This sewer, unlike others, is not rendered inside, and on examining it at the close of the contract there were no leaks of any importance visible, those there were consisting of pin-holes in the mortar of the joints. The arch was, however, rendered on the outside with a cotton joint between the two arch rings.

Where clay occurred, the bottom was excavated to templates, and bricks were butted against the clay; in sand or other unstable ground, a foundation and sides of concrete were constructed, with a lining or single brick.

At the junction of Elizabeth Street a junction was constructed, and in turning the arch, which usually requires complicated centering, the contractor adopted a novel method. The side and head walls, as well as the tongue, were first built, and then clean sand was thrown in, well watered and consolidated. The sand surface was cambered to the soffit of the arch, templates of the different sections being used to ensure that the arch had the proper radius. The arch was turned, and head wall built up, and allowed to set for two days, the sand was removed, and a more perfectly turned arch it would be impossible to find. It was, certainly, a saving to the contractor, and no detriment to the stability of the work. It has shown no defects, and is in good condition to the present day.

This section was the second contract let in connection with the new system, and the manholes were designed on the system then in vogue — viz., with side ventilating chambers; but these have since been abandoned, and direct openings to the sewer made from the road.

Inlet House.—The southern sewer discharges into an inlet house, in which the sewage is screened before it passes into the syphon well. The building is constructed of concrete up to the floor line, with superstructure of red brick, with white brick facings; the roof is open principle, and covered with heavy galvanised iron.

There are two screening chambers controlled from the entrance chamber, with single-faced valves. In each screening chamber are three circular screens, attached to a main shaft, which is worked from gearing at one end. By turning the handle the whole of the screens revolve at the same time. The tines of the screens are spaced 3-inch, 2-inch, and 1-inch apart respectively. After passing through the screens, which intercept rags, paper, and other floating matter, the sewage passes under a head wall into the finer sludge basin, and over the crest of syphon well, from which it passes under the bed of Cook's River, and rises up in the outlet chamber on the south bank of the river. Thence it flows along the main carrier, from which it is distributed by offlets to the various beds on the farm. The screening chambers are worked in duplicate, and when one is active the other is being cleaned out and lime-washed.

The sludge is lifted by a grab, worked by a crab on an overhead traveller, and shot through scuppers in the side of the building into wrought-iron double-tip trucks, which are drawn by a small locomotive into the Farm, where it is used as manure.

Storm overflows are provided to prevent surcharging of the syphon, and also flushing valves, by means of which the syphon is flushed weekly to prevent the accumulation of silt. These works have quite fulfilled the object for which they were designed.

The foundations of both buildings had to be carried down to a solid bottom. In the case of the syphon wells the excavation was 46 feet deep.

An alteration has been made in the method of raising the sludge from the precipitating chambers. The original arrangement was by manual labour, which was found to be not only slow but expensive, and the introduction of a new type of oil-engine led to the idea of utilising this power in lieu thereof. Accordingly, a 2-h.p. "Capitaine" oil-engine has been attached to the existing crab, lifting a grab weighing 8 cwt, and the load of sludge weighing 7 cwt. The engine uses 3 gallons of kerosene in 17¾ hours of ordinary work, making the consumption a little over 1·3 pints per h.p. per hour. The cost of the engine cooling-tank and exhaust-chamber was £85, and attaching same to existing crab cost £60, or a total of £145. Since the engine enables the work to be done in one-fourth the time previously taken, and to dispense with the services of one of the men, there has been not only a clear saving of £80 per annum, but also in the services of the remaining men, which are now available for extra work when the engine is not running. The engine has been working since February, 1894, and has given every satisfaction.

