

SURVEY OF THE PIPING SYSTEM
OF THE EAST LANSING EAST WATER
PLANT

Thesis for the Degree of B. S.
MICHIGAN STATE COLLEGE

Thomas W. Postiff

1942

THESIS

**SUPPLEMENTARY
MATERIAL
IN BACK OF BOOK**

Survey of the Fiping System of the
East Lansing East Water Plant

A Thesis Submitted to

The Faculty of
MICHIGAN STATE COLLEGE
OF
AGRICULTURE AND APPLIED SCIENCE

by

Thomas W. Postiff
Thomas W. Postiff

Candidate for the Degree of

Bachelor of Science

June 1942

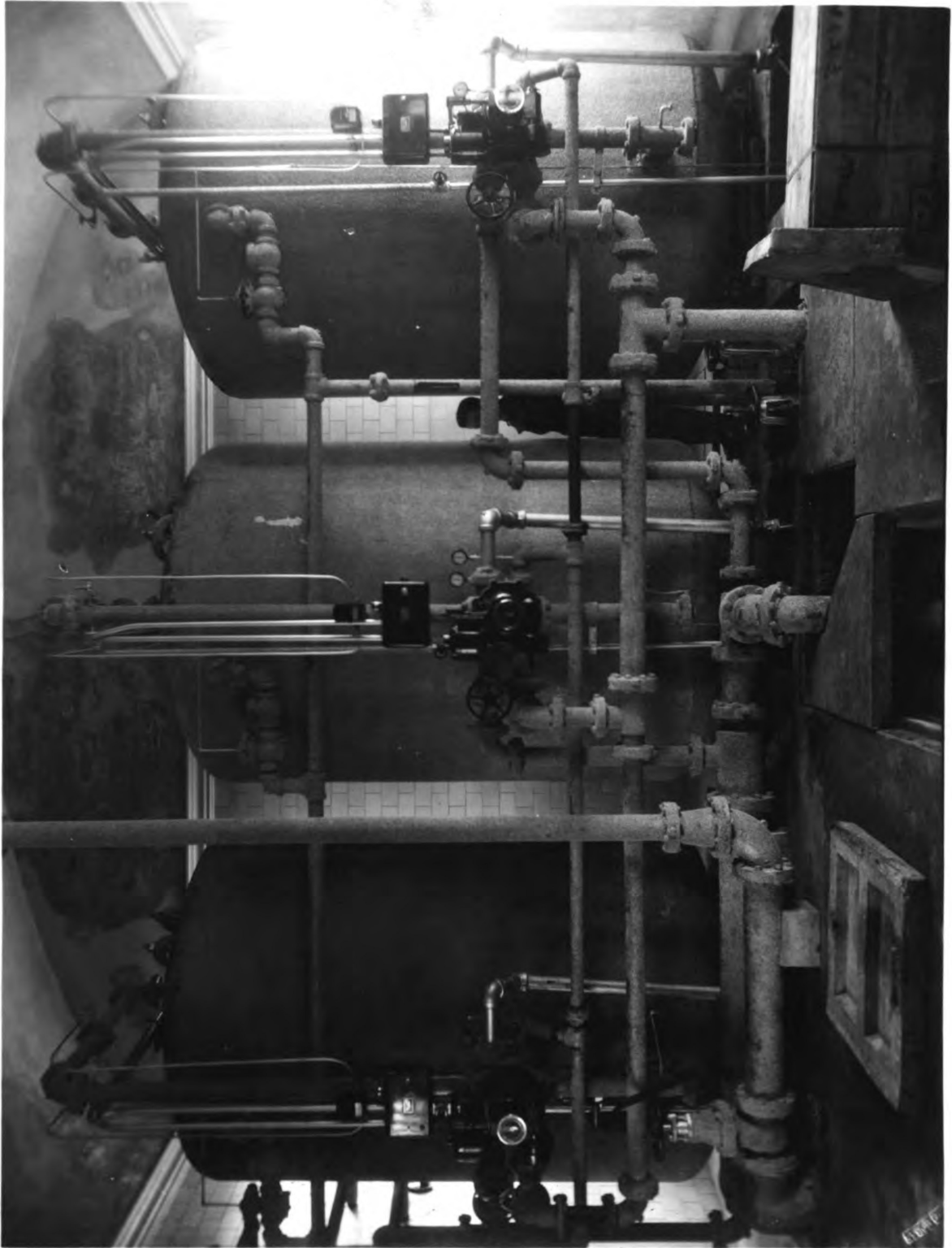
11-11-11

ACKNOWLEDGEMENT

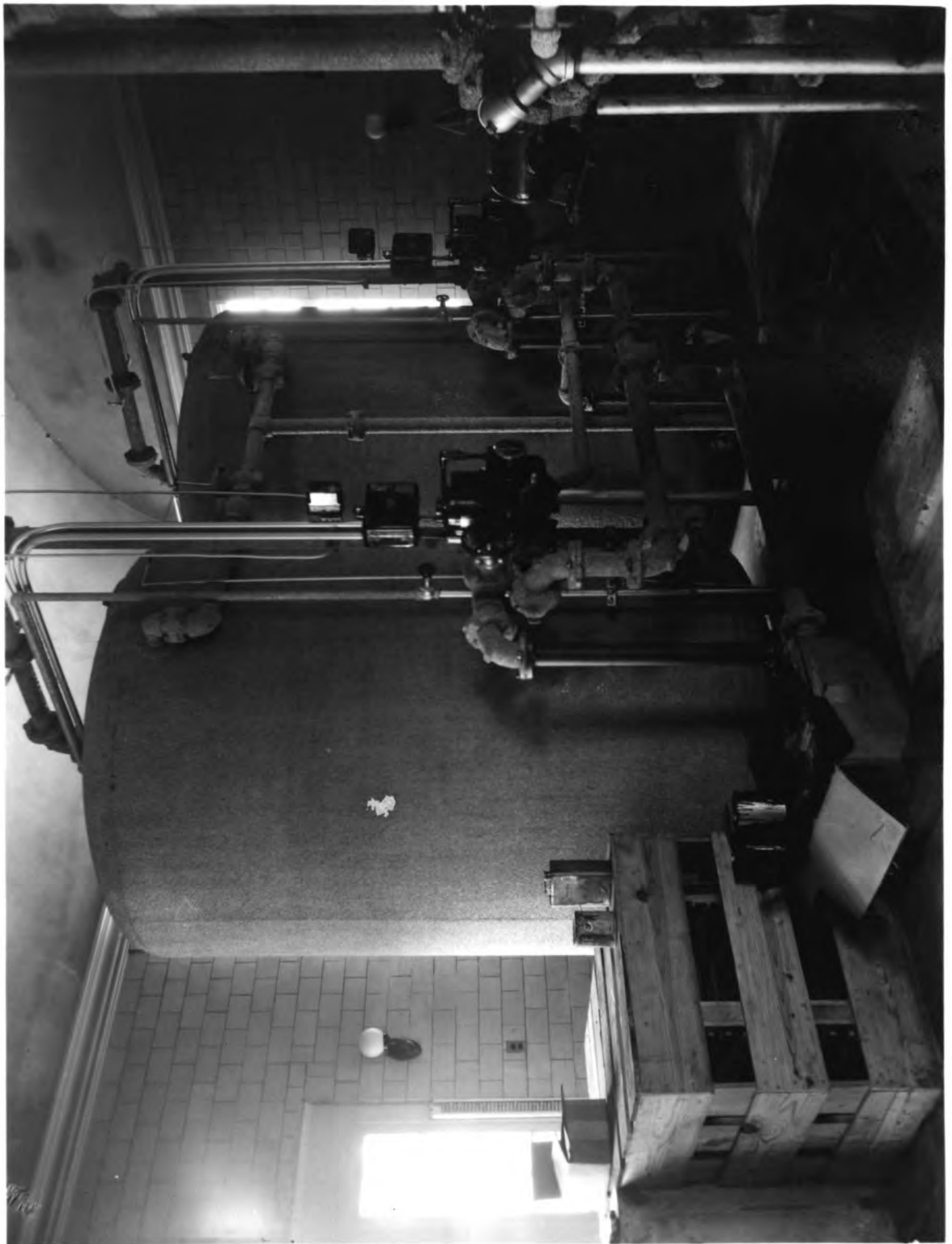
I wish to express my appreciation to the faculty of Michigan State College for considering me a candidate for the Degree of Bachelor of Science. I also wish to express my sincere gratitude to both Professor Chester L. Allen, Head of Civil Engineering Department, and Professor Frank R. Theroux, Associate Professor of Civil Engineering, for their assistance in writing this thesis.



