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SHONE'S HYDRO-PNEUMATIC SYSTEM OF DRAINAGE.

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THE special attention that has been given to sanitary engineering during comparatively recent years, has been productive of many marked advances in that science, particularly in regard to that section which deals with the sewerage of cities and towns. Experience has shown clearly what the principles are, observance of which is essential to the success of the water carriage system of sewerage, and, in a large measure, how these principles may be practically applied. A successful result now mainly depends upon the skill and judgment of the engineer in the practical adaptation of these principles to the peculiarities of the locality where a system of sewerage has to be constructed.

Briefly stated, the principles are these :—

(*a*) As to collection and removal of sewage.—

1. Rapid and complete removal of excreta and liquid refuse from dwelling houses, and transmission beyond the limits of populated area.
2. Impermeability of conduits.
3. Thorough ventilation of conduits.
4. Exclusion of storm water from sewage conduits as far as practicable.

(*b*) As to disposal of sewage—

5. Non-pollution of sources or possible sources of water supply.
6. Non-pollution of the atmosphere.
7. The restoration to the soil of the fertilizing matters contained in the sewage.

The system which forms the subject of this paper was designed mainly to assist the engineer in carrying out the first principle enunciated under any circumstances whatsoever, and it has shown itself to render possible the realization of the remaining principles, in a higher degree of excellence, than has hitherto been known.

The proper construction of a system of sewerage has an important bearing upon the health of the community; there is no other engineering work which is brought into such important relations with the social habits and well-being of each individual family.

The water carriage system for the removal of sewage depends, in a great measure for its success, upon the speed with which the removal is effected. This is of the greatest importance in warm climates, where stagnation of the sewage should, under no circumstances, be permitted. Stagnation, whether caused by defective designs, or by the flatness of the site, causes the deposit of silt, decomposition, and the evolution of offensive and poisonous gases, which fill the sewers, and too often, penetrate into dwelling houses. In order to avoid stagnation, the sewage conduits should be laid at inclinations which will cause a velocity of flow of 2½ feet per second when the quantity of sewage flowing is at its minimum. When the surface conformation of a locality is favourable to the construction of sewers, with the necessary inclinations, this result is readily accomplished. Where, however, the surface of the site is flat, or low-lying, it is often impossible to obtain for the sewers the most desirable self-cleansing gradients to a natural outfall. In order to overcome this difficulty, in some instances pumping engines have been erected on centrally situated situ- which have afforded facilities for the collection of the sewage from a considerable area into a sumph, or well, from which it is continuously raised by the pumps. The sumph forms an artificial outfall for the sewers which descend towards it at the requisite grades. The construction of such works, however, nearly always renders necessary deep and expensive excavations, particularly if the sewers have to be extended to a considerable distance. Pumping cannot be economically applied to low-lying areas of small extent, the sewers on which have necessarily to be laid at most undesirable flat grades. These are the areas which too frequently give to the water carriage system a bad reputation, and it has been the aim of sanitary engineers to place such localities in as favourable a position, as regards sanitation, as those where better grades are obtainable.

The system invented by Isaac Shone, A.M. Inst. C. E., is an auxiliary to the modern water carriage system of sewerage, and is designed to enable the engineer to command gradients to the sewers under all circumstances, that will be suitable to the quantity of sewage he has to deal with, irrespective of the natural inclination of the surface. The system, since its initiation (about ten years ago), has been found to possess many collateral advantages, which extend its sphere of usefulness.

