The Shone hydro-pneumatic system of sewerage was invented by Mr. Isaac Shone, Civil Engineer, of Westminster, England, in 1878, and the first works on this system were executed in the year 1880, at Eastbourne, England. Since that date works upon the Shone system have been carried out in the United States, Europe, India and South America, involving an expenditure of several millions of dollars; which fact may be taken as prima facie evidence of the soundness of the principles upon which it is based, and the durability and reliability of the mechanical details of the apparatus employed.

Wherever natural gravitation can be employed to give a reasonably perfect system of sewerage, it is unquestionably the proper means to adopt; but not unfrequently upon the score of economy, this natural force is stretched to such limits that an imperfect and unsanitary method of discharging the liquid wastes of a city is the result.
The Shone system is applicable wherever the sewage of a city, district or building has, for any cause, to be raised by mechanical means, and may be applied successfully in any of the following cases:

1. Where there is no natural outlet.
2. Where the natural surface of the ground is so level that it is impracticable to construct self-cleansing sewers at grades above the natural outlet.
3. Where sewers, if laid at self-cleansing grades, and proportioned to the normal volume flowing through them, would have to be laid at such depths as to be prohibitive in point of cost.
4. In undulating districts containing several natural drainage areas, where deep and expensive cuttings or tunnels would be necessary if natural gravitation was employed.
5. In low-lying basins or flat districts from which it is not practicable to convey the sewage to the main gravitation system employed.
6. In asylums, barracks and large buildings, from which the liquid wastes cannot be discharged by gravitation.
7. For discharging sewage sludge.

The Shone system may briefly be described as one in which the motive power, viz., compressed air, is generated at one central power plant and distributed to numerous pumping stations. Each station is the outfall of the district tributary to it. The sewage from the various stations is automatically discharged into one common discharge leading to one common outlet.

In the use of this system the first step is to divide the territory under consideration into as many drainage areas as desirable; the extent and boundaries of each being determined, either by the contour of the ground, density of population or by other causes. The drainage areas being defined, the lowest point in each is located; or in the case of absolutely level ground, the central or most convenient point is determined. Here, at what is termed an "Ejector Station," all the sewers of the district are centered; these can be of the exact size to accommodate the maximum population of the district, and laid at such grades as to carry the sewage to the ejector station as rapidly as it is discharged from the houses and before decomposition sets in. In the ejector station, a pneumatic ejector (described hereafter) is placed. As fast as the sewage flows into and fills the ejector, compressed air is automatically admitted, forcing the sewage into a sealed iron main through which it is conveyed rapidly under pressure to the outfall or into a high level gravitation sewer.

The ejector chamber is a manhole-like chamber, built beneath the surface of the street or elsewhere, having an ordinary manhole cover on top.

The division of a city into separate areas for the purpose of sewerage, was first mooted as far back as the time when the best method of sewerage London was under discussion. Sir Edwin Chadwick then advocated the dividing of the whole site into natural drainage areas, and the employment of an independent pumping station in each division. It rested, however, with Mr. Shone to devise the means of carrying out this idea in a practical and economical manner.

The advantages of dividing a city into sewerage districts are many, among which the following may be mentioned:

Self-cleansing sewers from houses to outfall, with sewer pipes of small diameter.

The severance of each district from the rest of the drainage area, so that in the event of an epidemic disease breaking out in one district, it cannot be conveyed by the sewers into healthy districts.

The amount of water required for flushing and the volume of air required for ventilation, are, by reason of the small diameter of the sewers and the comparatively short lengths tributary to an outfall, reduced to a minimum.

The avoidance of deep cuttings.

The ready extension of the system as necessity demands.

If these advantages could only be obtained by separate and independent pumping stations, each with its own staff of attendants, the annual maintenance charges would be prohibitive; but by the Shone system, as already described, any number of stations can be worked from one central power plant.

In connection with the division of a city into districts for the purpose of applying the Shone system, it should be stated that the consumption of compressed air would not be appreciably increased by reason of multiplying the number of divisions. From one compressing station a number of ejector stations can, in most cases, be supplied more economically (in fuel cost) than if the whole of the sewage were brought to one spot and thence raised to the same outfall; because a considerable amount of the sewage would be intercepted at higher points,
and thus effect a saving in the work to be done. To apply an ordinary steam sewage pump it would be necessary to allow the whole of the sewage to gravitate to the lowest point, so that any advantage in the duty of the engine itself would be more than counterbalanced by the increased work it has to do, through so large a proportion of the sewage having to run down merely to be pumped up again.

