Schemes for the interception, conveyance, and utilisation of the sewage & drainage of Glasgow / by James Brown.

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FOR THE

INTERCEPTION, CONVEYANCE,

AND

UTILISATION

OF THE

SEWAGE & DRAINAGE

OF GLASGOW.

By JAMES BROWN.

GLASGOW:
PRINTED BY JAMES T. PETTIGREW, 138 GALLOWGATE.

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PREFACE TO RE-ISSUE.

SOME months ago, in compliance with the favourable opinions and the urgencies of friends, on it becoming apparent that the questions of the purification of the Clyde and disposal of the city sewage, with their attendant grave responsibilities and anxieties, would occupy the attention of the City Council at an early date for final action, the author revised and corrected the following proposals for re-issue. This had become the more incumbent in consequence of having discovered among a lot of old papers, and long thought lost, the data of his original conception in 1854, in a chart of the Clyde, by the late Mr. Thomas Kyle, land surveyor, prepared for the Clyde Trustees, and lithographed by Messrs. M'Lure & MacDonald, in 1838, for official and parliamentary purposes in respect of the formation of Kingston Dock. The necessary alterations and additions on this essential particular are textually introduced in page 10. Thus revised, the "Schemes, &c.," are again respectfully submitted, with estimate of costs of construction, to the just and unbiased consideration of the municipal authorities of the city, and the intelligence and judgment of the community, presumably that they will be found, at the least, as practicable and economical a solution of the momentous problem, *as a whole*, as any contribution yet made towards an attainment so vastly important.

In doing so, it is but due to the Council and to himself to mention, that some weeks after handing the revised copy to his printer, a friend in municipal position put into his hands a treatise, entitled, "Hints on Sanitary Reform, with a Plan for the Disposal of the Sewage; by James Gray, M.D.;" accompanied with a chart by our distinguished townsman, Mr. Baldie, Architect. On perusal, the projector found that, with some important omissions and triffling deviations, and the use and application of some of the calculations and data in Messrs. Bateman & Bazelgette's report of 1868, in relation to the Ayrshire Sands Scheme, which, unfortunately, he has omitted to acknowledge, the "plan" was identical with the "alternative proposal" in his "schemes, &c.," issued in November and December, 1869, the latter month and year being the date of Mr. Baldie's chart. To both gentlemen he tenders his hearty thanks, and gratefully avails himself of the opportune support afforded by their labours and the coincidence of their views. At the same time, as Dr. Gray states in page 7 of his "Hints, &c.," that "he lays claim to some originality of design," it is but due to him to infer that he could not have seen the author's proposals, neither in their drafted nor printed form, before sending his communication to press. He is also well persuaded that the same observation applies in the fullest sense of the words to Mr. Baldie.

173 SHAMROCK STREET,
2nd October, 1871.

UTILISATION OF SEWAGE & DRAINAGE.

THE following communication on the disposal of our City Sewage and Drainage was, for the most part, drafted immediately after the issue of Messrs. Bateman & Bazalgette's Report, and addressed in the form of a letter to the Honourable the Lord Provost. The reason for so doing was, that on perusing these gentlemen's report, it appeared to the author of this communication, that the proposal embraced in that report was, in principle, substantially the same as that of a scheme he had devised in 1854, viz.: the discharge of sewage upon open porous land for filtration, leaving the solids, &c., to become mixed up with soil for agricultural enrichment; the *desideratum* being the existence or possible improvising of such land of sufficient area and contiguity. This scheme he was in the habit of describing to friends when passing up and down the river in that and subsequent years; and among these to the late Mr. James Smith, architect, who, approving of it, took certain levels and measurements in relation thereto. These he afterwards submitted to the editor of the *Bulletin* newspaper, who, in a leader in his impression of 22nd July, 1858, put the scheme to a certain extent before the public, to which the writer replied on the same date, offering some criticisms, and supplying additional details, which appeared in that paper on the 28th of the same month.*

As an additional premise, it is proper to observe that, were any one of the numerous schemes of late promulgated in itself sufficiently comprehensive and practical for such a city as Glasgow, the writer would have shrunk from obtruding his own upon public or official notice. At the same time, it is his duty to frankly declare, that, in his humble judgment, many of those schemes, and much in them all, exhibit intelligent grasp of the subject, much reflective talent, and practical application. While submitting his own, he begs to be understood as pretending to neither engineering skill nor ability, but gives it on its own merits, and for what it is worth, leaving levels and measurements, and details necessarily left out in a mere general outline, to those whose business it is professionally to deal with them.

The schemes to which reference has just been made, and the discussions which have followed upon them, have suggested the propriety of putting the scheme embraced in this communication in a twofold or alternative form; but before propounding it, it is necessary to its enunciation to notice some of the features and defects of the schemes referred to.

