V.—MISCELLANEOUS.

Art. XLVIII.—*Sanitary Sewerage.*

By H. P. Higginson, M.Inst.C.E.

[*Read before the Wellington Philosophical Society, 9th January, 1889.*]

The question: "How shall sewage be dealt with?" is one that has been found extremely difficult to answer. It has occupied the minds of sanitary reformers for many years, and been treated in a variety of ways, not always successfully. At all periods of the world's history where civilisation attained to any degree of refinement sanitary measures were adopted. It is usual to discuss the question intermittently until the time at length arrives when action must be taken. A virulent epidemic forces the matter to the front in a most unpleasant manner.

The site of the City of Wellington in its original state consisted of hill-slopes falling on all sides towards the harbour, offering ready means of drainage, requiring little experience or thought in the carrying-out. Modern improvements and the expansion of trade have necessitated the reclamation from the harbour of the whole frontage; and though on the one hand this has covered the foreshore upon which sewage-mud festered in the sun to the annoyance of the citizens and detriment of the public health, on the other hand it has greatly increased the difficulty of constructing a properly effective sewerage system, as where the sewers traverse the reclaimed area they become tide-locked twice in twenty-four hours, with the result that, their contents being impounded, the loss of velocity is the cause of the deposition of the solid particles. This, in the form of sewage-mud, becomes mixed with road-detritus and material washed from the hill-slopes during heavy rains, gradually forming an ever-increasing deposit which solidifies to such an extent as to withstand the action of even the rush of water during heavy rainfall. When this accumulation threatens to block up the outlet it must be removed by hand-labour.

The worst feature of this stagnant deposit with which sewage-mud is incorporated is that it generates foul gases, which force their way upwards through the drains to the higher levels of the city. As the reclaimed land becomes more densely populated this evil will be more severely felt, and will most assuredly mark its effect upon the death-rate.

Many hold the opinion that the sewage of 30,000 inhabitants, if allowed to flow into a body of water the size of Wellington Harbour, becomes lost in its immensity, and that no evil result is likely to accrue. When it is considered that the flow of noxious matter is going on continuously at an ever-increasing rate, and that a great portion is deposited upon the bottom of the harbour in front of the city, it will be seen that it can only be a matter of a few years till, with these constantly recurring effects, our beautiful harbour, the chief pride of the citizens, will become a source of annoyance and disgust, instead of a pleasure and delight.

It has been asserted that sea-water rapidly becomes fouled by such discharge into it, especially where nearly landlocked, and consequently not swept by strong currents. As the population increases and other drainage arrangements are carried out, the difficulty of introducing an entirely new system, however meritorious and advantageous, becomes more and more felt, and presents a problem to be solved which, owing to the difficulty attending a satisfactory solution, is naturally shirked by those directing municipal affairs. In older countries, where towns have for many years been sewered upon some system or other (in many cases very unscientific ones), this difficulty has been much felt; notwithstanding which it has had to be faced, consequently the sanitary condition of many towns has been greatly improved. In England, the Rivers Pollution Act has obliged action to be taken in the case of inland towns.

Baldwin Latham, a recognised authority upon sanitary engineering, in his work upon the subject, remarks that "the good that has arisen from the prosecution of sanitary works wherever properly carried out may be taken as the harbinger of better times, when the benefit of sanitary measures will be better understood and more extensively adopted." Dr. Lyon Playfair, in his address at the Social Science Congress at Glasgow in 1874, gives an example of the gradual improvement in the health of London from the adoption of sanitary measures, when the death-rate fell from 80 per 1,000 during the period 1660–79 to 22·6 per 1,000 in 1871. How much society loses annually from preventible diseases it is impossible to fully estimate, as health is so intimately connected with all the branches of every-day life. If upon no other than economic grounds, it is true economy to spend some little of our earnings in the prosecution of sanitary works."