The accompanying figure is a sectional view of a Shone Pneumatic Ejector of ordinary construction. The action of the apparatus is as follows:

The sewage gravitates from the sewers through the inlet pipe \( A \) into the ejector and gradually rises therein until it reaches the under side of the bell \( D \). The air at atmospheric pressure inside this bell is then enclosed and the sewage continuing to rise around it, its buoyancy is sufficient to lift it with the spindle, etc., and to open the compressed air admission valve \( E \). The compressed air thus automatically admitted into the ejector presses on the surface of the sewage, driving the whole of the contents before it through the bell-mouthed opening at the bottom, and through the outlet pipe \( B \), into the iron sewage discharge pipe, or high level gravitation sewer, as the case may be. The sewage can only escape from the ejector by the outlet pipe, as the instant the air pressure is admitted upon the surface of the sewage the valve on the inlet pipe \( A \) falls on its seat and prevents the fluid escaping in that direction.

The sewage passes out of the ejector until its level falls to such a point that the weight of the sewage retained in the cup \( C \), which is no longer supported, is sufficient to pull down the bell and spindle, thereby reversing the compressed air admission valve, which first cuts off the supply of compressed air to the ejector, and then allows the air within the ejector to exhaust down to atmospheric pressure. The outlet valve then falls on its seat retaining the liquid in the sewage discharge main; and the sewage flows through the inlet once more, and so the action goes on as long as there is sewage to flow.

The position of the cup and bell is so adjusted that the compressed air is not admitted to the ejector until it is full of sewage, and the air is not allowed to exhaust until the ejector is emptied down to the discharge level; thus the ejector discharges a specific quantity each time it operates.

The advantages of this apparatus may be summed up as follows:

1. The working parts are reduced to a minimum, and these are of a kind not likely to get out of order.
2. The parts into which the sewage enters contain no finished surfaces, such as are unavoidable in pumps and are rapidly destroyed by the action of the sewage sludge and grit from road detritus, etc. In the ejector there is nothing but the hard skin of the castings, coated with a composition upon which the sewage can produce no detrimental effect.
3. The friction of a pump piston and other working parts is avoided; the compressed air itself, acting directly upon the fluid without the intervention of any machinery, forms an almost absolutely frictionless and perfect air piston, past which there can be no slip or leakage whatever.
4. The only finished parts are those in connection with the small automatic air valve, which makes only one movement of 2 or 3 ins. for each discharge of the ejector of from 50 to 1000 galls. (according to the size of the ejector), and they are in contact with the compressed air only, and out of the reach of the sewage.
5. The sewage inlet and outlet valves are so arranged as to give a passage-way of the full area of the pipe, allowing a free passage to all the solids that the sewer itself can carry.
BROUGHON ON SHONE HYDRO-PNEUMATIC SYSTEM.

(6) The outlet is from the bottom of the ejector, so that the whole of the sewage, including solids, sludge, grit, and everything brought down the sewer, is discharged out of the ejector.

(7) No screening or straining of the sewage is necessary, as is the case with pumps, and the nuisance caused by the cleaning of the pump gratings and sump wells is avoided.

(8) The sudden rush of the whole contents of the ejector, when the discharge is into a gravitation sewer, forms a most effective flash.

(9) The ejector forms an absolute severance of the house drains of each district from the main sewer, and it automatically works either slowly or rapidly according to the flow of sewage.

The Shone system has been applied with advantage to sewerage works upon the "combined system"; but, in the author’s opinion, greater benefit can be obtained when it is applied in connection with the "separate system," as in many cases, owing to the flatness of surface grades, it is impossible upon the gravitation system to obtain the fall necessary for small pipe sewers without carrying them down to excessive and prohibitive depths. The primary essential to a good system of sewers is that they should be laid at grades which will be self-cleansing when the normal flow of sewage is passing through them, and the raison d’être of the Shone system is to admit of this being obtained at a permissible cost regardless of natural adverse conditions.

