and action, extending to health, and extending, alas! to disease in its deepest foundations. A little aid from books of learned men, of *the* learned man of this branch of knowledge especially,—you know I can only mean Darwin,—would help the scholar much; but the aid she will soon be led to find in the yet higher authority of nature will help her most. She will see the descents from good to good, and even, though fortunately with decreasing ratio, from evil to evil. She will see the conquest of death as a natural conquest over evil, and being now in the groove of nature, she will detect how even she may availingly help nature. One effort here as a Sanitarian would call forth all her powers. She will stand to resist with her full persuasive might that process which I have elsewhere called the intermarriage of disease. She will tell her sisters what that terrible process means. She will tell that diseased heredity, united in marriage, means the continuance of the heredity as certainly as that two and two make four; that madness, consumption, cancer, scrofula, yes, and certain of the contagious diseases too, may be perpetuated from the altar; and that the first responsibilities of parents towards the offspring they expect ought to be, not how to provide for wealth and position over which they have no control, but that preliminary healthy parentage, which is the foundation of health, and without which position and wealth are shadowy legacies indeed. Delicate ground, you may say. I admit the fact. But in a world in which those who study the living and the dead most carefully rarely see a man or woman hereditarily free from disease, even this ground must be entered on by the enlightened scholar. I touch on it here for the best of all reasons, that the subject it includes, affecting deeply the human heart in its sympathies and affections, is one on which the influence of woman the arbitress of the natures that are to be, is all potent for good or for evil.

To know the first principles of animal physics and life; to learn the house and its perfect management; to learn the simpler problems relating to the fatal diseases; to ordain the training of the young; to grasp the elements of the three psycho-physical problems—the human temperaments, the moral contagions with their preventions, and the heredities of disease with their prevention, these, in all respect and earnestness, I set before this Congress as the heads of the educational programme for our modern woman in her sphere of life and duty. Let these studies be hers, and once more may be applied to her the promise of that wisest of men, with whose words I opened this discourse: 'She shall rejoice in time to come. The heart of her husband doth safely trust in her.' And—sun and sum of all hopes, ambitions, happiness!—'Her children shall rise up and call her blessed.'

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

SECTION III.

METEOROLOGY AND GEOLOGY.

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METEOROLOGY AND GEOLOGY.

The President of the Section, SIR ANTONIO BRADY, F.G.S., F.M.S., &c., delivered the following address:—

It is my privilege to address to you a few words, at this the fourth congress of the Sanitary Institute of Great Britain, an institution which, under our enlightened President and the other veterans in sanitary science with whom he is associated, is, I hope and believe, destined to do great things for the improvement of the health and happiness of the people.

The great aim of the Institute is to educate the people to a fuller sense of the necessity of better sanitary arrangements, and, secondly, to train a class of inspectors and artisans capable of superintending and carrying out sanitary works, designed upon the most improved principles of hygiene.

I feel much flattered by the trust reposed in me, of presiding over the deliberations of the section treating of meteorology, geology, and geography, in relation to health, and I could have wished that it had fallen into abler hands; but I must crave your indulgence while I endeavour to place before you some of the general leading facts and experiences upon which we base the generalisations which are the foundations of our science.

I shall venture to alter the order of the three parts of the subject upon which I have been invited to address you, and as geology, or the science treating of the history of the earth, is the basis on which the others rest, I shall place this before meteorology and geography.

These sciences require a due appreciation of the physical conditions of the world in which we live, and the laws which govern the changes to which it is subject, amongst which are climatology, and the arrangement and constant re-arrangement of the materials of which the earth is formed, and the forces and agencies by which these physical changes are affected.

My greatest difficulty in treating of this most interesting subject is its vastness, comprehending, as it does, the whole circle of the sciences, especially astronomy, the noblest of them all.

A few words, therefore, on the general cosmogony of our world may perhaps better enable us to grasp, and, in a measure, comprehend the vast changes continually going on around us, and to perceive how much depends on life and the hand of man in modifying the crust of our globe, and making it a more or less healthful residence for the people who inhabit it.

If modern science teaches us one thing more than other, it is that this world of ours was not created in its present form and condition, but that it has arrived at its present state by slow degrees, and by the agency of forces still in operation, though some of them, perhaps, not with the same intensity as in the earlier periods of the world's history.

By the aid of that most wonderful modern instrument, the spectroscope, we are led to the conclusion that our earth was originally a mass of nebulous, dim, hazy matter, thrown off from the sun, which contained all the elements of which our globe is composed; this matter becoming condensed by the cold of space, first formed a crust, not originally stratified like the rings of an onion, as some have supposed.

This crust, in progress of time, has been crumpled up, and mountains raised by the condensation and consequent contraction of its parts. It has all been greatly modified by the action of the elements, chemical agencies, and various other causes. The materials have been re-arranged and stratified, again and again, by denudation—action of currents in the ocean and rivers on land—so that new combinations of land and water have been continually formed. Both sea and land are constantly encroaching one upon the other, and are in a state of unstable equilibrium and constant change. It has been calculated that but for the forces bringing up fresh lands from the bottom of the ocean, as the abrading influences continually at work destroyed the existing lands, time enough has elapsed, and force enough has been exerted, to have reduced the whole earth to a dead level, which would in that case have been wholly submerged, and there would have been no dry land.

Heat is the principal agency by which these great upheavals have been effected. The volcano and the earthquake are the existing examples of this operation of force, and viewed in this light, instead

of being destructive agencies, they really prove great conservative influences, modifying the other disturbing causes, and preserving the earth in a state fit for animals and plants to inhabit.

To the due proportion of land and water we owe the benign influences of meteorology and the various climates and soils suitable for the production of food for man and beast; but many other subsidiary causes have in all time tended to modify the crust of the earth, animal life being one of the chief. Some of the least of created beings, acting over æons of ages, have been destined in the economy of the universe to alter the nature of the surface of the earth, and even to form continents and islands out of the materials extracted by them from the ocean. Thus the minute confounds the wise, and magnifies the power of the Almighty, who, by such apparently insignificant means, has effected such magnificent results.

Out of many forms of animal life which have contributed to this, I will only allude to two, viz., the Globigerina of the chalk and the coral insect of our eastern tropical seas. By the former our chalk hills were formed. The Globigerina lived and moved and had its being in the primitive ocean. Its shell is so minute that 400,000 would not occupy the space of a cubic inch, yet being showered down by billions during untold ages, formed a deposit at the bottom of the sea, which being by the forces already referred to raised above the waters in progress of time, formed dry land and the base upon which the whole of the rocks of the tertiary and post-tertiary systems, many thousand feet in thickness, were deposited. These, being denuded by the disintegrating and degrading forces before referred to, form our downs in Sussex and other places, and the removed materials, the *débris* of older rocks, made our newer stratified rocks, gravel beds, and deltas, on the surface of which are the alluvial deposits, mineral soils, and vegetable earths forming our agricultural soils.

Of the coral insect, I will only remark that it is still working on a grand scale. Madrepore rocks, which are of analogous origin, altered by heat, are marbles which, when free from impurity, form the statuary marble out of which sprang, under the inspiration of the genius of a Phidias and a Praxiteles, the greatest efforts of art to imitate the human form divine.

Of the Globigerina I wish to add a few words, and I trust I may be excused the digression on account of its marvellous interest.

It will be apparent from the foregoing that our world is an ever-changing scene. Though these changes are effected by slow degrees, they are always tending to a higher and better state, and adapted to a higher order of beings. At first appeared the little eozoon of Sir William

Logan, the oldest form of life as yet recognisable in the rocks; these minute organisms form the mass of the Laurentian limestone in Canada, thousands of square miles in extent and of vast thickness. Then, as the world became fitted for their existence, appeared in due order both in the sea and on the land the various creatures which from time to time have existed. Many forms of life have passed away, and are only known to have ever existed by the testimony of the rocks.

In progress of time there appeared on the earth mosses, then plants and trees, whose seed is in itself; in the air, insects, birds, and flying reptiles; in the sea, zoophytes, annelids, and creeping things, molluscs, and fishes, small and great, with the leviathan also, to take his pastime therein; on the land, soft-bodied molluscs, worms, and creeping things innumerable, the vertebrata, and all the host of them; lastly, man himself, the lord of all, to whom it was given to people the earth and subdue it. He alone, of all creation, was endowed with wisdom and the power to choose between good and evil, and to select the situation for his abode best suited to his health and well-being. He has for his guidance the accumulated experience and wisdom of all men in all ages. If he now neglects the laws of health, and the conditions of sanitary existence, he has only himself to thank for the inevitable consequences.

Whether all the forms of vegetable and animal life, which minister to man's wants and comfort, were the result of separate creations, or the development by evolution from a speck of primitive protoplasm, which chemists tell us is the basis of all living matter, we will not stop to inquire. The votaries of the evolution theory have no real proofs to offer; they admit they cannot show all the links in the chain of evidence; many are wanting, and great are the gaps between them. They show many varieties in species, and claim that, if time enough be granted, all creatures may be accounted for by their theory. But what is time enough? Some important types of life have disappeared, and the only trace we have that they ever existed is the testimony of the rocks in which their remains are found entombed. Indeed, whole districts are formed of their mortal remains; others have existed through many geological eras. What period of geological time would satisfy these evolution philosophers of the nineteenth century? Will the vast period of the world's history, dating from the secondary epoch to the present time? If so, we have direct proof to the contrary. Our eminent philosopher, Dr. W. B. Carpenter, than whom no greater authority on such a subject exists, stated in a recent lecture this impressive fact: that the Globigerina of the chalk sea was still

existing, nay, that its actual lineal descendants still live in our seas it is the Globigerina still, and exists in its primitive simplicity unchanged and undeveloped during millions of ages. It was the last form of life found living in the Arctic Seas, by the naturalists of Sir George Nares' recent Arctic Expedition. Certainly, in this case, at least, no evolution has taken place, and the Globigerina of the chalk still lives amongst us the oldest of our aristocracy—a marvellous example of persistence of form in animal life.

Thus far it will be apparent that the changes described have been effected by causes wholly independent of man, by cosmical and other means, and by laws impressed upon the matter of our globe, when, at the fiat of the Almighty, it was first launched into space.

It will, however, be seen in the sequel that many and vast changes have also been and are still being effected by the hand of man, though not always for the better, nor for his own well-being. Much, very much, depends on his acting in conformity with the laws which govern all things terrestrial, though he sometimes violates them from stupidity, or carelessness, or for temporary gain, or perhaps oftener still without consideration, and pays the penalty for so doing.

Having discussed some of the effects of geological change upon the earth, we will next consider how meteorology causes modification of climate, and so produces a distinct effect on health and disease.

METEOROLOGY.

In this short address we can only deal with general principles, and refer outsiders to the interesting volume of our 'Transactions' at Croydon last year, for it is not my purpose to trespass on the domain of the sanitary engineer or the medical and other professors of hygiene. I must, however, call attention to the recent addresses of our distinguished President, who, in his dream of Salutland, points out most of the means by which a healthy existence may be arrived at, the dream being about healthy houses, pure air, and pure water. Here, too, let me express my admiration of the addresses of Captain Douglas Galton, Dr. de Chaumont, Edwin Chadwick, C.B., Dr. Alfred Carpenter, Mr. Alfred Haviland, M.R.C.S., and others.

We have seen how meteorological influences have assisted geological changes in decomposing rocks and forming soils, &c. Let us now see how far they affect climate, and cause some parts to be healthy and others the reverse.

CLIMATOLOGY.

Solar heat is the prime mover and life-giving influence; it causes winds to blow, which are the great transporting power of the air. By evaporation it raises, in the form of vapour, all the fresh water in the earth to the height of the clouds, and by the winds transports them hither and thither to water the earth, form springs and mighty rivers.

To convert water into vapour or cloud the heat required is rendered latent, and is given out again when the vapour is condensed into water and falls in the form of rain.

How and where this happens is principally due to the distribution of land and water in the various geographical areas, modified by the contour of the land and mountain ranges, and the vegetation and forests on its surface.

Heat is also conveyed from the tropics by ocean currents, and moderates tropical, while tempering arctic climates. For instance, England and Ireland, between the same parallels of latitude as Nova Scotia and part of Greenland, owe their temperate climate to the beneficent influence of the Gulf Stream filling our seas with tepid water, while the prevailing westerly winds, charged with vapour, heated by passing over it, supply our land with fruitful showers, and make Ireland the Emerald Isle of the ocean.

Professor Maury, in his 'Physical Geography of the Sea,' says of the Gulf Stream:—

'There is a river in the ocean. In the severest droughts it never fails, and in the mightiest floods it never overflows. Its banks and its bottom are of cold water, while its current is of warm. The Gulf of Mexico is its fountain, and its mouth is in the Arctic Seas. It is the Gulf Stream. There is in the world no other such majestic flow of waters. Its current is more rapid than the Mississippi or the Amazon, and its volume more than a thousand times greater.'

I have previously reminded you that to convert water into vapour a large amount of heat is rendered latent, which on being condensed into rain gives out the heat so stored up. Captain Maury computes 'that the quantity of heat daily carried off by the Gulf Stream from tropical regions and discharged over the Atlantic is sufficient to raise mountains of iron from zero to the melting point, and to keep in flow from them a molten stream of metal greater in volume than the waters daily discharged from the Mississippi river.'[1]

[1] Maury, *Physical Geography of the Sea*, § 155.

Such is the enormous quantity of heat transported from the tropics, and distributed as a blessing over our native land, giving us fruitful seasons, and filling our hearts with food and gladness.

Viewing the plan of our world, as we find it most complete as regards its meteorology and geography, let us glance at some of the changes effected by the agency of man, both as regards climate and health and the production of food.

Originally, the greater part of the habitable land was clothed with forests, and great and unforeseen changes have often been effected by the indiscriminate clearing of the land by their destruction. Here I venture to copy extracts from an important article on the subject of forests and meteorology recently published in a publication called 'Polybiblion,' which is very instructive, and deserves to be more widely known. The paper gives the results of observations made during the last six years under trees, and not far from the edge of a forest, also in the plain, and far from all trees. It states: '1. Forests increase the quantity of meteoric waters which fall on the ground, and thus favour the growth of springs and of underground waters. 2. In a forest region the ground receives as much and more water under cover of the trees than the uncovered ground of regions with little or no wood. 3. The cover of the trees of a forest diminishes to a large degree the evaporation of the water received by the ground, and thus contributes to the maintenance of the moisture of the latter and to the regularity of the flow of watercourses. 4. The temperature in a forest is much less unequal than in the open, although, on the whole, it may be a little lower; but the minima are there constantly higher, and the maxima lower, than in regions not covered with wood. These observations have been made in the neighbourhood of Nancy, and by the pupils of the School of Forestry of that city, under the direction of M. Mathieu, sub-director of the School. On the other hand, M. Fautrat, when sub-inspector of forests at Senlis, made during four years, but on a different method, observations on forestrial meteorology which fully and completely corroborate, in certain respects, those of M. Mathieu. The laws which seem to follow from the figures given by M. Fautrat, as well as an inspection of the curves which graphically represent them, are as follow:—

'1. It rains more abundantly, under identical circumstances, over forests than over non-wooded ground, and most abundantly over forests with trees in a green condition.

'2. The degree of saturation of the air by moisture is greater above forests than over non-wooded ground, and much greater over masses of Pinus Sylvestris than over masses of leafed species.

'3. The leafage and branches of leafed trees intercept one-third, and those of resinous trees the half of the rain water which afterwards returns to the atmosphere by evaporation. On the other hand, these same leaves and branches restrain the evaporation of the water which reaches the ground, and that evaporation is nearly four times less under a mass of leafed forest than in the open, and two and one-third times only under a mass of pines.

'4. The laws of the change of temperature out of and under wood are similar to those which result from the observations of M. Mathieu. The general conclusion seems to be that forests regulate the function of water, and exercise on the temperature, as on the atmosphere, an effect of "ponderation" and equilibrium.'

The following is from the *Statesman* of June 1 of this year, a review published in connection with the *Friend of India*, Calcutta. First, it appears the plains of India were burnt up, and rendered desolate by the destruction of the forests by invading armies, or to clear more land for agricultural purposes, which led to droughts and floods. Then by the canal system of irrigation, injudiciously carried out, many of the fertile lands of Oude and Upper India have, in a few years, been rendered sterile and salt wastes by the deposit of Reh, a salt perhaps unknown to many of my audience, and frightful famines have been the result :—

'A century ago, Hindostan was a richly-wooded country; but since that time, a variety of destructive agencies have been at work upon the beautiful groves which gave fertility to the soil, and cool and refreshing shade to the people. First in time and in destructiveness were the Mahrattas and the Sikhs. These savage conquerors overran the whole of Central India, of the North-west Provinces, and the Land of the Five Rivers. And wherever they came, they cut down the trees and used them as fire-wood. In this way, some of the most beautifully-wooded districts of India were swept as clean as the palm of a man's hand. Since the country has passed into our possession, though not carried on with the blind folly of savages, the process of denudation has not been stayed. Probably, the work having been done more systematically, and with an object, has also been done more effectually. The enlargement of the area of cultivation has occasioned the clearance of large tracts of woodland. Our railways have been grievously destructive to the trees of India. They have been cut down by the hundred thousand to supply fuel to the engines.'

'Colonel Corbett thus describes the influence of forest lands upon the soil of a country :—

'"Forests and woods preserve moisture in a country in so far as they prevent or retard surface-drainage by their leaves, which fall and form a soft porous carpet on the surface; this, yearly increasing in depth, holds water like a sponge, the lower layers gradually rot and become incorporated with the soil. Thus, in the course of time, there is in every forest (where not carried away by surface-drainage) above the mineral soil a layer of loose humus, the remains of decayed leaves, on which are other layers of leaves in varying stages of decay, the whole forming a mass which freely admits water, and prevents its escape by surface-drainage. The shade of the trees prevents the incidence of the direct rays of the sun; and the trees break the force of the wind, and prevent the surface of the ground being swept and dried by them. Thus forests preserve moisture in the country, firstly, by their soil being in a condition to arrest and retain water; and, secondly, by the trees preventing the incidence of the sun's rays on the surface, and checking the force of the wind; thus, the two chief causes of evaporation are absent." (Pp. 31, 32.)

'It follows in a country like Upper India, where the sun shines with an intolerable heat, and fierce, hot winds sweep across the plains, that the soil, in the absence of trees, will be entirely desiccated. And this evil will be aggravated by the effects of surface-drainage. The clearing of the hill-sides results, necessarily, in bringing down a heavier rush of water upon the plains. This pours over the hardened and desiccated higher lands as it might do over stone or marble, while it floods all the low lands. Thus, the upper lands are sterilised by the absence of moisture, and the low lands are desolated by excess of it. From these causes, according to Colonel Corbett, "the extent of barren lands—lands formerly cultivated, but now producing no crop, save, perhaps, some poor grass in the rains—is yearly increasing."

'The sun beats on these bare, unsheltered plains, and the hot winds sweep across them, drying them up to the hardness of stone. The heat is further intensified by this state of the surface soil, which retains and reflects it as a rock or stone would. The true remedy for this condition of the soil would be a system of deep ploughing. The land thus broken up would absorb and retain a far larger quantity of moisture than is possible for the present glazed surface to do. But deep ploughing, in the present condition of native agriculture, is out of the question. The native cultivators possess neither the draught-cattle nor the plough requisite for deep ploughing. The ploughing of a field in India is little more than a slight scarifying of the surface. If the rains be withheld, the earth literally becomes iron, and defies the puny efforts of the cultivator to prepare it for the reception of seed. Hence arose the notion that if we could cover India with a network of canals, so that every cultivator should have a stream of water brought to his field, we should be independent of the rainfall. The aid which the cultivator requires, in order to break up the soil, would never be wanting to him. There was, of course, a certain measure of truth in this supposition; but the canal engineers, not being agriculturists, were ignorant of the evil latent in their proposed remedy. By irrigation, Colonel Corbett tells us, "the whole surface soil is brought into the condition of sun-dried bricks: the more water that has been applied to the land, the harder the soil becomes; and while its powers of absorption and radiation are reduced, those of reflection and retention of heat are increased; and we also find that the power of capillary attraction possessed by the land is increased, and that the soil so compacted will sooner become dried up than soil left loose and open." As an illustration, he describes what takes place in a field of wheat, duly irrigated, but the extract is too long to quote.

'Thus, the direct and inevitable effects of canal irrigation are evil in every way. By hardening the soil they diminish its productiveness; and yet the cultivator is driven, by the fact of this hardening, to depend upon this poisonous agency before he can, in the absence of the rain, prepare the soil for cultivation at all. In other words, by the extension of canal-irrigation we obtain a temporary and precarious advantage, at the cost of the permanent sterilising of the soil.

'But worse, far worse, than any of the evils we have yet enumerated as the consequences of irrigation, is the production of what is called *Reh*, which follows in the wake of our canals like black care behind the horseman. So far back as 1850, the officiating superintendent of the Western Jumna Canal, in forwarding to Calcutta some samples of *Reh* for analysis, wrote thus:—

'"The attention of the Civil and Canal Authorities in these parts has, for a considerable period, been directed to a change which is taking place in the soil in various parts of the country irrigated by these canals. A white efflorescence has made, and is making, its appearance in various places, destroying all vegetation with which it comes in contact. The barren space gradually increases in area, and speedily the ground thus affected is deserted by the cultivators, who forthwith assail the civil officers with petitions for remission of revenue."

'In the twenty-eight years which have elapsed since the foregoing was written, there has been a most appalling extension of *Reh* in the canal-irrigated districts of the North-west Provinces. In 1874, a canal officer records his opinion in the following emphatic language:—

'"Canal water creates *Reh*, especially when it runs above the surface of the ground-level. It is with canal-water that the disease is propagated. The canal, in its passage through *oosar* lands, drains off the saline matter in the *oosar*, and deposits it elsewhere. *Three to seven years is the time required to poison the land, and the Reh to show itself.* No physical law governs the character of the land in which *Reh* appears. It is only necessary to irrigate good land with poisoned water for four or five years to propagate *Reh*."'

Other notable instances of change of climate are those of the Holy Land and part of Asia Minor respectively. Thus Mr. Geo. P. Marsh, in 'The Earth as Modified by Human Action,' page 450, says:—

'The summers in Egypt, in Syria, and in Asia Minor, and even Rumelia, are almost rainless. In such climates the necessity of irrigation is obvious, and the loss of the ancient means of furnishing it helps to explain the diminished fertility of most of the countries in question. The surface of Palestine, for example, is composed in a great measure of rounded limestone hills, once no doubt *covered with forests.* These were partially removed before the Jewish conquests, when the soil began to suffer from drought, and reservoirs to retain the waters of winter were hewn in the rock near the tops of the hills, and the declivities were terraced. So long as the cisterns were in good order and the terraces kept up, the fertility of Palestine was unsurpassed; but when misgovernment and foreign and intestine wars occasioned the neglect or destruction of their works, traces of which still meet the traveller's eye at every step, when the reservoirs were broken and the terrace walls had fallen down, there was no longer water for irrigation in summer, the rains of winter soon washed away most of the thin layer of earth upon the rocks, and Palestine was reduced almost to the condition of a desert.

'The course of events has been the same in Idumæa. The observing traveller discovers everywhere about Petra, particularly if he enters the city by the route of Wadi Ksheibeh, very extensive traces of ancient cultivation, and upon the neighbouring ridges are the ruins of numerous cisterns, evidently constructed to furnish a supply of water for irrigation. In primitive ages the precipitation of water in these hilly countries was in great part retained for a time in the superficial soil, first by the vegetable mould of the forests, and then by the artificial arrangements I have described. The water imbibed by the earth was partly taken up by direct evaporation, partly absorbed by vegetation, and partly carried down by infiltration to subjacent strata, which gave it out in springs at lower levels; and thus a fertility of soil and a condition of the atmosphere were maintained sufficient to admit of the dense population that once inhabited those now arid wastes. At present the rain water runs immediately off from the surface, and is carried down to the sea or is drunk up by the sands of the wadis; and the hillsides which once teemed with plenty are bare of vegetation and seared by the scorching winds of the desert.'

