GENERAL CONGRESS OF HYGIENE AT BRUSSELS.

FIRST MEETING, SEPT. 20, 1852.

ADDRESS OF MR. F. O. WARD.

‘Gentlemen,—Before we separate, I beg permission to bring before you very briefly the chief point of the new sanitary system—the system of circulation as opposed to stagnation—which we are here, my honourable friend Lord Ebrington and myself, to submit to your consideration. I shall not be able to treat the whole of the subject in one discourse, nor even in the sub-sections of the four sections in which we carry on our deliberations, and of which I have been obliged, according to rule, to choose one part to the exclusion of the three others. I beg you, therefore, to accord me your attention for a short time. (From all parts: ‘Speak, speak.’)

Gentlemen, this new system upsets many old ideas, in order to replace them by principles which, taken all together, constitute an entirely new combination.

Thus, for instance, this system, of which the fundamental basis is the incessant circulation of the water, which enters a town in a state of purity, and the equally continuous motion of the fouled water which leaves the house and the town, admits neither cisterns nor cesspools, which are, as before stated, two congenital forms of pestilential stagnation.

Furthermore, this system, which has for its object not only the carrying away of the fertilising matter which hitherto has been allowed to remain for a longer or shorter period in the midst of human habitations, but also the application of this matter to the use of agriculture, and its transformation from a source of disease and expense into one of riches and nourishment. This system, I say, does not allow (unless provisionally) the discharge of excrement into rivers—a process which we regard as deplorable waste.

To prevent this waste, and to replace it by fruitful circulation, we

connect towns and country by means of an immense tubular organisation consisting of two divisions, the one the urban drainage, the other the rural distribution; and these two divisions are again subdivided into two distinct parts, the one arterial, the other venous.

Thus, we construct in a town two systems of pipes, the one bringing in pure water, the other carrying off this water enriched by fertilising matter.

In like manner, too, we lay down two systems of pipes in country places, the one for irrigation, which takes the fertilising fluid to the crops, the other for drainage, which carries off the water after it has filtered through the soil, and which, if allowed to remain any length of time, would make the land marshy.

In the middle of these four systems of pipes we place a motive organ—a central heart so to say—in one word, a steam engine, which sets the whole system in motion.

Thus, at last we see the sanitary movement and the agricultural movement, after having long pursued their development in separate though parallel paths, meeting and blending in one great movement. It is from this union that has resulted the vast tubular organisation of which I have just described the broad outline, which is new, and of which I am about to point out to you some of the principal details, which are equally new.

And first, gentlemen, let me give you a few rapid hints on the difficult question of the source and of the collection of the water, the fluid which is to circulate in these arteries and veins—the blood of this immense organism.

Our system does not admit as suitable sources the rivers from which the water of towns is usually supplied, nor even the subterranean springs which feed our wells.

According to our experience river water is always more or less impregnated with organic and mineral impurities taken up from the fields which it washes, and the towns and villages through which it passes.

The water of subterranean springs holds likewise in solution particles of all the soluble minerals which it meets with on its way through the ground.

We leave, therefore, the beds of valleys and the bottoms of wells, to seek near the summit of hills pure water which has been distilled by the sun, and has descended afterwards in the form of rain, either on the primitive rock, or on its gravelly débris. When the rock fails to supply our wants, we go to sterile regions—to heath lands, where we know that we shall find pure water, our *liquid* food, precisely

because not containing soluble salts they are incapable of providing corn and meat, our *solid* food.

There, in the silicious gravel which has been washed and purified by centuries of rain, we lay down tubes of burnt clay, or large channels of permeable bricks or tiles, most commonly three, four, or five feet below the surface (according to the conditions of the strata), and these pipes collect rain-water which has attained its highest point of purity by filtration through the upper stratum, generally pure sand.

Just as an aqueduct represents an artificial river, so these tubes may be regarded as artificial sources—a rural prolongation of the aqueduct, accomplishing for the collection of water what the urban prolongation has long since done for its distribution. We might call it the capillary system which brings water to each house.

I come now to the second part of our metropolitan system—viz. the carrying off of this water with the excreta with which it may be charged, a process which, in our opinion, requires equally bold innovations. We abstain from the great and costly Roman constructions, nowadays so much vaunted by old engineers for metropolitan tunnel sewers. We do not admire these vast subterranean galleries, which with their slow current and their putrid accumulations are nothing more than extended cesspools. We would replace these semi-stagnant large conduits by small earthenware tubular pipes, concentrating the smallest flows, so as to carry away all the matter removable by water-carriage as soon as it is produced, at sufficient velocities, usually two or three miles an hour, thus removing it from the town where it would become pestilential, into the country, where, properly applied, it is of the highest efficacy in production.

We would have no more emptying of cesspools and cleaning out of drains by human labour. We would suppress for ever such degrading occupations, and where the levels and gravitation fail we look to steam to supply the inclinations and velocities.

Is it not indeed evident that steam power, which will lift a ton of water to a height of a hundred feet for less than a pennyworth of fuel, can replace human labour as economically in the clearing out of drains as it has already done in weaving and other industrial processes?