Syphon.—The laying of the syphon in the bed of the river was the most difficult part of the work. It was originally intended to lay the pipes forming the syphon from a gantry constructed across the river by sections, dredging out the bottom and laying the pipes with divers; but, on the contract being let, the contractor submitted his scheme for carrying out the work, which, after adjustment as to rates, was approved. This consisted of constructing coffer-dams with bulkheads at the leading ends. When the timbering forming the coffer-dam was completed the water was pumped out, the joints caulked up, and excavation begun. As soon as the excavation reached a certain point the permanent timbers for piles to carry the pipes were driven, and the transoms fixed, the width being sufficient to admit of the pipe being surrounded with concrete. There was no particular difficulty in carrying out this work on the north side; the trouble began when operations were commenced on the south side. On this side there was a deep bank of fine mud and sewage, the accumulation of years. When the piles forming the coffer-dam were driven—and

in this case the sections were shorter—the silt was dredged out, and sinking through the firmer strata was commenced. The trouble consisted of several "blows" which took place during the time of spring tides, and were no doubt due to the coffer-dam piles not having been driven deep enough to resist the pressure at the bottom. The plan adopted by the contractor for the coffer-dam, viz., the driving of 12in. by 12in. piles close together, was not so effective as the ordinary method of guide piles and sheet piling, but the mishaps affected his pocket more than the permanent work, and gave the Author some experience of dealing with deep deposits of river mud when constructing coffer-dams. The late James M. Rendel was asked once at what angle of slope would the Thames mud lie? He replied that he did not know; but he did know that it would not lie *flat*, and this has been the experience with the Cook's River mud.

The syphon is composed of cast-iron flanged pipes, 3'.9" diameter The original joint was designed to be of V-section, with a soft copper ring, but on the advice of Sir John Fowler this was altered to a rebated joint with a ring of soft lead, and there is no doubt that experience in laying showed that this was the best plan. As the pipes were laid in a coffer-dam free from water, the best plan to adopt would have been ordinary spigot and socket joints, since in screwing up the different lengths of pipes there is every danger of fracturing the flanges, as actually occurred in one instance with the flanged joints. The lines and levels had to be accurately given and transferred to the bottom, the transoms being laid and adjusted to the correct grade. After the pipes were laid they were surrounded with bluestone concrete, and the temporary timbers withdrawn.

To test the syphon, water was obtained from the temporary supply scheme which crossed the main sewer at Gardiner's Road, and the test was made in the presence of the late Mr. W. C. Bennett, M. Inst., C.E., then Engineer-in-Chief. When the valves were opened the water passed through the syphon into the main carrier without a hitch, and has continued to do so ever since.

The completion of the syphon and main carrier connected the Southern District with the Sewage Farm, and made the system complete.

Sewage Farm.—The Sewage Farm is laid out on each side of the main carrier in irrigation beds and filtering tanks. The former are laid out in plots in terraces, and the feeders are so arranged that each plot can be watered separately. The irrigation area is used for cropping; and the crops of sorghum, cabbages, turnips, and lucerne have exceeded all expectations. The filtering tanks are used alternately, so as to admit of the soil, after water has passed off, becoming dry and aerated. Experience has shown that to overdose land with sewage makes it sour, and the resultant effluent is unsatisfactory.

Cow sheds, piggeries, etc., have been erected, and stock and pig raising farms are an important part of the work of the Sewage Farm.

It might be stated that the natural formation is raw drift sand, and the application of the sewage in a systematic manner has gradually changed the character of the soil of a portion of the farm to a light garden loam.

Lately it has been found necessary to underdrain some of the older beds, and considerable trouble has been experienced in obtaining proper material which will admit of water percolating into the pipe, and at same time keep back the extremely fine sand.

Various forms of pipe joints and pipe materials are being tried, and the result will be interesting in dealing with subsoil water under like conditions of soil.

On the Sewage Farm of Berlin, where the subsoil drains aggregate fully 100 miles, the major portion were found to be entirely choked with the sand which found its way into the pipes through the joints. The soil of the Berlin Sewage Farm is of a sandy nature.

The foregoing description comprises the northern and southern outfalls. There are numerous sub-mains and branches, but it would be beyond the limits of a paper to describe them in detail.

RETICULATING SEWERS.

Without reticulating sewers to collect the sewage from the houses, outfall sewers would be of little use.

Nearly the whole of suburbs connected with the two outfalls have now been reticulated. The sizes of the sewers are from 9 inches up to 24 inches in diameter.

The pipes are of stoneware, and are subjected to a crushing test in a machine specially made for the purpose; they are also tested for porosity. Taken on the whole, the class of pipes turned out by the Sydney makers is very creditable.