The first of these, and generally characteristic of them all, is the want of provision for intercepting and carrying off the sewage and drainage of populous places eastwards of the city, and for disposing of the refuse waters from public works on the upper reaches of the river. Concerning

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* The author begs here to supply an omission in his first issue. In the autumn of 1868, the author having lost his copies of the *Bulletin* referred to, he applied to a member of Mr. Smith's family, in the hope that they might be among his family papers, and left with him the draft letter, with whom and his friends it lay for some weeks. He was disappointed in his hope, and has to express his obligation to Quentin Dick, Esq., writer, for the handsome manner in which, in reply to advertisement in February, 1869, he obliged him with examination of the office file of the *Bulletin* in his possession, and permission to copy his letters.

the foul discharges from these works, it is all but unnecessary to remark, that, were there no other sources of pollution, they would render the waters of the Clyde noxious and offensive in no ordinary degree. Not to speak of offence and effluvia, they act as a direct and most effective prohibition to bathing at those places of usual resort for the purpose; and multitudes of our working men have now to go without the invigorating and healthful plunge into the once pure waters of the Clyde, so much appreciated by ancestral Glasgow. Provision is indeed proposed by Messrs. Bateman & Bazalgette for intercepting and conveying away some six millions of gallons per day from public works; but this provision seems to be for only such works as are situated in the city proper, and the more immediately contiguous portions of the suburbs; otherwise the provision is inadequate. And while it is observed by these gentlemen, that "any scheme by which the sewage shall be discharged into the Clyde at any point, unless it has previously undergone purification, is out of the question," the observation seems to have reference to the harbour only, and relates to the city sewage alone.

It is further to be observed, that the schemes under review all but allow the several burns that intersect the city to remain in their present state—a diversion of a portion only of the waters of two of them being proposed by the eminent reporters just named. The fact is now a well ascertained one, that these burns—the arched portions of them—are pregnant sources of the febrile and choloraic diseases that so often fatally affect the public health. If they are even partially to continue the receptacles and conduits of all the rottenness, the filth and foulness, the putrid and nameless noxious matters that run and settle in them, deadly gases will infallibly continue to be generated in their respective courses. A mere diversion of a portion of the poluted waters of the Molindinar and Camlachie Burns, therefore, will leave the evil substantially untouched; and any scheme which does so, in whole or in part, utterly fails of a primary object. More than one of the schemes in question embrace the expedient of raising the sewage by pumping, with the necessary wells and reservoirs, to an elevation sufficient for conveyance or discharge, either over, or to higher levels than the city, by means of conduits within and around the city itself. To this the following remarks on the like proposal in Messrs. Bateman & Bazalgette's scheme substantially apply.

A sewage pumping station at the South West corner of the Green would, it is more than probable, evoke a new and intenser ebullition of popular hostility than anything of the kind yet experienced, and on popular grounds alone is highly objectionable. Being immediately contiguous to the junction of the two last named burns, it implies at least their partial diversion into two or more capacious reservoirs or wells, formed in the portion of the Green in question, and simply means the appropriation of the whole of the western part, from the line of Charlotte Street—an appropriation that would certainly evoke the most determined popular antagonism.

Apart from the local nuisance which the cleaning out of these reservoirs would occasion—and that would be frequent enough—taking the partial volume of the two burns, with their well known ingredients, along with the whole sewage and drainage of the lower level of the city, poured into

one seething, foaming flood in deep well or pit, and stirred and churned into a potential virulence by a powerful pumping process, could not fail, despite all local precautions possible, to impregnate the surrounding atmosphere with a fetid miasma—a neighbourhood, it is needless to remark, where nothing is more desirable than that the air should be sweet and pure, not only on account of the denizens of the locality, but also of the court-houses situated there.

It will not be difficult to see that the foregoing objections apply with still greater force to the pumping station at Pollokshields, where the whole of the fetid flood is concentrated. Wells or reservoirs more numerous and capacious must be provided, and a much more powerful pumping process put in operation; the whole reeking volume lifted to a higher elevation, and a greater cleaning and scouring out of these wells or reservoirs entailed. And it is most observable, that it is actually proposed to clean them out into the river, and so to discharge into it at frequent intervals large volumes of foul sedimentary accumulations, only to be drifted up and down the channel by flow and ebb of tides, as now and heretofore—*vide* Messrs. Bateman & Bazalgette's charts—and not only so, but aggravated by the downflow of the like discharges from the pumping station at the Green! Verily our poor afflicted river, and still more grievously afflicted and burdened citizens, would have little to boast of in return for the enormous expenditure the scheme embraced in Messrs. Bateman & Bazalgette's report proposes. It is also strange—and no one who has read the report can have failed to notice the anomaly—that while the rural residences on the lower part of the river are the subjects of the reporters' solicitude, those at Pollokshields are treated as of no more account than the hovels in Saltmarket and Bridgegate.

