THE DISPOSAL OF SEWAGE BY ELECTROLYSIS

CLASS of 1912 F. Curt Miller

Throop Polytechnic Institute

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BY ELECTROLYSIS

Preface

This subject was taken as a thesis owing to the present difficulties which the City of Pasadena is experiencing in operating and disposing of its sewage by the so-called Septic tank method.

The expense for labor and apparatus for carrying on this investigation was covered by the Public Works Scholarship Fund, the founder of which is Mayor William Thum of Pasadena, who, by special provision, made it possible to use this fund for carrying on the investigation of the subject to the extent described later.

I take this opportunity to express my thanks to Dr. Stanley P. Black, City Health Officer, for his instruction and cooperation in the Bacteriological department of this investigation.

Introduction

Sewage may be defined as the waste matter of a town of city which can not be classified as garbage. It is largely water polluted by the solid and liquid excreta of the population and waste from laundries and other industrial plants. It is water containing mineral, vegetable and animal matter in suspension and in solution.

Besides the mineral and organic matter, sewage always contains a vast number of living organisms, more commonly known as bacteria and their action upon the lifeless substratum of sewage occasions the obnoxious odors during the stage of putrefaction.

All methods of sewage treatment are for the purpose of hastening or preventing this stage of putrefaction, hence the primary object of sewage purification is the oxidation of organic matter - its conversion into a stable form, so that it will not putrefy and create a nuisance. Furthermore the object to destroy the bacteria whose presence produce putrefaction wherever they thrive.

The electrolytic method, which I propose, will accomplish these results as I will show by tests later discussed.

A brief outline of the method proposed is as follows:- An electric current (D. C.) is passed through effluent sewage by means of a series of cast iron positive and negative electrodes. By effluent sewage is meant, sewage which will strain through a screen of twenty to forty mesh. This process may be termed electo-chemical, as the desired results are accomplished by the chemicals freed within the sewage by electrolysis. Oxygen, hydrogen and chlorine are liberated in the nascent stage. The oxidation of albuminates or nitrogenious bodies prevents further putrefaction, and the oxy-chlorine acts as disinfectant and destroys all miscroscopic life. To aid in the destruction of bacteria there is also present in varying amounts, according to local conditions, quantities of magnesia and free sulphuric acid, generated in the process. The effluent when thus treated is cleared by the decomposition of the iron electrodes, a reddish tint resulting, due to the iron in suspension.

This process, to be applicable to Pasadena conditions, should meet the following requirements:-

(a) The effluent sewage to be putrefied, i.e. freed from bacteria.

(b) The sewage to be free from odor after treatment.

(c) The sewage not to re-putrefy.

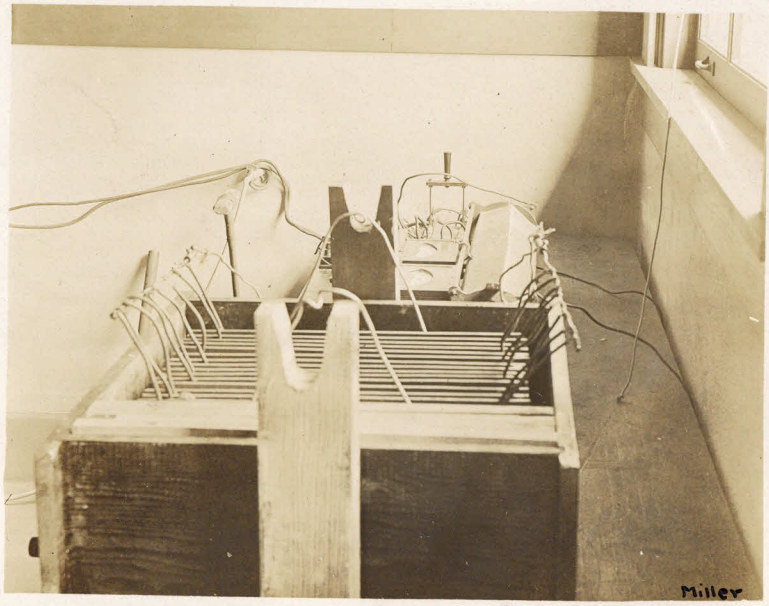
(d) The fertilizing qualities not to be impaired. This provision is desired but not mandatory.

(e) The cost of operation must compare favorably with other processes; local conditions and effectiveness taken into consideration.

Method Employed in Carrying on Tests.