Let us now cast a rapid glance at the agricultural part of our system. The same reformation is called for here, on the same principle—circulation; by the same means—steam-power; with the same results—economy and health. Manure, henceforth no longer toilsomely distributed by the hard labour of men and horses, will be driven in a liquid state either through iron or earthen pipes, or led

to flow by a prepared surface irrigation made of cast-iron, where gutters dug for the purpose cannot be used, and it may in some cases emerge through a flexible pipe and fall on the ground like artificial rain. By this means a man and a boy would be able to water no less than twenty acres a day. So much for the first part—the *arterial* division of the agricultural system.

With regard to the second part of the process—the final carrying off of the water by drainage—here, too, in default of natural gravitation, steam power now comes to our aid. For just as steam-pumps dry up marshes at an annual cost of four or five francs per 100 acres, so at an equally small cost will they carry off the superabundant water, which, after having deposited its manurial matter in the soil, filters into our drains. These drains then conduct it, purified by filtration, to the rivers, where it finally discharges itself in as clear and sparkling a state as when delivered from the hill-top.

Thus in the country, as well as in towns, we are easily able with the help of steam to master the difficulty which has hitherto been such a formidable obstacle both to the sanitary and the agricultural engineer—viz., the absence of slope to assist the running off of water.

And do not, gentlemen, allow yourselves to be alarmed by the expense of establishing this new system, which may be called hygiene by steam power. The service of pure water in towns can be organised for a sum represented (all expenses included) by a payment of 2*d.* a week from each house; and the construction of tubular drains with the steam-engine and all accessories, would be covered by about the same weekly expense. Tubular organisation in the country is even cheaper than in towns. It costs no more than 5*l.* to 8*l.* per acre for the system of irrigation, and 8*l.* to 10*l.* per acre for the system of drainage. I shall, I hope, have an opportunity of proving to you in detail that the new system may be organised at an absolutely less cost than the old one, while at the same time it is more productive. I shall, for instance, demonstrate to you that the mere proceeds of the sale of our discarded pumps and cisterns would not only pay for the machinery of the new system of distribution of water in our towns, but that we should remain with a surplus in hand—a direct and immediate benefit of the innovation.

But, gentlemen, if this were not the case, if the costs of this new system were very great instead of being very small, the diminution of the costs of maintenance in towns, and still more the enormous increase in the products of the country, would very soon reimburse us for our first outlay.

In one of the farms already worked on this principle in England,

the annual yield of hay has already risen from twelve stacks, which it amounted to in 1848, to eighty stacks.

In another case, in Scotland, a barren tract of sand which was formerly valueless has produced, since the application of steam irrigation, 20*l.* per acre annually.

I have thus no hesitation in saying that steam-power, after having quadrupled our means of transporting products from one place to another, will eventually, by the new application which we propose to make of it, quadruple the produce of the matter transported. *Hygiene by steam power* is thus both the logical extension and the necessary complement of the system of *locomotion by steam power* which Europe has lately adopted.

The scheme we are proposing is in fact nothing more than an adaptation of the great invention of Watt, to bring about in our domiciliary and agricultural arrangements the same happy and astounding transformation as it has already effected in nearly all the other branches of industrial art.

Such, gentlemen, is in general terms a description of our new system, each part of which rests on positive facts—facts, I may add, acquired by long and costly experience.

The water which falls on the hills in a state of purity, undergoes a natural process of filtration through sand, enters the rural collecting-pipes, and passing through the aqueduct to the metropolitan distribution pipes, finds its way to every storey of every house in the town; whence again, after having supplied the wants of the inhabitants, it runs off, enriched with fertilising matter, which it carries away before allowing it time to ferment. This manure, driven along irrigation pipes, is deposited in the soil, leaving the water to pass into drainage pipes, and flow on to the rivers. The rivers conduct it to the ocean, whence it rises as vapour under the heat of the sun, to re-descend as rain on the hills, enter again the collection pipes, and recommence its vast and useful course of circulation.

We hope by more detailed explanations in section to induce you to study this system seriously, and, after a thorough investigation, to adopt its fundamental principle—circulation instead of stagnation."

SUBSEQUENT PROGRESS OF THE PRINCIPLE OF CIRCULATION.

In a number of provincial towns, where works have been conducted on the principles promulgated by our first general Board of Health, the principles set forth on the arterial and venous system have been carried out more or less perfectly, but so far as completely to establish

the principle :—as, for instance, in Croydon, Bedford, Cheltenham, and Leamington, amongst others. In these towns the fresh water is carried into all the houses ;—the fouled water, with putrescent matter, carried out from them through self-cleansing drains and self-cleansing sewers, and that fouled water, or the water containing liquefied manure, is carried direct on to the land. In most of them, the whole excreta of the morning is removed within an hour or two, and by the afternoon is deposited on the land, not in mechanical suspension, but in chemical combination. The most complete study of the principle was given by M. Holbrecht, and the German engineers, and it is in the course of application for Berlin. In the provincial towns in England where it has been the least incompletely carried out, the reductions of the death-rates have been from one-fourth to one-third of the previous rates, with as yet few, if any, of the collateral aids which sanitary science may yet make available, as the prevention of over-crowding as in common lodgings, and better warming and ventilating schools, medical inspection of the scholars, and systematic appliances for personal and household cleanliness.

Water and Stagnation.

