THE

SHONE HYDRO-PNEUMATIC

SYSTEM OF SEWERAGE.

SCIENTIFIC AND SANITARY DRAINAGE

VERSUS

FLAT GRADIENT, FOUL TUNNEL SEWERS OF DEPOSIT.

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THE
Shone Hydro-Pneumatic System of Sewerage.

Scientific and Sanitary Drainage

VERSUS
Flat Gradient, Foul Tunnel Sewers of Deposit.

To SANITARY ENGINEERS AND LOCAL AUTHORITIES.

GENTLEMEN,

We venture to bring to your notice a few facts bearing on the important question of Drainage and Sewerage, with a description of the "Shone System"—the patents for which are licensed to us. We also publish some letters bearing on this subject, written by Gerald J. Cobb, Esq., M.A., of Cambridge University. Mr. Cobb is one of the Improvement Commissioners of Cambridge, and the whole question of sewerage now under their notice is treated by the author of these letters in so lucid and able a manner that we have ventured to republish them, as they appear to us to deal with many conditions not peculiar to Cambridge alone, the discussion of which will, in the interesting manner adopted by Mr. Cobb, be of service to gentlemen called upon to consider schemes for other places. There is only one point on which we would explain a matter which Mr. Cobb (in common with others) has misunderstood, viz. — "That the
sewage is necessarily passed from one ejector station to another and repeatedly ejected.” This process was adopted at Eastbourne and Warrington for special and purely local reasons, but unless special reasons exist, the sewage is at once sent to its destination from the several collecting ejector stations, which act quite independently of each other.

We trust the other matter advanced in this Pamphlet, especially the economics of the Shone system, as described by the Engineer—and its importance from a hygienic and agricultural point of view—will satisfy you that compressed air affords a cheaper means of raising sewage to such heights as are usually required than does the use of ordinary pumps, which latter render necessary either foul reservoirs, or foul reservoir sewers of deposit.

We are, Gentlemen,

Yours obediently,

HUGHES & LANCASTER.

Chester, March, 1885.
Letters addressed to "The Cambridge Independent Press

ON THE

BEST MODE OF SEWERING CAMBRIDGE,

By GERALD F COBB, Esq., M.A.

Fellow and Bursar of Trinity College, Cambridge.

LETTER NO. 1.—27th December, 1884.

As a commissioner of fifteen years' standing (during which time this question has been, in one form or another, continually under notice), I have been asked by many to place my views before the ratepayers; and by the courtesy of the Editor of The Cambridge Independent Press, I am allowed to use the columns of his paper for the purpose.

The question derives its urgency, not from direct sanitary pressure (for our bill of Health is a model), but from the pressure of central authority administering an Act of Parliament. As a loyal Englishman, I have, throughout this question, acted on the idea that we are bound to obey the law, and have used every effort to obtain such advice and information as may enable us to obey it to best advantage, and the subsequent portion of this communication will, I hope, prove that this aim is still before me. But, though bound to obey, every Englishman is free to criticise, and Acts so criticised are continually modified or repealed as public opinion may direct. There are many sanitarians who hailed the Rivers Pollution Act, 1876, with acclamation, but whom the experience of the eight intervening years has cured of such enthusiasm. They have come to regard it as an Act, the application of which though indeed necessary in certain cases, creates in others evils greater than those it would remove. Where the volume of water in a river ceases to bear a certain proportion to the sewage it conveys, or where, as in an estuary river, tidal action keeps the same sewage matter floating up and down for days or weeks together before it is dismissed to the sea, or where manufactures in which chemicals are employed poison the water and destroy the fish which are our food, there, no doubt, evils may be created calling for interference. But these cases are exceptional, and Cambridge is not one of them. The Act is being pressed against us in consequence of public animadversions on the state of the river, in which
the whole catalogue of unsavoury epithets has been exhausted, and it is not to the point to challenge the justice of their application.

* * *

A sweet pellucid stream undoubtedly adds a great deal to the charm and brightness of life, and is in itself a most desirable thing; but, from a sanitary point of view, it is more a luxury than a necessity, and as such its desirability has to be estimated in the light of the price to be paid for it.

All sanitary experience teaches us that, provided stagnation is avoided a perfectly open drain is the least injurious sewer you can have; and that in proportion as your sewer is enclosed and buried the danger to health is increased. People talk glibly enough of patent "traps" and of various modes of sewer ventilation. By all means trap and ventilate; it is undoubtedly better to do so than not to do so, but it is only a very little better. No trap exists which will uniformly resist the pressure of sewer gas, and no system of ventilating pipes has yet been found which will uniformly carry it off. On the contrary, the down draught of a neighbouring ventilating pipe will often be the cause of the forcible upheaval of the trap.

Assuming, however, that we have to divert, our wisest course, I venture to think, is to look well into the future. We know that the fertilising value of the excreta of a town of this size is very considerable if only they could be applied in proper condition and over a proper area. In all sewage questions we should never lose sight of this consideration: it means more to a country like England than to any other in the world. In one respect, we are the least free of any nation the world has known, for we are dependent on others for one-half our nourishment. Nothing but a war on a scale proportioned to that of eighty years since will ever teach us what this really means; still, we can recognise it as an important fact, and as one which lays upon all the imperative duty of doing what we can to minimise the loss which every year of our present waste of excreta entails upon us. No one questions that the application of excreta undiluted and in moderate quantity has great fertilising effects, and the most perfect system that could be devised would be one which could secure the widest area for their distribution in the least diluted form. A system of privies and cesspools, with constant removal in carts to all surrounding lands within a given radius of a town, is, in theory, the best and least wasteful method; but the difficulties of proper inspection and the outcry against the nuisance of the removal, place such a system, in the present unfortunate state of public opinion, out of practical range. Next, perhaps, in utility, is the system which substitutes compressed air for water, as the medium of transmission, thus entirely obviating the loss of value implied in dilution, and enormously facilitating distribution. But this involves too extensive a revolution
in the fitting-up of our houses to meet with approval. Then there
is the dry earth system, admirable, no doubt, from a sanitary point
of view (where under proper supervision), but somewhat costly
and disappointing as regards its application as a fertiliser. Deeply
as we may regret it, we must assume that our present water-closet
system is to be retained in bulk, however much we may endeavor
to cut its proportions down on all available occasions. We have then
to deal with sewage proper, by which is meant water-carried excreta.
For the last thirty years this question has been the subject of com-
missions, committees, and individual scientific investigation without any
intermission, and a full résumé of all that has been done will be found in
the Royal Commission Report, published a few days since. The history
of these inquiries, though presenting one unbroken series of defeat and
disappointment, so far as the question of utilisation is concerned, never-
theless points out sufficiently clearly the only direction in which we can
hope to advance towards the desired end. In the course of what follows
the word “profitable” may have to be used; but it is necessary to
premise that its meaning is relative and not absolute. The idea that we
can “make a profit” in the ordinary sense of the word by our applica-
tion of “sewage” (i.e., water-carried excreta) to land has long been
exploded; and if one course is spoken of as more profitable than another,
all that is meant is that it will go further in reducing the incident
burden of rate. In this sense experience proves that our application will
be more profitable in proportion as our sewage is the less diluted, and a less
amount of it applied to a given area. The first point is to be attained by
the separate system, which is the only gate by which we can even enter
upon the road of probable success in these matters. The second point is
to be attained by the double process of extending your acreage on
the one hand, and of reducing the amount of sewage you apply to it on the
other; and this, in its turn, is not attainable by the exclusive adoption
of any one system or method of sewage treatment in particular. The
most prudent course to adopt will, I venture to think, be that which, on
a careful consideration of the whole question, leaves us the most free to
deal with the sewage in the greatest variety of ways, and places us in the
best position to profit, in years to come, by such discoveries as further
experience in these matters may bring to light. I would advocate the
immediate purchase of sufficient land for a farm, as well as for filtration;
but I would not advocate the immediate application to it of a complete
and extensive system of preparation. It is for our future interest to get
the maximum amount of land now, because it is not likely that land will
be cheaper 15 or 20 years hence than it is now (especially in the neigh-
bourhood of a town), and, in deferring our purchase, we shall have to
purchase eventually under this disadvantage—viz., that the adjacent land
will be a necessity to us and will command, therefore, an “accommoda-
tion” price. The purchase of this land need not in itself be a very
appreciable burden on the rates. It is not like money sunk in sewers
and pumping stations, which has no realisable equivalent, and which, if
borrowed, must be paid off by a sinking fund within a short time. The land we do not take into immediate use can be let as before, and its rent will help to pay the interest on a mortgage made upon it; and, should the experience of the next twenty years show that we can do without it, it is ours to sell again. We should, I feel sure, be "penny wise and pound foolish" if we stinted ourselves at the outset in this matter of land.

With regard to the costs to be incurred upon the preparation of the land, it will scarcely be necessary to embark immediately on any such outlay as has been mentioned. We can surely proceed tentatively in this matter. We can, for instance, start by laying out twenty-five acres of it, say for filtration, and one hundred for irrigation, and this, I venture to think, will be found sufficient for ten or fifteen years to come if combined with other methods, which shall be mentioned subsequently. The Royal Commissioners adopt Mr. Bailey Denton's proportion of one acre to every 1,000 inhabitants for filtration where this is the only method adopted, and if we reduce the amount of sewage to be so applied by the introduction of other methods by way of margin or appendix, twenty-five acres will not be materially below their standard.

Fifteen years hence we shall know more about these matters than we do now, and if we find we have to use the rest of our land, we shall probably be able to lay it out to more profit than we can now. Still I feel confident that in one way or another it will be eventually necessary that we should use it, and we shall not, I think, be the losers by buying now rather than then. It has been said that land is depreciated by the proximity of a sewage farm, and that on that account we should be able to buy the land cheaper hereafter. I do not believe this. For building purposes, no doubt, the land will be depreciated, but not for agricultural. Considering the recent rapid fall in the value of land, it seems more likely that prices will soon experience some slight advance, especially in the case of land contiguous to a large market town. It seems to me that it would be a short-sighted policy to stint ourselves in this matter of land, though I would advocate extreme caution in our method of dealing with it, only advancing step by step as the actual necessities of the case may determine.

In a subsequent communication it is proposed to treat of the method by which our sewage should be conveyed to the land, and of our system of town sewering generally.

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LETTER No. II.—3rd January, 1885.

Last week the question was raised as to the necessity, from a sanitary point of view, of diverting our sewage from the river. Then, on the assumption that it would have to be diverted, whether advisable or not,
its application to land was considered. There now remains the question of the method of its conveyance, and of the town system of sewerage generally.

