A COMPARISON OF THE BIOCHEMICAL AND HIGH-RATE FILTRATION PROCESSES IN THE TREATMENT OF MILK WASTES OF THE BORDEN CONDENSERY AT PERRINTON, MICHIGAN

Thesis for the Degree of B. S.

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Robert W. Rothe

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A Comparison of the Biochemical and High-Rate Filtration Processes in the treatment of milk wastes of the Borden Condensery at Perrinton, Michigan

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by

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I wish to express my sincere appreciation and indebtedness to Mr. E.F. Eldridge for his advice and suggestions rendered to me in the preparation of this thesis.

INTRODUCTION

The purpose of this thesis is to compare two processes for the treatment of milk waste as applied to the needs of the Borden Company Milk Condensery located at Perrinton, Michigan.

This comparison will involve:

(1) A study of the factory and the wastes from it.

- (a) Source of wastes.
- (b) Volume.
- (c) Strength.

(2) A preliminary design of the treatment plant as follows:

- (a) High rate filtration with stone filter.
- (b) Biochemical treatment with ferric chloride and lime.

(3) Comparison of duties as to operation, etc.

(4) Determination of cost of each plant.

- (a) Initial or first cost.
- (b) Cost of operation.

(5) Comparison of relative effiencies of each plant as to treatment and operation.

(6) Selection of plant most suitable to Borden Condensery at Perrinton.

Experimental plants of both types have been set up and tried at the plant at Perrinton. Various rates of application and dosages being used. From the results of these tests and analyses compiled by Mr. E. F. Eldridge, the method giv-

ing the best results was determined and used in the writing of this thesis.

THE NATURE AND SOURCE OF THE WASTES

The selection of methods of treatment for milk wastes should be adapted to the local situation with particular reference to the degree of purification necessary and the characteristics of the waste from the milk plant in question.

The condensery at Perrinton is equipped for the separation of cream, condensing of milk, and the production of dry milk powder. The individual wastes that make up the composite for any one day at the plant consist of the following:

(1) Waste water from washing cans and other utensils.

(2) Scrub and rinse water from the floors. This includes any milk or cream and skimmed milk that spilled on the floor, and the dirt that collected.

(3) Waste water from toilets and washrooms.

Volume of Raw Waste

The volume of raw waste flow was determined by weir measurements from a 90° V-notch weir. The results of these measurements are compiled in Table 1.

Table No. 1 Flow Data $Q: 2.48(H)^{5/2}$

Date	9/14		9/15		10/4	
Time	H	Gal/Min.	H	Gal/Min.	H	Gal/Min.
8 A. M.	0.16	11.70	0.19	16.50	0.09	2.78
9 A. M.	0.19	16.50	0.23	28.20	0.15	9.70
10 A. M.	0.20	20.05	0.23	28.20	0.17	13.37
11 A. M.	0.19	16.50	0.23	28.20	0.20	20.05
12 Noon	0.23	28.20	0.28	46.25	0.20	20.05
1 P. M.	0.23	28.20	0.30	55.15	0.20	20.05
2 P. M.	0.26	33.44	0.30	55.15	0.22	26.50
3 P. M.	0.25	34.75	0.26	33.44	0.27	42.35
4 P. M.	0.25	34.75	0.28	46.25	0.29	50.20
		229.09/9		342.34/9		205.05/9
		= 25.47		= 38.04		= 22.80

25.47
38.04
<u>22.80</u>

86.39

86.39/3 equals 28.8 Average Flow (Gal/Min.)

TREATMENT OF MILK WASTES BY HIGH RATE FILTRATION

This method of disposal consists of applying the milk waste along with the recirculated effluent to a biological stone filter designed for a continuous application. In this way, the effluent which is returned from the filter mixes with the raw waste as it enters a holding tank, therefore causing considerable dilution and reducing the B. O. D.[1] of the raw waste. This reduced B. O. D. of the waste makes it possible to increase the amount and the rate in which it is applied. A quantity of treated waste equal in amount to the raw waste entering the holding tank is discharged continuously as the final effluent.

Design of a High Rate Filter

A plant giving complete treatment by this method consists of three units:

(1) A holding tank to equalize waste and give a longer period of operation for the filter.

(2) The filter.

(3) A settling tank to remove suspended material from the waste discharged by the filter.

Holding Tank:

Before any attempts were made at designing, the average daily flow from the condensery was determined from flow measurements taken over a period of several weeks under

1 Biochemical Oxygen Demand

conditions of normal operation. This data and results are shown in table number 1. Composite samples of the raw waste were also taken and analysed for 5 day B. O. D. as shown in Table number 2.

Results of Analyses of Milk Filter

Table No. 2 Composite Samples

Date	5-Day B. O. D.			Suspended Solids		
	Raw ppm	Final Effluent ppm	Reduction %	Raw ppm	Final Effluent ppm	Reduction %
9/6	355	27	92.4	304	76	75.0
9/7	675	38	94;4	472	70	85/0
9/8	350	70	80.0	272	98	64.0
9/9	803	48	94.0	1108	120	89.2
9/11	540	42	92.3	644	76	88.1
9/12	573	47	91.6	282	106	62.4
9/13	407	50	87.7	264	88	66.6
9/14	413	43	89.4	606	128	78.8
9/15	713	49	93.1	404	62	85.4
10/4	775	**	****	***	***	****
AVERAGE	560	46	91.8	434	92	77.1

The average B. O. D. of the effluent from the present filter at Perrinton is 46 ppm. The raw waste entering the holding tank has an average B. O. D. of 560 ppm.

