The Disposal of Sewage and City Refuse.

Thesis
by

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WEST CALDER
MIDLOTHIAN,
20th March, 1891.

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The Value of Sewage.

> Paris throws five millions a year into the sea. And this without metaphor. How, and in what manner? day and night. With what object? without any object. With what thought? without thinking of it. For what return? for nothing. By means of what organ? by means of its intestine. What is its intestine? its sewer. . . . . .
>
> We fit out convoys of ships, at great expense, to gather up at the South Pole, the droppings of petrels and penguins, and the incalculable element of wealth which we have under our own hand we send to the sea."
>
> Les Miserables. †

Value of Sewage.

This is a terrible indictment but it requires to be taken with a grain of salt. Had Victor Hugo been better acquainted with the Sewage Question he would have known that the theoretical and the market values of Sewage are two very different things, and that merchant-men are not so foolish as to send to the South Pole for what can be got equally as good at their own doors. A more sober and trust-worthy statement of the value of Sewage is that of Dr. Letheby, who says ※ "It is abundantly evident, indeed, that there is some other obstacle to the use of Sewage as a manure, than the "pig-headed reverence of the farmer for the practice of his forefathers" (Kaucet); for if Sewage had possessed but half the value which some loud talking people are ever proclaiming, it would long since have been the subject of successful

Dr. Letheby.

† From a very favourable account of the Paris Sewage Farm in the British med. Journal of 25. Aug. 1888, Victor Hugo's words seem to have been taken to heart.

※ The Sewage Question, Letheby, 1872.

speculation, and have formed the basis of many a flourishing joint-stock company." Again, "The great fallacy which is everywhere present in the theoretical estimate of the value of sewage is, that its constituents are supposed to be isolated in a solid and portable form, as is the case with guano, superphosphate, and ammoniacal manures.....
From such estimates as these, regardless of the worthless matter in sewage, the most extravagant notions have been entertained of its value, as that the sewage of this metropolis (London) is worth from one and a half to ten millions, sterling, annually."

Dr Tidy.

Dr. Letheby has pretty well pricked the bubble of "Gold in our filth", and although Dr. Tidy has estimated the value of the ammonia in urine passed by an average person per annum at 7/- and that in the faecal matter at 1/3, the difficulty is to practically make use of this ammonia.

Different writers on the subject have advocated different schemes for this purpose and one has only to glance at the lists of Patents for two or three years back to see and wonder at the variety of ways in which our filth may be converted into a veritable El Dorado.

Whatever the value of Sewage may be the question which Municipal Authorities have to face is how to get rid of it so that it shall neither be a nuisance to themselves nor their neighbours. To do that in the most economical way should be the next consideration, and without doubt it is

one which is hard to solve; nor can the solution be arrived at by any one plan or system, and the circumstances of each Town or Village must be considered on its own merits. There can be no hard and fast rule as to the Disposal of Sewage, and for a writer to advocate one system, and advise its adoption by every Local Authority is like the Quack with his nostrum to cure all diseases. It would require a deal of argument to convince a town like Glasgow, for instance, that it was necessary to adopt the Separate System of Drainage or that, if the Clyde was to be purified, the Dry method of Sewage removal was the only way to do it. One set of drains for the Sewage and another for the rain, may be the ideal, it is certainly that of some writers on the subject, but, supposing such an ideal to be reached, we have still the main question to face, What to do with the Sewage?

In the following pages I shall give a short account of the more notable of the efforts which have been proposed or tried to answer this question, contenting myself with describing them and quoting largely from the writings of men capable, by their experience, of giving an authoritative opinion on the subject. If I advocate one system more than another I shall do so without making my advocacy abortive by laying down as a sine qua non that this, that, or the other mode of removal must be adopted. A physician, when called to

a case of sickness, might as well tell the patient to obtain a new set of progenitors or alter the anatomy of his body, before he could prescribe.

Treatment of Sewage.

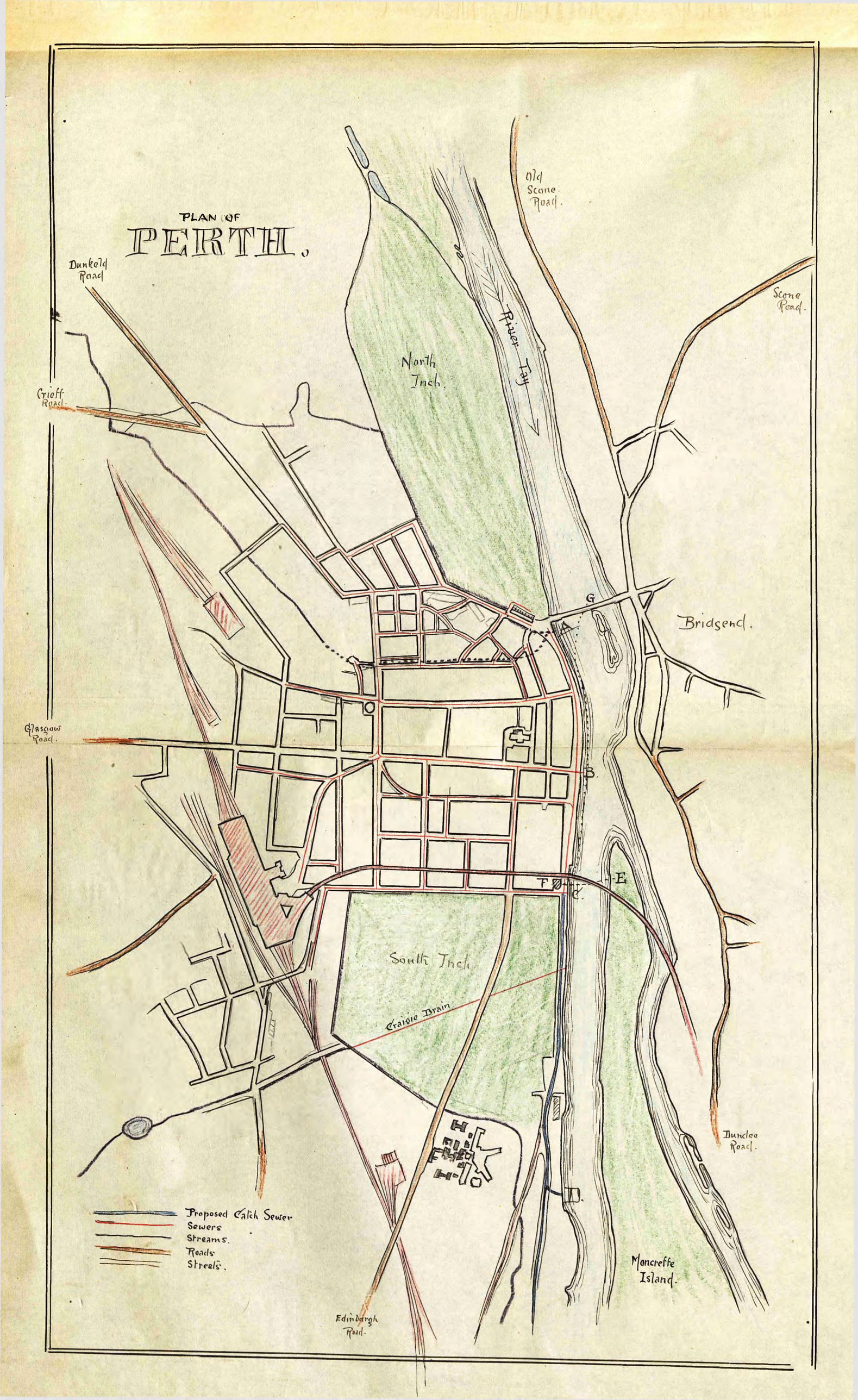
Three plans.

There are three outstanding ways in which Sewage may be treated, viz.- (1) Passing it directly into a large body of water, such as a river or the sea: (2) Application of the sewage to the land: and (3), Clarifying the sewage by chemical or electrical means.

Passing the Sewage into our Rivers and Streams. This is not a scientific proceeding by any means and yet it is largely practised at the present day. As notable examples of the nuisance which can be created in this way we have only to look at the Clyde and the Thames. These rivers have been rendered as unhealthy as they can well be, and the several authorities are being forced to adopt some means of preventing the continuance of the nuisance.

Perth.

As an example of a beautiful river, which is being gradually brought up to the perfection of abominableness of the Clyde, let us look for a little at the river Tay at Perth. On the accompanying plan, the Sewers are marked in Red: there are three Outlets at present, viz.- at A. B. and C. Besides the Sewage a large amount of refuse from the Dyers and manufacturers is also poured into the Tay, chiefly at Outlet A. The result is, that from the Perth Bridge, downwards, the river is seriously contaminated


PLAN OF
PERTH.
Old Scone Road.
Dunkeld Road
Scone Road.
River Tay
North Inch.
Crieff Road.
G
Bridgend.
Glasgow Road.
B.
F
E.
South Inch.
Craigie Brain
Dundee Road.
D.
Moncreffe Island.
Edinburgh Road.
Proposed Catch Sewer
Sewers
Streams.
Roads
Streets.

and, when it is pointed out that Perth is supplied with water filtered at E on the Moncrieffe Island, it is no wonder that there are frequent complaints about the quality of the water. Another filter is being laid down at G, but as the pipes, conveying the water from this filter, pass down to the pumping-engines at F, close to the right-bank of the river and directly under the worst of the sewage contaminated water, I fear that the last supply will be worse than the first, since there is a possibility of leakage into the pipes. If the proposed Catch-sewer, represented by the blue line, is carried out, this danger will be obviated. D shows the "proposed intermediate outlet", the "proposed ultimate outlet" being a little further down the river and not shown in plan.

To my mind, Perth, with the large Moncrieffe Island at its door, is admirably situated for the adoption of the Irrigation process of Sewage Utilization, but as that would mean the acquiring of the Island and the carrying of the Sewage by a Syphon Sewer to the Island there is little prospect of the Authorities entering into such a scheme.

Definition.

<u>Application of the Sewage to the Land.</u> This is carried out either by what is called "Irrigation" (and which Parkes defines as "The passage of sewer water over and through the soil, with the view of bringing it as soon as possible under the influence of growing plants") or "Intermittent Filtration". According to the Royal Commissioners

on Sewage Discharge: "Broad Irrigation means the distribution of Sewage over a large surface of ordinary agricultural ground, having in view a maximum growth of vegetation (consistently with due purification) for the amount of Sewage supplied.

Filtration means the concentration of the sewage, at short intervals on an area of specially chosen porous ground, as small as will absorb and cleanse it; not excluding vegetation, but making the produce of it of secondary importance. The intermittency of application is a sine qua non even in suitably constituted soils, wherever complete success is aimed at."

Broad Irrigation.