Some engineers who have not understood the Shone system have treated it as if it was a competitor of the steam pump in the lifting of sewage, and have decried compressed air as a wasteful method. The primary object of the system is to get as high a degree of sanitary efficiency in connection with the every-day working of house-drains and sewers as is possible, and, if it accomplishes this, the question of the relative efficiency of steam pumps and ejectors is of secondary importance.

With regard to the efficiency of compressed air as employed in ejectors, Professor William C. Unwin, M. Inst. C. E., made some tests on the ejectors now in use at Lowestoft, England, with the result that upon a lift of 25.26 ft. the percentage of useful work obtained, after allowing for all losses, was 48.9 per cent. This plant is a small one and was not specially prepared for testing. Owing to the nature of sewage, such a high efficiency cannot be obtained from pumps lifting sewage as from those lifting clean water. The author is of the opinion that the above efficiency will compare favorably with any steam sewage pump automatically lifting the same quantity of rough unscreened sewage to a similar height.

In connection with compressed air (the motive power used in the Shone system), the author would point out that very marked improvements have been made in recent years in air-compressing machinery, whereby the losses due to compression are considerably reduced. As a means of transmitting power to long distances, compressed air is largely in use. If the pipes are properly proportioned, the losses due to friction in the passage of air through them are trifling. By the use of pipes of moderate diameter the velocity of the air can be so adjusted that the loss by friction in transmission is only 1% of the absolute initial pressure per 1,000 ft. of pipe. Broadly speaking, it is more economical to produce air at low than high pressure, and it is not necessary upon the Shone system to use high pressures. An important loss in the use of compressed air, as generally applied, is the frictional and clearance losses of the executive machine. These are infinitesimal in the ejector, as there are no solid pistons, cylinders, and their connections, the body of the ejector being the cylinder, and the air itself the piston.

Recently Professor Unwin, in writing upon the subjects of power transmission by compressed air and water, made the following statements:

"Mr. Shone has adopted compressed air for distributing power, and there are good reasons for the choice. Compressed air has long been used for transmitting power for intermittent power for mining, and recently for distributing power in towns. All the details of an air transmission are simple, and the mechanism is well understood. For a hydraulic transmission an excessive pressure must be used; in fact, usually the pressure in hydraulic transmission is 750 lbs. per sq. in. But with air, more power can be transmitted through a 6-in. main with 45 lbs. air pressure than with 750 lbs. water pressure. This is because with air a velocity 20 times greater than that permitted with water can be allowed without incurring any practically appreciable loss in friction or adhesion. With air the quantity used adjusts itself to the work to be done, in consequence of the expansion of the air. But with water the quantity used depends only on the size of the motor-cylinder and is always the same whether the resistance is great or little. From the low pressure at which air can be used, an extremely simple form of pumping arrangement can be adopted, with small and simple working parts, little liable to get out of order and requiring very little attention or repair."

The Shone system is in practical operation for the sewage, either wholly or partially, of 24 towns in England; at Rangoon, Burma;
Campos and Rio de Janeiro, Brazil. It has also been applied for the
drainage of the public slaughter-houses of Moscow, Russia, and for
the Houses of Parliament and other large buildings in London.
A description of most of these works has appeared in engineering
journals and elsewhere, so the author will confine himself to what has
been done on this system in the United States.

Many large buildings in cities, such as hotels, office buildings, etc.,
require, for economical as well as other reasons, to have basements
in which boilers, pumps, electrical and other machinery, as well as sanita-
tary fixtures, may be placed; and it frequently occurs in cities in which
the public sewers are shallow, that it becomes necessary, in order to
obtain sufficient headroom in the basement, to construct the floor at
about the same level as, or below, that of the street sewer. It is then
of vital importance to remove all liquid wastes expeditiously, sanitarily,
and in a reliable manner from the building to the street sewer.

The Shone ejector has been found to serve this purpose effectually.
In a chamber underneath the floor of the basement, a small ejector is
placed at such a level that all the basement sewers and drains of the
building may have a good fall to it; these sewers and drains deliver
sewage, drips from engines, washings from boilers, and ground water
to the ejector, from which, when full, the contents are discharged into
the street sewer.