Previous experiments have shown that the mixture applied to the filter gave best results if the B. O. D. when applied was between 150-200 ppm.

By recirculating a mixture 8 times the raw waste flow,

the reduced B. O. D. of the mixture by dilution was found to be 110 ppm.

1/8 of recirculation is raw waste--B. O. D.=	560	1 x 560=	560
7/8 of recirculation is final eff. B. O. D.=	46	7 x 46=	322
		8 parts	882

B. O. D. of mixture is 882/8 = 110 ppm, which is within the limits prescribed for best results.

The holding tank is designed for a capacity equal to the total daily flow plus 25% for night flow. The waste is discharged for nine hours a day, the greatest concentration is around four o'clock in the afternoon, when considerable washing up of the plant occurs. The night flow is relatively low and is practically clear water.

Average flow equals 28.8 Gallons per minute.

28.8 x 9 x 60 equals 15,550 Gallons

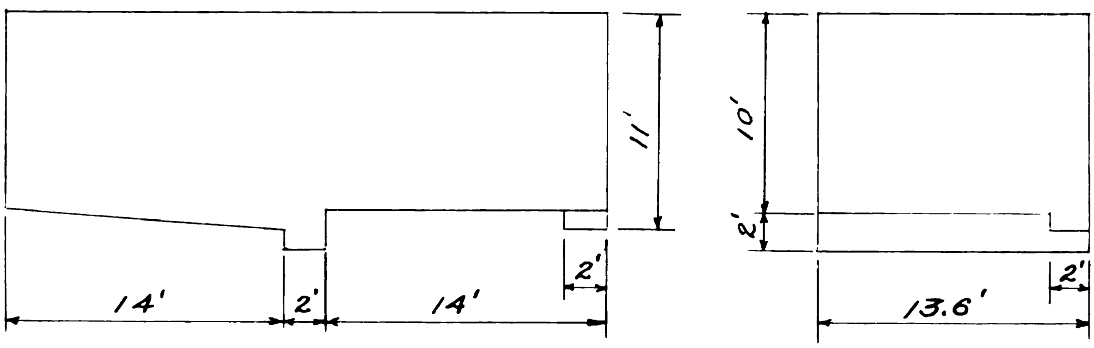
25% increase equals 3,885 "

19,435 Gallons

Required capacity of the tank: 19,435/7.48 = 2,598 Cubic feet. The tank was designed to allow for settling and the removal of sludge accumulated. The bottom of the tank was given a slope at the entrance so that there is a drop of one foot in fourteen feet to a sump which is deeper by one foot. The sump was made two feet in width and has a baffle separating it from the rest of the tank. A t one end of the sump there is a draw-off pipe and valve which runs through the wall separating the holding tank from the settling tank. (The same pump and pipe line is used for drawing sludge from both tanks. Gate valves are placed in the line so that they may be drawn off separately.) At the far end of the holding tank a 2' x 2' x 1' sump and pump was placed to pump the mixture to the filter.

Calculations:

Required capacity of tank equals 2,598 cubic feet.



Actual volume from adopted dimensions:

Sump (2 x 2 x 1)	=	4.0
Sludge tank (11 x 13.6)	=	149.6
Remainder of tank (30 x 6 x 13.6)	=	2448.0
		2601.6
Allow 3.5 foot freeboard	=	630.0
		3231.6 cubic feet

Actual height of water surface (from top of sump)

$$2598 - 4 - (11 \times 13.6) = 30 \times 13.6\ h$$

$$2598 - 149.6 = 408.8\ h$$

$$h = \frac{2444.4}{408} = 6 \text{ feet}$$

Design of Filter:

The filter is designed for the application of 200,000 gallons of water per acre per day.

The amount of waste applied is:

$Q = 8 \times$ average raw waste flow

$= 8 \times 28.8 \times 60 \times 24 = 332,000$ gallons per day

Filter area required:

$A = (332,000 \times 43,560)/2,000,000 = 726$ square feet

$d = V \times 4/3.142 \times 726$

$= 30.4$

The filter consists of a large cylindrical reinforced concrete tank set above the surface of the ground. The bottom was given a slope of 1" in 8' in the direction of the outlet. Drainage is by half-tile pipe laid in parallel rows with open joints running towards the outlet. To facilitate drainage, a small rectangular channel was set in the floor and covered with loosely jointed brick so that the upper surface of the brick is flush with the floor of the filter. At each end of the parallel lines of tile drains on the floor an upright 6" tile pipe is placed to provide circulation of air to the stone. This pipe is placed to provide circouculation and extends just to the surface and is supported by the stone surrounding it.

