THE

PURIFICATION OF SEWAGE AND WATER BY MICROBES,

WITH A DESCRIPTION OF

Lowcock's Patent System of Filtration,

AS CARRIED OUT BY

The Sewage and Effluent-Water Filtration Co., Ltd.,

35, WATERLOO STREET, BIRMINGHAM.

WITH TWO PLATES.

BIRMINGHAM:
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1894.

THE SEWAGE AND EFFLUENT-WATER FILTRATION Co.'s

SYSTEM OF SEWAGE AND WATER PURIFICATION.

This system is the invention of Mr. Sidney R. Lowcock, A.M.I.C.E., F.R. Met. Soc., &c., Consulting Engineer to the Company, who has for many years been engaged in the Technology of Water Supply and Sewage and Water Purification, and has recently conducted a long series of experiments with the process, the results of which are embodied in a paper contributed by him to the Institution of Civil Engineers (Vol. cxv., 1893-4, part i.), a review of which will be found on pages 12 to 16.

Improvements effected.

The improvements effected by this process over all others consist essentially in assisting natural means of purification by highly efficient yet simple mechanical arrangements.

Description of System.

The following description will show the advantages of this system over all others for the treatment of sewage and effluent water.

Drinking Water.

The process is equally adapted for the purification of drinking water.

Removal of Organic Matter.

As is well known the ultimate object to be attained in the purification of sewage or water is the resolution of the organic impurities contained in them into harmless constituents. This is usually attained, with more or less success, in the treatment of water, by subsidence in large reservoirs and subsequent filtration through specially prepared filters, and in the treatment of sewage, by the precipitation, chemically or otherwise, of the solids, followed by the application of the remaining liquid to the surface of large areas of land (irrigation) or specially prepared filters.

Irrigation.

The treatment of sewage by irrigation alone is well known to be anything but a financial success or a desirable means of sewage disposal, and has serious difficulties attending it.

In many districts, moreover, it is practically impossible to obtain the necessary area of land suitable for the purpose, since not only is land of the requisite character very difficult to obtain under any conditions, but the expense is great, and there is always a most determined opposition to be fought from adjacent occupiers and owners, so that sanitarians and economists are in search of some method of working and obtaining the desired results in a way which will avoid the necessity of securing large areas in the vicinity of towns or villages.

Under the old systems, where specially constructed filters are used, it has been necessary, as it is with land, to provide a sufficient area to allow of the filters being used alternately. Intermittent Filtration.

The precipitation of practically the whole of the matters in suspension can be easily obtained by several well-known methods, but the purification of the remaining liquid from the organic matters in solution has hitherto proved the great difficulty, no practical chemical process being able to do more than *clarify* the sewage, and consequently the subsequent treatment on land or filters is compulsory. Clarification is not Purification.

Under favourable conditions the destruction of the matters in solution is then slowly effected by micro-organisms which exist in the sewage itself, and also in the body of the soil or filter. Action of Microbes.

To produce these conditions, time and a plentiful supply of air are the first necessities, as the complete decomposition of the organic matters can only be effected, without putrefaction and consequent stench, in the presence of an ample supply of oxygen, and it is for this reason that the areas of land or filters have had to be used intermittently to enable them to become aërated; consequently it is necessary to provide areas many times greater than would be the case if they could be worked continuously. Aëration.

Under Mr. Lowcock's system these difficulties disappear, as his Patent Filter is worked continuously and the necessary aëration is provided by artificial means, air being forced into a highly porous layer in the body of the Filter and evenly distributed throughout its whole mass, the liquid in course of filtration passing downwards and becoming thoroughly purified. Continuity of Action.