The leading feature in Shone's system is a novel but effectual method of raising sewage or drainage water to any desirable elevation. This is done by the use of an ejector, worked by compressed air, and the action is automatic. The apparatus consists of an air-tight, cast-iron, spherical receiver, with two branches below. One of these branches is placed in communication with the system of sewers which deliver sewage into it, and the other with a high-level trunk sewer, or sealed main. Both branches are provided with reflux valves of the ball type. The top of the ejector as kept below the level of the sewers, which are thus enabled to deliver sewage freely into it. The compressed air supply pipe is connected to a valve chamber on the top of the ejector where the actuating mechanism of the ejector is placed. This mechanism consists of a small slide valve, controlling a piston valve below it. The slide valve is operated by a bell float and a cup, connected to each other within the ejector, and with a system of levers without. The cup is lowermost, and when in action is full of sewage water. As the sewage rises in the receiver, it submerges the cup, and neutralizes the weight of the liquid within it, which has acted as a counter balance. The system of floats and levers is now balanced. The sewage continues to rise, and ultimately reaches the bell float, which is simply an inverted cup. Still using, the air inside the bell is compressed, and presently the bell is lifted. This movement is conveyed by a rod passing through a stuffing box to the system of levers without, which transfer it to the slide valve. The movement of the slide valve admits compressed air to one end of the piston valve, and opens the other end to the exhaust. A stroke of the piston valve is made, and thus throws open the port through which compressed air is admitted into the receiver over the surface of the charge of sewage. The pressure immediately forces the sewage out through the discharge pipe, and this action continues until the sewage falls below the level of the cup; the weight of the liquid contained therein, which, whilst the cup was submerged, was neutralized, now comes into action, and pulls down the float rod, thus reversing the slide valve: the piston valve makes a back stroke, the compressed air is shut off, and the receiver opened to the exhaust. The action of the apparatus is thus reversed, and the sewage again flows in, the operation of filling and emptying proceeding at regular intervals.

It is found in practice that the ejectors require very little attention, an occasional visit for oiling being all that is necessary. The strainer, which is provided in the adjoining chamber for intercepting sticks and objects likely to interfere with the action of the ejector, has to be regularly visited and cleaned. The arrangement of the ejector is such that the heavy matters which are carried in with the sewage subside on the bottom, and are driven into the discharge-pipe at the commencement of the process of ejection; the after-rush of sewage water ensures their complete removal. During the space of time occupied by the act of ejection the inlet ball-valve is shut by the force of the air pressure within the receiver, consequently the sewage accumulates in the inlet pipe, which it fills and rises up into the straining chamber. As soon, however, as the air pressure is released the sewage, with the head it has attained in the vertical pipe, lifts the ball-valve and rushes into the ejector, carrying all heavy matters which may have settled in the bend with it.

The capacity of each ejector has to be carefully adjusted to the work it will be called upon to perform. As this work is properly restricted to the lifting of the sewage of a known area and not the rainfall it can be ascertained very accurately. A small amount of rainfall has, however, to be provided for, because it is found that, with the best arrangements, rainfall cannot be completely excluded from the sewers. The air-compressing machine may be placed at any convenient place. Reservoirs are provided for storing the compressed air, and from these the air is conveyed by strong iron pipes to the ejectors, which are placed in the most convenient positions for collecting the sewage from the area to be drained. The ejectors may be placed at any reasonable distance from the air compressor. A distance of two miles is not excessive, and no inconvenience is felt from loss of power in such a length; this is probably due to the intermittent action of the ejectors and the air main acting as a reservoir. The exhaust air may be used for ventilating the sewers.

From the foregoing description it will be readily seen how easily the sewerage of low-lying flat areas may be improved. The ejectors may be placed under the streets, at the depths necessary for securing the best grades for the sewers which lead to them. If the area to be drained be extensive the ejectors may be multiplied.

One air compressing station will command a very large area, and its site is not determined by the location of the sewage outfall, as is the case with a pumping-station. This allows a freedom of choice, and economy may therefore be exercised in the purchase of the necessary land.

From the ejectors the sewage is conveyed under pressure in a sealed main to any desired point of discharge, which may be an intercepting sewer at a much higher level.

The sewage is dealt with in a manner that offers no facilities for the disengagement of sewer gas, and it is not subjected to the churning up which is unavoidable with ordinary pumps, and which too often may be a source of nuisance.

Hitherto, Shone's system has been referred to chiefly as a means of remedying defects in existing sewerage works. The system, however, in these instances, does not exhibit all its capabilities. These are best seen when it is applied in its entirety for the removal of sewage from a populated area. The area is divided up into sections, containing an ejector station so adjusted that suitable grades will be obtained for the sewers with the least amount of excavation. The sewers are designed to convey ordinary sewage only, the rain water being allowed to follow its usual course over the surface. The sewers in each section all converge upon the ejector in that section into which they discharge their contents. At the head of each sewer an automatic flushing apparatus is placed. The sewers are well ventilated, and the house connections are made in a similar manner to that usually adopted in the best practice of sewerage work.