The following appeared in the 'Daily Telegraph,' September 7, 1880:—

'In consequence of the reckless and extravagant felling of timber that has prevailed throughout Western Russia during the greater part of the present century, several of the streams feeding the Dneiper have become dried up, whilst others contribute so little water to the great river that its navigation has already suffered serious prejudice, and is, in some portions of its course, threatened with absolute interruption. Rocks and sandy islands in great number, forming sections of its bed, may now be seen where a few years ago from twelve to fifteen feet of water hid them from view. As the Dneiper traverses and largely contributes to the prosperity of no fewer than nine Russian provinces, or "Governments," this falling off in its dimensions and capacities is in reality little short of a national calamity, for which, however, Russian landowners and the Mir have only to thank their own ignorance and improvidence.'

NOXIOUS TRADES.

Dr. Richardson's dream of a Salutland in last year's address consists mainly of ideal, healthy, well-drained, well ventilated houses with plenty of pure air, pure water, and wholesome food.

To obtain all these blessings is the object of Sanitary Science and Sanitary Legislation. Each division of the subject has been already so well and ably treated by master minds, that I will not venture to add to what has been advanced by them, but I will say a word or two on the result of modern sanitary legislation, which has to a great extent failed in its object. It is a notable example of how not to do it, for it places the power of dealing with and abating nuisances mainly in the hands of those who create them, and it is only in very serious cases, with great difficulty and expense, that public

opinion is able to compel local authorities to put the Acts in force. These public authorities seem to be under no responsibility; they consist mainly of officers appointed and removable by the large ratepayers, who, some of them being manufacturers carrying on noisome trades and *living at a distance*, think more of saving the rates and less of the health or comfort and happiness of the populous neighbourhoods cursed by their unwholesome factories. They seem to be under no obligation to carry on their works with the *least* possible injury to their neighbours, and often neglect the means afforded by science of doing so, frequently to their own loss. If they were compelled to either abate the nuisance or remove their factories, they would soon find the way to do it! The question is one of saving expense in altering plant, and adopting improved processes. It is well known that necessity is the mother of invention. Waste products chiefly create the nuisance, and ought to be utilised and made a source of profit, instead of poisoning the air we breath or the water we drink. For example, the obligation imposed on the makers of gas of getting rid of gas refuse led to the invention of aniline dyes, from which splendid fortunes have resulted; and many other instances might be adduced.

The whole mischief of noxious vapours being driven off into the atmosphere might be avoided if only the vicious system of permissive legislation were changed, and the law compelled the authorities, however appointed, to put the law in force, and held them, not only collectively but individually, personally responsible by fine or imprisonment for neglecting their duty. Especially Sanitary Inspectors and Medical Officers of Health, I submit, should be appointed by the State, but however appointed, they should be protected by it in the performance of their duties. As it is, the members of local boards, in view of re-election by ignorant ratepayers, think more of saving the rates than the health, of the neighbourhoods adjoining and surrounding; and the air is often polluted for miles by their neglect. Their interest would seem to be *laissez faire*—which reminds me of the advice given by that crafty old statesman Talleyrand to a young aspirant for promotion, who had shown too much anxiety to do his duty, 'Avant tout, mon ami, point de zèle!'

I have the misfortune to live in the far east of London. When I was a young man and first came to live there, more than forty years ago, ours was a suburban village, and the population of the whole parish was under 10,000. By the improvements in London, and the removal of the dens of St. Giles, the City, Shoreditch and Whitechapel, the population has been driven east, and West Ham is now a town of more than 120,000 inhabitants, daily increasing. It has also become a new centre of industry, and, by the formation of magnificent docks, a very important part of London. The Metropolitan Board, having regard to the metropolis only, drove the filthy factories of Bow Common over the border (that is, the River Lea) into Essex. They took refuge in the adjoining parish, West Ham, where, in the midst of a crowded population they carry on their noisome trades with impunity, mainly owing to the protection given to them by the curse of permissive legislation. Why should not animal charcoal makers, artificial manure makers, blood boilers, chemical works, and other kindred trades (if allowed at all to come into populous places) be compelled to use retorts or other means which science could point out to remedy this state of things? When the wind sets our way we cannot open our windows without being covered with smut, or sickened by filthy smells, especially at night, which is a great misfortune in sultry weather.

We cannot even get the Smoke Acts adopted, and our town is becoming the *beau ideal* of a Black Country.

An article in 'Household Words,' edited by the late Charles Dickens, published September 12, 1857, did much good in calling attention to the dangerous state of parts of West Ham for want of proper drainage. A providential attack of cholera was the cause of drainage works on a large scale being carried out. They have been a great blessing, and why should not the Local Government Board again interfere, and, by an amendment of the law, drain our atmosphere from pollution? The law protects our property and our liberties, why should not our health and lives be equally the care of our legislators?

HEALTHY HOUSES.

In regard to our houses too much care cannot be taken to have them built on dry soil. Our streets should be laid out as far as practicable in the direction of the prevailing winds, that they may blow through them. The walls should be built of suitable materials, and of sufficient thickness to be warm and dry. The rooms should be carefully ventilated, and the sanitary arrangements should receive the utmost attention of the architect. The local surveyor also should see that the drainage and water supply are properly attended to. In no case should the same cistern be used for drinking purposes and sanitation. Water absorbs gases, and the overflow pipes from cisterns should never discharge into closet traps, as is too frequently permitted; nor into cesspools. All such pipes should discharge over properly trapped sinks with a space of several inches of air between them, so that no connection exists between the discharge pipe and the receiving sink.

WATER.

All the fresh water in the world has been distilled from the sea, and transported in the form of clouds and vapour to water the earth. The largest lakes or inland seas, the most mighty rivers, and all springs and fountains, owe their origin to this source.

Where rain falls depends on meteorological causes and on the contour of the land, its forests, and the prevailing winds. Thus, on the eastern side of the Andes, the heavily-laden clouds coming from the tropics and the Atlantic are precipitated more or less according to the nature of the soils, the vegetation, and the districts they pass over, until, crossing the upper ranges of the lofty chains of the Andes, above the limit of perpetual snow, every particle of vapour forming the clouds is condensed, and, so to speak, every drop of water is wrung out of them; they are practically destroyed. Consequently on the western slopes there is a cloudless sky, rain is almost unknown, and what vegetation there is is supported by nocturnal dews, which are drawn from the adjacent water of the Pacific Ocean.

Thus on the east of the great mountain range, the heavy rains caused by the condensation of the clouds give rise to lakes and inland seas and mighty rivers, some of which flow for thousands of miles through alluvial plains, destined henceforth to grow corn, and feed cattle for the food of older inhabited and more densely populated lands, which, like England in the present day, are quite unequal to grow sufficient food for themselves.

The same thing, on a smaller scale, takes place in our own country. The clouds travelling over the warm water of the Gulf Stream, a branch of which impinges on our shores, are precipitated by the mountains and high lands of Ireland, Devonshire, Cumberland, Westmoreland, and Scotland. On the west side, therefore, of these ranges there is an abundant rainfall. At Seathwaite, under Seatollar, it is sometimes as much as 179·12 inches.

The wettest spot in England is the Stye, half a mile from Seathwaite, in Borrowdale, at the south end of Derwentwater, and 1,077 feet above the sea. The mean fall there is 175 inches; at Seathwaite, about 600 feet lower, and half a mile off, 140 inches; while at Keswick, about ten miles off, it is only 60 inches.

All along the west coast, Penzance, Pembroke, Lancashire, West of Ireland, Dumfries, and the flatter parts of the West of Scotland the rainfall is 40 inches, but is more where the ground is hilly.

The mean rainfall of—

All Cumberland is about	60 inches.
„ Westmoreland „	55 „
„ Northumberland „	25 „
„ Durham . . „	25 „
„ Eastern Counties, about	25 „
„ London (Greenwich) 1841 to 1879 . .	24 „

while at the driest spot in England (near Bedford) it is only about 22 inches.*

It is obvious from the foregoing that more water cannot be drawn from any watershed than falls as rain within it; and even all this is not available, for much runs off direct into the rivers, and flows again to the sea to be re-distilled and re-distributed, while the remainder sinks into the soil.

The Royal Commission appointed to inquire into the future sources of pure water for London and other large cities, have accurately mapped out all the various watersheds, and calculated the rainfall in each. The report of these able men, drawn up, I believe, by my friend, Joseph Prestwich, F.R.S., F.G.S., the Oxford Professor of Geology, and one of the ablest geologists living, has exhausted the question of whence London and our other large cities can derive abundant supplies of pure water. It will be for Parliament to choose from amongst the many schemes proposed that which, in their wisdom, after due inquiry, they may deem the best, and to pass the necessary Acts to enable our sanitary engineers to carry out this great object. Where the local watersheds cannot supply the required quantity, it is clear it must be brought from a distance.

Smaller towns and villages may be supplied by the way. And when Parliament shall have seen fit to provide the means for enforcing the law against the pollution of the streams and rivers made by nature for the benefit of all, it is hoped that at no distant date all our streams and rivers may afford the local inhabitants a supply of reasonably pure and wholesome water. It has been shown in the section on Geology how, by the breaking up of the older rocks, new combinations have been formed, and beds of sand and gravel deposited with water-bearing strata on impervious ones. These sands and gravels are the great natural filtering beds to clear the water of our springs

* I give this on the authority of my friend Mr. G. J. Symons, F.R.S.

and wells from any impurities it may have contracted in passing through the surface soils. Thus all has been preparing for the welfare of man, and for providing him with pure water, one of the first necessaries of life.

I fear I have exhausted your patience. Yet I have tried, as far as I could in the short time allowed for this address, to show that, from the earliest history of our globe, geology, meteorology, and the kindred sciences prove to demonstration that this world of ours has been prepared by laws given by Almighty wisdom to fit it for the well-being of the creatures destined to inhabit it, and that the hand that made it is Divine. There are tongues in trees, books in the running brooks, sermons in stones, and good in everything.

SEWAGE.

Mr. Haviland, whom I have before quoted, has well said that sanitary science ought not and does not consist in expedients for correcting the fault of others; we ought to go to the root of matters, and not first poison our rivers with manufacturing refuse and the sewage of large towns, and then again pay millions for guano to fertilise our fields and replace the sewage, while we pay millions more to construct sewers to convey it to the sea in utter waste, instead of using *it* to produce grass and grain for food, and to prevent our fields from becoming sterile by over-cropping, like the Campagna of Rome, once the granary of Europe. Obviously there should be returned to the soil what we take out of it, or its equivalent, which is the object of manuring.

Sewers, under the circumstances of large communities aggregated in small areas, huddled together in towns, built without any previous plan or regard to sanitary arrangements, are a necessity; for the land around large cities is not capable of chemically deodorising or purifying such prodigious quantities of sewage as are daily produced, together with the volume of water used to carry it. It would infallibly soon drown the land with the sludge, which would stagnate, putrefy, and generate malaria. Nature's laboratory—the soil and atmosphere—in such case would be unequal to oxygenate and purify either the solid particles or the water used to carry it. This is the great danger in over-tasking sewage farms. Chemistry always acts by equivalents and in definite proportions, and we must not attempt impossibilities or sin against natural laws. In such a case we must submit to the lesser evil of sewers, which are nothing more or less than elongated cesspools. These, for convenience, we connect with our dwellings; and we must do our best to keep the sewer gas out, first by ventilating the sewers and making them as far as possible self-cleansing, so that no accumulating pressure of gas shall force its way in. This is certain to happen if flood waters or waters used for flushing cannot more freely escape otherwise. At best a trap is only closed by the weight of two or three inches of water, which pent-up gases, often equal to a pressure of thirty inches, can easily displace, and then there is direct communication with the inside of our dwellings. In the first place we must look to our engineers for the most scientific form of traps they can furnish, and then see them fixed efficiently by skilful plumbing. Great danger and vast mischief have arisen from bad traps and defective plumbing. Mr. Eassie, C.E., one of our Council, did great service to sanitation at the Exhibition at the Croydon Congress, last year, by exhibiting traps which were defective, or had become so by corrosion in use, and which did deadly mischief before the cause was discovered. Rats also frequently burrow into the cellars and make free vents for sewer gas. It is feared that many fever dens exist from similar defects to those shown. Much, however, may be done to lessen the inherent danger of sewers by ventilation and constant flushing. Fresh sewage does no harm, unless fermenting or contaminated by the emanations, whether germ or gases, from fever or other contagious diseases, which, under certain circumstances of heat and fermentation, if not multiplied, are, at least, often conveyed by the sewers. What the nature of contagion and infection is, whether by germs *sui generis* or otherwise, is not yet thoroughly known or understood, but, I believe, the favourite theory of some eminent medical men is the germ theory. This I know is disbelieved in by others equally eminent; and who shall decide when doctors disagree? Dr. William Proctor, in his valuable treatise on 'The Hygiene of Air and Water, the Effects of their Impurities, their Detection, and the Modes of Remedying them' (London: R. Hardwicke, 1872, p. 67) says:—

'If it be true, as modern science has almost demonstrated, that the real agents of such diseases as infectious fevers, cholera, rinderpest and other allied (zymotic) affections are living germs and not a gas, or vapour, or dead organic matter, it becomes a physiological rather than a chemical question to decide on the best means fitted for their destruction. That which has been proved in respect of small-pox and other allied diseases is very applicable to the present inquiry so far as it relates to the most probable existence of germs in the water we may drink. The agents, then, of these diseases, it is believed, are living germs, capable of remaining dormant for an uncertain but not indefinite time, and then springing into activity when they find the conditions requisite for their development. But whether these germs are capable of destruction by oxidation in the atmosphere or water is an unsettled question. We do, however, know that these germs are destroyed by a high temperature, that they are killed by a large number of caustic substances, and that they cannot resist the action of certain agents, such as carbolic acid, which act on them as specific poisons. Therefore to this class, rather than to oxidising agents, we look for their removal. And in the case under consideration, the reliable agent is heat.' [This agrees with my late dear friend Dr. Crace Calvert's experiments, but he found that a very much higher temperature than boiling water was necessary to destroy them. *Vide* 'Transactions of Royal Society.']

Then as to the ultimate disposal of sewage. It must no longer be allowed to pollute our rivers, poison our drinking water, breed fever, and destroy our fish. We can do something to mitigate the mischief. We can precipitate and deodorise the solid matter by the aid of proper agents and intercepting tanks, and thus render the effluent water sufficiently harmless to justify its return to our streams and rivers, where the current is sufficiently strong to dilute it, so that the oxygen of the atmosphere, vegetation, and animal life may in turn purify it in nature's laboratory, and render it again fit for use. I know not how, with my present limited knowledge of chemistry, the salts of sewage in solution can be got rid of; and, to say the least, it is a filthy idea, that water, if ever impregnated or any way contaminated by sewage, or by passing through cemeteries, should be allowed to be supplied to our cities by water companies who take their supplies from polluted rivers. However bright and sparkling to the eye water may appear, if it contains any trace of sewage in solution, it is not fit for the use of man. In all cases of doubtful water, it should be boiled, left to cool, and be filtered through animal charcoal, which will eliminate a large portion both of organic or mineral impurities.

For small communities and villages with plenty of dry earth to be had, and fields and gardens for its disposal, any attempts at sewers would, I submit, be inexcusable; they would never be kept in order; and under proper regulations earth closets seem the natural remedy. They have even been adopted with success in some large towns in the north. But doubtless the disposal and utilisation of sewage and a pure water supply are the great sanitary problems of the day.

MARSH FEVER.

I have lately been reading an exhaustive work of great research by Dr. Macculloch, published in 1827, on the production and propagation of malaria, which deserves to be better known and studied than it is. It contains some sound advice and some startling facts. The doctor proves that, in all parts of the world, the same causes produce the same effects, and that drainage, cleanliness, and ventilation are the sovereign remedies.* He conclusively shows that decaying vegetable or animal matter under a hot sun in damp soils, swamps, or swampy stagnant pools, however small, is capable of generating the poison of malaria in sufficient quantity to poison those who inhale it, and cause fever which is often mistaken for, and treated as, typhoid. Many examples are given. The source of the poison is well known, but what that poison is, or how generated, our chemists have not yet been able to determine. Without going to Indian jungles, tropical rice-fields, or African swamps for examples, we have the melancholy fact that some of the fairest portions of the earth have, in all ages, been suffering from it in those parts where drainage has been neglected and natural swamps exist, especially on river banks.

Need I name Italy, with its Roman or Pontine marsh fever, and Greece? and this in spite of warning and the accumulated experience of ages, though the remedy, drainage, has been well known from the earliest time of which we have any record. Mr. Haviland writes, in a recent paper of his, read at Croydon (see page 193, vol. i., of our 'Transactions'):—'Hippocrates, who lived between two and three thousand years ago, was a physician and the founder of medicine. He was in advance of the age in which he lived, and, in many things, in advance of that in which we live. This extraordinary man lived at a time when there were, as contemporaries, spme of the most brilliant men the Greek Isles ever produced. He taught, at that remote period, how necessary it was to study the nature of the soil in relation to disease, the qualities of the water which either sprang from it or had flowed over it. He laid down certain rules, which are applicable now to the same locality wherein he practised, as to the selection of sites, &c.; and he wrote a philosophical treatise on airs, places, and waters, which may be read now with advantage, and especially by those who think there is nothing like the learning of the nineteenth century, for they will there see clearly and distinctly shown, that diseases have a geographical distribution, and that the soil on which a man lives must be studied by the physician who would wish to combat successfully with disease.

'The graphic description of the effect of the swampy country around

* Mr. Dunnage tells me that in all his experiences in New Zealand swamps he never heard of a case of fever or malaria.

the river Phasis on the dwellers there, shows how keenly he observed and how highly he appreciated the facts which nature pointed out to him on the bosom of mother earth. Hippocrates well knew that, whilst the crust of the earth remained as it was in his day, whilst there were deltas, swamps, and lagoons exposed to the heat of the sun, that disease would arise; and that, unless these spots were pointed out by the physicians, men would heedlessly settle there, and in the sequel pay the heavy penalty of ignorance, which we are doing every day. All this knowledge had been gathered, digested, and sent forth, in the most choice language that man could write, centuries before the Christian era; and yet we are, in this our boasted nineteenth century, piling up statistics, binding them in blue covers, placing them on our shelves, and converting these volumes that contain them into simple dust collectors. I say this is humiliating, and certainly does not encourage us in believing that the efforts which sanitary institutions are making now will be followed by the anticipated success, at least in this country.' And here let me pay my willing tribute of respect to the zeal and ability with which Mr. Haviland in his work has followed the teaching of his great master.

Dr. Macculloch conclusively shows that in our country some small spaces are sufficient to generate this poison, and cause fever where least expected, though, of course, in large districts, such as the Fen Country, it is more prevalent and more virulent. It occurs more or less on the marshy banks of our own rivers; and the Essex marshes on the banks of the Thames are not free from its dire effects. The 'Times' of October 8, 1879, had the following interesting account of the poison of marsh fever, which shows a laudable attempt to discover its nature:—

'THE POISON OF MARSH FEVER.

'The physical cause or poison to which marsh or intermittent fevers are due, was made the subject of special investigation during the spring of the present year, by Signor Tommasi, Professor of Pathological Anatomy at Rome, in conjunction with Professor Klebs, of Prague. According to an account laid by the former before the Academy of Rome, the investigation was rewarded with complete success. The two investigators spent several weeks during the spring season in the Agio Romano, which is notorious for the prevalence of this particular kind of fever. They examined minutely the lower state of the atmosphere of the district in question, as well as its soil and stagnant waters; and in the two former they discovered a microscopic fungus, consisting of numerous moveable shining spores, of a longish oval shape, and a micro-millimètre in diameter. This fungus was artificially generated in various kinds of soil; the fluid matter thus obtained was filtrated and repeatedly washed, and the residuum left after filtration was introduced under the skin of healthy dogs. The same thing was done with the firm microscopical particles obtained by washing large quantities of the surface soil. The animals experimented upon all had the fever with the regular typical course, showing free intervals, lasting various lengths of time up to sixty hours, and an increase in the temperature of the blood during the shivering fits up to nearly 42 degrees, the normal temperature in healthy dogs being from 38 degrees to 39 degrees Centigrade. The animals artificially infected with intermittent fever showed precisely the same acute enlargement of the spleen as human patients who have caught the disease in the ordinary way. And in the spleens of these animals a large quantity of the characteristic form of fungus was present. The fungus was also found abundantly in other lymphatic vessels of the animals. As the fungus here grows into the shape of small rods, Tommasi and Klebs gave it the name of Bacillus Malariæ. The strictest scientific method pursued in this investigation does not admit of a doubt that the accomplished investigators have really discovered the real cause of the disease in question. The discovery may be regarded as another of the series of which those in connection with inflammation of the spleen and diphtheritis were earlier examples. Against the intermittent fever poison, which is connected with this newly discovered microscopic fungus, the medical art was formerly as powerless as it still is against diphtheritis and inflammations of the spleen. For intermittent fever, however, medicine was provided with a remedy, when the virtues of quinine were made known, and it may be reasonably expected that, as in the latter case, so against the poison of the diphtheritic fungus and that of splenetic inflammation, medical science will sooner or later discover their appropriate antidote. Further particulars of the experiments and discovery of Tommasi and Klebs will be found in the July number of the "Zeitschrift," edited by Professor Klebs.'

Towards the beginning of the sixteenth century a very terrible malady made its first appearance in this land. The origin of the evil, called Sudor Anglicanus, was at that time supposed to be wrapped in mystery. The disease popularly known as the sweating sickness was looked upon as one of those visitations which have so often been attributed to an offended Providence, instead of to the true cause of their existence. Illumined by the light of modern teaching, we can entertain but little doubt that the dreaded sweating sickness, which created such havoc in the reigns of Henry VIII. and his son, was entirely due to the almost Eastern condition of things then apparent in our system of drainage and ventilation, such as it was in those days. The houses even of the great harboured filth and dirt, which were allowed to remain unremoved, and thus to exhale their noxious gases with fatal freedom. The narrow streets were the receptacles for all garbage, whilst open sewers slowly rolled their contents towards a polluted river, which became continually more polluted still. Pure water for drinking purposes was scarcely to be had. The brewers, it is stated, monopolised the springs for their trade, whilst the conduits, which even a century before had been insufficient for the wants of the people, now simply mocked at the requirements of the town. Meat it is stated, was cheap, and the English people notorious for their robust appetites. It is not, therefore, surprising that men breathing in their own homes, and out of doors, a fœtid atmosphere, with their blood heated by heavy consumptions of animal food, should fall easy victims to a pestilence which their own offensive habits had helped to engender and encourage.

ATMOSPHERE.

In treating of the geological part of our subject, I have spoken of the sea, but it is to be observed that our planet is invested with *two* great oceans—one visible, the other invisible; one entirely envelopes it, and at the bottom of this we live; the other covers two-thirds of its surface. All the waters of the one weigh about 400 times as much as all the air of the other. We used to speak of the sea as unfathomable, but, by modern improved instruments, it is ascertained that the greatest depth is from four to five miles, which is about the height of the loftiest mountains above the sea; whilst the shoreless aërial envelope, the great laboratory of nature—the atmosphere—is about 50 miles high; but air being a highly elastic fluid, it is impossible to obtain its exact depth. If the air were a non-elastic fluid like water, we could ascertain the height of the atmospherical ocean with the barometer, and gauge it by its pressure, but, owing to its elasticity, the lower strata are pressed down by the superincumbent air with a force of about 15 lbs. to the square inch, while those at the top are inconceivably light, and at the top of high mountains it is so attenuated that it is difficult to breathe. Chemists who have made the analysis tell us that, out of 100 parts of atmospheric air, 95·5 consist of oxygen and nitrogen, mixed in the proportion of 21 of oxygen to 79 of nitrogen by volume, and of 23 to 77 by weight; the remaining half part consists of 0·5 of carbonic acid and ·45 of aqueous vapour. Mixed with these there is generally a minute quantity of ammonia, and a small portion of oxygen in a highly electrical state, to which Schönbein gave the name of ozone.

