it is therefore of the utmost importance that the whole of the rooms contained in the house from the cellar to the attic, more especially the bedrooms, where we remain for eight or ten hours at a time, should be properly ventilated and provided with suitable means for the vitiated air to escape. Assuming that the sleeping apartment is 10ft. × 10ft. and 9ft. high = 900 cubic feet (not an uncommon size), and occupied by a man and his wife, they would in only six hours vitiate 900 cubic feet of fresh air. If any one from the open air enter such a bedroom when the occupants have just vacated it after a confinement of *eight* hours, the almost sickening character of the atmosphere will at once make itself apparent. But what can be expected? The door has been shut, the window closed, the unused fireplace is probably stuffed up, and there is no ventilator. Carbonic acid gas, though naturally heavy, immediately it is generated in a heated state rises towards the ceiling, and it will invariably be found that the atmosphere of a room is several degrees warmer and infinitely more disagreeable at the ceiling level than at the floor level. A simple and efficient mode of ventilation is to admit the fresh air by means of a grating or air brick, built in the external wall at the level of the floor of the room, with an opening from this to the back of the skirting or dado, either terminating at its top or carried up by means of a vertical pipe of 4in. or 5in. diameter to a height of four or five feet above the floor and covered with a grating of wire gauze. These tubes, commonly known as Tobin tubes, can be fixed by the side of the window and concealed by the curtains. Provision should be made for the formation of an air shaft or flue in all chimney stacks, to serve the sole purpose of ventilation, commencing in the basement, carried up through the different floors, and terminating with the flues of the chimneys in one stack. Communicating with this flue and in the ceiling of the rooms ventilators should be inserted. The volume of warm polluted air at the top of the rooms being extracted by these ventilators, will carry with it all noxious gases and exhalations, and fresh air will simultaneously be drawn in through the lower aperture to supply the loss of the displaced vitiated atmosphere. The air of the apartment being preserved fit for respiration by these means, no nuisance is experienced from dirt and smoke, which is so often attendant on the introduction of valves into chimneys; and I have never found in the winter time (whether with a fire burning in the room or not) that the temperature has been unduly affected by the incoming cold fresh air. The closets should be against an external wall and entered through lobbies, both being thoroughly and permanently ventilated by the windows. The foregoing is a simple, inexpensive, and efficient method of ventilation without draughts, possessing no complicated contrivances; and it should always be borne in mind that any ventilation dependent upon artificial and mechanical means for its action cannot be reliable owing to the possibility of its getting out of order.

2*nd. Water Supply.*—The manifold uses of water are so universally known and appreciated that it is almost unnecessary to speak of the incalculable benefit it is to mankind. The question now under consideration is the best source from which to derive a sufficient supply. Mr. Bailey Denton, in his admirable work on Sanitary Engineering, says: 'I hold the opinion that in fact there exists no more certain source of a pure and sufficient supply than that of properly collected and properly filtered rain water which is, with care, to be secured by all persons alike. There is no cleaner surface from which to collect rain than that of roofs formed of slates and the harder description of tiles, if pains are taken to prevent the growth of vegetation, the collection of decaying leaves, and the deposit of the excrement of birds.' Most houses have a wing at the back usually containing a scullery, &c., with small bedroom over, and the roof of this portion is nearly always a little lower than that of the main building. On the walls of this part, which should be constructed of strength, should be fixed two galvanised iron cisterns capable of holding 500 gallons each, and immediately adjoining these, and connected with them by means of stop cocks, a smaller one should be placed so as to form a catch-pit into which the whole of the water collected from the roof should be led. In this catch-pit should be placed some coarse sand and fine gravel through which the water would have to pass previous to entering the two cisterns. This would clear it from any suspended impurities it might have collected from the roof or air in the shape of dirt, soot, decayed leaves, or excreta of birds. Suitable overflow pipes should be fixed to each of the cisterns, which could be easily and separately emptied for cleaning by means of the stop cocks and two draw-off taps, the whole being covered with the wing roof and properly ventilated. The advantages of this arrangement for storage at once make themselves apparent. By adopting this method the expense of conducting the water by means of pipes from the roof to an underground tank is avoided, as well as a pump and the attendant labour of pumping it up again. The utility also which it possesses, on account of the pressure derived from its elevation, renders it important in case of fire. The cost of a perfectly watertight underground tank to hold 1,000 gallons properly constructed with brickwork or concrete, and rendered in cement, with a suitable catch-pit and the necessary inlet and overflow drains, would be £11 10*s*, and the cost of the cisterns above mentioned would be about 30*s*. more, whilst the superior ventilation and access of the latter, in addition to the increased facilities for cleaning strongly recommend it, and the slight additional cost is more than counterbalanced through the saving effected by dispensing with the conductor pipes and pumps. Assuming the area of the house to be 1,000 square feet, and the mean annual rainfall to be 35 inches (and during the recent dull, wet, and cloudy seasons this amount is somewhat under rather than over the mark), the mean daily yield of water derived from the rainfall descending on such a surface (as calculated by Mr. H. Sowerby Wallis), after allowing 15 per cent. for evaporation, would be 42·4 gallons. The quantity of water used by persons in rural districts, as estimated by Mr. Bailey Denton, does not amount to four gallons per head per diem for drinking, cooking, personal ablutions, washing the cooking utensils and the clothes we wear; whilst the additional supply for household purposes, if the rules of cleanliness are duly observed, including that used in W.C's., washing floors, &c., does not bring the total amount up to eight gallons per head, and my own experience for the last four years (with rain-water supply) is that seven-and-a-half gallons per head per diem, where five persons occupy a dwelling, is an abundant supply for a house of a similar description to the one now under consideration. Soft water is, in every respect much superior to hard for cooking and household purposes, and when properly filtered is equally pure and wholesome, and in many instances more so, than that supplied from wells or by Water Companies. From the foregoing calculations it will be seen that an ample supply of water would be provided by means of the rainfall for the use of five persons. The water used for dietetic purposes should be drawn from a self-supplying oxydising filter supplied from the cisterns. The advantage of this filter is that it is self-supplying, whereas if the water had to be carried in many cases, it would probably not be attended to and the water would not be filtered at all. The water for household purposes should be drawn direct from the cisterns by means of a tap, whilst that used for the W.C's should be supplied through water waste preventing cisterns.

