EVALUATION OF THE PERFORMANCE OF THE FLOATING ROTOR DESIGN FLOWMETER MANUFACTURED BY THE POTTERMETER COMPANY

FLOWMETER MODEL 2-353A

(Under Martin Contract No. F8-51390)

by

S. S. Karaki

and

Fred Videon

Conducted For

The Martin Company, Denver Division, Denver, Colorado

by

Colorado State University, Research Foundation

Civil Engineering Section

Fort Collins, Colorado

September 1959

CER59SSK45

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ABSTRACT

This report presents an evaluation of the performance of a Pottermeter Model 2-353A. The original meter tested was found to give erratic results due largely to the formation of a vapor pocket at the stationary cone. The meter was redesigned by the Pottermeter Company and the results of tests of the revised meter showed improvement in performance characteristics. Tests for head loss and pressure distribution through the meter were also made and are reported herein.

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I. INTRODUCTION

The objectives of the study reported herein were to determine the operational characteristics of the "floating rotor" design of flow-meter manufactured by the Pottermeter Company and to determine the head losses through the meter for various discharges.

There were two meters tested in this study. For convenience, they will be termed the original and revised designs. Both meters were encased with clear plastic. This facilitated observation and photography of the flow phenomen within the meter. The original meter was first tested in April 1958. Before evaluation of the meter could be completed the meter was recalled from the Colorado State University Laboratory to the Martin Company. Hence, this report does not contain results of tests on head losses or pressure gradients for the original meter.

The original meter was replaced later by a meter of revised design. This meter was subsequently tested and evaluated. Basically only the design of the rotor at the "floating bearing" was changed to prevent cavitation and inaccurate readings of discharges from the meter. The results of the tests for the original and revised meters are evaluated in this report.

II. THE FLOWMETERS.

THE ORIGINAL DESIGN.

The Model 2-353A Pottermeter Flowmeter (hereinafter termed Potter Flowmeter) was designed with a hydraulically self-positioning rotor (called floating bearing or floating rotor) to eliminate use of thrust bearings. The rotor assembly is shown schematically in Fig. 1.

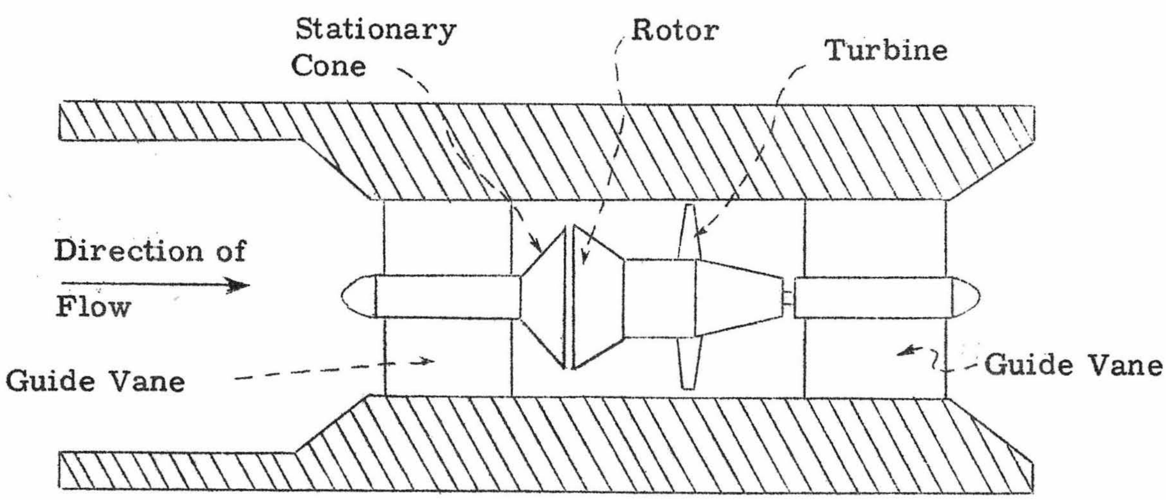


Fig. 1.