Two receptacles were obtained for the purpose of electrolyzing the sewage, one having a capacity of fifteen gallons, the other of one-tenth this size. In the larger tank a set of seventeen plates was placed, eight positive and nine negative. An odd number of plates were used to give an equal number of positive and negative surfaces. The seventeen plates arranged as above stated, gave sixteen positive and sixteen negative active surfaces, or vice versa when the current was reversed. Each electrode has the following dimensions: $\frac{1}{8}$" x 18$\frac{3}{4}$" x 12", thus giving a total positive or negative plate surface of approximately 3600 square inches. This plate surface for convenience in calculating, was divided into 20 units of 180square inches per unit. Sewage, for example, to receive treatment with a current density of one ampere per unit plate surface would require 20 amperes. The plates were arranged one-half of an inch apart, positive plates being connected together on one side to a bus-bar, and the negative plates being similarly connected on the other.

The second receptacle having one-tenth the sewage capacity of the first one had one-tenth the plate surface exposed. This made data obtainable from one readily



Apparatus.

comparable with that obtained from the other, both using the same unit surface for a given current density.

The apparatus was connected on a Direct Current circuit, a voltmeter and ammeter being connected across and in the circuit. A rheostat was used to control the current. See diagram and photographic illustration of larger tank and connections.

The sewage to be treated was first run through a forty mesh screen, and then placed in the treating tank. After mixing, an untreated sample was removed and the current passed through the remaining sewage, the amperes being adjusted to give the desired current density in the solution. Samples were removed at successive periods varying from one minute intervals, the tests being carried on for eight to twenty minutes, the duration depending upon the current density employed.

From each sample, one c. c. of sewage was taken and diluted to 1 - 10000. Then 1 c. c. of the diluted sample was placed in a standard (10 inches diameter) petriplate. This was then covered with 10 c.c. of Argar Agar Media and placed in an "electro thermostat" oven, for a period of forty-eight hours, after which the plates were removed and bacterial count made of the developing colonies.

All apparatus used in planting the sewage in Petriplates was thoroughly sterilized, the glass ware being

Experimental Apparatus.

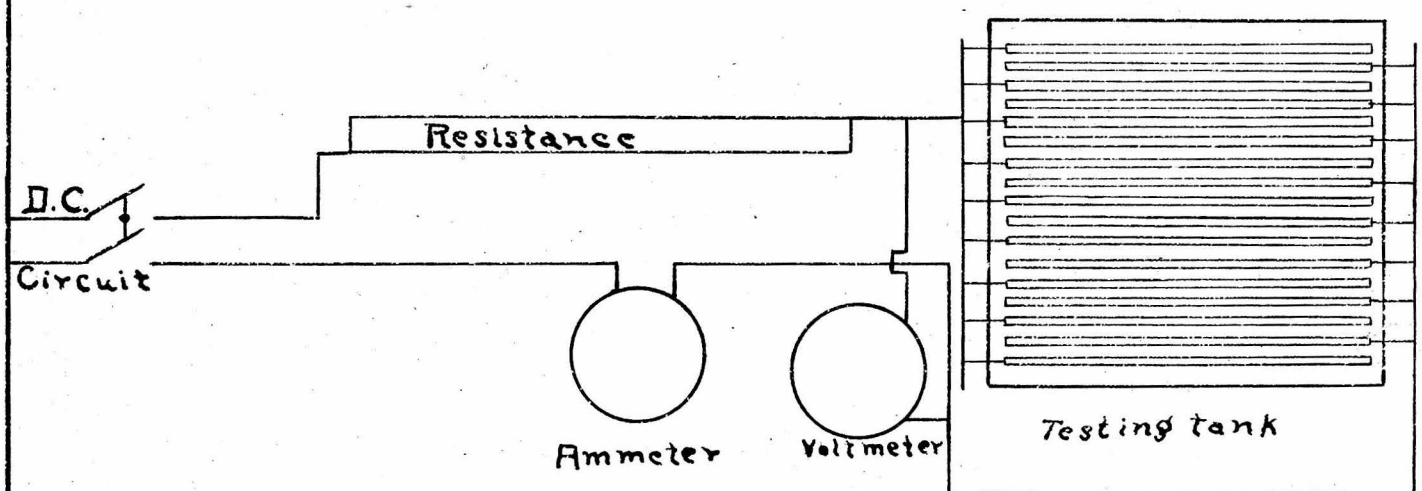


PLATE I.

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placed in hot air oven at a temperature of 165°C - 180°C for a period of thirty minutes. All water used for diluting purposes was thoroughly sterilized in an Auto-Clave at 110°C - 180°C and maintained at a pressure of 15- 25 lbs.

Other tests made upon the treated sewage were as follows , all samples being of one liter quantity.

Sealed samples were placed in dark room.

Unsealed samples were placed in a dark room.

Sealed samples were placed in sunlight.

Unsealed samples were placed in sunlight.