The leading points observed in carrying out the reticulating system are :—1st. Straight lines and even grades. Where a change of direction or grade is necessary a manhole is constructed, each manhole being so designed as to be used as a flushing station. Pipes must not be laid in their collar, but have a firm bed throughout the length of barrel. Where unstable ground is met with the pipes should be laid in a bed of concrete, which should be thoroughly set before the trench is filled in. It may in some instances be necessary to construct timber foundations in addition to the concrete. Where pipes are laid on a rock bottom there should be a bed of sand or poor mortar under the barrel. Junctions to manholes should be made with as long a sweep as possible, without interfering with the line of sight.

The lowest levels of yards or cellars should be ascertained before laying down the grades of sewers in sections. When passing alongside buildings with deep cuttings in unstable ground the timber should not be withdrawn, and the trench should be solidly filled in between timbers. In sand tunnels it is also advisable to leave timber in, as the withdrawing of same would endanger the lives of the workmen. No right-angle junctions should be allowed in the line of sewer.

The manholes are principally constructed of bluestone concrete, and are circular in form. Some of the shafts are from 20 to 30 feet deep. Where deep shafts occur the sewage from side branches is discharged into a vertical drop-pipe, provision being made for sighting and cleaning out when necessary. In moderate drops the pipe is carried straight through for sighting, but the sewage is discharged by a lower pipe at invert level.

Gas-checks were inserted in different sections in the first instance, but further experience and investigation led to their being abandoned, as they only interfered with the ventilation. By constructing a groove in the side of the channel and inserting a small board, each manhole can be turned into a flushing station.

The sizes of the different sewers are fixed according to the areas they have to drain. The limit in the northern system is 2 cubic feet per minute per acre, and on the southern it is 4 cubic feet per minute per acre.

Ventilation.—After the construction of the sewers the next work of importance is to adequately ventilate them. This question has occupied the minds of engineers for many years, and long and elaborate investigations have been made in connection with it. It has been laid down as an axiom with regard to sewer ventilation that the best results are obtained by motion for the sewage and air, since wherever sewage is ponded up decomposition sets in and gases are given off, and the same can be said with regard to air, so that the object to be aimed at in constructing a system of sewers is to ensure motion for both sewage and air.

The first visible attempt to ventilate the Sydney sewers was by the erection of the shaft or monument in Hyde Park, which was supposed to ventilate the old system discharging at Fort Macquarie – the first *visible* attempt, that is to say, because the main sewers were ventilated by every house drain connected with them. The rain water pipes were connected direct to the house drain ; and, since there was no intercepting trap between the house and the sewer, it is obvious that the air from the sewer would pass out by way of the down-pipes, or more often, through defective traps and fittings, inside the dwelling.

Whatever the object of erecting the Hyde Park shaft was, the intention of the engineer was frustrated by the ingenuity, if it may be termed such, of one of the workmen, as in one case the connection was solidly b ocked up with clay, and in another no connection existed.

In determining the system to be carried out in connection with the New System, careful examination and investigation of the open grids of the manholes then in use was made at all hours and conditions of weather, and the condition of what were known to be unventilated sewers tested and noted. The action of the wind, and its influence on the air-currents in the sewers, was tested on many occasions, and the result of such investigation led to the conclusion that the wind force was an important factor in sewer ventilation.

Formerly it was a generally accepted idea that the flow of air in a sewer was in a contrary direction to that of the sewage, but careful investigation showed that this held good only so long as the wind was in the same direction; a change of wind reversed the flow of the air-current.

It became very plain that in some of the narrow streets, where, on a hot summer's night, the occupants of the houses had to come to the front door for a breath of air, the open grids in the streets were not only a nuisance, but a positive danger.

Instead of using the manholes as downcast shafts, and shafts against the buildings as upcast shafts, it was considered the best plan to feed the sewer with fresh air from downcast shafts erected at some distance from the upcast. The initiation of this system led to the invention of numerous forms of cowls, and a visit to the Board's depôt at Crown Street will indicate the trend of some of the views of the patentees, which are, to say the least, original in conception, though worthless in practice. The best of the cowls were tested by the Board by an apparatus specially provided for the purpose, and the value of each was fixed in ratio of the wind power, either as an exhaust or an induct.