To work the ejector, a small vertical direct acting compressor is
employed, which is bolted to a wall in a convenient place in the engine-
room of the building, and the compressed air is conveyed to the
ejector through a wrought-iron pipe of small diameter. When steam
is turned on to the compressor, the whole apparatus is automatic.
The compressor delivers air into a receiver, and when the required
pressure is attained (usually about 8 lbs.) the compressor stops,
automatically starting up again when the pressure is reduced in the
receiver, by reason of the discharge of the ejector.

The ejector not only discharges the liquid wastes from the building
as rapidly as created, but forms an absolute barrier against a reverse
flow of sewage or sewer gas from the street sewer. It is preferable to
place these ejectors in duplicate, one for constant service and one in
reserve. The author has, however, knowledge of a single ejector which
has worked continuously day and night in a building in Chicago for
two and one-half years without a single stoppage for any cause. For

the above-described purpose there are 24 Shone ejector plants now in
operation in this country, the majority of them being in Chicago.

Rogers Park, Illinois, a small town situated on Lake Michigan,
immediately north of the City of Chicago and covering an area of
about 1,100 acres, is an example of how the Shone system can be
employed in conjunction with a natural gravitation system of sewers.
The eastern section of the village adjacent to the lake from the northern
to the southern limits is practically flat, the general elevation of
the ground being only 8 ft. above the average level of the water in Lake
Michigan. The western section of the village rises from east to west,
the western limit of the village having an elevation of 36 ft. above the
lake. As the water supply is taken from the lake it was decided that
there should be only one outlet for the sewage.

Three projects for the sewerage of this village were proposed by
different engineers.

The first was a gravitation plan upon the combined system, and
was rejected because the inverts of the sewers in the eastern or flat
section of the village would have been, even with poor grades avail-
able, below the level of water in the lake. The difficulty in devising
an efficient system of gravitation sewers in an area 1.5 miles in length
by 1 of a mile in width, where the elevation of the ground is only from
6 to 10 ft. above the average level of the lake (which frequently rises
2 ft. higher), when one outlet is made a sine qua non, is manifest. The
second project was one by which the sewage of the whole village was
to be pumped; this project was rejected as being unnecessary.

At this time the village trustees instructed the author to prepare
the project which was carried out and has been in operation since
August last. Its main features are that the combined gravitation plan
is employed in the western section of the village, where good grades
can be obtained; the collecting sewers are at the foot of the slope and
unite into one main which passes through the flat or eastern district
about midway between the northern and southern limits and discharges
into Lake Michigan at a level of 6 ins. below the average level of the
lake. In the flat districts north and south of the main sewer, the
Shone system is employed and the sewage is lifted into the main gravi-
tation sewer, while the surface water is conveyed to the lake by a
system of shallow sewers.

Only about one-half of the village requires sewers at present. There
have been constructed 9.6 miles of sewers on the combined system, 3.7 miles on the Shone system, and 3.7 miles of storm water drains, at a cost of $165,100. The combined gravitation sewers and the storm water drains present no special features.

The area embraced by the Shone system is 214 acres, and this is divided into three sections embracing respectively 50, 70 and 94 acres. The subsoil generally is sand and gravel, and ground water stands permanently about 4 ft. 6 ins. from the surface. Sheet piling was necessary throughout, and steam pumping had to be kept up day and night during construction.

The sewers commence at their summits at a level of 6 ft. below grade, and at the ejector stations are 14 ft. deep. For economical as well as sanitary reasons it was necessary that they should be watertight, and with this object in view the pipe sewers, which are all 8 ins. in diameter, were made in 3-ft. lengths, with special sockets 3 ins. in depth, and of such diameter as to leave an annular space of half an inch around the spigot end of the adjoining pipe.

The joints were made by first caulking a hempen gasket back into the joint around the whole pipe, then 2 ins. in depth of the joint was filled with Portland cement mortar, and rammed into place with a hard wood rammer. The joint was then completely filled by pressing into it with the fingers all the mortar it would hold. No filling in was allowed until the cement in the joints had set and all joints had been examined. These conditions were rigidly enforced. It was ascertained, by careful measurement through the ejectors, before any house connections had been made, that the maximum amount of leakage through 9,200 ft. of sewers (which is the longest line now built tributary to one ejector station) was only 15 galls. per minute, and this is due to seepage through the brickwork of the manholes. Considering that these sewers have a head of water constantly over them varying from 1 ft. 6 ins. at their summits to 9 ft. 6 ins. at their deepest points, the result is considered by the author to be satisfactory. All sewers have automatic flush tanks at their dead ends. The minimum grade employed is 1 in 250.