The design of the rotor and assembly is such that the flow of the fluid past the upstream cone held rigidly in place causes local fluid acceleration and accompanying reduction in fluid pressure. As the flow expands over the cone of the rotor there is reduction in velocity with accompanying increase in pressure. This gives rise to an upstream pressure gradient and the resulting force balances or counteracts the downstream thrust caused by the force of the flow on the impellers of the rotor. This operation causes very little wear on the guide bushings used to retain the rotor in place and purportedly allows greater linearity and flow range over meters of similar design using thrust bearings. Linearity is a meter characteristic expressed as a dimensional constant (cycles per gallon) accompanied by expressions of accuracy and flow range. It is a measure of meter range and accuracy.

THE REVISED DESIGN.

The revised meter also employs the floating rotor design. The shape of the rotor was altered slightly, as shown in Fig. 2, so that the shaft was not tapered immediately downstream from the rigidly held upstream cone. The reduction in rotor diameter was made downstream of the impellers to effect a pressure differential and upstream thrust.

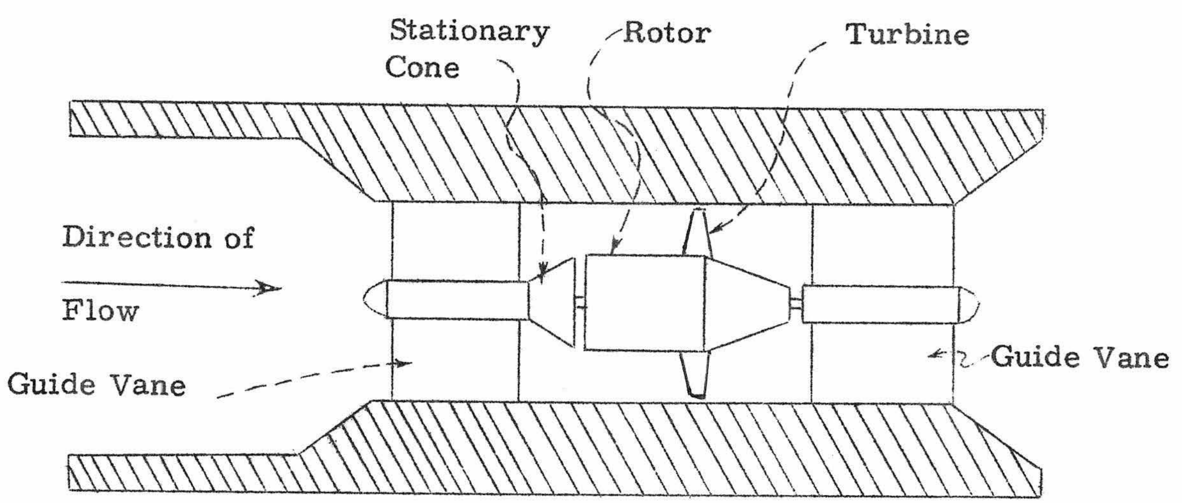


Fig. 2.