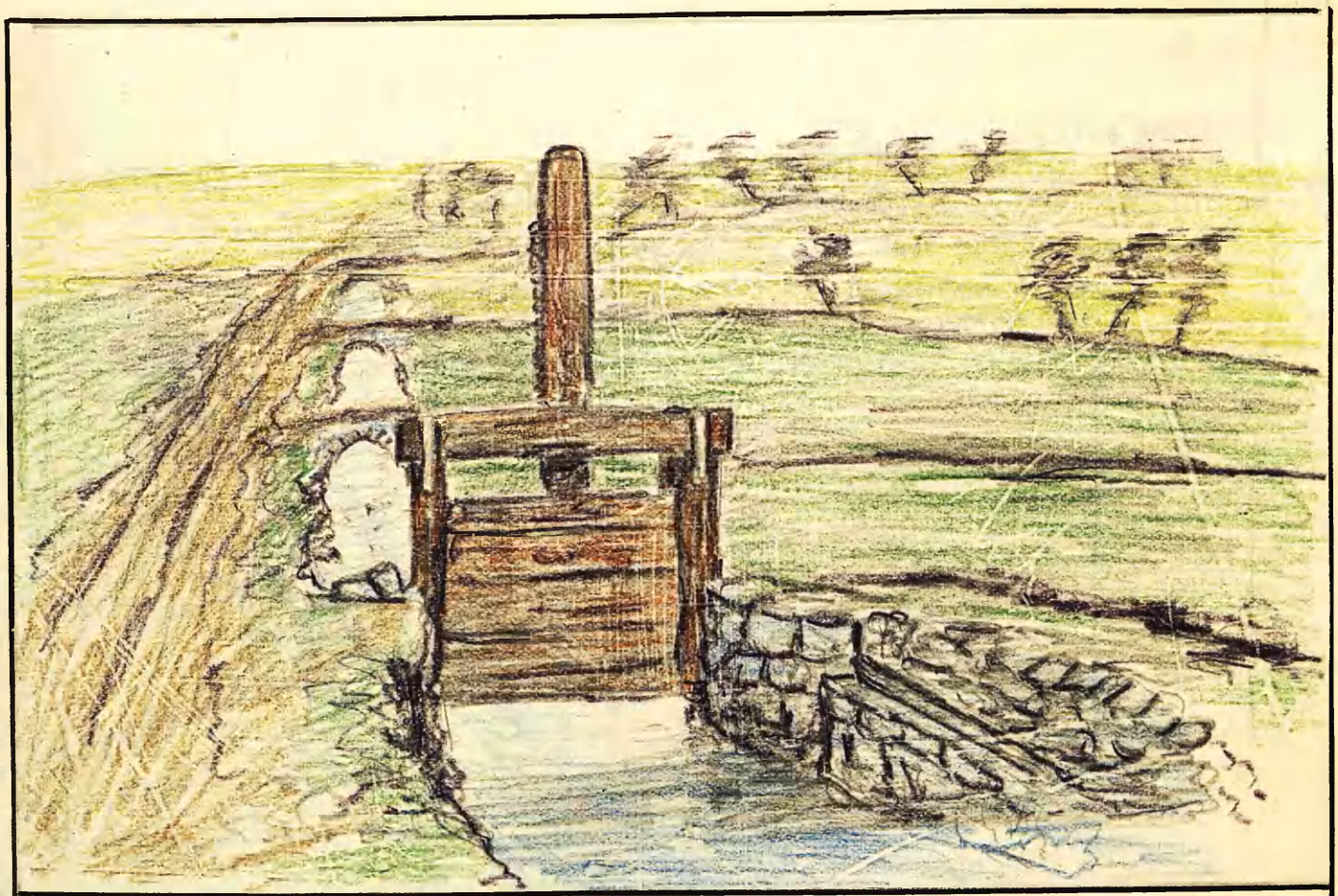
Broad Irrigation. Reporting on this subject the Royal Sewage Commissioners, in 1865, said "The right way to dispose of Town Sewage is to apply it continuously to land, and it is only by such application that the pollution of rivers can be avoided." The Committee appointed by the Local Government Board in 1875 concluded "That town sewage can best and most cheaply be disposed of and purified by the process of land irrigation for agricultural purposes, where local conditions are favourable to its application, but that the chemical value of sewage is greatly reduced to the farmer by the fact that it must be disposed of day by day throughout the entire year, and that its volume is generally greatest when it is of the least service to the land." "That land irrigation is not practicable in all cases: and, therefore, other modes of dealing with sewage must be allowed."

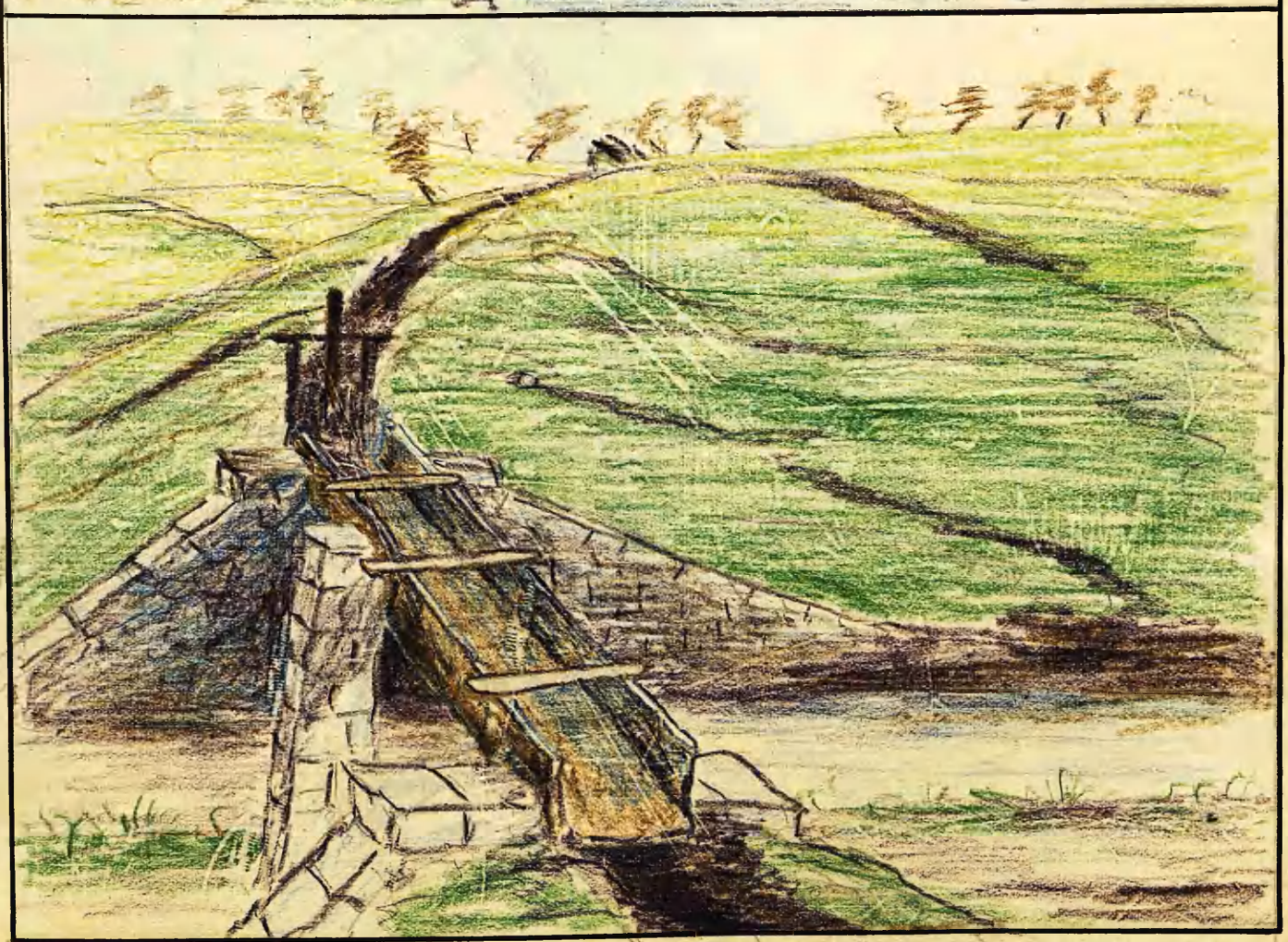
It is calculated that for every 100 persons, one acre of land is required, so that for a city like Glasgow, with a population of half a million, a farm of 5000 acres would be necessary. If possible, the sewage the sewage should pass to the Farm by gravitation, but it is seldom the farm is so favourably situated as to do without any pumping of the sewage. It is essential, to prevent the Farm becoming a nuisance, I should perhaps say a "glaring nuisance", as some experts hold it to be a nuisance in any case, that the sewage arrive at the Farm as fresh as possible. Otherwise, some means may be adopted to prevent the decomposition of the sewage, as at Carlisle, where Carbolic acid is added to it. As regards the laying out of the Farm, the kind of soil and the preparation of it, some one having practical experience of this work must be consulted, but as showing how these works may be carried out the following two pictures are instructive. I shall give the first place to the Craigentinny meadows, "the parent of Sewage Farming"

Dr Letheby

Craigentinny Meadows* "These meadows have long been notorious as the most filthy and offensive plots of cultivated ground in Great Britain.... ...They are situated about two miles to the East of Edinburgh, upon the sandy shore of the Frith of Forth, and they have an area of about 250 acres. The sewage is poured upon them from an open sewer called the "Foul Burn" which drains a district in Edinburgh with about 80,000 inhabitants

* Dr Letheby, "The Sewage Question"





PLAN SHOWING CRAIGENTINNY MEADOWS

and their position as regards EDINBURGH LEITH and PORTOBELLO.

LEITH.

Lochend Loch.

Lochend Ha.

Restalrig Ho.

Craigentinny Ho

Fillyside

Seaside Meadows.

RESTALRIG

CRAIGENTINNY.

South side Bank.

PORTOBELLO.

Figgate Burn.

EDINBURGH.

One Mile

where water closets are not in general use. The "Burn" runs eastward and northward from the City and passes through a small Sewage Farm of about 30 acres (the Lochend Farm), twenty of which are in Permanent Grass and the rest in Italian Rye Grass. The Tenant of this farm takes the Sewage when he likes and he also takes as much of it as he likes and the rest of it runs eastward, in the open "Burn" to the Craigentinny Meadows, and thence, if not wanted, to the Sea. As it passes thro' the meadows it is distributed upon them in the most profuse manner, rendering the Ground a swampy Sewage morass: in fact, the effluent water which runs off by many Channels, and trickles away to the Sea-shore, is as foul as it can well be. The smell from the open burn and the swampy meadow is so powerful that it is offensive to the whole neighbourhood, the Soldiers, at the neighbouring Cavalry Barracks at Piershill, complain of it as a serious nuisance and say that at times it is quite sickening.....

"The Soil of the meadows at the lower part is almost entirely sand reclaimed from the sea shore but at higher levels it is good arable land. A little of the higher land, (about 8 acres) is irrigated by means of a steam pump..... It will be evident from this that the Craigentinny meadows are not examples of what should be done with Sewage, but rather of what can be done with it, when all sanitary Considerations are out of the question and when, at the will of the Tenant, the sewage can be utilized or not. But how would it be if there was no neighbouring sea shore for the

reception of the sewage and the purification of it by proper irrigation were an imperative necessity-?"

This was written twenty-years ago but is true to a great extent at the present day. At the time of my visit the thermometer was at 34° F, the sewage was being run over the land, and the effluent was certainly an improvement on the sewage but not what could be passed into a moderately-sized River. Edinburgh is, however, particularly well-placed with the Forth, into which I understand the sewage is frequently passed without ever passing over the land at all. Walking through the Farm and meadows the smell made it distinctly evident that we were near sewage, and I should say that there is little fear of the ground near these meadows being fenced.