At page 22 of their report, Messrs. Bateman & Bazalgette say, "That all attempts at deodorization or precipitation on a large scale have hitherto failed," and curtly dismiss all idea of entertaining any such process. But it does not by any means follow that such processes are impossibilities, and that attempts at them must always, *per se*, fail. After making that statement, these eminent engineers proceed to detail the grand features of their own scheme, which is simply, as formerly noticed, spreading the sewage for absorption on the Ayrshire sands; and describe with much clearness the perfect purity of the sewage water after it shall have undergone filtration. One cannot help here remarking, that if there be such perfect identity of the purified sewage water, as at Croydon, and the Loch Katrine water, as appeared to two of the distinguished reporters—one of them mistaking the purified Croydon for the Loch Katrine—might not our purified sewage water be impounded on the Ayrshire sands and sold to the good people of Irvine, Troon, and Saltcoats, as a "most excellent drinking water?" Or if these people should be so foolish as to refuse the "precious boon," why not return it to the city by another pumping process and system of conduits, for sale and distribution to our ill-used print and dye works. At all events, the authorities and inhabitants of these contiguous Ayrshire towns—assuming the scheme carried out—will not object to, ought rather to rejoice in, the prospective increased pellucid character of the waters that wash their healthful shores!

But—merely to pursue the argument before leaving it—supposing the

sewage conveyed to the sands of Ayr, how is it to be distributed upon them? Is it to be by surface floodings, or by open trenches? It requires but little reflection to comprehend that in either case—and it may be taken that one or other, more likely both, would be the method—there would be incessant labour, and costs in abundance. It is not difficult to understand—albeit the report gives no information—that the main stream would necessarily be made to run off into a number of small conduits as outfalls, making, in short, a sort of Nile-Delta of the sands. But during the earlier period of the working of the scheme, as the most ordinary observer on the sands cannot fail to realize, almost every wind that blew would constantly, and in very brief space of time, silt up both outfalls and trenches. The mouths of the Nile on the Egyptian Delta furnish a cogent and appropriate illustration.

A very important consideration remains in respect of the discharge of sewage upon open porous lands. No data whatever has yet been given as to the permanency of the absorbent powers of such lands; and the questions arise, will they not eventually become gorged and choked with the more solid sewage matters discharged upon them; and what length of time will elapse before they are effectually so? At the most, it is only a question of time; and when that inevitable consummation is reached, what becomes of all such schemes? Messrs. Bateman & Bazalgette say that the Craigentiny meadows are already "overdosed," and their silence on the foregoing primary questions in their own proposal is not without significance. If the Craigentiny meadows have become "overdosed" by a "superabundance of sewage," what is to prevent a like "superabundance" being discharged upon, and "surfeiting" the sewage lands at Croydon, Barking, Rugby, and the Ayrshire sands into the bargain? There is here certainly no use whatever in speculating as to requirements forty years hence, unless it be as to something else than absorption. Long ere that period arrives there will remain nothing for it but to treat the whole volume of the sewage, wherever discharged, whether on "hungry gravel" or on "greedy sand," by some such means as science and experience may yet devise.

The observation is here interposed, that the scheme proposed by Mr. Chapman offers to supply such means, or fairly points in their direction. In itself it is but a half measure. So is that of M. Liernur, with which it is substantially a competing scheme. Both deal with the *excreta* and *urina* only, and leave the whole drainage and refuse waters from all sorts of public works to be separately treated and disposed of. Their assumed profits are illusory therefore, when the works necessary for the latter are taken into account. For both, as presently put, it is important that the matters with which they deal should be as undiluted as possible, and how that is to be secured has yet to be seen. No doubt Mr. Hoey's closet is a valuable contribution towards its attainment, if the people could only be brought universally to be common sense and thrifty in their domestic economy. But the prospect is at best distant, if not doubtful; although the advent of so desirable a state of matters would gladden all hearts. As half-measures, however, neither of these gentlemen's schemes can be considered a satisfactory solution of the question. For non-manufacturing communities they may be so; but as far as Glasgow is concerned, the question must be treated as a whole. Of the two, if Mr. Chapman's can

be brought to boil down and evaporise the whole volume of the sewage, &c.,—a very formidable process certainly, but one which the writer ventures to say, from what he has seen of the scheme, it is not incapable of achieving—it may become, or something like it, the ultimate method of utilising the sewage and drainage of large manufacturing cities. In the meantime, it is little more than in an embryo state, so far at least as the purposes it may be made to serve are concerned; and in order to its being possibly brought to accomplish these purposes, it requires to be applied and wrought for experiment and perfecting, where facilities are afforded for doing so, on a scale commensurate with the magnitude of its object. The outfall of a main sewage conduit alone properly supplies those facilities; and it would be unreasonable to suppose, after such sewage works for our city are completed, that it would not demand many trials, alterations, and improvements, extending over a considerable space of time, for its thorough adaptation and success.

For the present, the disposal of city sewage and drainage by absorption and filtration is the only method in operation, with so far apparently satisfactory results; and the question presents itself, is there not ground more suitable nearer home, more accessible, and capable of affording ample area, than the Ayrshire sands? With all deference to the distinguished projectors of the Ayrshire sands proposal, it is affirmed that there is, and that the *termini* of the scheme the writer conceived and spoke of in 1854, and subsequently, and wrote concerning in 1858, viz.—The two banks, respectively on the north and south sides of the estuary—the one extending from the mouth of the Leven to [redacted] Cardross and the other from below Erskine House to Newark Castle, or thereby, but to the east of Port-Glasgow.