III. EXPERIMENTAL PROCEDURE.

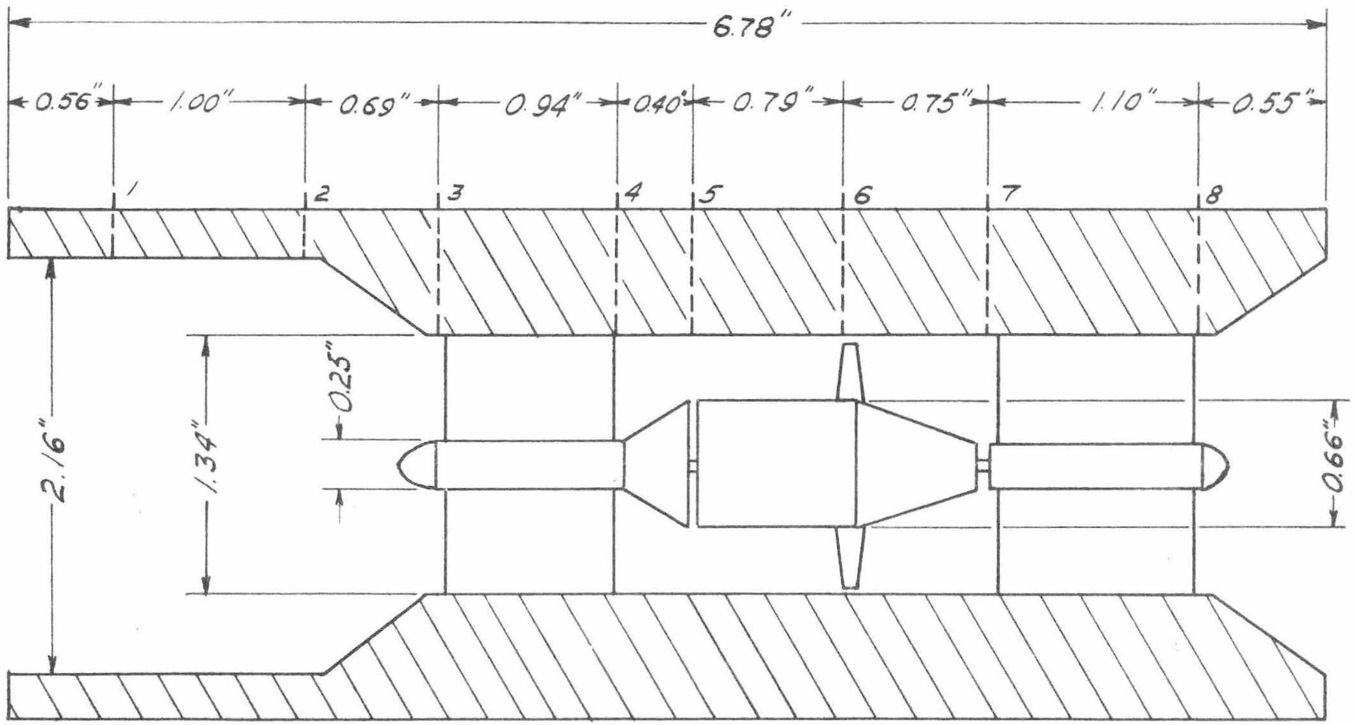
THE ORIGINAL DESIGN

The original meter was tested for performance. This consisted of calibrating the meter, at a constant back pressure of 20 p.s.i.g. After completing the calibration, photographs of flow conditions were taken of various discharges at different back pressures. Before tests for head losses could be conducted the meter was recalled to the Martin Company and subsequently to the Pottermeter Company for redesign because of the great amount of cavitation developed at the upstream cone.

THE REVISED DESIGN.

The revised meter was also calibrated and photographs of flow conditions in the meter chamber were taken for direct comparison with the original meter. Tests for head losses through the meter were made. To enable pressure readings within the meter a line of piezometers was placed along the body of the meter in the locations shown in Fig. 3. Pressure readings were taken for various discharges from which calculations of head losses were made.

The meter was then recalibrated and subjected to a bearing-life test of 100 hours of operating time. Subsequently the meter was calibrated a third time to determine if any difference or shift in calibration occurred due to wear of the guide bushings.



Location of Piezometers
Revised Meter

Fig. 3

IV. PRESENTATION AND DISCUSSION OF RESULTS.

THE ORIGINAL DESIGN.

Performance. - The performance characteristics of the original Potter flowmeter 2-353-A is given in Fig. 4. In this figure frequency output of the meter in terms of cycles per second is plotted against the measured volumetric flow rate, in gallons per minute, on rectangular coordinates to form a straight line. This indicates that the flowmeter operates linearly with discharge. Linearity therefore, is characterized by the slope of the line, which dimensionally becomes cycles per gallon. However, linearity must also be accompanied by expressions of accuracy and a definitive range. On the upper part of Fig. 4 is a graph indicating the linearity of the meter plotted in terms of cycles per gallon shown on the ordinate to the right of the graph against flow rate in gallons per minute. The mean value of 116.13 cy/gal is the average slope of the frequency line. The horizontal dashed lines above and below the mean value are limits of +0.5 % and −0.5 % accuracy respectively. The linearity of this meter can be expressed as 116.13 cy/gal to ± 1.1% over a flow range of 8 to 142 gallons per minute. Repeatability on the other hand, as indicated by the data, is approximately 0.1%.

