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AN EXPERIMENTAL STUDY OF
SALT CONSUMPTION IN THE
EAST LANSING WATER PLANT

Thesis for the Degree of B. S.
Floyd Vermette
1936

THESIS

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Water - Softening

Civil engineering Sanitary engineering

An Experimental Study of Salt Consumption
in
The East Lansing Water Plant

A Thesis Submitted to
The Faculty of
MICHIGAN STATE COLLEGE
of
AGRICULTURE AND APPLIED SCIENCE

By

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Candidate for the Degree of
Bachelor of Science

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THESIS

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F. L. V.



East Lansing Water Treatment Plant

OBJECT

The object of this thesis is to find by experiment the least amount of salt it is necessary to use in each of the five softening tanks of The East Lansing Water Plant, and to suggest any improvements which would make the plant operate more economically.

INTRODUCTION

Zeolite is a name given to a group of minerals commonly found in cavities in igneous rocks, from which they are derived through secondary alteration. They include thompsonite, natrolite, scolecite, analcite, chabazite, gmelinite, phillipsite, harmotome, stillite and heulandite. The name is derived from the boiling reaction before the blowpipe. The engineer, though, defines a zeolite as any chemical compound so imperfectly bound together that its composition will change dependent upon the concentration of chemicals in solution in its presence.

Commercial zeolite is usually artificially manufactured because of its greater purity. Artificial sodium zeolite ($\text{NaAlSiO}_4 \cdot 3\text{H}_2\text{O}$) known as "permutite," is the material used in water softeners, because it will exchange its sodium for the calcium, magnesium, iron and aluminum of the hardness producing compounds in the water, thus leaving the water with as many chemicals in it but with zero hardness. When the calcium, magnesium, iron or aluminum zeolite is then placed in a solution containing a greater concentration of sodium, the sodium replaces the previously mentioned elements and the original zeolite is obtained.

In a zeolite softening plant the sand is contained in tanks - over a layer of gravel - through which the water to be softened is passed down until the non-hardness producing substances of the zeolite have been exchanged for hard-

ness producing substances of the water. The sand is then washed by running water upward through the tank to remove any particles of material and dirt which may have been caught in the sand. A standard sodium salt brine is then run through the tank in the same direction as is the water to be softened, until the reverse of the chemical reaction of softening takes place. The filter is then rinsed by passing raw water downward through it for a certain length of time. All effluent of the regenerating process is discharged into the sewer.

A portion of the brine which has passed through the tanks is saved in some cases but its value is doubtful. Its practical value will be shown in this paper to be negative.

The largest cost item in the operation of a zeolite water softening plant is for the salt necessary to regenerate the zeolite sand; therefore, in order to operate most economically, the salt dose must be cut to a minimum. A zeolite water softening plant has the advantage over other types of being able to produce zero hardness water if desired, and there is no sludge to dispose of as in other methods. A zeolite plant can also be made automatic so that it does not require the constant attention of an attendant, whereas it would be a much more difficult task to construct a soda ash or lime treatment plant to be entirely automatic. Other types of softening with coagulation, though, are more adapted to use with water which must be filtered, for the coagulant removing the hardness also serves to re-

move other objectionable impurities, but it requires more space than the zeolite plant and a method of disposing of sludge must be provided.

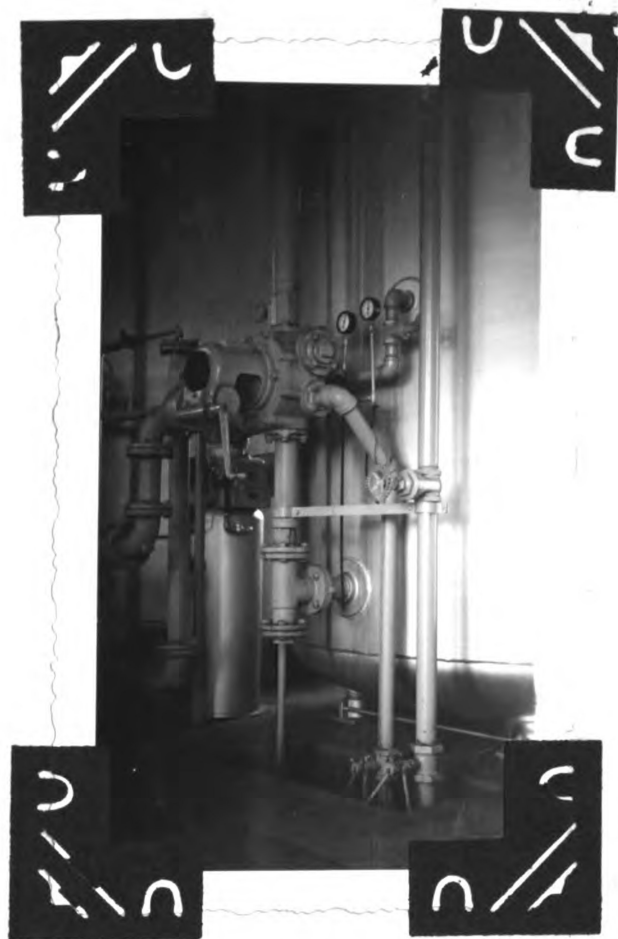
In the United States and abroad, zeolite softeners have been used for more than twenty five years for softening water from various supplies and for various consumers such as laundries, the textile industries, boiler feed, breweries, etc. At the present time there are over 150,000 installations of zeolite water softeners, both large and small, in the United States. Household installations, however, are decreasing in number with the increased use of municipal softening and treatment.



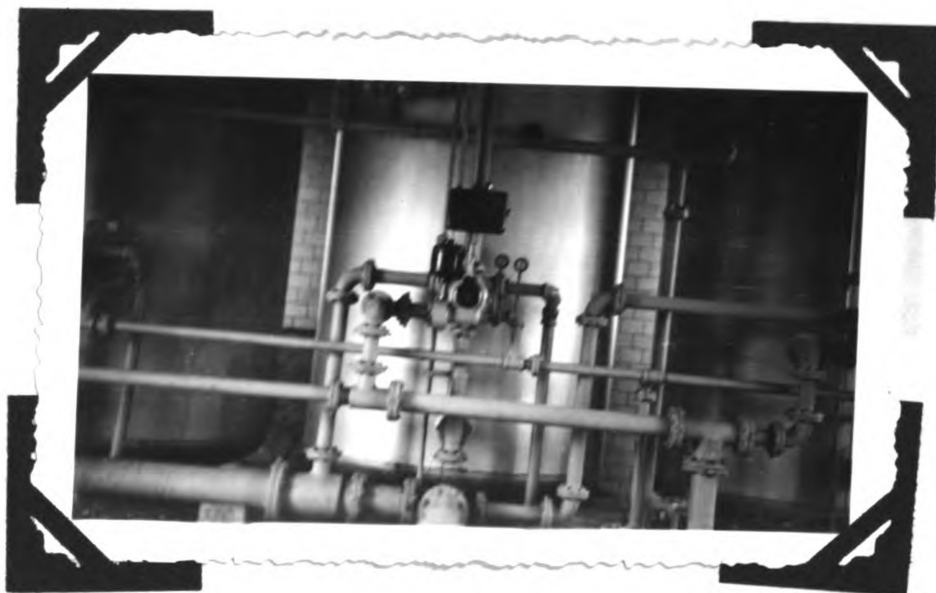
Well pump motor
Well # 1

DESCRIPTION OF THE EAST LANSING WATER PLANT

East Lansing's water treatment plant is on the east side of town, working with a total clear water storage of 110,000 gallons, 100,000 of which is effective. There is a 100,000 gallon storage tank at the site of the treatment plant and a 10,000 gallon tank on the west side of town, but some of the total capacity must be used for cushioning. This is small for a population of 8000, as East Lansing has, for it provides only a two hour average flow. The daily consumption of water ranges from approximately 350,000 gallons in winter to 800,000 or 1,000,000 gallons in summer. The plant runs intermittently, alternately filling and allowing the tank at the site of the plant to be emptied. If the plant ran continuously it would have a capacity of 1,000,000 gallons per day. The water is drawn from two 12 inch diameter wells. Well number one is directly under the plant and is 390 feet deep, its casing sunk to a depth of 150 feet with a strainer 170 feet below the floor of the pumping pit. The floor of the pumping pit is 10 feet below the surface of the ground. Well number two is a little to the north of the plant and is automatically cut in only in case well number one is insufficient to supply the demand. Well number two is 392 feet 9 inches deep and equipped with a six stage centrifugal pump. Well number one has a five stage pump. The casing is sunk to a depth of 150 feet and the strainer is 170 feet down as in well number one.



Multiport valve and piping
Tank # 6



Multiport valve and piping
Tank # 12

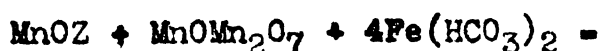


Control panel

The water, as it comes from the wells, has a hardness of approximately 300 parts per million and is softened to about 70 parts per million by dividing the flow to go nearly one-fourth through two iron removal tanks, and the rest through five softening tanks. The iron removal tanks are the same size as the softening tanks, seven feet in diameter by nine feet in height. They each contain 100 cubic feet of manganese zeolite sand and reduce the iron content of the water from 1.0 part per million to 0.1 part per million. This amount of iron in water, although very small, is objectionable because of the rust it produces on clothes washed in water containing as small an amount as 1.0 part per million of iron. Manganese zeolite sand is made by treating sodium zeolite sand with manganese chloride, and then oxidizing it with sodium or potassium permanganate. The reactions are:



In the latter reaction, the higher oxides of manganese formed are carried to the surface of the grains of zeolite. When water is then passed through the sand, these oxides give up their oxygen to the iron of the water in the following reaction:



The ferric oxide thus formed is insoluble and is precipita-

ted on the grains of zeolite. These iron removal tanks are regenerated by hand with a manganese salt solution each time *after* approximately 1,050,000 gallons of water has passed through each tank. The maximum rate of flow through the iron removal tanks is 105 gallons per minute per tank, and the maximum working pressure is 75 pounds per square inch.