The size of stone used varies from four inch diameter for a depth of one foot to a size between 2½" and 3½" up to the surface making a total depth of six feet. A four foot pier was constructed in the center for holding the shaft of the ro-

tating distributor. It is of rectangular cross section varying from a side of two feet at the base to one foot at the top. The shaft of the rotating arm is stationary, and fixed into the concrete so that over 2/3 of it is embedded for support. The pipe line from the pump at the holding tank joins this shaft in a tee connection just above the pier, but below the surface of the stone. Various types of distributors may be purchased from concerns specializing in their construction. The type contemplated for use in this problem was one which would be supported on the end of the fixed shaft by a ball bearing arragement at the end.

The influent from the holding tank is mixed with the recirculated waste from the filter and applied at the rate of 230 gallons per minute.. This diluted waste was proportioned so that 1/8 of it is raw waste and 7/8 the recirculated effluent from the settling tank. Thus, a volume equal to 8 times the raw waste from the plant is applied continuously to the filter, and an amount equal in volume to the raw waste is discharged to the stream, after passing through the settling tank.

The Settling Tank:

The effluent from the filter flows by gravity into the settling tank. The pipe enters the end of the tank at an angle so that the wall is used as a baffle in abating its velocity. A weir equal in length to the width of the tank was placed at the other end. The effluent flows over this weir into a small channel which in turn discharges into a

weir box with a 90° V-notch. An outlet in the bottom of the box returns 7/8 of the flow to the inlet pipe of the raw waste as it enters the holding tank. The remainder of 1/8 of the effluent, which is equal to the volume of the raw waste flows over the weir and is discharged into the stream.

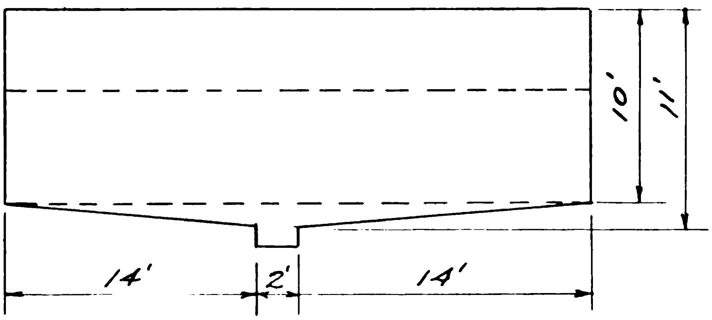
The tank is designed with a hoppered bottom designed so there is a detention period of 30 minutes. A sludge draw-off pipe and valve is placed at the center of the tank. This same pump and pipe line is used for drawing sludge from the holding tank.

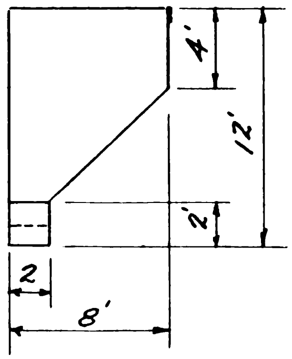
Calculations:

Tank Capacity:= 1/24 x detention period x flow

1/24 x 1/2 x 332,000 = 6,920

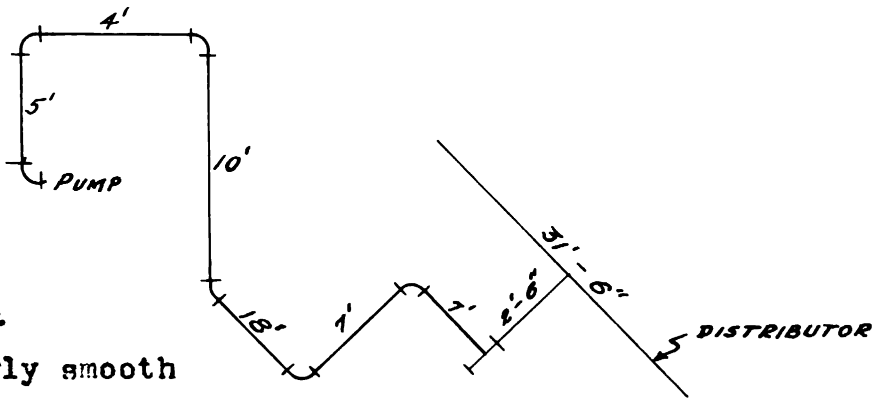
6,920/7.48 = 925 cubic feet required





Volume of designed tank:

2 x 2 x 2	=	8
2(1 x 7) x 2	=	28
6 x 2 x 30	=	360
6/2 x 6 x 30	=	540
		936 cubic feet
3.5 x 8 x 30	=	840 " " Freeboard



Pipe friction

c 120 - fairly smooth
f 0.0269

h $fl/d \times V^2/2g$

$\frac{0.0269}{4/12} \times V^2/2g$
$0.0807 \times V^2/2g$

Item		$V^2/2g$
Entry		1.00
90	Bend	0.50
5' -4"Pipe		0.42
90	Bend	0.50
4'	Pipe	0.32
90	Bend	0.50
10'	Pipe	0.81
45	Bend	0.13
18'	Pipe	1.45
90	Bend	0.50
7'	Pipe	0.56
	Tee	1.50
2' - 6"Pipe		0.21
	Total	9.46

Area of 4" pipe 0.0873

Q 230.4 g.p.m.
0.513 c.f.s.

V Q/A $\frac{0.513}{0.0873}$ 5.87'/sec.