Can these banks be made available? Messrs. Bateman & Bazalgette say—"Both banks"—the banks of the estuary here—"possess great natural beauty, and every inducement for the further erection of houses and places of sea-side resort." Few indeed of our fellow-citizens will coincide with these gentlemen in calling the places indicated "places of sea-side resort." Of sea there is none. What they call "the shallow sides of the estuary," but which are here designated "banks," bound the shore land for about a mile from low to high water mark, where the "natural beauties," such as they are, begin to arise. The foul river alone washes these shores, and deposits on them by every flood and tide large quantities of the solids of the sewage and other offensive matters with which it is abundantly charged. And even were Messrs. Bateman & Bazalgette's scheme carried out in its entirety, the scouring out process at the Green and Pollokshields pumping stations would not greatly improve the "inducements" for the "erection of houses and places of sea-side resort." But they further report, that "the physical features on both sides also are such that any works of conveyance would be of a difficult and expensive character; and any attempt to enclose the shallow sides of the estuary would be strenuously and, we have no doubt, effectually opposed." There is probably more in this sentence than it expresses; but taken as it stands, the "strenuous" and "effectual" opposition can only be taken as a ghost of these gentlemen's own raising, for the purpose of frightening our authorities, and good citizens in general, to the Ayrshire sands for irrigation! Who is to oppose? Apart from any knowledge Messrs. Bateman & Bazalgette may have on

this point, the erection of "houses and places of sea-side resort" on the "fragrant shores" in question "have been few and far between;" and in good reason too, for the nuisance already created on them could scarcely be made greater. Anything almost would be an improvement; and if such can be effected, and the existent natural "beauties" conserved and added to, it may be safely assumed that the proprietors of the contiguous lands will be the last to object.

The spectre of "physical difficulties" and "expensive character of works of conveyance" is also raised. Most people at all acquainted with the banks of the Clyde will have very great difficulty in discovering what "physical difficulties" are presented by them to "works of conveyance," and where their comparatively expensive character lies. But taken along with "physical difficulties" in the construction of "works of conveyance," expensive character included, through deep cuttings in blaes formations, and tunnelling hills, the apparition assumes a peculiar aspect. It seems a startling incongruity! and one is tempted to ask if it has not been assumed that the people in these northern parts are somewhat credulous. Be that as it may, the community can scarcely have failed to observe, that it is only for purposes of *irrigation* on the Ayrshire sands that *cold water* is thrown upon the *shallow sides of the estuary*. But, drenching conclusions apart, on every consideration, engineering and pecuniary, these banks present advantages and facilities for the disposal and utilization of our city sewage beyond anything that has yet been shown; the only questions being their area and proper treatment.

It has been already observed that these banks extend for about a mile from low to high water mark. This may be taken as the average. In length they are not less than seven miles; in all about [redacted] 8000 acres, or thereby—a quantity amply sufficient for the scheme which forms the subject of this communication. These banks it was proposed to enclose by piling along their whole margin, at and under low water mark; a strong retaining wall built thereon, of heavy whin rubble, at an angle similar to that of the river banks below the harbour, and at a sufficient height above high water mark to provide against storms and floods, backed with heavy loose whin for about six yards, and which would form a carriage way along the enclosures. In the enclosed spaces it was proposed that the dredgings of the river should be deposited, so as ultimately to bring up the whole to the level of the proposed river wall; and meanwhile, during the operation, that the whole sewage and drainage of the city (by a system of conduits to be afterwards described), should be conveyed to and discharged into these spaces as filtering beds, common field drains being plentifully introduced as filling up proceeded, the filtered sewage water thereby finding its way into the river by openings constructed in the river walls. The solids would thus become mixed up with the dredgings from the river bed, which would in turn go far to neutralise any effluvia.

In support of this view generally, Messrs. Bateman & Bazalgette give gratifying support. Speaking of pouring the sewage on the Ayrshire sands they say—"This ground would of itself be sufficient to deprive the sewage of all objectionable character before flowing into the sea." The same result would more certainly follow as regards the river, from the sewage being poured upon the extensive sandbanks from the estuary, the

removed

sand dredgings from the river being daily superadded. There are other testimonies from actual experience of the almost entire absence of effluvia, outside a very limited distance, from sewage when poured upon open porous land. Messrs. Bateman & Bazalgette say—"At Croydon, the purification of the sewage of that town, by passing over grass lands in the immediate neighbourhood, has been so successful that people residing close up to the sewage irrigated land do not complain of any nuisance." But still further to provide against anything offensive arising from the discharge of the sewage into the inclosed banks, it was proposed that inside the carriage ways, and also along the landward sides, a belt of forest trees and shrubbery should be planted. This belt would serve the double purpose of secluding from public view the process of depositing and filling up, as well as the works of the alternative scheme yet to be indicated, and of effectually preventing the spread of any effluvia that might arise. At the same time, not to speak of the remedy—the best, it is presumed, that present knowledge supplies for the nuisance existing on the banks—the proposed belt would shelter and conserve the amenity of the conterminous uplands, where, be it remarked, there is at present, with very few exceptions, scarcely a patch of growing timber. These works, it was assumed, would extend over a number of years; and with the opportunities and facilities afforded by the progress of the works, the whole question of the ultimate and profitable utilisation and disposal of the sewage could be studied practically on a scale commensurate with itself. More particularly, Mr. Chapman's, or some similar scheme, could be applied and wrought, improved in either principle or detail, and perfected so as to satisfy the purposes it is designed to serve.