I will not weary you by repeating the thousand arguments in favour of sanitary reform, so much advocated of late years, and relating to which a whole library of literature and statistics has been published. We, no doubt, all agree upon the point that the best arrangements possible should be adopted; but at the same time we do not appreciate heavy taxation, and, above all things, if we have to spend large sums in endeavouring to effect the object in view, we should like to feel that the money is not being squandered in useless and, in many cases, positively injurious works. Nor shall I enter upon the subject of the ultimate disposal of sewage: suffice it to say that it is an open question, considered apart from the drainage itself. The fertilising quality of sewage is of great value, and will eventually be made use of more generally, as in the cities of Adelaide and Christchurch. The application of sewage in that manner opens up an economic question, and it becomes one of pounds, shillings, and pence whether it can be made use of for fertilising land, or with greater advantage to the ratepayers be cast into the sea.

It is well known that for many years the Wellington City Council has contemplated the construction of an efficient sewerage system, to which end a report was obtained from Mr. Climie, in 1877. Mr. W. Clark, M.Inst.C.E., an able sanitary engineer, was also employed to report upon the same subject in 1878, and did so in a comprehensive manner: since that date no further steps appear to have been taken towards the attainment of the object, although the latter gentleman's scheme was, I believe, adopted at the time.

I have no intention of criticizing these various schemes, but will mention that Mr. Clark's estimate amounted to £145,000, the working-expenses to an annual sum of £1,434, and the annual charges, including interest on capital, to £10,154. It is to be inferred that the magnitude of these sums has militated against the prosecution of the work.

One of my objects in bringing the subject of this paper before the members of the society is to advocate a system of drainage for Wellington which not only provides a more efficient one than that adopted, but—what is also a very important point—reduces the present cost to little more than one-half.

The system is based upon scientific principles easily understood when a little explanation is afforded, and is known as "Shone's Hydro-pneumatic System," Mr. Isaac Shone, civil engineer, of Westminster, being the inventor, and this system during the last few years he has successfully introduced into many towns in England and other parts of the world.

In carrying the system out water-carriage is essential, and this is universally allowed to be the cleanliest and most effectual means for conveyance if properly designed and constructed. Baldwin Latham says, "It is the best adapted to the requirements of a town-population for effecting the speedy removal of the principal matter liable to decomposition, the storage of which, even for a brief period, near our dwellings may be attended with dangerous consequences." An efficient and abundant water-supply is therefore necessary, and this the City of Wellington is fortunate in possessing.

By any system the sewers should be entirely free from sewer-gas, the result of fermentation, requiring time to become generated; consequently there must be a rapid and entire discharge of the sewage throughout the whole. In stagnant tide-locked sewers, in those laid with insufficient fall in which solid matters become deposited, and in old wooden or brick drains of faulty construction, this gas is generated in abundance. Ventilation and traps may lessen the danger, but do not remove it.

The Superintendent of Sewers in Boston in a recent report shows that in all sewers there is a constant movement of air in the direction contrary to the grade, the gas flowing upwards through every vent into houses, and through cesspools, thus permeating the atmosphere of dwellings. He proposes to erect a large fan, to be operated by a powerful engine, exhausting the air, and creating a draught in the direction of the exit which shall attain a speed of 3in. per second, thus overcoming the upward movement of the gases. It is evident from the foregoing that the Boston sewers are not constructed according to modern sanitary laws. So important is the subject of ventilation that Baldwin Latham devotes over a hundred pages to it in "Sanitary Engineering."

In carrying out the ordinary systems of sewerage in low-lying districts ratepayers are subject to three varieties of heavy expenditure—

(1.) Initial, which is the cost of constructing sewers.

(2.) Chronic, being the cost of raising the sewage by pumping.

(3.) Intermittent, being the cost of repairs and freeing the sewers from stoppages—a serious item where the works are of faulty design, and much increased where, in order to obtain the necessary inclination, the sewers have to be placed at great depth.

The "Shone" system greatly lessens the danger, expense, and inconvenience, for reasons which I shall shortly endeavour to explain.

It is generally allowed that the separate system is to be preferred, both on the score of efficiency and cost, especially where sewage must be raised by the expenditure of power. This was, I believe, advocated by both Messrs. Climie and

Clark, though the latter admitted a large proportion of rainfall. In explanation of the term, I may state that only the house-sewage is admitted, the surface-water and ordinary drainage being carried by distinct drains into the natural watercourses, and so to the nearest river or sea, as the case may be. By the adoption of the separate system we are enabled to calculate almost exactly what quantity we have to deal with, as the discharge will closely correspond with the amount of water supplied to the population for domestic purposes, and we are not called upon to provide for an unknown quantity, which must be the case when the rainfall is admitted.