Dr. Littlejohn, speaking on this question of irrigation at the annual meeting of the British Medical Association in 1885, said .... "the old town (Edinburgh) had for the last two hundred years disposed of its slop water, and ultimately of its sewage, on a sandy waste, now well known to Sanitarians as the Craigentinny meadows. This sewage Farm was so well managed financially as frequently to have a revenue of £40 per acre, but at the same time was laid out in a most imperfect manner and in the hot months became a source of nuisance from the bad odours." Dr Littlejohn.

Beddington Irrigation Farm.* "The area of the Borough is 9,014 acres, about 6,314 acres in the South, Central and west parts of it drain to this Farm, with

* Sewage Disposal Work. W. Santo Crimp. 1890.

a population of about 73,000. The rateable value of property draining to this farm is about £410,000.

The 14,600 houses in this drainage area have, with very few exceptions, only water closets of which it is estimated there are about 20,000 .....

The whole of the Farm is the freehold of the Corporation and contains 525 statute acres, with four farm steads, the managers house, and 14 cottages. Four hundred and twenty acres are laid down for Broad irrigation ..... Irrigation upon part of the farm was begun in 1860 and has since been continuous. There was no underdrainage until ten years ago and now about 100 acres have drains, generally very wide apart, and from 4 to 9 feet deep, varying in diameter from 4 inches to 2 feet. Altho' these do not assist in cleansing the Sewage, yet they help to quicken the drainage of the land after the sewage is taken off it..... The system in use is that of surface or broad irrigation and as a rule the Sewage passes over three separate portions of the Farm. It is first passed on to one portion which is covered with it: from thence the sewage, partially purified, flows to a second portion of the Farm, and then to a third, from which it passes in a pure state. The time occupied in passing over the farm is about three hours. It is estimated that two out of every three gallons of sewage pass off the farm as pure effluent water, the other gallon being either evaporated or absorbed by the land and the growing crop."

Any reference to the question of Broad Irrigation would be incomplete without taking notice of the Address read by Dr. Alfred Carpenter at the Annual meeting of the British Medical Association in 1888, in which he meets most of

the Objections advanced against Sewage Farming and concludes in the following words.- "I earnestly recommend Sewage farming as applicable to all Water-Closet Towns without exception, and feel sure that it will be far more satisfactory for the kingdom at large when it is so utilized than for it to be sent into the Thames, the Mersey, or the Clyde, to the gradual destruction of our water-ways and the removal from our midst of that which will give sinew, muscle, bone, and marrow to a people languishing for such material, and in consequence of its scarcity at home at this moment we have to import the material required for its production from the other side of the Globe." Dr Carpenter.

Intermittent Filtration. In carrying out this process of sewage treatment there are, according to Mr. Dyke ※ two or three points which must be carefully attended to." There should be (1) a porous soil: (2) an effluent drain, not less than six feet from the surface: (3) proper fall of land to allow the sewage to spread over the whole land; and (4) division of filtering area into four parts, each part to receive sewage for six hours and to have an interval of eighteen hours." Mr Dyke.

At Merthyr-Tydvil where intermittent filtration is in operation "The sewage is first treated with lime and is strained in special tanks through cinders: it then flows on to the conduit which conveys it to the filtering areas these last being arranged on a plan devised by Mr Bailey Denton. The land is a loamy soil, eighteen inches thick overlaying a bed of gravel. The whole area Merthyr-Tydvil.

※ On the Downward Intermittent Filtration of Sewage at Merthyr-Tydvil. T. D. Dyke, F.R.C.S. Eng.

is underdrained to a depth of from five to seven feet. Lateral drains, placed at regular distances the one from the other, run towards the main or effluent drain, which drain is everywhere six feet deep.

The surface of the land has been formed into beds: these slope towards the main drain with a fall of 1:150. The surface is ploughed into ridges: on these vegetables are planted or seeds sown: the line of the ridged furrow is in the direction of the underdrain. Along the raised margin of each bed, in each area, delivering carriers are placed, one edge being slightly depressed. The strained sewage passes from the conduits into the delivering carriers and as it overflows the depressed edges runs gently into and along the furrows down to the lowest and most distant part of the plot. The sewage continues to be so delivered for six hours: then an interval of rest for eighteen hours takes place and again the land is thoroughly charged with the fertilizing stream. The water percolates through the six feet of earth and reaches the lateral drains which convey it to the main effluent drain (A. Wynter Blyth.) The same writer says "Intermittent irrigation is now carried on largely both at home and abroad with the most satisfactory results as regards purity of effluent."....

Notwithstanding the above it is doubtful if a soil can go on day after day receiving large quantities of sewage without after a time, which will be longer or shorter according to the soil, at last failing to act as a filter. The following is somewhat plain speaking on the subject * However carefully

* The Treatment of Sewage. Arthur Jurley. 1890.

this system is worked, however rigidly the system of intermittent-dosing is carried out, however favourable the conditions may be, earth filters must in course of time cease to satisfactorily purify sewage. This system could not efficiently deal with sewage after a wet season or during a severe frost."

At Forfar and Kirkintilloch I understand intermittent filtration is the plan adopted to purify the sewage and certainly the subjoined analysis speaks highly in favour of the process.—

Forfar Sewage Disposal ※

Analysis of samples of water from Forfar Sewage Works, taken July 1888.

		Natural Sewage.	Sewage after passing through area
Solids dissolved	Grains per gallon	37.5	36.5
Chlorine	" "	5.2	3.7
Free Ammonia	Parts per million	69.0	0.12
Alb. "	" "	2.5	0.78
Suspended matter	Organic, grs per gall.	21.0	0.00
	Inorganic " "	23.5	0.00
Nitrate	Nitrate of Soda (grs. per gallon)	0.00	9.6

※ W. Santo Crimp. Op. cit.

Chemical Processes.

Day after day patents are taken out for dealing chemically with Sewage, many of them evidently by men who have no practical acquaintance with the subject and who do not seem to realize the body of Sewage water which has to be dealt with.

The following are some of the "substances proposed to be used for the disinfection and utilisation of sewage and cesspool matters" (Letheby).-

Name of substance.	Inventor.	Date.
Acetate of Lead and protosulphate of Iron.	Deborissieu	1762
Chlorine.	Hallé	1785
Quicklime.	Esteinne	1802
Powdered Charcoal	Guiard	1805
Ashes	Chaumette	1815
Sand	Duprat	1818.
Sulphate of Iron.	Briant	1824.
Waste Chloride of manganese.	Payen and Chevalier.	1825.
Animal Charcoal.	Frigerio.	1829.
Sulphate of Iron and Zinc with lime and tar.	Suret	1837.
Impure alum.	"	1843.
Nitrate of Lead.	Ledoyen.	1847
Spent lime, carbonised.	Darling.	1850.
Soft sludge from alum works with lime and charcoal.	Manning.	1854.
Manganates and permanganates.	Condy	1857.
Superphosphate of lime with magnesia and lime.	Blyth.	1858

The conclusions of the Committee appointed by the Local Government Board in 1875 were, as regards the use of chemicals, "As far as we have been able to ascertain, none of the existing modes of treating town sewage by deposition and by chemicals in tanks appear to effect much change beyond the separation of the solids and the clarification of the liquid. That the treatment of sewage in this manner, however, effects a considerable improvement and when carried to its greatest perfection may in some cases be accepted."

The Committee appointed by the Corporation of Glasgow, in 1880, reported on this subject, as follows:-
"Probably the only proposition of universal acceptance is that crude sewage cannot be disposed of anywhere, by any means without nuisance or risk of nuisance."
"There are processes of precipitation now in operation which give an effluent capable of being discharged into a river with perfect inoffensiveness and without sensibly destroying its purity - provided always that the volume of sewage is small compared with that of the river." "Whatever be the process of chemical purification to which the sewage is subjected the effluent is still impure and will putrefy and give off noxious gases if kept for some time; and we know of no way in which the purification can be completed but oxidation. Filtration through cultivated land - viz. - Irrigation - is probably the best means. But oxidation of the effluent may in most cases be effected by the simple and natural process of running it into the nearest water course when, if the proportion of clean water be sufficient, the organic matter will be gradually oxidised and the effluent water

will not become putrid or offensive in any way, even in warm weather."

Various Processes. The following are the principal chemical processes in use.—

Lime Salts. Quicklime is the precipitant in most common use, the dose, recommended by Dr Tidy,* being "not less than 10 grains per gallon to a sewage that does not exceed 30 gallons per head." The following description of the process as carried out at Birmingham will best convey an idea how it is worked.—

Birmingham. "† The Mixing Shed is a large square building divided into three sections on the ground floor, and having a second floor over the central section. The engines, of the portable type, are placed in one section; in another are a pair of pumps which raise sewage to the floor above for the lime mixers, which consist of a pair of large-edge runner mortar mills with specially constructed high sides. The lime shed or third section is a large room into the ends of which the lime is deposited and slaked, each end of the building being cleared on alternate days. The slaked lime is fed into an elevator consisting of an endless chain and buckets, by which means it is conveyed to the mortar mills and converted into milk of lime.

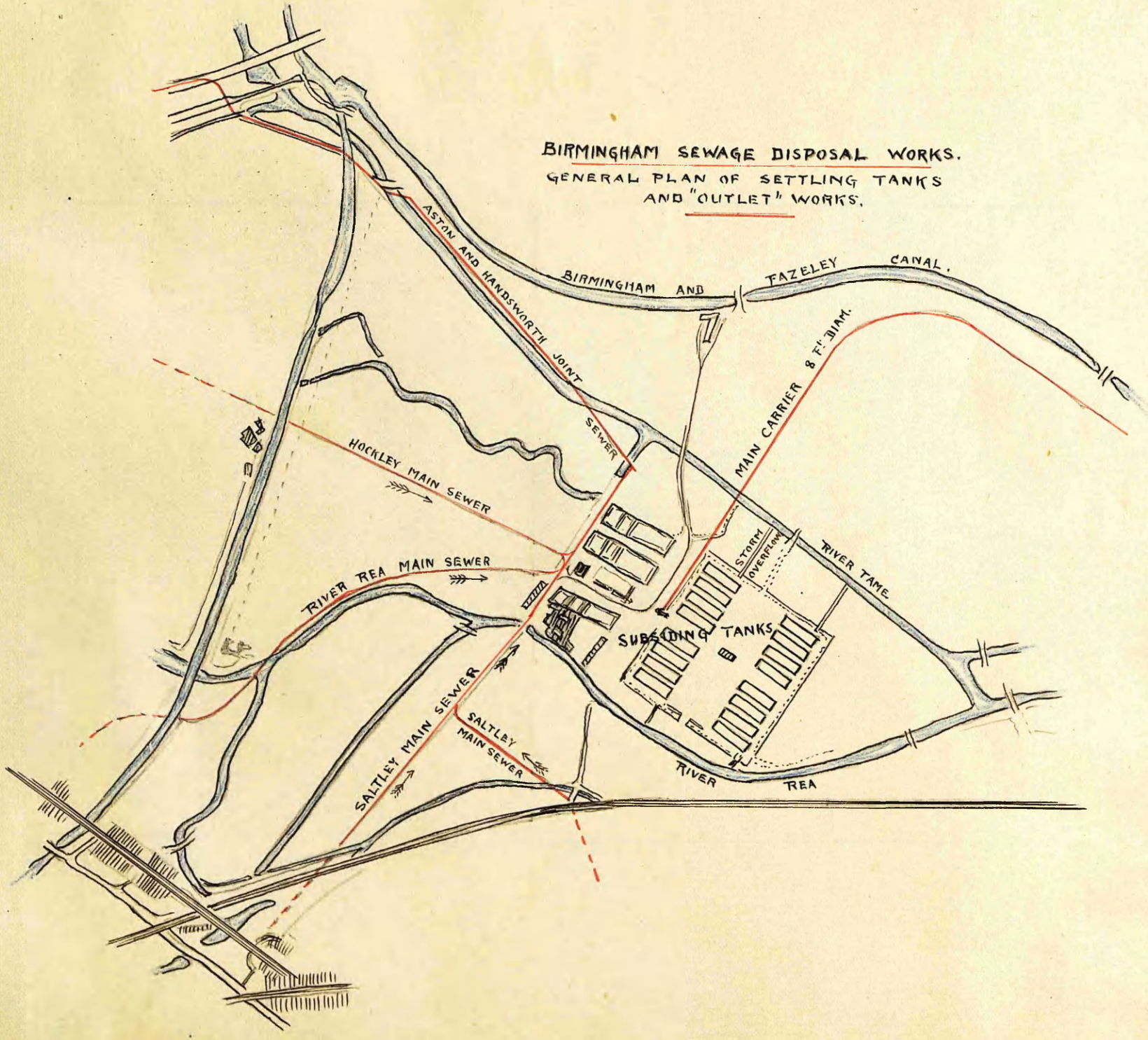
"Long troughs supported upon trestles convey the milk of lime to the outfall sewers in which it is well mixed with the sewage as the latter flows towards the settling tanks.