Should a more expeditious filling up of the enclosed banks than would be afforded by the river dredgings turn out to be desirable, the large bank outside the harbour of Port-Glasgow, from year to year increasing, and threatening the existence of the port, would supply abundant material; and with an adequate number of dredges at work, the raising of the enclosed banks to the level of the river walls could be accomplished in a comparatively brief period. A very important benefit would here accrue to the River Trust. The tidal waters being confined between the banks thus built up, instead of spreading over the immense area they now cover, would furnish a very efficient scour for the river bed, and soon save the Trust a handsome sum annually for dredging.

The works would doubtless be expensive. It is only first cost, however; and meanwhile a valuable property of a deep rich soil would have been created in the interest of the corporation and community, which, taken at mere agricultural value, would yield a revenue of about £30,000 per annum—sufficient, it is assumed, to cover interest on the cost of construction of the whole works. But taken as building ground, for which it is not unreasonable to suppose it would ere long come to be in demand, and all the more so, as the nuisance which prevents "places of sea-side resort" being erected would have been removed, and the whole converted into fields of health and beauty; the annual revenue would rise to something considerable—above £100,000: a sum which would not only furnish an ample sinking fund for discharge of costs of construction and for maintenance, but would also, at no great distance of time, relieve the citizens of rates and burdens under which they at present groan and protest in vain.

The question presents itself here—Is there sufficient fall from the city to the proposed outfalls? *Prima facie*, if there be fall for the river there is fall for the sewage in properly constructed conduits. Mr. Smith, to whom reference was formerly made, ascertained from levels taken by him, that the fall afforded ample run to carry down the whole sewage and drainage of the city. This estimation may be held as conclusively settled, and that under official imprimatur, by levels taken by the late Mr. Thomas Kyle, and indicated on his chart of the Clyde prepared for the Clyde Trustees, and published by Messrs. Maclure & Macdonald in 1838. Starting from Hydepark Ferry, marked "The old Glasgow Fishery," to the mouth of the [redacted], Mr. Kyle gives the incline at about 53 feet; and taking the length in as straight a line as possible at 18 miles, we have a continuous fall of nearly 3 feet per mile. From Springfield to Hydepark Ferry there cannot be less than from 3 to 4 feet of an equable fall. At page 29 of their report, Messrs. Bateman & Bazalgette give 20 inches per mile for their scheme to the Ayrshire sands, as "sufficient to prevent deposits and secure the minimum rate of flow in the sewers being never less than $1\frac{3}{4}$ feet per second, or $1\frac{1}{3}$ miles per hour; and when full, or half full, $2\frac{1}{2}$ feet per second, or $1\frac{9}{10}$ miles per hour." On Mr. Kyle's measurements, these velocities would be nearly doubled in the proposed Clyde conduits. But giving effect to the obvious fact that the raising of the banks would affect the natural levels for discharge by gravitation, even if necessary, it is here alone where motive power could be most fitly and innocuously introduced. The fatal objections to the pumping stations at the Green and Pollokshields do not apply here. At present, both banks are remote from "houses and places of sea-side resort;" the sewage would be much more diluted, and to that extent less offensive; the residuum in the wells, instead of being thrown into the river, could be lifted and spread over the banks, or utilised as yet to be indicated in the alternative proposals; and surrounded as the works would be with thick foliage, nothing inodorous could pass even to the immediate neighbourhood.

Before further detailing the scheme, it is necessary to remark that, as an essential condition, and in order to restore the waters of the Clyde to anything like their normal state, not a gill of sewage, or waste, or refuse waters, from city or public works, should be allowed to enter it, or any of the burns or streams falling into it. Any scheme which does not make provision for this clamant necessity is utterly at fault. The nascent evil is left as it exists and as it has done. The mass of the community, in particular, have here a deep and vital interest. The river, which a beneficent Providence has especially provided for them, for refreshing, for health, and for beauty, commonly, almost wears the semblance of a very Styx; while on them chiefly will fall the incidence and burden of taxation for any scheme that may be adopted. The whole of the discharges from public works, &c., not directly falling into the Clyde, should therefore be carried off in the main sewers. For those directly entering the river on both sides no further provision is necessary, as they can be received into the main conduits formerly mentioned.

And this leads to a second indispensable condition, viz.—That a complete system of drains and sewers, embracing every court, close, vennel, lane, and street, extending to the utmost lines of the suburbs, and having their

outfalls along the river banks, be constructed, or laid where not already done; and those in existence overhauled, and everything defective or wrong remedied. Loose, open-jointed, and dry built brick drains should be rejected and demolished with inexorable rigour, and strong glazed ware faucet pipes introduced where suitable. Built sewers and street mains to be of the best material, of good, hard, compact building, and all connections formed secure and tight. In any system of effectually dealing with the sewage and drainage of our city these operations would require to be done, and cannot therefore be regarded as involving an extra outlay.