I beg now to repeat for the sake of connection that, as will be seen in our reports at the time when the system was first propounded, the rural population, whether living in detached cottages or in villages, were, as they are mostly now, generally supplied by well water. Unless the surface of the wells be deep, such water, by stagnation, imbibes floating particles of vegetable or animal matter, and is deteriorated by stagnation. It is also rendered additionally impure by soakage from cesspits or from house-drains. It is seldom wholesome, and often dangerous to drink. The population either drink tea, which makes the water safe by boiling, or they drink beer. It is rare for any collection of rain-water to be made. For large towns, the practice of engineers has been to collect supplies from the nearest river sources. These, like the greater part of the supplies of London, are more or less polluted, by the surface-washings of lands, often of highly cultivated lands heavily manured with putrid manure, and also by the sewage from ill-drained houses. In some instances the supplies are derived not from rivers but from lakes, and obtained from the surface washings of uncultivated uplands, from granite, slate, or sandstone grit. In these instances there is less of impurity from these than from river sources ; the chief impurities being in winter time from infusions of peat, which is apt to produce dyspepsia and diarrhoea.

The Aëration of Water.

But the aëration of water as affected by stagnation has not yet been taken into proper account, or completely examined specially as affecting the potability of water.

Failure of Common Artificial Filtration.

The supplies taken from rivers might be very well aërated, particularly that derived from spring sources; but it is taken into subsidence or storage reservoirs, where it is detained in a stagnant condition, and to a considerable extent de-aërated by stagnation. Algæ and other aquatic vegetation are rapidly developed, and almost as rapidly die and animalcules appear; and if the stagnation is prolonged in open reservoirs, putrefaction of vegetable and animal matter, and marsh miasmata, arise. The next stage is removal to filtration-reservoirs, which removes most of the solid matters which the subsiding reservoirs may have generated or absorbed. Thence the water is carried to the towns, where, under the intermittent systems of supply, it is again kept in a condition of stagnation in cisterns, and absorbs the air, whatever may be its quality, surrounding the cistern. The first filtration by large reservoirs, a first sieving, does not usually dispense with a second filtration:—that is to say, a second or final sieving is given. For a few days, a charcoal filter may be a little more than a sieve, but unless frequently renewed, it will be no more than a sieve. The water, by repeated filtrations, is rendered perfectly transparent, and being so, is commonly received as pure, but the microscope now detects animalcules of species denoting impurity, and demonstrates that clarification and purification are widely different.

But for the great mass of the population there is no second filtration. For those in the metropolis, and throughout the country where the supplies are intermittent, there is stagnation in butts and cisterns, and situated as these cisterns are in close courts or alleys, sometimes directly over cesspools, or having overflow pipes into sewers which are sewers of deposit or extended cesspools, they rapidly absorb the noxious gases of decomposition, and the purest of the supplies from spring sources become dangerous to drink at certain seasons. It may be said that in drinking water taken, if it be, direct from mountain springs, the taste is refreshing, for the people are drinking mountain air;—taken from mountain sources, after stagnation in cisterns in middle-class dwellings in town, the taste is

flat, for they are drinking town air ;—taken after stagnation in butts, in close courts and habitations, near to cesspools, it is mawkish or nauseous, for they are drinking cesspool air. From the conditions in which the majority of the population in towns are placed, the de-aërated or the mal-aërated water is not habitually drunk by them, but only tea or beer.

The great remedy is the avoidance of stagnation at every stage, by taking the water direct from its source, and, wherever it is practicable, by taking it from a natural or an artificial spring source.

Natural Filtration.

The conception of the proper artificial spring sources naturally occurred to me in the study of the drainage, by permeable tile drains, of lands surcharged with moisture.

To the extent of their depth, wells may be regarded as vertical earth filters ; but the permeable land drains may be considered as longer *horizontal* earth filters. They may be regarded as filters some hundred yards long, as against the well filter of two or three yards deep. The vertical filter is uncovered, and exposed to light and accidental pollution, but the horizontal filter is covered, and protected for its whole length. Where the horizontal filter can be carried through a pure sand, with only a light amount of vegetation and without cultivation, the water derived is even purer than rain water, as the filter takes out any floating spores or particles that the rain imbibes. These are effectually removed in passing through the filter of a yard or so in thickness and the roots of the vegetation which may permeate the stratum. Water so collected, having had the best of filtration, through long surfaces, needs no second filtration, and is highly aërated, and, collected at once and delivered direct into the houses as it may be, it is cool and refreshing, often effervescent, and equal to the spring water obtained from the best springs at any of the health resorts. We proposed, as stated, an improved supply of water on this principle for the metropolis from the Surrey sands, from which it was evident that a supply amply sufficient was available for the then population of the metropolis. The engineers of two of the companies have recently struck upon this method of collection,—Mr. Taylor, of the Lambeth Company, and Mr. Fraser, of the Grand Junction Company, and though it has been from inferior strata, yielding only a harder water, the water derived is deemed the purest of any yet obtained in the metropolis. It is stated to be so remarkably pure, so far as the works have yet been carried, as to need neither primary nor secondary fil-