"The arrangements for dealing with the sludge are simple almost to crudeness. After being elevated to a sufficient height to command the most distant part of the farm used for sludge disposal, the sludge is conveyed to the site where it is intended to trench it in, by means of a long wooden trough made up in sections, twenty-two feet in length

* Journal Society of Arts, 1886.
† W. Santo Crimp. Op. cit.

BIRMINGHAM SEWAGE DISPOSAL WORKS.

GENERAL PLAN OF SETTLING TANKS AND "OUTLET" WORKS.



and supported upon scaffold poles. Each section of the trough is formed of two boards, one and a quarter inches in thickness and eleven inches in width, bolted together for the bottom, then one board of like dimensions is spiked on each side; small pieces of board are then nailed on the outside of the trough at one end and each section looks like half of a rectangular socketted pipe.

"The sections are readily taken down when it is desired to convey the sludge to a fresh field being merely dropped into their places on the supports, the joint being made by the sludge itself.

"The accumulation of sludge on the land is not large, the work of trenching is being carried on continuously as the sludge becomes partly solidified."

Dr Tidy.

Lime and Chloride of Lime. * Dr. Tidy, speaking of this process says "... my experience enables me to speak favourably of the employment of Chloride of Lime with lime, especially in hot weather. About 56 pounds (lbs) per million gallons of sewage will be found, as a rule, fully sufficient for a sewage represented by 30 gallons per head of the population."

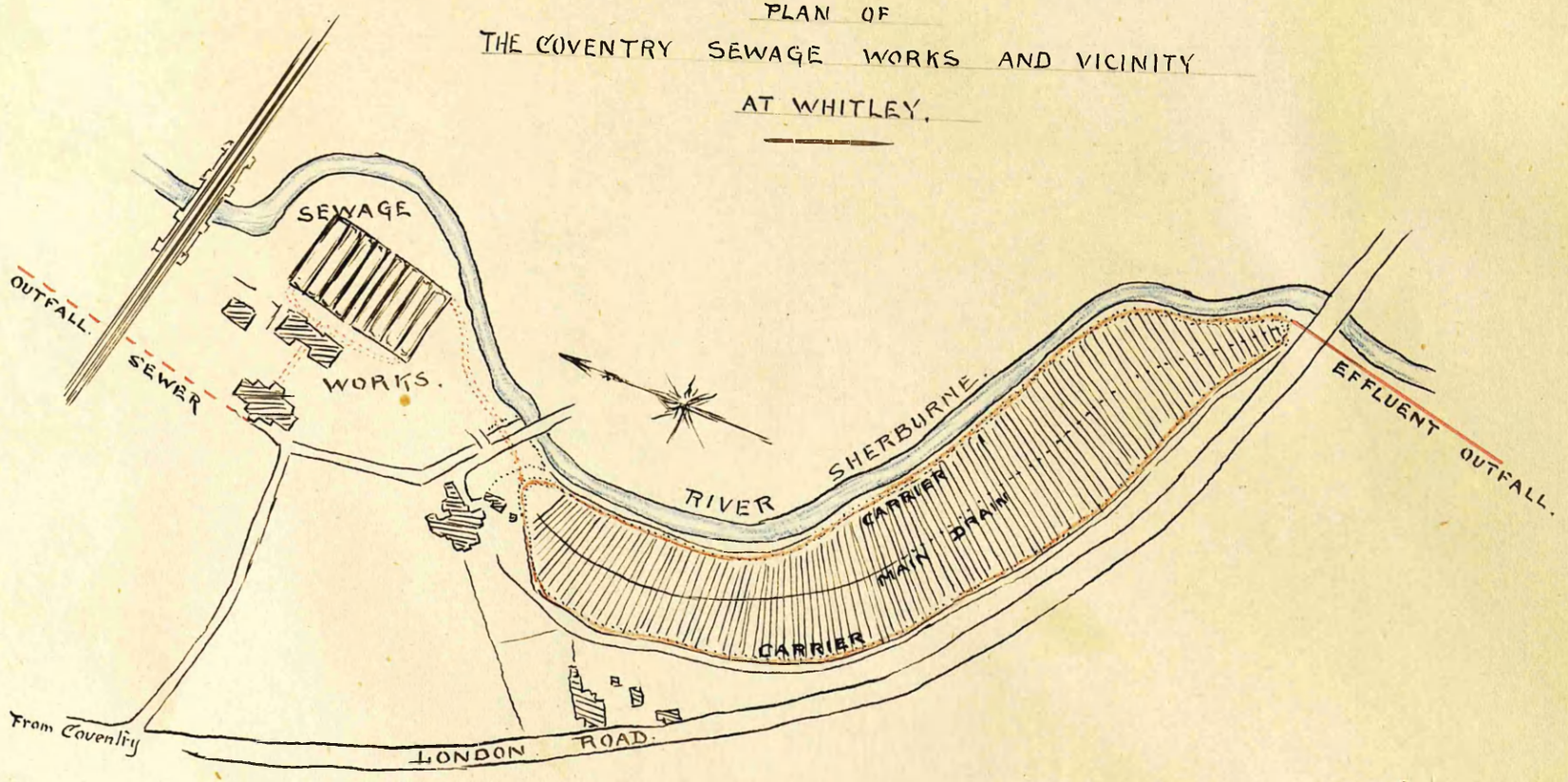
Lime and Sulphate of Alumina. † "A portion of the lime will be at once converted into Carbonate of Lime by combining with the carbonic acid present in the sewage and serve as a weighting material to aid in the deposition of the lighter flocculent materials. This mechanical action of the lime carbonate is of great importance. The flocculent suspended matter is no doubt one of the most important materials to remove because it is this ingredient of the sewage which readily putrefies and in this way causes a nuisance.

"It is moreover so light that unless weighted it is difficult to precipitate. A second portion of the lime combines with some of the organic matter in

* Journal Society of Arts 1885.

† Report to Local Government Board, 1882 Dr Angus Smith.

PLAN OF THE COVENTRY SEWAGE WORKS AND VICINITY AT WHITLEY.



solution producing an insoluble precipitate (of uncertain composition) of a compound of lime and organic matter the subsidence of which is again assisted by the formation of the carbonate of lime previously described.

A third portion of the lime renders the sewage faintly alkaline.

" The alumina salt is now to be added, the alumina is precipitated owing to the alkalinity effected by the slight excess of lime. This alumina combines with some of the organic matter in solution not precipitated by the action of the lime."

Mr Forbes F.R.S.
Dr Price.

Lime and Phosphoric Acid. The patentees, Mr Forbes, F.R.S and Dr Price, say " Whilst the sewage is contained in a cistern or reservoir or whilst it is in the act of flowing thereinto, the requisite amount of the soluble phosphates of alumina is to be added thereto and after thorough admixture with the sewage by the use of agitators or other well known means, the sewage so treated may be allowed to remain tranquil in the reservoir in order that subsidence of the resulting precipitate may be effected, or after having added to the sewage the requisite amount of the soluble phosphate of alumina lime (by preference in the form of milk of lime) is to be added in such quantity as that the phosphates in solution shall be precipitated.

" This result will be known by the sewage acquiring a neutral or alkaline reaction, or the lime may be firstly added and the solution of the phosphates of alumina added subsequently, but we prefer the former process; or the soluble phosphates of alumina may be firstly decomposed by means of the lime or carbonate of lime and the resulting precipitate may be employed for the purpose of effecting the separation of certain constituents of sewage."

Lime and Protosulphate of Iron. From the (1887) Report of the Metropolitan Board of Works it appears that chemical precipitation could be satisfactorily effected by this process, but "the clarification of the sewage would not be sufficient to insure complete immunity from smell arising from secondary fermentation and fresh development of offensive gases in hot weather."

Lime and Black Ash Waste. *"In this process the black ash waste produced in great abundance at alkali works is prepared by Mr. Hanson and used in conjunction with lime. "When tried at Wimbledon the results were not encouraging as the sludge was greatly increased in quantity, whilst the effluent was not appreciably affected."

A.B.C. process of Mr. Sillars consisted originally in adding a mixture of Alum, Blood, Charcoal, and Clay to the sewage but now the blood is not found necessary. At Kingston-on-Thames this mode of dealing with sewage has lately been introduced. The annexed plan shows the arrangement of the works. "All the sewage is pumped into the channel - 13 on the block plan - where it immediately receives its dose of B.C. mixture and is quite deodourised; the solution of alum is then added and the treated sewage is conveyed to the settling tanks which are eight in number, in two sets of four. The tanks are each 85 feet long and 49 feet broad and are partially divided in the middle, longitudinally, by a wall about three quarters the distance of the entire length: ..... the compressed

Kingston-on-Thames.

* W. Santo Crimp. Op. cit. p. 78.

cakes of sludge are dried, put into a disintegrator and broken down into a fine manure which is put into sacks and sold at £3 per ton to farmers and gardeners, under the name of native guano.*

In General Scott's process lime and clay are added to the sewage and the resulting sludge is burnt and made into cement.

Dr Bird's process consists in treating the sewage with a crude Sulphate of Alumina and iron obtained by adding Sulphuric acid to clay.

The Amines process. In this process milk of lime and herring brine are added to the sewage, the claim of the inventor, Herr Wollheim, being that it not only clarifies the sewage but renders the effluent sterile. † "Dr Klein has examined (by inoculation on nutrient gelatine) both the sludge and the effluent. In the former he reports finding fewer organisms than are found in filtered river water supplied by the London Companies, and in the latter absolutely no organisms at all. And further that when the effluent is diluted with water containing organisms actual decrease in the number takes place rather than increase."

Herr Wollheim.

Dr Klein.

The International process. According to the International Water and Sewage Purification Coy, Ltd. this consists of:-

"(1) The precipitation and deodourization of sewage by means of a magnetic precipitant and deodourant called "Ferozone" which is produced from "Polarite" by a Chemical process.