The ejector chambers are water-tight; they are circular, 11 ft. 6 ins. in diameter, and the floor and walls are constructed of cast-iron flanged sections, 7 in. in thickness, bolted together. The joints between the sections are made with lead pipe inserted between the flanges. The roofs of the chambers are constructed of steel beams and brick arches covered with asphalt. The entrances to the chambers are through manholes in the roofs. In each of them are two Shone ejectors of a capacity of 300 galls. each, one for constant use, the other held in reserve.

The air compressor supplying the power is located at the Rogers Park Water Company's pumping station, and steam and attendance are furnished by that company. It is of the type known as the "Duplex Crank and Fly Wheel," and either half of the machine can be run without connection with the other. The steam cylinders are 8 ins. in diameter by 12-in. stroke; the air cylinders are 12 ins. diameter by 12-in. stroke, and are double acting and water jacketed. The steam cylinders are fitted with adjustable cut-off valves. The speed of the engine is regulated automatically by means of an air governor.

The ejector station most remote from the air compressor is 5,070 ft. distant. There are 1.33 miles of air pipe, which is ordinary light weight cast-iron water pipe. The discharge pipes from the ejector stations lead to three points in the main sewer, where the discharge of 300 galls. of sewage at each point in 30 seconds forms a very effectual means of flushing. The cost of these 3.7 miles of sewers, ejector chambers, ejectors, air-compressing machinery, air and sewage discharge pipes, was $52,400; but as the contract was let for payment in special assessment warrants on the five years' installment plan, which cannot be discounted for less than 10%, the cash cost may be said to be $47,160.

It also may be pointed out that the plant at the central station and at one of the ejector stations is designed with a capacity for 13,000 ft. of additional sewer pipes to be connected later on, when required.

The City of Winona, Minnesota, is situated on the right bank of the Mississippi River upon a sandy gravel subsoil. The level of the ground water is governed by the level of the water in the river, which at certain periods rises to within a few feet of the surface of the principal business streets of the city. It is impracticable to discharge the sewage by gravitation into the river at all periods of the year. Owning to the configuration of the ground, the cost of constructing a sewer system for the entire city leading to one pumping station would have been excessive. The arguments which induced the city authorities to adopt the Shone system were:

First.—The sewerage works could be carried out in sections as requirements demanded, each section being complete in itself.
Second.—As pumping is necessary, more satisfactory grades and much less costly sewers could be obtained by having several ejector stations than by collecting the sewage of the whole city at one pumping station.

As the power can be located at the water-pumping station owned by the city, and distributed to the ejector stations, the city would be saved the expense of special attendants, as the slight attention required by the air-compressing engines can be given by the men in charge of the water-pumping engines.

The portion of the city in which the sewerage works have been constructed is the business section, and covers an area of about 220 acres. Four and a half miles of sewers have been built, consisting of 8-in. pipes, with the exception of short lengths of 10 and 12-in. pipes.

Absolute tightness of sewers has been aimed at. The ground water has a vertical range of 17 ft., and all sewers that lie 5 ft. or more below the highest level of ground water are constructed of extra smooth cast-iron water pipes laid with lead joints, the others are of vitrified stoneware pipes, made in 3-ft. lengths with special joints, as at Rogers Park.

The minimum grade for the 8-in. sewers is 1 in 250. Automatic flush tanks are placed at all dead ends. These sewers converge at an ejector station, built in brickwork underneath the surface of the main street, in which are placed two Shone pneumatic ejectors of a capacity of 1,500,000 gallons per 24 hours. The air compressing engines—two in number—are of the same design as those at Rogers Park, and are located at the city water-works, about 1,000 ft. away from the ejector station. These engines are run by the employees in charge of the city water-works. In connection with the ejector station, there is an arrangement of valves by which the sewage can be shut off from entering the ejectors, and allowed to flow direct by gravitation to the river, during the levels of the water which generally prevail from six to eight months every year. The works which were designed by, and executed under the superintendence of the author cost $42,000.