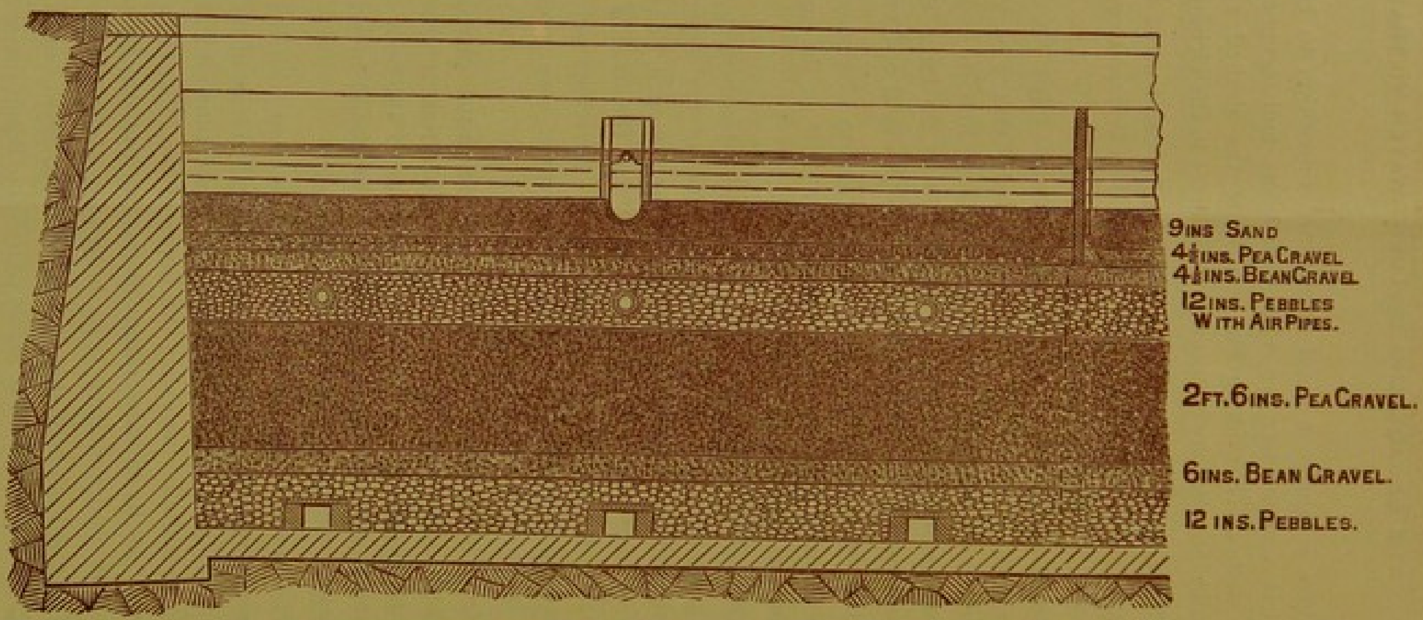
The result obtained by this system is that with the *same depth* of filter its area can be reduced from one third to one half at least of the area now required for the intermittent principle, and still give the same time for treatment to each particle of the liquid, while by increasing the depth of the Filter (which is unattended with any beneficial results in intermittent filters) the area can be still further reduced, and the results produced have been hitherto unapproached. Reduction of Area.

The application of this system to sludge drying beds overcomes the difficulty now experienced with the highly putrescible liquid draining from the sludge. Sludge Draining.

LOWCOCK'S PATENT FILTER.

SECTION OF ONE DIVISION OF FILTER BED

SCALE ¼ IN. TO A FOOT



Description of Filter.

The illustration on the opposite page shows the construction of the Filter.

The liquid to be filtered is run evenly over the surface by means of sunk channels, and passes downwards to the drains shown in the bottom layer of pebbles, whence it flows away in a purified condition.