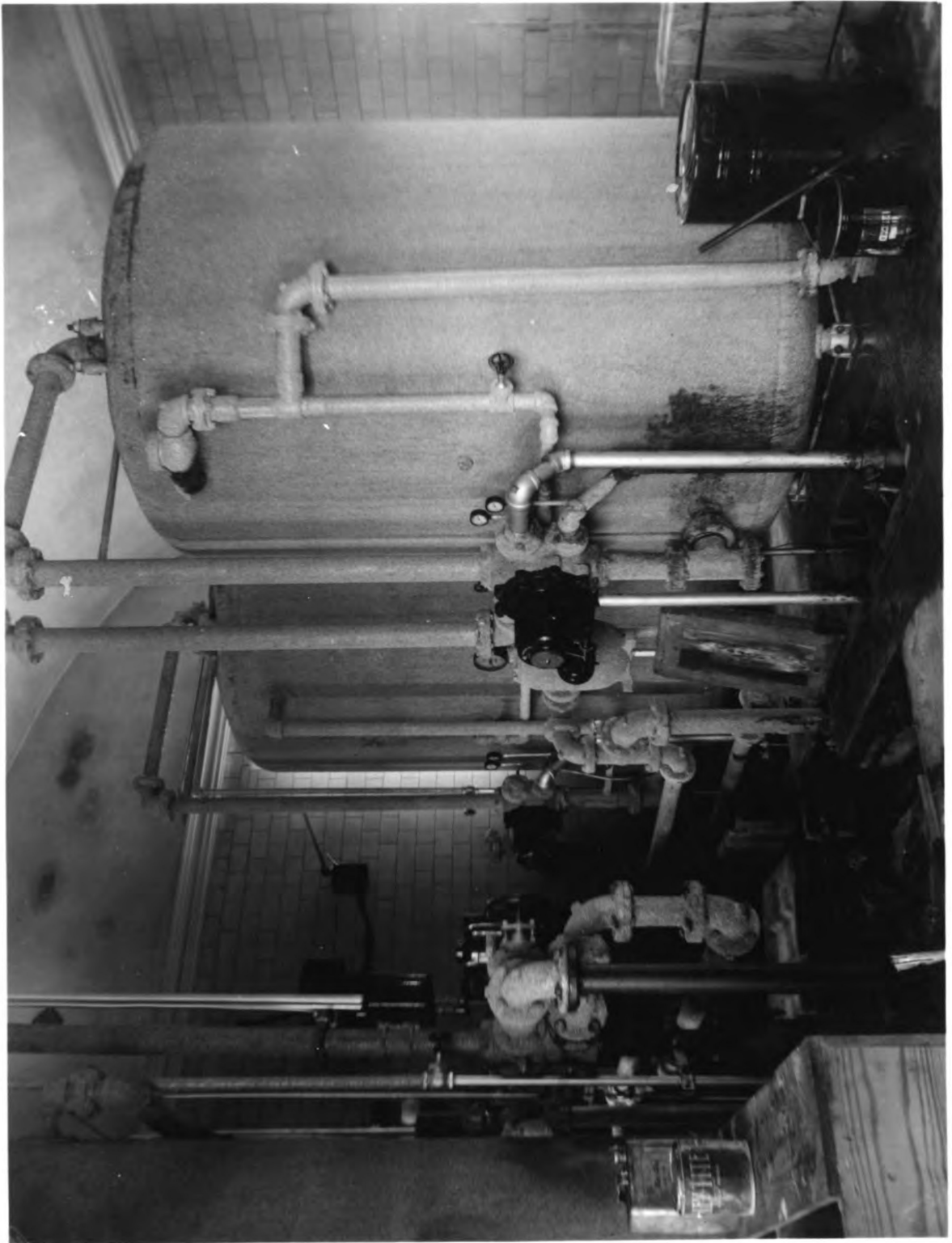
View of the Softening Plant



Tanks 1,2,&3



Tanks 4 & 5



Tanks 6 & 7



Raw Water Line to Tanks 4,5,& 7
and return lines from 4,5,6,& 7

DESCRIPTION OF PLANT

The principal reason for making this survey was to investigate the piping causing the degeneration of the zeolite sand in the softening tanks and how it could be remedied. First, a description of the plant and how it operates will be given.

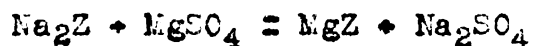
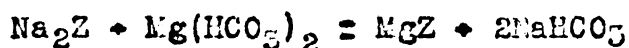
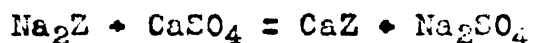
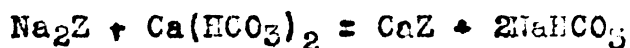
The objects of the plant are to reduce hardness, to remove iron, and to remove free carbon dioxide. The plant, which is fully automatic, is located between the pump and the distribution system as a pressure plant. All operations are automatic, or at least a major portion of them. An operator is not required at the plant except for inspections.

Supposedly 80% of the water is softened by passing it through five automatic cylindrical zeolite softening units and through one that is manually operated. Each tank is seven feet in diameter and eleven feet high and contains 200 cu.ft. of zeolite sand (Zeo-Dur in the 5 automatic tanks and Zeo-Karb in the manually operated tank) at a depth of 5.19 feet. The sand is supported by 12 inches of gravel which covers a strainer system. Both the hardness and the iron are removed in these units.

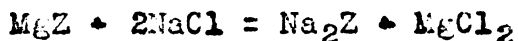
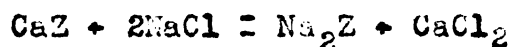
The raw water from the well contains between 18 & 20 grains of hardness per gallon. The Zeo-Dur in the five automatic tanks will remove 2800 grains of hardness per cubic foot of sand which determines the amount of water

that can be treated before the sand has to be regenerated. The hardness of the water is caused by calcium and magnesium bicarbonates and sulfates.

The zeolite used in removing this hardness is a processed greensand base zeolite which has the property of exchanging its sodium for the calcium and magnesium of the hardness producing compounds in the water. The resulting sodium compounds do not cause hardness. The sodium zeolite compound is indicated as Na_2Z . The softening reactions are shown in these equations:



The zeolite is regenerated by passing a sodium chloride brine through the sand bed.



The calcium and magnesium zeolites are changed back to sodium zeolites and are ready to soften water again.

The other 20% of the water is passed through tank No. 7, another manually operated tank. This tank has 100 cu. ft. of a manganese zeolite in it which removes iron, but not hardness. The flow from this tank and the flow from the six other tanks are mixed, giving a water with 80% of the hardness removed and all the iron compounds removed.

The principal item of expense in the operation of this plant is the sodium chloride (table salt). It costs approximately 2 cents per 1000 gallons of water. The salt is used in regenerating the zeolite sand. Recently the sand in the five automatic tanks has lost its softening power which requires more salt for the more frequent regenerations.

Also the sand, which is expensive, lasted only 60% of its guaranteed life. The Permutit Co. of New York, N.Y. is now ready to replace the worn sand.

CAUSE OF SAND FAILURE

The reason for the sand losing its softening power was that there was unequal distribution to the five automatic units. Consequently, the unequal distribution overworked some of the sand and did not work the full capacity of the rest. The softening, washing, brining, and rinsing are controlled by an electrically driven multiport valve. The valve is controlled by a timing device which is set at a cycle as desired. But the cycles are equal for each of the five automatic tanks (tanks are numbered 1,2,3,4,5, on the diagrams). However, the piping to the tanks is such that there is unequal flow. At the pumping rate required by the water demand, some of the tanks were overworked and weakened while the others were being regenerated before it was necessary. This was the reason for making a survey of the piping system. The rates were found to be:

Tank No. G.P.M.

1----- 101.5

2----- 103.5

3----- 105.5

4----- 90.0

5----- 90.5

6----- 117.0

7----- 92.0

METHOD OF DETERMINING PRESENT RATES

All the pipes in the plant were measured and located. A drawing showing the layout is in the back cover of this book. Table I has all the pipes and fittings listed for each of the seven routes to the seven tanks.

The purpose of Table I is to tabulate the coefficients of the head losses through the pipes, fittings, and tanks in terms of $V_3^2/2g$. V_3 is the velocity in a 3 in. pipe. The coefficient equals $f \frac{L}{D}$ in the formula $h_f = f L/D V^2/2g$. f equals coefficient of friction, L equals length of pipe in inches or feet, D equals diameter of pipe in inches or in feet, and h_f equals head in feet. The f 's were taken from figure 114-"Flow of water in pipes", Hydraulics, Schoeder and Dawson, p.198, using "fairly smooth pipe" at a velocity of 5 ft./ sec. The following f 's were used: 8"- f -.022, 6"- f -.023, 5"- f -.024, 4"- f -.026, 3"- f -.028.