tration, and has the most complete aëration for direct distribution. The method of collection has been applied with success for Brussels, and by long conduits (open for economy there) through sand strata for Amsterdam, by Mr. Quick. It is also successfully applied for Dresden, and is in the course of application by the engineer, Holbrecht, of Berlin, who is following closely our principle as devised for the metropolis. Of course, the mineral quality of the water derived from this method of collection will vary with the strata; and that derived from some of the sands is hard. But the constants of the principle are complete and final filtration and good aëration, and superior potability. Of late, the method of softening waters, whether on a large or a small scale, has been greatly improved. It was stated by M. Jager, at the Congress on Hygiene, that during the last attack of cholera in 1866, different results were found to attend different supplies of water:—well water, river water, and other water. During the epidemic, the authorities of Rotterdam changed the supplies to a purer source, with an immediate reduction of the deaths by one-half, and while the deaths in the districts supplied by well waters were at the rate of 16·8 per 1,000, and of the river waters 11·9 per 1,000, the death-rate at Amsterdam, supplied from the horizontal, sand-filtered collection, was the lowest of any, being only 4 per 1,000—a comparative result which, from what I saw of the works, I should expect from them.

Steam Power.

Generally, and with the exception of high, upland sources, which afford the force of gravitation, steam power is, as stated, the heart working the arteries as well as the veins of the system. The cost of the power may be exemplified in the instance of the British metropolis. Water is, in one instance, collected from springs forty miles distant; in another it is conveyed after filtration, through pipes, from sources more than twenty miles distant; and a constant supply, at high pressure, is given in each instance, that will carry thirty-two gallons per head to the tops of the highest apartments, for a rate of three-fourths of a farthing per head.

Now, even at that rate of charge,—which is the subject of contestation in Parliament as excessive,—it is so cheap as to make it dear and wasteful for the poorest housewife to go down from the top of any house to the bottom to pump water at the basement (even if the water were to be had gratis) and carry up sixteen pailfuls to the top. Indeed, if the supplies were delivered only at the basement, the cost of carrying them to the upper rooms would evidently exceed all

the rates, i.e. the three-fourths of a farthing per head now paid for it, or even the full farthing per head, for which the companies are now in effect contending. Nevertheless, if the measure of the first General Board of Health had been carried, as I believe it will yet have to be, the service per diem would have been actually rendered for half a farthing per head in principle. Supposing the pitcher of a Rebecca to hold two gallons or 22 lbs. of water, a labour equivalent to that of sixteen of her journeys to a distant spring, would be rendered for half a farthing (by some millions of capital invested in machinery). To aid the conception of the economy of labour by this power, it may be stated that one hundred-horse Cornish engine working one hour per day would do the work of 50,000 Rebeccas.

Fire Extinction.

It is to be noted that a part of the service of the constant supply as proposed in our report on the supply of water to the metropolis, was for having hydrants, to which a hose might be attached, for a key to be given to the person who might in a minute or two attach a hose to it, and on perceiving a fire in any house, bring to bear upon it for its extinction jets equal in force to one or two horse-power. By the subsequent adoption at Liverpool, Manchester, and Glasgow of this measure then suggested, the large manual or steam-engine power, which has to be fetched from distances whilst the fire is raging, is dispensed with, except in some three per cent. of cases; and the losses of life and fire, and the insurance risks are reduced to one-third of those prevalent in the metropolis, whilst the expenses of the administration for the inferior result are reduced by one-half. Since this measure was proposed, electricity has been employed to speed information and relief. In the provincial cities, when a fire was getting ahead, and additional force of water by jets was needed, information had to be sent, by foot or horse messenger, to the distant pumping station, to put the engines at high pressure. But now the information is communicated instantaneously by the telegraph, and in a minute the force of the steam power at miles of distance will be felt on the spot where it is needed. By the unification of the works of the companies in the metropolis on a public footing, the force of the whole of fifteen thousand of horse-power may be made to converge from the extreme points of the metropolis to stay any threatened devastation by fire in any particular quarter where it may arise.

That the most important apparatus—the smaller apparatus for fire extinction, may be constantly ready without fail, it must, we consi-

dered, be kept in constant use, and it was proposed that it should be in constant use for street cleansing by the jet, which would cleanse completely and quickly at half the expense of the imperfect cleansing by the broom. Paris, Vienna, and Madrid even, are in advance of our metropolis, by the adoption of this mode of cleansing.

Present partial and fragmentary conceptions of the system commonly prevalent.

It will be found on examining the public discussions and proceedings in relation to the supply of water to the metropolis, that no general conception of any system, such as that hereinbefore propounded for its sanitation, has yet been attained. Fragments of it only are adopted, each very incompletely, and important parts are disregarded. The only part of the arterial and venous system which has gained a place in the common conception in the metropolis, is that of bringing the water to the doors of the houses in bulk under a responsible public authority. But what that authority shall be is imperfectly conceived or enunciated on political platforms. The comparative eligibility of different qualities of water for the supply of the metropolis, whether hard chalk water or such soft water supplies as those of Manchester and Glasgow, with infusions of peat during part of the year, are, as yet, unconsidered or disregarded by the representative authorities undertaking to deal with the subject. Nor is any account taken by them of the work of fire-prevention, as an addition to the service of the police force of ten thousand men, nor how the service of that force is to be combined or brought to bear in the metropolis as in provincial cities; nor what alteration of the service of cleansing sixteen hundred miles of street surface is required. Even on the preliminary questions of financial economy and the terms of purchase, there commonly prevails the greatest confusion of opinion, and that in the face of settled but utterly disregarded practice and principle. Moreover, no consideration has yet been taken of how, when the supplies of water are got to the door, they shall be got into the houses. Whilst mechanical, chemical, and engineering science have made the advance stated, their application is delayed for an advance of legislative science and administration for the protection of the health of the population. It is true that the political obstructions have not been confined to this country. The most serious obstruction to be apprehended is the intrusion into sanitary work of the element of political party spirit, which is more intent on showing

