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INFLUENCE OF ELBOW
LOCATION AND DYNAMIC VISCOSITY
ON
TURBINE FLOWMETER CALIBRATIONS
(Under Contract DEN-57-10195)

By
Fred Videon
and
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ENGINEERING RESEARCH

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I. Introduction

The insertion of ninety-degree elbows in a pipe introduces a considerable change in the velocity distribution normally encountered in a straight pipe. The tests recently completed at Colorado State University were run to determine if elbows placed close to flowmeters, either upstream or downstream, will appreciably affect their accuracy and if so, will the magnitude of the error be influenced by the Reynold's number. The results of the tests indicate that the error caused by the elbows is negligible over most of the test conditions used, and that the error is somewhat greater when the Reynold's number is high.

Results

Tests were run on two nominal 3/4-inch flowmeters using a straight test section and U-shaped sections made up of four ninety-degree elbows. The latter were so constructed that the U-shaped section could be placed at various distances from the meter both upstream and downstream. Figs. 1 and 2 show the dimensions and positions of the elbow section during testing.

Tests were run on both a Waugh and a Potter turbinemeter using both MIL-O-5606 and water as fluids. The results obtained with the



U18401 0591312

MIL-O-5606 fluid indicated small deviations from a standard calibration with MIL-O-5606 due to the elbow. The error introduced in the water tests by the elbow was somewhat higher compared to a standard calibration with water. The deviations of the oil calibrations from a water calibration at 100° F were quite large. The figures which follow compare the two meters.

Table one shows the mean cycles per gallon and the error introduced for each calibration with water, and table two gives the corresponding information for the MIL-O-5606 hydraulic fluid tests, referenced to the standard water calibration at 100° F.

Table I

Summary of Data Taken with Water

Waugh Meter MT-110, Serial No. 2511

Run No.	Elbow Location*	$\frac{x}{d}$	Mean CPG	Diff. from CPG of Run 0	Percent Deviation	Temp. ° F
0	No elbow		1687.5	0	0	100
1	3-1/4" upstream	5.56	1696.7	9.2	0.55	100
2	4-1/4" upstream	7.28	1689.7	2.2	0.13	100
3	8" upstream	13.7	1687.3	0.2	0.01	100
4	10" upstream	17.1	1688.2	0.7	0.04	100
5	2-3/4" downstream	4.71	1694.0	6.5	0.39	100
6	3-3/4" downstream	6.43	1688.1	0.6	0.04	100

Meter 3/4-80, GLMD-1 (Potter Aeronautical)

Run No.	Elbow Location	$\frac{x}{d}$	Mean CPG	Diff. from CPG of Run 0	Percent Deviation	Temp. ° F
0	No elbow		776.22	0	0	100
1	3-1/4" upstream	5.56	782.38	6.16	0.79	100
2	4-1/4" upstream	7.28	785.99	9.77	1.26	85
3	8" upstream	13.7	781.58	5.36	0.69	100
4	10" upstream	17.1	780.78	4.56	0.59	100
5	3-1/4" downstream	5.56	785.39	9.17	1.18	100
6	4-1/4" downstream	7.28	780.34	4.12	0.53	100

* All measurements are from the centerline of the elbow to the centerline of the rotor in the meter.

Table II

Summary of Data Taken with MIL-O-5606 Fluid

Waugh Meter MT-110, Serial No. 2511

Run No.	Elbow Location*	$\frac{x}{d}$	Mean CPG	Diff. in CPG From Run 0 with Water	Percent Deviation	Temp. ° F
0	No elbow		1704.8	17.3	1.03	120
1	3-1/4' upstream	5.56	1713.8	26.3	1.56	120
2	4-1/4' upstream	7.28	1711.8	24.3	1.44	120
3	8' upstream	13.7	1705.9	18.4	1.09	120

Meter 3/4 - 80, GLMD-1 (Potter Aeronautical)

Run No.	Elbow Location	$\frac{x}{d}$	Mean CPG	Diff. in CPG From Run 0 with Water	Percent Deviation	Temp. ° F
0	No elbow		805.30	29.08	3.75	120
1	3-1/4' upstream	5.56	811.73	35.51	4.57	120
2	4-1/4' upstream	7.28	807.37	31.15	4.01	120
3	8' upstream	13.7	806.90	30.68	3.95	120

* All measurements are from the centerline of the elbow to the centerline of the rotor in the meter.

Figs. 3 and 4 show in graphical form the results of the effect of elbows on the mean performance of the two flowmeters. The parameter $\frac{x}{d}$ is a measure of the number of diameters upstream and downstream from the centerline of the rotor to the centerline of the elbow. The diameter d (0.584 in.) is the internal diameter of the pipe and x is the distance from the rotor centerline to the elbow centerline. The water at 100° F has a dynamic viscosity of $1.40 \times 10^{-5} \frac{\text{lb-sec}}{\text{ft}^2}$ and MIL-O-5606 at 120° F has a dynamic viscosity of $2.29 \times 10^{-4} \frac{\text{lb-sec}}{\text{ft}^2}$.

Figs. 5 to 8 inclusive show the performance of the meters throughout their complete calibrations for the two dynamic viscosities with the elbows at several locations. The effect of dynamic viscosity is particularly evident.

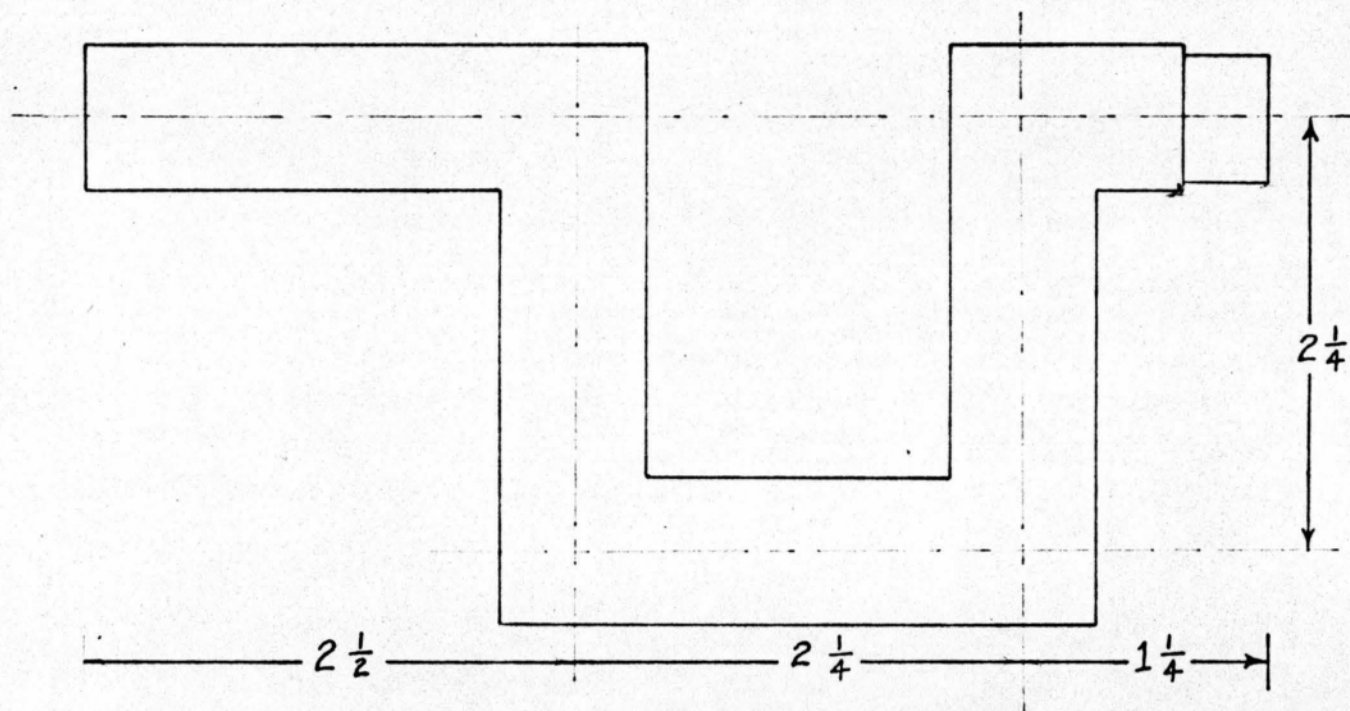
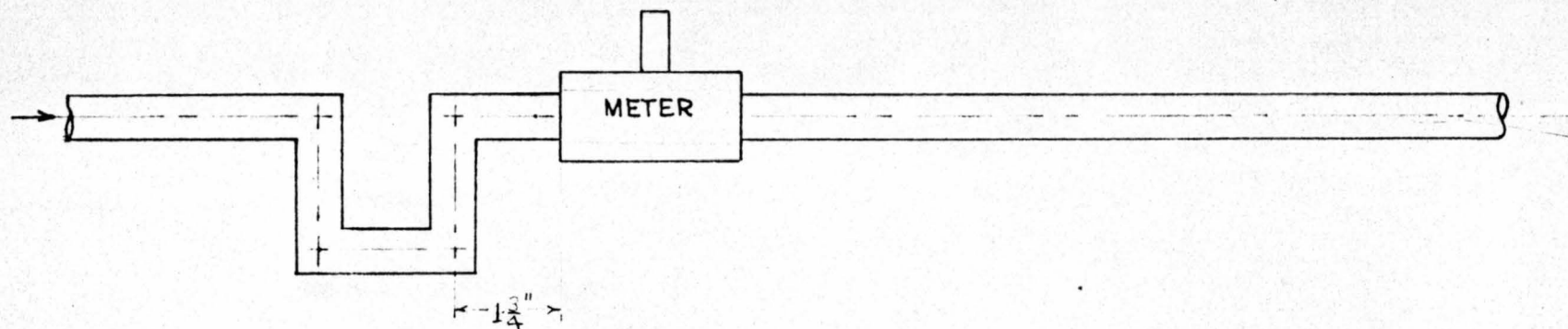
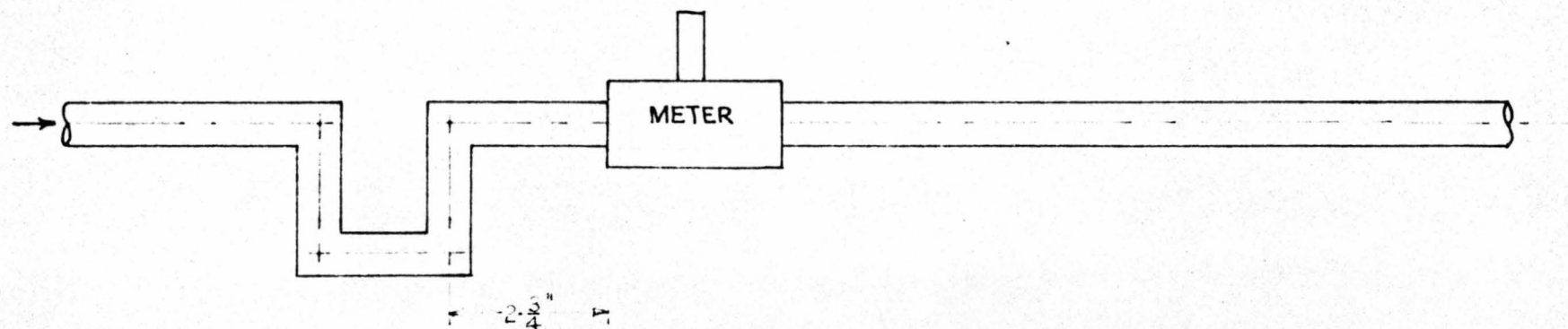