TABLE I
COEFFICIENTS FOR HEAD LOSSES
IN TERMS OF $\frac{V^2}{2g}$

(Tank No. 1)

Number.	Item	Amount	$\frac{V^2}{2g}$
1	8"x 8"x 6" 90 Bend	1	.02
2	8"x 3"x 8" Tee	1	.50
3	3" 90 Degree Bend	1	.50
4	3" Pipe	3' - 3"	.36
5	3"x 2 1/2"x 3" Tee	1	1.50
6	3" Pipe	4"	.04
7	3" Gate Valve	1	.05
8	3" Pipe	5"	.04
9	3" Multiport Valve	1	5.00
10	3" Pipe	6' - 8"	.73
11	3" 90 Degree Bend	1	.50
12	3" Pipe	1' - 10"	.20
13	2"x 3" Orifice Plate	1	5.05
14	3" Pipe	1' - 10"	.20
15	3" 90 Degree Bend	1	.50
16	3" Pipe	4"	.04
17	Softening Tank	1	3.99
18	3" Pipe	6"	.04
19	3"x 2 1/2"x 3" Tee	1	1.50
20	3" Pipe	1' - 6"	.17
21	Multiport Valve	1	5.00
22	3" Pipe	6"	.04
23	3" 90 Degree Bend	2	1.00
24	3" Pipe	9"	.08
25	3" 90 Degree Bend	1	.50
26	3" Pipe	7' - 0"	.80
27	3"x 4"x 3" Tee	1	.19
28	4" Pipe	5' - 2"	.59
29	4"x 5"x 4" Tee	1	.39
30	5" Pipe	2' - 2"	.02
31	4"x 6"x 5" Tee	1	.16
32	6" Gate Valve	1	.01
33	6"x 8"x 4" Tee	1	.01

(Tank No. 2)

Number.	Item	Amount	$V \frac{2}{3} / 2g$
1	8"x 8"x 6" 90 Bend	1	.02
2	8"x 3"x 8" Tee	1	.03
3	8" Pipe	5' - 4"	.01
4	8"x 6"x 3" Tee	1	.52
5	3" Pipe	3' - 0"	.34
6	3" 90 Degree Bend	1	.50
7	3" Pipe	4"	.04
8	3" Gate Valve	1	.05
9	3" Pipe	4"	.04
10	3" Multiport Valve	1	5.00
11	3" Pipe	6' - 8"	.73
12	3" 90 Degree Bend	1	.50
13	3" Pipe	1' - 10"	.20
14	2"x 3" Orifice Plate	1	5.05
15	3" Pipe	1' - 10"	.20
16	3" 90 Degree Bend	1	.50
17	3" Pipe	4"	.04
18	Softening Tank	1	3.99
19	3" Pipe	6"	.04
20	3"x 2 1/2"x 3" Tee	1	1.50
21	3" Pipe	1' - 6"	.17
22	Multiport Valve	1	5.00
23	3" Pipe	6"	.04
24	3" 90 Degree Bend	2	1.00
25	3" Pipe	9"	.08
26	3"x 4"x 3" Tee	1	1.16
27	4" Pipe	5' - 2"	.59
28	4"x 4"x 5" Tee	1	.39
29	5" Pipe	2' - 2"	.02
30	4"x 5"x 6" Tee	1	.16
31	6" Gate Valve	1	.01
32	6"x 8"x 4" Tee	1	.01

(Tank No. 3)

1	8"x 8"x 6" 90 Bend	1	.02
2	8"x 3"x 8" Tee	1	.03
3	8" Pipe	5' - 4"	.01
4	8"x 6"x 3" Tee	1	.03
5	6" Pipe	12"	.01
6	6"x 3"x 6" Tee	1	.50
7	3" Pipe	1' - 4"	.14
8	3" 90 Degree Bend	1	.50
9	3" Pipe	3' - 3"	.36
10	3" 90 Degree Bend	1	.50

Number.	Item	Amount	$V \frac{2}{3\pi} / 2g$
11	3" Pipe	3' - 6"	.39
12	3" Gate Valve	1	.05
13	3" Pipe	4"	.04
14	3" Multiport Valve	1	5.00
15	3" Pipe	6' - 8"	.73
16	3" 90 Degree Bend	1	.50
17	3" Pipe	1' - 10"	.20
18	2"x 3" Orifice Plate	1	5.05
19	3" Pipe	1' - 10"	.20
20	3" 90 Degree Bend	1	.50
21	3" Pipe	4"	.04
22	Softening Tank	1	3.99
23	3" Pipe	6"	.04
24	3"x 2 1/2"x 3" Tee	1	1.50
25	3" Pipe	1' - 6"	.17
26	Multiport Valve	1	5.00
27	3" Pipe	6"	.04
28	3" 90 Degree Bend	2	1.00
29	3" Pipe	9"	.08
30	3" 90 Degree Bend	1	.50
31	3" Pipe	6"	.04
32	4"x 4"x 5" Tee	1	.39
33	5" Pipe	2' - 2"	.02
34	4"x 6"x 5" Tee	1	.16
35	6" Gate Valve	1	.01
36	6"x 8"x 4" Tee	1	.01

(Tank No. 4)

1	8"x 8"x 6" 90 Bend	1	.02
2	8"x 3"x 8" Tee	1	.03
3	8" Pipe	5' - 4"	.01
4	8"x 6"x 3" Tee	1	.03
5	6" Pipe	12"	.01
6	6"x 3"x 6" Tee	1	.09
7	6" 45 Degree Bend	1	.02
8	6" Pipe	1' - 6"	.01
9	6" 45 Degree Bend	1	.02
10	6" Pipe	19' - 0"	.07
11	4"x 4"x 6" Tee	1	.22
12	4" Pipe	2' - 0"	.06
13	4" 90 Degree Bend	1	.16
14	3"x 3"x 4" Tee	1	.66
15	3" Pipe	6' - 0"	.67
16	3" 90 Degree Bend	1	.50
17	3" Pipe	3' - 4"	.36
18	3" 90 Degree Bend	1	.50

Number.	Item	Amount	V $\frac{2}{3}$ " / 2g
19	3" Pipe	4"	.04
20	3" Gate Valve	1	.05
21	3" Pipe	5"	.04
22	Multiport Valve	1	500
23	3" Pipe	6' - 8"	.73
24	3" 90 degree Bend	1	.50
25	3" Pipe	1' - 10"	.20
26	2"x3" Orifice Plate	1	5.05
27	3" Pipe	1' - 10"	.20
28	3" 90 degree Bend	1	.50
29	3" Pipe	4"	.04
30	Softening Tank	1	3.99
31	3" Pipe	6"	.04
32	3" x 2½" x 3" Tee	1	1.50
33	3" Pipe	1' - 6"	.17
34	Multiport Valve	1	5.00
35	3" Pipe	6"	.04
36	3" 90 Degree Bend	2	1.00
37	3" Pipe	9"	.08
38	3" 90 Degree Bend	1	.50
39	3" Pipe	4' - 1"	.45
40	3"x 3"x 4" Tee	1	1.16
41	4" Pipe	2' - 9"	.08
42	4" 90 Degree Bend	1	.16
43	4" Pipe	6"	.02
44	4" 90 Degree Bend	1	.16
45	4" Pipe	17' - 6"	.47
46	4" 90 Degree Bend	1	.16
47	4" Pipe	2' - 9"	.08
48	4" 90 Degree Bend	1	.16
49	4" Pipe	9"	.02
50	4"x 6"x 5" Tee	1	.09
51	6" Gate Valve	1	.01
52	6"x 8"x 4" Tee	1	.01

(Tank No. 5)

1	8"x 8"x 6" 90 Bend	1	.02
2	8"x 3"x 8" Tee	1	.03
3	8" Pipe	5' - 4"	.01
4	8"x 6"x 3" Tee	1	.03
5	6" Pipe	12"	.01
6	6"x 3"x 6" Tee	1	.09
7	6" 45 Degree Bend	1	.02
8	6" Pipe	1' - 6"	.01
9	6" 45 Degree Bend	1	.02
10	6" Pipe	19' - 0"	.07
11	4"x 4"x 6" Tee	1	.22

Number.	Item	Amount	V $\frac{2}{3}$ " / 29
12	4" Pipe	2'-0"	.06
13	4" 90 Degree Bend	1	.16
14	3"x 3"x 4" Tee	1	.66
15	3" 90 Degree Bend	1	.50
16	3" Pipe	3'-4"	.36
17	3" 90 Degree Bend	1	.50
18	3" Pipe	4"	.04
19	3" Gate Valve	1	.05
20	3" Pipe	5"	.04
21	Multiport Valve	1	5.00
22	3" Pipe	6'-8"	.73
23	3" 90 Degree Bend	1	.50
24	3" Pipe	1'-10"	.20
25	2"x 3" Orifice Plate	1	5.05
26	3" Pipe	1'-10"	.20
27	3" 90 Degree Bend	1	.50
28	3" Pipe	4"	.04
29	Softening Tank	1	3.99
30	3" Pipe	6"	.04
31	3"x 2½"x 3" Tee	1	1.50
32	3" pipe	1'-6"	.17
33	Multiport Valve	1	5.00
34	3" Pipe	6"	.04
35	3" 90 Degree Bend	2	1.00
36	3" Pipe	9"	.08
37	3" 90 Degree Bend	1	.50
38	3" Pipe	1'-10"	.20
39	3"x 3"x 4" Tee	1	1.16
40	4" Pipe	2'-9"	.08
41	4" 90 Degree Bend	1	.16
42	4" Pipe	6"	.02
43	4" 90 Degree Bend	1	.16
44	4" Pipe	17'-6"	.47
45	4" 90 Degree Bend	1	.16
46	4" Pipe	2'-9"	.08
47	4" 90 Degree Bend	1	.16
48	4" Pipe	9"	.02
49	4"x 6"x 5" Tee	1	.09
50	6" Gate Valve	1	.01
51	6"x 8"x 4" Tee	1	.01