The largest installation on the Shone system in this country is at the World’s Columbian Exposition, Chicago. The site is Jackson Park, lying on the shore of Lake Michigan, and contains rather more than 600 acres. The buildings provided for the purposes of the Exhibition are 16 in number, and vary in size from 1 to 32 acres each; in addition there are 40 or more buildings of smaller size, built by individual States and Foreign Governments, which bring the total roof area up to about 150 acres.

A daily attendance of 150,000, with a possible maximum of 400,000, is anticipated. For the accommodation and convenience of this multitude there will be provided in the Exposition buildings 25 or 30 cafés or restaurants, of an average area of 5,000 to 6,000 sq. ft. each, with public and private dining rooms. There are also in these buildings toilet rooms and lavatories, containing a total of 3,000 water-closets, and urinals and wash-basins in proportion. In addition there are toilet rooms with water-closets, etc., in the 40 or more buildings of the States and Governments. As the site is very flat, varying from 5 to 11 ft. above Lake Michigan, any system of collection of sewage by gravitation sewers alone would necessitate very light grades; it was therefore decided to put in a separate system of sewers for the removal of the sewage proper, and to pump the sewage to purification works situated in the southeast corner of the grounds. Mr. W. S. MacHarg, Chief Engineer of Water Sewerage and Fire Protection, having had practical experience of the working of the Shone system in Chicago, recommended its employment for the removal of the sewage of the entire area.

Over the area of the grounds 26 ejector stations are located, the majority of them underneath the floors of the buildings, some underneath grass swards, and others underneath roadways. In each station two ejectors are placed, varying in capacity from 60 to 600 galls. each per minute, and having a united discharging capacity of 17,000,000 galls. per 24 hours. This is a larger plant than would be required for the removal of the sewage of any city in the United States, with probably ten exceptions.

Converging to these ejector stations are 3 miles of gravitation main sewers, the minimum grade adopted being 1 in 250. The vitrified sewer pipes are laid in 21-ft. lengths, and have extra deep sockets in order that water-tight joints may be ensured; inside the buildings the sewers are of iron.

The air-compressing plant for operating the ejectors was designed and built and is placed as an exhibit in the Machinery Hall by the Norwalk Iron Works Company, of South Norwalk, Conn. It consists of three compound air compressors, and one double compound air compressor, the principal dimensions of which are as follows:
Broughton on Shone Hydro-Pneumatic System. 673

One compound compressor... 26" 30" 24" 171
Two compound compressors... 22" 24" 20" 131

One double compound compressor, diameter of air cylinder, 16 ins.; length of stroke, 16 ins.; diameter of compressing cylinder, 91 ins.; diameter of high-pressure steam cylinder, 10 ins.; diameter of low-pressure steam cylinder, 16 in.

The distinctive features of these air compressors are that they have two air cylinders with cooling chamber between. A large air cylinder is employed to make the initial, and a small cylinder the final, compression. By such an arrangement a more nearly uniform resistance for the whole stroke is obtained.

The air is admitted to the large cylinder by valves of the Corliss steam-engine pattern, which have positive movement from the main shaft. The air is partially compressed in the large cylinder and forced thence into the small one through a chamber filled with copper pipes, through which cold water circulates. In the small cylinder the air is compressed to the extent desired. Both inlet and outlet valves can be taken out without removing a cylinder head. The piston rings can also be taken out without removing the piston from the cylinder. Both air cylinders are surrounded by water jackets.

The steam and air pistons and cross head are mounted on the same piston rod, so as to render the application of power uniform. Two fly-wheels are used, one on each side of the machines, and, by means of a swivel in the center of the cross-head, the work is made exactly equal upon both connecting rods. The steam cut-off is changed by turning a hand wheel at the back end of the valve chest.

The plant has a capacity of 4,537 cu. ft. of free air per minute. Leading from the central plant is a system of air pipes 5 miles in length, varying in diameter from 2 to 10 ins. The air pipe outside the buildings is ordinary cast-iron water pipe laid with lead joints, with an average depth of covering of 4 ft. Inside the buildings it is of wrought iron with screw joints. This pipe line was tested to withstand 90 lbs. pressure per square inch without any appreciable loss. From the ejectors to the purification works is a system of cast-iron sewage discharge pipes 4.8 miles in length, varying in diameter from 6 to 30 ins.