FIGURE ONE: ELBOW DIMENSIONS , $\frac{3}{4}$ " - O.D. ALUMINUM TUBE

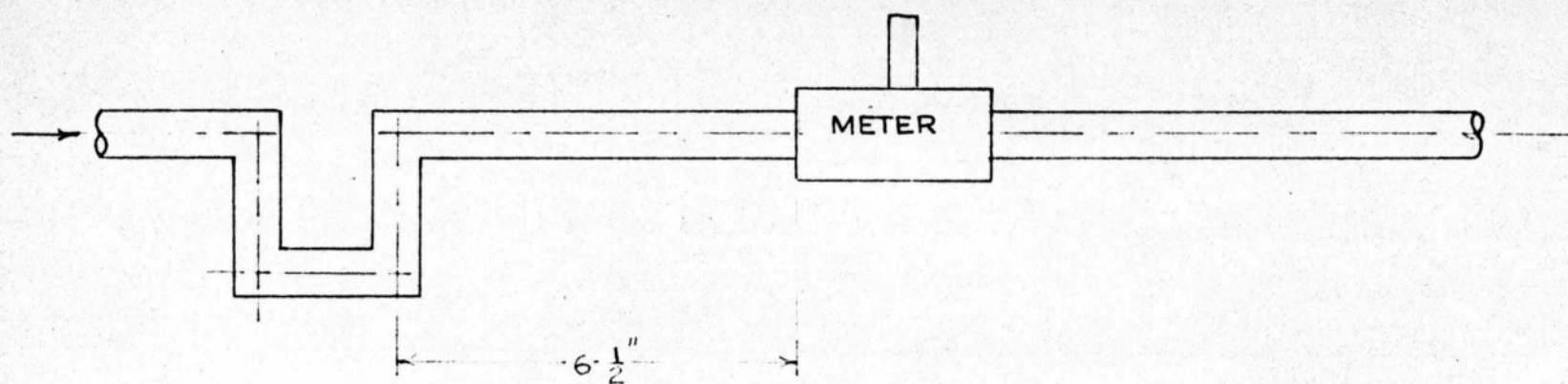


RUN NUMBER ONE: ELBOW UPSTREAM

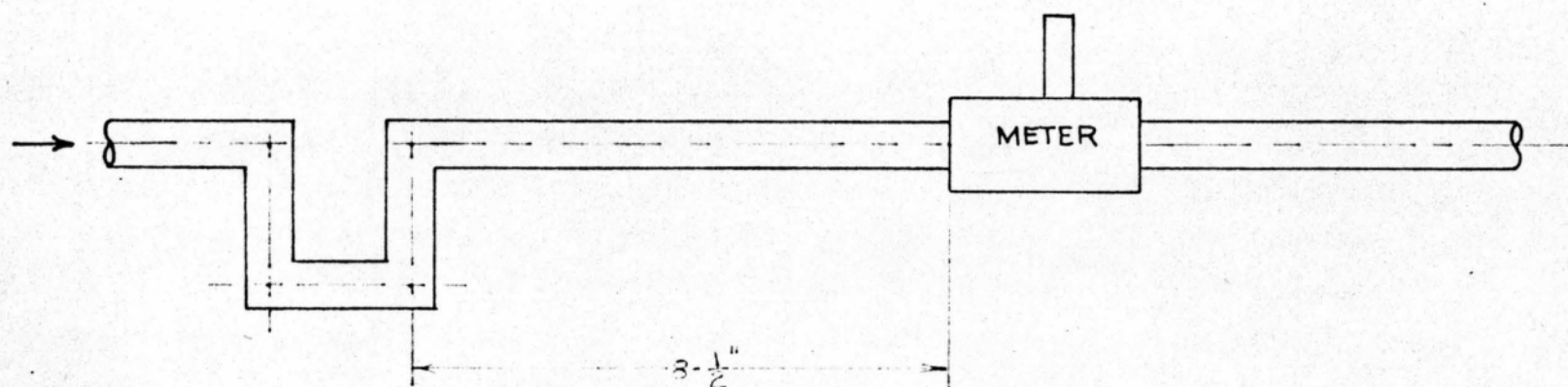


RUN NUMBER TWO: ELBOW UPSTREAM

FIGURE TWO: ELBOW POSITIONS

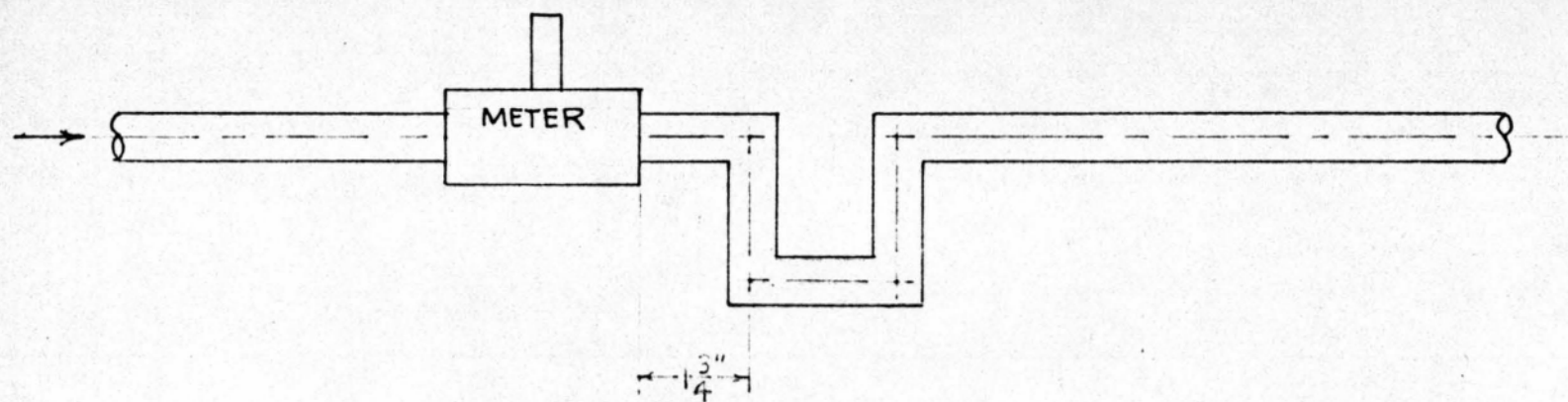


RUN NUMBER THREE: ELBOW UPSTREAM

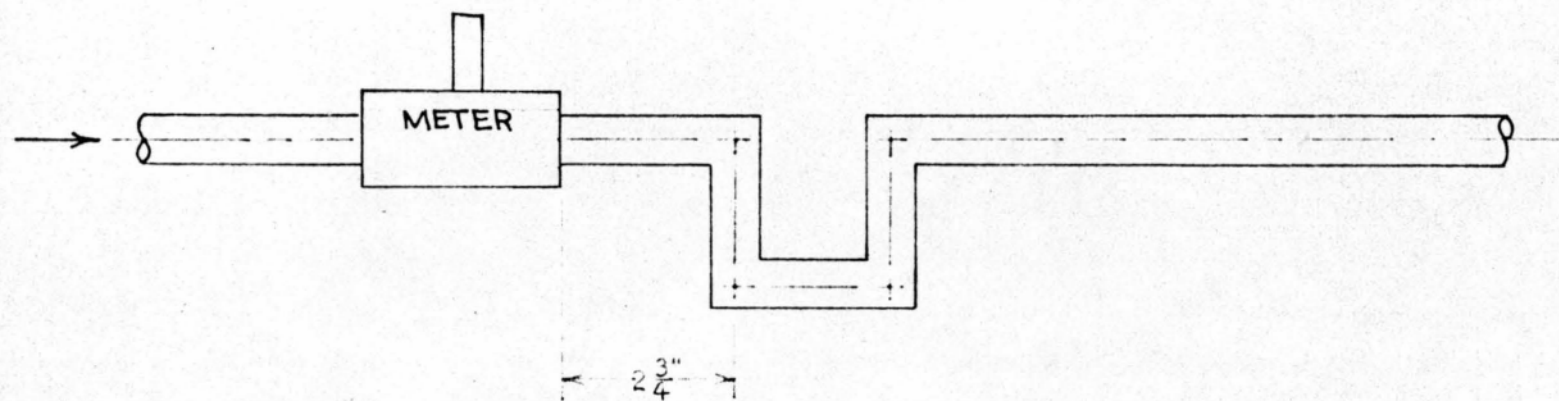


RUN NUMBER FOUR: ELBOW UPSTREAM

FIGURE TWO (CONT.)



RUN NUMBER FIVE: ELBOW DOWNSTREAM



RUN NUMBER SIX: ELBOW DOWNSTREAM

FIGURE TWO (CONT.)

PERCENT DEVIATION FROM WATER CALIBRATION AT 100°F

PLOT OF THE PERCENT DEVIATION FROM THE WATER CALIBRATION AT 100°F VERSUS THE DISTANCE OF THE WAUGH TURBINEMETER FROM A U-SHAPED ELBOW AT TWO VISCOSITIES.

x = DISTANCE FROM ELBOW TO ROTOR OF METER

d = I.D. OF PIPE

Δ MIL-O-5606 DYNAMIC VISCOSITY $2.29 \times 10^{-4} \frac{\text{LB} \cdot \text{SEC}}{\text{FT}^2}$

○ WATER DYNAMIC VISCOSITY $1.40 \times 10^{-5} \frac{\text{LB} \cdot \text{SEC}}{\text{FT}^2}$

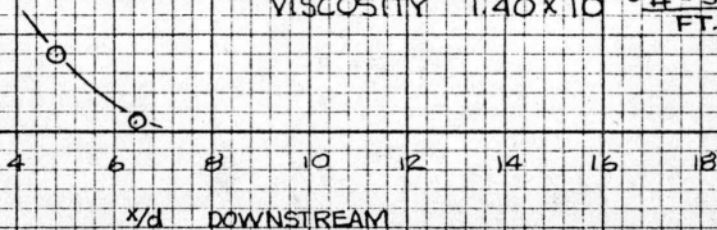
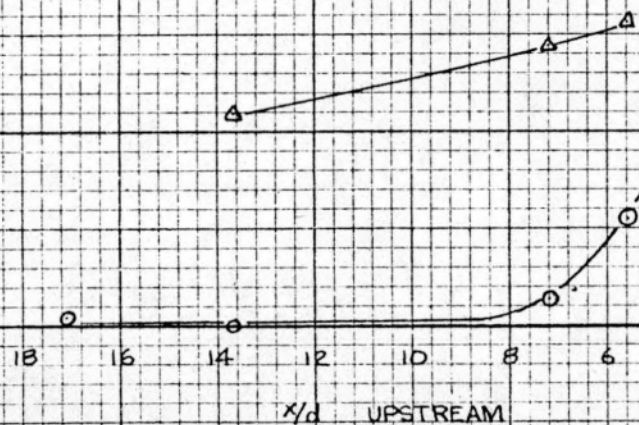