$V^2/2g$ $\frac{(5.87)^2}{64.4}$ $\frac{34.7}{64.4}$ 0.538

Loss -
9.46 x 0.538 5.10

Loss in distributor

30 Openings
assume 3/8" diameter

A $0.7856(1/32)^2$
0.000767

Q per nozzle -
$\frac{0.513}{30}$ 0.0171 c.f.s.

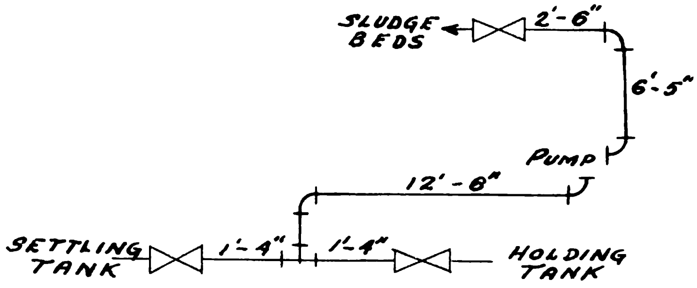
V Q/A

$\frac{0.0171}{0.000767}$ 22.3'/sec.

1.5 $V^2/2g$ $\frac{1.5(22.3)^2}{64.4}$

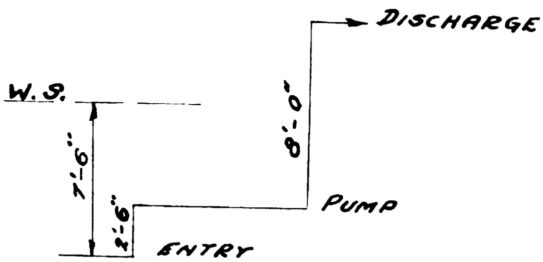
Loss 11.64'

ws	elevation of dist.	103.5
w.s.	" in hold tank	93.0
	static head	10.5
	dist. loss	11.64
	pipe losses	5.10
	Total pumping head	27.24



Item	$V^2/2g$
Entry	1.00
Gate valve	0.10
1'-4"Pipe	0.11
Tee	1.50
90 Bend	0.50
12 1/2'Pipe	1.01
90 Bend	0.50
Pump	
90 Bend	0.50
6 1/2'Pipe	0.64
90 Bend	0.50
2' - 6"Pipe	0.20
Gate valve	0.10
Discharge	1.00
Total	7.66

h 7.66 x 0.00405 0.031



Pipe friction

c 120 fairly smooth

f 0.0269

h $fl/d \times V^2/2g$

$\frac{0.0269}{4/12} L\ V^2/2g$

$0.0807(L)\ V^2/2g$

A 4" pipe 0.0873

Q 20 g.p.m.
0.0445 c.f.s.

V Q/A $\frac{0.0445}{0.0873}$ 0.51'/sec.

$V^2/2g$ $\frac{(0.51)^2}{64.4}$

$\frac{0.2615}{64.4}$ 0.00405

Static head	3.00'
friction "	0.03
Total pumping "	3.03 feet

BIOCHEMICAL TREATMENT

The biochemical treatment process of milk waste treatment is known as the Guggenheim Process, patented by the Guggenheim Brothers, New York City.

In this process the milk waste is treated with ferric chloride and lime and then aerated. The floc resulting from aeration is allowed to settle, and the sludge which is accumulated is returned to the raw waste to pass again through the process.

From previous tests run on the raw wastes at Perrinton, it was found that lime applied at the rate of 100 ppm and ferric chloride at 30 to 40 ppm gave the best results when aerated for a period of four hours.

DESIGN OF TREATMENT PLANT

The plant for this type of treatment consists of the following units:

(1) A holding tank for receiving the raw waste.

(2) Chemical tanks.

(3) Mixing device.

(4) Aeration tank.

(5) Settling tank.

<u>Holding Tank</u>:

The volume of the tank is designed so that is is possible to pump at a constant rate and have the tank emptied once every 24 hours. The pumping rate was determined from

The average hourly flows compiled from the flow data of the plant. A pumping rate of 25 gallons per minute was found to be sufficient. By starting the pump in operation at 10 A. M., there is sufficient accumulation of raw waste to permit a constant operation of the pump through the whole working day. The maximum raw waste flow occurs at 4 o'clock when considerable washing up occurs in the plant. The maximum volume which will be in the tank will occur at about this time and amounts to 6,328 gallons. The raw waste flowing into the tank gradually decreases after four o'clock so that the pumping rate soon exceeds it and eventually empties the tank.

A tank of 8,000 gallons capacity was required.

$$\frac{8,000}{7.48} : 1,070 \text{ cubic feet}$$

Thus the pump will be in operation about 12 hours each day.

The table below shows volume of waste in the tank for any hour of the day.