The maximum direct lift from the discharging level of the lowest ejectors to the top of the sewage receiving tanks is 67.62 ft.; and the total head to be pumped against when the maximum estimated amount of sewage is being discharged is 107.87 ft. The air in the air mains will be maintained at a pressure of 47 lbs. to the square inch, and supplied to each ejector station through reducing valves at the exact pressure required at each station.

The sewage receiving tanks, four in number, are constructed of steel plates riveted together. Each tank is 32 ft. in diameter and 55 ft. high, the bottom, 22 ft., being in the form of a cone. This design of tank was first used at Dortmund, Germany, by Herr Carl Kinzbuhrer.

After the sewage has received its precipitating agent, it flows through a large tube fixed vertically in the center of the tank to a depth of about 30 ft., where, by means of radial arms, it is distributed over the area of the tank and slowly rises to the top. The heavier matter settles gradually to the bottom of the tank as sludge, and in the process of doing so acts as a filter for the rising sewage. It is claimed that by means of this mechanical operation the chemicals are utilized to their full advantage. The effluent water overflows at the top of the tank and will be conveyed to Lake Michigan, while the sludge will be pressed into cakes and burnt. This form of tank takes up very little space. The tanks, mixing vats, engines, boilers and sludge presses are contained in a building 100 x 125 ft. For economical reasons it was deemed advisable to build the tanks above the surface of the ground.

The works are nearly completed and a section of them was put into operation during the Dedication Ceremonies in October last, for the convenience of an attendance estimated at two hundred thousand.

Two Shone plants each of 1,500,000 gallons capacity per diem, are in operation in Chicago. One is situated at Sixty-ninth and Halsted Streets, and is employed to lift the sewage from a low level into a high-level gravitation sewer, a vertical height of 15 ft. The ejector chamber is built underneath the surface of Halsted Street, and the air compressor located about 700 ft. away. This plant has been in continuous operation for two and one-half years.

The second plant has been in operation three years, is located underneath West Taylor Street, and is used for pumping water to the Chicago Sugar Refining Company. The inlet to the ejectors is connected with one of the Chicago city water tunnels, from which the water flows by gravity into the ejectors. The air compressor is located in the engine room of the Chicago Sugar Refining Company,
4,000 ft. away. A 6-in. air pipe and a 12-in. force main are laid along West Taylor Street from the refinery to the ejectors, and the water is delivered into a large tank on the premises of the Refinery Company. These ejectors are fitted with alternating air valves, which allow one ejector to fill while the other empties, so that a steady discharge takes place.

There is one more application of the Shone ejector to which the author desires to call attention, viz., for pumping sewage sludge. Owing to the nature of the inlet and discharge valves and the shape of ejector, this apparatus has been found to be a very successful and economical sludge pump. Ejectors are employed for pumping sewage sludge at four towns in England. In this country an ejector is employed to discharge the sludge from the purification tanks at the Asylum for the Insane, Rochester, Minn., and one will shortly be in operation for the same purpose at Worcester, Mass.

The proper ventilation of sewers is a matter requiring consideration. The almost universal custom which has hitherto prevailed is to trust to natural atmospheric influences which are variable and unreliable. Mr. Shone has recently introduced a novel system of ventilating sewers.

The exhaust air pipe from the ejectors is led to "a nozzle" placed in a chamber adjoining the ejector chamber. This nozzle chamber communicates with the atmosphere by means of an outlet shaft about 30 ft. in height in close proximity to it, and again by means of the gravitation sewers and an inlet shaft at their upper ends.

When the ejector is filled with sewage and compressed air has been admitted and has forced out the sewage, the exhaust valve is opened and the whole volume of compressed air rushes along the exhaust pipe and through the nozzle. The effect of this is to produce a current of air down the inlet shaft and through the sewer every time the ejector has completed its discharge of sewage. Any number of sewers may communicate with one nozzle, and they may vary in length. The volume of air admitted to each sewer is regulated by a cap on the inlet shaft, and by this means the large sewers are given their due proportion of air.

This method of ventilation is suitable for adoption where Shone ejectors are in use, and also for ordinary gravitation sewers, by supplying compressed air to the nozzle direct. It is in successful operation at Wallingford, England.