The five softening tanks are regenerated as previously described. Their operation is automatic, being electrically controlled by a time sequence switch especially designed for the purpose. The time sequence switch operates the motor on the multiport valve to regenerate the tanks at the proper time. Each tank contains 200 cubic feet of sodium zeolite sand and uses about 14 inches of brine from the 18" x 60" brine tank (655 gallons) for each regeneration. The washing period of each softening tank is about 10 minutes with a flow of wash water of 230 gallons per minute. The brine is then run through the tank for approximately 15 minutes, depending on the salt dose used. Then wash water is run through the tank for about 20 minutes at 115 gallons per minute.

The plant also embodies equipment for the use of recovery brine, that which has been used but still contains a certain amount of salt. This brine, when used, is run through the regenerating tank before the new brine, to reclaim any of its value.

PROCEDURE

The procedure was to decrease the salt dose for regeneration a small amount at a time until it could be cut no more without causing the tanks to deliver hard water before the time of their next regeneration. The soap test for hardness was run at intervals before regeneration to determine if and when the tank started to deliver hard water. The recovery brine was used at the beginning of the experimental work, but discontinued so that its practical value could be determined after the economical amount of salt to use was found. After this was done, the economical amount of new salt brine was determined while using the recovery brine.

Some unforeseen difficulties in the operation of the plant were encountered, which caused the experimental work to proceed less smoothly than it might have otherwise.

The theoretical amount of flow of water to each softening tank was confirmed by the economical amounts of salt necessary to regenerate each tank.

RESULTS

No attempt will be made in this paper to explain the irregularities in amounts of soap solution necessary to produce a lather in 40 cubic centimeters of the effluent from the various softening tanks as found at the beginning of the experimental work, for the operation of the plant at that time was very irregular, due to various causes. On occasions, at that time, regenerations were skipped and tank number five once got two doses of brine in one regeneration. The recovery brine was also being used then, thus introducing two unknown quantities, a circumstance which usually makes any experimental work of little importance. Any irregularities experienced before the critical point in amount of brine used was reached were due to these or other similar causes. Another variable introduced at one time during the work was the cutting of the amount of water going through the iron removal tanks, thus increasing that through the softening tanks, but this had to be discontinued.

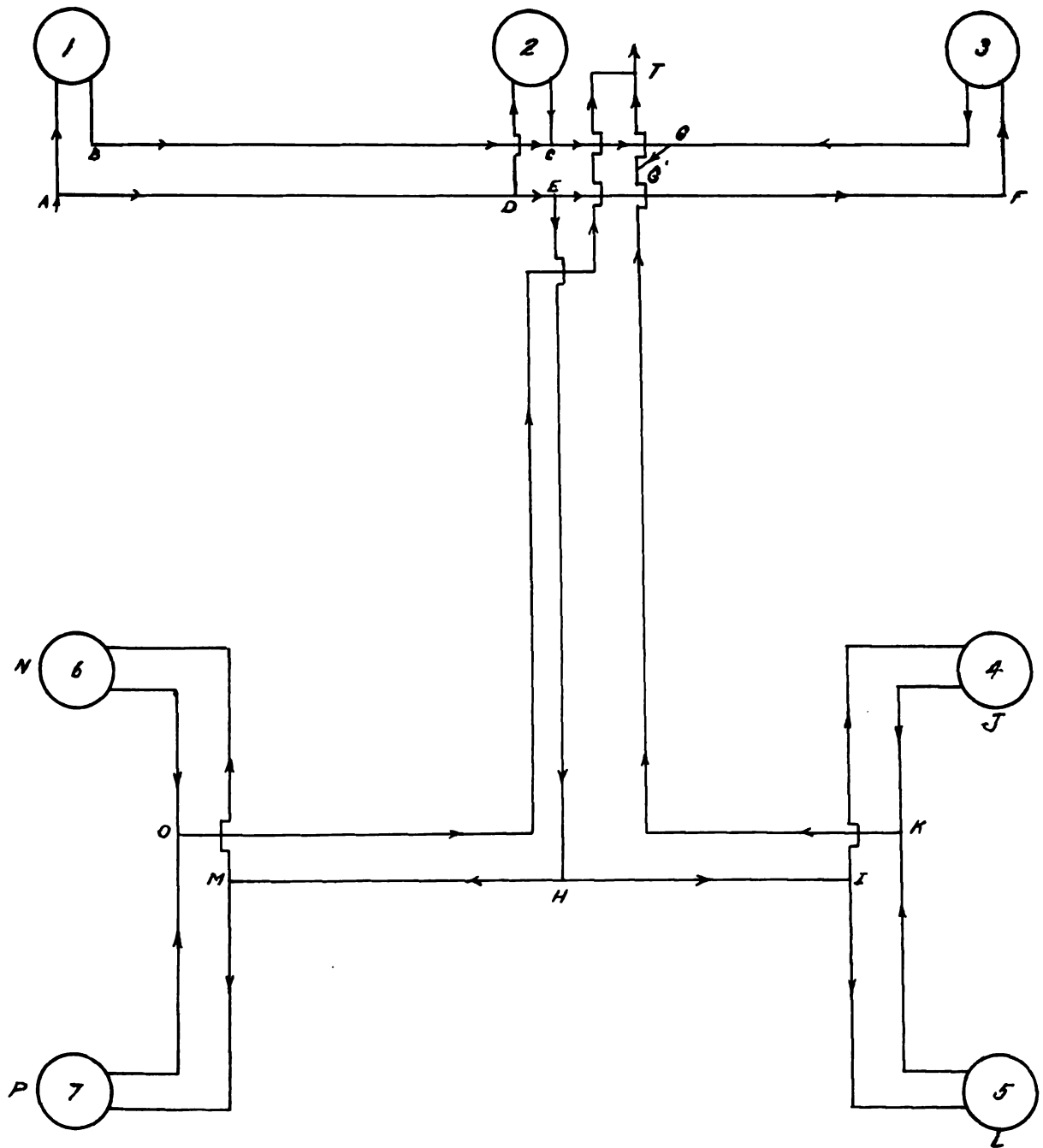
Tank numbers one, two and three delivered zero soft water during their entire runs until the brine dose was cut to 13 inches, indicating $13\frac{1}{2}$ inches as the least amount which would give proper results. These tanks were then delivered 14 inches to provide a factor of safety.

Tank numbers four and five went hard with 11 and $10\frac{1}{2}$ inches of brine respectively, thus indicating $11\frac{1}{2}$ and 11 inches as their economic values of salt dose. These lower

figures for four and five were due to the decreased flow of water through these tanks. The decreased flow was caused by their 4 inch effluent pipe being too small.

The economical amount of new brine to be used with the recovery brine in operation was found to be 16 inches for tanks one, two and three; and 14 and $13\frac{1}{2}$ inches with four and five, respectively.