(Tank No. 6)

Number.	Item	Amount	$\nabla \frac{2}{3}'' / 2g$
1	8"x 8"x 6" 90 Bend	1	.05
2	6" Gate Valve	1	.01
3	6" Pipe	3'-6"	.06
4	6" 90 Degree Bend	1	.03
5	6" to 4" Reducer	1	.16
6	4" Pipe	10'-7"	.29
7	4" 90 Degree Bend	1	.16
8	4" Pipe	17'-0"	.46
9	4" 90 Degree Bend	1	.16
10	4" Pipe	7'-6"	.21
11	4" 90 Degree Bend	1	.16
12	4" Pipe	4"	.01
13	4" Multiport Valve	1	5.00
14	4" Pipe	7'-0"	.19
15	4" 90 Degree Bend	1	.16
16	4" Pipe	3'-6"	.10
17	4" 90 Degree Bend	1	.16
18	4" Pipe	6"	.01
19	Softening Tank	1	3.99
20	4" Pipe	6"	.01
21	4"x 4"x 4" Tee	1	.48
22	4" Pipe	13"	.13
23	4" Multiport Valve	1	5.00
24	3" Pipe	7"	.06
25	Fermutit Meter	1	
26	3" Pipe	4"	.03
27	3" 90 Degree Bend	2	1.00
28	3"x 3"x 4" Tee	1	1.16
29	4" 90 Degree Bend	1	.16
30	4" Pipe	3'-0"	.08
31	4" 90 Degree Bend	1	.16
32	4" Pipe	6"	.01
33	4" 90 Degree Bend	1	.16
34	4" Pipe	18'-8"	.50
35	4" 90 Degree Bend	1	.16
36	4" Pipe	3'-0"	.08
37	4" 90 Degree Bend	1	.16
38	4" Gate Valve	1	.03
39	4" Pipe	12"	.03
40	4" 90 Degree Bend	1	.16
41	6"x 8"x 4" Tee	1	.33

(Tank No. 7)

Number.	Item	Amount	V $\frac{2}{3}$ / 2g
1	8"x 8"x 6" 90 Bend	1	.02
2	8"x 3"x 8" Tee	1	.03
3	8" Pipe	5'-4"	.01
4	8"x 6"x 3" Tee	1	.03
5	6" Pipe	12"	.01
6	6"x 3"x 6" Tee	1	.09
7	6" 45 Degree Bend	1	.02
8	6" Pipe	1'-6"	.01
9	6" 45 Degree Bend	1	.02
10	6" Pipe	19'-0"	.07
11	4"x 4"x 6" Tee	1	.22
12	4" Pipe	2'-2"	.06
13	4" 90 Degree Bend	1	.16
14	4" Pipe	6"	.02
15	3"x 3"x 4" Tee	1	.82
16	3" Pipe	4'-1"	.45
17	3" Gate Valve	1	.05
18	3" 90 Degree Bend	1	.50
19	3" Pipe	3'-3"	.36
20	3"x 2½"x 3" Tee	1	1.50
21	3" Pipe	1'-2"	.14
22	3" Multiport Valve	1	5.00
23	3" Pipe	6'-7"	.73
24	3" 90 Degree Bend	1	.50
25	3" Pipe	3'-10"	.42
26	3" 90 Degree Bend	1	.50
27	3" Pipe	6"	.05
28	Iron Removal Tank	1	2.64
29	3" Pipe	6"	.04
30	3"x 2½"x 3" Tee	1	1.50
31	3" Pipe	1'-5"	.17
32	3" Multiport Valve	1	5.00
33	3" Pipe	6"	.04
34	3" 90 Degree Bend	2	1.00
35	3" Pipe	1'-3"	.14
36	3" 90 Degree Bend	1	.50
37	3" Pipe	4'-5"	.50
38	3" 90 Degree Bend	1	.50
39	3"x 3"x 4" Tee	1	1.16
40	4" 90 Degree Bend	1	.16
41	4" Pipe	3'-0"	.08
42	4" 90 Degree Bend	1	.16
43	4" Pipe	6"	.01
44	4" 90 Degree Bend	1	.16
45	4" Pipe	18'-8"	.50
46	4" 90 Degree Bend	1	.16
47	4" Pipe	3'-0"	.08
48	4" 90 Degree Bend	1	.16
49	4" Gate Valve	1	.03
50	4" Pipe	12"	.03
51	4" 90 Degree Bend	1	.16
52	6"x 8"x 4" Tee	1	.33

For the fittings, as elbows, tees, reducers, and valves, Table IV-"Special Losses of Head in Terms of $V^2/2g$ ", Hydraulics, Schoeder and Dawson, p.213, was used. All velocity heads were then converted to $V_3^2/2g$ by these conversion factors:

$$V_8^2/2g = .02 V_3^2/2g \qquad V_6^2/2g = .0625 V_3^2/2g$$

$$V_5^2/2g = .130 V_3^2/2g \qquad V_4^2/2g = .516 V_3^2/2g$$

The number of velocity heads lost thru the tanks were computed as follows:

Loss of Head in Sand

from Hazen's formula $V=cd^2 h/l(0.70+0.30t)$

V =velocity in meters per day

$c=1000$

d =effective size of sand in mm.= 0.28mm.

t =temperature in C = 50° = 100

Q =approximately 100 G.P.M.

$A=38.5$ sq. ft.

$V=Q/A=0.00577$ ft./sec.= 152.4 meters/day

$l=5'-2"$

$h_f=Vl/cd^2(.7+.3t)= 2.71$ ft. which varies directly as Q

Loss of Head in Underdrainage

nozzles at 6" centers

diameter of nozzle(opening)= 1/8"

area served by each nozzle = $1/4$ sq.ft.

take $Q=100$ G.P.M.

each nozzle, $Q=(100/449 \times 38.5) \times 0.25 = 0.00145$ c.f.s.

$V=Q/A = .00145 \times 144 / (1/8)^2 \times 0.7854 = 17$ ft./sec.

$V=C(2gh)^{1/2}$ $h=(17)^2 / (.97^2 \times 64.4) = 4.81$

nozzle loss = $(1-c^5)h = (1-.97^5)4.81 = 0.29'$

Loss in gravel and underdrainage = $0.29 + .01 = 0.30'$

which varies as Q^2

Loss in Entry to Tank

Flow goes from 3" pipe to 4-1 1/2" pipes at 90 deg.

at a loss of $1 V_4^2 / 2g$

$V_4 = (3/1.5)^2 V_3$ $V_4^2 / 2g = 2.07 V_3^2 / 2g$

, 3" vel. hd. for $Q=100$ G.P.M. = $0.32'$

For 100 G.P.M. $(1+2.07)0.32 = 0.98'$ (varies as Q^2)

Total loss through tank = 2.71 plus $.30$ plus $.98 = 3.99'$

Now we have head losses in terms of velocity heads for 3" pipe for pipes, fittings, and tanks. These velocity heads will be later converted into ft.hd. loss as Q is determined for each route as it is shown in Table III