Mention was previously made of the danger to be apprehended from a prolonged deep sewer with its manifold opportunities for the formation of sewer gas. Traps and ventilation may indeed lessen this danger; but they are far, very far from removing it. The only really safe course is to prevent its existence altogether. If sewer gas is generated at all, the health of the community is endangered. We must have no sewer gas. Sewer gas is the result of bacterial fermentation, and fermentation requires time. If you can secure a complete and rapid passage of your sewage through your drain system there is no opportunity for fermentation, and, therefore, no gas. But in sewers of a sluggish flow, and especially in old brick drains where there are settlements, or where the mortar has been worked out by rats or storm flow, and gaping interstices are left, there we have stagnation and deposit, and gas reigns supreme. The natural fall of Cambridge is so inconsiderable, that in order to obtain any gradient at all we have to carry our sewers very far below the surface. In this way we not only encourage gas formation and render ventilation difficult; but we are exposed to three kinds of heavy expenditure—(1) initial, as regards cost of sewer construction—(2) chronic, as regards pumping at the outfall—(3) intermittent, as regards the depth of the excavations to be made in the case of repairs or attachments. It is, however, perfectly possible for us to avoid all this danger, expense, and inconvenience, if we choose. Mention was previously made of a system of air closets as a substitute for water closets, but it was dismissed as practically beyond our reach. But there is a method by which the air system can be applied to help the water system, the principle of which may be stated as follows:—Where a sewer reaches a certain depth, instead of carrying it further at a continually increasing depth, it is made to terminate in an air-tight receiver. Directly the contents of the receiver reach a certain level, compressed air generated at some central station and laid on in small air pipes automatically introduces itself, and sweeps the contents out and up to any height required, where they are started on a fresh journey in a new sewer at a higher level. When this new sewer reaches a certain depth the process is repeated, and so on, as often as may be wanted. By this means difficulties arising from deficiency of natural gravitation are overcome, and we are enabled to lay our sewers at steeper gradients than is otherwise possible, thus securing for their contents more rapid removal. This rapid flow not only gives us immunity from gas, but enables us to employ drain pipes of proportionately smaller diameter, a point of very considerable financial importance where the sewer mileage is as great as it is in this town, the area of which (owing to our numerous open spaces, &c.) is exceptionally large as compared with its population. Again, as this process of pneumatic elevation can be applied at any point or points of the sewer system that
may be wanted, we can construct our intercepting sewer along the river side at any level we like—even above ground, if we prefer it so—and thus avoid all the difficulty and expense of laying it in the gravel below the water level. Further, when we reach our intended terminus, instead of having the sewage pumped up with its attendant nuisance, the air may be again applied to eject the sewage through an air-tight receiver to any height or distance that may be required for land application without any smell whatever. Once more; the Report of the Royal Commission warns us that both filtration and irrigation often fail to produce an effluent of the required standard of purity; but, even here the pneumatic ejector will offer most pertinent assistance. Impure water, as is well known, purifies itself with great rapidity, if it be exposed to the air by falling over a weir. If then the effluent from our land be collected into a drain and raised again by passing through one of these ejectors, so as to make it tumble in a succession of little cascades over a broad weir constructed for that purpose, there can be very little doubt of the required standard of purity being attained.

Another great advantage of this system of pneumatic ejection is the elasticity of its application. It will always enable us to meet the case of any further expansion of our sanitary district, or to connect the drainage of any adjacent districts with our own should any such federation be desirable. It offers a ready remedy for already existing difficulties, such as that of the valley portion of Romsey Town, where the only method of sewerage by gravitation will involve a long separate route to the outfall. With the aid of the ejector the drains of houses built on land lying below the level of our Mill-road sewer can be at once brought into communication with it, and the expense of the proposed long sewer from Romsey Town by Coldham-lane to our outfall avoided.

In my last communication I spoke of the separate system as the only gate by which we could ever enter on the road of progress as regards sewage disposal; and so, indeed, it is. On its own merits, no one would question the desirability of its adoption; but it has failed to meet with the practical consideration it deserves on the ground of the great outlay supposed to be involved in its introduction. But that outlay will be very materially reduced by the adoption of the ejector system; for, as has been already pointed out, it will enable us to substitute comparatively small drain pipes for big sewers, as well as to avoid the expenses attendant upon deep levels. With this aid, the cost of separating our systems will be reduced to much less formidable dimensions, and I venture to think that it will be well recouped—(1) in our immunity from sewer gas (2) in the enormous reduction of the volume of liquid to be lifted (whether by direct pumping or by air) at the outfall—a reduction which it is well within the mark to estimate as one of from five to three (3) in the increased facilities as well as
prospects of productiveness it offers in the ultimate disposal of the less-diluted sewage on the land. Something, too, may be added to this account on the credit side, by the consideration of the fact that our existing drainage system merely regarded in itself (apart, that is, from the question of sewage-dilution) is not wholly satisfactory. Cambridge was probably early in the field with its drainage, and a considerable portion of our main drains are what would now be considered constructively inferior, besides having suffered somewhat from time and use; and even in the case of others of comparatively recent construction we have not been without our warnings of late that their meagre gradient is liable to be a source of recurring trouble and expense to us. I think the majority of us would live happier if we knew that they had been promoted to the less responsible office of relieving us of our surface and subsoil drainage only, and that more dangerous matters were consigned to safer and more approved channels. Neither need the actual process of introducing separate drains, if thus assisted by the ejector system, be very alarming. There will be no need to open out our existing sewers and envelope the town in pestilential exhalations, as alarmists are fond of asserting: we have only to lay our new drains at a moderate level, and to intercept the house pipes by them.

But it is well, perhaps, to point out that the "separate system" and the "ejector system" are in no sense inter-dependent parts of one scheme. The only connection between the two is that the cost of introducing a separate system is enormously reduced in cases where the application of compressed air is available. The ejector system will be found valuable whether we separate or not, and, with regard to this system, I think it right to add that my opinion of it is not based upon any ad captandum descriptions given by parties commercially interested in it. I have, indeed, been favoured (along with other commissioners) with a call from the engineer with whose name it is associated; but he did not find me at home. My opinion of it is based upon considerations of the value of pneumatic methods generally, and upon the result of personal inquiries made a few days since at Eastbourne; where, as at other places, its application to sewage removal has been tested by practical experience. In the course of some recent communications to the Independent Press on the drainage question, the writer expressed some surprise that our sub-committee should have, as it were, gone out of their way to visit a seaside place, implying that there was some special connection between the pneumatic system and the discharge of sewage into the sea. This is not the case. From the information I obtained at Eastbourne it would appear that it has been mainly applied there, as at inland towns, to meet the difficulties of levels and gradients caused by natural valleys and hollows in the town itself; to meet, in fact, precisely the same class of difficulties we have to contend with here.

The practical value of compressed air as a transmitting medium has,
of course, been tested long ago in the case of Post Office tubes and other similar appliances; and at the present moment a combined movement is going on among manufacturers and others at Birmingham, under the auspices of the corporation, for its application to factories, &c., as a motive power. There is nothing visionary or unpractical in urging its adoption here, for it has been endorsed with the approval of some of the shrewdest and most practical men of the time. As possessors of an air-station, the engines of which would be to a considerable extent worked by the burning of our refuse, we should possess a power which we can at any time apply to any point or section of our sewage system, whether single or separate, and which will enable us to meet all eventualities of the expansion of our sanitary district, whether beyond Romsey Town, along the Hills-road, the Trumpington-road, or elsewhere. Wherever we may be called upon to drain, no matter what the difficulties of level, we can at once meet them, and, by an ejector, connect new drains with our existing system. A pertinent case occurs to me at this moment. About a quarter of a mile beyond the railway bridge, ground has been advertised for building lease, and a road has been laid out. The case is one of the most vital interest to the town, and it has already received the anxious attention of the commissioners. As natural levels go, the drainage of any row of houses there will have to go into a hollow from which there is no outlet. At present there would be no possibility of connecting any of their sewers with our own. But, in this particular instance some absolutely safe method of drainage is essential to the health of our town generally, as the hollow alluded to is immediately contiguous to the wells from which the Cambridge Waterworks derive their supply. With air power at hand, the difficulty is solved.

It was urged, at the outset, that our wisest, by which I mean our most economical, course as regards diversion is to look well into the future. I have shown that, as regards sewage transmission and the future requirements for draining new districts, pneumatic aid will be of the greatest value to us. I would also point out that, as regards sewage application, it will give us a freedom not to be attained by any other method. I look forward to a time when the fertilising value of excreta and the desirability of minimising their dilution will be such a household word among us, that our present heedless and needless extravagance in the use of water for domestic purposes will die out and that, instead of the monstrous allowance our engineers are now obliged to credit us with of 30 gallons a head for every 24 hours, a far smaller amount will have to enter our sewers and a corresponding increase in the fertilising value of our sewage be realised. When this is so, other outlying farms on other sides of the town may be found ready to take, at intervals, moderate quantities of our sewage from us. In such a case, it will be easy to intercept a main sewer at any convenient point to insert an ejector and periodically lift the sewage for carting as may be desired. And at our
proposed outfall station, it is possible that this power of ready elevation may be found of use in helping to fill barges with it for the fertilisation of farms lower down the river. If, again, we should find it possible to reduce in any way the amount of our sewage, by introducing in any particular localities a pail-system we can apply the pneumatic process, as at Warrington, to the transmission of their contents as convenience may suggest. Indeed, the resources which this system opens out to us in all directions, as we look into the future, are practically inexhaustible.

But, supposing we confine our view of it for the present to our bare immediate wants in their narrowest possible form, viz., the mere intercepting of our existing sewers and the transmission of their contents on to land, we shall be the gainers by adopting the pneumatic system in the following points:—

(1.) The intercepting sewer can be laid at any level we like so as (a) to avoid all the difficulties, initial or permanent, of river percolation, and at such a gradient as shall (b) secure rapid discharge and immunity from gas. Both these points, high level and rapid discharge, will save initial expense, both as regards excavation and diameter of pipes.

(2.) Instead of a pumping station with its smells and with the wear and tear of machinery involved in the passage of troublesome substances, such as hair, string, &c., through it, our sewage will be passed through one of these air-tight receivers direct on to the land. Moreover, as the ejector works automatically just according to the demands put upon it, there will be no need of those large intercepting tanks which in ordinary pumping stations the variations in the volume of sewage render necessary, and which are the chief cause of nuisance.

(3.) By a further application of the same power, we shall be able to expose our effluent to the oxygenating influence of the air, and so secure its purity.

(4.) We shall have the constant satisfaction of knowing that we possess a power which can be brought to our assistance under any necessities of modification or expansion that the future may have in store for us.

Much interest has been aroused by a scheme which has been suggested by a local authority, and which has not unnaturally been received with a certain enthusiasm by his fellow-townsmen. From the first appearance of Mr. Bullock’s letters in the newspapers (copies of which I carefully kept and have now before me), I have followed the development of his scheme in its various phases with the closest
attention, and if I cannot give it my approval, it is not from any want of due consideration or of full appreciation of his public-spirited conduct in suggesting it. I have never felt much doubt as to its perfect feasibility, meaning thereby that clay was there and, being there, could, of course, be tunnelled through; but it has always seemed to me that the cost of constructing such a sewer was very seriously underestimated, and I am not surprised to find that the expert to whom the scheme has been referred differs in his estimate from Mr. Bullock's in the ratio of (roughly) two to one. On the occasion of Mr. Hawksley's first interview with the committee, having carefully abstained from previously expressing any opinion myself on Mr. Bullock's scheme, I put to him the following questions:

Q.—You have told us that the scheme is feasible; do you consider it advantageous?

Q.—If you were called upon to advise us generally as to the settlement of this question of sewage diversion, is it a scheme which you would recommend us to adopt?

That there might be no possible misunderstanding in the matter I repeated these questions at the conclusion of the interview, the chairman requesting the clerk to take special note of question and answer. The answer to both questions was an unqualified negative.

This interview, it should be mentioned, was previous to the borings, and the answer was given on the assumption that their results would be favourable.

It must certainly be assumed that the site proposed in that scheme for pumping-station and land purification is out of the question. Our prevailing winds will blow steadily from it on to the large and increasing village of Old Chesterton, and, considering that the Local Government Board have on several occasions formally alluded to the site suggested by Sir Joseph Bazalgette and others as being in their opinion the best, the slightest protest from Chesterton would secure their veto. We must then add at least another 1300 to Mr. Bullock's original 3700 yards of main sewer, besides a permanently increased demand on pumping power at the end of it. This would make the length of proposed tunneling 5000 yards, which, at £7 10/- a yard, is £37,500, a sum which, as will presently be seen, is only a very little short of that for which the pneumatic engineers offer to provide not only a main intercepting sewer, but an entire system of separate drainage for the whole of our sanitary district.

But, apart from this initial outlay, there are other serious objections to the proposed tunnel. First—in a town like ours, with so many
large and important buildings, we cannot afford to trifle with foundations; and we have had abundant warnings in places not so far away of the effect of under-drainage and consequent shrinkage of sub-soils in this respect. Second—A long, deep sewer, such as is proposed, with its proportionate difficulties of ventilation, must have a very good gradient indeed to secure us against gas; and it is especially important to call attention to this point, because it is suggested in the scheme (see page 9) that, as the sewer will be of such ample capacity, the sewage should be allowed to accumulate in it and the pumping be intermittent and not continuous. Third—Even at the gradient proposed, the depth attained at the outfall, and consequent permanent expense of pumping, will be very great. Fourth—Although it is perfectly true that the great depth of the sewer will not in any way add to the difficulty of making new connections where main sewers already exist, it will certainly not facilitate matters when we come to deal with new districts.