the opposite party to have been wrong than of doing for the many what has been proved to be right. Impartial specialists are clearly of opinion that the politician has thrown back the progress of sanitary reform, including the principle of circulation, by a quarter of a century in this country. The like influences have been baleful abroad. From our Board we sent over to Paris to ascertain how the system of fixed fosses, with removal of their contents by cart, worked there. We found Paris stinking worse than London, and very heavily death-rated. The potent barrier to the introduction of the principle of circulation by water carriage was, in the view of the political officer, the interest of a large and troublesome body of men, the *porteurs d'eau*, who might raise an *émeute*—though it would be cheap to give them all retiring pensions. Besides these there stood in the way the large contractors for the *vidange*, the emptiers of the fixed fosses or the tanks in which such matter is detained in conditions of putrefaction, whom it would have been a large gain to the public to have paid off at the full profit of their contract.

The exposition of the arterial and venous system there was futile, and Paris yet stinks from the stagnation of putrefactive matter, though the sanitary officers are clear and hopeful about the adoption of the principle. A recent report to the State Board of Health at Boston indicates the obstruction to sanitary improvements from work in the cities being regarded as a reward for political services; and of course the more expensive the work, nay, usually the more ineffective, the greater the reward. Contract work is the most economical and eligible, 'if such work could be divorced from politics,' says the able assistant engineer in charge of improved sewerage for Boston; but as that may not be, 'day work' must be put up with. Sir Joseph Whitworth invented a very successful street-sweeping machine, which by the labour of one man and a boy did the work of twenty scavengers; and he conceived that in so enlightened a city as New York, that it was sure to be adopted. But there he was told at once that it would not work, because every machine would displace some eighteen voters. In London, being desirous of promoting the use of hydrants for street cleansing as well as fire prevention, I was ready to urge it, but I was myself warned in one influential district not to speak of the street-cleansing service, because the scavenging interest, which was preponderant at the Board, would probably oppose hydrants altogether.

In respect to the more immediate subject, the development of the system of circulation, it is to be stated that the practice has been in the larger provincial cities, as well as in the metropolis, to leave the

work of carrying in the supplies from the mains at the door into the houses, and that of carrying away the fouled water and the excretory matter removable by water-carriage from the houses—to be done by uninformed tradesmen, plumbers and builders, without any qualification whatever, for a work which requires very special knowledge to execute it successfully. Those tradesmen persistently use lead-pipes, at a double and treble expense, to carry water, which sometimes acts powerfully on lead and seriously affects the health. Then it is conveyed into cisterns, often of lead instead of slate, or into common butts, where it stagnates, and imbibes the gases which make it dangerous to drink. Then they carry the overflow from these cisterns into the drains and sewers generally of deposit, evolving gases of putrefaction which ascend and contaminate the water in the cistern, more frequently with fatal results than are made known by any inquiries. The house services, which should be the capillaries of the system, are badly formed, without proper retaining arrangements, so that a constant supply becomes a source of constant pernicious waste. In London more than three-fifths of the water is pumped to waste. In the common conditions of the apparatus it is constant pernicious waste for a house. The house-drains (commonly) are made for a house of a size that would serve for a large street, and of permeable material, or loosely jointed, so as to detain beneath the foundation what it is intended to remove from it. Hence the sites and subsoils of towns become supersaturated, and the excrement sodden, and malaria is generated. Thus augmented supplies of the purest water are often made the sources of augmented disease. Thus it was shown in a recent inquiry before the Royal Commission into the sanitary condition of Dublin, that the introduction of a new supply of water of the finest quality at its source (except in winter time, when it has an infusion of peat unquestionably causing diarrhoea) was attended by a considerable augmentation of the death-rate, bringing it up to thirty-eight in a thousand, or double that of a healthy urban district. This was accounted for by the supersaturation of the subsoil by this additional water mixing with the matter detained in bad drains.

Prevalent Conditions of Stagnation in Towns.

In Liverpool a reduction of the waste of water is reported to have been attended by a reduction of damp in the lower houses, and by a marked reduction of the disease generated by damp, with an improvement