(2) The removal of the organic matter in Solution and the aeration of the tank effluent by

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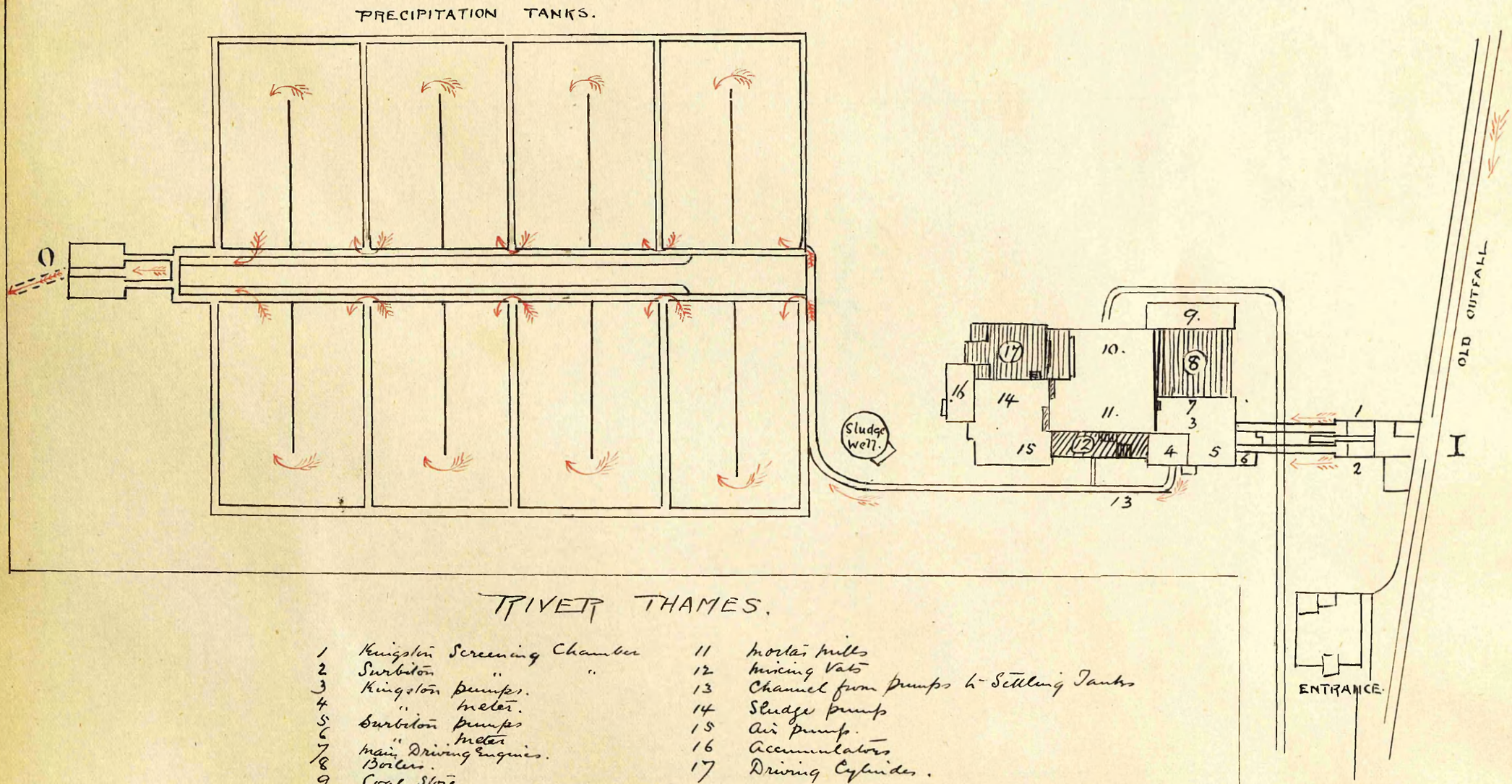
* W. Santo Crimp. Op. Cit. p. 171.

† Lancet 21. Sep. 1889.



1 Kingston Screening Chamber
2 Surbiton " "
3 Kingston pumps.
4 " meter.
5 Surbiton pumps
6 " meter
7 main Driving Engines.
8 Boilers.
9 Coal Store.
10 Chemicals
11 mortar mills
12 mixing Vats
13 Channel from pumps to Settling Tanks
14 Sludge pump
15 Air pump.
16 Accumulators
17 Driving Cylinders.

I. Inlet
O. Outlet to Thames.

KINGSTON SEWAGE DISPOSAL WORKS.

passing it through a specially constructed filter-bed containing "Polarite".

Sir Henry E. Roscoe.

Sir Henry E. Roscoe, reporting on this process, says "I visited the works at Acton on Monday July the 9th 1888, and found that the sewage ran along a channel into which was flowing a solution of your precipitant Ferozone.

"This mixture flows with the raw sewage into a large precipitating tank of 138,000 gallons capacity. Of these there are three side by side. Subsidence is allowed to take place for a period of from one to three hours after which the top liquid is run off from the surface, by means of a "floating arm", direct on to the filter bed which is made up of sand as a top layer, then a layer of your preparation known as "Polarite", the bottom being made up of coarse gravel.

"I found the resulting filtered effluent to be bright-clear and colourless and free from any objectionable smell".

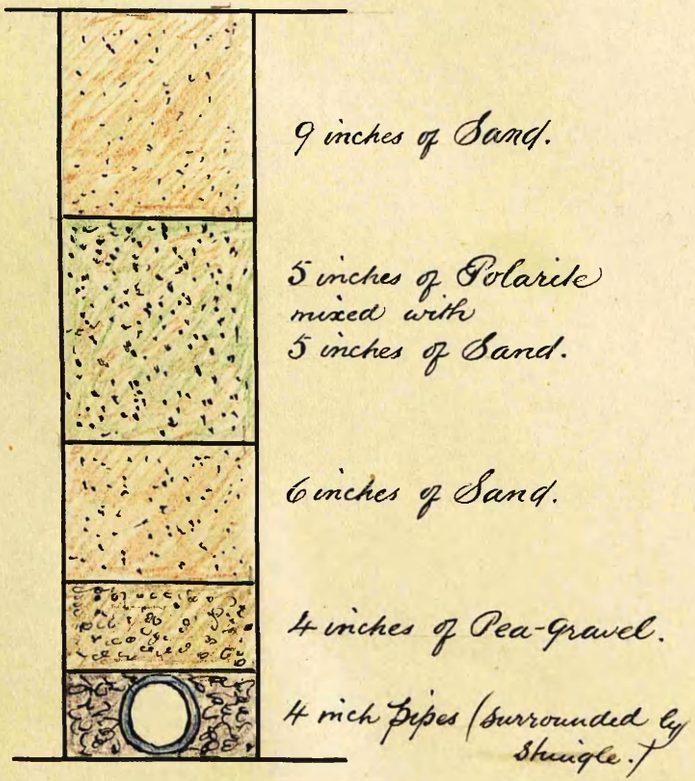
Mr. Arthur Angell.

Mr. Arthur Angell says, in a paper read before the Society of Mining and metallurgical Industries (1888) "The filter beds at Acton Sewage works have been doing daily service for a period of about 18 months including the time of the very trying drought of the Summer and Autumn of 1887, and at the present moment are yielding, out and out, and far away, the purest effluent which up to this time the science of sewage chemistry has been able to produce."

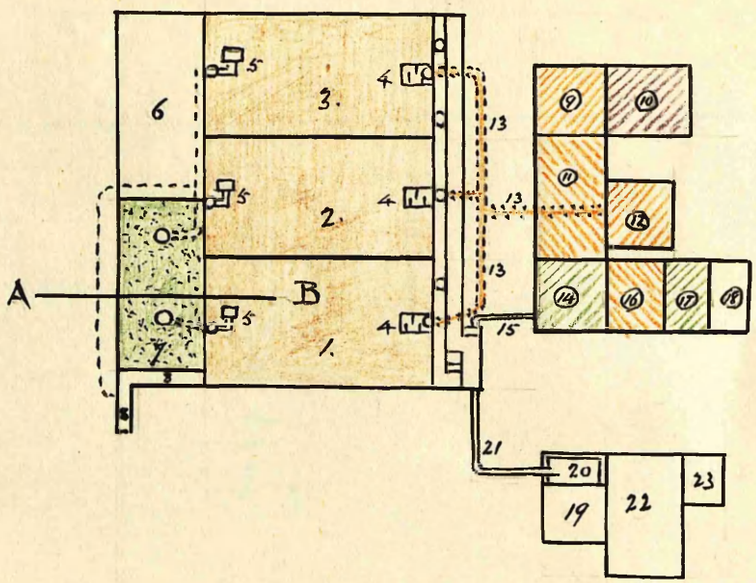
The Electrical Treatment of Sewage.

Mr. Webster, describing his process, says "The

Section on line A. B. of Polarite Filter Bed.



Vertical Section of Polarite Filter Bed.



1 2 3 Precipitating Tanks
4 Floating Entrances
5 Floating Delivery
6 Reserved for alternate Filter-Bed.
7 Polarite Filter Beds
8 Culvert for purified Effluent.
9 Sludge Cake, Grinding and Drying House.
10 International Manure Stores.
11. Sludge pressing House
12. Sludge Well
13. Sludge pipes
14 Ferozone mixing House.
15 Ferozone delivery Conduit.
16 Sludge mixing House.
17 Ferozone Stores
18 Office, &c.
19 Pump Ho.
20 " Well.
21 Sewage Main.
22 Boiler Ho.
23 Coal Store
24 Chalk Tank.

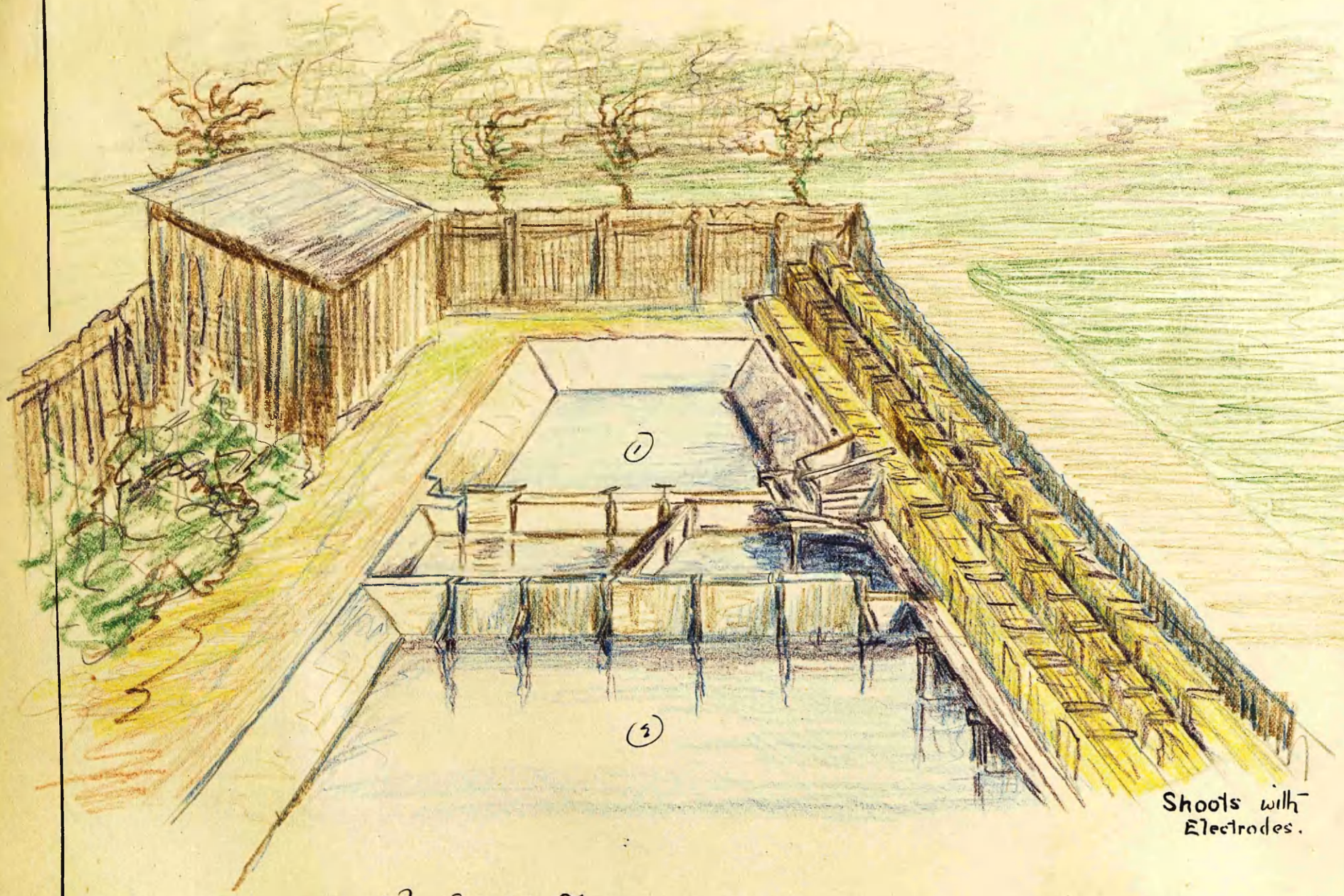
Sketch Plan of the Acton Sewage Works and Section of the Polarite Filter Beds.