These samples were allowed to stand for a period of four days, (96 hours), then tested for odor and re-putrefaction. The time of four days was used, owing to the fact that I considered this sufficient time for water used for irrigation purposes to evaporate or sink into the soil.

A set of the above samples prepared March 21, 1912, was kept until the closing of the school year May 29, 1912, without enough putrefaction occuring to produce objectionable odor.

Samples were also examined for fertilizing qualities both before and after treatment by City Chemist, Mr. Frank Marks.

The electrolytic tests were made with current densities varying from one-half ampere to four amperes per

unit area or from .00278 amperes to .0222 amperes per square inch of positive or negative plate surface, that is, per square inch of electrolyte or sewage.

PLATE 2

Sewage

Test No 2 — Mar 19 1912

Time in Minutes	Volts	Amps	Bacteria per c c	Remarks
0	0	0	1,650,000	Effluent discharge of Septic tank
1	6	20	20000	
2	5.9	20	10000	1 Amp per 180 sq in plate surface
3	5.9	20	00	
4	5.8	20	00	American Voltmeter No 20104
5	5.8	20	00	" Ammeter No 37604

Test No 6 — Mar 21 1912

Time in Minutes	Volts	Amps	Bacteria per c c	Remarks
0	0	0	2600000	Raw Sewage entrance Septic tank
1	11	50	1,600,000	2.5 Amps per 180 Sq in plate surface
2	11.2	50	140,000	
3	11.4	50	120,000	Weston Voltmeter No 6402
4	11.6	50	00	Keystone Ammeter No 9944
5	11.8	50	00	

Test No 7 — Mar 25 1912

Time in Minutes	Volts	Amps	Bacteria per c c	Remarks
0	0	0	710,000	Raw Sewage entrance Septic tank
1	12	60	30,000	
2	12	60	30,000	3 Amps per 180 sq in plate surface
3	12	60	00	
4	12.2	60	00	Weston Voltmeter No 6402
5	12.2	60	00	Keystone Ammeter No 9944

Test No 8 — Mar 26 1912

Time in Minutes	Volts	Amps	Bacteria per c c	Remarks
0	0	0	210000	Raw Sewage entrance Septic tank
1	11.2	70	70000	
2	11.2	70	10000	3.5 Amps per 180 sq in plate surface
3	11.4	70	00	
4	11.4	70	00	Weston Voltmeter No 6402
5	11.6	70	00	Keystone Ammeter No 9944

Capacity of testing tank
15 Gal's.

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Results from Tests

The electrolytic samples planted for bacterial counts gave the following average results. Three tests were run under each condition, and when results were doubtful two further tests were made:

Time for Complete Destruction of Bacteria vs. current per unit area.

Amperes per unit Area 180 sq.in.	Amperes per sq.in. Plate surface	Raw Sewage Thru 40 m.scr Length of	Effluent from Septic tank. Time Treated.
.5	.00278	18 min.	18 min.
.6	.00334	16 "	
.7	.00390	13 "	11 "
.8	.00446	11 "	
.9	.00500	5 "	
1.0	.00556	5 "	3 "
1.25	.00695	5 "	
1.50	.00834	5 "	3 "
2.00	.01106	4 "	4 "
2.50	.01395	3 "	2 "
3.00	.01670	3 "	2 "
3.50	.01950	3 "	2 "
4.00	.02223	3 "	-

For further details see sample data sheets.

Samples sealed and placed in dark room showed no bacteria and had no odor with the exception of that of iron caused by the decomposition of the electrodes during the electrolysis treatment.

PLATE 3

Sewage

Test No11. Mar.29.1912.

Time in Minutes	Volts	Amps	Bacteria per c.c.	Remarks
0	0	0	180000	Raw Sewage entrance Septic
1	3.5	1.8	220000	tank
2	3.4	1.8	100000	.9 Amps per 180 sq in plate surface
3	3.2	1.8	60000	
4	3.1	1.8	20000	American Voltmeter No 20104
5	3.0	1.8	00	American Ammeter No 37604
6	3.0	1.8	00	

Test No12. Mar.29.1912

Time in Minutes	Volts	Amps	Bacteria per c.c.	Remarks
0	0	0	410000	Raw Sewage entrance Septic tank
1	2.4	1.6	390000	.8 Amps per 180 sq in plate surface.
2	2.6	1.6	40000	
3	2.8	1.6	180000	American Voltmeter No 20104
4	3.0	1.6	150000	" Ammeter No 37604
5	3.1	1.6	200000	
6	3.0	1.6	110000	Tests on this blue print
7	2.9	1.6	140000	run in small test
8	2.9	1.6	60000	tank Capacity
9	3.0	1.6	50000	1.5 Gal's.
10	3.0	1.6	30000	
11	2.9	1.6	00	
12	2.8	1.6	00	

Test No.13. Apr.2.1912.