In the upper layer of pebbles are imbedded perforated pipes, or pipes laid with open joints, by means of which air is forced into the Filter by a blower or other similar arrangement, and finds its way through the whole body of the Filter and out with the purified liquid through the drains, which have a free discharge. In its passage through the Filter the liquid is only allowed to percolate slowly down by the top layer of sand, after passing which it travels somewhat faster in thin films over the grains of the coarser material below, and thus presents an enormous surface to the purifying organisms and to the air contained in the interstitial spaces. The air pressure required is so slight that the requisite power and the cost is very small indeed: about $1\frac{1}{2}$ horse power being sufficient to supply the air necessary for the purification of a million gallons of sewage.

Cleaning Surface.

The surface of the Filter is divided up into small areas by divisions extending a short distance below the top layer of sand; the liquid to be filtered can thus be diverted at will from any one of these spaces by shutting down the sluices in the divisions, so as to allow of the surface of any section or sections being cleaned without interfering with the working of the lower part of the Filter.

Results obtained.

The following analyses by Mr. Alex. E. Tucker, F.I.C., F.C.S., show the extraordinary success attained with this Company's system when *crude* sewage was applied to the Filter :—

	Sewage.	Effluent from Filter.	
Free Ammonia	4·65	... ·04	Parts per 100,000.
Albumenoid Ammonia ...	2·40	... ·036	
Totals	7·05	·076	

Measure of Impurities.

These constituents may be taken as a measure of the relative impurities of the two liquids, and it will be seen that the impurities in the sewage have been reduced **99 per cent.**

Further analyses, made when the sewage was first precipitated in tanks, and the effluent from the tanks applied to the Filter, show :—

	Effluent applied to Filter.		Effluent from Filter.	
Free Ammonia	6·40	...	·008	Parts per 100,000.
Albumenoid Ammonia ...	·70	...	·022	
Totals ...	7·10	...	·030	

giving a reduction of more than **99½ per cent.**

These results were in each case obtained after the Filter had been working continuously for six weeks.

The advantages of this process are as follows:—

Advantages of Process.

1. The effluent produced is tasteless, colourless, and odourless, and is of a very high degree of purity, quite capable of maintaining fish life (chemical analysis showing it to be purer than the water of the majority of the streams and rivers in the country), **and absolutely non-putrescent, all putrescible matter being utterly destroyed.**
2. The Filter is extremely simple in construction and working, and is formed entirely of ordinary sand and gravel, or broken stone, and does not contain or depend upon any patented or special material.
3. It occupies very much less space than any other system ; only $\frac{1}{5}$ to $\frac{1}{8}$ of the area of intermittent filters where preliminary precipitation is in use, or $\frac{1}{20}$ to $\frac{1}{40}$ of the area of similar filters without preliminary precipitation, and only $\frac{1}{100}$ to $\frac{1}{200}$ of the area of land now necessary for broad irrigation, is required.
4. The initial cost and expense of working is extremely small, and very little attention is required, all that is necessary being the occasional cleaning of the top surface from suspended matters. The more efficient the preliminary precipitation, the less frequently this has to be done. Neglect in this respect does not impair the purity of the effluent, as in other

systems, for the more the surface becomes blocked the more slowly does the liquid pass through the Filter, and greater purification is the result.

5. The main body of the Filter requires no attention or renewal.

6. It can be added to any existing process where efficient precipitation is carried on, and existing intermittent filters can be easily converted and worked on this system.

7. The efficiency of porous soil now used or intended to be used for the treatment of sewage or effluent water can be largely increased, and the necessary area of land thus reduced.

8. The process can be used without preliminary precipitation of the sewage, but in this case the necessary area of Filters will be increased.

9. It is applicable for the purification of any putrescible effluent from manufactories, &c.

10. The process can be applied on any scale.

11. It creates no nuisance.

12. It is equally adapted for the purification of drinking water.

Comparison of Capital Cost.

The saving in space and expense effected by this system will be seen by the following comparison of estimated cost of the various leading systems of sewage disposal adapted for the treatment of the sewage of a town having a population of 100,000 persons.