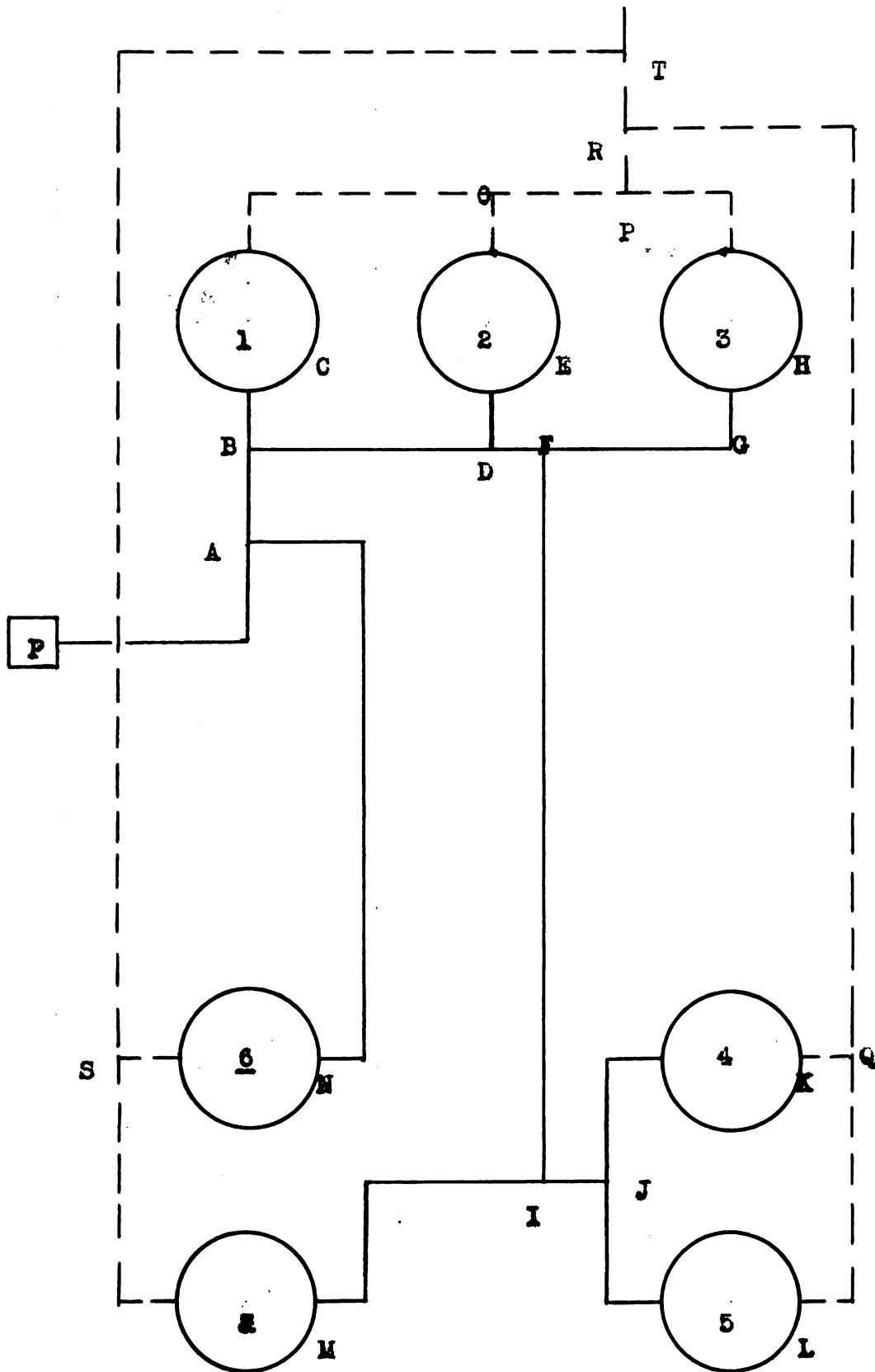
To have the velocity heads in Table I mean anything, Table II was tabulated to show which items carried water to tanks 1,2,3,4,5,6,7, or their combinations. The groups of items were lettered and shown on the flow diagram.

For each grouping the number of $V^2/2g$ were added.

TABLE II
ROUTE SELECTIONS

Items	Of tank "	Common to Tank Nos.	Route on Diagram	Coef. of $V^2/2g$
1	1	1,2,3,4,5,7	AB	.02
2 thru 27	1	1	BCD	28.52
28	1	1,2	OP	.59
29 thru 31	1	1,2,3	PR	.57
32 thru 33	1	1,2,3,4,5	RT	.02
3 thru 3	2	2,3,4,5,7	ED	.04
4 thru 26	2	2	DEO	26.69
4 thru 5	3	3,4,5,7	DF	.04
6 thru 31	3	3	FGHP	27.06
12 thru 14	4	4,5	IJ	.88
6 thru 11	4	4,5,7	FI	.43
13 thru 30	4	4	JMO	27.15
40 thru 50	4	4,5	QR	2.56
15 thru 38	5	5	JIK	26.23
1 thru 27	6	6	ANS	17.98
38 thru 41	6	6,7	ST	3.02
12 thru 38	7	7	IMS	23.73

FLOW DIAGRAM



Raw Water

Treated Water

The 3 in. velocity heads from Table II were entered in Table III opposite their corresponding group. Rates in G.P.M. were assumed for each of the seven tanks and the resulting flows through the routes were noted. Now the velocity heads for the chosen Q's can be figured and multiplied by the number of those heads as summed in Table II to obtain the head losses in feet.

In the system the point of beginning was so chosen to be common to all seven routes as was the end point. The head losses in feet or lbs. through each route are equal. However, the various pipes and fittings for the different routes are so located at the present as to require different quantities of water through the seven routes to obtain that equality of head loss. The purpose of Table III is to obtain those rates. Trial NO.1 gave unequal losses so trials no.2 and no.3 were taken. Trial no.3 gave approximately equal head losses with the following rates;

Tank NO.	G.P.M.
1-----	101.5
2-----	103.5
3-----	105.5
4-----	90.0
5-----	90.5
6-----	117.0
7-----	92.0

The above unequal flows caused the present sand to

TABLE III
PUMPING 700 G.P.M. UNDER PRESENT CONDITIONS

TRIAL #1

Tank No.	Route (see flow diagram)	G.P.M.	Coef. $v_3^2/2g$	$v_3^2/2g$	FT. HEAD
1	AB	590	.02	11.08	0.22
	*BCO	110	29.03	0.384	1.12
	OP	220	0.59	1.538	0.91
	PR	330	0.57	3.456	1.97
	RT	500	.02	7.925	0.16
					<u>14.38</u>
2	Ab	590	.02	11.08	0.22
	BD	480	.04	7.30	0.29
	*LEP	110	27.20	0.384	10.43
	OP	220	0.59	1.536	0.91
	PR	330	0.57	3.456	1.97
	RT	500	.02	7.925	0.16
					<u>13.98</u>
3	AB	590	.02	11.08	0.22
	BD	480	.04	7.30	0.29
	DF	370	.04	4.34	0.17
	*FGHP	110	27.57	0.384	10.58
	PR	330	.57	3.456	1.97
	RT	500	.02	7.925	0.16
					<u>13.39</u>
4	AB	590	.02	11.08	0.22
	BD	480	.04	7.30	0.29
	DF	370	.04	4.34	0.17
	FI	260	0.43	2.15	0.93
	IJ	170	0.88	0.915	0.81
	*JHQ	85	26.43	0.231	6.12
	QR	170	2.58	0.915	2.34
	RT	500	.02	7.925	0.16
					<u>11.04</u>

Tank No.	Route	G.P.M.	Coef.	$V_{3''}^2/2g$	FT.HD.
5	AB	590	.02	11.08	0.22
	BD	480	.04	7.30	0.29
	DF	370	.04	4.34	0.17
	FI	260	.43	2.15	0.93
	IJ	170	.88	0.915	0.81
	*JLQ	85	25.51	0.231	5.90
	QR	170	2.56	0.915	2.34
	RT	500	.02	7.925	0.16
					<u>10.82</u>
6	ANS	110	18.49	0.384	7.10
	ST	200	3.02	1.268	3.83
					<u>10.93</u>
7	AB	590	.02	11.08	0.22
	BD	480	.04	7.30	0.29
	DF	370	.04	4.34	0.17
	FI	260	.43	2.15	0.93
	*IMS	90	23.37	.257	6.00
	ST	200	3.03	1.268	3.83
					<u>11.44</u>
TRIAL NO. 2					
1	AB	585	.02	10.98	0.22
	*BCD	100	28.52	.321	9.15
	OP	205	0.59	1.35	.80
	PR	310	0.57	3.09	1.76
	RT	490	.02	7.74	.15
					<u>12.08</u>
2	AB	585	.02	10.98	0.22
	BD	485	.04	7.52	0.30
	*DEO	105	26.94	.353	9.51
	OP	205	0.59	1.35	0.80
	PR	310	0.57	3.09	1.76
	RT	490	.02	7.74	.15
					<u>12.74</u>
3	AB	585	.02	10.98	0.22
	BD	485	.04	7.52	.30
	DF	380	.04	4.62	.19
	FGHP*	105	27.31	.353	9.63
	PR	310	.57	3.09	1.76
	RT	490	.02	7.74	.15
					<u>12.25</u>

Tank No.	Route	G.P.M.	Coef.	$V_{3''}^2/2g$	FT.HD.
4	AB	585	.02	10.98	0.28
	BD	485	.04	7.52	.30
	DF	380	.04	4.62	.19
	FI	275	.43	2.42	1.04
	IJ	180	.88	1.04	.92
	*JKQ	90	26.67	.259	6.91
	QR	180	2.56	1.04	2.66
	RT	490	.02	7.74	.15
					<u>12.39</u>

5	AB	585	.02	10.98	.28
	BD	485	.04	7.52	.30
	DF	380	.04	4.62	.19
	FI	275	.43	2.42	1.04
	IJ	180	.88	1.04	.92
	*JLQ	90	25.75	.259	6.66
	QR	180	2.56	1.04	2.66
	RT	490	.02	7.74	.15
					<u>12.14</u>

6	*ANS	115	18.70	.425	7.94
	ST	210	3.02	1.41	4.26
					<u>12.20</u>

7	AB	585	.02	10.98	0.22
	BD	485	.04	7.52	.30
	DF	380	.04	4.62	.19
	FI	275	.43	2.42	1.04
	*IMS	95	23.55	.289	6.80
	ST	210	3.02	1.41	4.26
					<u>12.81</u>

TRIAL NO. 5

1	AB	582	.02	10.86	0.22
	*BCO	101	28.57	.326	9.31
	OP	204	.59	1.33	.79
	PR	309	.57	3.06	1.75
	RT	489	.02	7.65	.15
					<u>12.22</u>

2	AB	582	.02	10.86	0.22
	BD	481	.04	7.43	.30
	*DEO	103	26.84	.341	9.22
	OP	204	.59	1.33	.79
	PR	309	.57	3.06	1.75
	RT	489	.02	7.65	.15
					<u>12.23</u>

TRIAL NO.3 (cont'd.)