FLOW DIAGRAM



Item

8:50:11

3" L

8:50:11

8" P

8:50:11

8:50:11

8" P

8:50:11

8" P

3" L

8:50:11

7" G

8" P

4:50:11

4" P

4" L

3:50:11

3" P

3" L

3" P

3:50:11

3" L

3" P

3" L

3:50:11

3" P

3" L

3:50:11

3" P

3" L

3:50:11

3" P

3" L

3:50:11

3" P

3" L

3:50:11

3" P

3" L

3:50:11

3" P

3" L

3:50:11

3" P

3" L

3:50:11

HEAD LOSSES

Item	Tank # 1		Tank # 2		Tank # 3		Tank # 4	
	Loss		Loss		Loss		Loss	
	Amt.	as √/2g (3")	Amt.	as √/2g (3")	Amt.	as √/2g (3")	Amt.	as √/2g (3")
8x3"x3 Tee	A.1	.50						
3" L	1	.50						
8x3"x3 Tee			A.1	.01	B.1	.01	A.1	.01
8" Pipe			5'-3"	.01	5'-3"	.01	5'-3"	.01
8x3"x3 Tee			D.1	.60				
8x3"x3 Tee					D.1	.02	D.1	.02
8" Pipe					1'-0"	.01	1'-0"	.01
6x3"x3 Tee					E.1	.41		
3" Pipe					4'-5"	.53		
3" L					1	.50		
6x3"x3 Tee							E.1	.03
8" 45 Bend							2	.01
6" Pipe							20'-4"	.03
4"x4"x3 Tee							H.1	.10
4" Pipe							2'-8"	.03
4" L							1	.12
3"x3"x4 Tee							I.1	.60
3" Pipe							6'-0"	.72
3" L							1	.50
3" Pipe	3'-5"	.39	3'-0"	.36	3'-3"	.39	3'-3"	.39
3x21/5x3 Tee	1	.60						
3" L			1	.50	1	.50	1	.50
3" Pipe	1'-3"	.15	1'-3"	.15	1'-3"	.15	1'-3"	.15
3" H. P. V.	1	5.00	1	5.00	1	5.00	1	5.00
3" Pipe	10'-4"	1.24	10'-4"	1.24	10'-4"	1.24	10'-4"	1.24
3" L	2	1.00	2	1.00	2	1.00	2	1.00
Soft. Tank	1	14.00	1	14.00	1	14.00	1	14.00
3" Pipe	2'-1"	.25	2'-1"	.25	2'-1"	.25	2'-1"	.25
3x21/5x3 Tee	1	.60	1	.60	1	.60	1	.60
3" H. P. V.	1	5.00	1	5.00	1	5.00	1	5.00
3" Pipe	1'-3"	.15	1'-3"	.15	1'-3"	.15	1'-3"	.15
3" L	2	1.00	2	1.00	2	1.00	2	1.00
3" L	1	.50			1	.50	1	.50
3x4"x3 Tee			C.1	.60				
3" Pipe	7'-0"	.84			0'-7"	.07	4'-1"	.29
3x4"x3 Tee	C.1	.20					K.1	.60
3" Pipe	5'-2"	.15	5'-2"	.15			24'-0"	.71
3"x4" Flange					1	.20		
4x4"x5 Tee	C.1	.20	C.1	.20	C.1	.20		
3" Pipe	2'-2"	.02	2'-2"	.02	2'-2"	.02		
6x4"x5 Tee	C.1	.10	C.1	.10	C.1	.10		
4" L							4	.64
6x4"x5 Tee							G.1	.10
6" Gate V.	1	.01	1	.01	1	.01	1	.01
6x4"x5 Tee	1	.01	1	.01	1	.01	1	.01

ITEM LOSS (continued)

Item	Tank # 5		Tank # 6		Tank # 7	
	Ant.	Loss as v ² /2g (3")	Ant.	Loss as v ² /2g (3")	Ant.	Loss as v ² /2g (3")
8"x8"x8 Tee	A.1	.01	A.1	.01	A.1	.01
8" Pipe	5'-3"	.01	5'-3"	.01	5'-3"	.01
8"x6"x3 Tee	D.1	.02	D.1	.02	D.1	.02
6" Pipe	1'-0"	.01	1'-0"	.01	1'-0"	.01
6"x3"x3 Tee	E.1	.03	E.1	.03	E.1	.03
6" 45 Bend	2	.01	2	.01	2	.01
6" Pipe	20'-4"	.08	20'-4"	.08	20'-4"	.08
4"x4"x3 Tee	H.1	.10	H.1	.10	H.1	.10
4" Pipe	2'-8"	.08	2'-8"	.08	2'-8"	.08
4" L	1	.12	1	.12	1	.12
3"x3"x3 Tee	I.1	.60	H.1	.60	H.1	.60
3" Pipe			0'-11"	.11	4'-10"	.58
3" L	1	.50	1	.50	1	.50
3" Pipe	3'-3"	.39	3'-3"	.39	3'-3"	.39
3" L	1	.50				
3"x3"x3 Tee			1	.60	1	.60
3" Pipe	1'-3"	.15	1'-3"	.15	1'-3"	.15
3" H. P. V.	1	5.00	1	5.00	1	5.00
3" Pipe	10'-4"	1.24	10'-4"	1.24	10'-4"	1.24
3" L	2	1.00	2	1.00	2	1.00
Soft. Tank	1	14.00				
I. Rem. Tank			1	12.00	1	12.00
3" Pipe	2'-1"	.25	2'-1"	.25	2'-1"	.25
3"x21/2"x3 Tee	1	.60	1	.60	1	.60
3" H. P. V.	1	5.00	1	5.00	1	5.00
3" Pipe	1'-3"	.15	1'-3"	.15	1'-3"	.15
3" L	3	1.50	3	1.50	3	1.50
3" Pipe	1'-11"	.23	0'-6"	.06	5'-5"	.65
3"x4"x3 Tee	K.1	.60	0.1	.60	0.1	.60
4" Pipe	24'-0"	.71	24'-7"	.72	24'-7"	.72
4" L	4	.64	5	.80	5	.80
6"x4"x5 Tee	G.1	.10				
6" Gate Valve	1	.01				
6"x3"x3 Tee	T.1	.01				
4" D. Valve			1	2.00	1	2.00
4" Gate Valve			1	.03	1	.03
6"x3"x3 Tee			3.1	.20	3.1	.20

FLOW DISTRIBUTION

With present piping

Section of line	Head loss as $v/2g$ (5")	Pipe and fittings to be changed	Estimated flow in G.P.N. ft, of H O	Head loss in
ABC	51.92		97	9.60
AD	0.02		503	0.16
DC	30.43		99	9.50
DEF	31.69		97	9.50
GG'	0.12		293	0.35
GG'	0.02	Head loss as	600	0.25
HI	0.22	$v/2g$ (5")	307	0.63
DI	0.03		404	0.16
HI	0.80		187	0.37
		4" pipe 2'-8"		0.03
		4" L 1		0.12
		6x4x4 T 1		0.60
JK	31.11		94	9.50
		3" pipe 6'-0"		0.72
		3" L 1		0.50
		3" pipe 3'-3"		0.39
		3" L 1		0.50
KL	31.11		98	9.50
		3" L 1		0.50
		3" pipe 3'-3"		0.39
		3" L 1		0.50
KK*	1.45		107	1.55
		4" pipe 24'-0"		0.71
		4" L 1		0.64
		6x4x5 T 1		0.10

FLOW DISTRIBUTION

With supported piping

Section of line	Head loss as $v/2g$ (3")	Pipe and fittings changed	Estimated flow in g.p.m.	Head loss in ft. of H ₂ O
ABC	51.92		95	9.50
AD	0.02		305	0.16
BC	30.45		97	9.50
BE	51.69		95	9.20
GG'	0.12		207	0.52
G'T	0.02	Head loss as	300	0.25
HI	0.22	$v/2g$ (3")	315	0.65
DE	0.05		408	0.14
HI	0.11		193	0.15
		6" pipe 2'-8"	0.01	
		6" L 1	0.02	
		6" F36 T 1	0.08	
IJK	30.85		96	9.20
		5" pipe 8'-0"	0.06	
		5" L 1	0.06	
		5" pipe 3'-3"	0.05	
		5" reducing L	0.70	
ILK	30.81		97	9.50
		5" L 1	0.06	
		5" pipe 5'-3"	0.05	
		5" reducing L	0.70	
KL'	0.28		195	0.77
		4" pipe 24'-0"	0.08	
		6" L 1	0.13	
		6" F36 T 1	0.06	

DATA

Numbers represent drops of soap to lather 40 c.c.,

Date	Time	Bank # 1	Bank # 2	Bank # 3	Bank # 4	Bank # 5	Sta.	Raw
4-21-56	12:25 P.M.			3	W		24	
	8:05 P.M.		3	3				
	8:13 P.M. S		3	3				
	8:20		3	3			23	
	8:30		W	3			23	
	8:40		3	3	3		30	
	8:50			3	3	3		
	9:05			W9	3	3		
	9:15			3	3	3	27	
	9:30				3		23	
	9:40		3		3		23	
	9:50				3		23	
4-22-56	1:05 P.M.						15	
	1:20		22				15	
	1:30		29				15	
4-27-56	7:13 P.M.					W		
	7:30	5					25	
	7:47	3				R	25	
	7:55	6						
	7:56	8						
	8:01	18					24	
	8:07	24				S		
	8:10	W					29	
	8:19	3	3				23	
	9:51		3					
	9:58		6					
	10:10		10					
	10:18	R	25					
	10:40	S	78					
	10:48		W	3			24	
	10:50		B	3				
	11:00			3				
	11:02			3				
4-28-56	8:22 A.M.				S	3		
	8:30	3			W3			
	8:40				R7	B		
	8:48	3			3			
	9:24	3			3			
	10:43	3						
	10:49	W3	5					
	10:58	B	3					
	11:27	R	3					
	11:43		3					
	11:49	S	W9	3				
	11:53	15						
	11:57	9	B					
4-29-56	11:54 A.M.			3	3	17		

DATA (continued)

Date	Time	Tank # 1	Tank # 2	Tank # 3	Tank # 4	Tank # 5	Sta.	Raw
	11:59 A.M.	8						
	12:05 P.M.	V12				5		
	12:14	B	3					
	12:33		5					
	12:37		6					
	12:42	R	8	3				
	1:04	S	45	3				
	1:06		V	5				
	1:10			7				
	1:12	11						
	1:14		B					
	1:23	3		3				
	1:30			14			Plant Stop	
	2:41						Plant Start	132
	2:51		R	25				
	3:13		E					
	3:15			V62				
	3:24		B	B			Plant Stop	
	4:58						Plant Start	
	5:20					3		130
	5:26			R	3			
	5:43			S	3			
	5:53			11	W3	3		
	6:03			6	B	3	Plant Stop	
	6:16						Plant Start	
	6:32	3				R		
	6:53	5				5		
	6:58	7						
	9:05	V12				7		
	9:12					3		
	9:14	B	5					
	9:37		5				Plant Stop	
4-30-56	7:58 A.M.	3		W3	3	3		
	6:19 P.M.				V		Plant Start	
	6:28			10		B		
	6:46							130
	6:50			8	R	3	27	
	9:17						Plant Start	
	9:30	3				E		
	9:51	V		17				
	9:40	B	3	17				
	10:00		6	12				
	10:08	R	8	12				
	10:15		12	12			Plant Stop	
5-1-56	8:16 A.M.					W3		
	8:17						Plant Start	
	9:23						Plant Stop	
	9:43	3	3	3	3		52	130