Regarded as a scheme for the transmission of our sewage, Mr. Bullock's proposals do not commend themselves to me. With regard to what should be done with the sewage after its transmission, that is a separate question altogether and should be treated as such in all our discussions. Undoubtedly, Mr. Bullock's proposal for filtration pure and simple has much to say for itself on the grounds of immediate economy; and, so long as we take such present steps as will secure us full liberty to extend our system by irrigation hereafter, as our needs and experience may suggest, I, for one, am by no means eager for hasty or expensive outlay in the preparation of the land acquired—more particularly if, by the adoption of ejectors, we are enabled to purify our effluent by exposure to air in the manner suggested. But I do hope the rate-payers will clearly understand that the question of the application of sewage has nothing to do with that of its transmission, whether by tunnel or otherwise, and that, whilst applauding the efforts of Mr. Bullock and others to minimise expenditure on the former head, they will decline to accept his scheme for transmission, the economical merits of which it will, I think, severely tax their ingenuity to discover.

A few figures may be added in conclusion by way of illustration. They have reference to transmission; i.e., to sewerage only, excluding pumping station, rising main, purchase and preparation of land, and the annual charges for pumping and farm labour. The three schemes we have had before us in recent years—Sir Joseph Bazalgette's, the Pneumatic Company's, and Mr. Bullock's—give us the following estimates under the head of transmission:—

(1) Sir J. Bazalgette's, submitted in November, 1878 (see Report, p. 12), gives us £19,397 10s. 10 per cent. for contingencies,” which, with the additions in their 3rd Report of April 14, 1879, gives us a total of £21,925 for sewerage. Let us call it £22,000.
(2) The Pneumatic estimate, submitted to the commissioners in October, 1879, gives us—

For intercepting sewers, &c. ... ... £10,720 17 0
For air mains and ejectors ... ... 5,540 17 6
Ten per cent. for contingencies ... ... 1,636 0 0

£17,897 14 6

Call it £18,000, with a complete scheme for resewering the whole district on the separate system for an additional £30,000. (N.B.—The charge for intercepting sewers in this case includes the rising main. I have no means of estimating the sum to be deducted for this; but, as both Sir J. Bazalgette and Mr. Hawksley estimate it at £5000, I think we might safely put this at £2000, thus reducing the total cost for transmission to the outfall to £16,000).

(3) Mr. Bullock’s intercepting tunnel and attachments, according to his own latest estimate (see p. 16 of his Report of April, 1884) will cost £17,500, to which he appends as “necessary to complete his system” of transmission, further “similar deep sewers” and shafts, etc., at £24,500. To this must, of course, be added as in the other cases, 10 per cent. for contingencies, making a total of £46,000; call it £46,000. But, according to the views of most competent judges, Mr. Bullock has seriously underestimated the cost of tunnelling, and Mr. Hawksley—to whom his scheme was referred—put it (previous to the borings) at “not less” than £7 10s per yard, whereas Mr. Bullock (see Report p. 16, “3700 yards at £14,300”) puts it at £3 17s 3½d per yard. Moreover, it is as certain as anything can well be that owing to the difficulties of site, another 1300 yards will have to be added to it, making 5000 yards in all. At Mr. Hawksley’s price, this gives us £37,500, and at Mr. Bullock’s £19,317 14s 2d. I see myself no reason to dispute Mr. Hawksley’s estimate; but suppose we “split the difference” and say the intercepting tunnel will cost £28,408 17s 1d. Let us further allow that Mr. Bullock’s complementary “similar deep sewering” (£24,500) has not been under-estimated—though, as being (as I infer from his word “similar”) tunnel work, it probably has been—and we get the sum as follows:

5000 yards of intercepting tunnel and shaft at the mean estimate between the two ............... £28,400
The necessary sewer attachments in Mr. Bullock’s £17,500 (see Report, page 16) ...................... 3,200
“Similar deep-sewering to complete the scheme” (at his own estimate) ...................................... 24,500
10 per cent. for contingencies .......................... 5,600

£61,700
All this is charge for sewering only, before we reach the outfall. If we apply Mr. Hawksley's estimate of £7 10s per lineal yard to the whole of Mr. Bullock's proposed tunnelling, we arrive at a total of £85,750, which is nearly double the price (£46,000) for which we are offered not only transmission to our outfall, but the whole re-sewering of our district on the separate system. Adding to Mr. Bullock's estimate the cost of the additional 1300 yards of tunnel at his own price per yard, we have the following three totals for his scheme of transmission (i.e., for sewering only):

(a) At Mr. Bullock's own figures .................. £51,750
(b) At a mean estimate.............................. 61,700
(c) At Mr. Hawksley's figures ..................... 85,750

We will now translate these figures into their annual equivalents, on the assumption that we borrow from the Public Works Loan Commissioners for fifty years at 3½; i.e., that we have to repay for interest and Sinking Fund at the rate of 4¼ on the amount borrowed:

(1) Sir J. Bazalgette's diversion is equivalent to an annual charge on the rates of £935.

(2) The Pneumatic diversion (£16,000) gives £680, and the separation (£30,000) £1275, making a total for the two of £1955.

(3) Mr. Bullock's diversion will give us £2190 at his own figures, £2622 at the mean, and £3645 at Mr. Hawksley's.

It only remains to add that Mr. Bullock's tunnel will, on his own figures, land our sewage at a depth of 75 feet below the level (of the Milton site) to which it will have to be lifted.
IMPORTANCE OF THE
“Shone System” from a Hygienic & Agricultural
POINT OF VIEW.

We have deemed it expedient to take advantage of the opportunity
which the publication of Mr. Cobb’s letters affords us of explaining, as
briefly as possible, what the “Shone System” really means. The nu-
merous inquiries which we receive from time to time satisfy us, that if
we can only succeed in doing this, once for all, we shall not only save
ourselves much trouble hereafter, in writing impromptu descriptions of
the System, but we shall at the same time make it easier for inquirers
to read what we have to state about it, because reading printed matter
is always less tedious than reading written matter, however plain the
latter may be.

In the first place we desire to emphasise the fact that the “Shone
System” does not require, as some suppose it does, special water closets,
house drains, and town sewers to make it work. It readily adapts itself
to the water closets, house drains, and town sewers which are always
used in connection with what is known as the English water carriage
plan of sewage removal; and it will adapt itself to this plan whether
the house, town or district to be benefited by it is drained on the “com-
bined” or the “separate” system.

Hitherto, Sanitary Engineers have generally adopted what is known
as the combined system of drainage, for the sake of getting the drains
and sewers flushed by rainfall-waters, without which, as they have con-
tended, house-drains and sewers receiving sewage only would become
a greater nuisance than the house-drains and sewers of the combined
system, which are designed to take both sewage and rainfall.

We believe that in this respect the Engineers having recourse simply
to gravitation sewers, have been right in their conclusions, because, when
the sewage is separated from the rainfall, its volume is considerably
reduced; so much so, that even the whole, when it reaches the outfall
sewer, instead of being sufficient to nearly half fill the sewer, as it should
do, is frequently not sufficient to half fill the smallest tributary sewers
of the combined system; and as there are miles of these tributary sewers
in every town, it follows that during the dry periods, which usually
form two-thirds of the whole year, the flow of the sewage must be torpid,
and the sewers, sewers of deposit. From this cause the nuisance of sewage gas arises.

With a view to arrest the attention of Sanitary Authorities to this fact, Mr. Shone has prepared Hydraulic Tables for practical reference, which are published by Messrs. E. & F. N. Spon, 125 Strand, London, by which we find, for instance, that a 12-inch sewer pipe, laid at a gradient of 1 in 350, will pass, when it is running full bore, 115.56 cubic feet per minute; a quantity equal to the greatest quantity of sewage which could possibly proceed from a population of 23,112, when that population was pouring into its sewers the greatest quantity at any one minute of the day, and reckoning the sewage discharges to be 4 cubic feet or 25 gallons per head per day! These Hydraulic Tables tell at a glance what gradients, what quantities of sewage, and what populations are indispensably necessary to render sewer pipes self-cleansing. They show clearly, by figures and explanatory matter, that small volumes require small pipes laid at comparatively steep inclinations, but as the surfaces of few towns and districts are so favorably inclined naturally, so to admit of the required inclination being uniformly obtained, it follows that the essentials of Sanitary drainage can only be secured in towns unfavorably situated for gravitation sewers, on the old lines, by our resorting to some artificial means for procuring them. In the face, therefore, of this natural surface-of-ground hindrance to the more general adoption of the "separate system," it is not surprising to find that its advocates, though numerous and energetic, have as yet made but little headway.

By the adoption of the "Shone System," however, the conditions essential to the successful working of the separate system, which is now acknowledged by the highest Sanitary Authorities to be the best,* is made possible under the most adverse natural difficulties.

Knowing this statement to be literally true, we feel that we are not asking too much of those interested in questions relating to Sanitary Sewerage and Sewage disposal, which undoubtedly are questions of the first public importance, to be good enough to give the "Shone System" their calm and impartial consideration, more especially as, upon investigation, it will be found that it is more economical in first cost and annual charges than the gravitating system of drainage, pure and simple, which too often, as everybody knows, pollutes the ground we live upon, the air we breathe, and the water we drink.

It is well known to all sanitarions who have given the subject any

* "I submit, therefore, as a point to be argued out, that this Society can never be soundly assisting Sanitation until it assists some other mode for removal of excreta than the separate system."—BENJAMIN WARD RICHARDSON, M.D., F.R.S.

See also Appendix for Views of the Royal Commission on the Metropolitan Sewage Discharge on the Separate System. (Page 50.)
thought at all, that the numerous and various patents which have been taken out from time to time, for the sanitary treatment and utilisation of English water-carried sewage, have invariably failed, because they have dealt with the effects, and not with the cause, of the foul state of our house-drains and sewers, &c.

The merest tyro in sanitary matters, however, will admit that if we could but remove the sewage from our houses and towns, practically, as rapidly as it is discharged therefrom, we should by so doing put an end to foul smells and dangerous sewage-gas nuisances; and every sewage farmer will tell us that if he could only get fresh sewage discharged in that fashion, its value for distribution on land as liquid manure would be enhanced enormously.

The "Shone system" accomplishes these desiderata in a simple but natural and efficacious manner, by removing the cause of ground water and air pollution; for, by its aid, the polluting element (the sewage) is ejected innocuously outside the limits of our town areas, before it can possibly enter into a state of decomposition within our town areas, but it does not stop here; the system is so elastic that it can be designed to eject the sewage not to one spot only, but to as many spots or fields as may be determined upon without having more than one air-compressing station, and the quantity thus ejected can be measured by simply attaching a counter to each ejector to register the number of times the ejectors are filled and emptied.

We believe that sewage proper, thus collected and ejected, would soon be sought after and bought by agriculturists.

The "Shone System," however, will prove itself to be equally efficacious if it is preferred to eject the sewage in combination with rainfall to one outfall for chemical or other treatment, or to a river or the sea. In these days, however, when we hear so much about throwing the sewage of the metropolis into the Thames and the sea, it may not be inopportune for us to be reminded of what Sir Robert Rawlinson, C.B., said a few years ago about sewage, viz.:—"The sanitary engineer and manufacturer of the future will know nothing of waste products, because sewage will be used as manure; and the ingredients which now pollute and destroy our rivers will be converted to profitable uses."

We venture to think that the systematic adoption of the "Shone System" would enable the sanitary engineer to do all that Sir Robert Rawlinson prophesied in 1870 would come to pass.

Twenty-three years ago (1862) Victor Hugo, in his 'Les Misérables,' vol. iii., chapter xlvii., wrote the following:—

"The Earth impoverished by the Sea.