Mr Webster.

chemical changes that take place in sewage when it is electrolysed, depend chiefly on the well known fact that water as well as sodium, magnesium and other chlorides (which are always present in sewage), are split up by the electric current into their constituent parts. Thus, we have at the positive pole chlorine and oxygen set free, and these elements are liberated in a nascent state, a condition in which they are intensely active, so that the organic matter in the sewage is rapidly oxidized into innocuous compounds. "So rapid is this action that, provided the sewage contains a sufficiency of chlorides, it is possible to produce a disinfecting fluid from it consisting of oxides of chlorine."....

"After many months of exhaustive experiments, carried out on a large scale at Crossness, it has been conclusively proved that cast-iron plates of the commonest quality, employed as electrodes, give the best result."....

"The drawing represents the experimental plant at Crossness, but experience has shown a better arrangement of electrical channels for actual working. A channel should be kept at the bottom of the electrodes for the collection of the silt, with a culvert at side to flush it into so as to prevent any block occurring. The advantage of this is obvious. The plates in each section are about an inch thick, and can be of any length up to 6 feet. It may possibly be objected that a large number of plates is required. This may be so, but the larger the



Purification of Sewage by Electrolysis — Crossness Experimental Works.

number of plates the less the engine-power required, and the longer they last. In each section the electrodes are in parallel, and any one section is in series with the other, the arrangement being exactly like that of a series of primary battery cells."

"In putting down plates for the above quantity (1,000,000 in 24 hours) of sewage, it would be as well to allow in them sufficient weight for five or ten years consumption; what remained of this could be sold as old iron at the end of that time. One of the advantages of having the plates in series is, that if anything goes wrong in any particular section, it can easily be set right, the current being cut-off during the repairs. The shoot containing the electrodes should be coated inside with some sort of asphalt so as to prevent, as far as possible, any leakage of current to earth, the asphalt acting as an insulator."

"The effluent produced by the above process contains about three grains per gallon of suspended matters, which consist almost entirely of oxide of iron, which is quite innocuous. Where this is objectionable from a sentimental point of view it can be entirely removed by filtration through a few inches of sand. Where an even higher degree of purification is required, for instance, when the effluent has to be run into a trout-stream, it is possible to produce any further degree of purity required by

passing it through an electric filter, which is arranged as follows:—

Alternate layers of small coke, free from sulphur, are separated either by layers of sand or perforated tiles; by suitable connection, these beds of coke form positive and negative electrodes — the first layer of material being sand so as to mechanically separate matters in suspension. It is impossible for disease germs to propagate owing to the nascent oxygen and chlorine produced when the filter is in action. The oxygen given off in the pores of the carbon also prevents the filter from choking.

"In this case the sewage, after action with the iron electrodes, is allowed to flow into a settling tank and after remaining there for an hour or longer for the precipitate to subside the effluent is passed through the filter, any oxide of iron that may be present tending to keep the top layer of filtering medium free from any objectionable action and in its turn forming a filtering medium."

Sludge.

In all these precipitation processes, whilst the sewage is more or less clarified and the effluent rendered fit to be passed into streams, there is still left the sludge which is now estimated at its proper value. Formerly it was thought the sludge would have a high

manurial value but now it is proved that, weight for weight, it is about the same as farm-yard manure.

Disposal.

How to dispose of the sludge is a question which has taxed the ingenuity of many authorities, especially those using the Salts of Lime as precipitants, which materially increase the amount of sludge to be dealt with. As a mat-

As a Manure it is neither a success financially nor from a health point of view.

Burning it in a Destructor certainly gets rid of it and is not more wasteful than what goes on day by day in the Destructor

The Cement process of General Scott has been already referred to.

Carrying the Sludge out to Sea. Mr. Dibdin says with regard to this ※ "The great advantage of this method is that the sludge will never be seen. Precipitated in covered reservoirs, transferred from the precipitating tanks to special settling tanks, from thence pumped into the sludge vessel and discharged under water, far from land, the sludge will disappear in the most speedy, cleanly and safe manner that can be devised.

Mr Dibdin.

"The Objections to this system are threefold.-

(1) Waste of valuable manure.

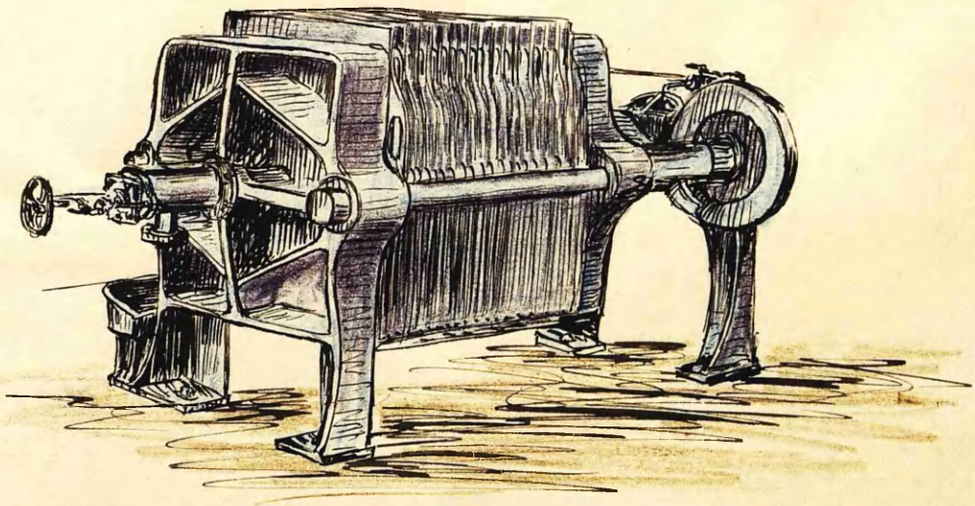
(2) possibility of nuisance on the coast.

(3) Delay in transit, by fogs and stress of weather.

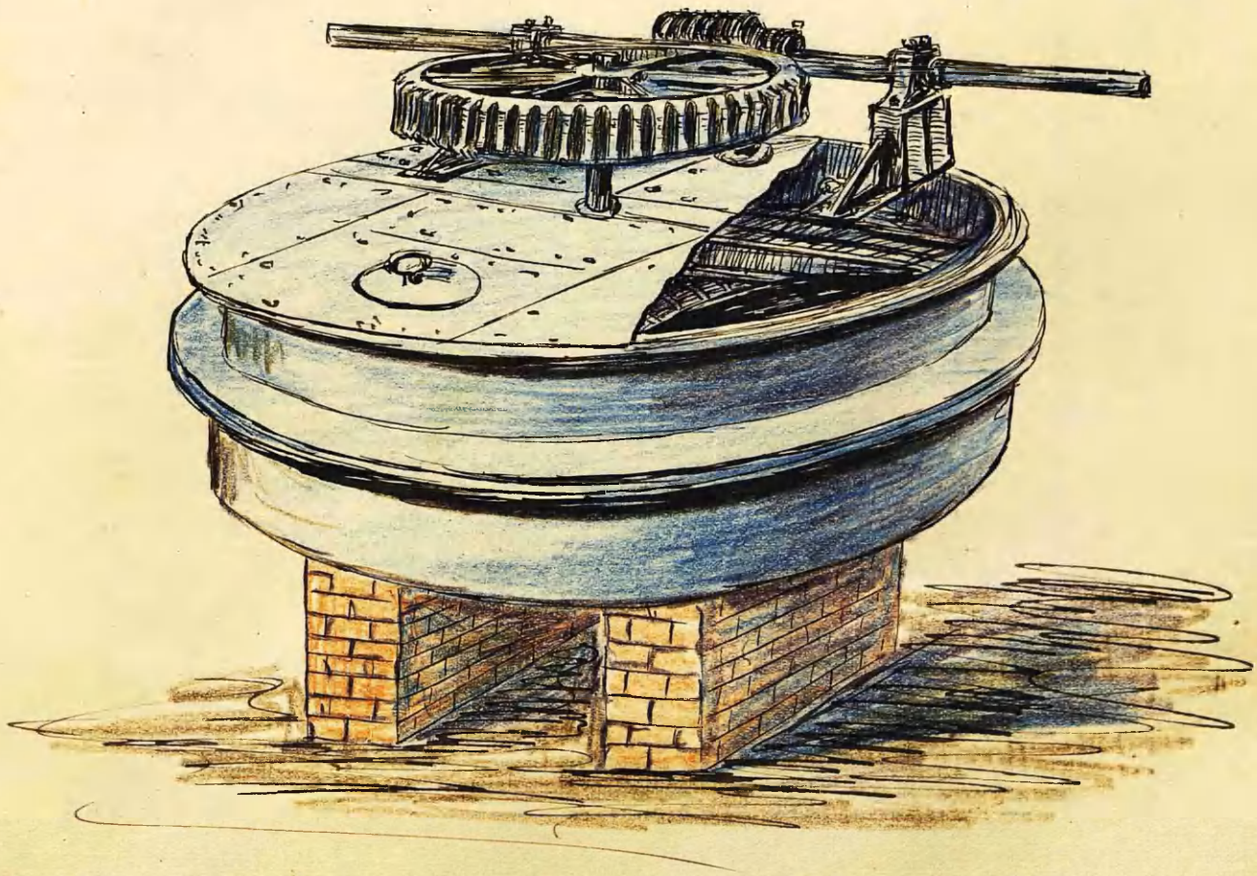
"The first objection is decidedly met by the reply, that if the commercial manurial value of the sludge is a fact, commercial men may be safely relied upon to utilize it. . . .

"The second Objection is a mistaken one. Some 3000 tons of settled sludge, equal to about

※ Min. proc. Inst. C.E. 1887.



Patent Sludge Press.