in the death-rates. London has been water-closeted in a rudimentary way, but the work has been frustrated in great part by bad house-drains and badly constructed sewers. In respect to the construction of sewers, in my sanitary report of 1842 I described them and their connections as the bulb of a retort charged with putrefactive matter, and the house-drain as the neck of the retort, which carried the gaseous products of the putrefaction into the house. That condition still prevails through the greatest part of the metropolis. I would direct particular attention to the terms in which the chief engineer to the Local Government Board, occupying part of the new Government buildings at Whitehall, has described the sanitary condition of that head centre of sanitary administration. He said on a recent occasion: 'He had in his possession a report with regard to the sewers in Whitehall, Downing Street, Great George Street, and Victoria Street. He had felt obliged to make complaints of the closets connected with the new buildings in Whitehall, occupied by the Board of Health, and he declared that there was no new public building in Great Britain in a worse sanitary condition. It appeared from the return to which he had alluded that the sewers were flat-bottomed, flushing was never thought of, and that there was a deposit 15 to 18 inches deep in these sewers. The drains coming from the buildings had flap valves where they entered the sewer; these drains went direct into the buildings without any break, or other means of ventilation, to prevent the inflow of gas. The closet in the corridor leading to his office was occasionally so bad that he could not use it. Sometimes the wind entering from the drain would, he believed, have blown out a lighted candle, and the stench was horrible. Every drain had been tried upon that length of sewer all round Whitehall, and there was not a single instance where the inflow was not direct into the building. If such things were properly attended to the rates of mortality would be very different.' In the other parts of that great building there have been two fevers and two deaths ascribed to sewer poisoning. One officer described to me a disablement of nine months as due to it. A former Secretary of State for the Home Department stated that after long sitting in his office he felt low headaches, symptomatic of air contamination, and he was led to do as much work as he could at home. A former Premier was advised by his physician not to reside in Downing Street, and certainly its condition is detrimental to the official working force there. I can undertake to say of the lower apartments, occupied by the most industrious workers, that if they were lived and slept in, and were crowded as the common dwellings are, the seat of the Government of the Empire would be a fever nest.

The condition of that spot is pregnant with instruction as to the state of information on sanitary legislation and administration there, which is impotent for action, either for the relief of itself or of the general population by self-cleansing drains and self-cleansing sewers.

One attendant on all these defective constructions is their excessive expense, especially as respects the house drainage and sewerage works on the principle of stagnation: for it may be shown that on correct principles three houses and three towns may be well drained, at the cost hitherto incurred for draining one on the principle of stagnation.

The Tub System.

In the widely prevalent ignorance of any other conditions than those of stagnation in house-drains and sewers, the eruption of noxious gases from them is regarded as a constant, and a reaction has been occasioned for the application of the tub system for collection and removal in turns. In rural districts, and for detached cottages away from any system of proper drainage work, I have myself recommended the use of a pail with water under a seat, and the daily removal and application of the liquefied manure for garden culture on land trenched and prepared to receive it there, instead of bringing prepared soil to receive it in the house. The rude tub system of carrying excreta from the house to the land partakes of the expensive converse of the pail system of collecting water from the land, or the distant well to the house. Only consider the labour of sending earth to hundreds of thousands, or in the instance of the metropolis, half a million of houses, and bringing it away *daily*, as would be required by cleanliness and security from disease. In consequence of the excessive expense of carriage on the tub system, the removal of the solid excreta, where it is practised, is only effected at long intervals. At Paris it is retained in fixed fosses, which are emptied about twice a year, by a most offensive process, despite engagements to deodorise the matter. It is little better with all the movable fosses. At Manchester and other cities in England the receptacles were formerly only emptied once a year, and great injury to health was occasioned by the emanations of putridity. It was doubtless an improvement to provide a tub system, at the public expense (which would save the house owners the expense of outlays for a water carriage system), and remove the excreta weekly. But this weekly removal is still attended with pernicious results, for putrefactive decomposition begins in three or four days, often in some weathers in two days, or less, for which reason during the cholera and other epidemic periods we ordered that all excretive, indeed, all

animal and vegetable matter, including the dust heaps, should be removed daily. But with a proper water apparatus the removal is effected instantaneously, and at many times less cost. Persons who have only been aware of the conditions of the bad organism which I have described—conditions of malformation and consequent diseased action of congested house-drains and congested sewers with deleterious effusions, and who know of no other conditions, may be told that in the healthiest sanatoria in the country, where epidemic disease is now entirely banished—namely, well-constructed and well-managed prisons, there is a soil pan in every cell. Provincial experiences are now demonstrative of the conclusions—that on a complete circulating organisation the whole of the excreta of the metropolis, which now remain within it in putrefactive conditions for weeks, months, and sometimes more than a year,—that these conditions of stagnation may be cured completely by the removal of all putrefactive matter by water carriage from beneath the site within the day; that such a capital as Paris might be purified within half a day; and if correct principles are adhered to in its works, Berlin will shortly be purified in still less time.

Distributed Cost of the System of Circulation.

Prejudice against the system is frequently raised by immediate payment of the whole charge for the works being exacted, instead of being duly distributed over a number of years. The experiences to which I have referred of complete provincial works would give the charge of the chief parts of the system of circulation. First for the works and service, and for bringing the supplies of water to the door of the house, one penny per week;—next, for services and works for carrying the water into the house, and for carrying the fouled water out of the house, a penny halfpenny per week;—and for the service of carrying it away from the door of the house, another penny per week; or a halfpenny per diem per house for the whole work of the circulating system, up to the removal of the fouled water from the site of the town. Some of the towns have charged much more for the service of the water supply, and have derived a revenue from it, and jobbing and malversation might in some cases have raised the amounts paid by the ratepayers; but the above would be about the correct general charge to the whole of the population. Since the first works were executed, the cost of labour has been largely augmented, and the total cost ought now, as I am informed, to be doubled, or brought to full one penny per diem per house, or nearly to a farthing

per head of the population per diem if the entire work were to be done *de novo*. For the accomplishment of the propositions which I have first enumerated, and completing the system of circulation, it will sometimes be necessary to organise the steam power for action from several centres.