The importance of ozone in the economy of nature has only quite recently been ascertained and appreciated. During the thirty years which have elapsed since the famous researches of Schönbein, ozone has been studied by some of the most illustrious scientific men of the century. The most recent work on the subject which has come under my notice is by Dr. Cornelius B. Fox, and it contains a resumé of all that was known up to the date of its publication in 1873.

Schönbein, in his work on the action of oxygen (the life-giving principle in the air), expressed his opinion that the blood globules, like phosphorus, are endowed with the property of chemically polarising the oxygen of the air with which they are brought in contact in the lungs, and of thus splitting it up into ozone and anti-ozone. I must not, however, quote further, but refer my hearers for full particulars to the many learned treatises on the subject, which treat of the abstract principles of experimental chemistry. All I can add about it here is, that it is believed to be the chief oxidising principle of the air we breathe, and is one of the chief agents by which the many impurities contracted by air and water are removed altogether, or changed into harmless oxides.

Breathing consists of two acts, viz.: inspiration or taking into the lungs pure air (when it may be had), and expiration, or expelling it again from the lungs in an impure state—for, by the act of breathing, it is deprived of its vital oxygen, which is replaced by carbonic acid, accompanied by a variable quantity of organic substances, consisting of fatty matter and particles of epithelium or skin, estimated for an adult at as much as 30 to 40 grains a day.

This is the cause of the disagreeable odour of close and crowded rooms. The watery vapour given out in respiration, laden with these impurities, condenses on the walls of confined and ill-ventilated bedrooms and buildings, is condensed, and trickles down in fœtid streams. Hence the absolute necessity of ventilation if we wish to enjoy a healthy home.

One means of preventing the air becoming continually more impure by the gases discharged into it, is the chemical law of diffusion, by which they are diluted and carried away by the wind, which substitutes a fresh supply of pure air.

When the air stagnates, whether in mountain valley, or in closely shut rooms, or in crowded courts and alleys into which a breath of air or gleam of sunshine can scarcely enter, there can be little wonder that disease and death are the result.

The legislature has passed Acts for the purification of the atmosphere of smoke and noxious vapours, but has not taken measures for putting these Sanitary Acts in force. Nature is more beneficent, and by the aid of winds does much to remedy the pollutions made by man, by diluting them by ventilation on a grand scale; and we ought to see that no impediment is laid in their way.

Falconer, in his beautiful poem, 'The Shipwreck,' makes the pious sailor say:—

> Perhaps this storm is sent with healing breath,
> From neighbouring shores to scourge disease and death;
> 'Tis ours on thine Almighty Wisdom to rely,
> Thy mercy supplicate if doomed to die.

Rain also has a beneficial influence in washing out many of the more solid impurities floating in the air, and we Londoners welcome a heavy rain to wash our dirty streets, and clear away a London fog, which is mainly smoke, and ought economically to be burnt, and not mixed with the damp and vapour of a winter's day. Rain also washes out of the atmosphere the ammonia suspended in it, and assists greatly in fertilising the soil. Snow has a similar beneficial effect.

In all the books on ventilation, I find reference is made to the dreadful tragedy at Calcutta, when 146 people were shut up in what was called the Black Hole, and in the morning 123 were found to be dead, and others dying. That is an extreme case, but too much stress cannot be laid upon the necessity of ventilating our houses, and it has been well remarked, that we have too many Black Holes from overcrowding and closely shut-up bedrooms. Sometimes a broken window is a positive blessing, and it is a good precaution to lay out streets in the direction of the prevailing winds, that they may blow through them as much as possible.

A man consumes the vital principle of a gallon of air every minute, and a candle or lamp burns the oxygen of the air in proportion to the size of its flame, and, if placed under a receiver, is extinguished as soon as the oxygen is consumed.

A ready mode of ascertaining the amount of carbonic acid thrown off from our lungs is by breathing through a tube inserted into clear lime water; the water soon turns milky, and the lime is thrown down in the form of a carbonate.

Need more be said to enforce the necessity of ventilation?

BAD FOOD AND JEWS.

Bad food, and especially diseased animal food, as well as unripe or decaying fruit, is the cause of many serious illnesses, which our physicians find it difficult and often impossible to grapple with. Too great severity cannot be visited upon those villains who knowingly sell diseased meat, poultry, or fish. The immunity of the Jews from scrofula is a great fact. They are forbidden by their law to eat the foul animal. The pig (*sus scrofa*) is the principal—nearly the only—animal food of the inhabitants of the Western prairies. Scrofula (from *sus scrofa*) I learned when in America was the cause of much suffering from that sad disease. It is first cousin to consumption, which is terribly fatal in the United States.

The following extract from the 'Ecclesiastical Review' of July 31, 1880, fully bears out the above experience, and is a very remarkable testimony in favour of carefully-selected animal food, it being well-known that the chosen people only eat food killed by their priests, after careful examination, and that any beast discovered to be in any way unhealthy, or found to be in any way defective, is discarded, or more probably sold to Christians, who are not so particular:—

'What he (Dr. Thring) states as to the survival of Abraham's children is very interesting, and fully borne out by vital statistics as well as by Scripture prophecies. A Jew's life (he says) is found on an average to be worth fifty-seven years in duration, whilst a Christian's in the same country is only worth twenty-seven, or less than half as much. Dr. Septimus Gibbon, speaking at the Pathological Society of London, in 1876, said:—"The Hebrews of the metropolis are notoriously exempt from scrofulous and tubercular taint. During the last twenty-five years I have attended a large number of Hebrews, both as hospital and private patients, and have never met with a single case of pulmonary consumption amongst them; and a former colleague at the London Hospital, who had a large *clientèle* amongst this favoured people, told me that for forty years he had only met with two cases. The medical officer of one of their large schools has remarked that their children do not die in anything like the ratio of Gentile children; and in the district of Whitechapel the Medical Officer of Health has reported that on the north side of the High Street, occupied by Jews, the average death-rate is 20 per 1,000 inhabitants; whilst on the south side, occupied by English and Irish, it is 43 per 1,000."'—('Trans. of the Pathological Society,' vol. xxvii., p. 437.)

ANTONIO BRADY, F.M.S., F.G.S.

The BISHOP of Exeter, in proposing a vote of thanks to the President, said he did not think it was possible to have listened to his address without feeling more and more interested. There was a great deal in it for after consideration. The lecture contained a great deal of that which was altogether new to the majority of them. It was impossible that they could have listened without interest to the causes to which were attributed the famine in India. Scientific men had done much for good and evil, for scientific men had made mistakes, and there still remained a great deal for science, with caution, to do. He did not propose to criticise the irrigation system of India, but they must all feel an interest in their fellow-men, and could see the value of a better application of scientific principles to these matters. He did not think it was possible to abstain from expressing their gratitude to one who had given them such valuable information, and he hoped it would stimulate those who had listened to it to the scientific investigation of these matters in the interest of human life.

Mr. RAWLINSON seconded the motion. The paper was so discursive that it would be impossible to attempt to deal with all its points. With some of the opinions expressed he agreed, but he must confess that there was a considerable portion of the opinions expressed on the paper with which he did not agree, and it would be hopeless for humanity if they were true. They had heard a great deal about tree-planting. No doubt tree-planting did modify the climate, but, unquestionably, it did not in any great feature change it; and when they heard that springs and rains were caused by it he looked upon the statement with great hesitation. They had also heard of malaria. Very few men had had the opportunities of considering what was called malaria that he had had, and he had come to the conclusion that in the vast proportion of these cases the cause of mortality was not the earth or the climate, but the filthy habits of the people upon the surface. Climate was not so deadly a thing as even scientific men supposed. He would give them an instance. Before he went out to the Crimea he read Dr. Clark's Travels, and was there told that in the Crimea fevers were the great cause of complaint; that if you were exposed to the morning sun you were liable to fever, and that if you were exposed to the evening dews or drank the water you were liable. When he got there what did he find? The Government had sent out the finest army that had ever left our shores—seasoned men in the maturity of health. They knew how shamefully our soldiers were neglected, and how they were kept under conditions in which life was sacrificed to a shocking degree. There were British regiments there that in three months lost 700 men out of 1,000. He did not wish to take credit to himself, but the Government of that day selected him and certain medical gentlemen to go out to the great hospitals on the Bosphorus and in the Crimea, and see if it was possible to modify that state of things. At the same time a Commissariat Department was sent out, and, public indignation being aroused, all sorts of relief despatched, and therefore the Sanitary Commission could not take all the credit: but he maintained that they did good they did not receive credit for. Instead of the climate of the Crimea being the deadly one represented, after their arrangements were carried out the soldiers were in a better position than they were in their own barracks at home, although they were exposed morning and evening.

Dr. RICHARDSON said the address had brought forward Colonel Corbett's report, and if that should turn out to be true nothing would be more remarkable. The statement in it was that the canal system in India had been an utter failure, and that if the process went on the whole of the irrigated part of India would be soon a sterile desert. He knew that if his friend Colonel Cotton was present, he would declare that this was not the case. He mentioned this to show that this matter was controverted. He himself had tried to get at the facts through the natives, but their accounts were very contradictory.

Sir ANTONIO BRADY, in responding, said that he must not be held responsible for all that was in his paper. He should not have quoted as he had unless he had believed in what was written, but as he had not been able to verify the statements, he had given his authority for them. His desire was that this matter should be discussed.

Observations on the Geology of Exeter, and the Improbability of there being a Subterranean Water Supply for Economical Purposes.

IN consequence of an alleged insufficient supply of water from its source in the Exe for the City of Exeter, the Corporation, about two years and a half ago, purchased the Water Works from the Company, in order that such alterations and additions should be made as might from time to time be considered necessary. Since then the possibility of a sufficient subterranean supply has been frequently discussed in the local newspapers. It has been argued that inasmuch as Exeter is on the New Red, an undoubted supply of very pure water, enough for drinking purposes, might be obtained; that is to say, enough for the wants of from 45,000 to 50,000 persons.

The purpose of this paper is to raise the question among scientific men as to the probability or improbability of so much water being obtained by boring within the city or its environs.

Of course, all subterranean water must have, at some time or other, percolated through the cracks and rents of the surface rocks, and the quantity of water must largely depend upon the surface configuration of the locality. A flat surface is more likely to retain the water than rising ground. Remembering that Exeter is on a tongue of land, and, except towards the east, is surrounded by valleys, it may be fairly assumed that more than the average quantity of rainwater finds its way to the sea. An authority on these matters stated

at a recent meeting of the British Association that probably one-third of the rainfall entered the rocks. But I question very much if such a proportion will be found in the rocks of Exeter. Necessarily, any computation as to the proportion of the 30 inches of annual rainfall that enters its rocks must be hypothetical. It must also be remembered that the inclination of the beds from or towards the city will be an important factor, as water usually works its way along the plane of the beds. I have known instances of well-water being abundant on one side of a valley, and none to be met with at similar depths on the other side. But with this I will deal more fully hereafter.

Reference to a geological map will show that Exeter is in part on carboniferous shales, in part on the Trap, and also on the New Red. During the formation of the shales, and most likely towards the close of the carboniferous period, the whole of this neighbourhood—and more or less, from Dartmouth to the Land's End—was greatly exposed to earthquakes and volcanic eruptions. De la Beche says: 'The whole of the Slates and Sandstones are intermingled with the Trappean in a way to show that there must have been considerable igneous action, during which ashes and vesicular lavas showing little pressure were ejected contemporaneously with the deposit of the slates and the sandstones.' This authority here more particularly refers to the district between Dartmoor and the Land's End; but it appears that a similar volcanic action characterised the termination of the shale period in this locality. Between Exeter and Dartmoor are several volcanic vents, and everywhere in this locality the shale is contorted and torn in almost every conceivable manner. I might also observe that in an important section of the New Red in the Heavitree Quarry, the cleavage joints are for the most part so filled with carbonate of lime as to render it impossible for water to find its way through them. Hence the action of springs in that quarry.

Exeter, geologically, may be divided into several areas:—

1st. From the South Western Railway Station to the bottom of Exe Lane, along what was formerly the Brook, then around the Princess Road to Fore Street Hill, and thence by Fore Street Hill to the West of England Insurance Office, an area will be described which has a stratum of clay from 2ft. to 4ft. thick, of a yellowish colour and very tough, and beneath the carboniferous shale, commonly called shillet, to a considerable depth. My friend Mr. Parfitt, of the Devon and Exeter Institution, has kindly supplied me with the notes of a boring at St. Ann's Well Brewery, commenced in March of last year. This well will be found situated about midway between Queen Street Station and Exe Lane, and before the filling up of the valley for railway purposes was on the 'nap' of the hill descending to the valley. The boring commenced in the shillet and only reached water at a depth of 305 feet, and then only in quantity not much in excess of the requirements of the Brewery. Mr. Parfitt has also furnished me with the notes of a boring of a well for the City Brewery in 1849. At a depth of 15 feet the boring was through water gravel, then for 85 feet through the shillet, for 54 feet more through alternate layers of trap and red shillet, then for 90 feet through blue shale, for 3ft. through water sand, and for 23 feet more through blue shale, making a total of 270 feet. This great depth was necessary in order to obtain water, and although in a valley, you will perceive, is not much less than the number of feet necessary to be bored for the St. Ann's Well Brewery.

In digging wells in this rock the depths at which water is obtained differ very extraordinarily. A well has a fairly good supply at a depth of nine or ten feet in one place, while others not 20 yards off have not had water at less than 50 or 60 feet, and in the cases of the St. Ann's and City Brewery Wells an approximate depth of 300 feet had to be reached. This probably results from the presence of numerous faults, or slides of large masses of rock, from various causes, but mainly volcanic. A very good section of this rock may be seen in the Princess Road, close to Head Weir.

2nd. If another line be drawn from Gandy Street up High Street, along Longbrook Street, then descending to the bottom of the street and following the line of the ancient brook to the South Western Railway station, it will be found to encircle the igneous rock on which the Castle of Exeter stands. The least exposed portion of this rock is very compact and ponderous, and when a portion of the base of the hill was cut away for the South Western station it was thought that the stone was sufficiently hard for the bridge which spans the railway near the prison; but after a few years of exposure the stone softened and gradually crumbled away. It has a granulated, or small grainy, and purple ground, sprinkled with minute shining points. It has numerous fissures crossing in all directions, or filled with white hard veins of calcareous spar. After long exposure this stone degenerates into a red clay, and this clay composes the surface of the Castle Hill, from whence no doubt this eminence derives the name of 'Rougemont.' This, it must be remembered, was a volcanic rock, and was probably thrust up at the close of the carboniferous period, which will probably account for the very broken and disturbed condition of the surrounding shillet.

3rd. From St. Stephen's Bow to St. John's Hospital, including Bedford Circus, the stratum is of sand and gravel; this is followed by clay, mixed with small masses of the disintegrated rock of the Castle, and the masses becoming larger and more compact soon form a rock of the same kind. The wells in this area are from 20 feet to 30 feet deep, and give excellent water. The well water of this locality is far preferable to that of the shale; but immediately beyond the Circus, or Southernhay, we find water certainly unfit for domestic use. In a well behind my own house, in the middle of Southernhay, the water was declared by the city analyst some twelve months ago to be unfit for such use. I have been unable to trace the cause of the presence of so much ammonia in this water.

4th. Above St. John's Hospital and Longbrook Street, the second stratum is a fine red sand about 60 feet thick. Under this, in some places, is a bed of soft marl from 4 feet to 6 feet deep, and then again the red sand. The sand extends all over St. Sidwell's to the Black Boy Turnpike Gate. The soil of the adjacent fields has been for a century and upwards used by the brickmakers. But in this area of the New Red there is less water than might be supposed. At Lion's Holt there has been a very fine spring from time immemorial, and although it comes through the thin bed of the Trias at that place, I have been long in doubt whether it really came from the New Red or from the shale underneath. At Polsloe Road the wells are from 20 feet to 30 feet deep, and yield an average supply of water, but, as I am told, not much in excess of the wants of the owners thereof. Mr. Hitt, of Heavitree, told me a few days ago that there was a well 100 feet deep in the New Red at the corner of the road leading from Magdalen Road to the Barnfield, and, although at so great a depth, there was scarcely any water.

5th. But to be more comprehensive it may be briefly stated that a line drawn from Taylor and Boxley's iron foundry in Commercial Road to Lion's Holt, thence to the Blackboy Turnpike Gate, will describe the boundary line between the shillet and the Trias. In other words, the half of the city on the north and west sides will be altogether on the shillet, and that on the south and eastern portion will be on the New Red; but, necessarily from its conjunction with the shale, there will be no considerable depth of New Red except at some distance from the city.

My conclusions are, first, that in and around Exeter natural underground basins for the collection of water are not likely to be met with, and that the improbability is rendered greater by the presence in the very heart of the city of an extinct volcano, which has considerably upheaved the beds and broken them in almost every conceivable variety of manner. 2nd, that the depth at which water can be obtained in the shale, indeed the finding of water at all in any large quantity, is so uncertain as scarcely to justify the expenditure necessary for an experiment. 3rd, that the New Red on the south-eastern side of the city being so thin, and the surface configuration of this part of the city unfavourable to the collection of a large quantity of water, I am unable to believe that water in anything like a large supply can possibly be obtained at a nearer point than the lower part of Heavitree, about one mile and a half from the centre of the city.

THOMAS ANDREW, F.G.S.

MR. MARTIN, C.E., said that, as a citizen, he desired to say that they ought to feel greatly obliged to Mr. Andrew for the light he had thrown on the subject. They had been reminded from time to time that there was a report by a distinguished hydraulic engineer which recommended them to search for water immediately under their feet. That report had not been published. He thought it a pity that they should be so often reminded of this without their knowing its tendency. He quite endorsed the remarks as to the supply of water at Lion's Holt. Mr. Andrew did not say in direct terms, but left them to infer, that the water issued from the carboniferous mass and simply oozed out through the new red in the lower part of the valley. He had under consideration the boring of a deep well at Teignmouth, and on making inquiries as to the boring of wells, he was surprised at the result. Two cases were mentioned by Mr. Andrew. At Exminster the boring was made in the new red sandstone, and then they had to go to a great depth into the carboniferous shale. He mentioned the depths of the wells in several places to show to what extent they had to bore, viz., at Exminster, 473 feet; at Crediton, 246 feet; at Silverton, 257 feet; Topsham, 220 feet. If they had to go to such a great depth they would have to pump it up at some cost. They were told from time to time that there was abundance of water at Lion's Holt to supply the city. People imagined that because there was water upon the surface there was an inexhaustible supply underneath. Some time ago he was asked to go to Marypole Head and report on a supply there. A report from a gentleman who signed himself 'C.E.,' stated that there was abundance of water on the top of Marypole Head. He went there, but declined to report, as there was not enough to report on. There was just enough water to flow through an inch pipe.

Mr. Parfitt said they must bear in mind that from the river Exe, extending about 1¾ mile in an easterly direction, was the collecting ground of the water, broken up by geological 'faults,' and he was certain that it would be impossible to collect from this land sufficient water for Exeter. Just below Polsloe Farm there was a very thin layer of the new red sandstone over the carboniferous; it lay along the whole of the valley cut by the South-Western Railway. Two gunshots beyond that, there was a cutting, where the brook had cut its way down to 30 feet or 40 feet, and this showed that it was 'faulted' against the carboniferous. It held the water in this particular place for what was called St. Ann's Well. There was no other place where there was anything like a supply for a large city. At Heavitree Brewery the well was 375 feet deep, and as it did not yield a sufficient supply it was intended to sink it to a depth of 400 feet, to ascertain if it would yield more water. In his opinion, the ground all round about Exeter, within the collecting area, with a diameter of about two miles, was so 'faulted' that it was not likely that water would be obtained from it in sufficient quantity for the city of Exeter.

Mr. Bodley had been told that in Exeter they had an imaginary supply of water immediately beneath their feet; but having been engaged in connection with the large pumping wells in the neighbourhood, he could refute that piece of imagination. The local papermakers, in an endeavour to compete with the Kent papermakers, tried three wells at Exeter, but the water was unsuitable for papermaking. At Huxham and Heavitree wells were bored with the same result. At the Lunatic Asylum at Exminster there were wells 114 feet and 120 feet deep.

Mr. Parfitt: 375 at Exminster.

Mr. Bodley maintained that his figures were correct. He had been unable to find such a bore as 375 feet at Exminster. In that neighbourhood the wells did not supply anything like the quantity of water they were supposed to do. As to the St. Thomas water-supply, the well first went through the top soil, then through 9 feet or 10 feet of gravel to the shillet. No water was obtained from the gravel to the shillet; all that was obtained was from the gravel, a quantity so small as to be unappreciable. It was foolish of the citizens to attempt to sink a well—unless, indeed, they went to an enormous depth. There was

no percolation through the shillet from which they could get the water. At the brickyards a sufficient supply of water could not be obtained from the wells to saturate the clay for making into bricks.

Dr. Carpenter said that the water he had had since he came to Exeter had been very good so far as its appearance went, and he should be satisfied with it if the source were not polluted. He understood that this was obtained from their natural source, the collecting ground which nature had provided for the city of Exeter. The citizens of Exeter would not have far to go for a water supply, for nature had provided them with a collecting ground in their neighbourhood, the overflow of which went into the river. It was very wrong of the authorities to allow such rivers to be defiled, as they ran from their pure source. It was morally and physically wrong on the part of any local authority to pour into those rivers the sewage of their towns in the unpurified state in which it was poured into their rivers, and as he knew that it was poured into the river at Exeter. They should compel the authorities in the higher part of the district, as well as those nearer Exeter, to refrain from polluting the river, and then there would be an abundant supply of good water. Providence had some other object in providing rivers than—as a gentleman once said he regarded them—for the supply of canals or to build our towns upon. The rivers never failed, and were provided for our supply of water; and the lake districts were intended to provide for the great centres of population that which they want, pure water. If the law were carried out properly, there would be no deficiency in the water supply for the city of Exeter.

Mr. Rawlinson said this was essentially a local question. Whether water could be got in sufficient quantity from wells could only be tested by the fact of its being got. It was no use to speculate, geologically or meteorologically; and after the evidence they had heard it was not very encouraging for them at Exeter to go to a large expenditure in the endeavour to get a water supply from that source. Liverpool and Manchester, once supplied from wells, had had to give them up and go beyond. Wolverhampton had had to go outside and get water *plus* the wells. Birmingham had also to supplement its wells. New York had had to do the same. Many persons, and perhaps there were some of them here, were so stubborn that the Archangel Gabriel would not be able to convince them to the contrary if they had once got it into their crotchetty heads, that they had only to sink a well and get water—leading the Town Councils into expenditure because they would listen to neither rhyme nor reason. They declared that water could be got, and they induced Town Councils to expend money because they thought that the water ought to be got. It was important that Exeter should not be led such a dance. Others said, 'Go deep enough, and you are sure to get water.' Those gentlemen showed that they knew nothing of the crust of the earth. In Yorkshire there were mines of from 1,000ft. to 2,000ft. in depth, and he did not know any mine exceeding 1,000ft. deep which did not go below the water-bearing strata, so that they had to send down water to water the subterranean roads. Bath stood upon the oolites, and its hot water was got from the stratification.

Buxton and Matlock stood on the limestone. All limestones were fissured. Rain was the purest water. It filtered into the cracks or fissures, combined with the lime and took away the bicarbonate, until ultimately we had the surface water, after descending in a syphon to perhaps 5,000ft. or 6,000ft., coming up to the surface. There was nothing magical about it. If they attempted at Exeter to get water from the new red sandstone, they would fail; as, judging from the geological 'dip,' as now exhibited in the diagrams, it all went away, although he could not say where it went to. But there must be places, not very far distant, where they could get a good supply, if the river was not satisfactory. He would recommend the Town Council, before expending any money on well-sinking, to obtain the Sixth Report of the Rivers Pollution Commission, which contained more information on wells, well-boring, and analyses, than any he knew; and if their member, Mr. Stafford Northcote, would get them a copy of that report, they might study it with great advantage.