Time in Minutes	Volts	Amps	Bacteria per c.c.	Remarks
0	0	0	1840000	Raw Sewage entrance Septic
1	2.8	1.4	1450000	tank
2	2.9	1.4	1300000	.7 Amps per 180 sq in plate surface
3	3.0	1.4	1210000	
4	3.1	1.4	160000	
6	3.0	1.4	140000	
8	2.8	1.4	160000	American Voltmeter No 20104
10	2.8	1.4	100000	" Ammeter No 37604
12	2.9	1.4	10000	
13	2.8	1.4	00	
14	2.9	1.4	00	
15	3.0	1.4	00	

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Samples sealed and unsealed placed in sunlight were odorless. The unsealed when planted for bacterial counts gave the following results.

Test No.	Number of Bacteria Sample diluted 1 - 10000
2	0
5	2
8	1
11	3
14	5
26	0
29	4
34	0

In all samples the solid matter in suspension settled within an hour and the solution was clear with the exception of a reddish tint caused by the presence of iron.

Upon filtering through ordinary filter paper, the samples, that had been treated electrolytically, were perfectly clear, the untreated remained cloudy.

The samples prepared March 31, when tested for odor on May 29, had lost the iron scent and had acquired an odor typical of all water which is permitted to stand such a length of time. There was no sewage odor.

The tests for fertilizing qualities before and after treatment gave the following results: The test made by Pasadena City Chemist, Mr. Marks.

The fertilizing qualities were impaired by the process to an extent of 50%.

ELECTRODE DETAILS.

PLATE 4

INSULATING FIBER

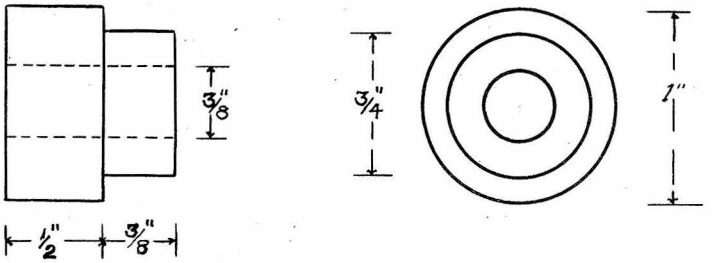
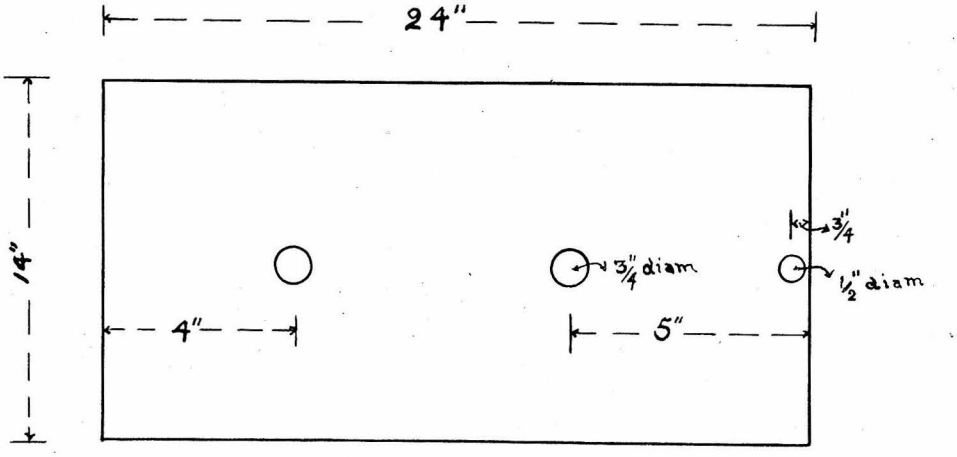


PLATE DIMENSIONS

24" X 14" X 3/8"

CAST IRON



ELECTRODE

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THE PLANT

The plant for which drawings are herein shown is designed for a capacity of 3,500,000 gallons per 24 hours. This plant would handle the peak loads of the City of Pasadena without a receiving reservoir. The daily flow of the City is 2,500,000 gallons.

Plate 4 shows a detailed design of electrode and insulators.

Plate 5 shows electrodes assembled in flumes.

Plate 6 shows general plan of electro-chemical sewage disposal plant.

In this plant are sixteen flumes, rectangles, 30' long x 25" wide, 18" deep, in which a series of ten sets of electrodes, twenty-seven plates to a set, dimensions of which are 24" long x 3/8" thick x 14" wide, are placed. A current of 1322.5 Amperes is required for the ten sets of electrodes in the flume.