DATA (continued)

Date	Time	Tank # 1	Tank # 2	Tank # 3	Tank # 4	Tank # 5	Sta. Raw
	10:18	3				3	
	10:29	W3	3	3	3	3	30
	10:36		5	5	3	3	Plant Stop
	12:09 P.M.						Plant Start
	12:12		6	3	3	3	
	12:18	3					
	12:39	3	27				
	12:41		W				
	12:50		B				
	1:40			W3			
	1:49		8	B			
	1:54		5				Plant Stop
	8:54		5				
	8:57		5	3	3	3	
	9:10	3	9				
	9:13		W10				
	9:17	12					23" of brine to # 2
	9:29	3		5			
	9:40		R	9			
	10:02		5	16			
	10:12			W24			24" of brine to # 3
5-2-56	8:10 A.M.					B	
	8:15	5	3	3	3		26 150
	9:35	3	3	5	3		26
	9:15	W3					
	9:20						34
	9:24	3					
	9:30		5	5	5	3	29
	10:53						Plant Start
	11:01	3					
	11:10		W3				52
	11:14	6					
	11:19		B	3			
	11:53		3				
	12:09 P.M.		3	W3	3		
	1:42			B			
	2:04			5			
	2:15			5	3		
	2:22			W3			Plant Stop
	4:33				5	3	Plant Start
	4:43	3			W3		
	4:53					B	
	5:08	3				B	
	5:19	W3					Plant Stop
5-3-56	11:21 A.M.		W				Plant Start
	11:22	3	3	3	3	3	25

DATA (continued)

Date	Time	Tank # 1	Tank # 2	Tank # 3	Tank # 4	Tank # 5	Sta.	Raw
	11:29		B					
	11:42		R	3			25	
	12:04 P.M.		S	3				
	12:16		5	3				
	12:18			W3				
	4:55 P.M.	3		3	5	3		
	4:41		R					
	6:55				Plant Start			
	6:55		S	3				
	7:05		3	3				
	7:09			W3				
5-4-56	7:05	R						
	7:41		W3		Brine dose cut			
	7:49		B		161/2-161/4			
	8:07		R	3				
	8:55						22	
	8:40	5	3	W3	5	3		104
	8:43			B	3			
	9:05			R	3			
	9:25	5	3	S	3	3	13	
	9:35				3	Plant Stop		
	1:48 P.M.	W3	3			5		
	1:57	B						
	2:11	R						
	2:25		3	Plant Stop				
	4:05		Plant Start					
	4:12	S	3					
	4:28	W3	W3					
	4:56		B					
	4:50		R	3				
	4:55						15	
	5:12		S					
	5:15			Plant Stop				
	6:25			Plant Start				
	6:58			W3	Brine dose cut to 15 1/2"			
5-5-56	7:25 A.M.	3		3	3	3	20	
	7:55		R		(Start # 4 P.M.)		20	
	7:55		S					
	7:53	5	3	5	3	5	20	
	9:10			W3				
	5:22 P.M.	5		100	3	3	52	
	5:26	5	B	100	3	3		
	5:40		R	100	3		44	
	5:55			W	3			
	6:01		S				23	110
	6:07			B	3	6" Extra brine to 3		

DA 'A (continued)

[illegible]

DATA (continued)

Date	Time	Tank #1	Tank #2	Tank #3	Tank #4	Tank #5	Sta.	Raw
	12:53 P.M.			W3	3	3		
	5:03	7	3			3		
	5:15	8				4		
	5:17	W3						
	5:20					5		
	5:35	B	3					
	5:40	R	3					
	5:50			Plant Stop				
	6:03	3	3	Plant Start				
	6:47	6	3					
	6:55	3	3					
	6:59		W3	3				
	7:07		B					
	7:20		R	3				
	7:43		3	3				
	8:02			W3				
5-9-56	7:56 A.M.			Plant Start				
	8:04		B	3				
	8:27		R	3				
	8:39		3	3				
	8:59			W3				
	4:02 P.M.	3	3	B	3	3	Brine dose	
	4:15			R			15 1/4" to #3	
	7:11	W3		Plant Stop				
5-10-56	9:10 A.M.	W3	3	3	3	3	23	112
	9:11	W3						
	9:20	B						
	9:33	R	3					
	5:57 P.M.	3	3	3	3	3	24	
	4:20	3					Brine dose cut to	
	6:07		3	3	149/16"		starting with	
	6:13		W3		#1			
	6:55		3	3				
	7:00	3	3	3	3	3	23	
	7:07		3	3				
	7:17		W3	Plant Stop				
5-11-56	7:13 A.M.	3	3	3	3	3	23	
	7:57	3	3	Brine tank filled up 14" too				
	7:55		W7	full after #1				
	8:03		3					
	8:15		R					
	8:56		3	2				
	8:59			W7				
	12:04 P.M.			Plant Start				
	12:09	3	3	3	3	3	23	116

DATA (continued)

Date	Time	Tank # 1	Tank # 2	Tank # 3	Tank # 4	Tank # 5	Sta.	How
	12:34							
	12:45	3						14 1/2" of
	1:05							brine to # 4
	1:06	3						
	1:15	W3						
	3:11			Plant Start				
	3:15		3	3	3	3		
	3:26	3	3					
	5:35	5	3					
	5:55		W3					
	5:50			Plant Start				
	5:53	3	7	3	3	3		
	5:58			W3				
	5:58						25	
	7:42				Plant Start			
	7:45			5	14 5/8" brine to # 4			
	7:50			3	R			
	8:31				5	3		
	8:40							13 5/8" brine
	9:00			Plant Stop				to # 5
8-12-56	6:30 A.M.			Plant Start				
	6:32	3	5	3				
	6:39		7					
	6:43			W3				
	6:52		3	3	14" of brine to # 3			
	7:05			3	3			
	7:25			7	3			
	7:32			Plant Stop				
					15 3/4" of brine to # 4			
	9:17	3	3	3	3	3		
	9:26					W3		
	9:37							13 1/2" of
	10:49			Plant Start				brine
	11:03	W3						
	11:12	B		14" of brine				112
	11:32		3	Plant Stop				
	1:23 P.M.	3		3	3	3	25	
				brine set at 14 1/4" to start				
				with # 22				
	2: 7			3 Pump Stop				
	4:59			3				
	5:07				3	13 1/2" of brine		
	5:15			Plant Stop				
	6:22			Plant Start				
	6:40				3	3		

DATA (continued)

Date	Time	Tank # 1	Tank # 2	Tank # 3	Tank # 4	Tank # 5	Sta.	Raw
	6:45				7	3		
	6:53				5	3		
	7:00				3	3		
	7:11					W3		
	7:21					B	13" of brine	
	8:49	B					to # 5	
	9:00	R						
	9:07		3		Plant Stop			
5-13-36	7:14 A.M.				3	5	Brine tank	
	7:25				W3		6 1/8" too	
	7:35				B		after # 3	
	7:41				R		13" of brine to # 4	
	8:02				S			
	8:08	3	3	3	5	3		
	8:34					W3		
	8:35					Plant Stop		
	10:34	W3	3				Brine dose set at 13 1/2"	
	10:43	B					starts with # 1	
	10:53	R	3					
	12:00 Noon		3				Plant Start	
	12:14 P.M.	S	3					
	12:20		3					
	12:30	3	3					
	12:45		W3					
	3:03		3	3				
	3:10		6	3				102
	3:15		4	W3				
	5:15						Plant Start	
	5:24					W3		
	5:34				B		12 1/2" of brine to	
	5:40				R		# 4	
	6:57						Plant Start	
	7:06				7	3		
	7:13				W3	23		
	7:23				B			
5-14-36	7:22 A.M.					W3	2 1/2" too	
							much brine in tank	
							after # 4	
	7:32				B		12 1/2" of	
							brine to # 5	
					R			
	7:58							
	11:37				Plant Stop			
	1:09 P.M.	R		3				
	1:15							1024
	1:31	S		3				

DATA (continued)

Date	Time	Tank # 1	Tank # 2	Tank # 3	Tank # 4	Tank # 5	Sta.	Raw
	1:38			3				
	1:42			W5				
	2:43				W5			
	2:45			Plant Stop				
	4:01			Plant Start				
	4:09				W	23		
	4:15				R	12" of brine to # 4		
	4:35				S			
	4:40				8	3		
	5:03				3	3		
	5:07					W5		
	5:17					B 12" of brine		
	5:23					R to # 5		
	5:25			Plant Stop				
	6:50			Plant Start				
	6:45					S		
	6:52	W5						
	8:04		W5					
	9:54		P					
	10:15		S	15				
	10:27			W56				
	10:36			B 14 1/2" of brine to # 3				
	10:51			R				
	10:57				3			
	11:13			S	3			
	11:28				W5			
	11:37				R	12" of brine to # 4		
	11:43				R			
5-15-56	12:04 A.M.				S	3		
	12:30					4		
	12:35					W6		
	12:46					B 12" of brine		
	12:52					R to # 5		
	10:14	3	3	5	3	4		
	10:25	3	3	4	W5	4	24	100
	10:33				B	15" of brine to # 4		
	10:40			3	R	4 Plant Stop		
	11:30					Plant Start		
	11:42					4		
	11:50				S	4		
	12:26					W6		
	12:56					B 12" of brine		
						to # 5		