Mr. Symons wished to scold the Devonshire people. The Devonshire Association for the Advancement of Science, of which all England was proud, had a branch devoted to Meteorology; but it seemed that their efforts in the direction of Meteorology were going to collapse, and that was not creditable to Devonshire. It was one of the illustrations of the contact of science and practical life. In reference to the subject of the paper, Mr. Rawlinson had epitomised for them the experience of other places. Some people liked to buy their experience. He advised Exeter not to do so, in regard to sinking wells for water. No matter how much sewage might be purified, he did not like the idea of drinking the water after it came from the sewage farm. He should infinitely prefer going to those glorious moors and taking the water, which was perfectly pure, only tinged with a little peat, which was absolutely harmless. Whatever engineer might be employed, he would be to a great extent blindfold if he went to Dartmoor without ascertaining the rainfall, while the expenditure of a trumpery sum, perhaps £20, would supply the requisite meteorological data, and might save the expenditure of thousands of pounds.

The Rev. Treasurer Hawker remarked that nobody would attempt to keep a rain-gauge on Dartmoor unless he wished to kill himself or his friends, as, for some months the centre of Dartmoor was inaccessible. The only means of obtaining meteorological information would be by sending out relays of convicts.

Mr. Symons could not understand why Dartmoor should be worse than Helvellyn, Skiddaw, Scawfell, Birkside, and other mountains in Cumberland, on all of which records were kept.

Mr. Bodley advised Mr. Symons to go across Dartmoor to Princetown and Tavistock.

Mr. Symons had spent a week at Princetown, and had placed more rain-gauges on Dartmoor than all the Devonshire gentlemen put together. He wished they would give him their co-operation.

Mr. Grantham had just completed some well-borings in the tertiary, in the endeavour to get down to the greensand, under the supposition that they would get a larger and better quantity of water than from the chalk. In boring they found that they completely tubbed out the vein which contained the water in the chalk. In Devonshire it would be almost impossible to calculate where they would get water from subterranean wells; and with the geological formation represented, to be supplied with subterranean wells was not to be expected. The Dartmoor supply, if it could be got, would be a very simple thing.

Mr. Parfitt would endeavour, as one of the members of the Devonshire Association and connected with its meteorological branch, to rub out Mr. Symons's stigma of want of interest in meteorology. The Meteorological Society had undertaken to take all the rain-gauges into their keeping. It was not considered advisable that the Meteorological Society and the Devonshire Association should be working on the same ground; and, although they were very reluctant to do so, the Devonshire Association gave up the maintenance of the rain-gauges. He hoped that Mr. Symons would lift the veil of mystery which seemed to hang over the proceedings of the Meteorological Society in connection with this subject. As to the Dartmoor supply, on Dartmoor in the summer he had seen the streams dry, except in the pools, and at Totnes he had taken samples of water like Dublin stout.

Mr. Rawlinson said this showed how dangerous it was to speak without book. If anyone said it was useless to attempt to get water because he saw none when the streams were dry in the summer, it showed that he knew nothing about it. It was for the engineer to step in and provide reservoirs in which to store the water, except where they had rivers like the Lea and Thames, which supplied the 155,000,000 gallons a day pumped into London.

Mr. Symons said that he was the President of the Meteorological Society, to which these stations were proposed to be entrusted, and he thought it a very singular thing that the Devonshire Association should wish to drop their supervision and quietly hand it over to them. He explained that the Meteorological Society did not desire to monopolise the work, but wished that the Devonshire Association should render its energetic co-operation.

Mr. C. Fox (Wellington) suggested that if Dartmoor could supply Plymouth, certainly it should supply Exeter. He also recommended the perforation of Haldon.

The President, as a geologist, had no hesitation in saying that the author of the paper was abundantly justified in the advice which he had given. Strata like that at Exeter, could not have a water-bearing power. If the Exe were purified as nature made it, there would be no difficulty in the supply of water to the city.

The Mayor of Exeter, in moving a vote of thanks to Mr. Andrew, said that it was fortunate for the citizens that the discussion had been raised. After the opinions expressed by Mr. Rawlinson and Mr. Symons, instead of wasting time on impracticable schemes, Exonians should now set to work and call upon the towns on the banks of the Exe to stop the flow of sewage into the river.

Mr. Grantham said that Mr. Andrew had contributed a highly valuable paper for the inhabitants of Exeter, and the evidence which had come out had proved what the author had advanced.

Mr. ANDREW, in acknowledging the vote of thanks, remarked on the suggestion that Haldon should be perforated, that he did not believe it would be advantageous, judging from the surface configuration.

The PRESIDENT observed that there was a supply of water on the west side of Dartmoor, and he had very little doubt that there was a similar supply on the east side, which he should recommend to be tried. The President said that since the discussion of Mr. Andrew's paper he had received a letter which Mr. Symons would read.—The communication was from Dr. BANKART, who wrote that as he had only heard part of the paper read he was unable to say then what he wished to be said. The fact was that though, before the purchase of the Water Works by the city, a great outcry was made against the impurity of the water as now supplied, yet, since the purchase, the question of impurity appeared to be ignored. The quantity had been improved, and he believed the Council were anxious to do their best for the town, but they were afraid to meet the popular outcry against spending money. As the chief question with them was one of rates, they required the support of a powerful body like the Sanitary Institute to enable them to do their duty. In spite of analysis, there was the well-known fact that at one spot there was daily poured into the Exeter water supply the excreta of 10,000 people, with their diseases, not to mention the sewage of the smaller towns and villages, and the drainage of land along the twenty miles of river. The Institute would confer a lasting benefit upon the citizens if it would record its opinion that the city authorities were leaving undone a very important duty so long as they failed to give the citizens a constant supply, the quality of which should be above suspicion.

On the Sanitary Condition of Wells in Exeter and Neighbourhood.

THIS is not the first time that the wells situated in or near Exeter have formed a theme for writing or discussion. In Dr. Shapter's 'Climate of the South of Devon' is an interesting account of many of the natural springs and wells of the neighbourhood, and in the 'History of the Cholera in Exeter,' by the same author, the closing of certain wells of the city, which at that time were considered impure, is mentioned. In older works, too, devoted to the doings of ancient Exeter, frequent allusions are made to the then important subject—the maintenance in proper condition of the wells of the city.

The aim of this short paper, however, is not so much to deal with their past history as to show the connection existing, or which is frequently established, between health and disease by means of wells (often nothing but mere pits for the reception of drainage water and contaminations of the worst kind), to show that it is often best—putting a new construction on an old adage—'to leave the well alone.'

To paraphrase the words of a distinguished chemist, what people had to find out for themselves by long and perhaps hazardous experience it is the lot of the analyst in these days to do for them, and in this capacity I have had the opportunity within the last few years of examining many wells, both in the city and out of it. The analyses now placed before you are selected from the worst and the best specimens of water analysed.

The first on the list is from a farm not far from Alphington. The water had been used freely for drinking, for household purposes, for the cattle, for washing butter, &c. Ill-health prevailed. The means of getting a good supply was suggested—viz. to sink a well in the sandstone far away from the present source of contamination (the farmyard). This advice was acted on, good water was obtained, and with it improved health to the inmates of the farm.

It will be observed that for the estimation of organic matter the ammonia process has been adopted. It has many detractors, but it still holds its own, and for sanitary purposes it is very convenient. It has its faults undoubtedly, but where is the process that is perfection?

To pronounce on a water, however, merely from the determination of one constituent, would be folly. Many of the most impure waters figuring in the above table may thus be made to pass muster. Whatever method is used, each figure in the analysis must have its signification, and it is only by a careful study of the whole that the analyst is led to a correct conclusion.

In example No. 1 the free ammonia vastly preponderates over the organic, while the chlorine is also high; the water evidently belongs to the ureal class, and fresh sewage is constantly percolating to the well.

The next examples (Nos. 2, 3) are from the village of Alphington, where it appears the drinking water is far from good. The analyses are from a couple of wells situated very near each other. They resemble each other closely, both showing a large proportion of nitrogen as nitrates and nitrites.*

Of the water of St. Thomas I have, unfortunately, no examples.

At Topsham, on the other side of the Exe, we find that the wells near the river are extremely foul, but in higher situations there is good water. Cases of fever are, I believe, not unfrequent in the lower regions, brought on without doubt by drinking the river impurities

* Since writing the above, I have been informed that these wells are not far from the churchyard.

which have filtered through to the wells. The analysis No. 4 is that of a horrible specimen; the water contained so much salt as to taste of it.

Coming nearer to Exeter on the Topsham Road, about half a mile from the city, there is Parker's well, formerly in estimation as a holy well. Whether the small proportion of iron it contains really did act beneficially on the pilgrim's sight, or whether it was merely the invigorating walk and the coolness of the water, is open to question. However, analysis shows it in a favourable light. The water is clear as crystal, and contains but few impurities past or present.

Just below this well, and close to the river, is one which is rather notorious—a well, from which it was proposed at one time to draw a supply for the city, and which has been stated to be artesian. This assertion has evidently been founded on an observation by Sir H. De la Beche (see 'Geol. Report on Devon and Cornwall,' page 116), but the frequent disturbances of strata which have taken place in the neighbourhood of Exeter entirely preclude the idea of an arrangement favourable to the sinking of an artesian well. The boring is stated to be less than 100 feet deep, and the supply constant; but that it is derived from a distant outcrop and filters through the sandstone is impossible. This statement is confirmed by the analysis, for water that had filtered through such a depth of sandstone could not contain so large an amount of organic matter. It would have been almost entirely oxidised. Its bright and sparkling appearance is deceptive, for looked at through a deep stratum it is turbid and has a tint of yellow. Much of it, doubtless, is river water that has found its way through natural crevices in the rock, and the organic matter shown here as organic ammonia is the remains of Exeter sewage. This is not the only analysis that has been made of this water. One eminent authority gives it as his opinion that 'it is more suited for irrigation than for drinking.'

But a short distance from Parker's well we come to examples which show how the abominable system of dealing with sewage by water ruins wells, for in St. Leonard's are wells which have been spoiled in this way. Both the organic ammonia and the chlorine in Nos. 8 and 9 show that the water is filthy, and from its use fever has resulted.

No. 10 is a specimen of fairly good water from the same district, and not 200 yards from the contaminated wells.

We now go towards Pennsylvania. At Edgerton Park and at the terrace above, good water is found, but at a villa below it is unfit for use, the drainage being defective. The Lion's Holt supply has long been known as superior. The well of St. Anne was formerly *the* supply of Exeter. In the history of the cholera in Exeter is a note stating that 'as early as 1221 this water was brought into the city from its present sources in the upper part of the parish of St. Sidwell, and delivered by a conduit erected in the centre of the High Street below the Quatrefois.' In 1346 it is mentioned as 'conveyed into St. Peter's yard,' 'whence,' Dr. Oliver informs us, 'it branched into three channels, one for the use of the members of the cathedral, another for the city, and a third for St. Nicholas Priory.' During the cutting of the

London and South Western Railway the springs were seriously damaged, but even now the water brought down to the city and the cathedral is supplied as in olden time. Analysis No. 14 proves it to be a good, cool, pleasant water, showing but little organic matter.

Rather above this well, in Well Lane, just under York Buildings and close by the St. Sidwell's Churchyard, is a public well, which in 'days gone by' was doubtless as pure as the fount of St. Anne. It has, however, lost its reputation and is now closed. Analysis No. 16 shows it to be teeming with impurities. As I have noticed the boys of the school opposite filling their hands or their caps with water from the pump and drinking therefrom, I have been unable to resist the conclusion that their drink might very probably consist of a solution of ancient parishioners, and that possibly they would pay for their draught by a serious attack of illness.

In the high ground of Polsloe Road the water, as may be expected, is naturally good, but the devices of man tend to contaminate it. In analysis No. 18, traces of recent contamination having been discovered, the well was examined and a dead cat was pulled out.

At Heavitree Bridge, very close to the brook flowing by the little village of East Worford, is a spring which Jenkins, in his 'Memories of Exeter,' tells us, 'from an iron ladle formerly fastened to a chain to the wall for the benefit of passengers drinking, obtained the name of Iron Dish.' Analysis No. 19 shows the water is still good. The brook is now nothing better than an open sewer, giving off its foul emanations and poisoning the air of one of the most beautiful walks in the neighbourhood, viz. the Worford Fields. Of city wells but little of good can be said; the soil there is saturated with impurities which find their way into the wells. 'Beautiful water and preferred to any other' is said of many a specimen which when analysed proves to be a mass of corruption, and on inquiry it has generally been found that, if there has not been fever, the people using it are what is called 'ailing.' Not one of the old public wells within the city yet examined yields good water. Formerly they abounded; every street had its pump. The Palace Street pump was one of the last to be closed. From these examples, then, it will be evident that nature supplies the provinces with good water, for on every side of the city, be it from the red sandstone or from carboniferous strata, favourable analyses are obtained. It is only when by defective drainage the ground is given too much to do, when from the excess of impurities with which it is loaded it is unable to perform the office of purification appointed to it, that we find unwholesome water, and this cannot be remedied until the system of *dealing with sewage by means of water* is finished with. Then, and not till then, may we who live in cities hope to drink water rendered healthful by Nature's own filtration.

FRANK P. PERKINS,
Public Analyst for the City of Exeter.

Composition of Various Waters.

No.	Description	Total solid matter	Free Ammonia	Organic Ammonia	Nitrogen as Nitrates and Nitrites	Organic Nitrogen	Inorganic Nitrogen	Total combined Nitrogen	Total Chlorine	Chlorine calculated as Common Salt
1	Farm near Alphington	—	·105	·033	·366	·0271	·696	·7231	9·3	15·3
2	Alphington . . .	45	·0025	·0083	1·09	·0068	1·092	1·0989	4·0	6·59
3	" . . .	47	·001	·008	1·09	·0065	1·0908	1·0973	6·5	9·34
4	Topsham . . .	50	·0026	·0044	·443	·0036	·4151	·3667	6·7	9·39
5	" . . .	186	·0106	·012	2·08	·0345	2·0887	2·1233	40·5	66·6
6	Parker's Well . .	45	·0036	·0022	·362	·0018	·3619	·3667	4·8	7·9
7	Trew's Weir . .	78	·0106	·0174	1·01	·0143	1·0187	1·033	6·5	1·07
8	St. Leonard's . .	82	·008	·004	·792	·0033	·7986	·8018	8·0	13·1
9	" . .	78	·0106	·0187	·757	·0151	·7637	·7811	15·0	24·7
10	" . .	55	·0053	·0047	·549	·0038	·5333	·5572	3·2	5·27
11	Pennsylvania . .	—	—	·007	·256	·0057	·256	·2617	3·9	6·42
12	" . .	—	·001	·006	·290	·0019	·2908	·2957	2·6	4·28
13	" . .	128	·0665	·0135	·44	·0111	·4947	·5058	42·0	69·2
14	Lion's Holt . . .	—	·004	·0074	·236	·0061	·2393	·2454	5·7	9·39
15	" Cathedral School	—	·0013	·006	·445	·0019	·446	·4509	5·6	9·22
16	Well Lane Public Pump	—	·078	·0225	·313	·0191	·3711	·3902	9·0	14·84
17	Polstoe Road . .	—	·0015	·0665	·321	·0053	·3222	·3275	4·6	7·6
18	" . . .	45	·0532	·010	·548	·0082	·5918	·600	2·4	3·95
19	Heavitree . . .	42	·001	·0012	·579	·0034	·5572	·5606	3·0	4·9
20	City Wells, High St. .	136	·0053	·0125	·900	·0103	·9043	·9176	12·3	20·1
21	" Fore St. .	90	·260	·0266	·5476	·0219	·7616	·7835	17·2	28·3
22	" Palace St. (P. P.)	—	·006	·0118	·428	·0037	·4329	·4126	16·5	27·22
23	" Frog St. .	43	·008	·005	410	·0041	·4466	·4507	5·7	9·39
24	" Fuernhay St.	20	·0027	·0103	214	·0084	·2162	·2246	1·2	1·93

Mr. Parfitt considered this paper a most important one, and, taken in conjunction with that of Mr. Andrews, it should have considerable weight in the Town Council in the discussion of any proposition brought before them for the supply of water.

Mr. Grantham said that when he heard that the wells were 24 feet or 25 feet in depth, he suspected that some of them must be in a dangerous state. With so slight a depth it was almost impossible to avoid pollution, which could only be done in wells at a great depth. He was not at all surprised to find the results indicated by Mr. Perkins after hearing Mr. Andrews' paper. As to the well particularly near a churchyard, common sense would tell them that its pollution could be fairly traced to its source. No one in his senses would sink a well near a churchyard or a slaughter-house, or in the precincts of a town where pollution could come to it.

Mr. Symons said it was not everybody who knew that churchyard water was bad. At Cromer a few years since he was recommended to try the water at a stationer's shop, as he and his wife were rendered ill by the ordinary supply. He got some out of curiosity, and found it bright and sparkling; but the stationer's shop was next but one to the churchyard, and the sparkle was the lure of death.

The President concurred, and said that the London pumps in Bishopsgate and Moorgate, to which the City bankers and merchants used to send for water for their luncheon, had been removed since

the demonstration that churchyard water is so bad. It was very bright and refreshing, although so deleterious, for the salts that it contained gave it the bright and sparkling appearance.

Some Deficiencies in our Knowledge Respecting Health Resorts.

The remarks which I have to offer upon the present occasion differ materially in their character from those which are assumed to usually form the basis of those submitted to scientific bodies.

As a rule, an author reads a paper in order to bring before his audience, and perhaps still more before that far larger audience which he addresses through the press, something which he believes to be new, something which he hopes will make the world wiser and better than it would be without it.

I am aware that there are persons who read papers with the sole desire to see their names in print, and others who do so to puff the commodities in which they deal—but they are beneath notice.

The usual object of a paper is, then, to afford information. But mine is to obtain it, and although perhaps I shall give a little in the mere explanation of what I want, still I hope that the balance will eventually be largely in my favour, and that is why the title of this paper does not promise any information at all.

It has lately been said, and I think with truth, that whereas in past years the Autumn holiday was a *luxury*, it has, through increasing exhaustion due to modern high pressure, become a *necessity*.

Assuming that to be true, it is obviously of increasing importance that the localities to which we temporarily migrate should be as healthy as they can be made.

And here it may be as well to remark that the visitors are better judges of what is healthy than the residents. Those who spend the whole twelvemonth on a bracing mountain slope cannot realise that it matters whether the bedroom windows open at the top or not; and, as sleeping in a close room does not affect them, they set any remonstrance down as a whim of their visitors, forgetting that it is the constant breathing of a pure atmosphere during the day and all through the year which enables them to sleep in a used-up atmosphere with impunity—and equally forgetting that it is largely for the sake of pure air that their visitors come, that where they get most pure air they will derive most benefit, and will therefore be most likely to come again

I have quoted only one feature—windows; but need hardly say that identical reasoning applies to cleanliness in every respect—to purity of water, to the quality and cooking of food, and, indeed, to all the ministrations of life.

This digression has taken me far away from the subject I wish to bring before you. I must return abruptly, and try to keep closer to it.

I am far from denying that, in spite of the very unsanitary—and, to our notions, offensive—arrangements existing at many places on the Continent, it is often better for persons to go to a continental health resort than to stop in the United Kingdom, because the change of air, scene, habit, and language is much greater. Yet, I believe, it would be far better to bestow more attention on our own health resorts than we do.

And I think that few persons have the least idea of the number of the mineral springs and sea-bathing places in the British Isles. Many years ago, when investigating the rainfall at some of our health resorts, I compiled a list of those that I then knew of. The total number was rather more than three hundred, but having learnt of several since, and made the list far more extensive than any that I have ever seen, I have inserted it in this paper in the hope that it may prove an acceptable contribution to our Transactions.

At the outset, however, it is necessary to consider what constitutes a health resort. The definition is by no means easy. Are all places where mineral springs exist to be called health resorts? If so, scores of places where there is not the slightest accommodation for visitors, and of which 999 persons out of every 1,000 have never heard, must be included. Are all seaside towns and villages to be considered health resorts? Some of them are, I fear, far from being either salubrious or adapted for receiving visitors. Are we to exclude all places which have neither mineral springs nor sea bathing? If so, we must exclude some localities which are extremely well adapted for the restoration of persons suffering the penalty of 'life at high pressure.'

I think that in this matter, as in most others, no hard and fast line is possible, and the course which I have adopted is, therefore, an intermediate one.

There are yet a few other prefatory remarks. The places are arranged alphabetically. The prefix M denotes that a mineral spring exists there, except when the **M** is substituted for M, in which case I have reason to believe that, as at Bagnigge Wells, Hartlepool, and other places, the spring has been lost. The prefix S denotes a seaside resort, and in most cases one with bathing accommodation.

I shall be much obliged to anyone who will enable me to correct this table, by sending me statements of facts *within his own personal knowledge.* I do not wish for second-hand information.