System of Sewage Disposal.	Total Area Required.	Cost at £100 per Acre.	Cost of Preparation of Land or Filters.	Cost of Buildings, Tanks, &c.	Total Cost.
	Acres.	£	£	£	£
(*a*) Broad Irrigation	1,000	100,000	35,000	—	135,000
(*b*) Intermittent Filtration	200	20,000	80,000	—	100,000
(*c*) Chemical Treatment and Irrigation	290	29,000	28,600	17,500	74,700
(*d*) Chemical Treatment and Intermittent Filtration with specially prepared Filters ...	23	2,300	40,000	17,500	59,800
(*e*) **Sewage and Effluent Water Company's System**	**6**	**600**	**12,650**	**17,500**	**30,750**

In the last three cases the buildings, tanks, &c., are estimated to occupy three acres.

Annual Cost per head.

The average annual cost of working, taken from typical examples of the above systems, compares as follows:—

(*a*) 22d. per head, per annum.
(*b*) 22¼d. ,, ,,
(*c*) 20½d. ,, ,,
(*d*) 28d. ,, ,,
(e) 15d. ,, ,,

In making the above comparisons it must be noticed that not only is this process much cheaper, but the results are *vastly better* than those produced by any other. The results are, therefore, in this sense hardly comparable, as the last traces of impurity are those which are the most difficult to remove; *i.e.*, it is far easier to reduce the ammonias from 4·0 to 1·0 than from 1·0 to 0·25.

Co., Ld.

systems will be seen
leading systems of
f a town having a

Cost of Buildings, Lands, &c.	Total Cost.
£	£
—	135,000
—	100,000
7,500	74,700
7,500	59,800
7,500	80,750

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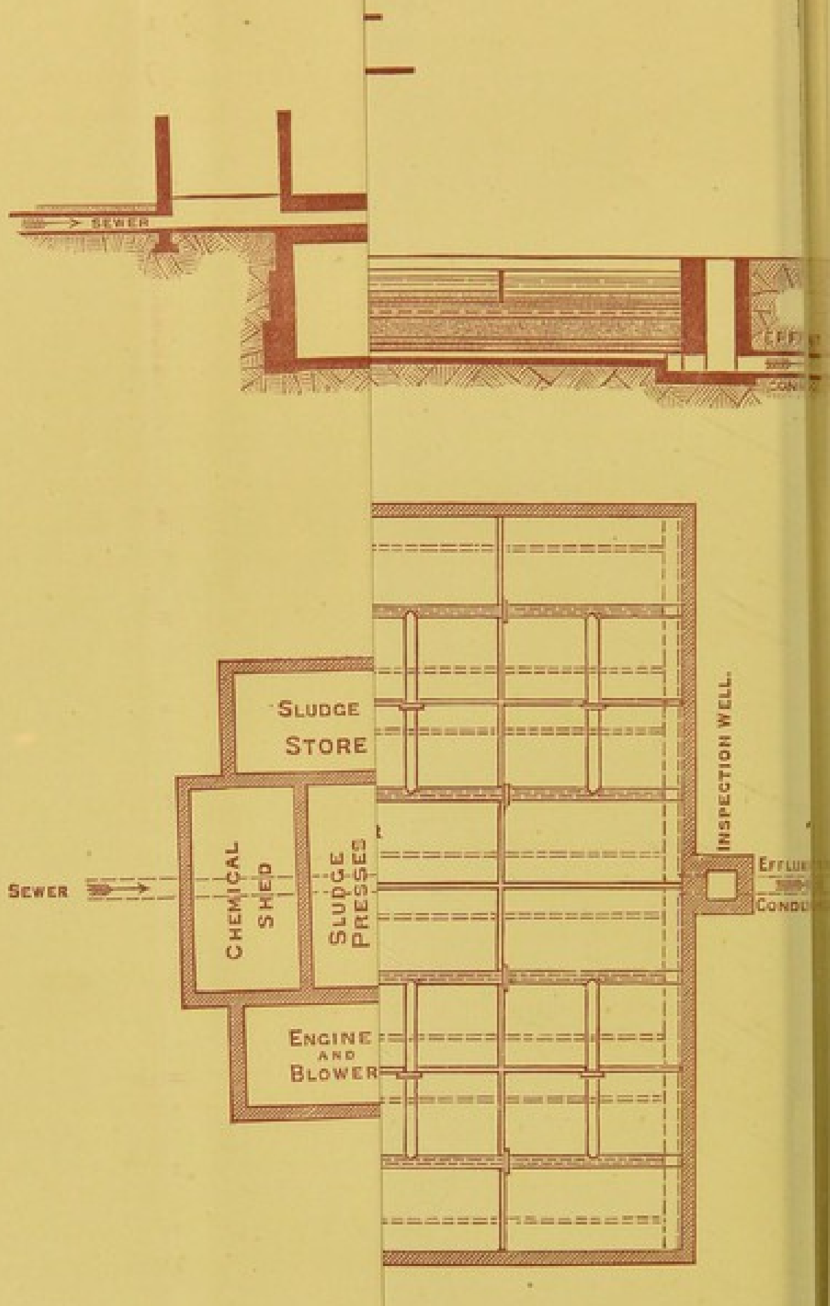