DATA (continued)

Date	Time	Tank # 1	Tank # 2	Tank # 3	Tank # 4	Tank # 5	Sta.	Raw
	12:24 P.M.						R	Plant Stop
	2:59	B		Brine dose measured=13	5/8"			
	2:51	R	3	3	3	3	24	112
	3:15	B	3					
	3:42		W3					
	3:50		B					
	4:01		R					
	4:06			3	Plant Stop			
	5:38			W3				
	5:46			B				
	5:48			R	12" of brine to # 4 & # 5			
5-16-56	7:05 A.M.			R	P.M. of 5-15-56			
	7:27			S	4			
	7:34			3	4			
	7:45				W4			
	7:55				B 12" of brine to # 4			
	8:00				R			
	8:03				Plant Stop			
	9:01	3	3	3	3	3		
	9:31					W4		
	9:41					B 11 1/2" of brine to # 5		
	9:48	3				R brine to # 5		
	10:13	3				3		
	10:21	W3			Salt dose set at 13" start with # 1			
	10:25				Plant Stop			
					11 1/2" of brine to # 4			
	22:25 P.M.				R			
	2:27				Plant Stop			
	3:44				S	3		
	4:13					W5		
	4:23					B 11 1/2" of brine to # 5		
	6:46		R					
	6:47				Plant Stop			
	8:35				S			
	92:45	Plant Stop			4	11 1/2" brine to # 4 & 5 P.M.		
5-17-56	1:16 A.M.			Plant Start				
	1:24 A.M.	B					5-16-56	
	9:35			S	4			
	9:55				W4			
	10:05				B	11 1/2" brine to # 4		
	10:11				R			
	10:13				Plant Stop			
	11:19					4		
	11:31					W4 11" of brine to # 5		
	11:41					B to # 5		

DATA (continued)

Date	Time	Tank # 1	Tank # 2	Tank # 3	Tank # 4	Tank # 5	Sta.	Raw
	11:53					R		
	12:04 P.M.	5				B		
	12:30	5						
	12:35	11						
	12:42	W19						
	12:44			Plant Stop				
	2:12			16				
	2:22		16		14 3/4" of brine to # 2			
	2:27		34	22				
	2:37		W23					
	2:43			23	Brine dose set at 14"			
	2:45		B		start with # 3			
	2:50		Plant Stop					
	5:03				5	5		
	5:19				W4			
	5:29				B	11" to # 4		
	5:54				R			
	5:58				Plant Stop			
	7:10					W4		
	7:25					B	11" of brine to # 5	
5-18-56	12:56 A.M.			Plant Start				
	12:51			S	4			
	1:11				W26			
	11:00			11" of brine to # 4 & 5 A.M.				
	12:22 P.M.			of 5-18-56				
	12:30			Plant Stop		W17		
	1:00					B		
	1:31					R	4	
	1:41					W5		
	1:37					B	10 1/2" of brine	
	1:43					R	to # 5	
	8:20			Plant Stop				
	8:25					5		
	8:55					5		
	8:40					6		
	8:45					7		
						W9		

DATA

Testing value of recovery brine

Date	Time	Tank # 1	Tank # 2	Tank # 3	Tank # 4	Tank # 5	Sta.	Raw
5-19-56	4:30 P.M.	3	3	3	3	3	25	Now brine
	4:35					W3		only, 15"
	6:24	W						Recovery brine on
	7:30		W					
	9:35			W				
5-20-56	12:50 A.M.				W			
	1:30					W		
	6:30	W						
	7:50		W					
			Hard					
	8:52			W				
	11:00				W			
	12:00 Noon					W		Now brine only
	12:52 P.M.	W96						start with # 1
	1:52		W94					15 1/4" brine
	3:53			W				
	4:58				W25			
	6:14					W18		
	7:43	W						14 1/4" brine set to start
	8:51		W					with # 1
	9:44			W				
	10:52				W		24	
	11:53					W		
5-21-56	8:54 A.M.	W						
	8:00		W5					13 1/8" brine, start # 2
	9:05			W3				
	10:37				W			
	11:58					W		
	12:45 P.M.	W						
	1:55		W					
	4:05			W				
	5:06				W			
	6:41					W		
	8:00	W						
	9:05		W					
	10:13			W				
	11:04				W			
5-22-56	12:02 A.M.					W		
	1:17	W						
	2:13		W					
	7:05			W				Recovery brine start # 4
	8:04	3	3	3	W3	5		
	9:08					W5		
	10:20	W95	8	3	5	3		

DATA (continued)

Date	Time	Tank: # 1	Tank: # 2	Tank: # 3	Tank: # 4	Tank: # 5	Sta. Raw
				Brine	14 1/2"	start # 1	
	11:37		W95				110
	12:30 P.M.			W			
	1:53	3	3	3	W90	New brine only,	
	3:18	3	3	3	3	W16 start # 4	
	4:27	W95	18	3	3	3	
	5:22		W95	60			
	6:30			W			
	7:59				W		
	9:12					W	
	10:19	W					
	11:19		W				
5-25-56	12:00 A.M.			W			
	1:25				W		
	6:40	3	3	3	3	W3	
	7:32	W					
	8:50		W				
	9:43	3	3	W3	3	3	25
	10:55				W		
	11:56					W	24
	1:00 P.M.	W					
	1:59		W				
	2:49	3	3	3	3	3	24 112
	2:56			W3			
	4:05				W		
	5:06					W	
	6:25	W					
	7:22		W				
	8:24			W			
	9:23				W		
	10:23					W	
	11:58	W					
5-24-56	3:45 A.M.		W				
	4:53			W			
	5:53				W		
	6:55					W	
	9:52	W					
	10:50		W				
	11:50	3	3	W3	3	3	
	12:56 P.M.				W		
	1:56					W	
	3:02	W					
	4:16		W				
	5:15			W			

DATA (continued)

Date	Time	Tank: # 1	Tank: # 2	Tank: # 3	Tank: # 4	Tank: # 5	Sta. Ray
	6:43				W		
	7:46					W	
	8:53	W					
	10:05		W				
	11:05			W			
5-25-56	4:26 A.M.				27		
	5:26					W	
	6:28	W					
	9:05			3			
	9:15			8			
	9:20	5	5	VH15	5	5	22 115
	10:25				W3		
	11:26					W	start # 4
	12:26	W					
	1:54		W				
	2:55			W			

CALIBRATION OF SOAP SOLUTION

Hardness of Water in p.p.m.	Drops of Soap to Produce a Lather
20	12
25	14
30	16
35	18
40	20
45	22
50	24
55	26
60	28
65	31
70	34
80	38
90	42
100	46
110	50
115	54
120	58
125	62

Two different dropping bottles were used during this experimental work on The East Lansing Water Plant. The above calibration was made with the first bottle (1).

Bottle (1) 500 drops = 7.9 ml.
 38 drops = 1.0 ml.

Bottle (2) 305 drops = 10.0 ml.
 30.5 drops = 1.0 ml.

40 c.c. of water were used in the calibration.

CONCLUSIONS

From the results of the work done in performance of this thesis, it has been concluded that the claims made by the Permutite Company for the value of the recovery brine equipment are based on the chemical analysis of the recovery brine and not on actual tests of its regenerating power, for it has been found to have a detrimental effect instead of a practical value.

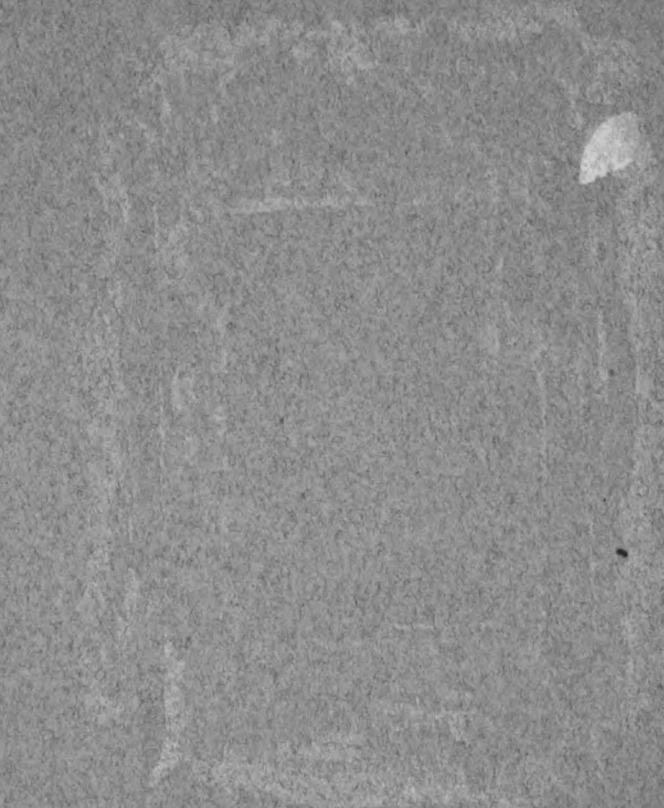
The flow of water, as calculated, has compared quite favorably with the amounts of salt brine found necessary to use in the various softening tanks, except for the indicated difference in flow of tank number four over tank number five. This difference was probably caused by some unseen obstruction causing excess friction in number five.