Each set of electrodes is connected to a set of bus-bars running the length of the flume. These bus-bars are connected by a single throw switch to a distributing bus which is connected to the generating bus on the switch board.

Each flume is connected to the 7" sewage supply main by a 1½" intake pipe, fitted with a cutoff valve. The discharge pipe and main are 1½" and 7" respectively.

PLATE 5

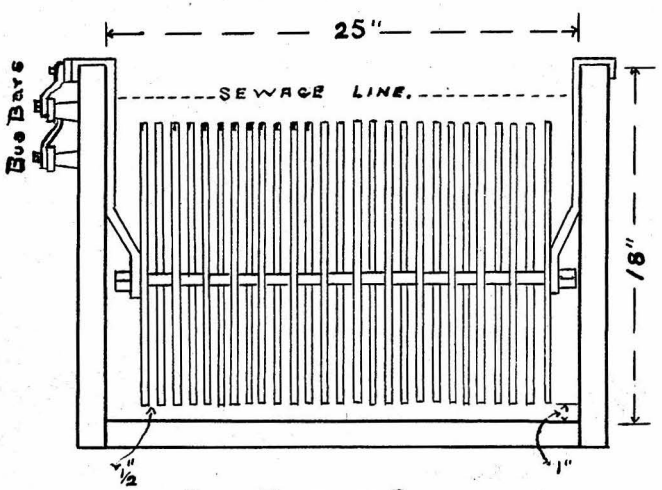
ELECTRODES IN FLUME

AND

CONNECTIONS

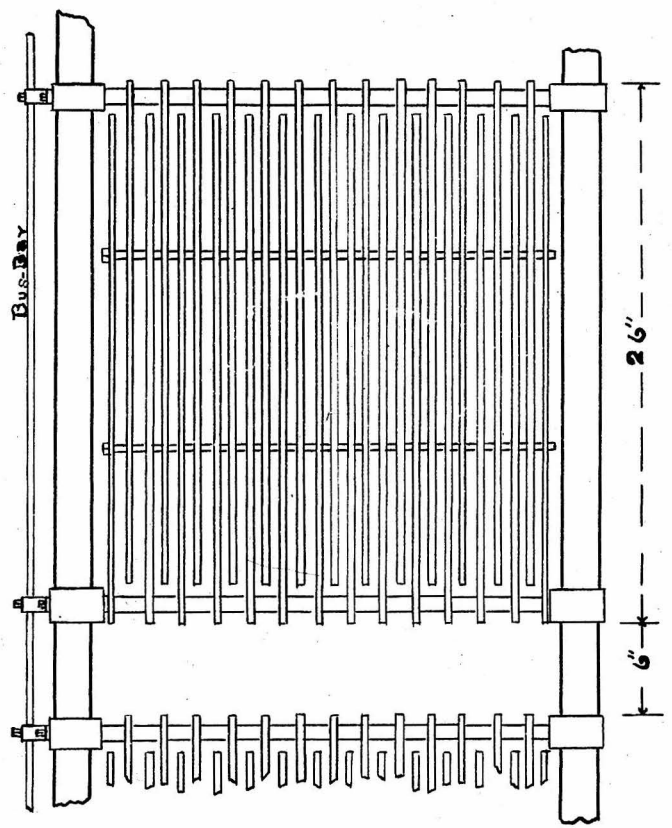
INSIDE DIMENSIONS OF FLUME

30' X 25" x 18"



END VIEW OF PLATES IN TROUGH

TOP VIEW OF PLATES IN TROUGH



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The electrical equipment consists of three 25 K.W. 6000 Amperes low voltage motor generator sets, switch board, meters, rheostats and bus-bars.

Auxiliary Equipment

For the purpose of exact regulation, a testing laboratory should be installed in connection with the plant. This department should run tests daily keeping records of results, as a basis for future operations. This is necessitated by the fact that the content of the sewage is subject to variations such as to require a knowledge of average conditions over long periods of time.

Probable First Cost of Plant

Not including building and cost of installation.