Exception has been taken to the confined character of such a system of drains and sewers, on account of the rapid development and accumulation of mephitic gases in them. With great deference, it is conceived that there are mistakes running through much that has been advanced on this subject. No doubt, these gases are of a highly subtle and volatile character; and acting by their own laws, where concentrated in sufficient quantity and strength, would percolate drain and sewer of the best material and build, or burst them open. And it is known that the heat found to exist in underground sewers gives energy to the laws by which these gases act. It is argued also, that this heat naturally drawing streams of cold atmospheric air into the sewers, the pestilent miasma is thereby driven towards the higher openings, whence it escapes. Quantity, or volume here, can only at most be assumed; and actual experience does not bear out the conclusion. The writer has on frequent occasions been exposed to emanations from open drains and sewers in the higher levels of the city, and unless the drain or sewer was locally foul—a circumstance that quite often enough happens—no offensive odour was experienced. This could not have been the case had the gases in question—being present in quantity—followed their known natural law. Here, as in every department of the economy of nature, there are counteracting agencies and modifying elements at work, each acting in inflexible obedience to its own laws, and producing beneficent results. Among these the sewer heat is not the least. Arising from decomposition, it accelerates the process to its own increase; but as it becomes generated, it draws to itself the colder outer air, and yields up to it the fetid gases it contains. In return, the absorbent air robs these gases of a large proportion of their volatile character; or, taken in an opposite sense, having received them into its own volume, weighs them down with its superior gravity. Percolation in soundly constructed drains and sewers is thus, in all ordinary circumstances, impossible. The process goes on continually, and the law of action seems to be, not that atmospheric air drives the gases to the higher openings, but that it takes them up in its embrace and carries them off in return currents, and by every opening, in an immensely modified if not altogether innocuous form. But the argument destroys itself. Do heated volatile gases require to be driven to higher openings for escape? Certainly not. Alone, they inevitably follow their own law, and that they do not so escape is demonstration of itself that streams of atmospheric air passing into sewers perform functions such as have been glanced at.

What becomes of these gases? That their presence is often terribly felt is indisputable; but it must be under other conditions than those of

their first development. When set free, their immediate volatile character necessitates their instant upward flight; and their volume and virulence on escape is doubtless the *ratio* of their action on the vital organs with which they come in contact. But still, where do they go, and how return? Like other subtle elements, first diffusing themselves in atmosphere, do they rise to their equipoise in air or ether, there, by laws and affinities unknown, entering into various combinations, and condensing, float invisible plague clouds on upper strata of air? Held there by the Omnipotent will, do they at His command return to earth's surface in impalpable shower or current, to be drifted about by the eddying atmosphere, spreading plague or pestilence of every name, in virtue of previous combination at His behest, wherever He bids the shower to fall or directs the current's course? Man nor science cannot tell. Some, indeed, now speak of choleraic currents, though, like the wind, they cannot tell whence they come nor whither they go. Following their natural laws, by the attraction of affinities, shower or current seem oft to fall where their constituents rise—whether from the feculent and putrescent soil of human abodes, or from the sweltering forest swamp, or from the rotting carrion on some battle field, or along some pilgrim route, or where famine has left its unburied dead—but not always. The history of our world but too emphatically tells of times and places where not a sign of pestilence or plague gave premonitory warning, the destroying messenger fell upon city and plain alike, striking down the panic-stricken people by the thousand. Were sanitary duties neglected, its laws unfulfilled, in such places and at such times? Of not a few it cannot be so affirmed; albeit, their neglect or unfulfillment counts the sin of murder in His righteous reckoning. And let our public men look well to it; for it would be difficult to affirm that the hands of all—the community in all its grades not excepted—from one cause and another, are altogether clean in this matter. But to talk and write glibly, as some do, of diseases endemic and epidemic, of infection and contagion, relating them to this and that cause in support of some favourite scheme or theory, is but confusing and perplexing the public mind, and procrastinating all remedy, only to provoke the return in ample shower or current of the putrescent exhalations and malaria that meanwhile rise and accumulate over our guilty heads.

In the case of high winds acting within sewers, of which not a little has been sometimes made, it is only necessary to remark that the greater the volume of atmospheric air traversing them, the more rapidly and completely does absorption proceed. In short, high wind currents in sewers are virtually an aerial and beneficent flushing of them. The truth is, that it is chiefly in local accumulations in the neighbourhood of dwellings, and deposits on the margins and in the beds of covered burns, where the evil lies. The remedy is well-constructed drains and sewers of ample capacity and sufficient fall; care being taken that nothing enter them to choke them, and rigorous seclusion of all fecal and other nameless matters from the burns.

The channels of these streams being redeemed from their foulness, and their waters from the pollutions that poison them, no provision is neccssary for intercepting and carrying off any portion of their volume. And by dealing with the sewage and drainage of the north and south sides of the river separately, main intercepting conduits, of much smaller

dimensions than those required for Messrs. Bateman & Bazalgette's scheme, are secured, are much more manageable, and less likely to get out of order. Such conduits it was proposed should be laid along the margin of the river, on the north and south sides respectively, commencing as far up as Springfield and opposite, and terminating along the enclosed banks.