"Paris casts twenty-five millions of francs annually into the sea, and
we assert this without any metaphor. How so, and in what way? By day and night. For what object? For no object. With what thought? Without thinking. What to do? Nothing. By means of what organs? Its intestines. What are its intestines? Its sewers. Twenty-five millions are the most moderate of the approximate amounts given by the estimates of modern science. Science, after groping for a long time, knows now that the most fertilizing and effective of manures is human manure. The Chinese, let us say it to our shame, knew this before we did; not a Chinese peasant—it is Eckeberg who states the fact—who goes to the city, but brings at either end of his bamboo a bucketful of what we call filth. Thanks to the human manure, the soil in China is still as youthful as in the days of Abraham, and Chinese wheat yields just one hundred and twenty fold the sowing. There is no guano comparable in fertility to the detritus of a capital, and a large city is the most important of dung mixes. To employ the town in manuring the plain would be certain success; for if gold be dross, on the other hand our dross is gold.

"What is done with this golden dung? It is swept into the gulf. We send at a great expense fleets of ships to collect at the Southern pole the guano of petrels and penguins and cast into the sea the incalculable element of wealth which we have under our hand. All the human and animal manure which the world loses, if returned to the land instead of being thrown into the sea, would suffice to nourish the world. Do you know what those piles of ordure are, collected at the corners of streets, those carts of mud carried off at night from the streets, the frightful barrels of the nightman, and the fetid streams of subterranean mud which the pavement conceals from you? All this is a flowering field; it is green grass; it is mint; and thyme, and sage; it is game; it is cattle; it is the satisfied lowing of heavy kine at night; it is perfumed hay; it is gilded wheat; it is bread on your table; it is warm blood in your veins; it is health; it is joy; it is life. So desires that mysterious creation, which is transformation on earth, and transfiguration in heaven; restore this to the great crucible, and your abundance will issue from it, for the nutrition of the plains produces the nourishment of men. You are at liberty to lose this wealth and consider me ridiculous in the bargain; that would be the masterpiece of your ignorance. Statistics have calculated that France alone pours every year into the Atlantic a sum of half a milliard. Note this: With these five hundred millions one-quarter of the expenses of the budget would be paid. The cleverness of man is so great that he prefers to get rid of these five hundred millions in the gutter. The very substance of the people is borne away; here drop by drop, and there in streams by the wretched vomiting of our sewers into the rivers, and the gigantic vomiting of our rivers into ocean. Each eruption of our drains costs us one thousand francs, and this has two results; the earth impoverished and the water poisoned; hunger issuing from the furrow, and
illness from the river. It is notorious that at this very hour the Thames poisons London; and as regards Paris, it has been found necessary to remove most of the mouths of the sewers down the river below the last bridge.

"A double tubular apparatus supplied with valves and floodgates, a system of elementary drainage as simple as the human lungs, and which is already in full work in several English parishes, would suffice to bring into our towns the pure water of the fields and send to the fields the rich water of the towns, and this easy ebb and flow, the most simple in the world, would retain among us the five hundred millions thrown away. But people are thinking of other things. The present process does mischief while meaning well. The intention is good, but the result is sorrowful; they believe they are draining the city while they are destroying the population. A sewer is a misunderstanding, and when drainage, with its double functions, restoring what it takes, is everywhere substituted for the sewer, that simple and impoverishing washing, and is also combined with the data of a new social economy, the produce of the soil will be increased tenfold, and the problem of the misery will be singularly attenuated. Add the suppression of parasitisms, and it will be solved. In the meanwhile, the public wealth goes to the river, and a sinking takes place—sinking is the right word, for for Europe is being ruined in this way by exhaustion.

"As for France, we have mentioned the figures. Now as Paris contains one twenty-fifth of the whole French population, and the Parisian guano is the richest of all, we are beneath the truth when we estimate at twenty-five millions the share of Paris in the half milliard which France annually refuses. These twenty-five millions, employed in assistance and enjoyment, would double the splendour of Paris, and the city expends them in sewers. So that we may say the great prodigality of Paris, its marvellous fête, its Folie Beaujon, its orgie, its lavishing of gold, its luxury, splendour, and magnificence, is its sewerage. It is in this way that in the blindness of a bad political economy, people allow the comfort of all to be drowned and wasted in the water; there ought to be St. Cloud nets to catch the public fortunes.

"Economically regarded, the fact may be resumed thus: Paris is a Danaë's cask. Paris, that model city, that pattern of well-conducted capitals, of which every people strives to have a copy, that metropolis of the ideal, that august home of initiative, impulse, and experiments, that centre and gathering-place of minds, that nation city, that beehive of the future, that marvellous composite of Babylon and Corinth, would make a peasant of Fo-kian shrug his shoulders, from our present point of view. Imitate Paris, and you will ruin yourself; moreover, Paris imitates itself particularly in this immemorial and insensate squandering. These surprising follies are not new; it is no youthful nonsense. The
ancients acted like the moderns. 'The drains of Rome,' says Liebig, 'absorbed the entire welfare of the Roman peasant.' When the Campagna of Rome was ruined by the Roman drains, Rome exhausted Italy, and when it had placed Italy in its cloaca, it poured into it Sicily, and then Sardinia, and then Africa. The drains of Rome swallowed up the world, and this cloaca offered its tunnels to the city and to the world, Urbi et orbi. Eternal city and unfathomable drain.

"For these things, as for others, Rome gives the example, and this example Paris follows with all the folly peculiar to witty cities. For the requirements of the operation which we have been explaining, Paris has beneath it another Paris, a Paris of sewers, which has its streets, squares, lanes, arteries, and circulation, which is mud, with the human forces at least. For nothing must be flattered, not even a great people; where there is everything, there is ignominy by the side of sublimity, and if Paris contain Athens, the city of light, Tyre, the city of power, Sparta, the city of virtue, Nineveh, the city of prodigies, it also contains Lutetia, the city of mud. Moreover, the stamp of its power is there too, and the Titanic sewer of Paris realizes among monuments the strange ideal realized in humanity by a few men like Machiavelli, Bacon, and Mirabeau—the grand abject. The subsoil of Paris, if the eye could pierce the surface, would offer the aspect of a gigantic madrepore; a sponge has not more passages and holes than the piece of ground, six leagues in circumference, upon which the old great city rests. Without alluding to the catacombs, which are a separate cellar, without speaking of the inextricable net of gas-pipes, without referring to the vast tubular system for the distribution of running water, the drains alone form an either bank of the river a prodigious dark ramification, a labyrinth which has its incline for its clue. In the damp mist of this labyrinth is seen the rat, which seems the produce of the accouchement of Paris."

No one can read the foregoing without feeling that the author has drawn attention to a most important subject. That his eloquent charge to Frenchmen twenty-three years ago, was successful in arousing attention to this subject is certain, for we find from Mr. Felix Target's (Assoc. Inst. C.E.) paper "On the Main Drainage of Paris, and Utilization of its Sewage,"* abundant evidence to prove that the Parisians in particular have long since initiated works having for their object the utilization of the Paris sewage, as suggested by Victor Hugo.

* Vide 'Transactions of the Institution of Civil Engineers,' vol. liii., Session 1877-78, Part III.
The following is from Mr. Target's most interesting and valuable paper:

"The available surface for irrigation in the Plain of Gennevilliers was estimated by the Paris authorities at about 2,470 acres; but the municipality of Gennevilliers consider that only 1,373 acres are available. The City Engineers estimate that in the environs of Colombes, Nanterre, and Rueil about 3,057 acres more are available; and as a last resource, they propose extending the conduits to St. Germain on the Government lands 3,057 acres in extent, as also to 2,223 acres of the Plaine d'Achères. As it is estimated that 3,458 acres more could be irrigated in the environs of Carrière, Bézons, Argenteuil, and Sartonville, this would make a total of, say, 12,350 acres of land available for utilising the sewage of Paris. Taking the population at two millions, the result is 0.61 acre per one hundred inhabitants, which appears ample on such permeable soil. The lands are well adapted for the purpose, there being only from 4 to 5 inches depth of vegetable soil, with a subsoil of at least 10 feet mixed sand and gravel.

"Owing to the subdivision of property in these parts, and to overcome the prejudice attached to sewage utilisation, the sewage has been distributed gratis to a number of small proprietors, who have turned it to very good account for the 'culture maréchaîre,'—market gardening of every description. However, an English company, the 'Société d'Exploitation des Égouts de Paris,' has now about 1,253 acres under cultivation, and has contracted with the city to take sufficient sewage to irrigate 998 acres, estimated at 4,453,400 gallons per acre per annum.

"The actual quantity of sewage utilised at Gennevilliers in the month of July 1876 was 1,625,570 cubic yards, representing about one-sixth of the whole sewage delivered by the collecteurs of Asnières and St. Ouen, the remaining five-sixths being still discharged into the Seine. This quantity irrigated an area of from 136 to 148 acres per day, which absorbed at the rate of from 2298 to 2432 cubic yards of sewage per acre in twenty-four hours. As 544 acres are under irrigation, it may be assumed that each acre was irrigated every four days, which would be equal to about 3/4-inch of rainfall per day.

"The cultivation generally adopted by those who utilise the sewage is the 'culture maréchaîre.'

"The results are most satisfactory. The produce to the acre has been on an average as follows:—Carrots, 384½ cwt.; beetroot, 615½ cwt.; beans, 115½ cwt.; greens, 557 cwt.; spinach, 70 cwt.; and as many as 24,000 heads of artichokes. A plot of 2.47 acres of asparagus two years old, sold for £80; another of 4.94 acres produced 589 cwt. of
mint, selling for £200. The following comparative statement, taken from the report of the Société des Agriculteurs de France, at a meeting held on the 16th March, 1876, will give a good idea of the value of sewage irrigation on such poor soils as those of Gennevilliers:

<table>
<thead>
<tr>
<th>On Irrigated Lands, per acre.</th>
<th>On Lands, not Irrigated, per acre.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat, from 30 to 55 bushels</td>
<td>From 38½ to 65 cwt.</td>
</tr>
<tr>
<td>Rye (green) from 125 to 210 cwt.</td>
<td>84 to 131 cwt.</td>
</tr>
<tr>
<td>Grass</td>
<td>Green Lucerne from 492 to 923 cwt.</td>
</tr>
<tr>
<td>lands</td>
<td>Rye Grass 1023 cwt.</td>
</tr>
<tr>
<td>Mangold Wurzel 892 cwt.</td>
<td></td>
</tr>
<tr>
<td>Potatoes from 687 to 797 bushels</td>
<td></td>
</tr>
</tbody>
</table>

"The sales realised per acre were:

Greens ... ... ... £. 48 0 to 60 0
Asparagus ... ... ... 60 0
Mangold Wurzel ... ... ... 19 4 to 22 8
Lucerne ... ... ... 12 16 to 16 0
Potatoes ... ... ... 11 4 to 16 0
Mint ... ... ... 40 0 to 64 0

"The annual rental of land under irrigation has in the space of five years increased from 32 francs (25s 4d) to 140 francs (111s 1d) per acre." This is equal to an increase in the value of the land of 438 per cent.

We may add that Mr. W. Allen Sturge, M.D., read a paper on "Sewage Irrigation in Paris" at the last conference on "National Water supply, Sewage, and Health," which was held at the Society of Arts in May last. This paper is well worth the perusal of parties interested in its subject, for it shows conclusively that the French people, taking the hint from Victor Hugo, are determined not to impoverish the earth by throwing their sewage into the sea!