FIGURE THREE

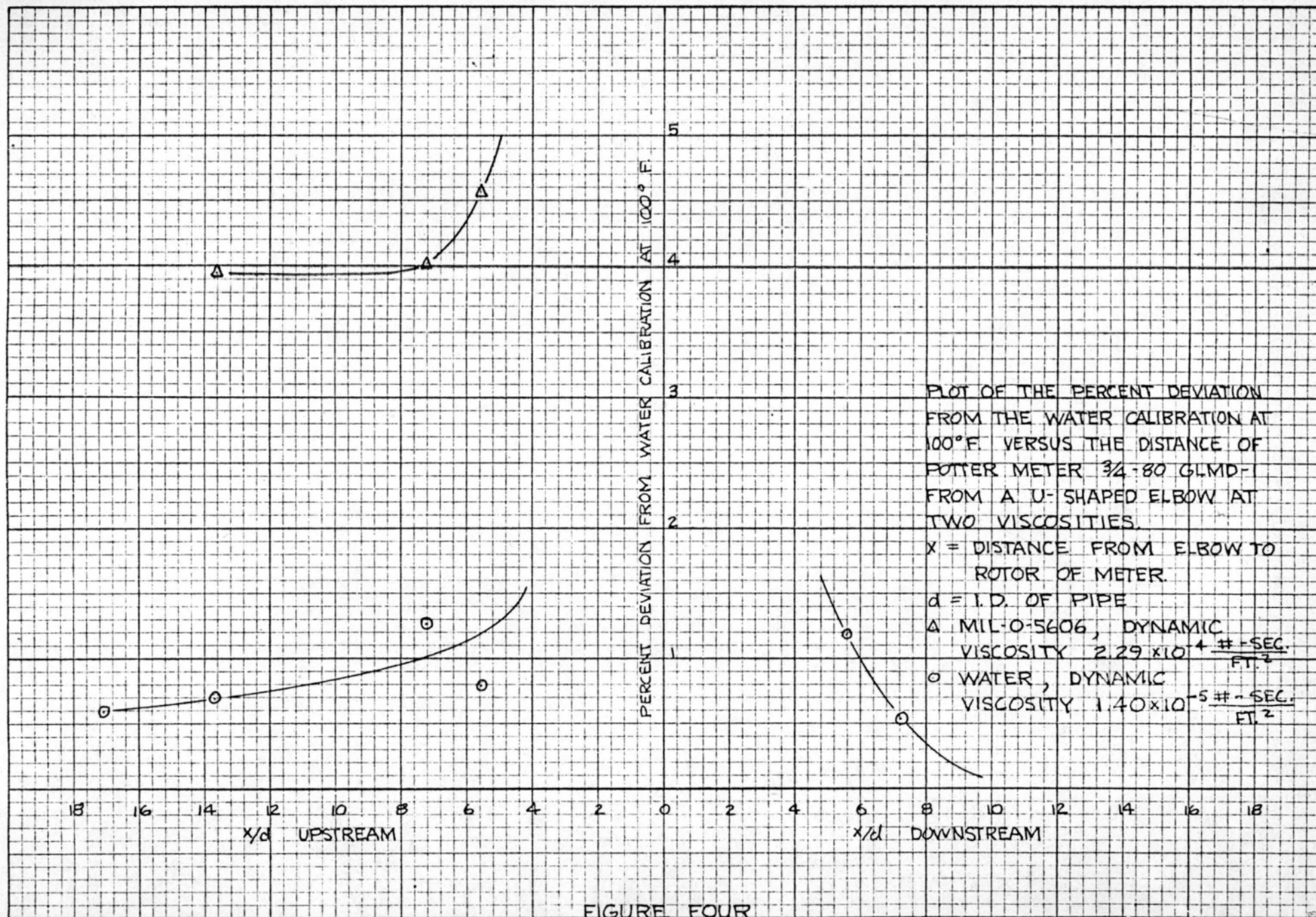
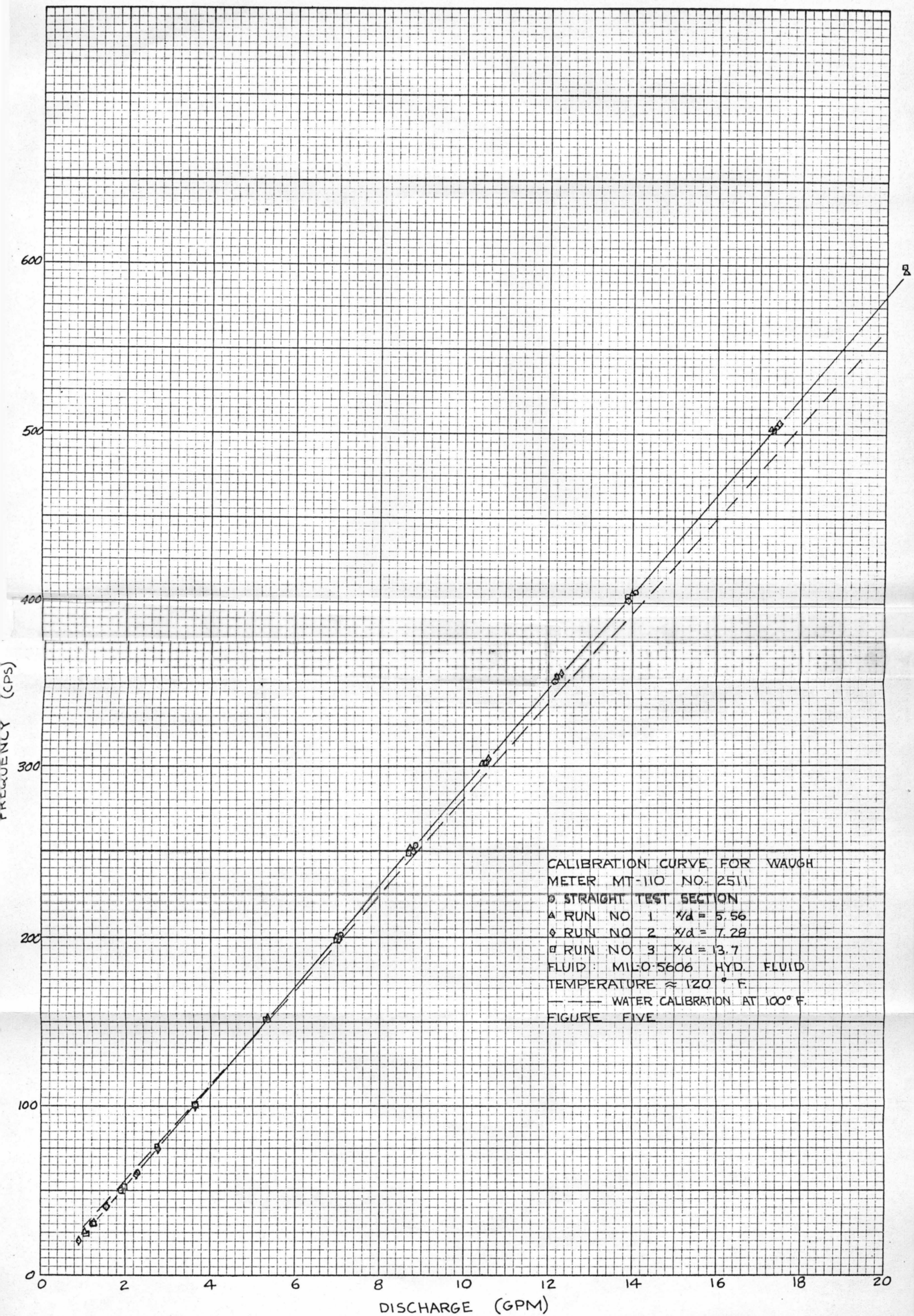


FIGURE FOUR



300

200

100

0

0

2

4

6

8

10

12

14

16

18

20

DISCHARGE (GPM)

CALIBRATION CURVE FOR POTTER
METER $\frac{3}{4}$ -80 GLMD-1

○ STRAIGHT TEST SECTION

△ RUN NO. 1 $x/d = 5.56$

◇ RUN NO. 2 $x/d = 7.28$

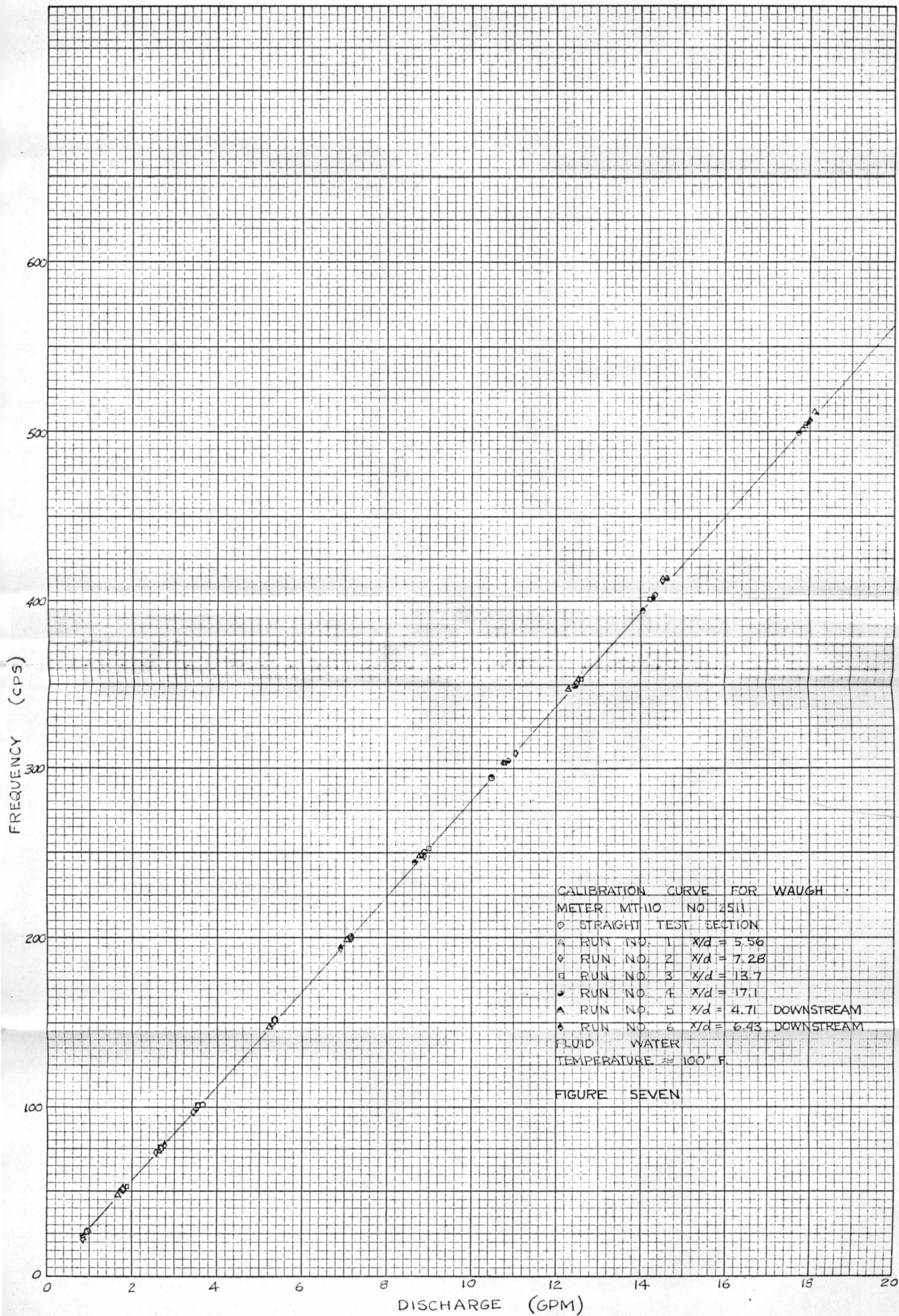
□ RUN NO. 3 $x/d = 13.7$

FLUID : MIL-O-5606 HYD. FLUID

TEMPERATURE $\approx 120^\circ \text{ F.}$

--- WATER CALIBRATION AT 100° F.

FIGURE SIX



300

200

100

0

DISCHARGE (GPM)

CALIBRATION CURVE FOR POTTER METER $\frac{3}{4}$ -80 GLMD-1

○ STRAIGHT TEST SECTION

△ RUN NO. 1 $x/d = 5.56$

◇ RUN NO. 2 $x/d = 7.28$

□ RUN NO. 3 $x/d = 13.7$

● RUN NO. 4 $x/d = 17.1$

▲ RUN NO. 5 $x/d = 5.56$ DOWNSTREAM

◆ RUN NO. 6 $x/d = 7.28$ DOWNSTREAM

FLUID: WATER

TEMPERATURE $\approx 100^\circ \text{F}$

FIGURE EIGHT

FLOW METER CALIBRATION COLORADO STATE UNIVERSITY DATA

ER NO. 3/4 - 80 GLMD - 1 NO. OF PULSES / REV. _____ MANUFACTURED BY: PETTER
 OF FLUID: MIL - Q - 5606 TUBE O.D. _____ TUBE I.D. _____
 BRATED BY: MOORE DATE: 1-3-58 TIME: 4:30 P.M.
 ARKS: THE INFLUENCE OF ELBOWS UPSTREAM - RUN NO. 1 AT APPROX. 120°F