Tank No.	Route	G.P.M.	Coef.	$V_3^2/2g$	FT.HD.
3	AB	582	.02	10.86	0.22
	BD	481	.04	7.43	.30
	DF	378	.04	4.58	.18
	*FGHP	105	27.31	.553	9.63
	PR	309	.57	3.06	1.75
	RT	489	.02	7.65	.15
					<u>12.23</u>
4	AB	582	.02	10.86	0.22
	BD	481	.04	7.43	.30
	DF	378	.04	4.58	.18
	FI	273	.43	2.39	1.03
	IJ	180	.88	1.04	0.92
	*JKQ	90	26.67	.259	6.91
	QR	180	2.56	1.04	2.66
	RT	489	.02	7.65	.15
					<u>12.37</u>
5	AB	582	.02	10.86	.22
	BD	481	.04	7.43	.30
	DF	378	.04	4.58	.18
	FI	273	.43	2.39	1.03
	IJ	180	.88	1.04	.92
	*JLQ	90	25.74	.259	6.66
	QR	180	2.56	1.04	2.66
	RT	489	.02	7.65	.15
					<u>12.12</u>
6	*ANS	118	18.91	.445	8.42
	ST	211	3.02	1.43	4.32
					<u>12.74</u>
7	AB	582	.02	10.86	.22
	BD	481	.04	7.43	.30
	DF	378	.04	4.58	.18
	FI	273	.43	2.39	1.03
	*IMS	93	23.48	.278	6.55
	ST	211	3.02	1.43	4.32
					<u>12.60</u>

* routes through tanks

Final rates through tanks 1 to 7 are 101.5 G.P.M., 103.5 G.P.M., 105.5 G.P.M., 90.0 G.P.M., 90.5 G.P.M., 117.0 G.P.M., & 92.0 G.P.M. respectively at a plant loss of 12.36ft. or 5.35 lbs.

wear out before its guarantee expired. The next section will give the changes to be made in the sand.

CHANGES IN SAND

The Permutit Co. will furnish new gravel for tanks 1,2,3,4,&5 consisting of a 12" layer $1/8$ to $1/2$ in. gravel. Also to be supplied by the Permutit Co. is 62 cu.ft. of Zeo-Karb for each of the five units. The City of East Lansing is to buy 70 cu.ft. of Zeo-Karb(14 cu.ft. for each of the five tanks) at the price of \$1275 which includes the price of 70 cu.ft. of sand plus the freight on 380 cu.ft. At present there is Zeo-Karb(200 cu.ft.) in tank no.6 which will be distributed to the five automatic tanks at 40 cu.ft. per tank. Each of the five tanks will then have a total of 116 cu. ft. of Zeo-Karb.

The best of the Zeo-Dur taken from the five tanks will be placed in tank no.6(200 cu.ft.) Tank no.7 will still have the 100 cu.ft. of manganese zeolite.

Tank No.	Vol. of Sand	# of 3" vel.hd.
1	116 cu.ft.	2.86
2	"	"
3	"	"
4	"	"
5	"	"
6	200 cu.ft.	3.99
7	100 cu.ft.	2.94

With these changes, the plant capacity will be greater. The next section gives new pumping rates.

NEW PUMPING RATES POSSIBLE

20 min. rinse; 10 min. wash; 10 min brine; 10 min. clearance
equals 50 min. cycle.

5x50min. equals 250 min. cycle for the 5 automatic units

5x116c.f.x5000 = 2,900,000 grains

water at 20 gr. per gal. = $2,900,000/20 = 145,000$ gals. for
the 5 tanks

wash at 250 G.P.M. x10 min. = 2500 gal./tank

rinse at 115 G.P.M. x20min. = 2300 gal./tank

5 x 4600 = 23,000 gal/5 tanks

$\frac{23,000 + 145,000 \text{ gal}}{250 \text{ min. cycle}} = 660 \text{ G.P.M. to 5 tanks}$

Tank No. 6

200c.f.x2800gr./c.f. = 560,000gr.

560,000gr./20gr./gal. = 28,000 gals.

28,000gals. plus 4600 gals. = 32,600 gals.

32,600 gals./150 min. = 130 G.P.M.

Tank No. 7

Treats 20% of processed water

$(145,000/170,000) \times (130 + 660) = 690 \text{ G.P.M. softened by}$
6 tanks.

$690 \text{ G.P.M.}/4 = 172 \times 5 = 860 \text{ G.P.M. processed water}$

Total Pumping equals 860 G.P.M. plus 120 G.P.M. equals 980 G.P.M.

RATE FOR DESIGN

The plant now pumps at a rate of 680 G.P.M. at a loss of 4.6 lbs. After the change in the sand has been made, a 1000 G.P.M. rate would be economical, 800 G.P.M. is all that is necessary at the present, and 1200 G.P.M. could be used in the future as water consumption demands.

At the present the system should be redesigned for 800 G.P.M. at a loss of 3 lbs. which would give a loss of 4.7 lbs. for 1000 G.P.M. and 6.8 lbs. for 1200 G.P.M.

It is desired to have tanks 1 thru 6 to each take 106 G.P.M. or a total of 80% and the iron-removal tank #7 to take 160 G.P.M. of 20% of the flow. This would give a desirable water having a hardness of about 70 ppm expressed as calcium carbonate. Using these flows, assuming the sand having been replaced, the following head losses expressed in feet are obtained for the seven tanks with the present piping: (see Table IV)

Tank No.	Ft. Head
1-----	13.09
2-----	12.86
3-----	12.42
4-----	17.49
5-----	17.15
6-----	13.40
7-----	20.20

TABLE IV

PUMPING 796 G.P.M.-PRESENT PIPES-NEW SAND

(1) Tank No.	(2) Route	(3) G.P.M.	(4) Coef.	(5) $V_{3n}^2/2g$	(6) Ft.Hd.
1	AB	690	.02	15.20	.30
	*BCO	106	27.62	.359	9.93
	OP	212	.59	1.44	.85
	PR	318	.57	3.22	1.83
	RT	530	.02	9.02	.18
					13.09
2	AB	690	.02	15.20	.30
	BD	584	.04	10.90	.44
	*DEO	106	25.79	.359	9.26
	OP	212	.59	1.44	.85
	PR	318	.57	3.22	1.83
	RT	530	.02	9.02	.18
					12.86
3	AB	690	.02	15.20	.30
	BD	584	.04	10.90	.44
	DF	478	.04	7.33	.29
	*FCHP	106	26.16	.359	9.38
	PR	318	.57	3.22	1.83
	RT	530	.02	9.02	.18
					12.42
4	AB	690	.02	15.20	.30
	BD	584	.04	10.90	.44
	DF	478	.04	7.33	.29
	FI	372	.43	4.43	1.90
	IJ	212	.88	1.44	1.27
	*JKQ	106	26.25	.359	9.42
	QR	212	2.56	1.44	3.69
	RT	530	.02	9.02	.18
					17.49
5	AB	690	.02	15.20	.30
	BD	584	.04	10.90	.44
	DF	478	.04	7.33	.29
	FI	372	.43	4.43	1.90
	IJ	212	.88	1.44	1.27
	*JLQ	106	25.53	.359	9.08
	QR	212	2.56	1.44	3.69
	RT	530	.02	9.02	.18
					17.15

TABLE IV (cont'd.)