The well-known Mr. J. J. Mechi, whose letters to the Times were regarded as authoritative on agricultural subjects, addressed a remarkable communication to that journal on "WASTE OF SEWAGE," dated 8th September, 1879, as follows:

"SIR,

"A destructive cancer is silently, gradually, but certainly undermining British agriculture. In these times of agricultural depression
every cause of loss should be sought for and, if possible, removed. No doubt, the penetrating eyes of our Royal Agricultural Commissioners will see in waste of sewage an important element of agricultural loss, affecting a very extensive area of this kingdom, for, in my early days, not a particle of sewage was permitted to enter any of the few underground conduits which were then existent. Many of us old folk have nasal reminiscences of the emptying of cesspools after midnight, for there was one in, or rather under, every town residence. Their contents were conveyed by carts many miles, and in barges to districts as far as 150 miles from London. I remember a large farmer a few miles from Reading lamenting his loss of manurial power owing to sewers having been substituted for cesspools. Probably one-half of our population is urban: if so, the loss to agriculture must be enormous and irreparable, despite the outlay for birds' and bats' dung from Peru and elsewhere, and bones (human and other) from other countries, besides the mineral apatite of foreign mines. Perhaps I may be too susceptible, but when in early morn I visit our markets (fish, meat, vegetable and animal), and know that within a week their contents will be flowing in the Thames and lost to British agriculture, my feelings are divided between pity, regret and indignation. Similar feelings pervade my mind on my way to Greenwich by steamer, when I see there monster steamships (a single ship sometimes brings 17,000 quarters of corn) loading innumerable barges with grain and other food for man, besides coffee, sugar, wine, and all the other luxuries of the breakfast and dinner table; so I cannot help asking myself, 'Are we a sane people, or are we so recklessly rich in agricultural production that the waste of millions is to us a matter of little import?' Hear what Liebig, that grandest magician of agricultural science, says as to this, at page 229 of his 'Modern Agriculture':—

'The sewers of the immense metropolis of the ancient world (Rome) engulfed, in the course of centuries, the prosperity of the Roman farmer; and when the fields of the latter would no longer yield the means of feeding her population, the same sewers devoured the wealth of Sicily, Sardinia, and the fertile lands on the coast of Africa.' And he adds:—

'Large towns, like bottomless pits, gradually swallow up the conditions of fertility of the greatest countries.' Years ago the Baron, in your columns, warned us against our wasteful practice. We have already exhausted and impoverished the early settled lands of America, and now the virgin soils of the Far West are undergoing a similar depletion. In fact, the agricultural treasures of the States are consigned to our streams instead of to our lands. Some idea of the vast loss sustained is proved by the fact that it costs Mr. Prout £2 15s per acre per annum for artificial manures to produce his crops. As our town populations consume the produce of probably 20,000,000 acres, the loss must be immense. I calculate that it takes the annual produce of 20,000 acres to feed the Londoners for a single day. I listen with astonishment when people talk to me of the difficulty and cost of transferring the manurial treasures from the sewers to the land. Contrast such a diffi-
ulty with others of our gigantic engineering undertakings, and it becomes, comparatively, a trifling affair. I hear that the contract for continuing the District Railway from Cannon Street to Aldgate, about a mile, is £5,000,000! Many are not aware that our Metropolitan Board of Works granted the sewage of London North of the Thames to a company for fifty years, to be carried to and through Essex, and to be applied on the reclaimed Maplin Sands. The Act of Parliament was obtained, the company formed, and £25,000 deposited with the Metropolitan Board of Works as security for the completion of the works within nine years, which, I believe, have now expired. But nothing has been done, and for nine precious years the waste has gone on and continues; the Thames gets the sewage from 4,000,000 people, and the Metropolitan Board of Works have got, and mean to keep, £25,000 forfeited deposit. But what has the land lost, and how much have the people paid for foreign food during those nine years—food which might have been grown at home? And this is only one of the great cities which are likewise sinning in this matter. I am frequently told by practical farmers that our land is gradually becoming poorer in productive power, despite the extensive use of artificial fertilisers, and no doubt it must be so.

"I am, Sir,

"Your obedient Servant,

"J. J. MECHI.”
THE WORKING OF THE "SHONE SYSTEM."

We now lay before our readers some Illustrations, which will help us to explain the modus operandi of the "Shone System."

FIG. 1.

Fig. 1 is a block plan, showing the way in which the "Shone System"
is applied to town drainage. In every case a sufficient number of Pneumatic Ejector stations are provided to admit of the laying of the whole of the collecting sewers in short lengths, and at such gradients as will render them permanently self-cleansing.

In the illustration the site selected for the Pneumatic station is at the junction of four streets. All these Pneumatic stations are built entirely under the surface of the streets, so that there is no necessity for Sanitary Authorities to buy land on which to construct them.

There is nothing to be seen of these stations in the streets beyond an ordinary manhole cover.

The plan also shows in the case of the private house drainage. Hydraulic Ejectors or Automatic Flush Tanks placed at the commencement of the private drains.

In the illustration the sewage of two houses is supposed to be discharged by one private house drain into the main sewer in the street. In many cases it will be found advisable to put an Hydraulic Ejector also at the head of the main street sewer, such an Hydraulic Ejector is shown on the plan.

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**Fig. 2.**

Fig. 2 shows a horizontal and vertical section of an Ejector station for one Pneumatic Ejector, and of the accompanying man-hole into
which the gravitating sewers converge. The plan also shows the position of the Pneumatic Ejector itself and the vertical section shows it in elevation in conjunction with the air main and rising main. The Pneumatic Ejectors are supplied with compressed air by means of the air mains from one central air compressing station, in the same way that coal-gas is supplied to our houses from a single central gas works.

The action of the ejector is perfectly automatic, as soon as it is filled with sewage, the compressed air is let on to the top of the sewage and forces it out into the rising main. Directly the Ejector is emptied, the automatic valve shuts off the compressed air and opens the exhaust port, through which the charge of compressed air, which has ejected the sewage, escapes, and the process of filling again commences.

A study of the block plan in Fig. 1, and of the details of the Ejector station, and Ejector, &c., shown in Fig. 2, will convince the reader that the sewage must of necessity be conveyed into the rising main whilst it is quite fresh, so that there is not the slightest possibility of the generation of sewage gas.

After the sewage has once entered the cast-iron rising main, it never leaves that main until it has reached its ultimate destination, unless for some special reasons it is ejected into an intermediate gravitating sewer.

When this is the case, the action of the Ejector always effectually flushes the gravitating sewers, and so prevents in this case also the possibility of the generation of sewage gas.

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Fig. 3 shows the details of the Hydraulic Ejector or Flush Tank.
The whole sewage of the household, including the discharges from the water closets should, whenever possible, be discharged into the Flush Tank. The Spherical Receiver at the top of the Tank contains a tilting bowl which empties itself automatically as soon as it is filled. This bowl should, by preference, be filled by the cleaner household liquids, such as Bath and Lavatory water.

The automatic action of the tank takes place in the following manner:

Directly the Tank is filled, the contents commence to flow over the syphon simply as fast as the sewage flows in, until the tilting bowl is filled and suddenly empties its contents. Directly this happens the water head in the tank is suddenly raised, causing the contents to charge the top of the syphon full bore, and so commence the syphon action which continues until the Tank is emptied. It will be seen that the Tank is self-contained, is so formed as to be properly ventilated and self-cleansing, and when it is empty even, it forms an effectual trap against foul air from the sewers, so that the discharging end of the Flush Tank may be directly connected to any existing foul sewers without further precautions.

*Fig. 4 shows the most perfect way of connecting the house drains with the main sewer by means of the “Shone Hydraulic Flush Tank.”*
MACHINERY AND MECHANICAL APPLIANCES

AT THE

International Health Exhibition.

No. VI.

Messrs. Hughes and Lancaster, Chester, the licensees of the Shone patents, have provided in full working order an interesting exhibit of the Shone system of sewerage, showing the action of the automatic pneumatic ejector and the automatic flush tank, the air for working the apparatus being compressed by a Westinghouse compressor, such as is used on locomotives. Before entering into a description of the machines, it will facilitate the comprehension of the principles of working if we first give a few particulars of the Shone system of sewerage. Two of the chief points to be aimed at in any scientific method of dealing with sewage are, the avoidance of large sewers at low gradients, in which the height of the liquid is subject to great variation, and the rapid delivery of the sewage to its destination before decomposition has set in to any very great extent. In the ordinary system, when the sewage cannot be directly conveyed by gravitation, the common practice is to construct a network of sewers converging to one point, at which is provided a reservoir of sufficient capacity to maintain a fairly uniform rate of pumping; and, as a rule, this plan necessitates the use of the sewers themselves for storage purposes, the gradients being generally very flat. Under these circumstances, the greatest vigilance, combined with frequent flushing, are unavailing to prevent the generation of foul gas, the greatest difficulty arising when the sewers are empty, owing to the surfaces being coated with slime, which decomposes when exposed to the action of the air. The network of sewers is also extremely costly, as they usually have to be constructed at great depths in excavations sometimes charged with subsoil water. By Mr. Shone's plan it is claimed that these difficulties are entirely avoided. The district to be sewered
is divided into small areas, within which gravitating sewers of the minimum size can be laid at good gradients without deep excavations, converging to a point suitable for the establishment of an ejector station, the ejectors being placed below the surface of ground—if necessary under the busiest thoroughfares—without occasioning any inconvenience. The various ejectors are connected together by mains conveying compressed air from the compressing engines, and no personal attendance is required beyond an occasional inspection. The position of the air compressors is not material. If the local authorities own a water pumping station or gasworks, the air may be compressed at either without increase to the existing staff; and failing this, the pumping plant may be erected near to a coal siding or on some other convenient site. If water power is available, it can be used in the place of steam, and in any case the cost of the whole installation is not much affected by the distance over which the compressed air has to be transmitted, as the size of the pipes is so small. When only a portion of the sewage has to be raised, or when the lift is so little that the total engine power required is small, it is more economical to use a hydraulic engine supplied with water from the town mains, because of the inefficiency of steam engines of low power. Water, even if it has to be pumped at a pressure of 50 lb. per square inch, only costs on a large scale some 20¢ per 1,000,000 gallons for fuel, &c.; while the outlay, as regards first cost of machinery, will not be affected by the small quantity required for air-compressing purposes. In this way the actual cost of pumping only comes to about \( \frac{1}{2} d \) per hour for a horse-power consumed in a water-pressure engine. To provide uniformity of working, receivers are required, the air being compressed to a slightly greater pressure than is necessary to raise the sewage, but in some instances, the mains themselves afford quite enough storage capacity. When the full pressure is attained, a self-acting arrangement stops the air pumps, so preventing useless expenditure of power. As soon as the ejector is filled, an automatic valve admits the compressed air, which forces the fresh sewage either into a rising main under pressure or into a gravitating sewer, and so on to the place where it is to be treated or utilized, the conveyance being so rapid that there is no possibility of the generation of foul gases by decomposition. In using compressed air in this manner it is obvious that the whole of the work done by the compressing engines is sacrificed, and for isothermal compression this is represented by the expression \( A V \log_{e} R \), where \( A \) is the atmospheric pressure on a unit of area, \( V \) the number of units of volumes of free air compressed and discharged into the receiver by one stroke, and \( R \) the ratio of compression. The total work done both by the engine and external air during one complete stroke is \( A V (r + \log_{e} R) \), the work done by the air being in all cases equal to that required to discharge the compressed air out of the cylinder. It is evident, therefore, that there must be a limiting value of the height to which liquids can be raised on the Shone system, as economically as by direct pumping, and the following table, showing the work done in compressing the air to different absolute
pressures in six cases, has been calculated with a few to ascertain this limit:

<table>
<thead>
<tr>
<th>Lift in Feet</th>
<th>Isothermal Compression</th>
<th>Adiabatic Compression</th>
<th>Mean value of Columns 3</th>
<th>Mean value increased by 25 per cent.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1.</td>
<td>2.</td>
<td>3.</td>
<td>1.</td>
</tr>
<tr>
<td>10½</td>
<td>859</td>
<td>708</td>
<td>1.22</td>
<td>900</td>
</tr>
<tr>
<td>33</td>
<td>1467</td>
<td>1053</td>
<td>1.39</td>
<td>1500</td>
</tr>
<tr>
<td>49½</td>
<td>1940</td>
<td>1270</td>
<td>1.53</td>
<td>2150</td>
</tr>
<tr>
<td>65</td>
<td>2328</td>
<td>1411</td>
<td>1.65</td>
<td>2700</td>
</tr>
<tr>
<td>82½</td>
<td>2650</td>
<td>1512</td>
<td>1.75</td>
<td>3200</td>
</tr>
<tr>
<td>99</td>
<td>2933</td>
<td>1587</td>
<td>1.84</td>
<td>3620</td>
</tr>
</tbody>
</table>