Relief of Low-lying Land from Stagnation.

Under the Sanitary Commission for inquiring into the means of improving the health of the metropolis, we found much of the low-lying parts of it literally marsh land, and surcharged with moisture, much of it from the upland waste waters and sewage. In the east there was a considerable extent of marsh land, so called, whence attacks of ague were at times distributed amongst the populations of contiguous urban districts. For the relief of these districts I consulted the engineering experiences of the fen districts of Lincolnshire, and there we found that relief was given by steam power applied at different levels, at 'sumps,' to which the drains of each level were made to converge, and by these means the water level was kept down to the depth required for agriculture. In our report we stated that in Lincolnshire the expense of pumping away the surplus rain water averages 2s. 6d. per acre, including all expenses of working with engines not of the most recent and improved construction. Calculating, however, that the expense of pumping the soil or waste water, in addition to the rainfall in London, would occasion a cost even twelve times greater than is incurred in agricultural or fen districts, or 30s. per annum per acre covered with houses; as there are in the lower districts of the metropolis about twenty houses to each acre, and as the operation would extend only over half the metropolitan area, it had been shown that 'the annual charge per house, spread over the whole area, that area including the upper districts which were affected by miasms from the lower districts, would be 9d. per house per annum; but in this instance, as shown in the whole investigation, the outlay and the rate would really lead to a great reduction of the existing charges.' Plans were prepared for the application of this principle, which has not, so far as I am aware, been applied to the relief of any district in England. But an examination of the works substituted for it in London, which there is not time to treat of at present, will show it to be the most eligible for future application. By the converging principle the most rapid falls may be obtained. The converging system, as applied for the relief of the fen districts, is by means of rude ditch drains; tubular drain pipes being originally unknown; but now tubular drain

may be made small, and artificial falls given, and the discharge in any direction accelerated according to requirements, and the circulation thus maintained within basins of land as well as from flats. This is the principle now adopted and in progress of application for the relief of Berlin, which has a very flat area. The sewerage there will, if the house-drainage be well completed, be discharged fresh into the sewers, and the sewage will be discharged in several directions in the best condition for agricultural production, on the land to which it is to be applied, from the 'sumps,' to which the drains carrying fresh undiluted sewage—converge. For detached houses, and villages and public institutions, a valuable improvement has been introduced by Mr. Rogers Field, called the 'flush tank.' This is a receptacle which collects dribbles of sewage, until it rises to a certain height in the tank, when it reaches a syphon mouth, and is discharged with increased force in a sweeping flush. For larger applications of the converging principle, Mr. Isaac Shone has invented a pneumatic apparatus as an ejector, which Colonel Jones, R.E., V.C., assures me is completely successful.

Applications of Unstagnated and Undecomposed Sewage.

By the relief of the land by horizontal spring collection, and the distribution of pure water, direct and well aerated, without any stagnation, into houses; and by the immediate removal of all the fouled water, with all putrescible matter removable in water, without stagnation and before the commencement of putrefaction, the entire systems of stagnation may be held to be superseded, and the system of arterial and venous circulation accomplished.

Completion of the System of Circulation by the Direct Application of the Sewage to the Land.

The obstructions that stand in the way of the completion of the system, by the application of the liquefied manure of towns to agricultural production, still remain to be noticed.

Persons who only know of sewerage by their experience of its emanations, under the common conditions of stagnation and putrefaction, very naturally object to its application in the vicinity of their residences, and would do so with much reason if those conditions were essential. Violent opposition is made to the discharge of sewers into rivers, on the score of pollution. Whilst sewage, however, in the common condition of putrefaction, kills fish, sewage in another condition, that is to say, in circulation—fresh, or before putrefaction—

feeds fish. But on the score of waste I object to its discharge into the rivers, or anywhere except on the land. People do not object to the cultivation of land, as market garden land, close to their dwellings, or to towns. Nevertheless, such culture and high farming are frequently conducted in a manner productive of noxious emanations that are injurious to health, and make the culture there a nuisance. This is done by heavy top dressings of what is called 'town manure,' in the solid form, in which condition it remains stagnating until it is disintegrated by decomposition (by which decomposition its fertilising power is diminished), and it is then carried down into the soil by the rain. The complete remedy of this evil is to liquefy the manure at once—to put it in solution, and apply it to the soil in doses proportioned to the soil's receptivity ;—in fact, to apply it as sewage, by which means one load of stable manure may be made to do the work of more than two. I was advised when I looked into the subject, that the waste of the farmyard manures and other manures, by the methods the farmers used, was in extensive districts equivalent to another rental. On the other hand, it was pointed out in our instructions that applications of plain water in excess, by the method of submersion, creating marsh surfaces and marsh miasma, were often conducive to the rot in sheep and ague in men ; and, of course, that the distribution of sewage in the like manner would be productive of still worse results. At the irrigations at Paris, as I am informed, this danger has been incurred through excessive submersion by the unskilfulness of the small farmers to whom the sewage has been given, and that sewage—not fresh sewage—of a bad quality, as nearly all there is.