(1) Tank No.	(2) Route	(3) G.P.M.	(4) Coef.	(5) $V_{3n}^2/2g$	(6) .Ft.Hd.
.	.	.	.	.	.
.	*ANS	106	18.28	.359	6.55
.	ST	266	3.02	2.27	6.85
.	.	.	.	.	13.40
.	AB	690	.02	15.20	.30
.	ED	584	.04	10.90	.44
.	DF	478	.04	7.33	.29
.	FI	372	.43	4.43	1.90
.	*IMS	160	25.26	.818	21.42
.	ST	266	3.02	2.27	6.85
.	.	.	.	.	28.20

* = routes through separate tanks

METHOD OF REDESIGNING SYSTEM

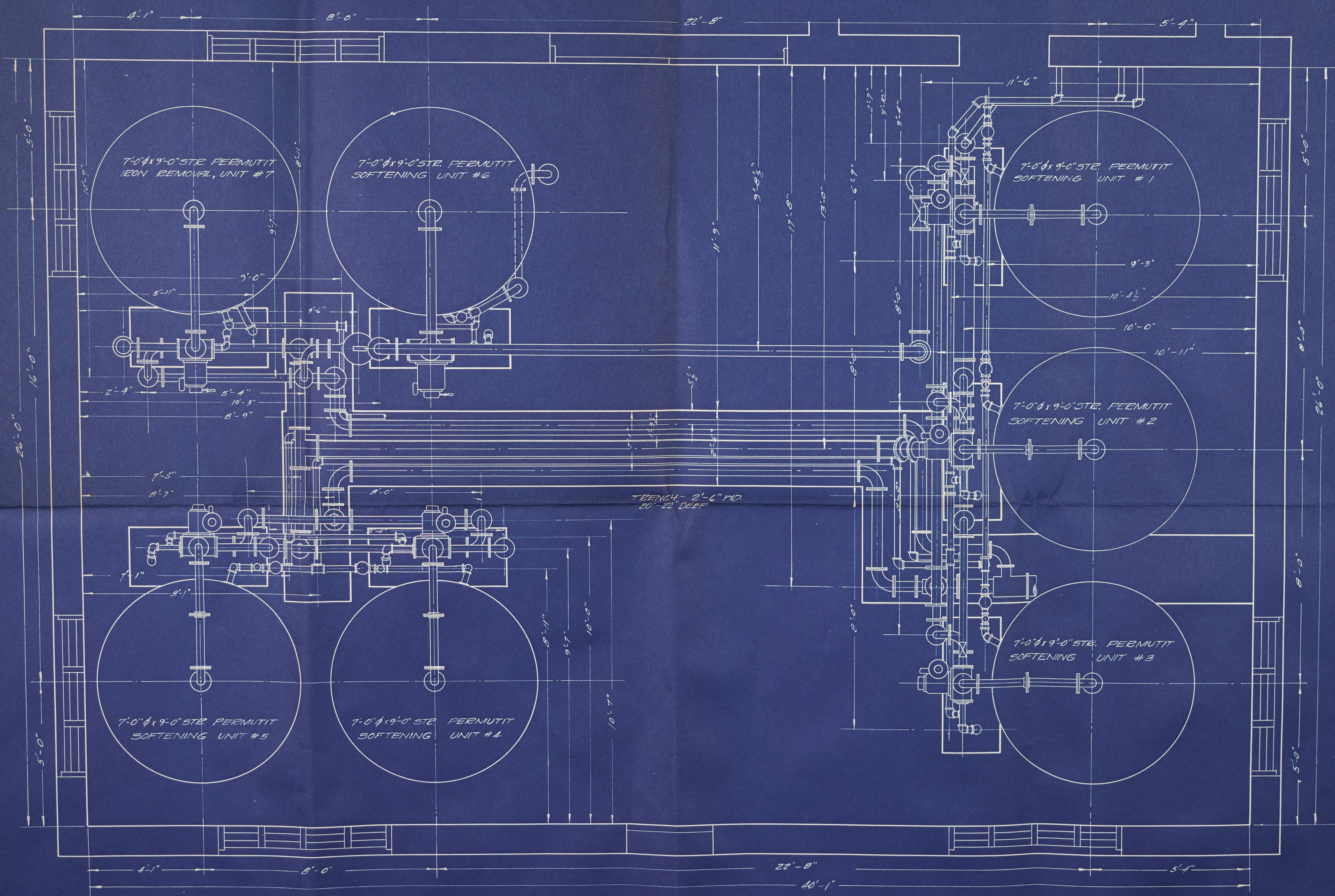
The problem of redesigning this piping system to obtain equal head losses with the desired flow is more than a mere routine. Table II shows that many of the same items are used by two or more routes. Therefore, changes made for one route may affect as many as five other routes. In order to finally get the whole system to balance so as to obtain equal frictional losses or head losses, many trials would have to be performed. Then to , the most economical change must be made rather than taking the perfection of one idea.

As time does not permit the computing of the numerous calculations to redesign the system, the method will be given.

In Table IV columns 3 and 5 are constant, or G.P.M. and 3" vel. heads. Adjust the pipes and fittings and calculate the velocity heads as in Table I. Group the items of Table I as in Table II. When the 3" vel. heads from Table II are placed in column 4 of Table IV, the sum of the products of columns 4 and 6 should be equal for the seven routes if the adjustments are correct. If altogether new routes were chosen, col.2,3,4, & 5 would all change making an entirely new problem.