S	Aberayron	Cardigan
S	Aberdeen	Aberdeen
S	Aberdour	Fife
S	Aberdovey	Merioneth
S	Abergele	Denbigh
S	Aberystwith	Cardigan
M	Acton	Middlesex
M	Admaston	Salop
M	Airthrie	Stirling
S	Aldborough	Suffolk
S	Alderney	Alderney
M	Aldfield	York, W.R.
M	Alford	Lincoln
M	Alford	Somerset
M S	Arbroath	Forfar
S	Ardrossan	Ayr
M	Ashby-de-la-Zouch	Leicester
M	Ashtead	Surrey
M	Askern	York
M	Astrop	Northampton
M	Axwell	Durham
M	Bagnigge Wells	Middlesex
M	Baillieborough	Cavan
M	Ballycastle	Antrim

M	Ballynahinch	Down
M	Ballyspellan	Kilkenny
S	Banff	Banff
S	Bangor	Carnarvon
S	Barmouth	Merioneth
M	Barnet	Herts
M	Bath	Somerset
S	Beaumaris	Anglesea
M	Belturbet	Cavan
	Ben Rhydding, *see Ilkley*	
M	Beulah	Surrey
S	Bideford	Devon
M	Bilton	York, W.R.
M	Bircham	Berwick
S	Blackpool	Lancaster
M	Block	Dumfries
S	Bognor	Sussex
M	Bonnington	Edinburgh
S	Borth	Cardigan
M	Boscombe	Hants
M	Bourne Moor	Durham
M S	Bournemouth	Hants
S	Bray	Wicklow
M	Brentwood	Essex
	Bridge of Allan, *see Airthrie.*	
	Bridge of Earn, *see Pitcaithly.*	
M S	Bridlington	York, E. R.
M S	Brighton	Sussex
M	Bristol	Gloucester
S	Broadstairs	Kent
M	Bromley	Kent
M	Brough	Westmoreland
M	Broughton	York, W. R.
S	Broughty Ferry	Forfar
M S	Buckie	Banff
S	Budleigh Salterton	Devon
M	Buglawton	Chester
M	Builth	Brecknock
S	Bundoran	Donegal
S	Burghead	Elgin
S	Burntisland	Fife
M	Butterby	Durham
M	Buxton	Derby
M	Candren	Renfrew
M S	Carrickfergus	Antrim
S	Cartmel	Lancaster
M	Castle Comer	Kilkenny
M	Castle Connel	Limerick
M	Chapelizod	Dublin
M	Cheltenham	Gloucester
M	Cherry Rock	Gloucester
M	Chigwell Row	Essex
M	Chippenham	Wilts
S	Cleethorpes	Lincoln
S	Clevedon	Somerset
M	Clifton	Gloucester
M	Clitheroe	Lancaster
M	Closeburn	Dumfries
M	Clunie	Perth
M	Cobham	Surrey
M	Codsall	Stafford
M	Colchester	Essex
M	Coldbath	Middlesex
S	Colwyn	Denbigh
	Cootehill, *see Drumgoon.*	
M	Corstorphine	Edinburgh
S	Cove	Cork
M	Crickle	York, W. R.
M	Croft	York, N. R.
S	Cromer	Norfolk
M	Cronebawn	Wicklow
M	Culgask	Perth
M	Cumner	Berks
S	Cushendall	Antrim
S	Cushendun	Antrim
S	Dawlish	Devon
M	Delamere	Cheshire
M	Dinsdale Spa	Durham
M	Dog and Duck	Surrey
M	Dorton	Bucks
S	Dover	Kent
S	Dovercourt	Essex
M	Drigg	Cumberland
M	Droitwich	Worcester
M	Drumgoon	Cavan
M	Drumsna	Leitrim
	Dulwich, *see Streatham.*	
M	Dunblane	Perth
M	Dungannon	Tyrone
S	Dunmore	Waterford
M	Dunse Spa	Berwick
S	Eastbourne	Sussex
M	Epsom	Surrey
M	Eskdaleside	York, N. R.
M	Ewell	Surrey
S	Exmouth	Devon
S	Felixstowe	Suffolk
M	Felstead	Essex
M S	Filey	York, E. R.
M	Fir Hill	Aberdeen
S	Fishguard	Pembroke
S	Fleetwood	Lancaster
M S	Folkestone	Kent
M	Gainsborough	Lincoln
M	Gethlyonen	Glamorgan
M	Gilcomston	Aberdeen
M	Gilsland	Cumberland
M	Glastonbury	Somerset
S	Glenarm	Antrim
M	Glendy	Kincardine
M	Gloucester	Gloucester
S	Gourock	Renfrew
M S	Grange	Lancaster
S	Guernsey	Guernsey
M	Guisborough	York, N. R.
M	Gunfreston	Pembroke
M	Hail Weston	Hunts
M	Hampstead	Middlesex
M	Hanley's Spa	Salop
M	Harlow Carr	York, W. R.
M	Harrogate	York, W. R.
	Hartfell, *see Moffat.*	
M	Hartlepool	Durham
S	Harwich	Essex
M S	Hastings	Sussex
S	Helensburgh	Dumbarton
S	Herne Bay	Kent
M	Hockley	Essex
M	Holbeck	York, W. R.
M	Holt	Wilts
M	Holt	Leicester
M	Holywell Spa	Lancaster
M	Horley Green	York, W. R.
	Hotwells, *see Clifton.*	
M	Hovingham	York, N. R.
M	Hoxton	Middlesex

S	Hunstanton . . .	Norfolk
M	Hyde	Gloucester
S	Hythe	Kent
S	Ilfracombe . . .	Devon
M	Ilkley	York, W. R.
M	Ilmington . . .	Gloucester
M	Innerleithen . .	Peebles
M S	Inverkeithing . .	Fife
M	Ipswich	Suffolk
M	Islington	Middlesex
S	Jersey.	Jersey
M	Johnston	Kilkenny
M	Joppa	Edinburgh
M	Kedlestone . . .	Derby
M	Kensington . . .	Middlesex
M	Kilburn	Middlesex
M	Kilburn	Dumfries
M S	Kilkee	Clare
M	Killymard . . .	Donegal
M	Kilroot	Antrim
M	Kincardine . . .	Kincardine
M	Kinghorn . . .	Fife
M	King's Cliffe . .	Northampton
M	Kinoulton . . .	Nottingham
M	Knaresborough	York, W. R.
M	Knaresdale . . .	Northumberland
M	Krevenish . . .	Fermanagh
S	Largs	Ayr
M	Lathom	Lancashire
M	Leamington. . .	Warwick
S	Lehinch	Clare
M	Lees	Lancashire
M	Lewes	Sussex
	Lewisham, *see Streatham.*	
M	Lisdoonvarna . .	Clare
S	Littlehampton . .	Sussex
M	Llandegley . . .	Radnor
M	Llandeinislen . .	Carnarvon
M	Llandrindod . .	Radnor
S	Llandudno . . .	Carnarvon
M	Llangammarch	Brecon
M	Llangybi	Carnarvon
S	Llanstephan . .	Carmarthen
M	Llanwrtydd . . .	Brecon
S	Lossiemouth . .	Elgin
M	Lough Lea . . .	Cavan
S	Lowestoft . . .	Suffolk
M S	Lucan	Dublin
S	Lyme Regis . . .	Dorset
S	Lynmouth . . .	Devon
S	Lynton	Devon
S	Lytham	Lancaster
M S	Mallow	Cork
M	Malton	York, N. R.
M	Malvern	Worcester
S	Margate	Kent
M	Markshall . . .	Essex
M	Matlock	Derby
M	Melksham . . .	Wiltshire
M	Middleton . . .	Durham
	Middleton, *see Stony Middleton.*	
M	Middleton . . .	Carmarthen
M	Middlewich . . .	Cheshire
S	Miltown Malbay	Clare
S	Minehead . . .	Somerset
M	Minty	Gloucester
M	Moffat	Dumfries
S	Morecambe . . .	Lancashire
M	Muirtown . . .	Ross
S	Mumbles	Glamorgan
S	Nairn	Nairn
M	Nantwich . . .	Cheshire
S	New Brighton . .	Cheshire
S	Newcastle . . .	Down
M	Newent	Gloucester
M	Newnham Regis	Warwick
M	Newtondale . . .	York, N. R.
M	Normanby . . .	York, E. R.
	Northaw, *see Barnet.*	
S	N. Berwick . . .	Haddington
M	Nottington . . .	Dorset
S	Oban	Argyll
M	Offerton	Durham
M	Orston	Nottingham
S	Paignton	Devon
M	Pannanich . . .	Aberdeen
S	Penmaenmawr . .	Carnarvon
S	Penzance	Cornwall
M S	Peterhead . . .	Aberdeen
M	Pitcaithly . . .	Perth
S	Portobello . . .	Edinburgh
S	Portrush	Antrim
S	Port Stewart . .	Londonderry
M	Purton	Wilts
M	Radipole	Dorset
S	Ramsgate . . .	Kent
S	Redcar	York
M	Rhydryonem . .	Merioneth
S	Rhyll	Flint
M	Road	Wilts
M	Romford	Essex
S	Rosstrevor . . .	Down
M S	Rothesay	Bute
S	St. Andrews .	Fife
M	St. Bernards . .	Edinburgh
M	St. Chad	Middlesex
S	St. Leonards . .	Sussex
M	St. Pancras . . .	Middlesex
	St. Philip, *see Yarrow.*	
S	Salcombe	Devon
S	Saltburn	York
S	Sandown	Hants
S	Sandgate	Kent
M	Sandrock	Hants
S	Sark	Sark
M S	Scarborough . .	York
S	Seaford	Sussex
S	Seaton	Devon
S	Seaton Carew . .	Durham
M	Shadwell	Middlesex
S	Shanklin	Hants
M	Shap	Westmoreland
S	Sheerness . . .	Kent
M	Shirleywich . . .	Stafford
M	Shotley Bridge	Durham
S	Sidmouth . . .	Devon
S	Silloth	Cumberland
M	Skipton	York, W. R.
M	Slaithwaite . . .	York, W. R.
M	Somersham . . .	Hunts
S	Southend	Essex
S	Southport . . .	Lancaster
S	Southwold . . .	Suffolk
M S	Spital	Northumberland
M	Springkell . . .	Dumfries
M	Starbeck	York, W. R.

M	Stoke	Surrey
S	Stonehaven . . .	Kincardine
M	Stony Middleton	Derby
M	Stony Stratford	Bucks
M	Strathpeffer . . .	Ross
M	Streatham . . .	Surrey
M	Sunninghill . . .	Berks
M	Sutton	Surrey
M	Sutton Coldfield	Warwick
S	Swanage	Dorset
M	Swanlinbar . . .	Cavan
M S	Swansea	Glamorgan
	Sydenham, *see Streatham.*	
M	Taafe	Glamorgan
S	Teignmouth . .	Devon
M	Tenbury	Worcester
S	Tenby	Pembroke
M	Tewkesbury . . .	Gloucester
M	Thetford	Norfolk
M	Thorlies Hope . .	Roxburgh
M	Thorp Arch . . .	York
M	Tilbury	Essex
S	Torquay	Devon
S	Towyn	Merioneth
M S	Tralee	Kerry
S	Tramore	Waterford
M	Trefriw	Carnarvon
M	Tunbridge Wells	Kent
M S	Tynemouth . . .	Northumberland
M	Upminster . . .	Essex
M	Vicar's Bridge . .	Clackmannan
M	Victoria Spa . .	Warwick
S	Warrenpoint . .	Down
M	Wellingboro' . .	Northampton
S	Westgate . . .	Kent
S	Weston-super-Mare	Somerset
S	Westward Ho . .	Devon
S	Weymouth . . .	Dorset
M S	Whitby	York
M	Willoughby . . .	Warwick
M	Windsor Forest	Berks
M	Witham	Essex
M	Withyam . . .	Sussex
M	Woodhall Spa . .	Lincoln
S	Worthing . . .	Sussex
S	Yarmouth . . .	Norfolk
M	Yarrow	Selkirk

I purpose dwelling chiefly upon our ignorance of the climates of the health resorts. But, before passing to that, I wish to say a few words respecting the literature of the subject. How is it that we have no standard work in which the merits and demerits of all our mineral springs, sea-side bathing-places, and health resorts are impartially set forth?

I am far from ignoring the thousands of more or less ambitious books, each demonstrating that Slowcombe-on-Sea is equally well adapted for a winter and for a summer health resort, that it possesses every natural advantage, and that the sanitary arrangements are perfect. Added to this, there is a gradually rising stream of prospectuses from so-called hydropathic establishments which, without exception, chant the praises of the places whence they emanate. But all these are necessarily, inevitably, one-sided.

And our general treatises, where are they? I may be referred to Sir James Clark's *Sanative Influence of Climate*, an excellent book for its date, but the last edition was issued thirty-four years since, and it only devotes 70 pages to British Health Resorts.

Dr. Granville's *Spas of England*, 3 vols., published in 1841, is far more voluminous, but if the gossip and verbiage were struck out, it would leave little, if any, more information than is given by Sir James Clark; and all of it, be it remembered, is forty years old.

The more recent works, though I do not wish to say anything against them, leave much to be desired. What have we to compare with Lombard's *Traité de Climatologie Médicale*, in three or more volumes? with Dr. von Graefe's *Jahrbucher für Deutschlands Heilquellen und Seebäder?* or with the sumptuous quarto published for several years in Paris with the title of *Album universel des Eaux Minerales, des Bains de Mer, et des Stations d'Hiver?*

Not one of these, however, comes up to my own idea of what is required, and, what is more practical, of what I believe it would pay to publish. In the first place, I do not think that any one person is competent to write the book. Because (and I like to prove each proposition I lay down) it would not be easy to name a person who would command universal respect as (1) a physician, (2) a water analyst, (3) a geologist, (4) a meteorologist, (5) a sanitary engineer, and (6) a statistician. And I hold that a proper, full and true report upon Scarborough, for example, ought to contain data on all these heads, and it ought to give a map (with altitudes) of each town on the scale of at least two inches to the mile, one or two views, and details of the water supply and drainage.

Let me, however, say a few words as to how I think it possible to carry out this scheme to its full extent, and to defray the cost of the, perhaps, half-a-dozen volumes which it would fill.

In the first place, everything should be done to suppress the personal element in the book. It should be brought out under the auspices of some public body—perhaps a committee comprising representatives of the leading Medical, Sanitary, and Scientific societies would command the widest respect. Then there must be one editor in chief, and sub-editors for each of the branches already named. And every paragraph throughout the volume should be initialled, so that no responsibility be shirked.

As the preliminary basis of the publication, an exhaustive series of questions (together with an explanatory note) should be sent to the official representative of each town—the Mayor, where there is one; whom failing, the Chairman of the Local Board; or, in the absence of both, the leading medical practitioner. But these statements would merely serve as a basis; there must be a personal visit by an inspector appointed by the committee, and information must be collected from all possible sources.

As regards the mineral waters, properly attested specimens must be taken of each, and all must be analysed under the supervision of a single analyst, and the results published on a uniform system.

I have not shown how the cost of this is to be met. Probably it would not be more than the sum spent yearly in advertisements by two or three of the largest hydropathic establishments. See, for instance, the hundreds of boards respecting Ben Rhydding at the railway stations throughout the country. Fifty pages of advertisements in the last volume would do no harm to the book, and there is scarcely any price per page at which it would not be profitable to the hydropathic establishments and the larger hotels to insert illustrated prospectuses.

Such a work as this would be a necessity for the consulting physician, and would be of great interest to scientific men; well illustrated, and treating as it would do of many of the most beautiful spots in our country, it would find its way into the homes of the wealthy; and, as the standard authority upon the subject, it would find a sale on the Continent, in our Colonies, and in the United States.

I am aware that I have sketched a large, and perhaps I shall be told a visionary, scheme. Be it so. There is no harm in placing upon record that which is expedient, even if we cannot carry it out at once. We have pointed out the data required, and in the course of time they will be accumulated.

And now for the Climatology. Of course, one essential feature of the work is a full report on the climate of each health resort. I am sorry to say that that is what scarcely anyone can give. This is a sweeping statement, which, of course, I must prove to be true. In the first place, to show you that this is no temporary whim on my part, I ask permission to read a paragraph which I wrote in 1866, and published in 1867 in a little book (long since out of print), entitled *Rain, How, When, Where, and Why it is Measured*:—

'It would be of immense benefit to the medical profession, and the public at large, to know with truth and absolute impartiality the relative climates of our various health resorts: but at present very little is known. There are a host of local treatises on "The Climate of Blankwater," &c., but they are mostly advocates of the place from whence they take their title. We have also some general treatises on the subject, but they are necessarily based on the returns made by persons interested in the popularity of the places in which they reside, and most of them have placed their instruments as well as they know how, but the result is diverse indeed. How, then, can the indications of their instruments be comparable? Moreover, there have been cases strongly indicating a desire to "make things pleasant," by slight departures from impartiality in recording the observations, and hence (unjustly) there is a widespread want of confidence in returns from fashionable health resorts. This should not be. Might it not be removed by the local authorities at each appropriating a small portion of open space to the erection of a set of meteorological instruments, properly verified and properly mounted, and having them regularly recorded by one or more persons? Let the book of observations be always open to public inspection, let whoever takes the observations add his initials, and let the instruments be always readily accessible on application. This proposal might cost each town £10 or so, not more, and it would soon confirm the accuracy of most of those, on all of whom the records of *some* have cast suspicion.'

The great defects of the meteorological observations of bygone years arise from the fact that the importance of absolutely identical methods of observation and record was not fully realised, or, at any rate, was not acted upon. It may have been thought that with a staff of voluntary observers it was difficult to ensure absolute uniformity, that if a paid observer breaks rules the matter is soon rectified, but that when the observer buys all his instruments, and offers of his own free will to send you copies of the observations he makes, it is less easy to obtain strict uniformity. At least, I suppose it must have been so, though my own experience of amateur observers is that they will do almost anything that they are asked. However, whatever may have been the cause, there is no denying the fact that absolutely rigorous identity in the mode of observation is of very recent date. But since getting a Royal Charter, proper offices, and a paid staff, the Meteorological Society has being doing everything in its power towards ascertaining the precise characteristics of English climate. It has now between 80 and 100 stations, with identical instruments, all mounted uniformly, all read at the same instant of local time, recorded and in every respect discussed upon a uniform system, all the instruments tested and verified, and every station visited by the Society's inspector.

A map of the stations and a set of the instruments are now before you. And from the former you will now see what is the deficiency which I wish to see rectified. Take the coast from the Thames to the Land's End. We find the following sea-bathing places without any records being sent to the Society respecting their temperature or humidity:—Herne Bay, Westgate, Margate, Broadstairs, Deal, Dover, Folkestone, Sandgate, Hythe, Hastings, St. Leonards, Seaford, Brighton, Littlehampton, Bognor, Ryde, Sandown, Shanklin, Freshwater, Weymouth, Charmouth, Lyme Regis, Axmouth, Seaton, Exmouth, Dawlish, Looe, and Penzance. Twenty-eight places on the South Coast alone, each doubtless possessing features different from every other, slight probably in some cases—as, for example, Littlehampton and Bognor—but extremely marked in others, as, for instance, Margate and Penzance, or—to take two nearer places—Ryde and Shanklin.

I started by stating that I wished to obtain rather than to afford information. Have I not finished by showing a wide field for useful work?

G. J. Symons, F.R.S.
President of the Meteorological Society.

Mr. Mitchell held that the scheme proposed by Mr. Symons was not large enough—that it was wanting in completeness. He did not think that it would be possible to obtain one gentleman who could edit the work referred to, and who could also superintend the meteorological readings.

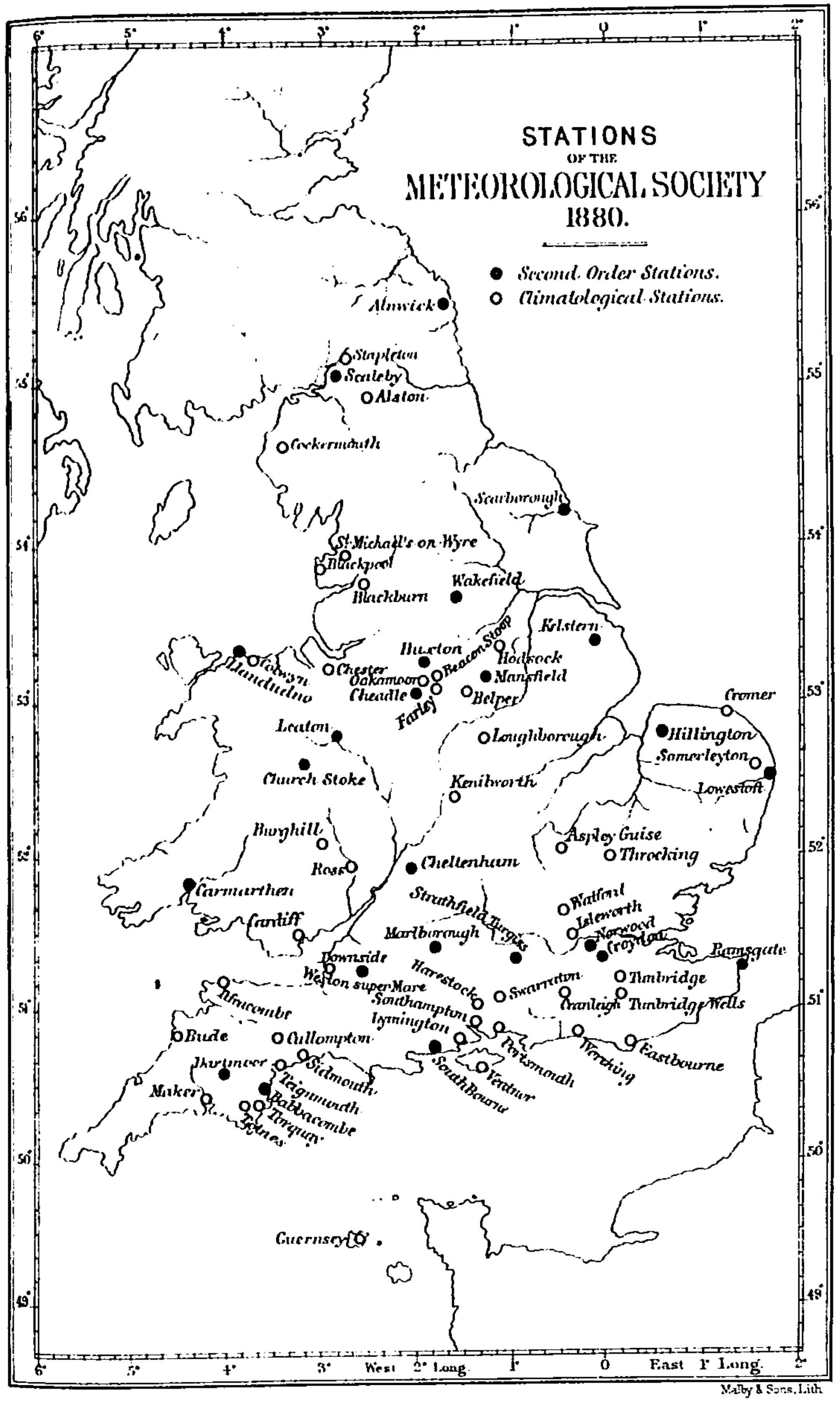
Mr. Symons replied that the qualification referred to by Mr. Mitchell was contemplated by him. (See bottom of page 249.)

Mr. Robins said it would be a great advantage to holiday seekers if they could have a report on the holiday resorts in respect to water-supply and drainage as well as climate.

A vote of thanks having been passed to Mr. Symons, he, in reply to some questions put by Mr. Parfitt, stated that though the colour in the liquid of the minimum thermometer might fade, yet the accuracy of the instrument was not lessened. The speaker also pointed out that there was room for a great deal more information being gathered about health resorts on matters of vital importance.

On the Amount of Organic Impurity contained in the Water of the Exe at Certain Points, in its Course from Tiverton to Stoke Railway Bridge, near Exeter.

Had it not been for the kind co-operation of Mr. Percy Boulnois, the City Surveyor, these experiments would not have been undertaken.



(Face page 252)

Mr. Boulnois furnished me with ten of the specimens of water examined by me, and I believe he will have something to say on their collection. I am aware that experiments such as these have been conducted before, and that attempts have been made to exhibit the rate at which the oxidation of organic matter in rivers is effected. First among such experiments are those of Professor Miller, and the observations of Professors Frankland and Tidy, in the same direction, are fresh in our minds.

For the performance of the present set of experiments I have relied on the oxygen or permanganate process, as elaborated by Dr. Tidy. The results obtained have been confirmed by evaporating (with certain precautions) a known volume of water, burning the residue, determining the amount of CO^2 evolved, and from this calculating the proportion of organic carbon. For this purpose I have employed a modification of Professor Dittmor's method, described by me in the July number of the 'Analyst.' I will now call your attention to the annexed table exhibiting the results obtained, the amount of impurity being expressed as 'oxygen consumed,' or 'organic carbon yielded,' by 100,000 parts of water. Dr. Frankland, in his new work on water analysis, has called attention to the relation existing between 'oxygen consumed' and 'organic carbon' as exhibited in the waters of the Thames and Lea. The figures obtained in these analyses confirm this relation in regard to the Exe. The constant multiplier for the conversion of 'oxygen consumed' to 'organic carbon' is found by averaging the second line of figures.

Dr. Frankland's experiments gave 2·38, while these give 2·61; the difference is probably due to less delicate manipulation on my part.

Starting a mile above Tiverton, we find the water of medium purity; No. 1 requiring ·0718 parts of oxygen to oxidise its organic matter. About 100 yards below Tiverton, after the water has been polluted by the sewage of the town, and has passed through the mills, the amount of oxygen absorbed is—as might be expected—larger, being ·0873.

At two miles below the town it is still more polluted, and the amount of oxygen it now takes is ·0929.

After flowing over a stony bottom, and just above Bickleigh bridge, in still water with plenty of weeds, we find the organic matter considerably reduced; the proportion of oxygen consumed being ·0738. Passing on to that taken below Bickleigh mill-stream, the amount of impurity again increases; for the quantity of oxygen required is ·0859. But the cause of this is at once apparent. The water of the Dart, which flows into the Exe, about one mile above the place from which the previous specimen was taken, is very foul, requiring not less than ·207 of oxygen for the oxidation of its organic matter. The water now passes over a gravelly bottom, and ripples over natural weirs, and at Bourne mills, just below the junction of the Bourne, the water becomes much improved in quality. At Thorverton it appears to be again slightly fouled, but recovers itself by the time it reaches Nether Exe, after flowing over a weir. At Stoke railway bridge the river is much deeper, and is not quite so pure.

There are two points gained in this examination.

1st. That were it not for the dirty river Dart, the water supply of Exeter would be much better than it is.