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DESCRIPTION OF

The accompanying
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The sewage enters
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In order that the system may be the more easily understood we have prepared plans, description, and estimates, which are based on the practical results hitherto obtained, for dealing with 100,000 gallons of sewage per day. They are approximate, however, as the arrangement and cost depend to some extent upon local conditions; but we shall be pleased in all cases, on receiving full particulars, to prepare special plans and estimates.

Description of Works for 100,000 Gallons of Sewage per day.

The accompanying plans show the Patent Filters in connection with the ordinary precipitation tanks, sludge well, &c., with suitable connections.

The sewage enters the works under the buildings, and on its way to the tanks receives the proper quantity of chemicals; it then passes into the tanks, these being used in rotation so as to allow the solid matters precipitated from the sewage in the form of sludge to be cleaned out into the sludge pit.

In passing through the tanks the matters in suspension are deposited, and the clear supernatant water flows on to the surface of the Filter through channels imbedded in the surface, and controlled by sluices in the end wall and partitions as shown.

These are so arranged that any of the divisions can be shut off for cleaning the surface without interfering with the others or with the action of the main body of the Filter.

The liquid passes downwards through the Filter and finds its way into the underdrains, which, with the air pipes, are shown by dotted lines on the plan, thence into the inspection well and so away by the effluent conduit in a thoroughly purified condition.

Air is supplied to the Filter by the air pipe shown, which communicates with branch pipes laid in the body of the Filter.

The blower for supplying the air is driven by the same engine that is used for mixing the chemicals and doing other work, consequently the cost of the additional power required is practically inappreciable.

Estimate of Cost.

The cost of the arrangement shown would be approximately as follows :—

CAPITAL COST.

Buildings, Tanks, &c.	£ s. d.	£ s. d.
Precipitating tanks, buildings, and sludge pit, with sluices, &c., complete	550 0 0	
Engine (if necessary) and chemical mixing machinery ...	150 0 0	
		700 0 0
Filters, &c.	£ s. d.	
Filter, filtering materials (sand and gravel), partitions, sluices, drain and air pipes, &c., complete	600 0 0	
Blower and connections to engine	15 0 0	
		615 0 0
Total		£1,315 0 0

ANNUAL COST OF WORKING.

Buildings, Tanks, &c.	£ s. d.	£ s. d.
Interest on capital, £700 at 5 per cent.	35 0 0	
Depreciation and repairs ...	10 0 0	
Labour—one man at 25s. per week	65 0 0	
Chemicals for precipitation ...	44 0 0	
Cost of working engine (if required)	50 0 0	
		204 0 0
Filters, &c.	£ s. d.	
Interest on capital, £615 at 5 per cent.	30 15 0	
Depreciation and repairs ...	5 0 0	
Labour (the same man who attends to the tanks, &c., also attends to the Filter) ...		
		35 15 0
Total		£239 15 0

The total annual cost is, therefore, £232 15s. od. where an engine is necessary, and £189 15s. od. where an engine is not required. Annual Cost.