Columns 1 gives the values of the work done by the engine in compressing the air isothermally and adiabatically respectively; Columns 2 the net work done in raising the liquid; and Columns 3 the ratio between the two values. As the actual compression is probably somewhere midway between isothermal and adiabatic, the mean ratio is given in Column 4; while these values increased by 25 per cent. to allow for friction and leakage are given in Column 5. No allowance has been made for slip past the ejector valves, as it is stated to be extremely small in proportion to the volume of each discharge. Besides this, Sir Frederick Bramwell, in the case of the Mekarski air compressors at Chautenay, found the value of this factor to be 18 per cent., so that there would appear to be more than sufficient margin to cover the loss from slip. In the case of engines used for sewage pumping, the indicated horse-power of the steam cylinder is not unfrequently equal to double the power estimated in net weight of water raised, and only under exceptional circumstances is the former less than one and a-half times the latter. Up to lifts, therefore, of about 60ft. it would seem that forcing by compressed air is more economical than direct pumping; while if the pumping machinery is of small capacity, the economy is likely to extend even beyond this height. In town sewerage, pumping by compressed air admits of a still greater economy, as in cases where the sewage has to be raised a great height and the levels of the drainage area vary considerably, the area may be divided into zones. With a single pumping station in the ordinary system, the whole of the sewage has to be pumped in one stage from the lowest to the highest level, but in Mr. Shone's plan the sewage from the lowest zone has only to be raised this height. In order to carry out this division of districts it is not necessary to have air mains under
different pressures. If it is thought desirable to raise the sewage from the lowest to the highest level at one lift, it will be necessary to compress the air in the first instance to the maximum density required for the highest lift, and to allow it to expand again to the volume corresponding to the pressure due to the next lift, and so on. The best way, however, is to divide the maximum lift into a number of as nearly as possible equal stages, and to compress the air to the density required for one lift, the sewage being ejected successively through the several stages. At first sight this might appear to involve a loss of economy, but it is not so, as in point of fact there is considerable gain in dividing up the lifts in the manner indicated. For the sake of illustration, we will suppose that a given volume $V$ of liquid has to be raised $R$ feet. If this is accomplished in one stage, the volume of free air required would be $5V$, and the work done with isothermal compression is represented by

$$5A_\log_e 5 = 8A_\log_e.$$

On the other hand, if the liquid is raised in four lifts, each of 33 ft., the free air compressed would be $2V$, and the work done

$$8A_\log_e 2 = 5.5A_\log_e.$$

If we add 25 per cent. as in the table for friction of machinery, &c., the indicated work of the steam cylinder would be represented by $7A_\log_e$ for the four lifts, which is about 75 per cent. in excess of the net work done in lifting the water, showing that by this method sewage may be raised 132 ft. with economy about equal to that in direct pumping. In this way a lift of 200 ft., if divided into six stages, would require about double the indicated horse-power estimated from the net work done. From the preceding description of the Shone system it will be seen that sewers with good gradients can be obtained even in flat districts, and it is therefore specially suited for seaside towns with long level frontages facing the sea. By providing a proper number of ejectors, the sewage is rapidly discharged before decomposition can take place, and any sudden rush of sewage is provided for by the accumulation of compressed air in the receivers. It is this latter feature which enables the ejectors to deal with the varying quantities of sewage as quickly as it comes, without suddenly affecting the rate of working of the compressing engine. Figure 1 shows one form of ejector station in section and plan (see page 28). The gravitating sewers delivering to the ejector converge to a manhole, say, at a cross street, and with this manhole the inlet pipe of the ejector communicates. Both inlet and outlet are provided with ball valves, this being the type best adapted for passing sewage matters. The automatic air valve, which in this design is fixed in a cast-iron box under the street, is actuated by two buckets, which are fixed to an iron rod passing out of the ejector through a stuffing-box, and which is attached to the main lever of the automatic air valve. The lower bucket is suspended near the bottom with the open end upwards, and the upper one is inverted at the top of the ejector. When the liquid rises and reaches the inverted bucket, the con-
tained air causes it to rise, and so actuate the air valve and admit compressed air to the interior of the ejector. The inlet sewage valve at once closes and the air pressure forces the sewage through the outlet valve into the rising main. When the surface of the liquid within the ejector sinks below the level of the lowest bucket, which remains full of sewage, its weight, suspended in the air, pulls down the rod, and so reverses the action of the air valve and allows the compressed air to escape into the atmosphere. The sewage delivery valve at once closes, and the ejector again commences to be filled through the inlet valve. The weight of the buckets, when empty, is balanced by the weight shown in the engraving above the valve box. It would seem that Shone's Pneumatic Ejectors are well adapted for raising liquids in chemical works and breweries, as they can easily be made of materials not acted on by chemicals. They are also adapted for raising heated liquids; and in this case the compressed air would be expanded by the heat imparted from the liquid, and its volume be increased, thus reducing the quantity of air required, and effecting a saving in pumping power. For pumping in mines there would, no doubt, be a benefit from the use of compressed air, which would assist the ventilation; and for irrigation purposes it would often be a great convenience to have a number of automatic pumping stations, all worked with air compressed at one central point, and transmitted in various directions through small pipes. The system is in operation at Eastbourne, Warrington, Winchester and other places, and we understand that the Corporation of Warrington have recently ascertainment, by actual experiment, that the contents of the pails on the tub system can be transmitted to great distances by the ejectors, and the offensive and costly cartage through the main streets avoided.

Another apparatus exhibited by Messrs. Hughes and Lancaster is Shone's hydraulic house sewage ejector (see Fig 3, page 30), which appears to be an exceedingly efficient instrument, more especially when good gradients cannot ordinarily be attained. Ordinary house drains even of small bore, and laid with due regard to inclination, very often become receptacles for, rather than the means for getting rid of, sewage, their foul condition being caused by the intermittent and greasy nature of the discharges that are made into them. It is to overcome this difficulty that the house ejector has been designed. The apparatus is intended to be fixed in some convenient position in the house premises, to which all drains can be made to converge, these drains being of short length, and so inclined that the discharge from a water-closet, for instance, cannot fail to gravitate quickly from the bottom of the soil pipe into the ejector, the same remark applying to the waste sinks, lavatories, &c. The sewage, therefore, reaches the ejector in a perfectly fresh condition, and if it has a capacity of fifty gallons, while the aggregate discharge is, say, 300 gallons per day, it will be filled and emptied six times. Fig 3, will enable our readers to understand this apparatus. It will be seen that
when it is coupled up to the drains which supply the fresh sewage, and when the ventilating pipe is fixed, and when it is also connected to the main drain, the apparatus forms a perfect trap as between the house drains, which carry the sewage into it, and the main drain which carries the sewage out of it. The illustration shows the apparatus as it would appear instantly after it had ejected its charge. Fresh sewage enough always remains in the ejector to effectually seal the bottom of the short leg of the syphon, by means of which the apparatus is emptied, and, of course, every drop of liquid flowing into the ejector after it has discharged its contents will deepen the seal, and thereby render it more and more perfect as a trap to prevent sewage gas generated in the public sewer from getting through the apparatus to the subsidiary drains of the house. When the house sewage ejector is charged, its syphon action is effected by an automatic tumbling basin, which, when full, topples over, and throws its contents—about two gallons—suddenly into a funnel-like pipe, at the top of which the basin is fixed. The effect of this quick tilting over of the basin is to instantly raise the water head in the pipe. It has also the effect, at the same time, of lifting the water over the syphon bend, and filling the syphon at that point full bore, causing the sewage to fall down the long leg, so bringing into operation the ejecting power of the apparatus. The difference in level between the descending column of the sewage in the long leg of the syphon and the sewage in the ejector is the measure of the power that is at work ejecting its contents. This power is at its maximum when the descending column first reaches the bottom of the long leg of the syphon, and as at its minimum when the charge has subsided in the ejector down to the bottom of the short leg. Theoretically the maximum velocity which the sewage would attain in passing from an apparatus dimensioned as per our illustration would be

\[ V = 8 \sqrt{2 \text{ ft. } 2 \text{ in.}} = 11.9 \text{ ft. per second.} \]

and from observation it has been found that the whole charge actually escapes in about 35 seconds. This sudden irush of fresh sewage into the house drain would produce an effect equal to the passing of the sewage of 3500 people at the time when the greatest flow obtains, and when the discharge averages 20 gallons per head per day. The main drains of houses, if flushed in this way by their own fresh sewage resources, would be much less liable to get foul from deposits than they are under the present system, and the air would be renewed every time the apparatus is emptied. It would seem, therefore, that the Shone hydraulic ejector would not only prevent the intrusion of sewage gas from public sewers, but would do away largely if not entirely with the nuisance constantly arising from the house drains themselves, while the whole sanitary arrangements would, in each case, be complete within the
premises. The engraving, Fig. 2, shows the details of a large

**SHONE'S PUBLIC SEWER FLUSH-TANK OR HYDRAULIC SEWAGE-EJECTOR AND TRAP**

![Diagram of Shone's Public Sewer Flush-Tank](image)

**LONGITUDINAL SECTION**

**TRANSVERSE SECTIONS ON LINES**

public sewer flush tank, which is simply a large brick barrel sewer, to which the syphon is attached at the delivery end. The tumbling basin may be fixed in any convenient place, and in this case must be supplied with water from a stream, or from the main. If the invert levels of the sewers admit of the arrangement, the flush tank may be filled with sewage from a drain discharging into its upper end, as shown in the engraving; but if this cannot be effected the tank itself must be supplied from a stream or from the mains, the rate of supply being adjusted to fill the tank in any desired period of time.
SELECTIONS FROM TESTIMONIALS

RECEIVED REGARDING THE

Working of the Pneumatic Sewage Ejectors,

EMPLOYED IN CONNECTION WITH THE

"SHONE" SEWERAGE SYSTEM.

BOROUGH OF EASTBOURNE.

Report of the Highways and Drainage Committee upon the working of Shone's Sewage Ejector System within the said Borough, made at the request of the Local Government Board, for the information of the German Embassy.

"The 'Shone System,' invented by Mr. Isaac Shone, of 4 Westminster Chambers, and by whom the works for Eastbourne were designed, was adopted at Eastbourne in the year 1881, to supplement the gravitating system designed for the town by Mr. G. A. Wallis, M. Inst. C.E., 1865.

"Previous to entering upon the report of the 'Shone System,' we think it desirable to give a short account of the Outfall Works of the gravitating system. It being of the utmost importance to a seaside health resort that the point of Outfall should be as far from the town as possible, we, in 1865, in consultation with Messrs. McClean & Stileman, Civil Engineers, of Westminster, selected Langney Point (shown on plan herewith) for the Outfall Works, for the following reasons:—

"The site is two and a-half miles from the town.

"The set of the tides at Langney Point are such that under any conditions the sewage is taken out to sea, so that the Bay of Eastbourne is kept perfectly free from contamination by sewage.

"It will be seen from the above that whatever system was adopted to augment the emptying capacity of the Outfall, it was of the utmost importance that the Outfall Works should be retained at Langney Point.

"By the adoption of the 'Shone System,' the present works are rendered capable of delivering a much larger quantity of sewage than would be the case under ordinary gravitation, so that the great advan-
tages derived from the disposal of sewage at Langney Point are still retained, as will be seen from the following description:

"The apparatus employed to put this system in operation are:

Two 12 h.p. Engines.
Two Air Compressors.
Seven Pneumatic Ejectors.

placed in the following positions:

"Engines and Air Compressors at point marked A on plan herewith.

Three Ejectors at point marked B
Two do. do. C
Two do. do. D

"These Pneumatic Ejectors are worked by compressed air, produced and stored at station A, and conveyed through 4 in. cast-iron air main to stations B, C, and D.