T ₀ SEC.	T _F SEC.	TIME SEC.	CYCLES	CPS	OSC. SCALE	READING	MULTI- PLIER	W ₀ LBS.	W _F LBS.	ΔW LBS.	TEMP °F	SPECIFIC WEIGHT	VOLUME GAL.	CPG	GPM	60 MIN
280	350	79	23994	303.72	B	30.40	10	2.00	208.00	206.00	120.0	6.9947	29.451	814.71	22.368	
844	914	70	20934	299.06	B	29.90	10	2.15	181.95	179.80	118.0	7.0012	25.681	815.16	22.012	
359	449	90	22572	250.80	B	25.00	10	2.00	194.95	192.95	120.0	6.9947	27.585	818.27	18.590	
914	994	80	20012	250.15	B	24.90	10	2.00	173.20	171.20	118.5	6.9996	24.458	818.22	18.344	
580	680	100	20160	201.60	B	20.15	10	2.00	173.80	171.80	120.0	6.9947	24.561	820.81	14.737	
000	100	100	19972	199.72	B	19.90	10	2.05	172.30	170.25	117.5	7.0029	24.311	821.52	14.587	
680	800	120	20802	173.35	A	17.30	10	2.00	178.95	176.95	120.5	6.9931	25.304	822.08	12.652	
100	220	120	21130	176.08	A	17.55	10	2.05	181.95	179.90	117.0	7.0045	25.683	822.72	12.842	
220	340	120	17963	149.69	A	14.95	10	2.00	154.65	152.65	116.5	7.0094	21.788	824.44	10.894	
												7.0062				
340	460	120	15164	126.37	A	12.60	10	2.05	131.90	129.85	116.5	7.0062	18.534	818.17	9.2670	
460	580	120	12086	100.72	A	10.05	10	2.00	105.50	103.50	116.5	7.0062	14.773	818.11	7.3865	
580	700	120	9082	75.68	A	7.55	10	2.00	80.20	78.20	116.0	7.0078	11.16	813.8	5.580	
700	820	120	6048	50.40	B	50.00	1	80.20	133.00	52.80	116.0	7.0078	7.534	803.8	3.767	
820	940	120	4837	40.31	B	40.00	1	2.00	44.40	42.40	115.5	7.0084	6.049	799.6	2.65	
									44.40	42.40					3.024	
940	120	180	5388	29.93	B	29.90	1	44.40	92.55	48.15	115.5	7.0094	6.869	784.4	2.280	
120	300	180	3598	19.99	B	20.00	1	92.55	126.45	33.90	115.5	7.0094	4.836	744.0	1.612	
300	540	240	3616	15.07	A	15.05	1	2.00	37.85	35.85	115.0	7.0010	5.113	707.2	1.278	
540	840	300	3060	10.20	A	10.15	1	37.85	71.55	33.70	114.5	7.0127	4.806	636.7	.9618	

TOTAL CYCLES: 250418
 TOTAL VOLUME: 308.50
 MIN CYCLES PER GALLON: 811.73

FLOW METER CALIBRATION COLORADO STATE UNIVERSITY DATA

METER NO. MODEL MT-110-SERIAL 2511 NO. OF PULSES/REV. _____ MANUFACTURED BY: WAUGH ENG.
 TYPE OF FLUID: MIL-O-5606 TUBE O.D. _____ TUBE I.D. _____
 CALIBRATED BY: HUCKEY & MOORE DATE: 1-3-58 TIME: 1:45 PM
 REMARKS: INFLUENCE OF ELBOWS UPSTREAM - RUN NO. 1 AT APPROX. 120° F.

RUN NO.	T ₀ SEC.	T _F SEC.	TIME SEC.	CYCLES	CPS	OSC. SCALE	READING	MULTIPLIER	W ₀ LBS.	W _F LBS.	ΔW LBS.	TEMP °F	SPECIFIC WEIGHT	VOLUME GAL.	CPG	GPM	60 MIN
1	440	520	80	47742	596.78	B	59.2	10	2.15	194.15	192.00	110.0	7.0275	27.321	1747.4	20.491	
2	520	610	90	45252	502.80	B	49.8	10	1.95	183.85	181.90	110.5	7.0258	25.890	1747.8	17.260	
3	610	720	110	44728	406.62	B	40.4	10	1.90	181.95	180.05	111.5	7.0224	25.639	1744.5	13.985	
4	720	840	120	42445	353.71	B	35.1	10	2.00	173.15	171.15	112.5	7.0192	24.383	1740.8	12.192	
5	840	960	120	36148	301.23	B	30.1	10	2.00	148.20	146.20	113.0	7.0175	20.834	1735.0	10.417	
6	960	080	120	30182	251.52	B	25.1	10	2.05	124.40	122.35	113.5	7.0159	17.439	1730.7	8.7195	
7	080	200	120	24069	200.58	B	20.0	10	2.00	100.25	98.25	114.0	7.0143	14.01	1718	7.005	
8	200	320	120	18145	151.21	A	15.1	10	2.00	76.80	74.80	114.0	7.0143	10.66	1702	5.330	
9	320	440	120	12104	100.87	A	10.2	10	2.00	52.75	50.75	114.0	7.0143	7.235	1673	3.618	
10	440	560	120	9038	75.32	A	7.52	10	2.00	40.60	38.60	115.0	7.0110	5.506	1641	2.753	
11	560	740	180	9054	50.30	B	50.20	1	40.60	80.55	39.95	116.5	7.0062	5.702	1588	1.901	
12	740	980	240	7248	30.20	B	30.10	1	80.55	114.55	34.00	118.0	7.0012	4.856	1493	1.214	
13	980	280	300	7534	25.11	B	25.00	1	114.55	151.15	36.60	120.0	6.9947	5.232	1440	1.046	

TOTAL CYCLES: 333689
 TOTAL VOLUME: 194.71
 MEAN CYCLES PER GALLON: 1712.8

60 CYCLE CHECK	
TIME	READING
10	600

FLOW METER CALIBRATION COLORADO STATE UNIVERSITY DATA

METER NO. 3/4 - 80 GLMD - 1 NO. OF PULSES/REV. _____ MANUFACTURED BY: POTTER
 TYPE OF FLUID: MIL - O - 5606 TUBE O.D. _____ TUBE I.D. _____
 CALIBRATED BY: HUCKEY & MOORE DATE: 1-4-58 TIME: 11:00 A.M.
 REMARKS: THE INFLUENCE OF ELBOWS UPSTREAM - RUN NO. 2 AT APPROX. 120°F

NO.	T ₀ SEC.	T _F SEC.	TIME SEC.	CYCLES	CPS	OSC. SCALE	READING	MULTI- PLIER	W ₀ LBS.	W _F LBS.	ΔW LBS.	TEMP °F	SPECIFIC WEIGHT	VOLUME GAL.	CPG	GPM	60 MIN
1	770	840	70	20332	290.46	B	29.0	10	2.00	176.80	174.80	118.5	6.9996	24.973	814.16	21.406	
2	840 910	000	90	22589	250.99	D	24.9	10	1.95 2.00	195.55	193.55	117.5	7.0029	27.638	817.32	18.425	
3	000	110	110	21918	199.25	B	19.90	10	2.00	189.00	187.00	118.0	7.0012	26.710	820.59	14.569	
4	110	230	120	21223	176.86	A	17.60	10	2.00	182.80	180.80	118.0	7.0012	25.824	821.83	12.912	
5	230	350	120	18226	151.88	A	15.10	10	1.95	156.95	155.00	118.5	6.9996	22.144	823.07	11.072 11.072	
6	350	470	120	15221	126.84	A	12.60	10	2.00	132.45	130.45	118.5	6.9996	18.637	816.71	9.319 9.3185	
7	470	590	120	12136	101.13	A	10.10	10	2.00	105.90	103.90	119.0	6.9980	14.847	817.40	7.424 7.4235	
8	590	700	110	8308	75.53	A	7.55	10	2.00	73.30	71.30	119.0	6.9980	10.19	815.3	5.558	
9	700	820	120	5944	49.53	B	49.60	1	73.30	125.20	51.90	119.5	6.9964	7.418	801.3	3.709	
10	820	940	120	4866	40.55	B	40.40	1	2.00	44.65	42.65	119.5	6.9964	6.096	798.2	3.048	
11	940	120	180	5434	30.19	B	30.00	1	44.65	93.00	48.35	120.0	6.9947	6.912	786.2	2.304	
12	120	360	240	4818	20.08	B	20.00	1	93.00	137.70	44.70	120.5	6.9931	6.392	753.8	1.598	
13	360	600	240	3606	15.02	A	15.00	1	2.00	37.40	35.40	119.5	6.9964	5.060	712.6	1.265	
14	600	900	300	3038	10.13	A	10.10	1	37.40	71.10	33.70	120.0	6.9947	4.818	630.6	.9636	

TOTAL CYCLES: 167659
 TOTAL VOLUME: 207.66
 MEAN CYCLES PER GALLON: 807.37

60 CYCLE CHECK	
TIME	READING
10	600

FLOW METER CALIBRATION COLORADO STATE UNIVERSITY DATA

METER NO. MODEL MT-110 SERIAL 2511 NO. OF PULSES/REV. _____ MANUFACTURED BY: WAHBAH ENG.
 TYPE OF FLUID: MIL-O-5606 TUBE O.D. _____ TUBE I.D. _____
 CALIBRATED BY: HUCKEY & MOORE DATE: 1-4-58 TIME: 8:00 AM
 REMARKS: THE INFLUENCE OF ELBOWS UPSTREAM - RUN NO. 2 AT APPROX 120° F.

RUN NO.	T _i SEC.	T _f SEC.	TIME SEC.	CYCLES	CPS	OSC. SCALE	READING	MULTIPLIER	W _i LBS.	W _f LBS.	ΔW LBS.	TEMP °F	SPECIFIC WEIGHT	VOLUME GAL.	CPG	GPM	6 T
1	840	910	70	41596	599.37	B	59.1	10	2.05	169.50	167.45	112.5	7.0192	23.856	1743.6	20.448	
2	910	010	100	50382	503.82	B	50.4	10	2.00	204.60	202.60	113.5	7.0159	28.877	1744.7	17.326	
3	010	130	120	48378	403.15	B	40.2	10	1.95	196.65	194.70	115.0	7.0110	27.770	1742.1	13.885	
4	130	250	120	42361	353.01	B	35.4	10	2.00	182.70	180.70	117.5	7.0029	24.376	1737.8	12.188	
										172.70	170.70						
5	250	370	120	29912	249.27	B	25.0	10	2.00	123.30	121.30	118.0	7.0012	17.326	1726.4	8.6630	
5	370	490	120	36214	301.78	B	30.00	10	2.00	148.30	146.30	118.0	7.0012	20.896	1733.1	10.448	
7	490	610	120	23994	199.95	B	20.00	10	1.95	99.75	97.80	118.0	7.0012	13.97	1718	6.985	
8	610	740	130	19628	150.98	A	15.03	10	2.00	82.75	80.75	118.0	7.0012	11.53	1702	5.765	
																5.322	
9	740	860	120	12080	100.67	A	10.00	10	2.00	52.60	50.60	118.0	7.0012	7.227	1672	3.614	
10	860	980	120	24402	75.18	A	7.50	10	52.60	91.05	38.45	118.0	7.0012	5.492	1643	2.746	
				9022													
11	980	160	180	9280	51.56	B	51.50	1	91.05	132.20	41.15	118.5	6.9996	5.879	1578	1.960	
12	160	400	240	7250	30.21	B	30.50	1	2.00	36.00	34.00	118.5	6.9996	4.857	1493	1.214	
13	400	700	300	7504	25.01	B	25.00	1	36.00	72.15	36.15	119.0	6.9980	5.166	1453	1.033	

TOTAL CYCLES: 337601
 TOTAL VOLUME: 197.22
 MEAN CYCLES PER GALLON: 1711.8

60 CYCLE CHECK	
TIME	READING
10	600

FLOW METER CALIBRATION COLORADO STATE UNIVERSITY DATA

METER NO. 3/4-80 GLMD-1 NO. OF PULSES/REV. _____ MANUFACTURED BY: Potter
 TYPE OF FLUID: MIL-O-5406 TUBE O.D. _____ TUBE I.D. _____
 CALIBRATED BY: HUCKEY DATE: 1-7-58 TIME: 2:50 PM
 REMARKS: THE INFLUENCE OF ELBOWS UPSTREAM - RUN NO. 3 AT APPROX 120°E