The smaller flow of water going through tanks number four and five could be remedied by installing equipment to cause less head loss in the flow of water through those tanks. It is suggested that the effluent pipe from those tanks, marked KG' in the flow diagram, be made a 6 inch pipe instead of the 4 inch which is in place at present. If HI were made a 6 inch pipe, and the first ell and two sections of pipe of lines IJ and IL were made 5 inch, the flow should be evenly divided among the softening tanks.

A further refinement could be made by a slight adjustment of the time sequence switch.



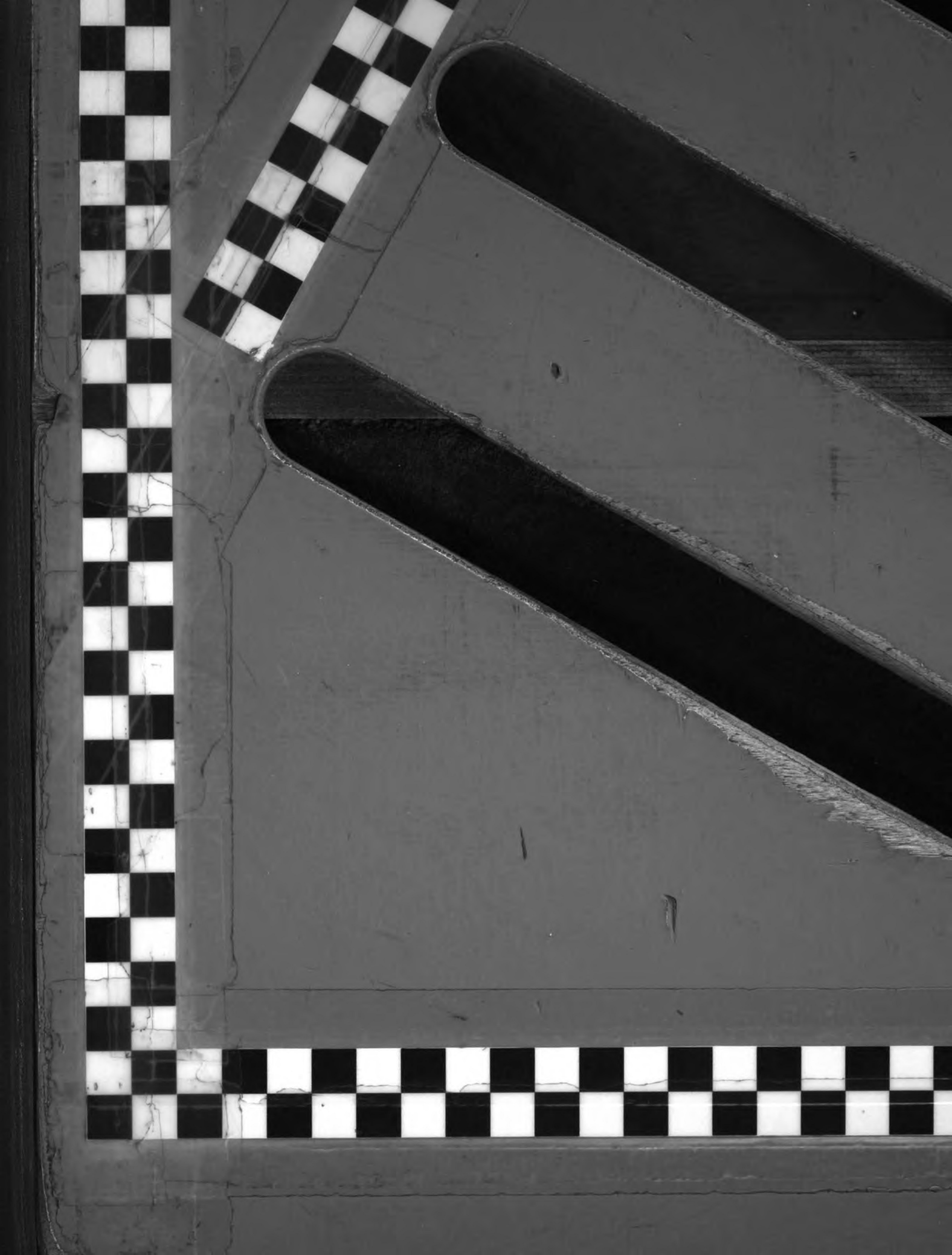
Aug 30 '48



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DATA

Numbers represent drops of soap to lather 40 c.c.,

Date	Time	Bank # 1	Bank # 2	Bank # 3	Bank # 4	Bank # 5	Sta.	Raw
4-21-56	12:25 P.M.			3	W		24	
	6:06 P.M.		3	3				
	6:13 P.M. S		3	3				
	6:20		3	3			23	
	6:30		W	3			23	
	6:40		3	3	3		30	
	6:50			3	3	3		
	9:05			W	3	3		
	9:15			3	3	3	27	
	9:30				3		23	
	9:40		3		3		23	
	9:50				3		23	
4-22-56	1:05 P.M.						15	
	1:20		22				15	
	1:30		40				15	
4-27-56	7:13 P.M.					W		
	7:30	5					25	
	7:47	3				R	25	
	7:55	6						
	7:58	8						
	8:01	16					24	
	8:07	24				S		
	8:10	W					29	
	8:19	3	3				23	
	9:51		3					
	9:58		6					
	10:10		10					
	10:18	R	25					
	10:40	S	78					
	10:48		W	3			24	
	10:50		B	3				
	11:00			3				
	11:02			3				
4-28-56	8:22 A.M.				S	3		
	8:30	3			W			
	8:40				W	B		
	8:48	3			3			
	9:24	3			3			
	10:45	3						
	10:49	W	3					
	10:58	B	3					
	11:27	R	3					
	11:43		3					
	11:49	S	W	3				
	11:53	15						
	11:57	9	B					
4-29-56	11:54 A.M.			3	3	17		

DATA (continued)

Date	Time	Tank # 1	Tank # 2	Tank # 3	Tank # 4	Tank # 5	Sta.	Raw
	11:59	A.C.I. 8						
	12:05	P.M. V12		.		5		
	12:14	B	3					
	12:33		3					
	12:37		6					
	12:42	R	8	3				
	1:04	S	45	3				
	1:05		V	3				
	1:10			7				
	1:12	11						
	1:14		B					
	1:23	3		3				
	1:30			14		Plant Stop		
	2:41					Plant Start		132
	2:51		R	25				
	3:13		S					
	3:15			V62				
	3:24		8	B		Plant Stop		
	4:58					Plant Start		
	5:20					3		130
	5:26			R	3			
	5:43			S	3			
	5:53			11	W3	3		
	6:03			6	B	3	Plant Stop	
	8:15						Plant Start	
	8:32	3				R		
	8:53	3				S		
	8:58	7						
	9:05	V12				7		
	9:12					3		
	9:14	B	5					
	9:37		5			Plant Stop		
4-30-56	7:58	A.C.I. 3		13	5	3		
	8:19	P.M.			V	Plant Start		
	8:28			10		3		
	8:44							130
	8:50			8	R	3	27	
	9:17					Plant Start		
	9:30	3				S		
	9:31	V		17				
	9:40	B	3	17				
	10:00		6	12				
	10:08	R	8	12				
	10:15		12	12		Plant Stop		
5-1-56	8:16	A.C.I.				W3		
	8:17					Plant Start	Stop	
	9:23					Plant Start		
	9:43	3	3	3	3		52	130

DATA (continued)

Date	Time	Tank # 1	Tank # 2	Tank # 3	Tank # 4	Tank # 5	Sta.	Raw
	10:18	3				S		
	10:29	W3	3	3	3	3	30	
	10:34		5	5	3	5	Plant Stop	
	12:09 P.M.						Plant Start	
	12:12		6	3	3	3		
	12:18	P						
	12:39	S	27					
	12:41		W					
	12:50		B					
	1:40			W3				
	1:49		8	B				
	1:54		5				Plant Stop	
	8:54		5					
	8:57		5	3	3	3		
	9:10	S	9					
	9:13		W10					
	9:17	12					23" of brine to # 2	
	9:29	3		5				
	9:40		R	9				
	10:02		S	16				
	10:12			W24			24" of brine to # 3	
5-2-56	8:10 A.M.					B		
	8:15	3	3	3	3		26	150
	8:33	3	3	5	3		26	
	9:15	W3						
	9:20						34	
	9:24	3						
	9:30		3	3	3	3	29	
	10:53						Plant Start	
	11:01	S						
	11:10		W5				32	
	11:14	6						
	11:19		B	3				
	11:53		S					
	12:09 P.M.		3	W3	3			
	1:42			B				
	2:04			5				
	3:15			3	3			
	3:22			W3			Plant Stop	
	4:33				5	3	Plant Start	
	4:48	3			W3			
	4:58				B			
	5:08	3			R			
	5:50	W3					Plant Stop	
5-3-56	11:21 A.M.		W				Plant Start	
	11:22	3	2	3	3	3	25	

DATA (continued)