"The Ejectors at B are three in number, each holds 600 gallons, and is made to receive and eject 600 gallons per minute; so that unitedly they will receive and eject 2,592,000 gallons in twenty-four hours; but at times of heavy rains they have been receiving and ejecting at the rate of four millions of gallons per day. These Ejectors are so fixed that a Penstock on the main sewer turns the sewage into them, to be ejected against the rising tide on the sea side of the Penstock.

"This arrangement prevents impounding in the sewers on the town side of the Penstock.

"The pressure under which the Ejectors discharge their contents into the Outfall Sewer gives an additional velocity to that due to gravitation, by which the Outfall is made to discharge a very much larger quantity of sewage than under ordinary gravitating principles, and is rendered sufficient to meet the growing demands upon it, due to increased population, thus saving the town a very great outlay, which would have been necessary in duplicating the Outfall Sewer, the cost of which, defrayed by the Duke of Devonshire, was about £40,000.

"The Ejectors at station C are two in number, each capable of holding 350 gallons, and discharging once in every minute, that is, discharging 504,000 gallons in twenty-four hours, and were put down for the purpose of draining 400 houses, situate at a low level, and are worked by compressed air, produced and stored at station A.

"The Ejectors at station D are of the same capacity as those at station C, and were laid down for the purpose of raising the sewage of 100
houses of a first-class character (averaging in rent from £150 to £200 per annum) from a Low Level into a High Level Sewer; these Ejectors have been laid down at the cost of His Grace the Duke of Devonshire.

"We have every reason to be satisfied with the works already executed on this system, which is undoubtedly based on scientific principles, easy of application in practice.

"Our experience warrants us stating that in low-lying and flat areas, good self-cleansing drains and sewers can be readily obtained by the adoption of the 'Shone System' of drainage.

"Once established in a town or district, it can be extended as the place grows. The works here afford an illustration of this.

"The air pipes are laid under the streets, and we have never had the least trouble with them, and the observations taken from time to time show that the loss by leakage and friction is practically nil. The Ejectors and the Automatic gear are strong and simple in construction, and they work in their chambers under the streets noiselessly and innocuously, and need little or no repair or personal attendance.

"The three stations, including ejectors, inspecting chambers, manholes, air and sewage mains, compressors and boilers in duplicate, engine house, boiler and receiver house, two cottages for the engineer and stoker, including land, engineering, law, and other expenses, amount in the aggregate to about £8,500.

"Our annual cost for running the plant, including engineer, stoker, fuel, water, oil, tallow, &c., is about £600.

"The whole of the works have been carried out by Mr. Chas. Tomes, the Borough Surveyor, and are under his management.

"JAMES RUDD,
"Chairman of the Highways and Drainage Committee."

"February 6, 1885."

"The ejectors have been working in connection with the Warrington drainage for upwards of eighteen months.

"I have experienced no trouble with them, and the attention required is very little.

"I have lately examined the valves and find them in perfect order, no (appreciable) wear being perceptible. I think it only justice to say that I am perfectly satisfied with the whole of the working, and consider the system is one that enables engineers to get over natural difficulties
in sewage works, at a comparatively small outlay, at the same time attaining a sanitary system of drainage which ought to be the aim of those who study the health, comfort and prosperity of the community."

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"We have much pleasure in stating that the sewage ejector fitted up by you as part of our contract for supplying the machinery at the Royal Courts of Justice Chambers (Palsgrave Restaurant) worked extremely well during the time that we were maintaining the machinery as contractors. It discharged both solid and liquid matter mixed with boiling water from the cooking apparatus without any difficulty, and from our experience of other pumps and ejectors, we think that no other system would have worked with such complete absence of breaks down.

"Since we have handed over the work, we have heard from the Company that the working of the ejector is equally satisfactory."

---

"I am very glad to give you my experience of the working of the Shone's Pneumatic Sewage Ejector supplied by you to this Corporation.

"It is working most satisfactorily, and successfully answers the purpose for which it was required, viz., to prevent the flooding and impounding of the sewage of the low-lying districts of this borough, which, until the Ejector came into operation, occurred nearly every day at high water and rainfall, but now, thanks to the Ejector, this is an event of the past.

"The particular district in which the Ejector has been placed (the first one of them) was rather peculiarly situated, inasmuch as before the sewage could discharge at the outfall it had to traverse a very old and over-sized sewer, three-quarters of a mile in length, with a flat and ineffectual gradient, and constantly tidal locked. The configuration of the ground was such that it was impossible to reconstruct it so as to obtain a self-cleansing gravitating flow to ordinary pumps if established at the outfall end for the purpose of raising the sewage.

"However, by the adoption of the Ejector system, we are enabled to divide the district into three, place an Ejector in each, concentrate the sewage by short quick delivering sewers into the same, raise and discharge it at all times of the tide, underground, out of sight, and all worked by compressed air from one compressing station 400 yards distant at the Corporation Wharf, without any perceptible loss of power in transmission.

"The engine and compressors are sufficiently powerful to work the other two Ejectors, which I hope soon to be in a position to give you
the order to supply; they are working most economically; in fact, owing to the automatic action of the Ejector, which only discharges when sufficient sewage is produced to fill it, coupled with the storing of the compressed air in the receiver, causes the engine to be often stationary.

"From the experience I have had with the system here and in other towns where I have seen it in operation, I am able to say that it is unquestionably economic, efficient, and admirably adapted for dealing with the sewage of low-lying and flat districts, and there can be no excuse now for constructing large, badly graded, unsanitary sewers again.

"It is one of the greatest sanitary improvements of the age.

"I feel gratified with the success of the system here, having advised the Corporation to adopt it. When the Ejector and plant was first started, it was subjected to very severe tests, which they satisfactorily withstood."

"Since forwarding my letter to you of the 29th, we have had several extraordinary high tides, rising two feet higher than known for many years before, on Friday, Saturday, Monday, and to-day, accompanied with constant and heavy rain. I am pleased to say that during this time a low water flow has been maintained in the sewers connected to the Ejector, consequently the whole of the basements have been kept dry."

"I have read the circular and the reports of the discussion on your admirable invention, which I feel convinced will become the proper process of purifying the sewers, by hastening the transit or current of their contents. I thoroughly comprehend the working of your system, which I consider to be the perfection of efficacy and simplicity. The air is always at hand in any quantity.

"I also feel sure that yours is the happy solution of the sewage question."

"By an arrangement such as this, town drainage can be conducted to almost any distance without any impounding, so that deposits should never occur, decomposition never set in, and therefore bad smells never be created."
WM. GANON,
Esq. C.E., City
Surveyor,
Winchester.
Jan. 6, 1883.

"I have much pleasure in testifying to the excellent working of the
Ejector supplied by the Shone Drainage, Sewerage, and Water Supply
Company.

"It is working most satisfactorily, filling and discharging its contents
(80 gallons when there is enough supply), in one minute and 20 seconds.
Initial pressure at commencement of discharge 15 lbs., average pressure
when discharging 3'75 lbs. It is supplied in a position where a pump
could not conveniently be worked. It forces the sewage of the St. Cross
district, which is at a low level, into the tank which receives the rest of
the Sewage of Winchester. It is worked by compressed air, supplied
by a Westinghouse Brake Air Compressor, fixed in the engine house,
worked from the steam from the main boiler, making a slight increase
in the consumption of coal. It is buried and concreted in the soil far
below the subsoil water level, the automatic gear being kept above that
level. If it continues, as I have no reason to doubt it will, to give the
satisfaction it has up to the present, it will be a great boon, as it has
overcome the greatest of our difficulties, namely, to keep the St. Cross
District relieved. I shall be pleased to show it to any of your friends
or customers, and can highly recommend the same."

James Lemon
Esq. C.E.,
M. Inst. C.E.,
Southampton
June 30, 1883.

"I was at Winchester today, and saw the Pneumatic Sewage
Ejector supplied to the Corporation in December last, doing its work
most effectively and satisfactorily; and on my asking Mr. Gannon, the
City Surveyor, whether he was as satisfied now of its value as he was
when he penned Mr. Shone his letter of approval on the 6th January
last, and which appears in Messrs. Shone and Wallis' "Scheme for
Amending the Drainage of Portsmouth, on the Shone Pneumatic
Sewerage System," at page 37, he said he was. This is the more gratifying
to me, because it was through my recommendation, as the Consulting
Engineer of the Corporation, that the Ejector was bought. You are at
liberty to make any use you like of this letter."

J. A. Russell,
Esq., M.A.,
M.R., B.S.,
Fellow of the
Sanitary
Institute of
England,
Lecturer on
Sanitation,
Edinburgh;
and formerly
Principal,
Demonstra-
tor of
Anatomy to
the
University of
Edinburgh.
June 23, 1879.

"I recently witnessed experiments, on a practical scale, with your
"Ejector" at Wrexham. They were perfectly satisfactory, and proved
the correctness of all that you had said to me, and I have now the
pleasure of stating my opinion regarding what I look upon as a most
valuable Sanitary Improvement.

"Experience has shown that the importance of a speedy and complete
removal of sewage from dwellings cannot be over-estimated in a sanitary
point of view.

"When pumping is declined, and the sewage is run into the sea at
low water, huge tanks are necessary to collect and store the sewage
for some hours, until the tide has sufficiently receded to permit the
discharge of their contents.

"Your 'Pneumatic' system offers important benefits to the inhabitants
of such districts, amongst others the following:—

"As regards removal of sewage, a town on flat ground, sewered in
the manner proposed by you, would, except in the single particular of
expense, be upon a par, or even better off than one situated on an
eminence, and where consequently the best arrangements by gravitation
were possible.

"One feature of your system which should commend it to the
consideration of ratepayers is, that it lends itself extremely well to the
partial adoption, either as a supplement to gravitation, or for trial on an
experimental scale. In the latter case power might be got from a factory
engine, near or distant; and should the trial give satisfaction, and the
system be extended, the portion laid down for experiment would, pro
tanto, be available at once.

"I may conclude by saying that I know of no recent sanitary
invention more deserving of careful consideration at the hands of Local
Authorities troubled by the "sewage question."

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"With your system, engineers can work by rule—without it, they
cannot."

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"In answer to your inquiry after the condition of the Pneumatic
Liquid Ejector you erected for us here, I have much pleasure in saying
it has gone on working automatically from the time it was started
to now (18 months) perfectly.

"It is, as you know, in a locked up house, and our Engineer told me
to-day that often for weeks together he does not open the door. It is
unquestionably the cheapest kept machine we have, and has not yet
cost us a farthing in repair.

"You can send anyone you like to look at it, and Mr. Griffiths (our
Engineer) will be glad at any time to show and explain it."

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"Nothing has been said so far against it, and he was desirous that
some one would have raised some abstruse question that would have
troubled Mr. Shone, but it appeared to have been so well thought out
by him, that if anything, he had not said quite sufficient in its favour."—
Vide page 169, Vol. V., of the "Proceedings" of the Association of
Municipal and Sanitary Engineers.
The late J. J. Moch, Esq., Tiptree Hall, Kelvedon, Essex; the eminent agriculturist.

"I have said before, and I repeat it, that in my opinion your Ejector system is, in economy and effect (sanitary and monetary), the only system that I can imagine as overcoming the difficulties, dangers, and cost of sufficient fall or outfall.

"We must come to the separate and Ejector system to make the matter cheap and perfect.

"The simplicity of your effective system is its greatest merit, and that simplicity ensures a certainty and continuity of action. * * *

"I also feel sure that yours is the happy solution of the sewage question."

Lt.-Col. Jones
V.C., Assoc.
M.Inst. C.E.
Winner of the Prize offered by the Royal Agricultural Society for the best Sewage Farm &c.
J. G. Lynde,
Esq., C.E.
Manchester.

"I could never believe in the practical application of Captain Liernur's Pneumatic system to the conditions of English life; but I am sure that if your countrymen will afford you one-half the opportunity he has enjoyed in Holland, you will succeed in revolutionising the art of sewering to the satisfaction of all nations."

Wm. Lowe,
Esq., C.E.
M.Inst., C.E.