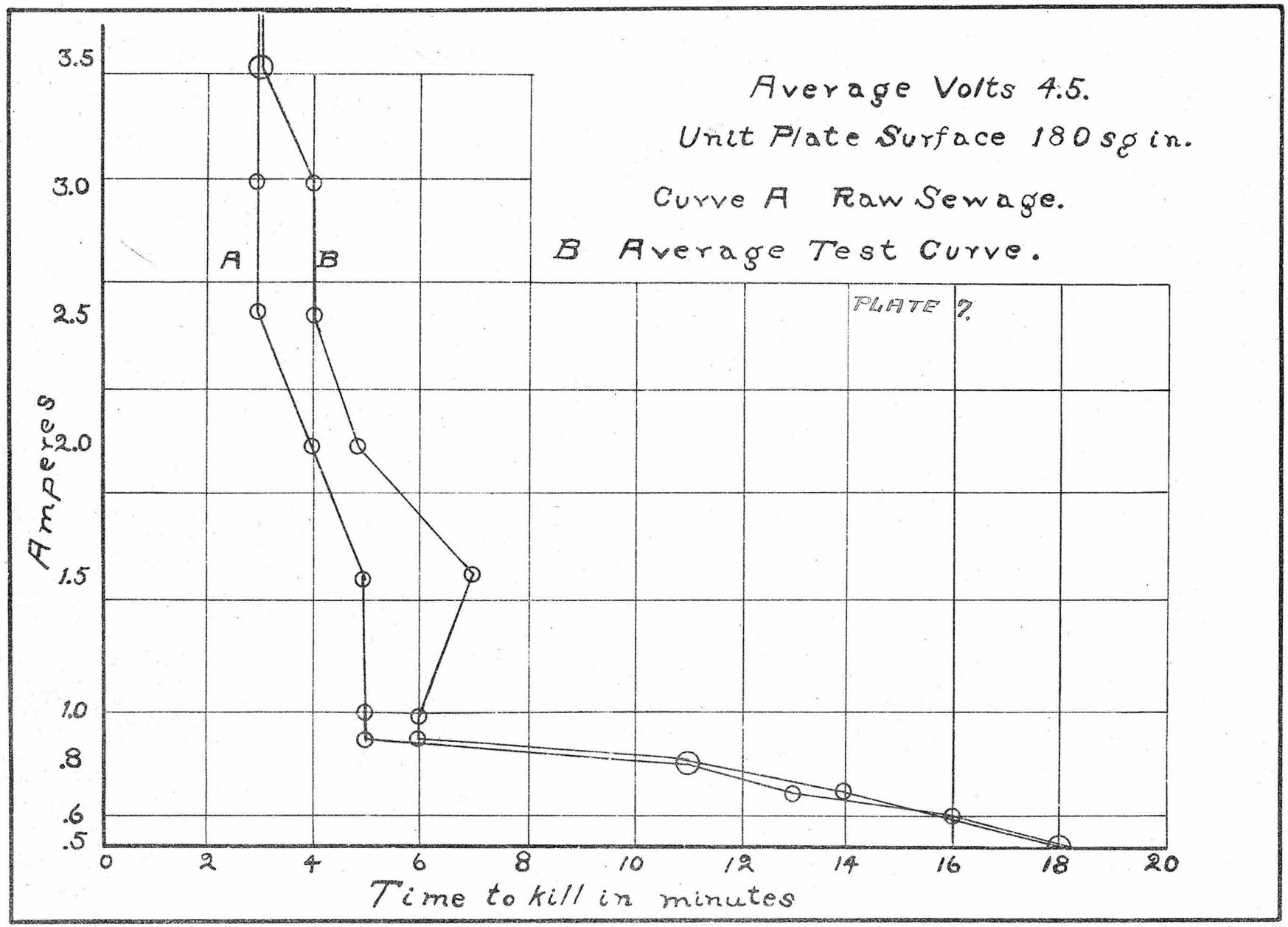
Three Motor Generator Sets @ $1600	$ 4,800
Bus-bars, Main)	1,095
" " , Secondary)	
Switch board equipment	500
Piping Main 7"	184
" Intake and Exit 1½"	19
Valves	45
Electrodes -complete	3,200
Auxiliary equipment	750
Flumes	192
	$10,783

Operating Expenses per day.

Energy - 3V x 15870A or 47.61 KW @ 1.50¢ x 24 hrs.	$17.15
Motor-Generator and transmission losses 30%	5.15
Labor, two attendants, 10 hours each	5.00
Labor, testing laboratory (This person to have general supervision and run plant four hours per day.)	3.50
Plate renewals	13.50
General up-keep	2.00
Tax and interest on investment	1.86
	$48.16

Receipts per day.

The sale of 2,500,000 gallons of water for irrigation purposes, valued at from $100.00 to $150.00


Average Volts 4.5.
Unit Plate Surface 180 sq in.
Curve A Raw Sewage.
B Average Test Curve.
PLATE 7.
A
B
Amperes
3.5
3.0
2.5
2.0
1.5
1.0
.8
.6
.5
0
2
4
6
8
10
12
14
16
18
20
Time to kill in minutes
Miller.