3rd. Drainage, &c.—Having thus arranged for the ventilation and water supply, we must now proceed to consider the closet arrangements, together with the drains and sewage disposal of our house. Commencing with the closets, long experience proves that those for water are undoubtedly the best. Two of them should be fixed, each on different floors, one directly under the other. The description of apparatus that I should decidedly give the preference to would be the trapless ones, several good specimens of which are now in the market, though, by the way, is it not rather paradoxical for certain makers to advertise *trapless* closets having *trapped* overflows? The overflow from the pan should be carried through the wall to empty on a grating outside, instead of being trapped into the soil pipe, although, by using the water-waste preventing cisterns, overflows are almost unnecessary. The old pan closets, with their iron containers, are highly objectionable, and always to be avoided; and even closets having a hinged valve at the bottom of the earthenware pan are far from reliable. I have found from experience, that in one or two instances this valve closet is liable to frequent stoppage (though this might in a great measure be obviated by a larger passage-way through a lower trap); in fact, they barely let clean water away fast enough; and if the user should happen to let the handle go down by itself, the valve not only catches and throws up a portion of the water in the trap, but hits back the incoming flush in a manner that is anything but pleasant, whilst the slightest obstruction between the valve and the pan lets out the after flush. It is a well-known fact that the water seal of a trap is useless when there is any great pressure of sewer gas, which generally manages to force its way through; whereas the solid seal of the plug in the trapless apparatus effectually prevents the passage of any noxious effluvia, and the flush of water is considerably more powerful and direct when there is no tortuous passage through traps. The contents of the closet should pass through a suitable bend, having a good fall, direct into a 4″ galvanised iron soil pipe, which should be fixed outside the external wall, and continued up as a ventilator, with perfectly air-tight joints, and terminate above the eaves of the roof with an open conical covering. Excreta appears to have a natural affection for lead, and adheres to it with wonderful tenacity. I have seen 4″ soil pipes of lead which, when new, were as clean and smooth as the interior of a telescope, and fixed vertically, fairly choked and stopped up in two years, whereas some pipes of galvanised iron, under similar conditions, were not nearly so foul. The soil pipe should be connected direct with the drain by means of an easy bend, so as to form one continuous flue from the cesspool to the roof of the house. This flue serving the double purpose of ventilating the cesspool and draining the W.C.'s, no disconnection or break whatever should be formed, neither should there be any trap fixed at the foot of the soil pipe, this latter frequently causing greater evils than those it professes to cure. By this arrangement traps are entirely dispensed with, the trapless W.C., as previously stated, effectually preventing the entrance of any sewer gas. This drain should be formed of 4′ glazed stoneware pipes of best quality, perfectly shaped and glazed, put together with a luting of clay, and securely jointed into the sockets with cement; it should also be bedded in and covered over with concrete, and made absolutely watertight, being laid to a fall of one in fifty, in a straight line from the cesspool to the foot of the soil pipe, at which point access could be obtained from a lidded or inspection pipe, thus greatly facilitating cleaning the drain in case of a stoppage. Adjacent to the soil pipe, and in a suitable position, should be fixed one of Field's self-acting flush tanks, over the grating of which should empty the wastes from the sink and the overflows from the cisterns and W.C. pans, their ends being provided with light hinged brass flaps, thus entirely preventing the entrance of any noxious gases that might possibly arise. The tank, being provided with a proper ventilating pipe, should have its outlet connected into the sewer. The important advantages derived from the intermittent discharge of Mr. Field's admirable invention for flushing drains, and preventing them getting choked or silted up, are so well known and appreciated to need no comment at my hands. The cesspool being constructed to hold 2,000 gallons, and made absolutely watertight, should be placed as far as possible away from the house, and should also be a double one, having an iron grating or drainer fixed in the division wall, so that the solid matter would be retained in the first compartment. This could be taken out once a year, and after being mixed with ashes, utilised for manuring the kitchen garden, and would form a particularly excellent dressing for stiff clayey soils, whilst the contents of the second compartment, which would be of a comparatively liquid nature, could be drawn up through a liquid manure-pump, and used over the ground for the trees and vegetables, &c., as required. The cesspool should be fenced round, and both compartments ventilated by means of open gratings in the stone covers, at their respective tops, through double trays of charcoal, as well as an air pipe connecting the two, and the soil drain already referred to. Isolated as the dwelling is from any system of sewers, and taking all things into consideration respecting the house and its surrounding ground, the utilisation of the sewage, in conjunction with the contents of the ash-pit, is undoubtedly in all respects the most advantageous method of disposal. It may probably be noticed that in this paper there is no mention made of surface water. Rain falling otherwise than on the roof would be caught and retained by the ground, it being noticeable that country houses seldom having any paving or other impermeable surfaces around them, but generally grass or garden ground instead, require no provision for carrying off the surface water, which is absorbed by the natural soil. Referring once more to the subject of ventilation, the reception rooms and offices of well-planned houses can generally be efficiently ventilated by a judicious arrangement of the doors and windows. But the thought of an open door or window in the bedroom appears to cause such an universal shudder, that it would be beneficial to have this apartment ventilated by the means previously proposed, more especially if we take into consideration the length of time it is occupied. It is desirable, under some circumstances in the winter time, to have the incoming current of fresh air warmed previous to entering the apartment; this can be done with heated pipes, though the admirable stove, invented by Captain Galton, and which bears his name, effectually accomplishes this. Ventilation is, however, an elastic subject, and must of necessity be governed in a great measure by its surrounding conditions.