The separate and hydro-pneumatic systems are in no sense interdependent parts of one scheme, the only connection between them being that the cost of the introduction of the "separate" system is very much reduced when compressed air is made use of in ejectors.

The application of compressed air as a transmitting medium has been of late extensively adopted in a variety of ways. There is nothing visionary or unpractical in urging its adoption, for it has been indorsed with the approval of most practical men of our time. Where the burning of town-refuse in a "destructor" furnace is carried out we have the power for compressing the air free of expense. It is a motive-power which, once produced, can be conveyed and divided amongst any number of stations at varying distances with little loss. It is open to question whether the use of air or water can be most economically adopted for the transmission of power. This has been much debated of late. Suffice it to say that for the purpose of transmitting sewage by Shone's system air is alone applicable. The loss from friction in the pipes is much less for air than water, and its compression is now well understood, rapid strides having of late been made in the perfection of the necessary machinery for the purpose.

In properly designing sewers one of the chief objects to be attained is that they shall be self-cleaning—that is, they shall be laid at such inclination as will generate a velocity which will prevent deposit. Where this is not the case they rapidly fail to act, necessitating constant expenditure to free them from obstructions, which is the source of the foul gas so deleterious to the occupants of houses with which they are connected.

Baldwin Latham states that "undoubtedly an open drain is the least injurious form of sewer, provided stagnation is avoided, and that in proportion as the sewers are enclosed the danger to health is increased. The usual remedies are to trap, ventilate, and flush the drains—measures which only succeed in partially remedying a defect that should not exist."

In flat districts where sufficient fall has not been provided these results are always to be found, and can only be obviated by deep and expensive sewers leading to a pumping-station, or by the adoption of the principle I now advocate.

By pneumatic pressure an artificial head is provided, which forces the contents of the intercepting sewer or pipe at a proper velocity along its whole length, regardless of its inclination, to the outfall. This artificial head takes the place of the natural head upon a gravitation sewer, and gives the requisite velocity to its flow. For example, with an 18in. pipe one mile in length, discharging 318 cubic feet per minute, the velocity of its contents will be 3ft. per second. The fall in a gravitating sewer to bring about this result would be 1 in 350, the height or head necessary to overcome the friction in the pipe being 15·1ft. By Shone's system we force the contents into and along the pipe (which can be laid on the level) at a pressure of 6·553lb. per square inch, that being the equivalent of a head of 15·1ft., the result in both cases being the same.

In the gravitating pipe we must have a natural fall of 15·1ft., and lay it below the hydraulic grade-line at a probably heavy expense. By Shone's system we may have no fall whatever, laying the pipes upon the undulating surface of the ground at the least possible cost. We must, however, supply 318 cubic feet of air at a minimum pressure of 6·553lb. per square inch, with which the sewage is forced into and along the pipe.

If it can be shown that to supply that quantity of air under pressure is less expensive than to gravitate the sewage to a pumping-station, and then lift it to a height corresponding to the loss of head, the pneumatic system must be preferable, even when other results are equal.

We will take the schemes as proposed for draining the low-lying parts of Wellington as an example.

By Clark's scheme the sewage from this area was to be collected by an expensive brick intercepting sewer terminating at a pumping-station where the sewer would be 9ft. below high-water mark. Thence it was to be pumped through a cast-iron main nearly a mile in length to a height of 37ft. above the intercepting sewer, where it would join the sewage flowing by the gravitation sewer which was to drain the higher portions of the city, and would thence flow through a tunnel a mile and a quarter long to the sand-hills near Lyall's Bay.

By the pneumatic system cast-iron mains are substituted for brick intercepting sewers, and are only laid sufficiently below the surface of the ground to keep them out of sight and free from damage. Into this cast-iron main the sewage from the lower areas is forced, that from the higher areas flowing by gravitation, the branch mains receiving it being carried up to an elevation sufficient to establish a head which will overcome the friction in the mains, thus enabling the whole to flow together to the outfall.