Time	Raw Waste Flow Gal/Min	Raw Waste Flow Gal/Hr	Draw Down By Pump 1500 Gal/Hr	Volume of Waste In Tank Gallons
7-8 AM	10.33	620	None	620
8-9 AM	14.80	888	None	1508
9-10 AM	20.54	1230	Start Pump	2738
10-11 AM	21.58	1295	1500	2533
11-12 AM	31.50	1890	1500	2923
12-1 PM	34.50	2070	1500	3493
1-2 PM	40.03	2400	1500	4393
2-3 PM	38.51	2310	1500	5203
3-4PM	43.73	2625	1500	6328

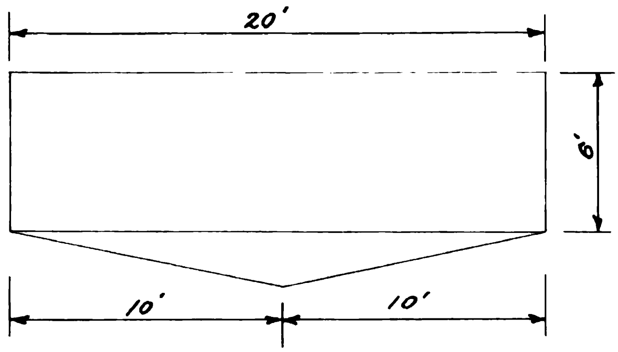
BIOCHEMICAL TREATMENT OF MILK WASTE

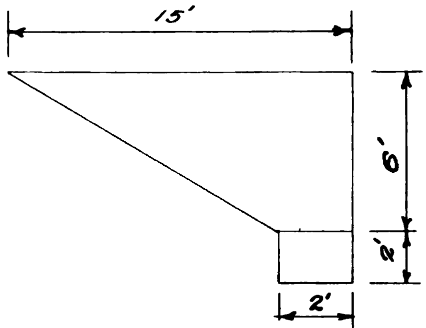
Aeration time ; 4 hours
Settling time : 2 hours
Lime : 100 p.p.m.
Ferric chloride : 30 p.p.m.

5-day B. O. D.			Aeration tank	
Raw ppm	Treated ppm	Reduction Percent	Air Cu.ft./Gal.	Suspended Solids ppm
122	5	95.8	-	3340
150	10	93.4	1.5	5004
170	11	98.8	2.0	2204
190	40	79.0	-	--
200	16	92.0	3.7	2792
204	15	92.8	1.3	2868
214	34	84.2	-	--
231	30	87.0	1.1	1048
233	5	97.8	2.5	4476
250	30	88.0	1.3	3064
258	33	91.1	1.3	--
263	17	93.6	3.6	2404
266	17	93.6	2.0	2168
285	55	80.6	2.0	--
290	39	86.5	2.5	--
290	23	92.0	3.1	--
336	30	91.0	1.1	1616
338	32	90.6	1.4	3844
343	60	82.5	2.0	2352
356	48	86.5	1.6	2568
400	37	91.0	2.8	3156
400	37	91.0	2.5	4292
408	129	68.5	-	--
415	34	91.7	2.6	3924
447	64	85.7	-	--
450	35	92.3	3.4	2208
480	34	93.0	3.0	1024
450	25	94.4	2.5	3664
500	36	92.9	3.0	3000
525	57	89.2	2.0	2264
536	52	90.2	2.0	1904
624	78	87.5	2.0	2200
650	48	92.6	2.7	1016
654	42	93.6	3.0	2524
664	147	77.9	2.0	2200
740	42	94.4	3.0	1032
815	107	86.8	2.8	3000
1000	107	89.3	3.0	7520
1004	120	88.0	3.0	1761
1268	135	89.5	2.0	2175
1300	43	96.5	3.0	2240
1550	156	90.0	2.0	2504
Avg 476	51	89.2	2.4	2746

DRAWING OF HOLDING TANK SHOWING DIMENSIONS

AND VOLUMES





Vpl. : 12 x 20 : 240
39 x 20 : 780
4 x 10 : 40
1060 cf
(Assume 1' free-board) 15 x 20 : 300

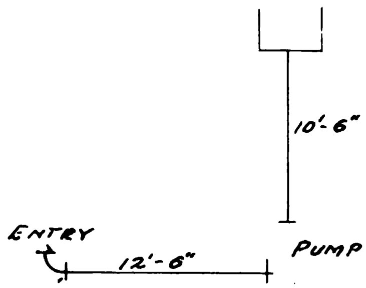
Maximum Volume : 1360 cf
(required volume : 1070 cf)

Volume of tank assuming one foot freeboard equals 1360 cubic feet. The tank was given a hoppered bottom to prevent any accumulation of solids on the sides. The draw off pipe was placed in the center so the exit is flush with bottom of the tank. The drawoff pipe runs to a pump set in the bottom of a well at the same elevation as the draw off pipe.

The tank is also provided with two lengths of air pipe, each 18 feet long to keep the raw waste in a fresh condition. A valve on the line permits adjustment in the amount of flow.

The raw waste pump is of the centrifugal type. The pipe line from tank to pump was designed to give a velocity of 215 feet per second at the point of discharge, into a mixing box $10\frac{1}{2}$ feet directly above the pump. A pipe 2 inches in diameter was used to give this velocity and thereby provide turbulence for the mixing of the chemicals in the box.