Recapitulation

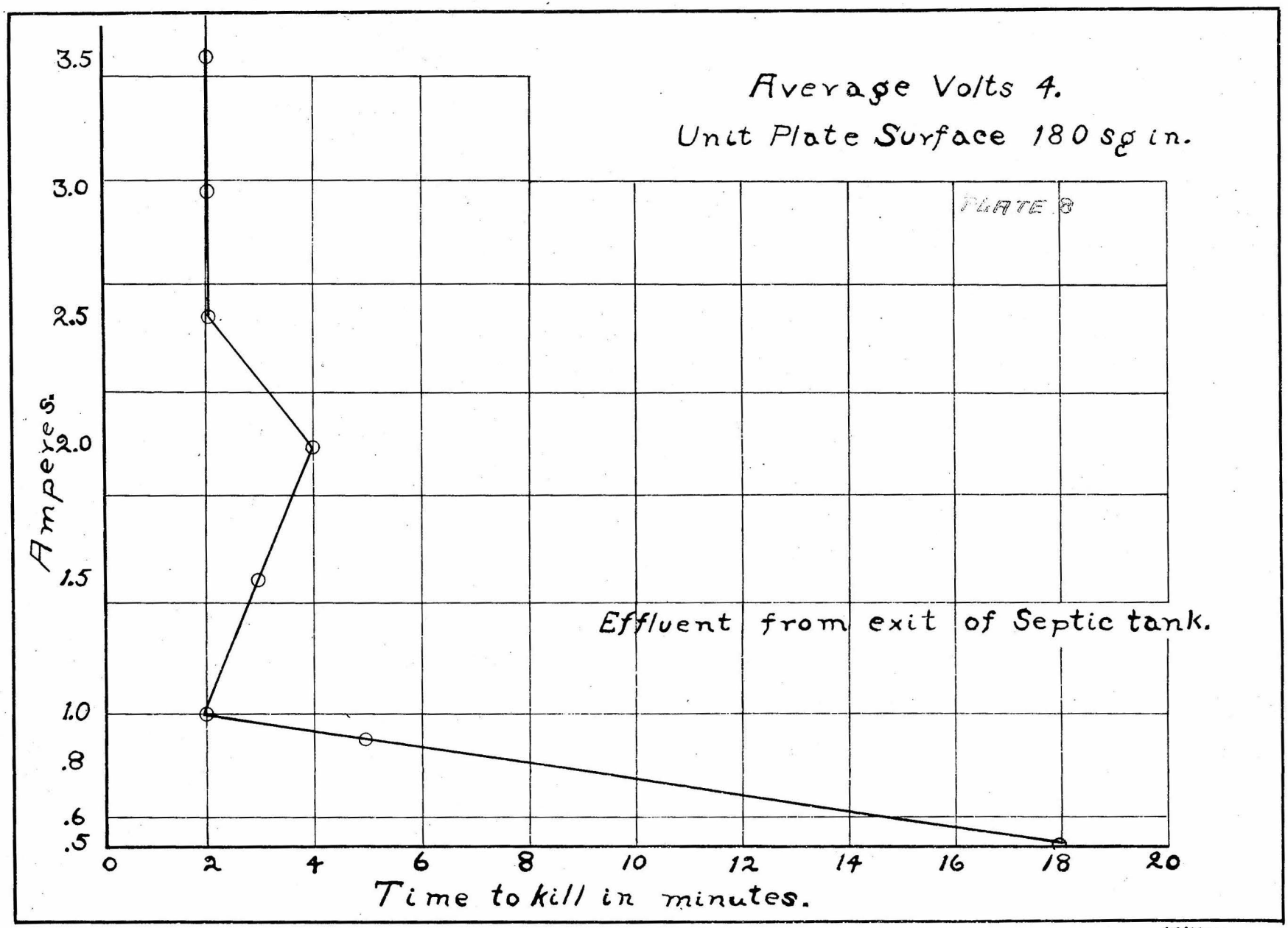
From the results obtained in my investigations of the proposed disposal of sewage by electro-chemical means, I am satisfied that the process has met the first three essential requirements stated in the earlier portion of this paper.

The cost of operation as compared with other processes, (local conditions taken into consideration), which use chemicals, is merely problematical, but after consulting a number of engineers posted on the subject they are unanimous in their reply, that this process is the less expensive.

From data collected in order to obtain cost of sewage disposal of other cities, I found that the costs ranges from 79¢ per million gallons to $217.00 per million gallons.

Curve sheets Nos. 7 and 8 which show the effectiveness of the process, are self- explanatory. But let it be born in mind that these curves, and in fact any statements made in this investigation of the electro-chemical process, are made as to apply to Pasadena conditions and to Pasadena only.