From the Corporation Yard, where the air-compressing station would be placed, the outfall main would be carried along the shore of the harbour and Evans's Bay to the same point on the sand-hills as by Clark's scheme; or, if necessary, to Lyall's Bay.

Mr. Clark, however, dealt with the sewage of a population of 70,000 and a rainfall of 1in. flowing off one-quarter of the area occupied by the city; while I propose to deal with the sewage alone of 50,000, leaving the rainfall to flow off by existing drains, and when the population exceeds 50,000 to extend the system, thereby avoiding the necessity for incurring a heavy present outlay for the benefit of future generations.

The pneumatic system can be readily adapted to the increase of population, wherein lies one of its chief merits: when the necessity arises additional "ejectors" can be introduced, and, by increasing the air-pressure, greater velocity, and therefore greater discharging-power, can be given to the main outfall pipe until it becomes necessary to duplicate it—a work readily done without in any way interfering with the works previously constructed. By Clark's scheme the intercepting sewers and long tunnel can only discharge a certain volume of sewage and rainfall; while to increase their capacity, which must eventually become necessary, means a very heavy outlay. By admitting so large a proportion of the rainfall to the sewers he has enormously increased the first cost and working-expenses of his scheme. It may have been done with the object of flushing the sewers; but I maintain this can be more effectually done by the adoption of automatic flush-tanks at the head of the sewers.

I will now describe the "pneumatic ejector" and its action.

From a central station, placed where most convenient, compressed air is forced through small pipes to the various ejectors, which are placed at the lowest point of each subdivision which it is intended to serve. Each ejector-station has its own particular system of pipe-drains leading into it from such subdivision, which, being of comparatively small extent, enables these pipes, even in flat ground, to be laid to proper self-cleansing gradients without burying them at a great depth. A drain-pipe 20 chains in length laid to an inclination of 1 in 250 will only have a vertical fall of 5·4ft. This fact is one of the important features of this system, long lengths of sewers being unnecessary, as from preference another ejector-station would be inserted. From the gravitating pipes or sewers the sewage enters the bottom of the ejector, a spherical cast-iron vessel usually holding 350 gallons, and 5ft. in diameter. In the inlet-

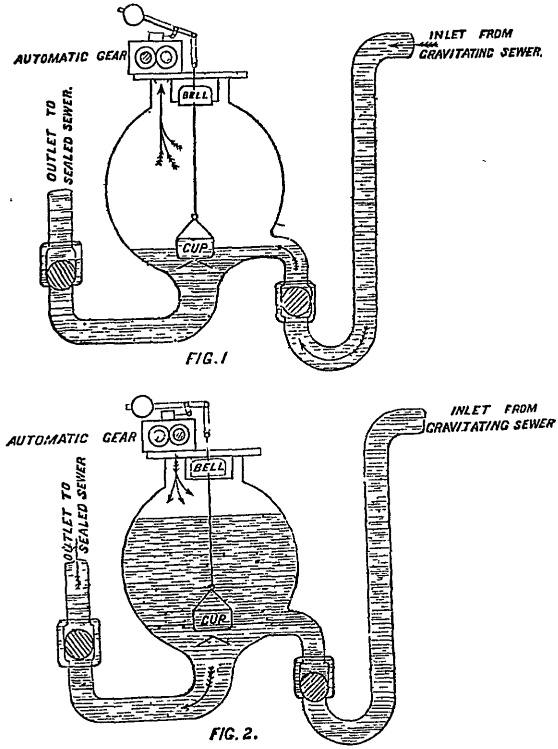

FIG. 1

FIG. 2.

pipe is a ball-valve which closes to prevent the return of the sewage. Upon the ejector being full (fig. 2) a bell-float actuates an automatic gun-metal valve placed on the top of the apparatus admitting air under pressure, which at once forces the contents through another ball-valve into the outfall main or sealed sewer. When the ejector is empty (fig. 1) the descending cup actuates the valve, releasing the compressed air, upon which the ball-valve in the outlet-pipe closes, while that in the inlet opens, when the sewage enters as before. This action can take place about once a minute, and is perfectly automatic, having been proved to work for several years without attention except an occasional oiling.