Patent Dryer

150 tons of organic matter, will be discharged per diem under water, several miles from the coast. This will not be discharged at one spot, but be spread over some thirty miles. Assuming that the discharge from one vessel, holding one thousand tons, equal to 50 tons of organic matter, formed a track, when diffused in the water, 4 yards deep by 4 yards wide, and 10 miles in length, what would be the quantity of organic matter in that polluted line of water? Only 16 grains in each gallon. Given a gallon of water, containing 16 grains of organic matter, situated, say 10 miles from the shore, and in a strong tidal way, how much offence will be given after diffusion, oxidation, the feeding of fish, &c. have acted their part by the time it has reached the coast, if ever it does reach it?...

"The third objection, delay by fogs and stress of weather is a trivial one. An increase in the capacity of the sludge settling tanks, with reserve steam power, which must be provided in any case to guard against breakdowns, will effectually overcome this difficulty."

Pressing into Cakes. Special filter-presses are made for this purpose, and it seems that after going through this process, a sludge-cake is obtained of a fairly high manurial value.

According to the Glasgow Corporation Committee of 1880, "Sewage-sludge may be disposed of in four ways — it may be compressed into portable cakes; or it may be conveyed in a semi-fluid condition to the open sea; or it-

may be used to make up waste land; or it may be dug into ground, so producing a highly fertile soil."

The Carbonised Refuse System of Treating Sewage, besides many other advantages, seems to get rid of the Sludge difficulty.

Mr. Arthur Turley, describing this process, says ※ "In Town refuse there is a large percentage of animal and vegetable matter. By carbonizing this refuse, animal and vegetable charcoal is obtained, which is a well known purifier and decoloriser. This is the Theory. I will now describe the practice. The dry refuse of a Town, viz.- the Refuse without any admixture of excreta, is taken up an inclined roadway and is deposited as required in a Carboniser the form of which, of course, will depend upon the size of the Town: but for various reasons, many of small capacity are preferred to a few having a large capacity; the charring will be done much more freely and expeditiously in the former than in the latter form, as the risk of saddening by an excess of material is dispensed with. The Carbonisers will be connected by a common flue to a Chimney shaft, which need not be of any great height, as a rule, but this again must be decided by studying carefully local circumstances of each particular case. The form of Carboniser is shown in Plate 2 figure 2. This design answers well for the purposes of a small Town, up to say 10,000 population.

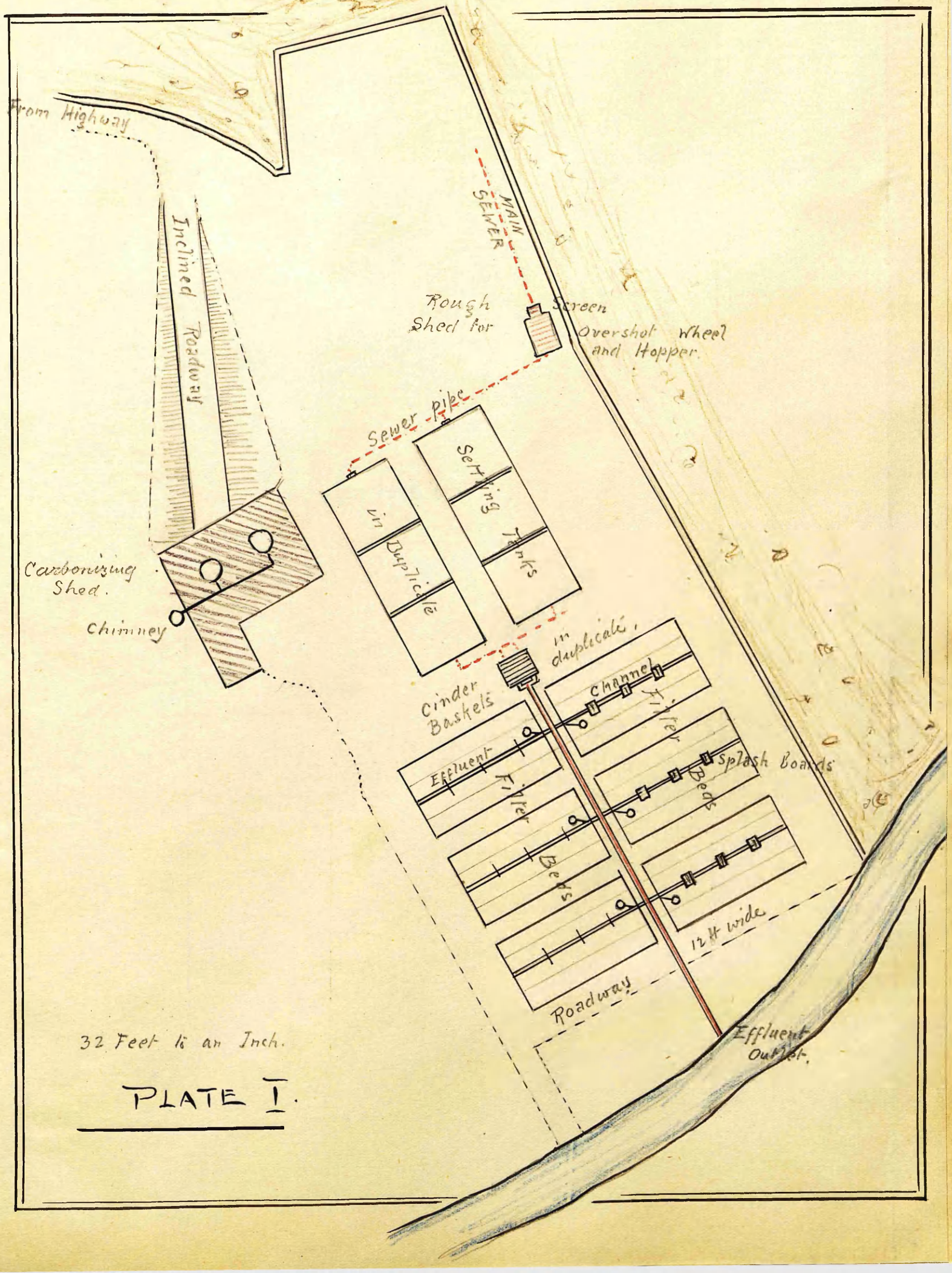
Mr. Arthur Turley.

" For larger Towns, the Carbonising should be done in much the same way as coal is car-

※ The Treatment of Sewage, Arthur Turley C.E. 1890.

bonised for making Coal Gas. In populous Towns a great amount of refuse would require expeditiously dealing with, which would necessitate a more rapid process of Carbonising than would be requisite in a small Town or Village. The refuse in both cases is deposited in the Carbonising Chamber until the whole mass is thoroughly charred not burnt. The Carbonised material is first allowed to cool and is then placed in a circular riddle. Coarser portions of the Carbonised material, consisting of Coke of various grades, are used for forming the lower layers of the filter beds. The finer parts given out by the riddle, consisting of Carbon and ash, form an upper layer, four inches thick, of the filter beds. A detail showing the depth of the filters and sizes of the material forming the various layers are shown on plate 2. fig 1. Where broken stones or bricks or gravel, pebbles, &c can be readily obtained they are more suitable for forming the lower layers of the filters; the top layer, of course, must be composed of 4 inches of fine Carbonised refuse. The Coke &c, in this case could be utilized as fuel for getting up steam for driving an engine, which would be required for working the circular riddle, or a mortar mill, &c. The Coke, &c, could also be ground up for making mortar, or it could be used for road repairing, filling-up old disused Quarries, &c.

Everything coming from the Carboniser is thoroughly cleansed and any material not required at the Sewage works may be safely deposited in any suitable place. (In the large towns, the cinders, &c in the refuse would be used as fuel for carbonising the material placed in the Retorts.)


From Highway
Inclined Roadway
MAIN SEWER
Rough Shed for Screen
Overshot Wheel and Hopper
Sewer pipe
Settling Tanks
in Duplicate
Carbonizing Shed.
Chimney
in duplicate.
Cinder Baskets
Channel Filter Beds
Splash Boards
Effluent Filter Beds
12 ft wide
Roadways
Effluent Outlet.
32 Feet to an Inch.
PLATE I.

portable as a manure; the fouled cinders being treated as before."

Average percentage of Impurities removed from Sewage by different processes. *

Name of Process.	Percentage of soluble Organic Pollution removed.		Percentage of Suspended Organic matter removed.
	Organic C.	Organic N.	
Lime (Precipitation.)	28	44	97
A. B. C. process (Precipitation.)	32	54	92
Lime and Chloride of Iron. (Precipitation.)	50	37	99
Sulphate of Alumina. (Precipitation.)	4	48	79
Intermittent downward land Filtration.	72	87	100
Irrigation.	68	81	100
Carbonized Refuse (Filtration.)	70	97	99.

Mr. Jagger.

I understand from Mr. Jagger, the inventor of this system, "that permanent works are about being put down at

Baildon, near Bradford,
Horsforth, near Leeds,
Alton, Hants

and a large experiment is about to be tried at Burton-on-Trent, where the Sewage is of a very peculiar character; it is warm and fermenting and emits a fearful stench (the cause is the Yeasty washings from the Breweries.")

City Refuse.

This brings us to a consideration of the means by which the Refuse of our Cities is got rid of. And here, I cannot do better than give a description of the Works at Crawford Street, Glasgow, which appeared in the "Glasgow News" of 14th June 1884, when these works were commenced. "The Objects which the

* Arthur Jurley, Op. cit.

Manure Despatch Works,
Glasgow.

Cleansing Committee have in view are chiefly (1) to have each days collection of Refuse despatched to the Country directly as it is brought in by the Scavenging Carts, and thus do away with the storing depots in the City, and (2) to have the Refuse dealt with and loaded mechanically so that only the manurial portion, freed of all rubbish, will be sent to the farmers, while of the non manurial portion, every thing which can be sold or utilized will be turned to the best accomt, and the remainder reduced to inoffensive clinkers by Cremation. The principle adopted is to have the Refuse carted in to the highest point so that, without the use of elevators, it is mechanically dealt with as it descends — the manurial portion going into railway waggons, the cinders in front of the boilers, old iron, old boots, etc. to places appointed for them, and the other rubbish into Cremating furnaces. The contents of ash pits and bins are shot into revolving screens; each screen (making 14 revolutions per minute) has a double action, and though in one piece, is practically a screen within a screen. By the first action on the inner mesh, sloping from West to East, all the rougher rubbish which will not pass through a 1⅛ inch opening is separated and delivered on to a travelling carrier at the east end of the screen, and by the second action on the outer mesh, sloping in the opposite direction, the material which has passed through the inner mesh travels back over the ½ inch outer mesh. The material, chiefly cinder which passes over this ½ inch mesh, is delivered at the opposite end of the screen from the rubbish, and is passed down a shoot to the front of the boilers, where it is

used as fuel and serves to raise steam for the works. The fine ash and small manurial particles fall through both meshes and thence down a shoot into mixing machines which stand on an elevated platform on the floor below. Into these mixers there passes at the same time a mechanically regulated quantity of excreta. The carts in which this material is collected also ascend to the top floor where the contents are passed through gratings into closed cast-iron tanks resting on the second floor, and from which, by a simple mechanical arrangement, the desired supply is allowed to escape into the mixers with the fine ash which absorbs and deodourizes it. In order to fix the Ammonia and further deodourize the compound provision is made for adding H_2SO_4, or other disinfectant, to the excreta in the tanks. The other material which is shot into the mixer is the consolidated detritus from the paved streets, this being frequently collected in a very slushy condition and in large quantities. These sloppy sweepings are also carted to the top floor where they are shot through a series of openings into large cast-iron tanks. These draining tanks are specially designed for this purpose. They have sloping bottoms and are provided with apparatus for draining off the water as it is pressed to the surface. When the contents are sufficiently drained the large doors in the front are gradually raised by means of chain barrels and worm gear and the residuum, which is pulpy and rich looking, is shot down as desired into the mixers. Thus the various manurial constituents of the Refuse are passed in regulated quantities into the mixing machines whose revolving blades mix the whole into a deodourized compound suitable for spreading on the land.... Women are stationed in front of the travelling carrier to pick off anything that can be sold or utilized..... The remainder is shot from the

At the Carrier.