The calculations for the pipe line and the horsepower required follow:



Pipe friction

$c = 120$
$f = 0.033'/\text{sec.}$

$h = fl/d \times V^2/2g$

$= \dfrac{0.033}{2/12} L\ V^2/2g$
$= 0.198\ L(V^2/2g)$

$Q = 25$ g.p.m. $= 0.0556$ c.f.s.
$V = 2'/\text{sec.}$

Use a 2" pipe

$A = 0.7856 \times (2/12)^2$
$= 0.02182$

$V = Q/A$
$= \dfrac{0.0556}{0.02182}$
$= 2.55'/\text{sec.}$

$V^2/2g = \dfrac{(2.55)^2}{64.4}$
$= 0.101$

Item	$V^2/2g$
Entry	0.10
90 Bend	0.50
12.5'Pipe	2.50
10.5'Pipe	2.30
Discharge	1.00
	6.40

Friction head $= 6.40 \times 0.101 = 0.646'$
Static head $= 10.50$
Total head $= 11.146'$

Horse power of pump required. (assume 50% efficient)

$$\text{H.P.} = \frac{25 \times 8.34 \times 11.146}{330000 \times 0.50} = 0.1448$$

Assuming motor is 85% efficient -

$$\text{H.P.} = \frac{0.1448}{0.85} = 0.1700$$

Use a 1/4 H.P. motor

Mixing Box and Chemical Feeders:

The velocity from the centrifugal pump upon discharge into the mixing box gives sufficient turbulence to the waste so that the lime and ferric chloride which are added at this point are kept in constant motion.

The box is of rectangular cross-section with a 60 degree V-notch outlet at one end.

Amount of Lime:

The lime is applied by means of an electrically vibrated feeder manufactured by the Jeffry-Traylor Co. The capacity is regulated by means of a calibrated dial transformer. For this installation it is to be set to deliver 100 ppm or 1.25 pounds per hour.

Q : 25 Gallons per minute
1 ppm : 8.34 pounds per million gallons

$$\frac{100 \times 25 \times 60 \times 8.34}{1,000,000} : 1.25 \text{ lbs./hour}$$

The feeder can be provided with one, three, or five cubic feet hopper capacities, furnished by the manufacturer.

Amount of Ferric Chloride:

A 40% solution of ferric chloride is to be applied by means of a siphon set to deliver 30 ppm or 0.375 pounds per hour.

$$\frac{30 \times 25 \times 60 \times 8.34}{1,000,000} : 0.375 \text{ lbs./hour}$$

$$.375 \times 1000/2.2 : 170.5 \text{ grams}$$

A 40% solution is used:

$$170.5/.40 : x/6$$
$$x : 255.5 \text{ g of } H_2O$$
$$170.5 \text{ g of } FeCl_3$$

$170.5/255.5 = .677$ grams per cubic centimeter

$255.5/60 = 4.26$ cc per minute

$.677 \times 4.26 \times 2.2/1{,}000 \times 60 = 0.375$ # per hour.

Therefore, the ferric chloride siphon is set so that it delivers 4.26 cubic centimeters per minute. With a constant flow of this amount, a five gallon bottle is of sufficient capacity to allow a run of six days before refilling.

1 gallon = 3,785 cubic centimeters

$$\frac{5 \times 3{,}785}{4.26 \times 60 \times 12} = 6.18 \text{ days}$$

Gravity Flow to Aeration Tank:

The milk waste flows by gravity from the mixing tank to the aeration tank. It is carried by means of a 60° triangular trough with a side of one foot in length attached to the outlet at the end of the box. The trough has a slope of ½ foot in ten feet from the mixing box to the return sludge pipe. At this point, the trough changes its direction 90° and follows the wall of the aeration tank to within one foot of the end wall where the waste is discharged. This slope of the trough and the 90° bend provides a hydraulic pump effect so that the milk waste chemicals and return sludge should be well mixed upon discharge into the aeration tank.

Aeration Tank:

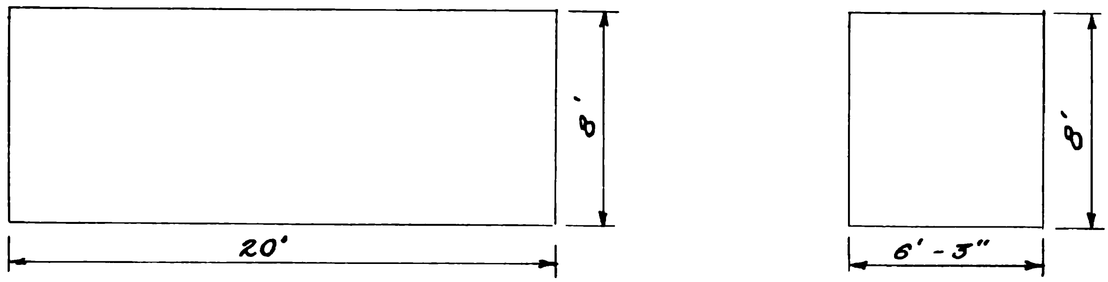
The capacity of this tank is designed so that there is four hours retention.

4.0 x 25 x 60 equals 6000 gallons

Twenty-five percent of the total flow is allowed in the aeration tank also for return sludge.

6000 plus 1500 equals 7500 gallons

$\frac{7500}{7.43}$ equals 100 cubic feet required.



Vol. 8 x 6.25 x 20 : 1000cf
Assume 1 foot freeboard
20 x 6.25 : 125

1125 c. f.