Date	Time	Tank # 1	Tank # 2	Tank # 3	Tank # 4	Tank # 5	Sta.	Raw
	11:29		B					
	11:42		R	3			25	
	12:04 P.M.		S	3				
	12:15		5	3				
	12:18			W3				
	4:35 P.M.	3		3	5	3		
	4:41		R					
	6:55				Plant Start			
	6:55		S	3				
	7:05		3	3				
	7:09			W3				
5-4-56	7:05	R						
	7:41		W3		Brine dose cut			
	7:49		B		161/2-161/4			
	8:07		R	3				
	8:55						22	
	8:40	5	3	W3	5	3		104
	8:53			B	3			
	9:05			R	3			
	9:25	5	5	5	3	3	15	
	9:35				3	Plant Stop		
	1:48 P.M.	W3	3			5		
	1:57	B						
	2:11	R						
	2:25		3		Plant Stop			
	4:05			Plant Start				
	4:12	S	3					
	4:28	W3	W3					
	4:56		B					
	4:50		R	3				
	4:55						13	
	5:12		S					
	5:15				Plant Stop			
	5:25				Plant Start			
	5:58			W3	Brine dose cut to 15 1/2"			
5-5-56	7:25 A.M.	5		3		3	21	
	7:35		R		(Start # 4 P.M.) 20			
	7:35		S					
	7:33	5	3	5	3	5	29	
	9:10			W3				
	8:25 P.M.	5		100	3	3	52	
	8:26	5	B	100	3	3		
	8:40		R	100	3		44	
	5:53			W	3			
	7:01		S				23	110
	6:07			B	3	6" Extra brine to 3		

DATA (continued)

Date	Time		Tank #1	Tank #2	Tank #3	Tank #4	Tank #5	Sta.	Raw	
New soap and dropping bottle										
5-6-56	6:26				R	S				
	7:54 A.M.	3	R	3	3	3	3	25	113	
	8:11				W3				113	
	8:13		S	W3						
	8:19			3	Brine dose out to 151/8"					
	8:33			R	start with #4					
1:49 P.M.		Plant Start								
1:55		3					S			
2:00		3					4			
2:07		W3	3	3	3	3	4	25		
2:13		R					3			
2:19		R	3							
2:51		S	4							
2:57			3	Plant stop						
4:40		3	W3							
5:02			R	3						
5:10								24		
5:23			3	3						
5:37			3	W3						
6:51			Plant Start							
6:55			4	3	3					
7:12			3	3	3					
7:25							3	25		
7:35						W3				
7:45		3	3	3	B	3	3			
5-7-56	7:54 A.M.	3	3	W3	3	3	3	26		
	8:03 P.M.	3	3	W3	Plant stop					
	8:04			S						
8:20					W3					
9:13			3				3	24		
9:22		S	3							
9:33		3	3							
9:38		3	W3	Plant stop						
5-8-56	7:15 A.M.	3	3	3			3	25		
	7:30					S				
	7:35						W3			
	7:44					3	3	24		
	8:15						3			
	8:45		3	3	3	3				
	8:52		W3							
	9:23			3	Plant stop					
	11:34		3		3	3	3	25		
	11:40			S						
11:58				3	Plant stop					

DATA (continued)

Date	Time	Tank # 1	Tank # 2	Tank # 3	Tank # 4	Tank # 5	Sta.	Raw
	12:53 P.M.			13	3	3		
	5:03	7	3			3		
	5:15	8				4		
	5:17	W3						
	5:20					5		
	5:35	B	3					
	5:40	R	3					
	5:50			Plant Stop				
	6:53	B	3	Plant Start				
	6:47	6	5					
	6:55	3	3					
	6:59		W3	3				
	7:07		B					
	7:20		R	3				
	7:33		S	3				
	8:02			W3				
5-9-56	7:56 A.M.			Plant Start				
	8:04		B	3				
	8:27		R	3				
	8:39		S	3				
	8:59			W3				
	4:02 P.M.	3	3	B	3	3	Brine dose	
	4:15			R			15 1/4" to # 3	
	7:11	W3		Plant Stop				
5-10-56	9:10 A.M.	W3	5	5	3	3	23	112
	9:11	W3						
	9:20	B						
	9:53	R	3					
	5:57 P.M.	3	3	3	3	3	24	
	4:20	S					Brine dose out to	
	6:07		3	3			140/16" starting with	
	6:15		W3				# 11	
	6:55		3	3				
	7:00	3	3	3	3	3	23	
	7:07		3	3				
	7:17			W3	Plant Stop			
5-11-56	7:13 A.M.		3	3	3	3	23	
	7:57	S	3	Brine tank filled up 11" too				
	7:55		W3	full after # 1				
	8:03		B					
	8:15		R					
	8:56		3	2				
	8:59			W3				
	12:04 P.M.		Plant Start					
	12:09	3	3	3	3	3	23	116

DATA (continued)

Date	Time	Tank # 1	Tank # 2	Tank # 3	Tank # 4	Tank # 5	Sta. Low
	12:34					B	14 1/2" of
	12:43	S				R	brine to # 4
	1:05					B	
	1:06	S				G	
	1:15	W3				5	
	3:11			Plant Start			
	3:15		S	3	3	3	
	3:26	S	S				
	3:35	5	S				
	3:56		W3				
	5:50			Plant Start			
	5:53	S	7	3	3	3	
	5:56			W3			
	5:58					25	
	7:42			Plant Start			
	7:45			5	14 5/8" brine to # 4		
	7:50			3	R		
	8:31				5	3	
	8:40					B	13 5/8" brine to # 5
	9:01			Plant Stop			
1-12-56	6:30 A.M.			Plant Start			
	6:32	S	S	3			
	6:39		7				132
	6:43			W3			
	6:52		S	3	14" of brine to # 3		
	7:05			S	3		
	7:26			7	3		
	7:32			Plant Stop			
					15 3/4" of brine to # 4		
	9:17	S	S	3	3	3	
	9:26					W3	
	9:37					B	13 1/2" of brine
	10:49			Plant Start			
	11:03	W3					
	11:12	B		14" of brine			132
	11:32		S	Plant Stop			
	1:25 P.M.	S		3	3	3	25
				Brine set at 14 1/4" to start with # 122			
	2: 7			3	Plant Stop		
	4:39			S			
	5:07				3	13 1/2" of brine	
	5:15			Plant Stop			
	6:22			Plant Start			
	6:40				S	3	

DATA (continued)

Date	Time	Work # 1	Tank # 2	Tank # 3	Tank # 4	Tank # 5	Sta.	Raw
	6:45				7	3		
	6:53				5	3		
	7:00				3	3		
	7:11					W3		
	7:21					B	13" of brine	
	8:49	B					to # 5	
	9:00	R						
	9:07		3		Plant Stop			
5-15-56	7:14 A.M.				3	5	Brine tank	
	7:25				W3		6 1/8" too	
	7:36				B		after # 3	
	7:41				R		13" of brine to # 4	
	8:02				S			
	8:08		3	3	3	5		
	8:34					W3		
	8:35					Plant Stop		
	10:54	W3	3				Brine dose set at 13 1/2"	
	10:43	B					starts with # 1	
	10:53	R	3					
	12:00 Noon		3				Plant Start	
	12:14 P.M.	S	3					
	12:20	"	3					
	12:50	3	3					
	12:45		W3					
	3:03		3	3				
	3:10		6	3				22
	3:15		4	W3				
	5:15						Plant Start	
	5:24				W3			
	5:34				B		12 1/2" of brine to	
	5:40				R		# 4	
	6:57				Plant Start			
	7:05				7	3		
	7:13				W3	W3	23	
	7:23					B		
5-14-56	7:22 A.M.					W3	2 1/2" too	
							much brine in tank	
							after # 4	
	7:32					B	12 1/2" of	
							brine to # 5	
					R			
	7:58							
	11:37				Plant Stop			
	1:09 P.M.		R	3				
	1:15							1424
	1:51		3	3				

DATA (continued)

Date	Time	Tank # 1	Tank # 2	Tank # 3	Tank # 4	Tank # 5	Sta.	Raw
	1:35			3				
	1:42			W5				
	2:45				W5			
	2:45			Plant Stop				
	4:01			Plant Start				
	4:09				B	25		
	4:15				R	12" of brine to # 4		
	4:35				S			
	4:40				8	3		
	5:03				3	3		
	5:07					W5		
	5:17					B 12" of brine		
	5:25					R to # 5		
	5:25			Plant Stop				
	6:56			Plant Start				
	6:45					S		
	6:52	W5						
	8:04		W5					
	9:54		R					
	10:15		S	15				
	10:27			W5				
	10:35			B	14 1/2" of brine to # 3			
	10:51			R				
	10:57				3			
	11:15			S	3			
	11:23				W5			
	11:37				B	12" of brine to # 4		
	11:43				R			
5-15-56	12:04 A.M.				S	3		
	12:50					4		
	12:55					W6		
	12:45					B 12" of brine		
	12:52					R to # 5		
	10:14	3	3	5	3	4		
	10:23	3	3	4	W5	4	24	100
	10:33				B	13" of brine to # 4		
	10:40			3	R	4 Plant Stop		
	11:36					Plant Start		
	11:42					4		
	11:56				S	4		
	12:26					W6		
	12:56					B 12" of brine		
						to # 5		

DATA (continued)