The ejectors are placed below the level of the street and are free from all objection; while in practice they are provided in duplicate, in order to guard against the possibility of stoppage from accident. From the dwelling-house to the ejector the sewage flows uninterruptedly, and upon entering the ejector the sewage is practically done with, no back-flow even of gas being possible. The velocity of 2½ft. per second will convey sewage through a mile of pipes in thirty-five minutes, so that there is no possibility of gas being generated under proper conditions.

The whole apparatus is exceedingly simple, and, having few working-parts, is little liable to damage, and costs equally little for repair. The air-valves are constructed of gun-metal, and occupy but a small space. The ball-valves in the inlet and outlet-pipes are of hardwood, and are found to pass substances such as hair, string, &c., which are a constant source of trouble to the valves of pumping-engines.

One special feature in favour of this system over Mr. Clark's is, that there is no possibility of sea-water finding its way into the main, while with a brick sewer two miles and a third in length, carried to a depth at one end of 9ft. below high-water mark, the sea-water must find its way in through every crevice and crack in the work. This water has to be pumped out, together with the sewage, at the cost of the ratepayers.

It will be readily understood that there is considerable difficulty in introducing an entirely novel system. Its being based upon scientific principles not thoroughly understood by every one, is quite sufficient to warrant unthinking persons in jumping to the conclusion that it is complicated and liable to result in failure; although the experience of the last few years at numerous places where the system has been adopted has resulted in universal satisfaction being given.

Any improvements in sanitation should become of deep interest to the community; and that must be my excuse for taking up so much of your time. Many people shut their eyes to all matters relating to the subject, leaving it to others whose sphere of life is more intimately connected therewith to work out the problems; and it is as well, perhaps, that it is so, or the discussion would be endless, and we should never arrive at the stage for action being taken.

In conclusion, I repeat that were Wellington sewered upon the pneumatic system the sewage would be rapidly, effectually, and inodorously conveyed from the city in a sealed iron main to any outfall deemed desirable. In such main there would be neither manholes nor ventilators to annoy the public. By the exclusion of the rainfall the quantity to be dealt with could be accurately determined, so that to convey that quantity the sizes of the sewers and pipes could be properly adjusted.

The sewage being discharged in a concentrated form, undiluted with rain-water, its value would be much enhanced as a liquid manure for the purpose of irrigation, should it be decided to employ it in that manner. For the same reason the first cost and working-expenses would be greatly reduced.

Provision for serving a population of 50,000 is, I maintain, ample, the possibility existing of extending the system to meet the future increase without sacrificing the work previously carried out.

The remarks in this paper have, of course, a catholic application: what has been said with reference to the difficulty of draining Wellington applies equally to all towns occupying flat sites, the difficulties which may arise, and sewage-gas nuisances which threaten, being the same.

The pneumatic system has, I venture to submit, solved the problem of how to drain localities effectually and cheaply which do not possess the natural conditions suitable for drainage by gravitation.

Art. XLIX.—*Notes on the Islands to the South of New Zealand.*

By A. Reischek, F.L.S.

[*Read before the Auckland Institute, 30th July, 1888.*]

At last the time came for me to say "Good-bye" to those solitary wilds on the west coast of the South Island where, amidst the grandest and most beautiful scenery, I had spent so many happy days. Truly, nature has lavished her favours on New Zealand, and I may well be excused for being sorry to leave it.

On the 19th January, 1888, the "Stella," under the charge of Captain Fairchild, left the Bluff for her annual tour to provision the dépôts kept up for the succour of shipwrecked sailors on the islands to the south of New Zealand. Mr. Dugald (the photographer), a few youths, and myself were the only passengers. We started first for Stewart Island, distant fifteen miles to the south-south-west. Passing through Foveaux Strait, dotted over with romantic little islands, we disturbed numerous flocks of mutton-birds (*Puffinus tristis*) which were feeding, playing, or sleeping on the water. A few nellies (*Ossifraga gigantea*) followed the vessel to pick up any scraps thrown overboard, which they greedily devoured.

Stewart Island is of irregular shape: its western or longest side runs in a north-and-south direction for about thirty-nine miles; the north and south-east sides are each