~~ROOM 504 WEST~~

CA 10-40

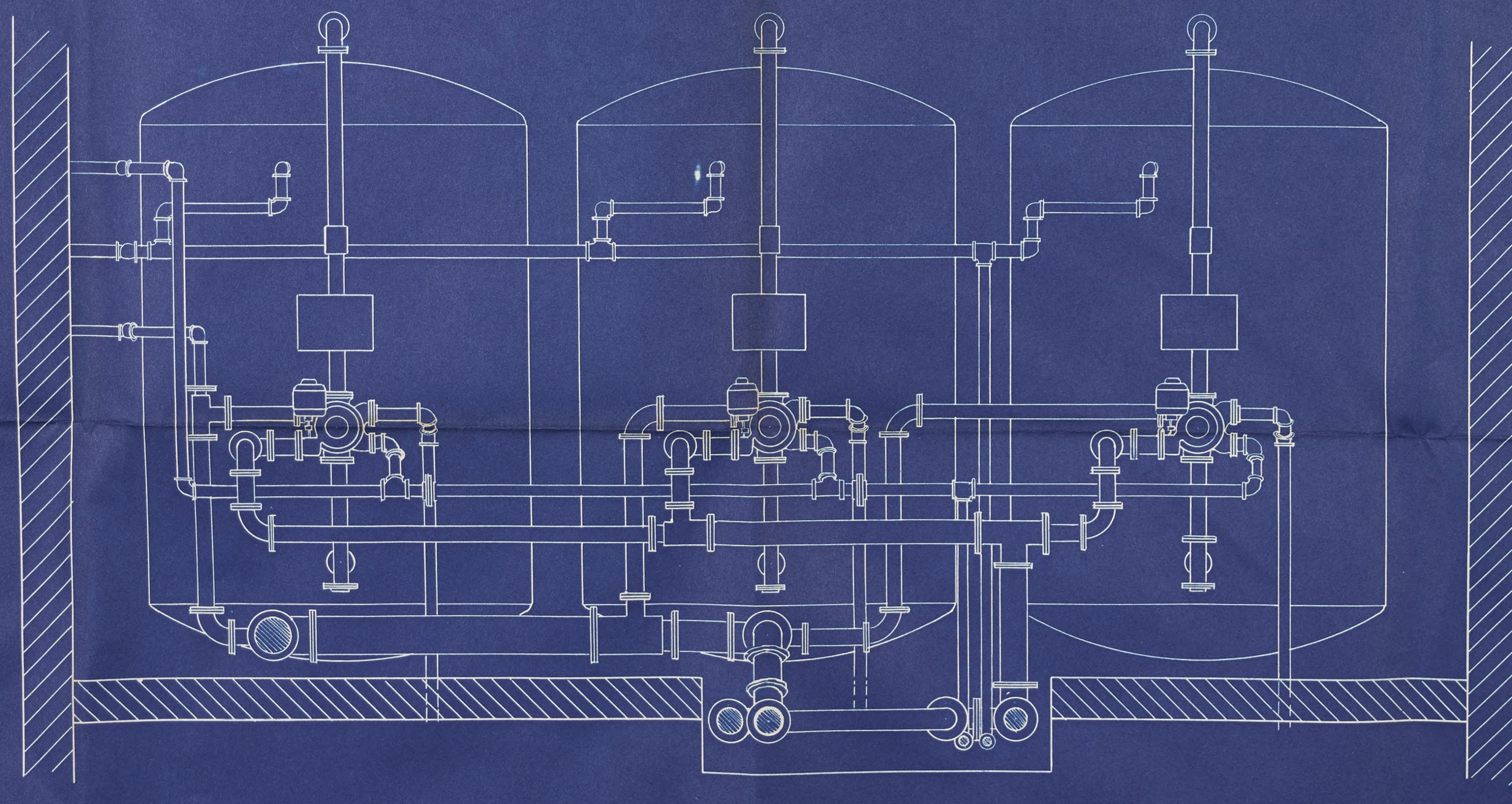


PLAN

WATER SOFTENING PLANT
EAST LANSING, MICHIGAN

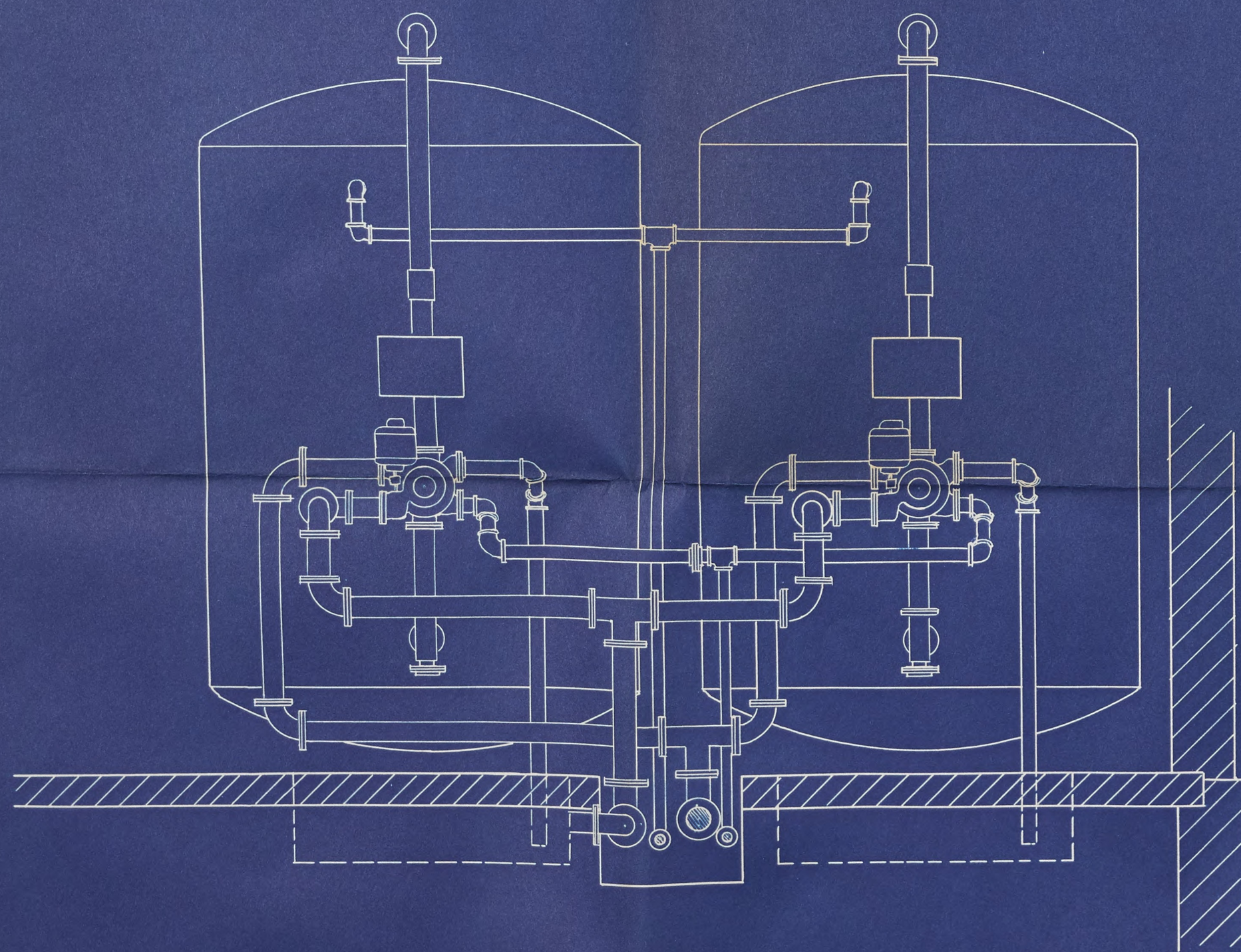
DRAWN BY T.W. POSTIFF

SCALE: $\frac{1}{2}" = 1'-0"$ JUNE 1942



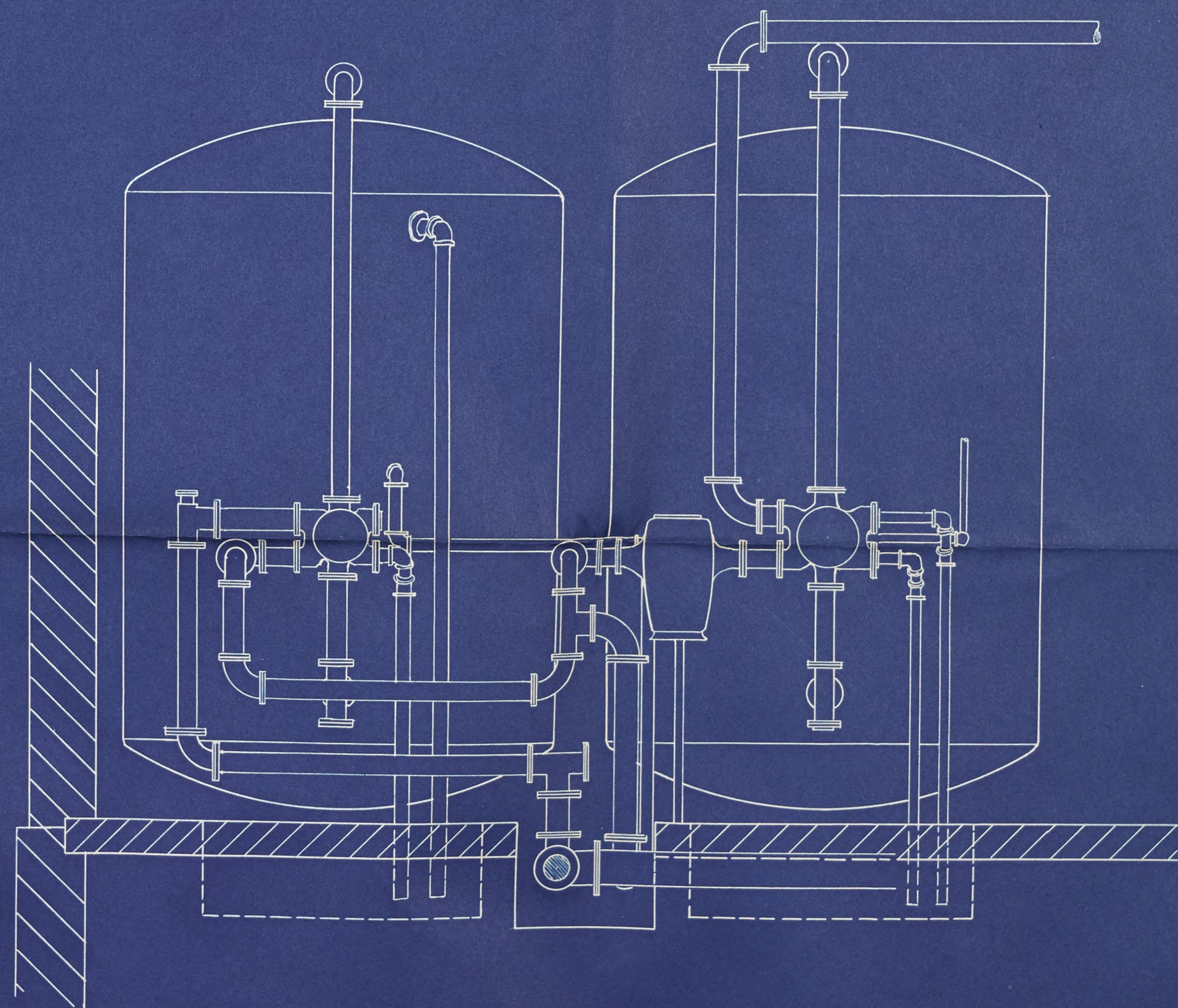
ELEVATION
TANKS 1, 2, & 3

WATER SOFTENING PLANT
EAST LANSING, MICHIGAN
DRAWN BY T. W. POSTIFF
SCALE: $\frac{1}{2}$ " = 1'-0" JUNE 1942



TANKS 4 & 5

ELEVATION



TANKS 7 & 6

WATER SOFTENING PLANT
EAST LANSING, MICHIGAN

DRAWN BY T.W. POSTIFF

SCALE: $\frac{1}{2}$ " = 1'-0" JUNE 1942

Pocket has:
3 Blueprints

SUPPLEMENTARY
MATERIAL

MICHIGAN STATE UNIVERSITY LIBRARIES
3 1293 03150 6573

122
195
THS
Blue-
print



MICHIGAN STATE UNIVERSITY LIBRARIES



3 1293 03177 9147