In treating the city sewage and drainage, the proposal in Messrs. Bateman & Bazalgette's report, due originally to our able and indefatigable city architect, should be so far carried out. The middle and lower levels could with advantage be thrown into one, and the higher level retained, but connected with the main intercepting conduit at or below Whiteinch. By such an arrangement a considerable impetus would be given to the flow of the sewage at and below that point. The middle and lower levels being thrown into one would necessarily have their outfalls along the margin of the river, and discharge into the main conduit as it passed the city.

Reference has been made to the entrance of atmospheric air into sewers at their outfalls as performing invaluable sanitary functions; but connected as just described, aerial currents are effectually cut off. Provision is therefore necessary for a copious admission of atmospheric air into the sewers. This provision is supplied by constructing an air-opening at each outfall, fitted with a cast-iron ventilator; and a former proposal for carrying off the diluted sewer gases carried out, viz., the formation of small openings in the upper segments of at least the main sewers, with iron pipes hermetically fastened into them, and all led into a main, to be carried to some upland locality, and passing into a stalk of such dimensions and height as may be considered desirable. Such arrangements would certainly provide against all possible contingencies. The stalk could be as ornate as possible—made a thing of beauty on the landscape, as of joy to all apprehensive minds.

Following out the respective courses of the main intercepting conduits, that on the north side would receive the drainage and sewage of Tollcross, Westmuir, Parkhead, and Camlachie—places for which no provision has been made in any scheme yet proposed, and which stand in much need of being provided for. As it approached the Kelvin it would require to be diverted northwards, so as cross that tributary a little above Messrs. Tod & M'Gregor's works, where it would form another weir on that useful stream. Thence along Dumbarton Road, crossing the Forth and Clyde Canal under its bed, intercepting in its course the sewage and drainage of Maryhill, along with that of the high level system of the city. At Dumbarton it would properly traverse the town meadows; thence, by a deflection, across the channel of the Leven, so as not to affect any navagable uses of that stream. At this point the drainage and sewage of Dumbarton, Renton, Alexandria, Bonhill, and Jamestown could be provided for. From the Leven it would necessarily turn southwards to the adjacent enclosed bank.

On the south side the main conduit would pursue a direct course, taking in the sewage, &c., of Rutherglen and Pollokshaws, as well as that of the city south of the Clyde, till it reached Kingston Dock, where it would require to be diverted southwards up West Street; thence along the Paisley and Renfrew Roads, receiving the sewage of Govan, Pollok-

shields, and neighbouring districts, till it reached Renfrew, and deflected across the Cart, so as to preserve intact the navigation of that tributary. Thence, after passing the shipbuilding yards, &c., in that locality, along the margin of the Clyde to the enclosed southren bank ; provision being made in this part of its course for intercepting the sewage and drainage of Paisley, Renfrew, and Johnstone.

In Messrs. Bateman & Bazalgette's report no provision is made for flushing the main conduit, and is a very serious defect in it. Provision was proposed for this essential condition by a number of branches projected into the river from Hutcheson's Bridge upwards, at an acute angle directed up-river, trumpet-shaped, with strong valve openings, and projected so far as to catch the force of the tidal back flow. From time to time, as might be deemed necessary, during night tides, when the sewage flow is at the lowest, these valves could be opened and the main conduit cleaned out. River floods would supply a still greater flushing force.

Thus far the original proposal. It only remains briefly to indicate the alternative scheme, and a word as to the principle on which it proceeds.

It is not by any means a new idea, or confined to the writer, that the quantity of acids contained in the discharges from our public works is, on the whole or all but so, sufficient to precipitate the ammonia contained in our city sewage. It is a question which the writer does not pretend to discuss—on which he will not dogmatise ; and believes can only be satisfactorily settled by experiments conducted on a large scale. Opportunity is here taken to suggest that such experiments should be made by taking one of our sewage burns—the foulest—and introducing the discharges of one or more of our print or dye works, receiving the whole into a tank or tanks—say for twenty-four hours at a time. By some such means the question could be determined. But it was on the assumption that these aciduous discharges would act with practically sufficient precipitating effect on the sewage that the alternative scheme was elaborated, and the communication already referred to drafted.

All that has been said in respect of sewers and of main conduits remains the same, the only difference is the treatment of the enclosed banks and the utilisation of the sewage. Instead of filling up the enclosed areas within the belt of shrubbery, the proposal is to divide as much of each as might be required into a double series of reservoirs running parallel. This arrangement obviously requires inside dividing walls ; and the divisions should be wide enough to form carriage ways. There should be also necessarily short lines connecting the works with the Helensburgh Railway on the north, and the South-Western or Caledonian on the south. It would also be of advantage to have loading berths on the river walls.