RUN NO.	T ₀ SEC.	T _F SEC.	TIME SEC.	CYCLES	CPS	OSC. SCALE	READING	MULTIPLIER	W ₀ LBS.	W _F LBS.	ΔW LBS.	TEMP °F	SPECIFIC WEIGHT	VOLUME GAL.	CPG	GPM	60 TIN
1	900	970	70	21368	305.26	B	30.4	10	2.00	186.65	184.65	114.5	7.0127	26.331	811.51	22.569	
2	970	060	90	22413	249.03	B	24.9	10	1.90	194.90	193.00	114.0	7.0143	27.515	814.57	18.343	
3	060	170	110	22326	202.96	B	20.3	10	2.00	193.50	191.50	116.0	7.0078	27.327	816.99	14.906	
4	170	290	120	21020	175.17	A	17.4	10	1.85	181.85	180.00	117.5	7.0029	25.704	817.77	12.852	
5	290	410	120	18094	150.78	A	15.0	10	1.80	156.30	154.50	117.0	7.0045	22.057	820.33	11.028	
6	410	530	120	15148	126.23	A	12.6	10	1.80	130.80	129.00	118.5	6.9996	18.430	821.92	9.2150	
7	530	650	120	12034	100.28	A	10.0	10	1.95	105.30	103.35	117.5	7.0029	14.758	815.42	7.3790	
8	650	770	120	9062	75.52	A	7.55	10	2.00	80.10	78.10	117.5	7.0029	11.15	812.7	5.575	
9	770	890	120	6032	50.27	B	50.2	1	1.90	54.70	52.80	117.5	7.0029	7.540	800.0	3.770	
10	890	010	120	4851	40.42	B	40.3	1	54.70	97.30	42.60	117.5	7.0029	6.083	797.5	3.042	
11	010	130	120	3634	30.28	B	30.2	1	2.00	34.40	32.40	117.0	7.0045	4.626	785.6	2.313	
12	130	310	180	3626	20.14	B	20.1	1	34.40	67.75	33.35	118.5	6.9996	4.764	761.1	1.588	
13	310	550	240	3602	15.01	A	15.0	1	67.75	102.60	34.85	118.5	6.9996	4.979	723.4	1.245	
14	550	850	300	3060	10.20	A	10.15	1	1.65	35.25	33.60	118.0	7.0012	4.799	637.6	.9598	

TOTAL CYCLES: 166270
 TOTAL VOLUME: 206.06
 MEAN CYCLES PER GALLON: 806.90

60 CYCLE CHECK	
TIME	READING
10	600
10	600

FLOW METER CALIBRATION COLORADO STATE UNIVERSITY DATA

METER NO. MODEL MT-110 SERIAL 2511 NO. OF PULSES / REV. _____ MANUFACTURED BY: WAUGH ENG.
 TYPE OF FLUID: MIL-D-5606 TUBE O.D. _____ TUBE I.D. _____
 CALIBRATED BY: HUCKEY & VIDEO DATE: 1-7-58 TIME: 4:35 PM
 REMARKS: THE INFLUENCE OF ELBOWS UPSTREAM - RUN NO. 3 AT APPROX 120° E

RUN NO.	T ₀ SEC.	T _F SEC.	TIME SEC.	CYCLES	CPS	OSC. SCALE	READING	MULTIPLIER	W ₀ LBS.	W _F LBS.	ΔW LBS.	TEMP °F	SPECIFIC WEIGHT	VOLUME GAL.	CPG	GPM
1	850	930	80	48540	606.75	B	60.2	10	0.85	196.00	195.15	117.5	7.0029	27.867	1741.8	20.900
2	930	030	100	50692	506.92	B	50.4	10	0.70	204.50	203.80	117.0	7.0045	29.096	1742.2	17.458
3	030	150	120	48276	402.30	B	40.2	10	0.55	195.20	194.65	117.0	7.0045	27.789	1737.2	13.894
4	150	270	120	42658	355.48	B	35.6	10	2.05	174.50	172.45	117.0	7.0045	24.620	1732.7	12.310
5	270	390	120	36538	304.48	B	30.4	10	1.20	149.25	148.05	117.0	7.0045	21.136	1728.7	10.568
6	390	510	120	30088	250.73	B	25.0	10	1.90	124.80	122.90	111.0	7.0240	17.497	1719.6	8.748
7	510	630	120	23952	199.60	B	19.95	10	2.00	104.50 100.45	98.45	112.5	7.0192	14.03	1707	7.015
8	630	750	120	18158	151.32	A	15.10	10	2.00	77.20	75.20	114.0	7.0143	10.72	1694	5.360
9	750	870	120	12066	100.55	A	10.00	10	77.20	128.20	51.00	115.5	7.0094	7.276	1658	3.638
10	870	990	120	9052	75.43	A	7.50	10	2.00	40.65	38.65	115.5	7.0094	5.514	1642	2.757
11	990	110	120	7226	60.22	B	60.00	1	40.65	72.20	31.55	116.0	7.0078	4.502	1605	2.251
12	110	290	180	9026	50.14	B	50.00	1	72.20	112.00	39.80	116.5	7.0062	5.681	1589	1.894
13	290	530	240	9654	40.22	B	40.10	1	2.00	45.60	43.60	116.5	7.0062	6.223	1551	1.556
14	530	830	300	6012	20.04	B	20.00	1	45.60	76.15	30.55	117.0	7.0045	4.361	1379	.8722

TOTAL CYCLES: 351938
 TOTAL VOLUME: 206.31
 MEAN CYCLES PER GALLON: 1705.9

60 CYCLE CHECK	
TIME	READING
10	600

FLOW METER CALIBRATION COLORADO STATE UNIVERSITY DATA

EVALUATION

METER NO. MODEL MT-110 SERIAL 2511 NO. OF PULSES/REV. _____ MANUFACTURED BY: WAUGH ENG.
TYPE OF FLUID: MIL-O-5604 TUBE O.D. _____ TUBE I.D. _____
CALIBRATED BY: HUCKEY DATE: 1-9-58 TIME: 2:15 PM
REMARKS: THE INFLUENCE OF ELBOWS UPSTREAM - RHN NO. 2 AT APPROX. 120°F

PUN NO.	T ₀ SEC.	T _F SEC.	TIME SEC.	CYCLES	CPS	OSC. SCALE	READING	MULTIPLIER	W ₀ LBS.	W _F LBS.	ΔW LBS.	TEMP °F	SPECIFIC WEIGHT	VOLUME GAL.	CPG	GPM	6 T.
1	830	920	90	54174	401.92	B	59.8	10	0.70	219.85	219.15	108.0	7.0339	31.156	1738.8	20.771	
2	920	020	100	50348	503.48	B	50.1	10	0.60	204.50	203.90	108.0	7.0339	28.988	1736.8	17.393	
3	020	140	120	48731	406.09	B	40.5	10	0.55	198.35	197.80	108.5	7.0323	28.127	1732.5	14.064	
4	140	260	120	42020	350.17	B	34.8	10	1.90	172.75	170.85	110.0	7.0275	24.312	1728.4	12.156	
5	260	380	120	36244	302.03	B	30.2	10	1.95	149.70	147.75	111.0	7.0240	21.035	1723.0	10.518	
6	380	500	120	30328	252.73	B	25.3	10	2.00	126.25	124.25	112.0	7.0208	17.697	1713.7	8.8485	
7	500	620	120	24128	201.07	B	20.1	10	2.00	101.40	99.40	113.5	7.0159	14.17	1703	7.085	
8	620	740	120	18130	151.08	A	15.1	10	2.00	77.35	75.35	115.5	7.0094	10.75	1686	5.375	
9	740	860	120	12094	100.78	A	10.05	10	77.35	128.55	51.20	117.0	7.0045	7.310	1654	3.655	
10	860	980	120	9056	75.47	A	7.54	10	2.00	40.80	38.80	118.0	7.0012	5.542	1634	2.771	
11	980	1100	120	7268	60.57	B	60.4	1	40.80	72.60	31.80	118.5	6.9996	4.543	1600	2.272	
12	100	280	180	9026	50.14	B	50.0	1	72.60	112.45	39.85	118.5	6.9996	5.693	1585	1.898	
13	280	460	180	7228	40.16	B	40.0	1	2.00	34.70	32.70	118.0	7.0012	4.671	1547	1.557	
14	460	700	240	7242	30.18	B	30.0	1	34.70	68.50	33.80	120.0	6.9947	4.832	1499	1.208	

TOTAL CYCLES: 356017
TOTAL VOLUME: 208.83
MEAN CYCLES PER GALLON: 1704.8

60 CYCLE CHECK	
TIME	READING
10	600
10	600

FLOW METER CALIBRATION
COLORADO STATE UNIVERSITY
DATA

METER NO. 3/4-80 GLMD-1 NO. OF PULSES/REV. _____ MANUFACTURED BY: POTTER
 TYPE OF FLUID: MIL-O-5606 TUBE O.D. _____ TUBE I.D. _____
 CALIBRATED BY: MAORE, C.W. DATE: 1-10-58 TIME: 10:00 A.M.
 REMARKS: INFLUENCE OF ELBOWS UPSTREAM AT APPROX. 120°F RUN # 0

N O.	T ₀ SEC.	T _F SEC.	TIME SEC.	CYCLES	CPS	OSC. SCALE	READING	MULTI- PLIER	V ₀ LBS.	V _F LBS.	ΔW LBS.	TEMP °F	SPECIFIC WEIGHT	VOLUME GAL.	CPG	GPM	60 TIN
	700	770	70	21178	302.54	B	30.20	10	2.10	185.80	183.70	115.0	7.0110	26.202	808.26	19.00	22.459
	770	850	80	20101	251.26	B	25.10	10	2.00	175.60	173.60	117.0	7.0045	24.784	811.05	18.588	
	850	960	110	22010	200.09	B	20.00	10	1.90	191.00	189.10	120.0	6.9947	27.035	814.13	14.746	
	960	080	120	21009	175.08	A	17.50	10	2.00	181.90	179.90	119.5	6.9964	25.713	817.06	12.856	
	080	220	140	21116	150.83	A	15.00	10	2.30	182.65	180.35	119.5	6.9964	25.778	819.15	11.048	
	220	340	120	15140	126.17	A	12.55	10	2.00	130.95	128.95	119.5	6.9964	18.431	821.44	9.2155	
	340	460	120	12050	100.42	A	10.00	10	2.00	105.40	103.40	119.5	6.9964	14.779	815.35	7.3895	
	460	580	120	8942	74.52	A	7.45	10	2.00	78.75	76.75	119.0	6.9980	10.97	815.1	5.485	
	580	700	120	6038	50.32	B	50.00	1	2.00	54.80	52.80	119.0	6.9980	7.545	800.3	3.772	
	700	820	120	4840	40.33	B	40.00	1	54.80	97.25	42.45	119.0	6.9980	6.066	797.9	3.033	
	820	940	120	3634	30.28	B	30.10	1	97.25	129.90	32.65	119.0	6.9980	4.666	778.8	2.333	
	940	120	180	3608	20.04	B	20.00	1	2.10	35.60	33.50	119.0	6.9980	4.787	753.7	1.596	
	120	360	240	3624	15.10	A	15.10	1	35.60	70.60	35.00	119.0	6.9980	5.001	724.7	1.250	
	360	660	300	3078	10.26	A	10.25	1	70.60	104.40	33.80	119.5	6.9964	4.831	637.1	.9662	

TOTAL CYCLES: 166368
 TOTAL VOLUME: 206.59
 AVERAGE CYCLES PER GALLON: 805.30

60 CYCLE CHECK	
TIME	READING
10	600
11	100

FLOW METER CALIBRATION
COLORADO STATE UNIVERSITY
DATA

METER NO. 3/4-80 GLMD-1 CALIBRATED BY: VIDEON
NO. OF PULSES / REV. _____ TYPE OF FLUID: WATER
MANUFACTURED BY: POTTER DATE: 3-5-58
REMARKS: 2" STUB ELBOW UPSTREAM RUN NO. 2 APPROX. ~~100~~ 85°F.