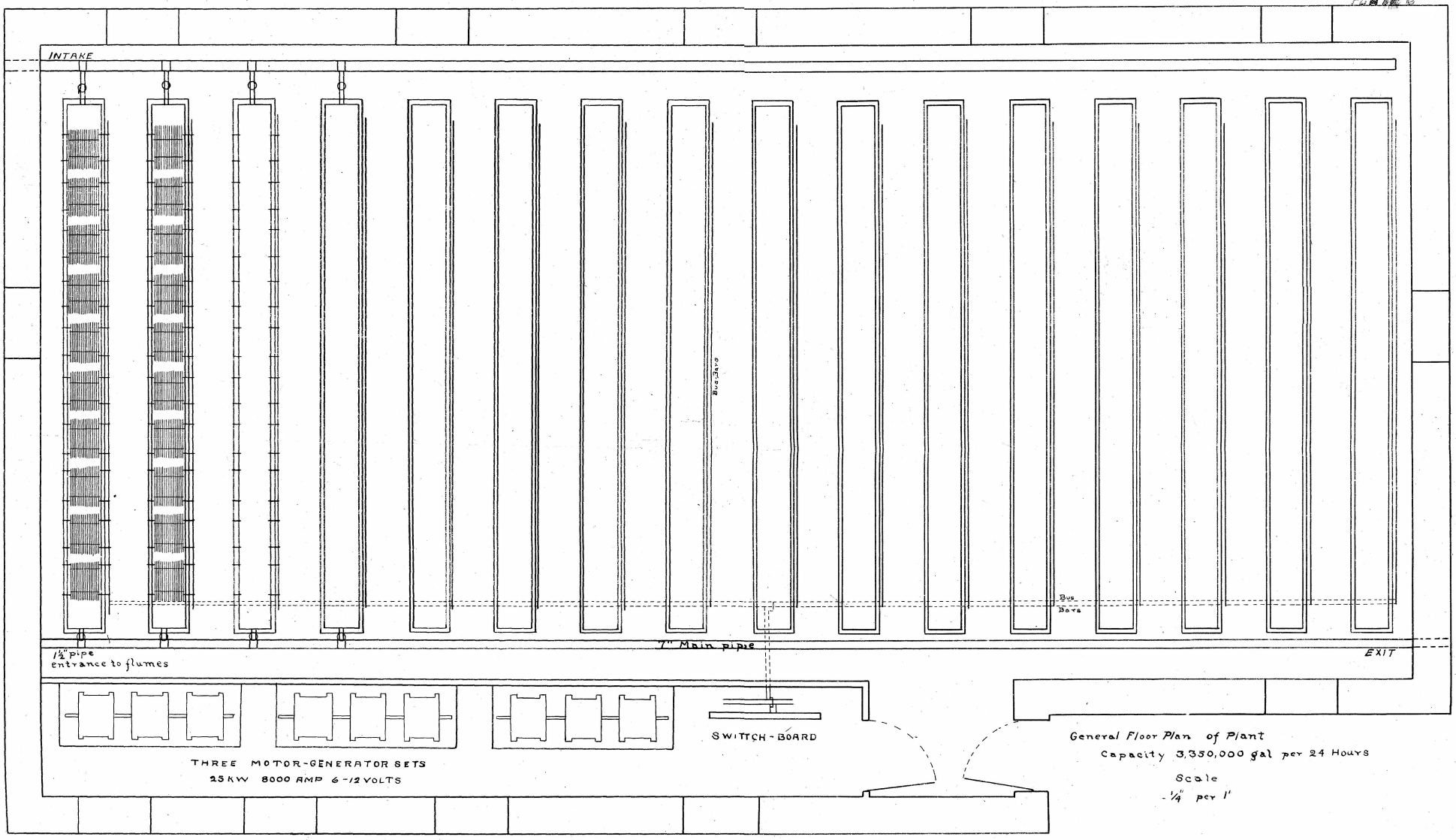
Other cities have in operation similar electro-chemical methods, but because this method appears applicable to Pasadena, the fact should have no bearing on other installations.


Average Volts 4.
Unit Plate Surface 180 sq in.
PLATE 8
Effluent from exit of Septic tank.
Amperes.
3.5
3.0
2.5
2.0
1.5
1.0
.8
.6
.5
0
2
4
6
8
10
12
14
16
18
20
Time to kill in minutes.
Miller.

The foundation for this statement is easily seen, when the basis of this process is reviewed, ie., the chemicals for the process are produced in the sewage by the electricity. The elements, Chlorine, Oxygen, Magnesia, Carbonate, etc., must exist therefore in appreciable quantities in the local water supply; as is the case in Pasadena. This is not said in condemnation of the process, but to offset any attempt to use this article for mercenary ends in other localities, without first investigating local conditions as has been done in this investigation.

ELECTRO-CHEMICAL SEWAGE DISPOSAL PLANT.

PLATE 6



General Floor Plan of Plant
Capacity 3,350,000 gal per 24 Hours
Scale
- ¼" per 1'