Date	Time	Tank # 1	Tank # 2	Tank # 3	Tank # 4	Tank # 5	Sta.	Raw
	12:44 P.M.						R	Plant Stop
	2:39	B		Brine dose measured=13 5/8"				
	2:51	R	3	3	3	3	2 1/2	112
	3:15	B	3					
	3:42		W3					
	3:50		B					
	4:01		R					
	4:06			3	Plant Stop			
	5:38			W3				
	5:46			B				
	5:58			R	12" of brine to # 4 & # 5			
5-16-36	7:05 A.M.			R	P.M. of 5-15-36			
	7:27			S	4			
	7:34			3	4			
	7:45				W4			
	7:55				B	12" of brine to # 4		
	8:00				R			
	8:03				Plant Stop			
	9:01	3	3	3	3	3		
	9:31					W4		
	9:41					B	11 1/2" of brine to # 5	
	9:48	3				R	brine to # 5	
	10:13	3				S		
	10:21	W3				Salt dose set at 13" start with # 1		
	10:25					Plant Stop		
						11 1/2" of brine to # 4		
	22:25 P.M.					R		
	2:27					Plant Stop		
	3:44					S	3	
	4:13					W5		
	4:23					B	11 1/2" of brine to # 5	
	6:46			R				
	6:47					Plant Stop		
	8:35					S		
	92:45	Plant Stop				4	11 1/2" brine to # 4 & 5 P.M.	
5-17-36	1:16 A.M.							
	1:24 A.M.	B						5-16-36
	9:35			S	4			
	9:55				W4			
	10:05				B	11 1/2" brine to # 4		
	10:11				R			
	10:13					Plant Stop		
	11:19					4		
	11:31					W4	11" of brine to # 5	
	11:41					B		

DATA (continued)

Date	Time	Tank # 1	Tank # 2	Tank # 3	Tank # 4	Tank # 5	Sta.	Raw
	11:43					R		
	12:04 P.M.	3				B		
	12:50	5						
	12:35	11						
	12:42	W19						
	12:44			Plant Stop				
	2:12			16				
	2:22		16		14 3/4"			of brine to # 2
	2:227		34		22			
	2:37		W33					
	2:43				25			Brine dose set at 14"
	2:45		B					start with # 3
	2:59		Plant Stop					
	5:03				3	3		
	5:19				W4			
	5:29				B	11"		to # 4
	5:54				R			
	5:56				Plant Stop			
	7:10					W4		
	7:25					B		11" of brine to # 5
5-18-56	12:36 A.M.			Plant Start				
	12:51			S	4			
	1:11				W5			
	11:00			11" of brine to # 4 & 5 A.M.				
	12:22 P.M.			Plant Stop				of 5-18-56
	12:33				W17			
	1:00				B			
	1:31				W5			
	1:41				B	10 1/4"		of brine to # 5
	1:57				R			
	1:43			Plant Stop				
	8:20					5		
	8:25					5		
	8:35					6		
	8:40					7		
	8:45					W9		

DATA

Testing value of recovery brine

Date	Time	Tank # 1	Tank # 2	Tank # 3	Tank # 4	Tank # 5	Sta.	Raw
5-19-56	4:30 P.M.	3	3	3	3	3	25	New brine
	4:35					W3		only, 15"
	6:24	W						Recovery brine on
	7:30		W					
	9:35			W				
5-20-56	12:50 A.M.				W			
	1:30					W		
	6:30	W						
	7:50		W					
			19rd					
	8:52			W				
	11:00				W			
	12:00 Noon					W		New brine only
	12:52 P.M.	W96						start with # 1
	1:52		W94					15 1/4" brine
	3:55			W				
	4:56				W25			
	6:54					W18		
	7:43	W						14 1/4" brine set to start
	8:51		W					with # 1
	9:44			W				
	10:52				W		24	
	11:53					W		
5-21-56	5:54 A.M.	W						
	8:00		W3					15 1/8" brine, start # 2
	9:05			W3				
	10:57				W			
	11:56					W		
	12:45 P.M.	W						
	1:55		W					
	4:05			W				
	5:06				W			
	6:41					W		
	8:00	W						
	9:05							
	10:03			W				
	11:04				W			
5-22-56	12:02 A.M.					W		
	1:17	W						
	2:18		W					
	7:05			W				Recovery brine start # 4
	8:04	3	3	3	W3	5		
	9:03					W5		
	10:20	W95	8	3	5	3		

DATA (continued)

Date	Time	Tank # 1	Tank # 2	Tank # 3	Tank # 4	Tank # 5	Sta.	Raw
				Brine 14 1/2", start # 1				
	11:27		W95					112
	12:50 P.M.			W				
	1:55	3	3	3	W90	New brine only,		
	3:18	3	3	3	3	W16 start # 4		
	4:27	W95	18	3	3	3		
	5:22		W95	60				
	6:30			W				
	7:59				W			
	9:12					W		
	10:19	W						
	11:19		W					
5-25-56	12:09 A.M.			W				
	1:25				W			
	6:40	3	3	3	3	W3		
	7:52	W						
	8:50		W					
	9:48	3	3	W3	3	3	25	
	10:55				W			
	11:56					W	24	
	1:00 P.M.	W						
	1:59		W					
	2:49	3	3	3	3	3	24	112
	2:56			W3				
	4:05				W			
	5:06					W		
	6:25	W						
	7:22		W					
	8:24			W				
	9:28				W			
	10:22					W		
	11:58	W						
5-24-56	3:15 A.M.		W					
	4:55			W				
	5:58				W			
	6:55					W		
	9:52	W						
	10:50		W					
	11:50	3	3	W3	3	3		
	12:56 P.M.				W			
	1:56					W		
	3:02	W						
	4:16		W					
	5:15			W				

DATA (continued)

Date	Time	Tank # 1	Tank # 2	Tank # 3	Tank # 4	Tank # 5	Sta.	Raw
	6:46				W			
	7:46					W		
	8:56	W						
	10:06		W					
	11:06			W				
5-27-56	4:26 A.M.				27			
	5:26					W		
	6:28	W						
	9:05			3				
	9:15			8				
	9:20	3	3	WMLB	5	5	24	110
	10:26				13			
	11:26					W	start # 4	
	12:26	W						
	1:34		W					
	2:33			W				

CALIBRATION OF SOAP SOLUTION

Hardness of Water in p.p.m.	Drops of Soap to Produce a Lather
20	12
25	14
30	16
35	18
40	20
45	22
50	24
55	26
60	28
65	31
70	34
80	38
90	42
100	46
110	50
115	54
120	58
125	62

Two different dropping bottles were used during this experimental work on The East Lansing Water Plant. The above calibration was made with the first bottle (1).

Bottle (1)	500 drops = 7.9 ml. 38 drops = 1.0 ml.
Bottle (2)	305 drops = 10.0 ml. 30.5 drops = 1.0 ml.

40 c.c. of water were used in the calibration.

CONCLUSIONS

From the results of the work done in performance of this thesis, it has been concluded that the claims made by the Permutite Company for the value of the recovery brine equipment are based on the chemical analysis of the recovery brine and not on actual tests of its regenerating power, for it has been found to have a detrimental effect instead of a practical value.

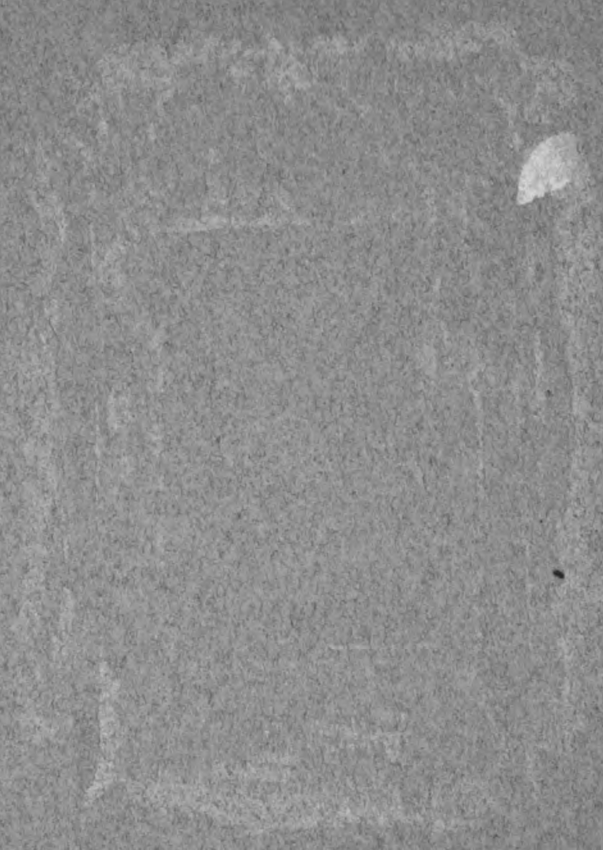
The flow of water, as calculated, has compared quite favorably with the amounts of salt brine found necessary to use in the various softening tanks, except for the indicated difference in flow of tank number four over tank number five. This difference was probably caused by some unseen obstruction causing excess friction in number five.

The smaller flow of water going through tanks number four and five could be remedied by installing equipment to cause less head loss in the flow of water through those tanks. It is suggested that the effluent pipe from those tanks, marked KG' in the flow diagram, be made a 6 inch pipe instead of the 4 inch which is in place at present. If HI were made a 6 inch pipe, and the first ell and two sections of pipe of lines IJ and IL were made 5 inch, the flow should be evenly divided among the softening tanks.

A further refinement could be made by a slight adjustment of the time sequence switch.

10-11-12

Aug 30 '48



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