RUN NO.	T ₀ SEC.	T _F SEC.	TIME SEC.	CYCLES	C.P.S.	OSC. SC.	READ.	MULT.	W ₀ LBS.	W _F LBS.	ΔW LBS.	TEMP. °F.	SP. WT.	VOLUME GAL.	CPG	GPM	BACK PR.
1	860	980	120	34414	286.78	B	28.7	10	0.10	361.65	361.55	72.0	8.3266	43.421	792.56	21.711	0
2	980	100	120	30002	250.01	B	25.1	10	1.95	317.15	315.20	75.0	8.3236	37.868	792.28	18.934	0
3	100	220	120	23746	197.88	B	19.8	10	1.95	250.70	248.75	77.0	8.3216	29.892	794.39	14.946	5
4	220	340	120	21317	177.64	A	17.8	10	0.40	223.20	222.80	79.0	8.3200	26.779	796.03	13.389	6
5	340	460	120	11908	99.233	A	10.00	10	1.00	125.10	124.10	80.5	8.3190	14.918	798.23	7.4591	6
6	460	580	120	5683	47.36	B	47.4	1	1.80	61.50	59.70	82.0	8.3177	7.177	791.8	3.589	5
7	580	700	120	4752	39.60	B	39.0	1	61.50	111.90	50.40	83.0	8.3168	6.060	784.2	3.030	5
8	700	820	120	2984	24.87	B	25.1	1	111.90	145.00	33.10	85.0	8.3150	3.981	749.6	1.990	5.5
9	820	000	180	2500	13.89	A	13.8	1	145.00	176.30	31.30	87.5	8.3125	3.765	664.0	1.255	6.5
10	000	300	300	2810	9.367	A	9.35	1	176.30	214.15	37.85	88.0	8.3120	4.554	617.0	.9108	6
11	300	420	120	18216	151.80	A	15.1	10	1.20	191.85	190.65	90.0	8.3100	22.942	794.00	11.471	6.5
12	420	540	120	14751	122.92	A	12.3	10	1.40	155.20	153.80	91.0	8.3092	18.510	796.92	9.255	5

TOTAL CYCLES: 151,766
TOTAL VOLUME: 193.088
MEAN CYCLES PER GALLON: 785.99

60 CYCLE CHECK	
TIME	READING
10	600
10	600

FLOW METER CALIBRATION
COLORADO STATE UNIVERSITY

DATA

MODEL # MT-110

METER NO. SERIAL # 2511

CALIBRATED BY: HUCKEY & MOORE

NO. OF PULSES / REV.

TYPE OF FLUID: WATER

MANUFACTURED BY: WAUGH

DATE: 3-5-58

REMARKS: 2" STUB ELBOW UPSTREAM RUN No. 2 Approx. 100°F.

RUN NO.	T ₀ SEC.	T _F SEC.	TIME SEC.	CYCLES	C.P.S.	OSC. SC.	READ.	MULT.	W ₀ LBS.	W _F LBS.	ΔW LBS.	TEMP. °F.	SP. WT.	VOLUME GAL.	CPG	GPM	BACK PR.
1	220	340	120	72984	608.20	B	60.6	10	2.20	359.10	356.90	102.5	8.3000	43.000	1697.3	21.500	0
2	340	460	120	60334	502.78	B	50.5	10	0.40	296.90	296.50	93.0	8.3076	35.690	1690.5	17.845	0
3	540	660	120	49578	413.15	B	41.1	10	1.40	243.30	241.90	98.5	8.3032	29.133	1701.8	14.567	0
4	660	780	120	42358	352.98	B	35.2	10	1.70	209.20	207.50	99.0	8.3028	24.992	1694.9	12.496	0
5	780	900	120	37109	309.24	B	31.0	10	3.50	186.35	182.85	100.5	8.3016	22.026	1684.8	11.013	6.0
6	900	020	120	29810	248.42	B	24.8	10	156.30	303.15	146.85	101.5	8.3008	17.691	1685.0	8.8455	6.0
7	020	140	120	24018	200.15	B	20.0	10	1.50	119.65	118.15	100.5	8.3016	14.232	1687.6	7.1160	5.0
8	140	260	120	18162	151.35	A	15.1	10	119.65	208.85	89.20	100.0	8.3020	10.74	1691	5.370	6.0
9	500	620	120	11674	97.283	A	9.71	10	75.30	132.60	57.30	100.5	8.3016	6.902	1691	3.451	8.0
10	620	740	120	8766	73.05	A	7.3	10	132.60	175.65	42.95	100.5	8.3016	5.174	1694	2.587	5.0
11	740	920	180	9066	50.37	B	50.3	1	175.65	220.30	44.65	100.5	8.3016	5.378	1686	1.793	6.5
12	920	220	300	6618	22.06	B	22.1	1	220.30	255.90	35.60	100.0	8.3020	4.288	1543	.8576	6.0

TOTAL CYCLES: 370477

TOTAL VOLUME: 219.25

MEAN CYCLES PER GALLON: 1689.7

60 CYCLE CHECK	
TIME	READING
10	600
10	600

FLOW METER CALIBRATION
COLORADO STATE UNIVERSITY

DATA

MODEL # MT-110

METER NO. SERIAL # 2511

CALIBRATED BY: VIDEON & HUCKEY

NO. OF PULSES / REV.

TYPE OF FLUID: WATER

MANUFACTURED BY: PETER Wough

DATE: 3-6-58

REMARKS: 1" STUB UPSTREAM RUN No. 1 Approx. 100°F

RUN NO.	T ₀ SEC.	T _F SEC.	TIME SEC.	CYCLES	C.P.S.	OSC. SC.	READ.	MULT.	W ₀ LBS.	W _F LBS.	ΔW LBS.	TEMP. °F	SP. WT.	VOLUME GAL.	CPG	GPM	BACK PR.
1	460	580	120	72160	601.33	B	60.0	10	9.85	362.60	352.75	93.5	8.3072	42.463	1699.4	21.232	Q
2	580	700	120	61438	511.98	B	51.0	10	1.65	302.45	300.80	95.0	8.3060	36.215	1696.5	18.108	5
3	700	820	120	49596	413.30	B	41.3	10	1.00	243.80	242.80	97.0	8.3044	29.238	1696.3	14.619	10.5
4	820	940	120	41723	347.69	B	34.9	10	0.85	205.05	204.20	98.0	8.3036	24.592	1696.6	12.296	6.5
5	940	060	120	36418	303.48	B	30.3	10	205.05	383.55	178.50	99.5	8.3024	21.500	1693.9	10.750	5.0
6	060	180	120	29748	247.90	B	24.8	10	0.70	146.25	145.55	100.5	8.3016	17.533	1696.7	8.7665	5.0
7	180	300	120	23844	198.70	B	19.8	10	21.25	137.90	116.65	99.5	8.3024	14.050	1697.1	7.0250	7.5
8	300	420	120	17731	147.76	A	14.9	10	12.90	99.60	86.70	101.5	8.3008	10.44	1698	5.220	5.0
9	420	540	120	12160	101.33	A	10.15	10	99.60	158.85	59.25	101.0	8.3012	7.138	1704	3.569	8.0
10	540	720	180	13476	74.867	A	7.5	10	0.90	66.40	65.50	100.0	8.3020	7.890	1708	2.630	5.5
11	720	900	180	8656	48.09	B	48.0	1	66.40	108.60	42.20	99.5	8.3024	5.083	1703	1.694	7.0
12	900	140	240	6120	25.50	B	25.5	1	108.60	139.60	31.00	100.0	8.3020	3.734	1639	.9335	8.0

TOTAL CYCLES: 373070

TOTAL VOLUME: 219.88

MEAN CYCLES PER GALLON: 1696.7

60 CYCLE CHECK	
TIME	READING

FLOW METER CALIBRATION
COLORADO STATE UNIVERSITY
DATA

METER NO. 3/4-80 GLMD-1 CALIBRATED BY: VIDEON & MOORE
 NO. OF PULSES/REV. _____ TYPE OF FLUID: WATER
 MANUFACTURED BY: POTTER DATE: 3-7-58
 REMARKS: 1" STUB UPSTREAM RUN NO. 1, Approx 100°F.

RUN NO.	T ₀ SEC.	T _F SEC.	TIME SEC.	CYCLES	C.P.S.	OSC. SC.	READ.	MULT.	W ₀ LBS.	W _F LBS.	ΔW LBS.	TEMP. °F.	SP. WT.	VOLUME GAL.	CPG	GPM	BACK PR.
1	150	270	120	33664	280.53	B	28.1	10	1.10	355.40	354.30	96.0	8.3052	42.660	789.12	21.330	0
2	270	390	120	30582	254.85	B	25.5	10	1.35	323.35	322.00	98.0	8.3036	38.778	788.64	19.389	8.0
3	390	510	120	24406	203.38	B	20.4	10	1.25	257.70	256.45	102.0	8.3004	30.896	789.94	15.448	8.0
4	510	630	120	17864	148.87	A	14.9	10	1.30	188.25	186.95	102.0	8.3004	22.523	793.14	11.262	5.5
5	630	750	120	14854	123.78	A	12.35	10	1.88.25	343.60	155.35	101.5	8.3008	18.715	793.69	9.3575	6.0
6	750	870	120	12102	100.85	A	10.0	10	1.30	127.60	126.30	101.5	8.3008	15.215	795.40	7.6075	6.0
7	870	990	120	8902	74.18	A	7.45	10	2.60	95.50	92.90	101.0	8.3012	11.19	795.5	5.595	6.0
8	990	110	120	5822	48.52	B	48.50	1	95.50	156.90	61.40	101.0	8.3012	7.397	787.1	3.699	5.0
9	110	230	120	4816	40.13	B	40.0	1	1.60	53.00	51.40	100.5	8.3016	6.192	777.8	3.096	5.0
10	230	350	120	3498	29.15	B	29.1	1	53.00	91.35	38.35	100.5	8.3016	4.620	757.1	2.310	6.0
11	350	530	180	3622	20.12	B	20.1	1	91.35	133.65	42.30	100.5	8.3016	5.095	710.9	1.698	7.0
12	530	770	240	2262	9.425	A	9.0	1	8.65	42.65	34.00	100.0	8.3020	4.095	552.4	1.024	7.5

TOTAL CYCLES: 153,492
 TOTAL VOLUME: 196.19
 MEAN CYCLES PER GALLON: 782.38

60 CYCLE CHECK	
TIME	READING
10	600
10	600

FLOW METER CALIBRATION
COLORADO STATE UNIVERSITY
DATA

METER NO. 3/4-80 GLMD-1 CALIBRATED BY: VIDEON & MOORE
NO. OF PULSES / REV. _____ TYPE OF FLUID: WATER
MANUFACTURED BY: POTTER DATE: 3-7-58
REMARKS: 1" STUB UPSTREAM 5" SPACER RUN NO. 3, Approx. 100°F

RUN NO.	T ₀ SEC.	T _F SEC.	TIME SEC.	CYCLES	C.P.S.	OSC. SC.	READ.	MULT.	W ₀ LBS.	W _F LBS.	ΔW LBS.	TEMP. °F.	SP. WT.	VOLUME GAL.	CPG	GPM	BACK PR.
1	770	890	120	34034	283.62	B	28.4	10	1.40	360.30	358.90	102.0	8.3004	43.239	787.11	21.620	0
2	890	010	120	30020	250.17	B	25.9	10	1.40	318.30	316.90	101.0	8.3012	39.175	786.38	19.088	7.5
3	010	130	120	24028	200.23	B	20.0	10	1.50	254.90	253.40	101.0	8.3012	30.526	787.13	15.263	6.0
4	130	250	120	18046	150.38	A	15.2	10	8.80	198.35	189.55	100.5	8.3016	22.833	790.35	11.417	6.0
5	370	490	120	15122	126.02	A	12.5	10	1.50	160.05	158.55	100.5	8.3016	19.099	791.77	9.549	6.5
6	250	370	120	11892	99.100	A	9.90	10	2.00	126.45	124.45	100.5	8.3016	14.991	793.28	7.496	7.5
7	490	610	120	8842	73.68	A	7.4	10	160.05	252.40	92.35	100.5	8.3016	11.12	795.1	5.560	7.5
8	610	730	120	5902	49.18	B	49.4	1	1.50	63.60	62.10	100.0	8.3020	7.480	789.0	3.740	7.0
9	730	850	120	4570	38.08	B	38.0	1	63.60	112.40	48.80	100.0	8.3020	5.878	777.5	2.939	6.0
10	850	970	120	3732	31.10	B	31.0	1	112.40	153.05	40.65	100.0	8.3020	4.896	762.3	2.448	5.0
11	970	150	180	3488	19.38	B	19.4	1	28.05	68.75	40.70	100.0	8.3020	4.902	711.5	1.634	7.0
12	150	390	240	2166	9.025	A	9.0	1	68.75	101.35	32.60	99.5	8.3024	3.927	551.6	.9818	5.0

TOTAL CYCLES: 161,842
TOTAL VOLUME: 207.07
MEAN CYCLES PER GALLON: 781.58

60 CYCLE CHECK	
TIME	READING
10	600
10	600

FLOW METER CALIBRATION
COLORADO STATE UNIVERSITY

DATA

MODEL # MT-110

METER NO. SERIAL # 2511

CALIBRATED BY: VIDEON & MOORE

NO. OF PULSES / REV.