Each ejector forces its contents into a sealed iron main, which traverses the area by which it is conveyed, irrespective of gradients, in any desired direction, and to any reasonable elevation—to a distant sewage farm or to a manure factory—to mid stream of a tidal river or to deep water on the coast.

The ejectors only work when they have work to do, quickly or slowly, according to the amount of sewage flowing in.

During the night time, and especially towards morning, the flow of sewage is at its minimum, and the ejectors may possibly take a long time to fill, causing an undesirable stagnation of the sewage. This is obviated by the action of the automatic flushing apparatus, the water to which is supplied from the water mains. Each sewer is flushed several times during the day. At night this action continues, and the flushing water being comparatively clean, the sewers and ejectors are thoroughly washed out and are ready for the next day's work.

A sewerage system constructed entirely upon Mr. Shone's designs, is said to be practically free from sewer gas. The sewage conduits are small and afford little space for the accumulation of sewer gas. The sewage flows at a velocity, which can always be attained, that allows but little time for the disengagement of gas. Sewage cast into a sewer at a point one and a-half miles distant from the ejector, would take under 20 minutes to complete its journey. Once passed through the ejector it has no further power for harm, and is delivered at a point far distant from the seat of population.

A counter may be attached to the lever on the top of an ejector to register the number of times it moves; the ejector thus becomes a sewage meter, and accurately records the amount of sewage passed through. Additional ejector stations may be constructed with radiating sewers, to provide accommodation for growing and expanding population. This element of flexibility is a most admirable feature of the system, and one which is of value in progressive communities.

The writer has no data upon which to base a comparison of Shone's for raising sewage from a low to a high level with steam pumps acting under similar conditions, but it is stated not to be more expensive.

Shone's system has been successfully applied to the sewerage of several towns in England. A recent example is Henley-on-Thames. A short notice of this work appears in a recent issue of *Engineering*. The sewage has been kept quite distinct from the storm and rain water, and is collected by a system of sewers and delivered on to a sewage farm four acres in area situated at a distance of two miles from the town and at a much higher level. The town is divided into four districts, from each of which the sewage gravitates through a 7-inch main-pipe to the ejector. The ejector has a capacity of 150 gallons; the air pressure is 40 lbs., and the sewage is forced into an 8-inch sealed main, which extends towards the sewage farm. An intermediate ejector is used to divide the total lift into two parts, for the purpose of reducing the air pressure. The total lift, including friction, is 180 feet. The air-compressing machinery is located at the sewage farm. The diameter of the air-pipe is 4 inches as far as the intermediate ejector, and from thence 3 inches. The works have been designed for a population of 6,000, and cost £18,000. The result has been satisfactory. For minor installations of Shone's system, air compressors worked by gas engines may be used with advantage. The consumption of gas is automatically regulated by the consumption of the compressed air at the ejectors.

Shone's system came under the writer's notice several years ago, and recent reports of its thorough success have led to the production of this paper, which has been written for the purpose of making public the advantages of a new system of sewerage that appears to have hitherto escaped attention, but which is eminently suited to local requirements. The area along the fore shores of the harbour lying between the city boundaries, the sewage from which cannot be discharged by gravitation into the new intercepting sewers, is equal to one-fourth of the entire area of the city. The irregularities of the shore line are such as to prevent the economical use of steam pumps for raising the sewage. Shone's system appears to be admirably suited to the case.

Its application to the requirements of the western suburbs, is worthy of consideration, as by its means the sewage may be collected and delivered into the main Bondi sewer, or sent inland on to a sewage farm.

Again, at Newcastle, Shone's system would probably solve two problems. First, the sewerage of the city, and secondly, the reclamation of the sand drift. The ejectors would enable the sewage from the city to be distributed over the drift sands, on which vegetation would soon spring up, and convert a sandy waste into a green field.

Inland cities and towns situated on the banks of streams, especially on the plains—as for instance, Hay—require such a system as Shone's to prevent pollution of the river waters, the depression of the river channel being the only natural outfall available.

In concluding this notice of Shone's system, the writer desires to observe that in any modern system of sewerage, thorough success is only achieved by the close and unremitting attention of the engineer, not only to the design of the whole work from the beginning to the end, but to the execution of the same from the heaviest work of construction to the minutest details relating to house connections. Failure at any point endangers the whole system.