These estimates are based on the assumption that no pumping of the sewage is necessary, and do not include dealing with the sludge, except in so far as they provide for a sludge pit and the removal of the sludge into it. Pumping Sewage.

The cost of larger or smaller works can be readily deduced from these figures, but in large works the cost per unit will be less than that shown. Larger or Smaller Works.

The whole area of the works as shown is only about one-third of an acre, and assuming the quantity of sewage at twenty-five gallons per head, the sewage from a population of 4,000 persons can be most satisfactorily dealt with on this small area. Area of Works.

The area of the Filter shown is arranged to allow of a rate of flow of 200 gallons per square yard per 24 hours, with two divisions shut off for cleaning. Area of Filters.

This rate of filtration gives a very high degree of purification. A smaller area and a higher rate may be adopted, but the standard of purification will thus be reduced. Rate of Filtration.

The estimates for the tanks and the Filter are kept separate in order that the cost of adding the Filter to existing works or to any other system of precipitating tanks may be easily seen. Existing Works.

Where the sewage has to be pumped, or sufficient fall exists for the erection of a turbine, a special engine for the chemical mixers and for driving the blower is unnecessary, and the working cost is much reduced. Cost of Driving Machinery.

The cost of dealing with the sludge will probably amount to about £48 per annum, so that the total cost will be, where engine power is necessary, 17¼d. per head per annum, and where no engine power is required 14¼d. per head per annum. When dealing with large quantities these amounts will be reduced to about 15d. and 12d. respectively. Sludge.

Plans and Estimates.

We shall be pleased in all cases, on receiving particulars, to prepare outline plans and estimates, and supply terms for the construction of works and use of our Patent Filtration System.

THE SEWAGE AND EFFLUENT-WATER FILTRATION CO., LTD.,
35, WATERLOO STREET,
1894. BIRMINGHAM.

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THE PURIFICATION OF SEWAGE BY MICROBES.

IN our last issue we published a paragraph dealing with a very ingenious and interesting attempt to increase the capacity of a sewage filter by supplying it mechanically with a large amount of air. The difficulty of filters, apart from liability to choke at the surface, is the considerable area required to deal with the refuse of a town. Those tried by the Massachusetts Board of Health dealt with quantities varying from 20,000 to 180,000 gallons per day, but the latter was exceptional. Probably 50,000 gallons may be taken as a fairly representative amount, and it must be remembered that the sewage experimented on was weak, as judged by English standards. Now if we assume thirty gallons per person as an average quantity, this would mean that a sewage plant for a town of 20,000 inhabitants must have a filter area of twelve acres, without any allowance for cleaning purposes and for reduced capacity during frost. What sanitarians are searching for is some method of working that will avoid the necessity of securing large areas of land near towns, since not only is the expense great, but there is always a most determined opposition to be fought from occupiers and owners. In many places it is now practically impossible to obtain suitable land for a sewage farm. If, however, the area could be reduced to one-tenth, or even to one-fifth, the case would be greatly altered for the better. Agricultural land would no longer be needed, and the place would have the characteristics of a works, rather than of a farm.

The experiments to which we refer were made by Mr. Sidney Richard Lowcock, at a sewage farm near Malvern, and the results were embodied in a paper he contributed to the Institution of Civil Engineers.* When we record that in some of his attempts he dealt with a flow of 484,000 gallons per acre per day, it will be seen how much promise there is attached to his researches. At this rate, a town of 20,000 inhabitants would only need 1¼ acres of filter, a piece of land that could be surrounded by a high wall, and, not being in sight, would escape the reputation of being the cause of every stink in the neighbourhood. We have not the space to detail the whole series of trials, and will restrict ourselves to the later ones, made after a considerable amount of experience had been gained. The sewage was not treated as received, but it was first conducted through a settling tank after having received a dose of lime. A great part of the solid matters was deposited in the tank, which was cleaned out once a month. Naturally, the constituents varied a good deal in the course of the month, the impurities becoming greater as the tank filled up.