The proposed series of reservoirs on the in or landward sides should be at least seven in number, one for each twenty four hours discharge ; that is—founding on Messrs. Bateman & Bazalgette's calculations, and which may be very safely relied upon for prospective requirements, and allowing for towns and inhabited places not taken into their reckoning—for about 60 million gallons each on the north side, and 40 million gallons each on the south side. Along these series of reservoirs, and on the landward sides, the main conduit should be led, provided with short branches, each with a strong valve, both with the necessary mechanical appliances for working. By this arrangement the consecutive reservoirs in this series

would receive the outflow of the sewage successively. At different depths a system of overflows, wrought with valve openings, should be constructed, communicating with the outer and parallel seriesi Twenty-four hours, it is assumed, would suffice for the subsidence of the sewage matters in the receiving reservoirs; and by the proposed system of overflows, the surface water could be run off into the outer series.

To facilitate the collection and convenient manipulation of the residuum, square iron tanks, each containing say half a ton, should be provided; and before turning on the sewage into the receiving reservoirs, spread closely packed over the whole area of the bottom. When filled, these tanks, with close fitted covers fastened down on flanges by bolts and nuts, could be conveniently and expeditiously lifted by suitable machinery, and the solids or residuum as a manure ready for sale and distribution per rail to any part of the country.

In the second series of reservoirs, a considerable subsidence of sewage matters would also take place. These would not require to be so numerous. Three might be sufficient, and a longer period allowed for subsidence, when, by a system of overflows similar to the former, the surface water could be discharged into the river substantially free of all really objectionable matter. The conditions so frequently introduced by Messrs. Bateman & Bazalgette into their report, and properly demanded as essential and indispensable to the discharge of sewage water into the Clyde "at any point" would thus be fulfilled. It is not necessary to observe that the deposits in the subsidiary series of reservoirs would be collected and removed in the same manner as from the first.

Thus, under a sense of much imperfection, has the writer attempted to sketch the foregoing schemes, and at too great length perhaps, presumed to controvert the opinions and proposals of others; and to review some of the main features of the scheme embraced in the report of the eminent engineers whom our civic authorities have consulted. And he trusts that any imperfection will be attributed to want of sufficient literary skill, and the credit accorded to him, as well to make himself intelligible without being intentionally prolix, as to aid to the extent of his humble ability the solution of the perplexing, and now most urgent and important, questions of the purification of the Clyde and disposal of the city sewage. If he shall have contributed in any measure to a solution so intensely urgent—of such overwhelming importance, his greatest reward will be in having done so, and in seeing the works completed and in satisfactory operation. Anything he has said, he further trusts, will not be deemed personally disrespectful by Messrs. Bateman & Bazalgette, or by any one else.

79 Great Hamilton St.,
1st Aug., 1869.

In attempting an estimate of probable costs, as a supplement for this re-issue, it is proper to observe that, in casting up the following, the author has availed himself to some extent of the rates in Dr. Gray's pamphlet, corrected, to the best of his judgment, by those in Messrs. Bateman & Bazalgette's report, and other information. Messrs. Bateman & Bazalgette have also been founded upon for quantities, as they have been followed by Dr. Gray.

SUMMATION OF PROBABLE COSTS.

Permanent Works.

Main Sewer, North Side, - - - - - -	£162,000	0	0		
Branch Sewers, Overflows, Ventilators, &c., North Side,	6,000	0	0		
Main Sewer, South Side, - - - - - -	144,000	0	0		
Branch Sewers, Overflows, Ventilators, &c., South Side,	4,000	0	0		
Enclosing Banks, River Walls, Piling, &c., both sides,	290,000	0	0		
Note.—This estimate is based on the River Trust depositing the dredgings at its own charges, in consideration of ultimate saving in dredging the channel, &c.					
Permanent Buildings, both sides, - - -	41,000	0	0		
Land, Compensation, &c., both sides, - - -	25,000	0	0		
Piping and Stalks for carrying off sewer gases, -	67,000	0	0		
Rails, Sidings, Turntables, &c., - - - -	8,500	0	0		
Making up and Repairing Street, Roads, &c., -	7,500	0	0		
				£755,000	0 0

Working Plant, &c.

Engines, Boilers, &c.—North Side, 200 H.P. South Side, 140 H.P.					
340 H.P., -	£34,000	0	0		
Note.—This item is entered conditionally to being necessary. A much lower sum may suffice.					
Steam and other Cranes, - - - - - -	5,000	0	0		
Barges, Waggons, Sewage Casks, &c., - - -	12,000	0	0		
				51,000	0 0
				£806,000	0 0
Interest on Money during Construction, Law, Parliamentary, Engineering, and preliminary expenses, 12½ per cent., - -				100,750	0 0
				£906,750	0 0
Interest on whole cost, at 4 per cent., - - - - - -				£36,240	0 0
Annual costs, maintainence, superintendance, &c., - - -				5,000	0 0
				£41,000	0 0

or a rate of about 3d. per £, taking in the Suburban Burghs and populous places, to which no objection by them need be anticipated. This rate might be considerably reduced by a reasonable charge for service on those burghs enumerated whose sewage would be received into the main conduits. To this also no reasonable objection could be raised by them; and all should be embraced in the act of parliament for carrying out the works. It may be assumed for certain, however, that at no distant date the agricultural value of the improvised land, and the profits on sale of the sewage manure, will cover the whole annual costs, with a considerable margin for contingencies and improvements.

JAMES BROWN.