In concluding this paper, a word respecting the present rage for patent sanitary appliances may not be out of place. This seems ever increasing, and the competition is now remarkably keen between the numerous manufacturers, some of whom pirate and adopt each other's ideas and inventions in the most serene manner; and it is surprising to see the trivial, and in some instances almost silly, things for which patents are taken out. True, there are some really good and useful inventions in the market, but the majority consist of imitations and slightly altered adaptations, some utterly worthless. The public are induced to purchase through the puff and plausible, but apocryphal, statements contained in many of the circulars and advertisements of these contrivances for house sanitation, so-called sanitary appliances, frequently unsightly, and seldom attaining their professed ends. A good and useful invention is sure to have a host of imitators, who alter and modify (and sometimes do actually improve upon it), so that although the principle remains the same, the component parts differ so greatly that it is hardly recognisable, and the result is so and so's *improved registered*. It is impossible, however, in sanitation to lay down a hard and fast law that applies to all places alike, circumstances so alter cases, that what would be considered most suitable and proper arrangements for one dwelling might be ill-adapted for another. The different points must be carefully considered, and their advantages determined and utilised by the engineer, according to their suitability to meet the requirements for the maintenance of health.

GEORGE ARTHUR FOSTER.

Mr. S. JONES (Sheriff of Exeter) eulogised the distinguished services of Mr. Rawlinson, and proposed a vote of thanks to him for his presidency over the Section.

Mr. BODLEY seconded the motion, and it was carried by acclamation.

The PRESIDENT returned thanks. It had given him great pleasure to visit Exeter, in which he should take some interest, for his mother was a Devonshire woman, married from Exeter.

The Sewerage of Memphis (Illustrated).

This paper, which was read in the Engineering Section by Mr. Rogers Field, B.A., C.E., will be found at page 291, *et seq.*

The proceedings of the Section then closed.

Dr. RICHARDSON then read his lecture on 'Woman as a Sanitary Reformer' (see pages 183 to 202), and was frequently applauded.

On the conclusion of the lecture, a vote of thanks was proposed by the BISHOP of EXETER. He had listened to the lecture with great attention, and he trusted that it would receive the consideration it deserved. It struck him that women were particularly fitted to take part in what the lecturer had called upon them to perform, for they had eyes, in nine cases out of ten, where men had not; and noses in nine cases out of ten where men had not. Women, as they knew, were often led at once to a point at which a man only arrived after careful investigation. Was it not the plague of a man's life that woman not only claimed to be right, but very often was right? They did not know how it happened, but it was a most provoking fact. He took it that the lecturer did not mean that before they commenced anything in the direction indicated they should study all he laid down, but that they should make use of, and cultivate, the knowledge they possessed.

Professor DE CHAUMONT seconded the motion, which was carried by acclamation.

A vote of thanks to the Mayor concluded the proceedings.

LECTURE TO THE CONGRESS.