The aeration tank was made rectangular, and the same in depth and length as the holding tank to make possible the use of a common wall for the two tanks. The total volume of the tank including one foot freeboard is 1125 cubic feet.

Previous experiments show that a quantity of air equal to 5 cubic feet per gallon give the best results, with 15% of the surface area provided as aeration area.

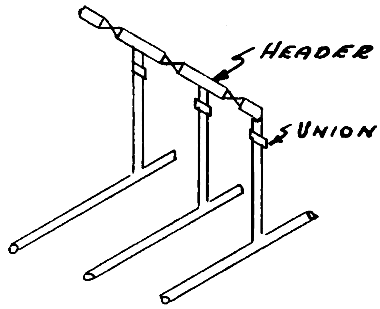
The diffuser pipe used in the experiments were of 18" lengths perforated with 3/8 inch circular openings. Each length of pipe was wrapped in cloth fabric of the following dimensions:

$$\text{Width} = 4'' \qquad \frac{4}{12} \times \frac{18}{12} = \frac{1}{2}^{\square'} \text{ per } 1.5' \text{ of pipe.}$$
$$\text{Length} = 18'' \qquad = 1^{\square'} \text{ '' } 3' \text{ of pipe.}$$

Surface area of tank -
$$20 \times 6.0 = 120^{\square'}$$

15% of surface area is for aeration -
$$120 \times 0.15 = 18 \text{ sq. ft.}$$
$$18 \times 3 = 54 \text{ ft. of fabric covered pipe required.}$$

Three lines of $1\frac{1}{4}$ " pipe at 18' per line were placed at the bottom of the tank. A header was placed above the surface of the tank as shown in the sketch.



The header is provided with valves, so that each line of air pipe may be regulated separately, or be removed for repairs without interrupting the operation of the others. Two air meters were placed on the delivery line from the air compressor so that the quantity cf flow may be measured for the aeration tank and the air lift.

The effluent from the aeration tank flows into the settling through a triangular outlet located disagonally opposite the point at which the waste enters.

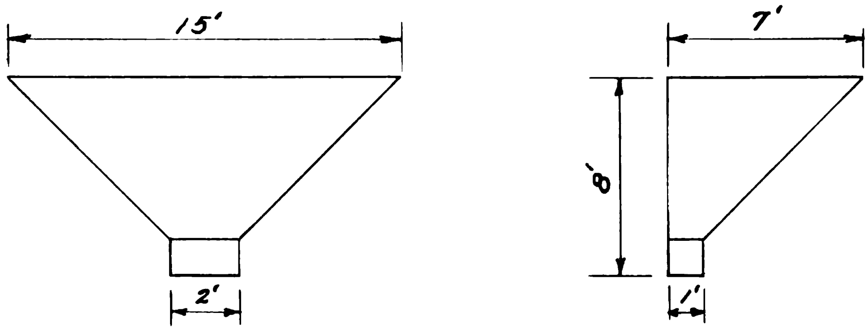
Settling Tank:

The settling tank is designed for a retention period of one hour.

25 x 60 x 1 : 1500 gallons

Allowing 25%, or about 400 gallons for the sludge which is being continually recirculated back with the raw waste, 2000 gallons capacity is sufficient.

$\frac{2000}{7.48}$ equals 267 cubic feet required



The tank is designed with hoppered bottom and small sump at bottom of 2 cubic feet capacity. An air lift pipe is used to lift the settled sludge to the surface where it is discharged into the raw waste as it flows to the aeration tank.

Air Lift:

25% of the flow is recirculated into the raw waste by the air lift

$Q = \frac{25}{4} = 6.25$ g.p.m. $= 0.0139$ c.f.s.

Try a 2" sludge pipe $A = 0.01228$

" " 1/2" air " $A = 0.00136$

$$V = Q/A = \frac{0.0139}{0.01228 - 0.00136} = \frac{0.0139}{0.01092} = 1.25'/\text{sec.}$$

The air pipe is placed within the eduction pipe.

The amount of air for the lift is regulated by a valve placed between the delivery pipe and the main line. To take care of excess sludge, a sludge pipe was placed at the top of the eduction pipe to carry the excess off where it can be discharged or hauled away. A valve was placed on both lines so that the flow of sludge through each may be regulated.

The elevation of the water surface in the aeration and settling tanks is kept constant by a rectangular weir placed on the discharge side of the settling tank. The supernatant effluent discharges over the weir into a small flume which in turn discharges into a weir box and thence to the stream.

The weir box will enable measurement of flow so that the pumping rate from the holding tank may be known at any time.

DETERMINATION OF COST

Concrete in Filtration Plant:

(1) Holding and settling tanks: (assuming a wall 10" thick)	2005 cu.ft.
(2) Filter base and wall (1" thick)	1810 cu.ft.
Covering of holding tank was assumed 6"	3815 cu.ft. / 27
	141.5 cu.yd.

Concrete in Biochemical Plant:

All walls and floors 10" thick

Holding tank cover 6" thick

Weir and mixing boxes 6" thick

Total volume required : 1647.7 cu.ft.

: 61.0 cu.yd.