The fact should be known that for sanitation it is a work of skill to avoid the supersaturation of the soil ;—for cultivation it is a work of skill to avoid supersaturation, and to adapt the supply of the liquid manure to the 'hygroscopicity' of the soil, and the periods of the growth of the plant for root, or for wood, or for leaf, or for fruit. For the avoidance of stagnation and waste, and the expense of storage tanks, it is a work of skill to place every day's supply from the town on one part of the land or another, whatever be the weather, in frost or snow. In frost this has been accomplished at Dantzic by distribution under the ice. The whole of sewage farming is an art foreign to the common agricultural practice, and is as yet confined to a high order of horticulturists, growers of prize fruit, to whom its application on a large scale should be confided. Nevertheless, in some hundred of sewage farms, now conducted throughout the country by all sorts of rudimentary methods, with bad sewage from ill-drained towns as well as good, and by various rudimentary work-

ings, the superior productive power of the liquefied manure has been established, not only in the bulk, but in the quality of the produce; and as to the bulk, whilst the average yield of agriculture in England may be taken to be as one, and the market-gardening as about three and a half, the sewage-farm produce has been as five. It is found that, as a rule, the sewage of more than a hundred of population may be utilised in an acre. As to the sanitary effect of sewage farming, the judges of the competition for prizes issued by the Royal Agricultural Society, of which Mr. Baldwin Latham, Mr. Clare Sewell Read, and Mr. Thursfield were judges, made particular inquiries about the sanitary results upon those engaged in the work, and they display them in a table of the death-rates. They state that the rate of mortality on an average of the number of years which these farms have been in operation (ten) does not exceed more than three per thousand per annum; that is to say, on a population of 380 men living on or working on the farms, and 137 children. From the difference of working under insanitary conditions amidst stable-dung and farm-yard manures, which are attended with fevers amongst families, and the working amidst liquefied manures, I should have expected a marked difference, but not so great as this, which must be about fourfold.

One obstruction to the application of the liquefied manure of towns has been the supposition that it can only be applied, by gravitation, on land immediately contiguous to the town, for which, as a consequence, consents are either refused, or, it being considered as accommodation land, excessive monopoly prices are exacted. Now on the converging system, and by 'ejectors,' the sewage may be carried all round, uphill, or in any direction of demand, with the addition of the cost of lifting—a cost, *i.e.*, for 80,000 gallons 100 feet high of 1s. which is inconsiderable, if the sewage is in its proper concentrated condition, unencumbered by an excess of rain or storm water, which, on a correct system, ought not to be admitted. A competent administration will utilise the ground allotted to, or contiguous to, public institutions, such as union houses, prisons, and others, and develop models of liquefied manure cultivation.

On the difficulty which presented itself for the completion of the system of circulation by the disposal of town sewage by surface irrigation near towns, particularly in the condition of putridity, in which all sewage was then only to be met with, I was led to consider of subsoil or subterranean irrigation. I got several friends who had gardens to try it, and the trials were very promising. Sir Joseph Paxton promised to try it systematically. But it was tried independently and systematically on a large scale by M. Charpentier, a

French vine grower, near Bordeaux, with whom I had correspondence on the subject. His trials were not with town sewage, but with liquefied manure; and certainly the results he obtained with vines and fruits, as well as with market garden produce, were most satisfactory. He contended for its superiority over surface irrigation, but it required great skill, and more capital than the ordinary surface irrigations. The early successes with surface distributions, however, withdrew my attention from it; but the method has been revived with success by Mr. Rogers Field in the disposal of the sewage of some villages; and his flushing tank greatly facilitates distribution by that subterranean method. It is also reported to have been carried out with success by Colonel Waring, of Newport, in America. I am confident that for high culture, for model gardens near towns, for deep-feeding plants and for fruit trees, for arboriculture generally and in hot climates, the method in skilful hands will be productive of very great results.

I would observe that about two-thirds of the general work of sanitation, in drainage works, is of earth-work on which, in the Continental States, soldiers may be well employed at extra pay.

In conclusion, if the subject be competently and impartially examined, the necessity for stagnation ('which nature abhors') is abolished. It is abolished in the collection and the distribution of water into towns; in the removal of the fouled water from houses and towns, and in its application to agricultural production; and the exposition of it by my deceased friend and ally as an arterial and venous system for the relief of urban populations, is fully justified by adequate experiences, for general application, by specialists. Indeed, it will be found on competent examination that the sanitary results of the complete arterial and venous system of circulation for towns are now so far assured by experiences as to warrant contracts being made for the reduction of common death-rates by one-fourth or by one-third. And with the addition of such collateral measures as Lord Shaftesbury's Act for the regulation of common lodging-houses, the ensuring of purer water supplies and good drainage, the prevention of overcrowding, and measures for the sanitary regulation of schools, and for physical training on the half school-time principle, a reduction of the common death-rate by one half may be made matter of contract. These things may under good administration be done, for all have been done. It should be our care to awaken public opinion so that it may insist that they shall be done.

EDWIN CHADWICK.

A LECTURE was given to the working classes of Exeter in the Victoria Hall on Saturday evening, October 25, 1880, by Dr. Bartlett, F.C.S. The Mayor presided, and there was a fair attendance of the working classes. The lecture was *extempore*, it was listened to with attention, and at its close a vote of thanks was unanimously presented to Dr. Bartlett.