The system of ventilation adopted in connection with the Sydney Sewerage Works is what might be termed the plenum-vacuum.

A section of sewers in a suburb which was admitted by the Mayor to be very bad was operated upon first, and on opening some of the pipes to connect the ventilating pipes two of the men were affected by tonsilitis, and were taken to the hospital. After six months' trial the improved condition of the sewers was so marked that manholes could be opened without any bad smell being detected.

Since the inception of the work the form of cowl and manufacture of the shafts have been much improved. Advantage has been taken of making a connection with adjacent chimney-stacks, the proprietors willingly giving permission to do so, and in some cases the exhaust steam has been turned into a shaft, the steam acting as an ejector, and giving very good results in ventilating the sewer. In one case as much as 6,800 cubic feet of air per hour has been exhausted through a 6in. pipe.

With one of the factory shaft connections as much as 31,000 cubic feet of air has been exhausted from one of the old sewers; and, since this

quantity of fresh air must be supplied to take the place of the exhausted air, some idea may be formed of the amount of aeration this particular sewer receives.

Water-sprays have also been used as a means of ventilation. This system is only adopted where the usual method cannot be applied. Two cases may be quoted:—

	Exhaust—Cubic Feet per Hour.
Obelisk, Hyde Park	268,613
Toxteth Road (Glebe Point) Induct ...	33,762

The average work of an exhaust shaft in the Sydney District is 2,932 cubic feet per hour; induct shaft, 3,917 cubic feet per hour.

It has been contended by some authorities that the exhausting of so much sewer air into the atmosphere is detrimental to the public health, and the Board some time ago engaged a gentleman to make a bacteriological investigation into the air of the sewers, but the result of his labours did not throw much light on the subject. However, so far as could be learned from the Report, the air in the sewer, in the matter of pathogenic germs, is no worse than the atmosphere.

In 1892 Mr. P. Laws, F.I.C, on behalf of the London County Council, was moving in the same direction, and after exhaustive investigation he submitted his report, in which he gives his conclusions, viz.:—

"The positive results of these experiments are the following:—

1. The micro-organisms in the sewer air are related to the micro-organisms outside, and not the micro-organisms of the sewage.

2. In the air, both within and without the sewer, the forms of micro-organisms present are almost exclusively moulds and micrococci. On the contrary, the micro-organisms of sewage are for the most part bacilli. Of the latter, sometimes as many as 25% very rapidly liquefy the gelatine in which they grow; whereas, in the whole course of my experiments with fresh air and sewer air, I only met with one colony, and that a micrococcus, rapidly liquefying gelatine.

3. That, for the purpose of deodorising, manganate of soda and sulphuric acid and carbolic acid are the most efficient.

The whole of my results point unmistakably to the conclusion that the principal, if not the only, source of micro-organisms in sewer air is the air without the sewer, and not the sewage; and they also tend to prove that there is very little ground for supposing that the micro-organisms of sewage, *in the absence of violent splashing*, become disseminated in the sewer air."

Mr. Laws further stated that these observations only held good for sewers in which the conditions are the same as those under which the Author has experimented. What the condition of air would be in sewers in which there is only an intermittent flow of sewage, or in which the sewage becomes "stagnant or highly putrefactive," further experiments alone can show.

On such an authority as this, and others which could be quoted, it would appear evident that the idea of the ventilating shafts being detrimental to the public health is fallacious. While there is motion for water and air there is no stagnation ; where there is no stagnation putrefaction is not set up, consequently pathogenic germs will not exist.

It was the Author's intention to have touched upon the various points of house drainage and plumbing ; but since this Paper has somewhat exceeded due bounds, a consideration of this important subject, which has been aptly termed the crowning point of a sewerage system, must be deferred to a future occasion.

In conclusion the Author is conscious that there are many points which have not been touched upon, but he ventures to think that a visit to the works comprising the Sydney Sewerage will be of value and interest in connection with this important subject.