COST OF FILTRATION PLA NT

Item	Quantity	Unit Price	Amount
Excavation	340 cu.yd.	$ 1.00	$ 340.00
Reinforced Concrete and forms	141.5 "	30.00	4250.00
4" C. I. Pipe	76.3'	.60	46.00
4" 90° Bends	9	1.25	12.50
4" 45° Bends	1	1.25	1.25
4" Gate Valves	2	50.00	100.00
4" x 4 x 2 Tees	2	1.25	2.50
Valve Stands	2	20.00	40.00
230 gpm Pump and Motor	1	400.00	400.00
20 gpm " " "	1	150.00	150.00
Rotating Distributor	1	150.00	150.00
Split drain tile	200 '	.10	20.00
Brick	200	$15./1000	3.00
6" Tile Uprights	54	.40	21.60
Filter Stone	187 cu.yd.	3.00	561.00
Electric Wiring		75.00	75.00
			$ 6172.00
Contingencies : 15%			925.00
Estimated Total Cost			$ 7098.85

COST OF BIOCHEMICAL TREATMENT PLANT

Item	Quantity	Unit Price	Amount
Excavation	200 cu. yd.	$ 1.00	$ 200.00
Reinforced Concrete and forms	61 cu. yd.	30.00	1830.00
4" Gate Valves	1	50.00	50.00
25 gpm pump and motor	1	150.00	150.00
Air meters	2	75.00	150.00
Air compressor	1	250.00	250.00
$1\frac{1}{4}$" Air Pipe Galvan.	150'	.14	21.00
$1\frac{1}{4}$" Brass Valves	6	6.00	36.00
$1\frac{1}{4}$" Elbows	5	.30	1.50
$1\frac{1}{4}$" Tees	8	130	2.40
Lime Feeder	1	125.00	125.00
2" Pipe	46'	.25	11.50
Concrete-Triangular Trough	.75 cu. yd.	30.00	22.50
4" C. I. Pipe	17.5'	.60	10.60
4" 90° Bend	2	1.25	2.50
			$ 2662.90
Contingencies: 15%			400.00
Estimated Total Cost:			$ 3062.90

OPERATING COSTS

High Rate Filtration:

(1) Depreciation:

A life of 20years is assumed with depreciation at 5% per year.

$7097.85 x 0.05 : $ 360.00

(2) Labor:

The labor required amounts to about two hours per day. Assuming $1.00 per day, 1 x 365 365.00

(3) Pumping costs:

The raw waste pump is the largest item. Cost of electricity is assumed to 2 cents per kilowatt hours. For a 3 H. P. pump,

3 x .746 x 24 x .02 x 365 : 392.00

Sludge pumping costs: 8.00

Total operating cost: $ 1125.00

Biochemical Treatment:

(1) Depreciation: at 12%

.12 x $3062 : $ 366.00

(2) Labor:

Approximately ½ day by skilled operator. $100 per month.

$100 x 12 : 1200.00

(3) Lime: 1.25 # per hour: 12 hour operation.

1.25 x 12 x 6 x 52 : 4675 lbs.per year

4625/2000 @ $18./Ton in sacks : 42.00

(4) Ferric Chloride: 0.375#/Hr.

0/375 x 12 x 6 x 52 : 1400 #/Yr.@ .07: 93.00

(5) Pumping Cost:

@ $.02 per kilowatt hour

For a 2 horsepower motor,

2 x .746 x 24 x .02 x 365	:	$ 260.00

Total Operating Cost:	$ 1966.00

COMPARISON OF DUTIES

Filtration Plant:

(1) Three to four weeks is required to develop the filter organisms. To aid in building it up, a water extract of manure may be used.

(2) Composite samples should be collected and analysed occasionally to determine the strength of the waste applied. If it becomes too strong, provision must be made for diluting it with clean water.

(3) The holes of the distributor arms must be made clean occasionally.

Chemical Treatment:

(1) A trained operator should be at hand at least half of the day. He should run tests and analyses occasionally to check the efficiency of treatment.

(2) The holding tank must be completely emptied once each day to prevent septic conditions. The walls should be washed with water once a week to prevent septic actions.

(3) Raw waste should be kept fresh by passing a small quantity of air into it.

(4) The lime feeder should be maintained to deliver 1.25# per hour at a pumping rate of 25 gpm.

(5) The ferric chloride siphon should be set to deliver about 4 cubic centimeters per minute.

(6) The amount of air delivered to the aeration tank should be 5 cubic feet per gallon or 125 cu.ft. per minute when pumping at 25 gallons per minute.

(7) The sludge in the setling tank must be kept moving into the aeration tank. If an accumulation of sludge occurs septic conditions will develop which may upset the process.

(8) Suspended solids in the aeration should be maintained at 3000 p.p.m.

COMPARISON OF ADVANTAGES

Treatment	First Cost	Operating Cost Per Year	Average Reduction B. O. D.
Filtration	$ 7097.85	$ 1125,00	91.8 %
Biochemical	$ 3062.90	$ 1966.00	89.2 %

From the comparison of duties it is evident that the high rate filtration process requires the least attention for efficient operation. The first cost of this plant is twice that of the biochemical treatment, but the operating costs of the latter is higher since much more attention is required to maintain the proper proportioning of chemicals, waste, and air. The average B. O. D. reduction is about the same for each plant, both processes being very efficient.

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Pocket has 3 Plans