2nd. That Nature's process of oxidation, as carried on in rivers, is, under favourable circumstances, anything but slow. Let but the water tumble over a weir or ripple along a stony bed, or let there be an abundant growth of plants, and we find, even in a short course, a great change for the better. This is well illustrated in the flow of the river from the Dart to above Thorverton, where the bed is rocky.

Even at Tiverton, after the water is churned up by passing through the mills, it must come out purer than it went in; for water taken at the point where the sewage is delivered into the river would be much more contaminated.

In the deeper parts of the stream, oxidation seems not to be so rapid.

No laboratory experiment, however skilfully devised, can ever approach Nature's process. Here is a river, open to the air, and subject to the variable yet constant action of heat and light. The supply of air is unlimited, and changing momentarily; every breeze that is wafted over the surface of the river bringing the purifying oxygen in contact with the effete matter, and every ripple showing its decomposition. The constant evaporation from the surface, and the continual molecular change that thereby ensues, must be the means of breaking up organic compounds, and also aid materially in purification. The old saying, then, that 'running water purifies itself,' is true; but for rapid purification, the water must be brought into close contact with the air or with oxygen. I conclude these notes with the remark that, although the Exe is not perfection, it is not the sewer some imagine it. As it is, it bears favourable comparison with any of the rivers of the kingdom; and when its water is carefully filtered it reaches a high standard of purity.

Specimens of Water from the Exe.—Amount of Organic Impurity in 100,000 parts.

No.	Where obtained	Oxygen consumed × $\frac{C}{O}$ =				Organic Carbon yielded
1	One mile above Tiverton . .	·0718	×	2·27	=	·163
2	Below Tiverton	·0873	×	2·81	=	·216
3	Two miles below Tiverton .	·0929	×	2·93	=	·273
4	Above Bickleigh bridge . .	·0788	×	2·41	=	·190
5	*The Dart*	·2070	×	2·11	=	·436
6	Below Bickleigh mill-stream	·0859	×	3·16	=	·272
7	Bourne farm below the stream	·080	×	2·7	=	·218
8	Thorverton *above* the weir .	·0831	×	2·6	=	·218
9	Nether Exe	·080	—	—	—	—
10	Stoke railway bridge . . .	·0831	—	—	—	—
11	Dane's Castle Works . . .	·0715 }	×	2·29	=	·164
12	From service-pipe supplying laboratory	— }				

FRANK P. PERKINS,
Public Analyst for the City of Exeter.

Mr. H. P. BOULNOIS said he desired to add a few remarks in addition to Mr. Perkins's valuable paper. The samples of water to which Mr. Perkins referred were taken by him on August 16, 1880, the water in the river being abnormally low. In taking the samples he noted the velocity of the flow of the water, the character of the bed of the river, the appearance of the water, its depth, and other particulars, which he would describe. The samples were all taken from as near the centre of the river as possible, but unfortunately he had no appliance with him for registering the temperature of the water. The fifth sample referred to was taken from the stream called the Dart, near its junction with the Exe at Bickleigh Bridge, its velocity at this point being at the rate of 3·2 feet per second, depth 6 inches, the bottom, which was of a gravelly, stony nature, being covered with a slimy, dark deposit or vegetation, giving to the water a grey, dark hue. This description gave an idea of the appearance of the stream and of the small rivulets joining it for about three miles above the confluence of the Exe. This stream rose on Gibbet-moor, on the outskirts of Exmoor, and close to it rose the Little Dart, which flowed westward, but both these streams were quite distinct from the well-known river Dart, and were not to be confounded with it. The stream from which the sample in question was taken flowed S. and S. by E. till it joined the Exe. It passed, apparently, exclusively through pasture land according to the Ordnance Map, and could not receive an amount of contamination from dwellings sufficient to give it the bad character Mr. Perkins had assigned to it, no populous place being in its vicinity. The presence of such an excessive amount of organic carbon must, therefore, be due to peat. He had not yet had an opportunity of inspecting this stream throughout its entire length, but he should be now tempted to do so after hearing Mr. Perkins's paper. With reference to the attack on the water-supply of Exeter made in the letter from Dr. Bankart (See *ante*, page 240), Dr. Bankart complained of the source from whence the water came, and that Tiverton drained into the Exe. The paper just read, he thought, clearly proved by actual facts that the water of the Exe, as supplied to the inhabitants, was as pure as it could possibly be expected to be. There was no doubt that a large comprehensive gravitation scheme for bringing water from either Exe or Dartmoor would be a great thing for the city, but it would probably cost over 100,000*l.* With reference to the question of a constant supply, he, and he believed the whole of the Town Council, were anxious to see this boon granted to the city; but the matter, to a certain extent, rested with the citizens. In some districts he had discovered waste to a certain extent of 75 gallons per head, and it was impossible to give a constant supply whilst that waste continued. Bye-laws, however, had been prepared to meet the case, and only needed confirmation; but he was afraid they could not get it until they were ready to give a constant supply, which they could not do until the waste was stopped.

The PRESIDENT said it was only fair to give Mr. Boulnois an opportunity of answering the letter, but he observed that the letter said, in spite of bye-laws, the Exe river received at one spot the excreta of several thousand people.

The SURVEYOR admitted that the sewerage of Tiverton discharged into the river.

Mr. SYMONS said the Town Council had only to put the law in force to compel the people of Tiverton to refrain from doing this.

Mr. J. DAW said he must give the people of Tiverton credit for one thing. They had lately brought water into the town so as to flush their sewers and purify their town by washing all the sewage into the Exe.

Mr. S. JONES (Sheriff of the city) thought that before the citizens came into court it would be necessary for them to have clean hands themselves.

Mr. W. MORTIMER said the circumstances of Tiverton and Exeter were different. Exeter was situated at the outlet, and there was no supply taken from the river below the city. One of the reasons why the authorities had not found a remedy for the water-supply before was the belief, which he hoped the discussion of that day had dispersed for ever, that there was a sufficient supply beneath their feet.

A vote of thanks was then accorded Mr. Perkins for his paper.

On the Ventilation of Water Mains.

IT will be conceded, I presume, that given a certain collection of good water in a tank or reservoir, it is equally pure whether it be discharged into a constant service system or an intermittent one, and also that the dangers inherent in an intermittent water supply have so far nothing to do with the water itself—only with the system—thanks to the imperfect details which are still permitted to be carried out and the evil results of present faulty systems.

The question is, how to obviate these dangers, if possible.

The great danger of the intermittent system arises, *cæteris paribus*, from the tendency of the system, when the supply is turned off, to produce in the water mains and service pipes a partial vacuum, the result being that these mains and pipes become rapidly filled by suction power, or, I should say, by the external pressure, with a leakage of air and soakings from more or less impure sources.

Were the mains and service pipes and taps all good and efficient, this leakage would not be so dangerous; but, unfortunately, they are not, and we must take things as they are. The whistling sound of the air rushing back through the house tap into the service pipes when the supply is cut off is, I am afraid, only too familiar to most of us. When this occurs in a sink tap, or a direct service closet tap—for such things continue to exist under the conservative energy of too many sanitary authorities in their efforts at local government—when such occurs, I say, we, as sanitarians, know only too well what the risk is—the absorption of foul gases into the water, rendering it a suitable fluid for the production of diarrhœa, enteritis, or fever. Now

I would propose to combat this great danger of the intermittent systems by ventilating the main or mains from above, and by introducing a V-shaped pipe, as an anti-suction valve, at the junction with every house pipe or other outlet.

We will take the latter first. Where the water supplied is previously filtered, it may consist of a simple bent pipe giving a dip of, say, a foot. In small towns and villages where the water is supplied unfiltered from a large collecting tank or reservoir, and where the water frequently carries with it a certain amount of grit, the bottom of the V-pipe would of course, in time, be liable to get filled up and stop the supply. To obviate this, in such cases, I would propose that at the bottom of the V there should be a screw plug for cleansing and washing out any deposit brought down by the water.

For ventilation of the water-main from above, I would propose, at a point immediately below the cut-off cock, to introduce a ventilating pipe which could be led up the side of a house or be fixed to a post, as convenient, at such a height and in such a position as to admit pure atmospheric air. At a convenient distance above the ground, say 5 feet, a box or chamber would be interposed in the pipe containing a floating valve, so fixed as to close the ventilating pipe when the water was turned on, thus preventing any waste; when the water was turned off, and the main began to empty, the valve would fall, and admit pure air to the mains and pipes

Such is the plan; and it requires, I hope, but little explanation. While the ventilating pipe at the head of the main will admit a free supply of fresh air to the system, the V-pipes, being full of water, will prevent the admission of any air or gas from houses or closets or any outlets of the water system.

It will still be possible, of course, to have a leakage of impurity from the surrounding soil through a hole or fault in the main, but as this must also lead to a leak of water *from* the main, it is likely soon to be discovered.

The ventilating pipe without the V-pipes would not suffice; for when the water had run out and the system was filled with air, the temperature of the dwellings and underground being greater than that of the atmosphere, we should soon have a backward current of air established, with the consequent risk of the inhalation of impure gases.

It has become manifest in the present day, that, both in our national foreign policy and our private domestic affairs, economy must be a ruling principle in all things; and thus we find that, in many instances, a constant water supply is necessarily vetoed on account of the expense. It remains, then, for science to help "the powers that be" out of the many difficulties which finance imposes upon them. I lay my first-born before you with fear and trembling, but not altogether without hope.

F. L. STEPHENSON, M.B.

Mr. BOULNOIS said he had listened with great interest to the paper. In the present intermittent system that prevailed, on account of the cost of a continuous one, it was frequently necessary to empty the mains as described, and no doubt foul air entered them. He considered the 'V' pipe or syphon a good idea, but with regard to the elaborate process for ventilation, he thought it could be dealt with by means of ball-hydrants.

Mr. STEPHENSON, in answer to a question, said that he proposed to put the 'V' syphons in every house, otherwise the people would not do right.

Mr. BOULNOIS said they could get bye-laws made.

Mr. STEPHENSON said they could not get bye-laws enforced in small districts, the authorities being afraid of their powers.

Mr. GRANTHAM also thought the pipe proposed would be good, but he doubted the ventilation.

A vote of thanks was accorded Mr. Stephenson for his paper.

At the conclusion of the section a vote of thanks was given to the President.

CIRCULATION OR STAGNATION

BEING THE TRANSLATION OF A PAPER BY F. O. WARD

ON THE

ARTERIAL AND VENOUS SYSTEM FOR THE SANITATION OF TOWNS

WITH A STATEMENT OF THE PROGRESS MADE SINCE THEN FOR ITS COMPLETION

BY

EDWIN CHADWICK, C.B.

LATE CHIEF EXECUTIVE OFFICER OF THE FIRST GENERAL BOARD OF HEALTH

PREFACE.

In my report on the sanitary condition of the labouring population of Great Britain, in 1842, I made the following statement of information, the result of extensive inquiries:—'Within many of the towns we find the houses and streets filthy, the air fœtid, disease, typhus, and other epidemics rife amongst the population, bringing in the train of these conditions destitution and the need of pecuniary as well as medical relief, all mainly arising from the presence of the richest materials of production, the complete absence of which would in a great measure restore health, avert the recurrence of disease, and, if properly applied, would promote abundance of production, cheapen food, and increase the demands for beneficial labour. Outside the afflicted districts, and at a short distance from them, as in the adjacent rural districts, we find the aspect of the country poor and thinly clad with vegetation (except rushes and plants favoured by a superabundance of moisture), the crops meagre, the labouring population afflicted with rheumatism and other maladies, arising from damp and an excess of water, which excess, if removed, would relieve them from a cause of disease and the land from an impediment to production, and if conveyed for the use of the population would give that population the element of which they stand in peculiar need, as a means to relieve them from what is their own cause of depression, and return it for use on other land as a means of the highest fertility.

'Later investigations have established two general conclusions applicable to the subject: That in towns all offensive smells from the decomposition of animal and vegetable matter indicate the generation and presence of the causes of insalubrity, and of preventable disease, at the same time that they prove defective local administration.

'And correlatively that in rural districts all continuous offensive smells from animal and vegetable decomposition indicate preventable loss of fertilising matter, loss of money, and bad husbandry.

'Of the first of these propositions any one may convince himself who will visit the spots most frequently afflicted with typhus and other epidemic and endemic diseases, where he will find that his own sensations, without any other direction, will commonly indicate the chief seats of insalubrity. Such indications are given by the sickening sensations occasioned by breathing air rendered impure by the admixture of organic vapours arising from decay, as well as by pungent and offensive stinks; for though the stinks always indicate danger, it does not follow that there is no danger when there are no such warnings. The danger is often greater from foul air, which less strongly affects the olfactory organs.'

The engineering and mechanical means for effecting these objects, of which I had made a long study, constituted an arterial venous system of sanitation for the relief of populations, and were comprised in various papers, first at the Consolidated Commission of Sewers for the metropolis and the Metropolitan Sanitary Commission, but chiefly in the report of the first General Board of Health in 1850 on the supply of water to the metropolis; then in the 'minutes of information on the drainage of land'; and the 'minutes of information on the drainage of houses and towns'; and the 'minutes of information on the practical application of sewer water and town manures to agricultural production' issued by that Board in 1851. This system so developed was early comprehended by the late Mr. F. O. Ward and ably expounded by him, when attending with Lord Ebrington (now Earl Fortescue) as delegates at the Congress on Hygiene held at Brussels in Sept. 1852. By my wish he abstained from mentioning myself, as it would give the opportunity of attacks on the principle by attacks on the person propounding it, as is the common practice. But that reason has very much passed.

Reference was made at the last International Congress held at Paris, to Mr. Ward's exposition of the system at Brussels, where it appears to have been followed with good effects. But the principle of the unity of the works in question, so needful for their efficiency, is as yet so little understood, that it is of importance to take occasion to republish his popular exposition of it, with the addition of what

may be taken as a varied exposition of it as it is presented to my view at the present time, comprising the chief points of progress in sanitary art and science for its completion since it was first made.

EDWIN CHADWICK.

EAST SHEEN, SURREY,
Oct. 1880.

In answer to the announcement that I proposed to republish the paper read at the Congress on Hygiene at Brussels, where Earl Fortescue was present and took active part, I have received the following note from his lordship:—

'Castle Hill, North Devon: *Oct.* 6, 1880.

'My dear Chadwick,—I rejoice that you should have thought of reproducing in English the very able exposition by our early friend and coadjutor of the leading principles of sanitation, principles long ago vindicated by him in speeches made in a foreign language and in a friendly foreign capital, to which I remember listening at the time with sympathy and admiration.

'Subsequent experience seems to have confirmed the general soundness of the conclusions which he so pointedly set forth in his little French pamphlet more than a quarter of a century ago, but which, in the present state of uncertainty and confusion of the public mind, seem to be still treated as debatable questions, instead of truths arrived at both by deduction from first principles and induction from a constantly increasing body of satisfactory experience. I say "general soundness," because it can hardly be affirmed that as regards agriculture the diffusion of sewage manure through pipes has hitherto been profitably carried on at the distance from towns or to the extent anticipated by yourself and by our somewhat oversanguine friend; though in particular cases where the rainfall has been excluded, where the length of the tubular channels has been moderate, and the work has been carried on with practical agricultural skill and with due attention to economy, the system has been proved, and will yet, I believe, increasingly prove, profitable.

'I trust his vivid description of the Circulating System, with your notes and additions, may have a wide circulation, such as the importance of the truths therein set forth deserves. For, such is the amount of prejudice and real or supposed self-interest arrayed against them, that they require constantly reiterating, and their practical influence upon the weal as well as wealth of the community again and again brought home to the public mind.

'Heartily wishing you success in this renewed effort to diffuse the sound doctrines which you began promulgating very nearly forty years ago, I remain,

'My dear Chadwick,

'Yours sincerely,

'FORTESCUE.'

PREFACE BY THE EDITOR TO THE BELGIAN EDITION OF THE PAPER.

'*Circulation or stagnation?*' Such is the neat and concise form in which Mr. F. O. Ward and his colleagues have just put the sanitary question before the Congress of General Hygiene at Brussels.

In reproducing under this title the two principal speeches of this sanitary reformer, we believe that we shall render a service to all who are interested in this great cause—the cause of humanity at large.

Continuous circulation is the fundamental principle of English sanitary reformers. According to their theory, the main conveyance of pure water into towns and its distribution into houses, as well as the removal of foul water by drains from the houses and from the streets into the fields for agricultural production, should go on without cessation and without stagnation either in the houses or the streets.

Hence they would do away altogether with cisterns and cesspools, which Mr. F. O. Ward designates as 'two congenital forms of pestilential stagnation;' and wherever the double movement of water and sewage is hindered by the flatness of the land, they maintain complete circulation by steam power. It is at this last point especially that, according to Mr. F. O. Ward, the new system of drainage coincides with the general progress of the nineteenth century.

'*Hygiene* by steam power' (we quote his exact words) 'is at once the logical extension and the necessary complement of *locomotion* by steam power, which has of late been organised throughout the whole of Europe. The steam engine, which has already quadrupled the means of transporting products from one place to another, will now quadruple the produce of the matter transported. This new application of the great invention of Watt will before long effect the same happy and astounding transformation in our domiciliary and agricultural arrangements as it has already produced in nearly all the other branches of industrial art.'

As to the method of thus applying steam to the service of public hygiene, it consists chiefly in the establishment of a vast tubular system. Mr. F. O. Ward has given us a rapid sketch of the physiological analogies and material organisation of such a system. In the words of this eminent sanitary reformer: 'the discovery by the immortal Harvey of the circulation which goes on in the individual body has prepared us for the reception of the strictly analogous and fruitful discovery of the circulation in the social body.'

Conceptions such as these, based as they are on numerous experiments and very positive results, deserve undoubtedly the impartial investigation which Mr. F. O. Ward and his colleagues solicit.

Let, then, these conceptions, these experiments, and these results be carefully examined. Let the press and the public join in the discussion of them. The scheme proposed to us is no less than the reconstruction, on principles of a very bold nature, and hitherto but little known, of the material bases of civilisation.

What answer, then, must we give to this question, so concisely formulated, and apparently so simple, but of which the scope is immense:—'Circulation or Stagnation?'

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 diarrhœa.

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 filtration, 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 considered, 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 diarrhœa) 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 sanitaria 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 2*s.* 6*d.* 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 30*s.* 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 9*d.* 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 aërated, 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 Dantzig 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 workings, 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 1*s.* 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 develope 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.

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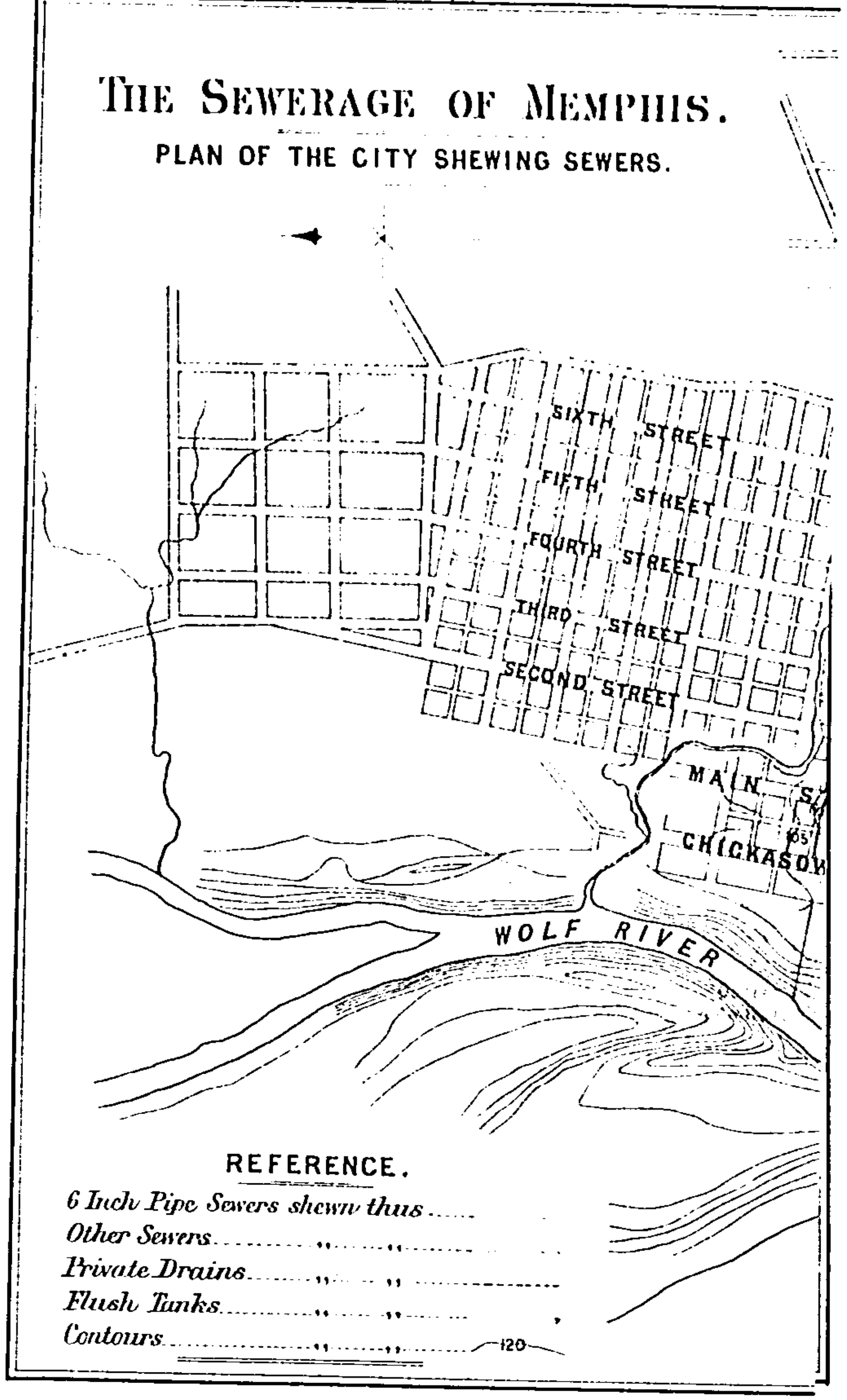


Paper on the Sewerage of Memphis (*Illustrated*).[1]

By Col. G. E. WARING, Junr., of Newport, R.I.

Memphis is a city of about 40,000 inhabitants, situated on the east bank of the Mississippi River, about midway between St. Louis and New Orleans. Its area, including its immediate occupied suburbs, is about four square miles. Of this about one square mile is the more strictly urban, being quite closely built over,—a considerable portion in compact blocks, and the remainder with semi-detached houses. Many streets of this part of the town were covered ten or twelve years ago with wood pavement, which, during the past four or five years, has fallen into very bad repair, and most of which is now being removed, its place being supplied by stone block pavement or macadam.