The filter was 7ft. 6in. square by 4ft. deep inside, and was constructed of grooved and tongued wood. At the bottom was a 6in. layer of rough stone, broken to pass through a sieve of 1in. meshes; in this layer was placed a row of open-jointed drain pipes to conduct away the filtered sewage. Over the broken stone was a 3in. layer of stone broken to pass through ⅜in. meshes; over this came 10½in. of screenings from the broken stone, passed through a sieve having seventy meshes to the square inch. Next came a 6in. layer of the rough stone, as before, and in it the air pipe, which constituted the notable feature of the entire experiment. The pipe was ¾in. in diameter, closed at one end, and pierced along both sides with holes $\frac{1}{16}$in. in diameter, 6in. from centre to centre. At its outer end it was connected to a blower, giving an air pressure equal to 4in. or 5in. of water. Over the coarse broken stone came a 3in. layer of ⅜in. stone, and then 9in. of seventy mesh screenings. The top layer was formed of 3in. of building sand, the object being to regulate the flow in such a manner that the top layer of sand would become saturated, and only allow the liquid to pass from it over the coarser material below in thin films. The total depth of filtering material was thus 3ft. 1½in.

On February 8th, 1893, this filter was started with the effluent from the tanks, applied at the rate of 484,000 gallons per acre per day. Stated in this way the

* Proceedings Inst. C.E., vol. cxv., part i.

quantity seems very large, as indeed it is, for it is equal to 22in. depth over the area. The rate of flow through the filter, however, is moderate enough, being less than 1in. per hour. We will give the history of this filter in Mr. Lowcock's words:—

"For four days the liquid disappeared as soon as it reached the surface of the filter, but on February 12th it began to spread evenly over the surface, and on the 14th the quantity applied was reduced to 373,890 gallons per day, and on the 15th to 178,390 gallons. The surface of the filter then showed a film of deposit, but after working for four days at this rate it cleared itself to some extent, and the rate of flow was increased to 263,780 gallons per acre for the next four days. On February 22nd the surface was raked over, and the flow increased. The surface was also raked on March 3rd, 11th, and 18th. On March 21st, after the filter had been at work forty-one days, the surface appeared to be so dirty that the supply of tank effluent was stopped, and 1in. of the sand surface was skimmed off and replaced with fresh sand. On March 30th the surface was again raked over. After April 1st the experiments had to be stopped owing to the illness of the assistant who had charge of them."

Now let us see what the filter did during this period. It was at work during fifty-three days; on eighteen days the flow on to it was at the rate of 484,000 gallons per acre per day; on eight days it was at 373,000 gallons; on one day, 318,835 gallons; on eighteen days, 263,700 gallons; on four days, 178,390 gallons; on two days it was stopped. The average was 353,800 gallons per acre per day. The free ammonia and the albumenoid ammonia in the sewage flowing to the filter, and also in the effluent of the filter, are given in the annexed table. It will be

	Tank Effluent.		Filter Effluent.	
	Free Ammonia.	Albumenoid Ammonia.	Free Ammonia.	Albumenoid Ammonia.
1893.	Parts per 100,000	Parts per 100,000	Parts per 100,000	Parts per 100,000
February				
10	3·20	0·60		
11	...	...	1·80	0·12
17	4·00	0·32		
18	...	...	1·30	0·12
24	3·00	0·28		
28	...	...	0·80	0·06
March				
6	4·00	0·48		
7	...	...	0·80	0·04
17	6·40	0·70		
18	...	...	·008	0·022
24	6·40	0·72		
25	...	...	0·40	0·04
31	8·00	0·92		
April				
1	...	...	0·03	0·024

noticed that the treated sewage from the tank became steadily worse in quality, both varieties of ammonia rising steadily in quantity. Concurrently there was an immense improvement in the filter effluent. After three days these ammonias were reduced to one-half, and by the close of the experiments to 0·67 per cent. of those in the liquid applied to the filter. This was with a somewhat reduced quantity of liquid; but even about March 25th, when the full quantity of sewage was passing, the result was wonderfully good.