"To my mind, you have solved the difficulties which sanitary engineers and sewage farmers have hitherto been labouring under, and the sooner the Local Government Board, as well as sanitary boards in general, recognise the fact, the better it will be for the health and agricultural wealth of the nation."

William Donaldson,
Esq., M.A.
C.E., M.Inst.
C.E.

In the autumn of 1879, said:—"If Shone's Ejector system achieves success, which I am confident it cannot fail to do, nothing larger than a 9-inch pipe will be required; and the sewers, replete with every modern scientific requirement for ventilation and flushing, can be built for 10/- a yard."

W. B. Bromley, Esq.
Assoc. M.Inst.
C.E.
Surveyor to Heston and Ickenworth Local Board.
Nov. 17, 1884.

"In reply to your inquiry about the separate system of sewering, I regret we have no system at all at present, but I may state that I have prepared a scheme for my district (comprising 7000 acres) upon the separate system, which scheme has been adopted by my Board, and will shortly be carried out.

"No doubt, the separate system is the right one in our days, as being
more economical, and I may say, more natural than the combined system.

"Of course, the sewers must have good gradients, and to insure this, I purpose using Shone's Pneumatic Ejectors. In fact, I am going to raise the sewage of \( \frac{1}{4} \) th area and population to the sewage works, by means of Shone's Ejectors, entirely raising the sewage some 40 feet, through a rising main nearly a mile long.

"I anticipate having to flush some of the sewers in the dry weather; but this would have to be done in either case; for on the combined system, in the dry weather, there would naturally be no rain to flush the sewers, which sewers, being so much longer than they would be on the separate system, would give much more trouble.

"I shall take all back-yard drainage into the sewers, the rainfall on the fronts of the houses going into the road drains only.

"I trust this information will be of some service to you."

"I can only assure you that whenever I have an opportunity to do so, I shall be glad to introduce your apparatus, and that my feeling concerning it is of the most favourable character."

"So far as I am concerned, I am perfectly satisfied as to its being the only system for Galveston."

"I have very carefully studied the very able Report of Mr. M. Knauff, on the Drainage of the Moabit District of Berlin, and compared the English translation with the German text. I fully endorse the views advocated by Mr. Knauff, and feel convinced that the adoption of the Shone system of sewerage would most effectually solve the vexed problem of the drainage and purification of that district. * * *"
Names of Gentlemen who have either prepared Schemes upon The SHONE SYSTEM, or who have pronounced strongly in its favor.

The late Major-General H. Y. D. Scott.
Major V. G. Clayton, R.E., Manchester.
Colonel M. J. Wheatley, R.E., London.
The late James Gascoigne Lynde, Esq., Mem. I.C.E., the Consulting Engineer to the Corporation of Manchester, and Past President of the Municipal Institute of Civil Engineers.
James Lemon, Esq., C.E., Consulting Engineer to the Corporation of Southampton.
W. B. G. Bennett, Esq., C.E., Borough Engineer, Southampton.
Thomas Longdin, Esq., C.E., Borough Engineer, Warrington.
Edward Pritchard, Esq., C.E., F.G.S., London and Birmingham, Past President of the Municipal Institute of Engineers and Surveyors.
George A. Wallis, Esq., C.E., Mem. I.C.E., Eastbourne.
Charles Tomes, Esq., C.E., Borough Surveyor, Eastbourne.
Lewis Nuttall, Esq., C.E.
Thomas Deakin, Esq., M.E., Durban, S. Africa.
W. Ham Hall, Esq., C.E., State Engineer, California.
L. F. Bassett, Esq., City Engineer, Sacramento, California.
Edward S. Philbrick, Esq., C.E., Mem. I.C.E., U.S.A.
Colonel Waring, Junior, Mem. I.C.E., Newport, U.S.A.
Benezette Williams, Esq., C.E., Chicago.
The late George Cole, Esq., C.E., City Surveyor, Hereford.
Messrs. Britton & De Saubergue, C.E., 12 Delahay St., Westminster.
Lord Dundonald, Ascot.
O. Deacon Clark, Esq., Municipal Engineer, Rangoon.
S. A. Goodall, Esq., C.E., Surveyor, Fenton.
J. Thornhill Harrison, Esq., C.E., Local Govt. Board Inspector.
Major L. Flower, C.E., Sanitary Engineer, Lea Conservancy Board.
Walter Horne, Esq., C.E., Town Hall, Worthing.
Carl Julius Hanssen, Esq., C.E., Kolding, Denmark.
G. E. Manigault, Esq., Charleston, U.S.A.
H. Malcolmson, Esq., C.E., Surveyor, Henley-on-Thames.
M. Neuhaus, Esq., C.E., Berlin.
John Phillips, Esq., C.E., late of Metropolitan Board of Works.
H. W. Stringfellow, Esq., C.E., Surveyor to the Local Board, Sheerness.

Dr. S. H. Wright, Southport.
J. F. E. Barnes, Esq., C.E., Durban.
M. Knauff, Esq., C.E., Pankow, Berlin.
Charles Colson, Esq., A.M., I.C.E., H.M. Dockyard, Malta.
Christopher Jas. Clarke, Esq., C.E., Hanwell, W.
M. Bienkiewiez, Esq., C.E., Nijuy, Novgorod, Russia.
A. L. Guillemard, Esq., C.E., Valparaiso, Chili.
John Austre, Esq., C.E., 7 Westminster Chambers, London.
R. B. Stirrat, Esq., C.E., Egham and Newcastle-on-Tyne.
G. Eccles Eachus, Esq., C.E., Westminster, S.W.
F. Target, Esq., A.M.I., C.E., Havre, France.
Walter Thomas, Esq., C.E., Borough Surveyor, Dorchester.
APPENDIX.

Extracted from the second and final Report of the Royal Commission on Metropolitan Sewage Discharge, 1884.

SEPARATION OF SEWAGE FROM RAINFALL.

179. We have pointed out that one of the difficulties attendant on the treatment and disposal of town sewage is its excessive and irregular dilution with water.

In the ordinary plan of drainage the sewers have to carry away both the sewage and the rainfall. This followed naturally from the manner in which the drainage system arose. The sewers already existed with the object of draining away the surface water, and when the house refuse was admitted to them, it was thought that the dilution would be an advantage, as tending to flush the noxious matters well away and keep the sewers clean.

But it was soon seen that this would lead to a difficulty affecting the disposal of the sewage, and as early as 1854, before the systematic drainage of London was undertaken, a proposal was made to adopt what was called the "separate system," providing independent channels for the sewage and the rainfall respectively, to facilitate the separate disposal of each, according to the aphorism "the rainfall to the river, the sewage to the soil."

But to do this effectively would have required the remodelling of the whole of the house drainage, a work which, from its enormous expense, could not be thought of. Moreover, the necessity of separation was not generally believed in, and there were doubts and difficulties as to whether there would be sufficient fall in the sewers to secure the passage of the sewage if they were not flushed by rainwater; indeed, it is manifest, from what happens to some sewers when large accumulations of sewage matter are washed out by heavy rain, that the fall in these sewers is not sufficient, and that they would be choked without this flushing.

The Government Referees in their Report of 1857 alluded to the proposal of separation, which they disapproved, on the grounds that the general surface drainage was but little better than house sewage; that the complications already in the streets would render a fresh system of drains impracticable; that the change would involve vast expense; and that the rain was beneficial in flushing the sewers.

Hence the designers of the London main drainage were obliged to undertake the removal of the sewage and the rainfall combined in one system.

We have already, in our first Report, remarked on one important consequence of this, namely, the fact that the storm overflows at present existing bring down, not
only the storm rain-waters, but large quantities of foul matter. We have here only to notice the effect of the combined system on the disposal of the sewage.

180. The mean dry weather flow of sewage proper, as determined by the water supply, may be taken roughly at about 150,000,000 gallons daily; but this quantity is tripled when the outfall sewers are running full under the pressure of heavy rain. The dilution of the excreta, even in dry weather, is already considerable and disadvantageous to their utilisation; but when this dilution is magnified by storms, the quantity becomes unmanageable. And, further, the frequent variation in the strength of the sewage, changing, as it does, with every shower of rain, interposes a further difficulty in treating it on any methodical and uniform system. Sometimes it has its normal strength, which might be calculated and allowed for; at other times it is merely useless dirty water; and it varies in all degrees between the two extremes.

If it had been possible to foresee the importance of this difficulty when the main drainage was laid out, probably some middle course might have been adopted by which the influx of the larger floods might have been prevented; but it is useless to speculate on this now.

181. The following are some opinions that have been expressed on this subject:

Sir Robert Rawlinson says (Q. 17,102):

If you had to begin at the beginning, and sewer London de novo, the Fleet ditch should not be a sewer; the Ranelagh river should not be a sewer; all the valley lines should not be sewers. They should have been surface water channels alone, and the sewage should have been intercepted on both sides, and carried into the main outlets which are now provided.

Mr. Bailey-Denton says, in his work of 1880:

Experience has established the fact that no mode of cleansing sewage by tank treatment, or by irrigation over or filtration through land, can be effective when the sewage is diluted by rainfall beyond a certain amount. It is easy enough to deal with an outflow from sewers if the quantity be constant and is ascertained; but it is quite beyond the powers of any engineer to devise a means of treating liquids swollen by sudden and extraordinary dilution.

In his evidence before us, Q. 18,617, he speaks strongly of the advisability of carrying out separation for the future in all extensions of the Metropolitan area. He says—

There is no remedy against the increasing evil but a decision to carry out separation from henceforth. I recognise great difficulty in altering the present state of things within the covered portion of the Metropolis, but that difficulty should not stand in the way of applying a remedy in respect of the part as yet uncovered.

Colonel Jones, also very experienced in sewage treatment, goes further, conceiving that alterations in this respect might advantageously be made without much difficulty in existing arrangements. He says (Q. 17,681):—

I have been confronted with the same argument at Wrexham for many years, but at last the Town Council have found it possible to meet my views by a very inexpensive diversion of surface water from its former course (of admission to the sewers) direct into a river which intersects the whole length of the town.
Now I conceive that a similar remedy, or, more properly speaking, palliative, might be applied in the Metropolis, which is also conveniently traversed by a river incapable of being vitiated to any appreciable extent by rainwater from roofs and well scavenged streets.

There are many streets in every town where the surface water might be cheaply conducted by shallow drains, converging on valley lines, down which a pipe or new brick sewer would carry storm water there collected on its direct course to the river.

The crown of such a drain need not be deeper than 2 or 3 feet below the roadway, and it would carry roof water from at least the front parts of houses on each side without interference with the complications of house drainage, and thus relieve the existing overcharged sewers from rainfall over a large acreage of the Metropolitan area.

Having practical experience of the great reduction in frequency and duration of storm overflows obtained at Wrexham by a small expenditure on the lines above indicated, I feel it my duty to suggest attention to this matter.

Moreover, a search for the sources of natural brooks and springs would. I am sure, demonstrate the fact that many tons of clean water unnecessarily swell the Metropolitan sewage.

We have not overlooked the well-known views of Mr. Edwin Chadwick on this matter. One of our body has already expressed an opinion in favour of the separate system; in that opinion he abides, and the other members agree with him; but the expense, trouble, and annoyance would make it impracticable now to apply to the Metropolitan drainage generally, the system which was rejected when the present arrangements were made.

182. We consider, however, that this is a matter of much importance as regards the future disposal of the sewage, in whatever way this disposal may be effected. If it is to be used on land, or treated chemically, its concentration and uniformity are highly desirable; and if is to be carried farther away by a long conduit, its volume should, from motives of economy, be reduced to a minimum. For these reasons the separation ought to be effected, as much as possible, in future extensions of the drainage.

183. We are glad to see that the Metropolitan Board are alive to the necessity of this measure. Sir Joseph Bazalgette says (Q. 19, 372):—

To carry out such a scheme as I am suggesting, or any scheme suitable for those districts, it would be necessary to separate the sewage from the rainfall. The areas are so large, and the quantity of sewage is so small, that it would be impossible to take them together; they must be taken separately.