TYPE OF FLUID: WATER

MANUFACTURED BY: WAUGH

DATE: 3-8-58

REMARKS: 1" STUB ELBOW UPSTREAM 5" SPARKER RUN No. 3
Approx. 100° F.

RUN NO.	T ₀ SEC.	T _F SEC.	TIME SEC.	CYCLES	C.P.S.	OSC. SC.	READ.	MULT.	W ₀ LBS.	W _F LBS.	ΔW LBS.	TEMP. °F.	SP. WT.	VOLUME GAL.	CPG	GPM	BACK PR.
1	510	630	120	72498	604.15	B	60.1	10	1.50	357.90	356.40	98.0	8.3036	42.921	1689.1	21.461	2.0
2	630	750	120	60722	506.02	B	50.4	10	2.00	300.65	298.65	100.0	8.3020	35.973	1688.0	17.987	7.0
3	750	870	120	48046	400.38	B	40.0	10	1.70	237.80	236.10	101.5	8.3008	28.443	1689.2	14.222	7.0
4	990	110	120	42404	353.37	B	35.0	10	180.00	388.75	208.75	100.5	8.3016	25.146	1686.3	12.573	6.5
5	870	990	120	36340	302.83	B	30.2	10	1.10	180.00	178.90	100.5	8.3016	21.550	1686.3	10.775	7.5
6	110	230	120	30290	252.42	B	25.20	10	2.10	151.00	148.90	100.5	8.3016	17.936	1688.8	8.9680	4.0
7	230	350	120	23860	198.83	B	20.0	10	151.00	268.30	117.30	100.5	8.3016	14.130	1688.6	7.0650	10.0
8	350	470	120	18090	150.75	A	15.0	10	1.85	90.60	88.75	100.0	8.3020	10.69	1692.5	345	6.5
9	470	590	120	12058	100.48	A	10.0	10	90.60	149.80	59.20	100.0	8.3020	7.131	1691	3.566	7.5
10	590	710	120	8894	74.12	A	7.43	10	24.80	68.35	43.55	100.0	8.3020	5.246	1695	2.623	7.5
11	710	890	180	9326	51.81	B	51.5	1	68.35	114.10	45.75	100.0	8.3020	5.511	1692	1.837	7.0
12	890	130	240	5602	23.34	B	23.0	1	114.10	143.20	29.10	99.5	8.3024	3.505	1598	.8763	5.5

TOTAL CYCLES: 368130

TOTAL VOLUME: 218.18

MEAN CYCLES PER GALLON: 1687.3

60 CYCLE CHECK	
TIME	READING
10	600
10	600

FLOW METER CALIBRATION
COLORADO STATE UNIVERSITY
DATA

ODEL # MT-110
METER NO. SERIAL # 2511
D. OF PULSES / REV. _____ CALIBRATED BY: MOORE
MANUFACTURED BY: WAUGH DATE: 3-8-58
REMARKS: 1" STUB ELBOW UPSTREAM 7" SPACER RYN No. 4
Approx. 100°F.

UN NO.	T ₀ SEC.	T _F SEC.	TIME SEC.	CYCLES	C.P.S.	OSC. SC.	READ.	MULT.	W ₀ LBS.	W _F LBS.	ΔW LBS.	TEMP. °F.	SP. WT.	VOLUME GAL.	CPG	GPM	BACK PR.
1	130	250	120	72248	602.08	B	60.00	10	0.00	354.90	354.90	102.0	8.3004	42.757	1689.7	21.379	0
2	250	370	120	59948	499.57	B	50.00	10	1.80	296.50	294.70	101.5	8.3008	35.503	1688.5	17.752	5.5
3	370	490	120	48307	402.56	B	40.00	10	2.50	239.90	237.40	101.5	8.3008	28.600	1689.1	14.300	6.0
4	490	610	120	41946	349.55	B	34.70	10	1.80	207.90	206.10	101.5	8.3008	24.829	1689.4	12.415	8.5
5	610	730	120	36517	304.31	B	30.40	10	2.00	181.50	179.50	101.5	8.3008	21.624	1688.7	10.812	7.0
6	730	850	120	29770	248.08	B	24.80	10	2.00	148.20	146.20	101.5	8.3008	17.613	1690.2	8.8065	7.5
7	850	970	120	23934	199.45	B	19.95	10	148.20	265.70	117.50	101.5	8.3008	14.156	1690.7	7.0780	5.5
8	970	090	120	17834	148.62	A	14.80	10	1.50	88.90	87.40	101.0	8.3012	10.53	1694	5.265	7.0
9	090	210	120	11846	98.716	A	9.90	10	88.90	147.00	58.10	101.0	8.3012	6.999	1693	3.499	7.0
10	210	390	180	13386	74.367	A	74.40	10	147.00	212.60	65.60	101.0	8.3012	7.902	1694	2.634	5.5
11	390	570	180	8898	49.43	B	49.50	1	2.00	45.70	43.70	101.0	8.3012	5.264	1690	1.755	7.0
12	570	870	300	7290	24.30	B	24.40	1	45.70	83.30	37.60	101.0	8.3012	4.529	1610	.9058	7.5

TOTAL CYCLES: 371924
TOTAL VOLUME: 220.31
MEAN CYCLES PER GALLON: 1688.2

60 CYCLE CHECK	
TIME	READING
10	600
10	600

FLOW METER CALIBRATION
COLORADO STATE UNIVERSITY
DATA

METER NO. 3/4 - 80 GLMD-1 CALIBRATED BY: MOORE
O. OF PULSES / REV. _____ TYPE OF FLUID: WATER
MANUFACTURED BY: POTTER DATE: 3-10-58
REMARKS: 1" STUB UPSTREAM 7" SPACER RUN NO. 4, Approx. 100°F.

UN. NO.	T ₀ SEC.	T _F SEC.	TIME SEC.	CYCLES	C.P.S.	OSC. SC.	READ.	MULT.	W ₀ LBS.	W _F LBS.	ΔW LBS.	TEMP. °F.	SP. WT.	VOLUME GAL.	CPG	GPM	BACK PR.
1	870	990	120	33716	280.97	B	28.0	10	1.10	355.20	354.10	94.5	8.3064	42.630	790.20	21.315	0
2	990	110	120	30256	252.13	B	25.2	10	1.60	319.40	317.80	95.5	8.3056	38.263	790.74	19.132	7.5
3	110	220	110	22146	201.33	B	20.2	10	2.40	239.85	237.45	97.0	8.3044	28.593	774.52	15.596	6.0
4	220	340	120	18338	152.82	A	15.1	10	2.70	194.70	192.00	98.5	8.3032	23.124	793.03	11.562	5.5
5	340	460	120	14952	124.60	A	12.4	10	2.00	158.20	156.20	99.0	8.3028	18.813	794.77	9.4065	7.0
6	460	580	120	12014	100.12	A	9.95	10	2.55	127.75	125.20	100.5	8.3016	15.081	796.63	7.5405	6.0
7	580	700	120	8888	74.07	A	7.40	10	127.75	220.20	92.45	101.5	8.3008	11.14	797.8	5.570	5.5
8	700	820	120	5998	49.98	B	50.0	1	2.00	64.90	62.90	100.0	8.3020	7.576	791.7	3.788	6.5
9	820	940	120	4800	40.00	B	40.0	1	1.80	52.85	51.05	100.0	8.3020	6.149	780.6	3.075	6.5
10	940	060	120	3640	30.33	B	30.20	1	52.85	92.10	39.25	102.0	8.3004	4.779	769.7	2.365	6.5
11	060	240	180	3586	19.92	B	20.00	1	92.10	133.50	41.40	100.5	8.3016	4.987	719.1	1.662	6.5
12	240	480	240	1702	7.092	A	7.40	1	133.50	165.35	31.85	100.0	8.3020	3836	443.7	.9590	6.5

TOTAL CYCLES: 160036
TOTAL VOLUME: 204.97
AN CYCLES PER GALLON: 780.78

60 CYCLE CHECK	
TIME	READING
10	600
10	600

FLOW METER CALIBRATION
COLORADO STATE UNIVERSITY

DATA

SERIAL # GLMD-1

METER NO. MODEL # 3/4-80

CALIBRATED BY: MOORE

NO. OF PULSES / REV. _____

TYPE OF FLUID: WATER

MANUFACTURED BY: POTTER

DATE: 3-15-58

REMARKS: STRAIGHT RUN AT APPROX. 100°F

RUN NO.	T ₀ SEC.	T _F SEC.	TIME SEC.	CYCLES	C.P.S.	OSC. SC.	READ.	MULT.	W ₀ LBS.	W _F LBS.	ΔW LBS.	TEMP. °F.	SP. WT.	VOLUME GAL.	CPG	GPM	BACK PR.
1	480	600	120	35248	293.73	B	29.40	10	0.55	374.40	373.85	97.0	8.3044	45.018	782.98	22.509	0
2	600	720	120	29906	249.22	B	25.0	10	1.60	318.40	316.80	101.0	8.3012	38.163	783.64	19.082	7.5
3	720	840	120	24169	201.41	B	20.0	10	1.75	257.55	255.80	102.0	8.3004	30.818	784.25	15.409	7.5
4	840	960	120	17962	149.68	A	14.95	10	1.60	191.35	189.75	100.5	8.3016	22.857	785.84	11.429	9.0
5	960	080	120	15096	125.80	A	12.50	10	1.60	160.80	159.20	100.0	8.3020	19.176	787.23	9.5880	6.5
6	080	200	120	11890	99.083	A	9.85	10	2.00	127.30	125.30	100.0	8.3020	15.093	787.78	7.5465	5.5
7	200	320	120	8818	73.48	A	7.35	10	1.70	94.40	92.70	100.0	8.3020	11.17	789.4	5.585	6.5
8	320	440	120	6028	50.23	B	50.0	1	94.40	158.30	63.90	100.0	8.3020	7.697	783.2	3.849	6.0
9	440	560	120	4788	39.90	B	40.0	1	2.00	53.25	51.25	100.0	8.3020	6.173	775.6	3.087	6.5
10	560	680	120	3516	29.30	B	29.5	1	1.60	41.10	39.50	100.0	8.3020	4.758	739.0	2.379	7.0
11	680	860	180	3572	19.84	B	19.85	1	41.10	83.75	42.65	99.5	8.3024	5.137	695.3	1.712	7.0
12	860	100	240	2204	9.183	A	9.50	1	83.75	118.45	34.70	99.5	8.3024	4.180	527.3	1.045	8.0
12'	100	340	240	2736	11.40	A	11.80	1	118.45	158.90	40.45	99.5	8.3024	4.872	561.6	1.218	9.5

TOTAL CYCLES: ~~165933~~ 163729

TOTAL VOLUME: ~~215.11~~ 210.93

~~221.00~~ 774.72

60 CYCLE CHECK	
TIME	READING
10	600
10	600

FLOW METER CALIBRATION COLORADO STATE UNIVERSITY

MODEL # MT-110

DATA

METER NO. SERIAL # 2511 CALIBRATED BY: MOORE

NO. OF PULSES / REV. TYPE OF FLUID: WATER

MANUFACTURED BY: WAUGH DATE: 3-15-58

REMARKS: STRAIGHT RUN AT APPROX. 100°F

RUN NO.	T ₀ SEC.	T _F SEC.	TIME SEC.	CYCLES	C.P.S.	OSC. SC.	READ.	MULT.	W ₀ LBS.	W _F LBS.	ΔW LBS.	TEMP. °F.	SP. WT.	VOLUME GAL.	CPG	GPM	BACK PR.
1	340	460	120	72354	602.95	B	60.0	10	0.60	356.25	355.65	102.0	8.3009	42.847	1688.7	21.424	5.0
2	460	580	120	60104	500.87	B	49.7	10	1.50	297.10	295.60	100.0	8.3020	35.606	1688.0	17.803	6.5
3	580	700	120	48428	403.57	B	40.30	10	1.55	239.60	238.05	100.0	8.3020	28.674	1688.9	14.337	7.5
4	700	820	120	42118	350.98	B	34.90	10	1.60	208.55	206.95	100.0	8.3020	24.928	1689.6	12.464	6.5
5	820	940	120	35342	294.52	B	29.50	10	0.90	174.75	173.85	100.0	8.3020	20.941	1687.7	10.471	8.0
6	940	060	120	30012	250.10	B	25.00	10	2.00	149.60	147.60	100.0	8.3020	17.779	1688.1	8.8895	7.5
7	060	180	120	24080	200.67	B	20.00	10	1.55	120.00	118.45	99.5	8.3024	14.267	1687.8	7.1335	6.5
8	180	300	120	18166	151.38	A	15.10	10	2.00	91.20	89.20	99.5	8.3024	10.74	1691	5.370	6.0
9	300	420	120	12164	101.37	A	10.10	10	2.00	61.85	59.85	99.5	8.3024	7.209	1687	3.605	7.0
10	440	560	120	9030	75.25	A	7.50	10	1.70	46.00	44.30	99.0	8.3028	5.336	1692	2.668	5.5
11	560	740	180	9098	50.54	B	50.5	1	46.00	90.60	44.60	101.5	8.3008	5.373	1693	1.791	6.0
12	740	980	240	6122	25.51	B	25.4	1	90.60	122.05	31.45	100.0	8.3020	3.788	1616	.9470	6.0

TOTAL CYCLES: 367018

TOTAL VOLUME: 217.49

MEAN CYCLES PER GALLON: 1687.5

60 CYCLE CHECK	
TIME	READING
10	600
10	600

FLOW METER CALIBRATION
COLORADO STATE UNIVERSITY

DATA

MODEL NO. 3/4-80

METER NO. SERIAL NO. GLMD-1

CALIBRATED BY: MOORE

NO. OF PULSES / REV.