An average analysis of the Lawrence sewage, employed in the Massachusetts experiments, shows ·5302 part of albumenoid ammonia, and 1·8202 parts of free ammonia per 100,000, so that it was far less polluted in this respect than the sewage effluent employed by Mr. Lowcock, even at its best. Albumenoid ammonia represents the nitrogen in organic matter which has not yet begun to decompose by oxidation. It affords in itself no indication whether the source of nitrogen is animal or vegetable matter. It may exist in waters that are unpolluted by sewage; and is always abundant in water from swamps. Neither is high albumenoid ammonia, when accompanied by high free ammonia, necessarily indication of sewage pollution. Considerable sewage pollution of a body of water is, nevertheless, accompanied by high free and albumenoid ammonia. Free ammonia is always a decomposition product of organic matter; its significance in water analysis rests on the fact that it may be accompanied by organic matter in the process of decomposition, or that it may indicate the presence of sewage, of which free ammonia is one of the characteristic ingredients.

The twenty-fourth annual report of the State Board of Massachusetts is to hand, and enables us to compare Mr. Lowcock's results with the latest obtained in America. The rate of flow in the Lawrence filters varied from 21,000 gallons to 140,000 gallons per day per acre. We have not the space to go through the entire series, but will give a few examples. Tank No. 1 was 16ft. 8in. in diameter, with a depth of sand of 5ft. 3in. During 1892 sewage was passed through it at an average rate of 106,600 gallons per acre per day; the results varied a good deal, the free ammonia ranging from ·0399 to ·6587, and the albumenoid ammonia from ·0389 to ·1328 part per 100,000. In tank No. 2 the average flow was 21,000 gallons; the free ammonia ranged from ·0005 to 1·635, and the albumenoid ammonia from ·0083 to ·0572. In tank No. 3A the flow was 53,300 gallons; the free ammonia was from ·0099 to ·6000 part, and the albumenoid ammonia from ·0128 to ·0420 part per 100,000. The sewage supplied to tank No. 3A had previously had the greater part of its sludge removed by settling, but without the addition of lime, the resulting analysis being free ammonia 2·379 parts, and albumenoid ammonia ·4975 part. The gallons applied per acre per day were about 150,000; the effluent showed free ammonia varying from ·0024 part to 1·985, and albumenoid ammonia varying from ·0231 part to ·0845.

It is not necessary to pursue this subject farther at present; on another occasion we shall return to the volume before us, which is too important to be fully dealt with in relation to sewage only. We have, however, shown that Mr. Lowcock's Filter treated sewage far stronger than that found at Lawrence, and that it did so most efficiently. If the final analysis did not reach the lowest figures obtained in Massachusetts, it must be remembered that the experiments were stopped just as the filter was getting into splendid working order, and it is possible that if they had been continued the result might have even been still better. Still they show what an immense increase of power follows the introduction of air into a filter. It seems very possible that both the depth of the filter and the pressure of the air might be increased with advantage, still further reducing the area required. The chief difficulty at present lies in the choking of the surface by solids, mostly fats, deposited from the sewage. It was this that caused the great variations in the flow, and necessitated the frequent stirrings of the surface of the filter. The choking, however, is confined almost entirely to the surface, and is now being investigated in America. We trust that in this country also this most interesting and valuable subject will be followed up on the lines inaugurated by Mr. Lowcock.