Feeding the Destructor.

Distritos

Carrier into a specially constructed furnace where it is reduced to clinkers, which go to make roads or fill up ground."……

During a recent visit to these works I was struck with the methodical way in which things were gone about, the absence of smell which one would naturally associate with such a work and which is evidently frightening the Feuers at Craigmillar near Edinburgh where it has been proposed to establish a work similar to the above.

Where so much economy is shown in utilizing the cinders, extracting the solder, and even getting good out of our old boots, one cannot fail to be impressed with the fact that there is great waste going on in the Destructors. Surely a furnace could be so made as, whilst serving its original purpose, would also act as a Retort and admit of the products of destruction being condensed and utilized. In this connection I would mention the Patent of Mr C. G. Moor, no. 11,798, 1889 which approaches very nearly to my own idea of treating Sewage and City Refuse. In his Patent, Mr Moor claims.-

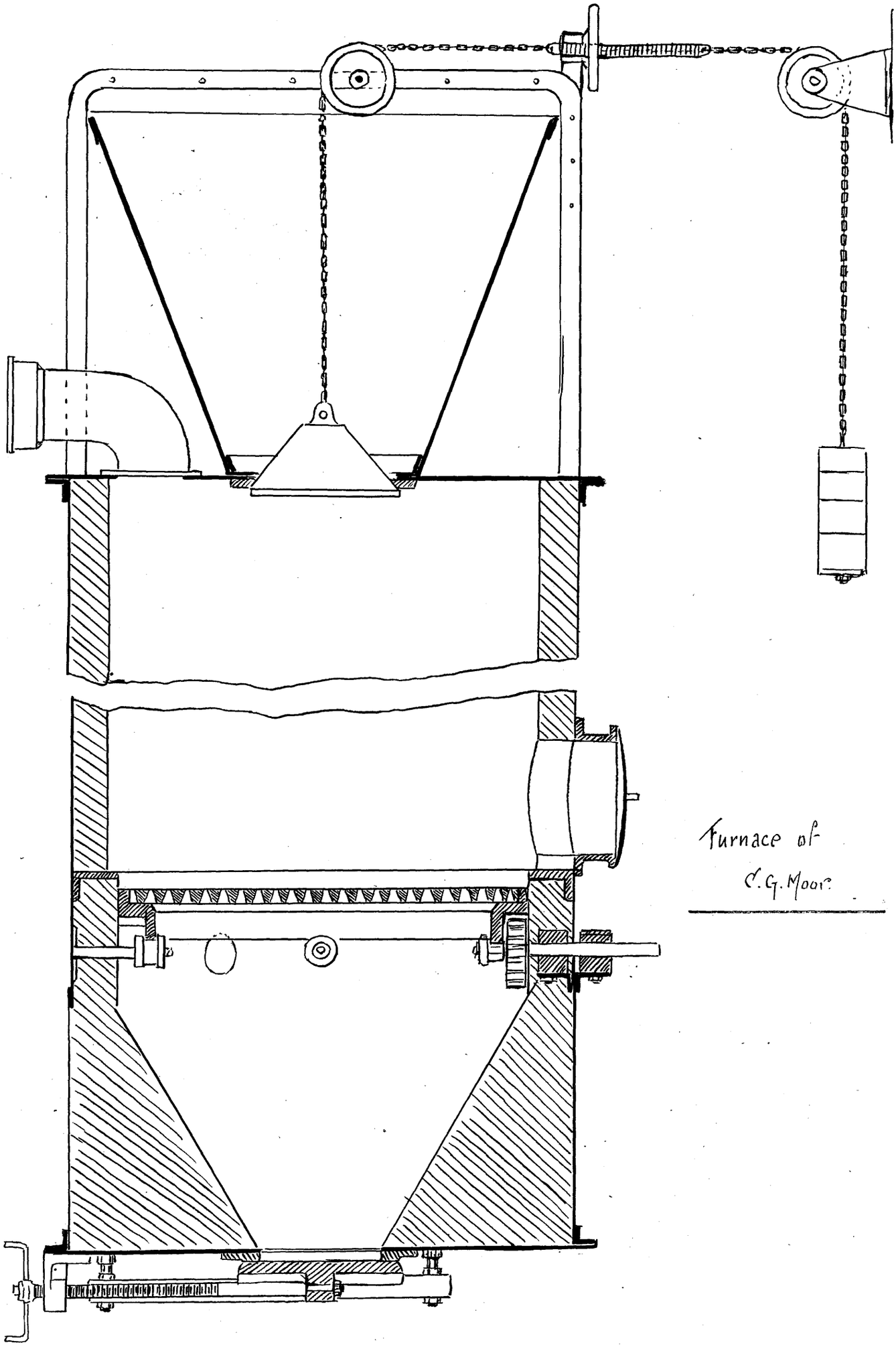
Patent of C.G. Moor. No. 11,798. (1889)

"① The herein described process of treating Sewage for obtaining a marketable manure therefrom, which consists in the series of operations or steps above mentioned, viz.- separation of the Sludge from the liquid Sewage, elimination of a portion of the moisture from the Sludge, distillation, carbonisation, and calcination of the sludge, and finally mixing the ash resulting from the calcination with the Ammonia (fixed as sulphate) resulting from the distillation, substantially as specified.

② In the herein described process of treating Sewage the operation of distilling, carbonising and calcining, blocks of partially dried Sewage Sludge, in a furnace, by the heat developed by the combustion of the sludge itself under the action of a forced draught……

③ …… the manufacture of a precipitating, filtering and purifying medium for Sewage by Carbonising blocks of sludge under the action of a forced draught……

④ ……. the treatment of the ash (resulting from the calcination of the Sewage sludge (in the second stage of the operation) by mixing it with the Ammonia (fixed as sulphate) resulting from the distillation…



Furnace of
C. G. Moore

Jornaes

Where the Dry Method of Sewage Removal is in practice various plans have been tried to render the excreta innocuous without destroying its manurial value. I would simply mention

(1) The "Poudrette" of the French, and the plan adopted by the Hyde Patent manure Eureka Company, who by the application of heat converted the excreta into manure but in doing so caused such a nuisance that they had to desist.

(2) The patent of Mr Hoey who claims (a) the saving of by far the greater portion of the water usually employed in water-closets; (b) the exclusion of the sewage from the ordinary drains; (c) the utilization of the whole product, urine and faeculent matter, by evaporating it to dryness after adding H_2SO_4 or sulphate of lime.
Dr Wallace reported favourably on this system in 1872.

(3) The process of Mr. Stanford, in which charred sea weed is used; after it has become impregnated with faeces and urine, it is reburnt in closed retorts, when the Charcoal is again fit for use and the products of distillation, (NH_3 Tar, Gas, etc) are valuable enough to make the process pay.
On this also Dr Wallace reported favourably.

(4) Mr. Moules Earth Closet makes use of dried earth and has been of great service in Countries where a supply of water is hard to obtain. A new material, crushed slag, has been proposed instead of earth, the advantages claimed for it being (1) The cheapness of the material (2) its supply being practically inexhaustible, (3) its porous property and (4) its manurial qualities.

(5) The "Goux" System utilizes, as absorbents, vegetable or animal refuse, such as chaff, shoddy, refuse wool, etc. These are placed in the pail and by means of a mould are pressed to the sides and bottom.

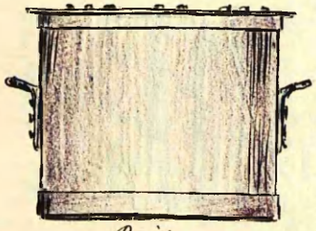
(6) Carbonisation. By this means the excreta are reduced to Carbon in retorts, the products of distillation being (a) Gas (viz- H. CO. CO_2, etc) (b) Tar-like stuff (c) "Ammoniacal liquor" (d) charcoal (Dr Macnamara.)

Conclusion.

Speaking at a meeting of the Society of medical Officers of Health, 1885, Dr Stevenson said "So far as I can

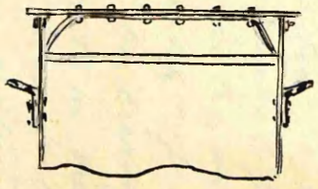
Excrement pail with lid on full, to return to works.

Excrement pail, empty, ready for use.

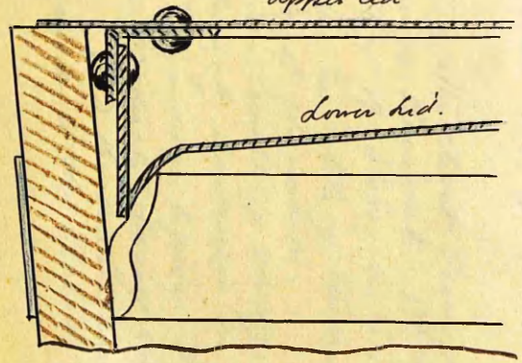


Pail.

Lid.



Mould.



Part section of the Rochdale pail & Cover.

Section showing the lid in position. Birmingham pail & Cover.

Absorbent Receptacle Liquid pail used for "Goux" System employed at Halifax.

foresee the Sewage Disposal of the future for our large Towns will be one where application to land supplements a preliminary precipitation process; and the land treatment will be a filtration process by which the area of land requisite will be limited."

Dr Stevenson.

It is hardly possible for a large Town to acquire land sufficient for a Sewage farm anywhere near its doors, and the custom of pouring untreated Sewage into, even a large body of water, such as the Sea, is not one to be commended. A chemical process which clarifies the Sewage at the expense of producing a large quantity of sludge, gets rid of one difficulty by creating another.

Keeping these points in view I would suggest the following plan of treatment for our Sewage and Refuse matter as one which meets most of the difficulties. Whether it would "pay" or not is a question which gives me little anxiety as I look at it from a health point of view, and where the health of a community is increased that always pays in the long run.

proposed plan.

Taking, then, a water closet Town, with no "special" System of Sewage Removal, I would

(1) provide for the overflow of Storm-waters;

(2) precipitate the Sewage in settling tanks, with or without the help of chemicals.

(3) Destructively distil the resulting sludge, along with what is ordinarily destroyed in the "Destructors", the Ammonia liquor, Tar and other condensable products being treated as at Gasworks, and the uncondensable Gases being returned to the Retorts to assist in firing.

(4) Utilize the "Spent Sewage and Refuse" as filter-beds for the sewage effluent as it comes from the settling tanks, and, when it has served its purpose there, return it to the Retorts to be redistilled.

By this means a sewage effluent would be obtained pure enough to be passed at once into a running-stream, what was of value in the sewage would be got in an easily-handled condition, and the great waste going on in the Destructors would be done away with.