TYPE OF FLUID: WATER

MANUFACTURED BY: POTTIER

DATE: 3-20-58

REMARKS: 1" STUB DOWNSTREAM

RUN NO. 5, Approx. 100°F.

RUN NO.	T ₀ SEC.	T _F SEC.	TIME SEC.	CYCLES	C.P.S.	OSC. SC.	READ.	MULT.	W ₀ LBS.	W _F LBS.	ΔW LBS.	TEMP. °F.	SP. WT.	VOLUME GAL.	CPG	GPM	BACK PR.
1	700	820	120	31434	261.95	B	26.2	10	8.30	340.30	332.00	98.5	8.3032	39.985	786.14	19.993	0
2	820	940	120	27062	225.52	B	22.5	10	1.50	287.00	285.50	104.0	8.2988	34.403	786.62	17.202	5
3	940	060	120	24204	201.70	B	20.5	10	1.55	256.65	255.10	101.5	8.3008	30.732	787.58	15.366	7.5
4	060	180	120	18067	150.56	A	14.95	10	1.60	190.90	189.30	101.0	8.3012	22.804	792.27	11.402	7.0
5	180	300	120	15052	125.43	A	12.42	10	1.60	159.00	157.40	100.5	8.3016	18.960	793.88	9.4800	5.5
6	300	420	120	11847	98.725	A	9.70	10	2.00	124.95	122.95	100.5	8.3016	14.810	799.93	7.4050	7.0
7	420	539	119	9085	76.34	A	7.50	10	1.40	95.20	93.80	100.0	8.3020	11.30	804.0	5.697	6.0
8	539	659	120	5921	49.34	B	48.50	1	95.20	156.20	61.00	99.5	8.3024	7.347	805.9	3.674	7.5
9	659	779	120	4989	41.58	B	40.20	1	2.00	53.05	51.05	99.0	8.3028	6.149	811.4	3.075	6.0
10	780	900	120	3530	29.42	B	28.20	1	1.70	38.00	36.30	98.5	8.3032	4.372	807.4	2.186	6.0
11	900	080	180	3848	21.38	B	19.90	1	38.00	79.70	41.70	100.0	8.3020	5.023	766.1	1.341	6.0
12	080	320	240	2636	10.98	A	9.90	1	79.70	113.90	34.20	98.5	8.3032	4.119	640.0	1.030	6.5

TOTAL CYCLES: 160313

TOTAL VOLUME: 204.12

MEAN CYCLES PER GALLON: 785.39

60 CYCLE CHECK	
TIME	READING
10	600
10	600

FLOW METER CALIBRATION
COLORADO STATE UNIVERSITY
DATA

MODEL NO. MT-110

METER NO. SERIAL NO. 2511

CALIBRATED BY: MOORE

NO. OF PULSES / REV.

TYPE OF FLUID: WATER

MANUFACTURED BY: WAUGH

DATE: 3-20-58

REMARKS: 1. STUB DOWNSTREAM

RUN No. 5 Approx. 100°F

RUN NO.	T ₀ SEC.	T _F SEC.	TIME SEC.	CYCLES	C.P.S.	OSC. SC.	READ.	MULT.	W ₀ LBS.	W _F LBS.	ΔW LBS.	TEMP. °F.	SP. WT.	VOLUME GAL.	CPG	GPM	BACK PR.
1	560	680	120	68640	572.00	B	57.0	10	2.30	339.80	337.50	100.0	8.3020	40.653	1688.4	20.327	0
2	680	800	120	60913	507.61	B	50.4	10	7.60	306.20	298.60	103.0	8.2996	35.978	1693.1	17.989	1
3	800	920	120	47368	394.73	B	39.3	10	1.25	233.85	232.60	101.5	8.3008	28.021	1690.4	14.011	6
4	920	040	120	42373	353.11	B	35.2	10	1.40	209.20	207.80	101.0	8.3012	25.033	1692.7	12.517	8
5	040	160	120	35425	295.21	B	29.4	10	1.50	175.00	173.50	101.0	8.3012	20.901	1694.9	10.451	7
6	160	280	120	29270	243.92	B	24.4	10	2.00	145.30	143.30	100.5	8.3016	17.262	1695.6	8.6310	8.5
7	280	400	120	24140	201.17	B	20.0	10	1.00	119.10	118.10	100.0	8.3020	14.225	1697.0	7.1125	5.5
8	400	520	120	17870	148.92	A	14.75	10	2.00	89.10	87.10	100.0	8.3020	10.49	1704	5.245	5.5
9	520	640	120	12276	102.30	A	10.05	10	2.00	61.90	59.90	100.0	8.3020	7.215	1702	3.608	6.0
10	640	760	120	8966	74.72	A	7.37	10	0.30	43.90	43.60	99.5	8.3024	5.251	1707	2.626	6.0
11	760	940	180	9080	50.44	B	49.50	1	43.90	87.50	43.60	99.0	8.3028	5.251	1729	1.750	5.5
12	940	240	300	7740	25.80	B	24.60	1	87.50	125.90	38.40	99.0	8.3028	4.625	1674	.9250	6.0

TOTAL CYCLES: 364061

TOTAL VOLUME: 214.91

1694.0

60 CYCLE CHECK	
TIME	READING
10	600
10	600

FLOW METER CALIBRATION
COLORADO STATE UNIVERSITY

DATA

MODEL NO 3/4-80

METER NO. SERIAL NO. 64MD-1

CALIBRATED BY: MOORE

NO. OF PULSES / REV. _____

TYPE OF FLUID: WATER

MANUFACTURED BY: POTTER

DATE: 3-21-58

REMARKS: 2" STUB DOWNSTREAM RUN NO. 6, Approx. 100°F.

RUN NO.	T ₀ SEC.	T _F SEC.	TIME SEC.	CYCLES	C.P.S.	OSC. SC.	READ.	MULT.	W ₀ LBS.	W _F LBS.	ΔW LBS.	TEMP. °F.	SP. WT.	VOLUME GAL.	CPG	GPM	BACK PR.
1	680	800	120	31161	259.68	B	26.0	10	1.40	330.70	329.30	101.0	8.3012	39.669	785.53	19.835	0
2	800	920	120	28085	234.04	B	23.4	10	1.40	298.90	297.50	101.5	8.3008	35.840	783.62	17.920	0
3	920	040	120	23902	199.18	B	19.9	10	1.40	254.40	253.00	101.0	8.3012	30.478	784.24	15.239	6.0
4	040	160	120	17742	147.85	A	14.72	10	1.40	188.60	187.20	101.0	8.3012	22.551	786.75	11.276	6.0
5	160	280	120	15217	126.81	A	12.60	10	1.40	161.00	159.60	100.5	8.3016	19.225	781.52	9.6125	6.0
6	280	400	120	11411	95.092	A	9.50	10	2.00	121.80	119.80	102.5	8.3016	14.431	790.73	7.2155	7.0
7	400	520	120	9225	76.88	A	7.67	10	1.40	98.00	96.60	100.0	8.3020	11.64	792.5	5.820	5.5
8	520	640	120	5812	48.43	B	48.0	1	98.00	159.10	61.10	99.5	8.3024	7.359	789.8	3.679	5.0
9	640	760	120	4727	39.39	B	39.2	1	2.00	51.90	49.90	99.5	8.3024	6.010	786.5	3.005	5.0
10	760	880	120	3467	28.89	B	28.6	1	1.40	38.80	37.40	98.5	8.3032	4.504	769.8	2.252	5.0
11	880	060	180	3555	19.75	B	19.7	1	38.80	79.10	40.30	100.5	8.3016	4.854	732.4	1.618	5.0
12	060	300	240	2077	8.654	A	9.0	1	79.10	111.00	31.90	99.0	8.3028	3.842	540.6	.9605	5.5

TOTAL CYCLES: 156,381

TOTAL VOLUME: 200.40

MEAN CYCLES PER GALLON: 780.34

60 CYCLE CHECK	
TIME	READING
10	600
10	600

FLOW METER CALIBRATION
COLORADO STATE UNIVERSITY

DATA

MODEL NO. MT-110

METER NO. SERIAL NO. 2511

CALIBRATED BY: MOORE

NO. OF PULSES / REV.

TYPE OF FLUID: WATER

MANUFACTURED BY: WAUGH

DATE: 3-21-58

REMARKS: 2" STUB DOWNSTREAM RUN NO. 6, Approx. 100°F

RUN NO.	T ₀ SEC.	T _F SEC.	TIME SEC.	CYCLES	C.P.S.	OSC. SC.	READ.	MULT.	W ₀ LBS.	W _F LBS.	ΔW LBS.	TEMP. °F.	SP. WT.	VOLUME GAL.	CPG	GPM	BACK PR.
1	240	360	120	68684	572.37	B	57.0	10	1.35	338.95	337.60	97.5	8.3040	40.655	1689.4	20.323	0
2	360	480	120	60590	504.92	B	50.2	10	1.10	298.50	297.40	99.5	8.3024	35.821	1691.5	17.911	3
3	480	600	120	48050	400.42	B	39.7	10	1.40	237.40	236.00	102.0	8.3004	28.432	1690.0	14.216	9
4	600	720	120	42290	352.42	B	35.3	10	1.40	209.30	207.90	100.5	8.3016	25.043	1688.7	12.522	9
5	720	840	120	36461	303.84	B	30.3	10	1.40	180.60	179.20	100.0	8.3020	21.585	1689.2	10.793	7
6	840	960	120	29828	248.57	B	24.8	10	2.00	149.85	147.85	99.5	8.3024	17.803	1675.0	8.9040	6.5
7	960	1080	120	23292	194.10	B	19.35	10	1.40	115.85	114.45	99.5	8.3024	13.785	1689.7	6.8925	5.5
8	1080	1200	120	18168	151.30	A	14.95	10	2.00	90.95	88.95	99.0	8.3028	10.71	1696	5.355	6.0
9	1200	1320	120	12302	102.52	A	10.12	10	2.00	62.40	60.40	99.0	8.3028	7.275	1691	3.638	7.5
10	1320	1440	120	9270	77.25	A	7.65	10	1.60	47.00	45.40	98.5	8.3032	5.468	1695	2.734	6.5
11	1440	1620	180	9088	50.49	B	49.60	1	47.00	91.20	44.20	100.5	8.3016	5.324	1707	1.775	5.5
12	1620	1800	180	8322	46.23	B	45.30	1	57.20	97.60	40.40	99.5	8.3024	4.866	1710	1.622	6.0
12	1800	2000	200	7018	23.39	B	23.40	1	4.00	40.50	36.50	96.5	8.3048	4.395	1597	.8790	7.0

TOTAL CYCLES: 373363

TOTAL VOLUME: 221.17

MEAN CYCLES PER GALLON: 1688.1

60 CYCLE CHECK	
TIME	READING
10	600
10	600