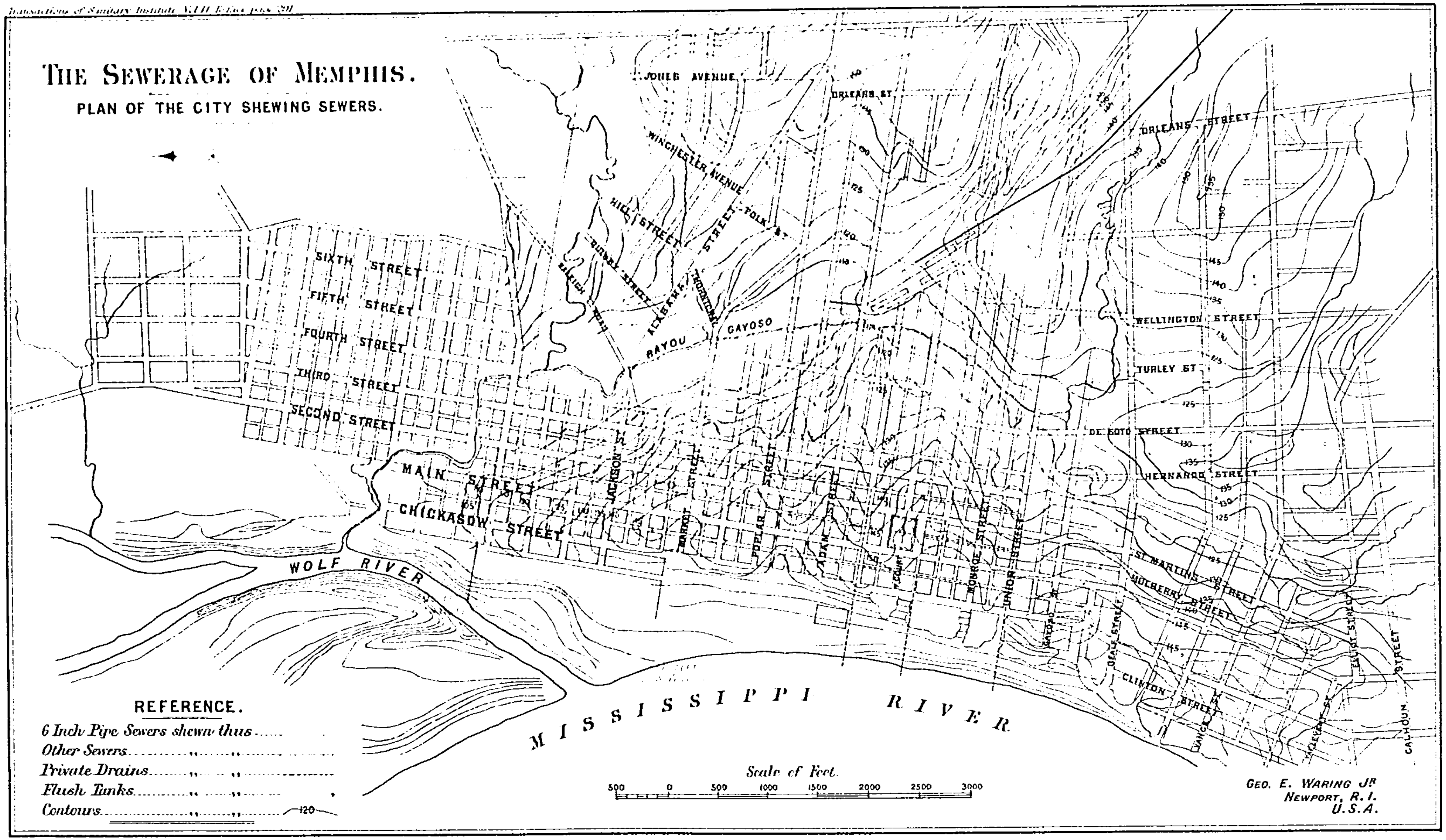
The accompanying map (Plate A) shows the conformation of the surface. The valley, beginning a little north of the northernmost portion of the main sewer, and occupied towards the south by the two branches of the main, is the lowest part of a gradual depression falling from the east and from the west. Through the bottom of this runs a deep cut called Bayou Gayoso. This bayou is the eroded channel of a stream ordinarily small, but, under occasional sudden showers, subject to an enormous increase of volume. Its sides are steep and irregular, and its depth is quite uniformly from 12 to 15 feet below the general level of its banks.

The Mississippi River has an extreme variation of level of about 35 feet. At least once during the year, and often two or three times, it fluctuates to the extent of from 20 to 25 feet. Extreme high water is reached, or nearly approached, almost yearly; but it is seldom that the subsidence goes to within several feet of extreme low water mark. At the highest stage of the Mississippi dead water sets back in the bayou for the distance of about one mile, or to Gayoso Street. From Market Street to the mouth of the bayou the left bank is quite flat for some distance back, so that at high water wide areas are overflowed, and in this part of the town many houses are built on piles. In places only the streets (artificially raised) are above the level of the flood.

The city was founded less than fifty years ago, and its growth (due to a most advantageous position in the heart of one of the best cotton-growing regions of the country, and on the great highway of western commerce), has been constantly interrupted by epidemics of various diseases, some of which have been so violent as to threaten the depopulation of the town. In 1878 there were over 5,000 deaths from yellow fever between August 14 and November 3, and on one single day the small heroic remainder of the Volunteer Relief Committee had 300 unburied bodies on their hands. Hope and heart seemed to have fled. When this epidemic was followed by another equally threatening in 1879, and when the voluntary and enforced exodus speedily reduced the population to one-third its normal amount, it was seriously proposed, as the only means for protecting the whole

[1] This paper was omitted from the Engineering Section, in which it was read as the first paper on the list, because of a delay in the proofs.—Eds. T. S. I.

PLATE A.


THE SEWERAGE OF MEMPHIS.
PLAN OF THE CITY SHEWING SEWERS.
SIXTH STREET
FIFTH STREET
FOURTH STREET
THIRD STREET
SECOND STREET
MAIN STREET
CHICKASOW STREET
WOLF RIVER
MISSISSIPPI RIVER
JONES AVENUE
ORLEANS ST
WINCHESTER AVENUE
POLK ST
HILL STREET
RALEIGH
ALABAMA STREET
BAYOU GAYOSO
JACKSON
POPLAR STREET
ADAMS STREET
MONROE STREET
UNION STREET
ORLEANS STREET
WELLINGTON STREET
TURLEY ST
DE SOTO STREET
HERNANDO STREET
ST MARTINS STREET
MULBERRY STREET
CLINTON STREET
CALHOUN STREET
REFERENCE.
6 Inch Pipe Sewers shewn thus
Other Sewers
Private Drains
Flush Tanks
Contours
120
Scale of Feet.
500 0 500 1000 1500 2000 2500 3000
GEO. E. WARING JR
NEWPORT, R. I.
U.S.A.

Mississippi valley against the serious menace to its prosperity, that a sufficient contribution should be raised to secure the control of Memphis, and that it should be blotted out of existence.

At this juncture a conference was held between the authorities of the city and officers of the National Board of Health, which resulted in the appointment of a Commission of physicians and experts to make a thorough survey of the situation, and to recommend measures of relief. I had the honour of serving as a member of that Commission, which sat in Memphis for a week in November 1879, and whose investigation was aided by a thorough house-to-house inspection of the entire city, and very careful chemical analysis of the water of the wells and cisterns, which constitute the chief source of supply, apart from the limited use of the very unsatisfactory water pumped up from a muddy river by a private company. These investigations disclosed an almost total absence of decent sanitary conditions. It is not worth while here to enter into details, nor is it to be understood that Memphis was worse in this respect than many other towns in the United States—North as well as South—nor worse, if we are to credit official reports, than many towns and villages in England. That it was seriously bad was fully demonstrated. The whole city, under as well as upon the surface, was reeking with organic filth. In another climate it would probably have escaped serious epidemics as successfully as other towns differently situated have done, but its condition, its situation, and its experiences made it evident that most radical measures of reformation must be adopted. The opinion of the Commission to this effect was accepted by every intelligent person in the city.

The situation at Memphis offered a rare opportunity for sanitary work. The absolute need of improvement was obvious, and the community had a full realisation of the fact that it was 'neck or nothing' with their city. The result has been that a community—overtaxed, plundered, and, indeed, driven by a former corrupt government to attempted repudiation—has accepted advice more radical, probably, than was ever seriously given before, has raised the money for the required work, and has put its house into more nearly perfect order than has any other town in the country. As an example, a year ago it had about 7,000 privy-vaults, many of which were from 40 to 60 feet deep (having been sunk to a porous stratum), and still more of which were full to overflowing. To-day hardly one of these vaults remains. Where shallow they were entirely emptied, and where deep their contents were removed to a depth of 20 feet from the surface of the ground, and all were filled with fresh clay. Every house was provided with a temporary earth-closet, and the contents of these have been *ad interim* removed by the health authorities. As fast as connections with public sewers have become possible, these earth-closets have been abandoned. The former custom of disposing of garbage, by shunting it into streets and alleys, has been entirely given up, and the most active and effective measures of surface cleanliness have been adopted. In short, apart from the work about to be described, which was only one element of the Commission's recommendations, much more has been done than would have been possible in a town less severely chastened by disease.

THE SEWERAGE SYSTEM.

In 1868, during the season of spasmodic prosperity which followed the close of the war, a careful survey of the city was made, and skilful engineers were employed for the preparation of a plan of sewers. This plan was the usual one of large storm-water sewers, varying in size from a 12-inch pipe to a 7-foot outlet main. The main sewers and the main branches, which alone were provided for in the plan, would probably have cost under present prices, 120,000*l.* The extension of the laterals to accommodate the whole city would have added very greatly to this. During the epidemic of 1879 this plan was revived, and estimates, varying from 200,000*l.* to 400,000*l.* were based upon it. It was evident to the Commission that such an expenditure would be found impracticable, and it became necessary to devise a cheaper plan for cleansing the town. I had had experience in the case of several small villages which indicated the feasibility of securing the desired result by the use of sewers of very small size, graduated to the single duty of removing household and manufacturing wastes. The suggestion had been formulated in a paper read at the meeting of the American Public Health Association at Nashville, shortly before the sitting of the Memphis Commission. It was determined to recommend this system as a substitute for the more costly one. The recommendation was accepted by the Citizens' Committee, and later by the government of the city.

The plan proposed was without precedent in the case of a large town, and the fear lest it should prove inadequate became a serious obstacle to its general acceptance. Those who were timid concerning novelties, and those who were interested in the supply of material for the larger works, were so effective in their opposition that it became necessary to repeat the arguments a second, and even a third time, before it was finally determined to undertake the work. This determination was reached about the middle of January, and ground was not broken until the 21st of that month. There was at that time no supply of material on the ground, no considerable force of labourers had been engaged, engineers had but just arrived, and preliminaries which might profitably have occupied several months had to be dispensed with. It was all-important to complete the sewerage of the thickly-settled part of the town by the end of May, the turning up of the soil in such a climate in hot weather being extremely hazardous, and in spite of the disadvantages and embarrassments, the sewerage of the closely-built part of the city was practically completed by June 1. By the middle of April many houses had already been connected with the sewers, and on June 1, when the work was stopped, about 1,200 connections had been made. The plumbers have been actively at work throughout the summer, and, while there are yet many houses depending on their earth closets, the use of the sewers has become sufficiently general to prove their entire adequacy for the work for which they were intended.

The system has recently been very carefully examined by a committee sent from New Orleans, to judge of its adaptability to the needs of that city. The chairman of the committee, in his preliminary report, speaks in the most favourable terms of the working of the system, and will recommend its adoption in New Orleans. The 'Memphis Avalanche' of July 23, in an editorial, says: 'The examination of the Memphis sewerage system yesterday, by the Taxing District authorities and the committee from New Orleans, resulted in convincing all parties that it was a great success. There is not a hitch anywhere, and no complaint has ever been heard of the slightest defect in the clockwork regularity with which all the parts of this vast net-work of underground pipes carry the sewage of the city to a given point, and deliver into the Mississippi River.' Every indication points to the possibility of the general adoption of this system as a substitute for storm-water sewers, hitherto universal in the United States.

It is proper here to recite the reasoning by which the recommendation of this system was influenced:—

1. There have been in the United States many instances in which small towns have employed engineers to prepare plans for sewerage, with the sole result of showing the cost of execution to be so great as to constitute an absolute embargo. While compactly built cities, each house having but a short frontage on the street, may well afford the cost of storm-water sewers, the execution of such work, where each proprietor has from one hundred to several hundred feet of front, would entail an expenditure so great as to constitute an insuperable objection to it. Practically the contemplated work is rarely if ever carried out under these circumstances—a community naturally prefers to continue the risk of danger from cesspools rather than to burden itself with such enormous indebtedness. One of the arguments by which the postponement of these costly works has been secured has been based on the very general offensiveness of the storm-water system, with its reeking inlet catch basins, and on the unavoidable production of sewer gas, arising from the decomposition of its unflushed contents.

2. An investigation into the history of the sewerage of many of the smaller cities disclosed the fact that in no single instance had the work been undertaken because of the injury or inconvenience resulting from the flow of storm-water over the surface of the streets. The desire to get rid of foul wastes was found to have been in every instance the controlling motive. The adoption of works large enough for the removal of surface water was simply a matter of tradition. No other system had been used, therefore no other was considered.

3. Assuming that the admission of storm-water to sewers might safely be neglected, to say nothing of its attendant disadvantages, the next question was to determine the pipe capacity needed for the removal of foul wastes only. There exist ample formulæ for the determination of this question, but the municipal mind often fails to appreciate the full force of scientific theory, and it naturally hesitates to try costly experiments. The only way to secure conviction in this matter was by actual physical demonstration. I had, fortunately, early in 1879, procured authority and a sufficient appropriation from the National Board of Health to make actual gaugings of the dry weather

flow of public sewers in different parts of the country. The results of these gaugings were the surest foundation of the Memphis recommendation. They may be briefly summarised as follows:—

A sewer in Madison Avenue, New York, with a length including its branches of about 7,000 feet, the district being about one-half built up with houses of good class, carried at the time of its greatest dry weather flow a stream 3·5 inches deep through a notch (in a weir) 4 inches wide.

A sewer in Providence, 1,391 feet long, draining forty-one houses with a population of 267, at its greatest flow filled a 6-inch pipe $\frac{3}{8}$ inch deep.

A sewer in Burlington, Vt., 2,790 feet long, draining fifty-four houses with a population of 325 persons, showed at its greatest flow a depth of 1·2 inches in a 6-inch pipe.

A sewer in Milwaukee, draining an area of 70 acres, containing 500 houses and a population of 3,035 persons, at its greatest flow filled a 6-inch pipe 5·5 inches deep.[1]

The outlet sewer of the Hudson River State Hospital at Poughkeepsie, N.Y., where the use of water is equal to that of an urban population of 2,000, had its greatest flow carried through a 6-inch sewer with a depth of 3·25 inches.

A characteristic street sewer in Poughkeepsie, removing the wastes of a population of 426, at the time of its greatest flow filled a 6-inch pipe to a depth of 2·25 inches.

The State Lunatic Hospital at Taunton, Mass., with 659 inmates and a most abundant water supply, has two separate outlets, one for general use and one for the laundry only. The greatest flow of the former reached a depth in a 6-inch pipe of 1·75 inches; and the laundry flow attained, through a pipe of the same size, when its ten large washing machines were emptied simultaneously, a depth of 2·25 inches. The flow from both drains, supposing the maximum of each to be concurrent, would have been carried through a pipe 4·58 inches in diameter if flowing at the average velocity of the two. It is suggestive that it had been seriously proposed that the State of Massachusetts should pay one-half the cost of a 5-foot sewer more than a mile long because of its contributing to the city of Taunton this small stream of sewage, which would be amply accommodated by a 6-inch pipe.

The most striking result of these gaugings was that developed in the city of St. Louis, where a sewer 7·25 feet in diameter (necessarily large because of the occasional need for carrying off ponded surface water) drained an area containing 1,370 houses occupied by a population of 8,200. This sewer had its greatest flow carried through a

[1] Incidentally the gaugings of this sewer are otherwise instructive. The diameter of the main is 42 inches. It was reduced in the course of the experiment to 10 inches, to 8 inches, and to 6 inches.

The influence on the velocity of the stream by increasing its hydraulic mean depth is illustrated by the following figures:

42-inch sewer, 6 inches deep; cross-section of stream, 121·3 square inches.
10-inch sewer, 4·5 inches deep; cross-section of stream, 33·1 square inches.
8-inch sewer, 4·5 inches deep; cross section of stream, 27·7 square inches.
6-inch sewer, 5·5 inches deep; cross-section of stream, 27·14 square inches.

12-inch pipe, which was filled to a depth of less than 7 inches. A calculation of the actual discharge of this pipe showed that the sewer must have received a very large amount of ground-water, and that the public supply must have been most wastefully used, for the discharge was over 1,000,000 gallons per day, or more than 130 gallons for each member of the population; that is, the flow was as great as it should be with a population of over 30,000 using only an abundant amount of water.

There is a satisfactory reason for not accepting the exact teachings of these gaugings in regulating the sizes of sewers, viz. that no sewer should be used of a smaller diameter than 6 inches, (*a*) because it will not be safe to adopt a smaller size than 4-inch for house drains, and the sewer must be large enough surely to remove whatever may be delivered by these; (*b*) because a smaller pipe than 6-inch would be less readily ventilated than is desirable; (*c*) and because it is not necessary to adopt a smaller radius than 3 inches to secure a cleansing of the channel by reasonably copious flushing.

On the other hand, it may be assumed that no sewer should be more than 6 inches in diameter until it and its branches have accumulated a sufficient flow at the hour of greatest use to fill this size half full, because the use of a larger size would be wasteful, and because when a sufficient ventilating capacity is secured, as it is in the use of a 6-inch pipe, the ventilation becomes less complete as the size increases, leaving a larger volume of contained air to be moved by friction of the current or by extraneous influences, or to be acted upon by changes of temperature and of volume of flow within the sewer. The size should be increased gradually, and only so rapidly as is made necessary by the filling of the sewer more than half full at the hour of greatest flow.

In making the recommendation for the adoption of this small pipe system for Memphis, no account was made of the fact, which is believed to be of serious importance, that all sewers large enough for the removal of surface-water, unless they are provided with a copious daily flush, are sure to be objectionable, especially in our hot summer climates, and during our very long summer and autumnal droughts. While this argument is believed to have great force, it was thought best not to antagonise the influential advocates of the large sewer systems.

THE MEMPHIS WORK.

It will be seen by reference to the map (Plate A) that the grades in Memphis are quite generally very good; so much so that it was considered safe, even in the most thickly settled parts of the city, to continue to use sewers of a diameter of 6 inches for a length of 3,000 feet (including the lateral branches). There were therefore very few cases where it was necessary to make lateral sewers of a larger size, though in a few instances they were increased to 8 inches. The two separate systems whose mains come together at Jackson Street begin at that point with a 15-inch pipe for the west side of the bayou (or river side), and a 12-inch pipe for the east side. The 15-inch main on the

west side is continued as far as the junction of Hernando and Beale Streets; from this point there is a 12-inch pipe as far as Vance Street. All tributaries are either 8 inches or 6 inches in diameter. On the east side the 12-inch main goes as far as Union Street, whence its extension to Vance Street, with a view to future work towards the south, is of 10-inch pipe. The rest of this system is of 8 and 6-inch pipes.

From the point where the two mains come together at Jackson Street, the outlet is by a 20-inch brick sewer reaching now as far as the 'switch' near Wolf River, whence it is continued with 20-inch pipe to a junction with the 3-foot iron pipe from the Jail, discharging into Wolf River below low water mark. This outlet is to be used, after the work is completed, only during high stages of the river. The low water main, which will be of brick to about the extension of Jackson Street, will be continued thence by a 20-inch iron pipe with leaded joints to below low water of the Mississippi near the foot of Market Street. During high water stages of the river, this extension of the main will be filled with dead water quite back to the switch, and it was feared that to discharge the foul outflow by this course would lead to the formation of serious deposits. Through the much shorter line by the jail pipe there would be less danger of difficulty from this source.

The switch by which the flow is diverted is not absolutely water-tight at either of its ends, but it serves perfectly for the diversion of all solid matters.

Concerning the construction of the work, there is not very much to be said which can interest an association of sanitary engineers. A few details are shown in the accompanying Plate B.

The object aimed at is simply to secure the complete and speedy removal of all foul sewage through pipes absolutely tight as to their joints; true as to grades, and laid on generous curves; to secure the most complete ventilation possible; to cause the least possible disturbance of the flow at the numerous inlets; and to give every pipe an effective daily flushing.

To prevent the adherence of solid matters at any point in the sewer, gaskets are used at all joints to prevent the intrusion of cement. These gaskets have the further effect of allowing the sections of pipe to be held in place until two or three lengths are secured, so that when the cement is once applied it need not be disturbed by the movement incident to the laying of new sections. In order to secure a concentric bore at the joints an 'adjuster' was used in the case of the smaller pipes. Its construction is shown in Plate B. It is simply a device by which, on tightening a screw, three buffers of india-rubber are brought to a firm bearing on both pipes, lapping the joints. When a new section is laid in place, the adjuster is put in position and tightened, holding the pipes concentric until the gasket is tightly pressed into place. It is then withdrawn and used for the making of a second joint, the previous gasket taking up any movement and allowing the cement two or three joints to the rear to remain undisturbed until it sets. This method has been found to work well in the hands of ordinary pipe-layers.

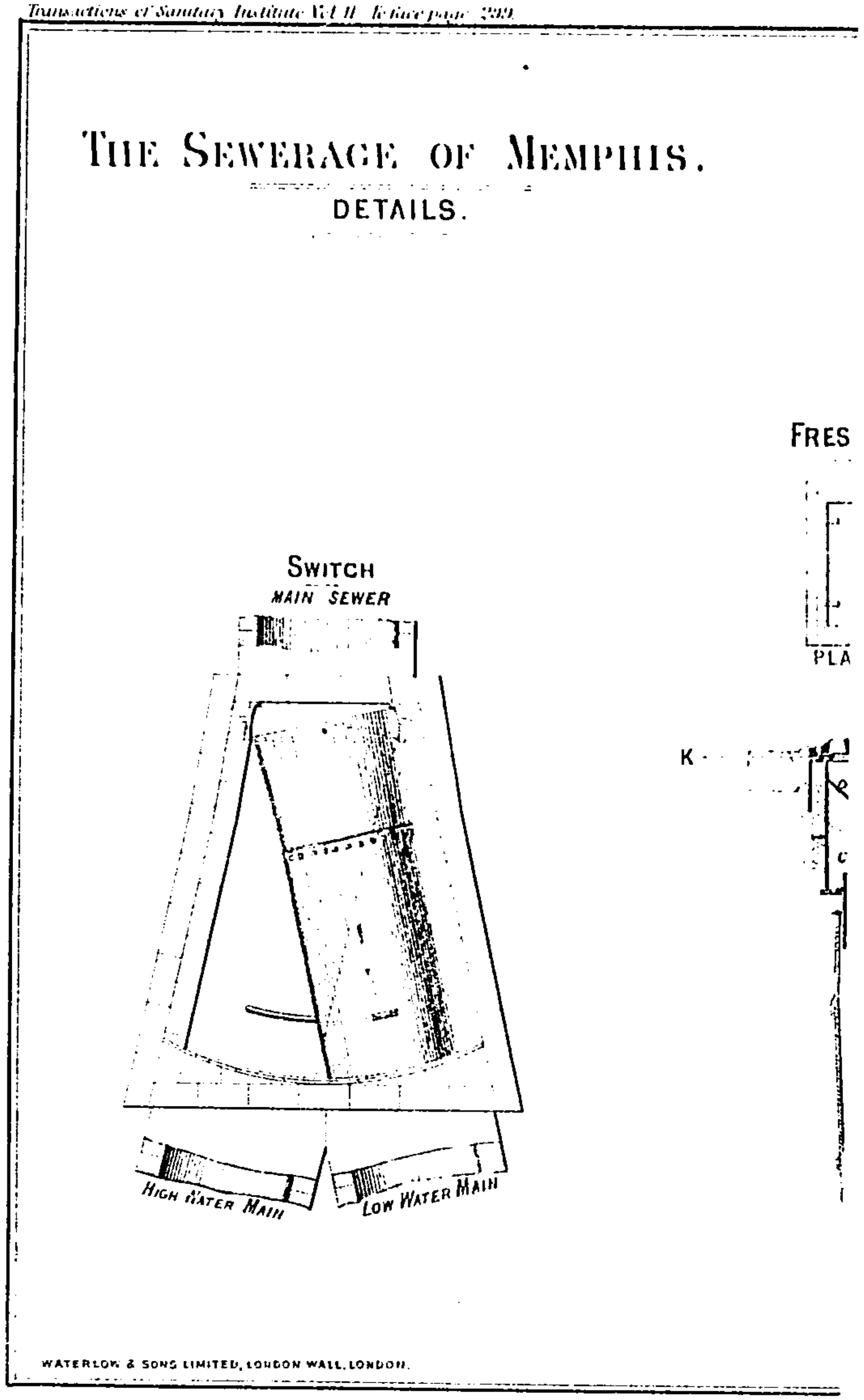
Although the natural soil of the site of Memphis is usually favourable, there were many places where artificial grading, and where the former use of the various depressions as a 'dumping ground,' had made an almost impossible foundation for the work. The difficulty in such cases was overcome by the use of 'saddle piles' made of 1-inch boards wider than the outside diameter of the pipe, and sawed to the proper radius. These piles were made longer or shorter according to the depth of the soft material, and were then driven exactly to grade, two piles being placed under each 2-foot section of pipe. This was found to be much better than the use of gravel or planking, making it easy to secure the exact grade at each point, and not subject to disturbance by the feet of the workmen. By excavating the bottom to a line a few inches below grade, the cement of the joint is allowed to set without contact with the water of the trench.

A new form of house connection or branch piece was adopted. This is shown on Plate B in two sections and in perspective. The house branches in all cases, even for the largest establishments, were restricted by law to a diameter of 4 inches. The extension of size from the diameter of the branch to the diameter of the main is made by a funnel-shaped branch piece delivering its flow at the very bottom of the main channel and, at the same time, furnishing ventilation to its very crown. This is a slight modification of the device in general use, but it seems to me to possess decided advantages.

By an ordinance which is strictly enforced, the furnishing of an unobstructed ventilator, 4 inches in diameter, reaching to the top of the house, is compulsory in every case. Connection with the sewer is also compulsory in the case of every building occupied for any purpose at any time during the day. In all probability these frequent ventilators, at various elevations, and variously exposed to different winds, would suffice for the complete ventilation of the whole sewer system.[1] To provide against any possible defect in this regard, as well as to afford an opportunity for inspecting the flow, there is placed at the lower end of each lateral, near its junction with the main sewer, a 'Fresh Air Inlet,' the construction of which is shown on Plate B. This furnishes a free access for air through an open grating at the surface of the street—following the course of the arrows to a T branch at the top of the sewer. The entrance of dirt and rubbish is prevented by a cast-iron plate shown in position at A. To facilitate the removal of accumulated dirt it is dropped to the position shown by the dotted lines B; and for the inspection of the sewer it is set back to the position C.

The most striking departure from ordinary custom and prescription is the entire absence of man-holes and lamp-holes, and the utter disregard of the alignment of the sewer, so far as the question of examination or cleansing is concerned. We trust to the open inlets for ventilation and to daily or half-daily flushing for cleansing. Should a sewer at any time become obstructed, the obstruction would manifest itself at the lowest house connection above the point of

[1] When the sewerage is completed there will be about 7,000 of these 4-inch ventilating pipes for the 40 miles of sewers of the city, being an average of one ventilator for every 30 feet of sewer, besides the air inlets at every lateral.



stoppage, and the stoppage would have to be removed by digging down and opening the sewer itself. This would, of course, cost more than to withdraw the obstructing substance at a man-hole; but no single instance of stoppage has yet occurred, and I am confident that the interest on the cost of man-holes and lamp-holes would be enormously greater than that of the occasional openings that may become necessary.

In fact, it is difficult to understand why these sewers should become obstructed at all. They have no projections or rough points to collect foreign substances; nothing can get into them except through pipes of materially smaller diameter than their own; and each sewer, with its branches, is swept from end to end at least daily, by a large volume of water, rapidly discharged from a Field's flush-tank. There are now about 120 of these flush-tanks in constant operation, and when the work is completed the number will be increased to over 150. Observations taken at the fresh-air inlets, at the time of discharge, show the current from the flush-tanks to be of such velocity and depth as to ensure the complete removal of any object which we can conceive to gain admission to the sewers.

It is certainly not necessary in describing this work to English sanitarians to enter into any long account of the flush-tank of Mr. Rogers Field. The particular arrangement of the apparatus employed at Memphis is shown in Plate B. The discharging capacity of each tank is over 100 gallons. The diameter of the discharging limb of the siphon is $3\frac{1}{2}$ inches, and the discharge occupies from thirty-five to forty seconds. It was found advantageous to make the outlet chamber and the subsidiary siphon—employed to unseal the large siphon—in one casting of iron. This casting includes a bearing for the iron plate upon which the flange of the siphon rests, thus obviating the danger of improper adjustment when the setting of the different parts is left to the eye and judgment of the builder. The theory upon which the flushing appliances have been arranged is that in a sewer of such small size as 6 inches, with frequent house connections, there is no danger of an accumulation of organic matter except toward the upper end of the sewer, where the constant flow is too slight to carry forward the heavier matters introduced through the house drains; that, after the discharge from a certain number of houses shall have been added to the current, everything is sure to be carried forward by the natural flow, so that all that we need to secure, so far as the prevention of deposits and stoppages is concerned, is the flushing of the first few hundred feet of each line. That 100 gallons of water discharged in forty seconds into the head of a 6-inch sewer, will effect this object, is not questionable. The effect of the increased flow through the lower part of the lateral sewer, and of the accumulation of the discharges of a number of flush tanks in the sub-mains and mains has, as a matter of course, a beneficial effect, by increasing their scour.

The ability of these sewers to keep themselves clean, and therefore to keep themselves free from sewer-gas, has been more severely tested, during the earlier months of their use, than it will be after all

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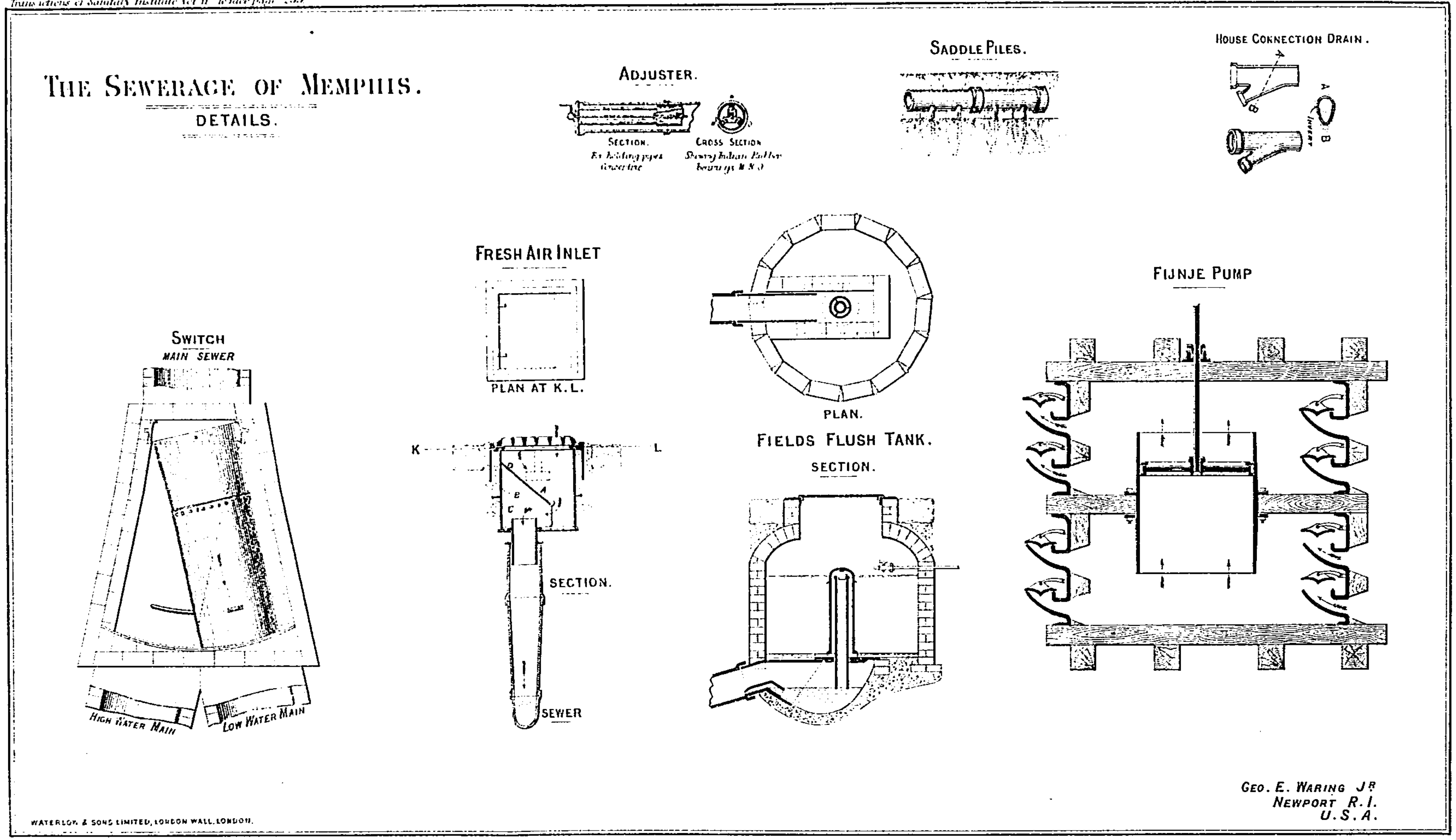
PLATE B.



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the houses of the city shall have been connected with them. The distance from the head of the sewer to which it is necessary that the effect of the tank flushing should reach, of course decreases as additional houses are connected, and it is, I believe, amply proven by three or four months of entirely successful use that these sewers will continue for all time to be entirely satisfactory in this respect so long as their flush-tanks are kept effective. The results of the gaugings of the dry-weather flow of a number of sewers, previously recited, show that the system, as established, will be effective for a population of 60,000. It is not, therefore, too much to say that the success of the Memphis sewerage is demonstrated. It is not, of course, to be hoped that there will be an entire immunity from stoppages, but there is every reason to hope that these will be so few, and so easily removed, that the wisdom of having avoided the expense of making man-holes and lamp-holes will be established by experience.

As Memphis, like nearly all of our southern cities, is, except in its business portion, without cellars—very many houses of a good class being built on piers, with a free circulation of air under the main floor,—the sewers have been laid almost uniformly at a depth of 6 feet.

In order to avoid the risk of danger from the careless making of connections, and to facilitate and cheapen the work of house connection, a 4-inch branch has been carried from the junction piece of the sewer to the outer line of each house lot. This branch is constructed as the work on the public sewer progresses, and its upper end is immediately closed with an earthenware cap, fastened in place with clean mortar.

The ordinance concerning private works requires that the 4-inch drain of iron or earthenware shall be extended from the foot of the soil-pipe to within one length of its junction with the branch from the sewer. It must communicate directly with the soil-pipe without the intervention of a trap or contraction of any sort, and the soil-pipe must extend above the roof of the house with the full diameter of 4 inches, and open at the top.

Every slop-stone, water-closet, sink, or other vessel within or without the house must have its own independent trap. Apparatus of all kinds must comply with certain restrictions, and all is subjected to official inspection before acceptance. Neither the 'pan'-closet, nor the 'Brahma'-closet, nor any other of their class, is allowed. The use of 'hopper'-closets is encouraged. All of the plumbing work of the establishment must be accepted by the inspecting engineer before the final connection with the sewer is permitted, and this final connection must in all cases be made under his immediate supervision.

In anticipation of the large amount of work to be done, the plumbers had laid in large stocks of pan-closets, and there was some opposition to the prohibition of their use; but a friendly conference with these mechanics, and an explanation of the object of the regulation was frankly accepted, all prohibited apparatus being returned to the manufacturers. The ordinance prohibits the use of any closet which has an unventilated space between two water-seals of more than 100 cubic inches capacity, or which has an unventilated space of any size within which any part of the mechanism moves.

It is thus made impossible for foul matters to lodge in any part of the house drainage or sewerage system except in the running traps of the different vessels, one side of the trap being exposed to the open air and the other side to the well-ventilated atmosphere of the drainage system. The requirements concerning the flushing of closets, &c., are such as to secure the most complete practicable removal of whatever they may receive.

SUBSOIL DRAINAGE.

One of the marked benefits arising from the construction of ordinary systems of sewerage results from the greater or less porosity of the works, which affords a means of escape for subsoil water—which, in other words, drains the ground. This benefit is accompanied by the marked disadvantage, that during dry seasons the liquid sewage, which is needed to carry forward the solid parts, and which is saturated with filth, leaks out into the soil, leaving the solid matters stranded in the sewer, and polluting the ground. In the work at Memphis this leakage is obviated by the absolute tightness of the jointing of the sewers. The draining of the soil is effected by the use of ordinary agricultural drain-tiles laid beside the sewer in the same trench. The effect of this part of the work has been so great as to have had a marked influence on the dryness of both soil and atmosphere, producing, as is believed by the sanitary authorities, a decided reduction of malaria and a modification of the prevailing local tendency to rheumatism and pulmonary irritation.

The subsoil drains do not deliver into the sewers, but find their outlet directly into the bayou and its branches. In more level ground it may frequently be necessary to discharge the tiles sooner or later into the sewer system. This should be done with precautions against the back-flow of sewage into the tiles.

THE BACKWATER OF THE MISSISSIPPI.

The improvement thus far described relates only to the high-lying parts of the city, and to a portion of the lower area only during low stages of the river. The exclusion of back water from the bayou is to be undertaken in the autumn. A dam will be built at the crossing of Second Street with a 3-foot brick conduit below the level of the bottom of the stream. The upper end of this conduit will be furnished with a Fijnje pump,[1] the principle of the construction of which is shown in the accompanying plans. This pump has been in successful use in Holland during the past thirty years, and its employment in the United States has been sufficient to show its entire efficiency. It seems admirably adapted for the case under consideration, inas-

[1] This pump is named after the inventor.

much as it will afford a perfectly free outlet for the flow of the bayou during low stages of the Mississippi, and will serve as an efficient valve-gate or back-flow preventer as the river rises. Its piston will be driven by a vertical cylinder directly above it, and as the river rises it will be able to discharge all ordinary flow with ease.

At times, even when the river is low, the immense volume poured into the bayou by copious thunder storms will be far beyond the capacity of the low-level outlet, and even during the season of high water there may be occasional storms which will exceed the capacity of this channel. To provide for this temporary flood the upper 6 feet of the dam are to be constructed with swinging valve-gates. All storms of the locality which cause such floods are of very short duration, so that the discharging capacity of the pump, or during low water, of the unaided low outlet, will be sufficient to discharge the stream, except during an hour or two of its greatest flow. And as soon as the excessive flood shall have passed, the accumulation will be removed by the pump within twelve, or at the utmost twenty-four hours.

For the completion of this part of the work a separate system of sewers of small extent will be constructed for the area lying between the 20-inch main and the bayou; its outlet discharging directly in front of the entrance to the pump. During low water this sewage will pass out with the natural flow of the bayou, and at high water it will be carried by the suction of the pump.

SANITARY EFFECT.

It would be premature to express an opinion as to the full effect of the work described on the sanitary condition of Memphis. Its epidemics of yellow fever and its excessive mortality from consumption, malarial diseases, and rheumatism have perhaps been due not entirely to the presence of filth and of soil moisture. All that it is safe to say is, that so far as they have been produced by these influences, it is fair to suppose that the sewerage and drainage will obviate them. The authorities of the city are already ascribing their present unprecedented low death rate and almost entire immunity from malarial diseases to the execution of these works. It will certainly be very gratifying if the experience of future years justifies their belief. Whether their belief shall be justified or not, I think it is already demonstrated that the methods adopted are effective in securing their immediate physical aims. I have described them thus minutely, at the request of a member of the Council of the Sanitary Institute, partly as a matter of information concerning an important American work, and partly to indicate the degree to which Mr. Rawlinson's original recommendations in favour of the use of small pipe sewers has been accepted by his Transatlantic followers.

GEO. E. WARING, JUNR., Newport, R.I.
Engineer of the Work.

The PRESIDENT said that they were much obliged for the paper sent by Colonel Waring. Sanitary works, if they were to extend, must be cheap. He must say that he thought the author of the paper had been acquainted with reports written in 1843 by Mr. Chadwick, in which the separate principle was advocated, and sewers of small diameter recommended. In 1849 Alnwick was drained on this principle, and no one had complained of the drains. After 1848 this mode of drainage was taken up and discussed by the opponents of the system with great virulence. He must confess that he never trembled in the presence of man in his life until he stood up at the Institution of Civil Engineers, knowing that he was alone to face the persecution against the small drains and small sewers proposed by Mr. Chadwick, a system which left the rainfall to be carried off on the surface From that meeting a resolution went forth which led to the adoption of the large sewers like those in Paris, Brussels, and other cities. But Paris and Brussels, with all their large sewers, were not sewered cities, but had the smells of cesspools, owing to the generation of gases in the vast space of these great sewers. In this plan of Memphis different principles were brought to bear. The engineer knew that he could not deal with the tropical rains that fell. If an engineer went into a city and made a rule-of-three sum as to what should be done to take away the rainfall, he made an egregious mistake. The surface water should not go into the sewers, but flow over the surface. There was one thing in the plans that he did not agree with, and that was the absence of man-holes. He thought it would be found that there must be man-holes, as there would be sure to be chokages at some time, and with man-holes there would be no necessity to break up the road to find the spot. He was a member of the Army Sanitary Committee, and, as they knew, great works were contemplated in India, and the chief thing he had to compete with there was the desire of engineers to make enormous sewers to meet the rainfall. The rainfall in India at times was 30 inches in twenty-four hours, and how was an engineer to provide for that? If he made railway tunnels for drains he could not get the rainfall in, while in dry weather the tunnel would be filled with foul air, and thus be a source of evil to the city. The rainfall must be allowed to flow over the surface. If this caused injury to the surface they must adopt means to repair the injury, but they should not make enormous sewers which, in dry seasons, would be areas for creating the very evils they were intended to cure. He had not succeeded in getting his advice followed in some large towns, but in Bombay they had decided to keep out the tropical rains from the drains and provide surface drains, leaving the sewers for sewerage alone, and he, therefore, hoped soon to see Bombay an example to other cities. They were told by one of our present great engineers that sewers should be large enough for men to get into to clean them out. Well, all he could say was, that the Legislature had passed a law to prevent boys going up chimneys, and he hoped a law would be passed to prevent men from going into sewers to clean them out. He, for one, would not have the blood of men who were killed in this work upon him. He mentioned instances of places sewered on the principle laid down in the paper with marked success. He moved a vote of thanks to Colonel Waring.

Mr. CHADWICK seconded the motion. Colonel Waring had just been consulted on the sewerage of Washington on the same principle as Memphis. If that was undertaken it would be a lesson for the Metropolis of Great Britain and other large cities both here and in Europe.

Dr. RICHARDSON asked the Section to consider whether it was not possible to correct the error in the Metropolitan Main Drainage Works, of mixing the sewage and storm water, by running sewerage pipes through the existing large sewers? If so, it would be a great advantage, by which the mistakes of the past could be corrected.

The PRESIDENT replied that when new sewerage plans were laid before his Department they always came before him. He asked if there were existing drains, and if so, he then advised that the old drains should be reserved for the water and the new drains for the sewage.

Dr. RICHARDSON asked whether such a plan as that which he had just suggested could not be adopted in the immense sewers of London.

The PRESIDENT said that London was sewered, and all the eloquence of an archangel would not avail to effect an improvement. Belgravia, the most fashionable part of London, notwithstanding the great expenditure on it, was subject to flooding in the basements from the sewers, and was the foulest part of all London. The sewers contained deposits, and were charged with sewer-gas. In the Government buildings, in Whitehall, when people came to reply to the Department's orders, they complained that they could sniff the sewer-gas as they came along the passage, and advised him to set his own house in order before ordering localities to sewer. Perhaps he was not wise in making these remarks; but he was so old, and had got so independent, that if he got a 'wigging' he should not very much care.

Mr. ROBINS observed that in justice to Sir Gilbert Scott there ought to be some power to control the drains in the lower parts of the new buildings at Whitehall.

The PRESIDENT disclaimed any wish to cast any reflection on Sir Gilbert Scott, but he justified his remarks by giving unsavoury details of the insanitary condition of the buildings in Whitehall. The plans of the sewers of public buildings were under one Department—not his Department—and when he asked for the plans he was told 'to mind his own business.' If the new Government buildings were bad, the basement of Somerset House was far worse. Somerset House was an old building, with an old system of sewerage, and was densely populated, and ill-ventilated. If he had to occupy offices in Somerset House, he would at once throw up his appointment. And as to the great War Office, there was no beggars' common lodging-house in the country fouler, in regard to the condition of the basement; and as the basement was so were the rooms.

Mr. HENRY C. BURDETT said he wished to make a few remarks from a householder's point of view. He looked on the plan adopted in Memphis with great satisfaction. Every house had a 4-inch ventilator carried above the roof, and this was compulsory. It was also necessary that the plans of every house should be approved. He wished that these rules were the law in England. He believed that they must have compulsory legislation on these points, and if a strong Government on sanitary questions were in power, and carried the necessary measures, it would not be so necessary for the Sanitary Congress to go from town to town. The placing of houses in a sanitary condition should not be a matter of option, but of necessity by law. They had had too much permissive legislation, and they now wanted the power to protect themselves against the carelessness and covetousness of those who lived in their midst.

Mr. LEMON, C.E. (Southampton), pointed out that under existing regulations it was necessary that plans of drainage should be submitted to the local authorities, who had ample powers, though they were too often reluctant to put them in force owing to the pressure put upon them from outside in all directions. He was also of opinion that no system was perfect which dispensed with man-holes. He was happy to say that the separate system was gaining ground, in the view that the rainfall should go to the streams.

Dr. MACLAGAN, as a Medical Officer of Health, corroborated Mr. Lemon's statement as to plans of drainage having to be approved by the local authorities.

Colonel JONES pointed out that the system used in Memphis was advocated so far back as 1847 by Mr. Chadwick.

Dr. CARPENTER took exception to the way in which the sewage of Memphis was disposed of in sending it into the sea. He endorsed the principle laid down:—'The rainfall to the river and the sewage to the soil.' Great Britain could not afford to lose the sewage, whatever America might do, and if it were cast into the sea it must eventually end in bankruptcy. He believed that we could get three times the produce from the land if the sewage were properly utilised, yet it was thrown away because they could see no benefit to themselves from applying it to the land; but this action would make this country to be more and more dependent for food upon the foreigner. He did not think that the towns would ever obtain direct profits from their sewage; but in his opinion it was the person who put it on his land that should get the profit.

Mr. W. WHITE said he believed that at Memphis it was necessary to get rid of the sewage effectually and at once, and that could not have been done if they had looked about for means of utilising it.

Mr. TOWLE (Oxford) advocated the distribution of sewage over the land, and maintained that it could be pumped to any height. The whole country should be one 'immense sewage farm.'

Mr. ROGERS FIELD (who was called on by the President to reply on behalf of Colonel Waring) was bound to say that he agreed with the President that it would have been better if there had been man-holes on the sewers. At the same time, there were several very special features in this case which altogether took it out of the ordinary category. Not a single old drain or street gully was connected with the sewers, and all the house drains were strictly limited to 4-inch pipes, so that nothing could get into the sewers that could not pass through a 4-inch pipe. All the service and branch sewers were automatically flushed every day by the discharge of the flush tanks.

The ventilation of the sewers was effected by an immense number of ventilating pipes, one of these being carried up every single house. These conditions were altogether unprecedented, and they could, therefore, hardly judge of the works by the rules applicable in ordinary cases. Moreover, the works had to be carried out with extraordinary rapidity, and at the least possible cost, in consequence of the impoverished state of the town.

The PRESIDENT, in his concluding remarks, stated that when he was a younger man, and engaged upon designing works of sewerage, he had not the advantage of the self-acting flush tank used on the Memphis works, otherwise he should certainly have availed himself of it.

A vote of thanks was then accorded to Colonel Waring for sending his paper.

APPENDIX.

REPORT OF THE JUDGES OF THE EXHIBITION HELD AT EXETER, SEPTEMBER AND OCTOBER 1880.

ALPHABETICAL LIST OF FELLOWS OF SANITARY INSTITUTE.