Performance Characteristics

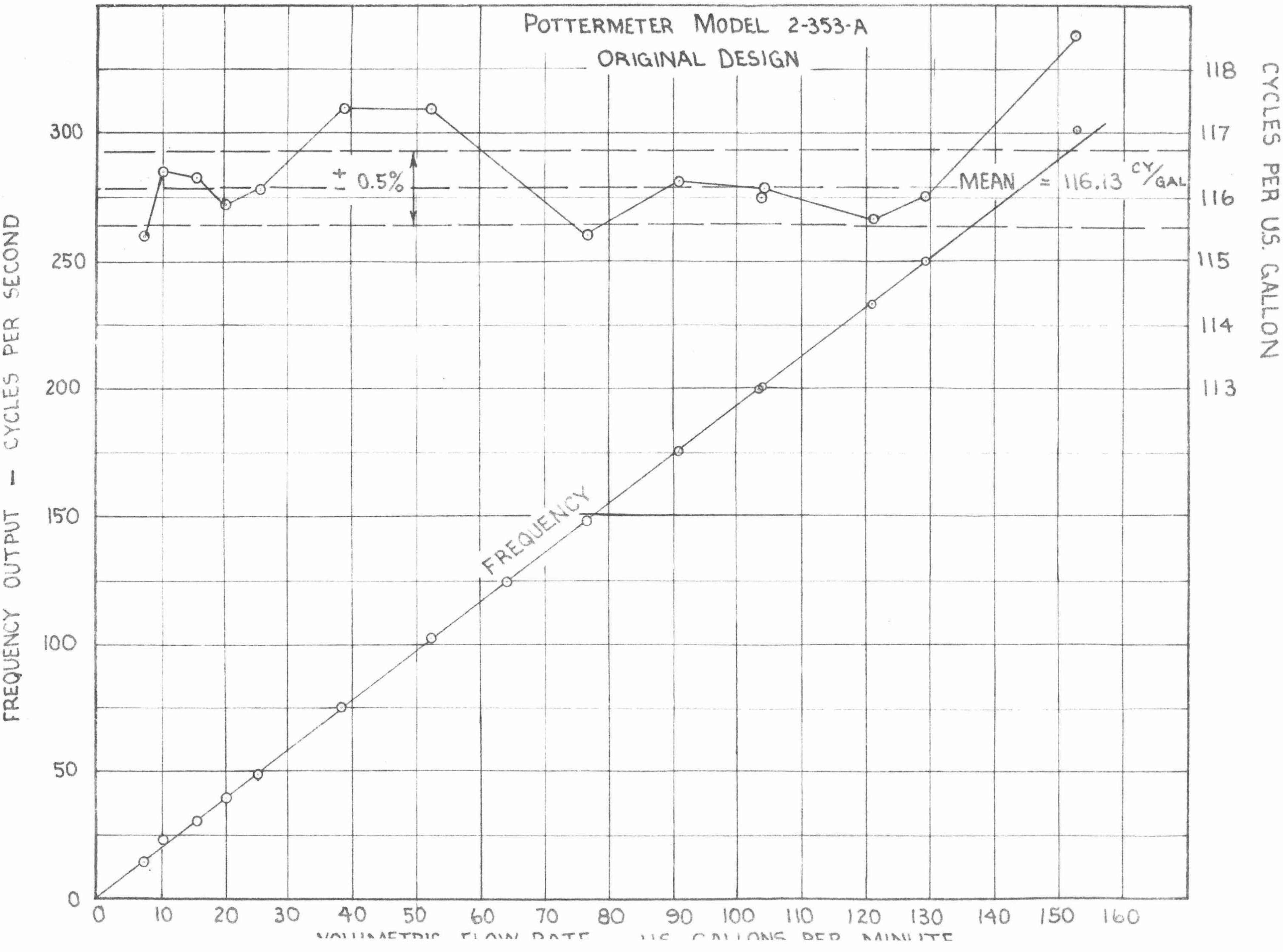


FIG 4

TABLE I

CALIBRATION DATA FOR ORIGINAL METER

METER NO. 2-353 GLMD-9
TYPE OF FLUID USED FOR CALIBRATION – WATER

NO. OF PULSES/REV – 2
DATE: 4-16-58

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	390	690	300	4420	14.73	A	14.8	1	54.0	373.5	319.5	47.5	8.3442	38.29	115.4	7.66	19.8
2	690	870	180	3654	20.30	B	22.0	1	190.5	452.5	262.0	47.5	8.3442	31.40	116.4	10.47	17.3
3	870	990	120	3720	31.00	B	30.9	1	170.0	437.0	267.0	47.5	8.3442	32.00	116.3	16.00	20.0
4	990	110	120	4790	39.92	B	40.0	1	180.0	525.0	345.0	47.0	8.3445	41.34	115.9	20.67	19.0
6	790	910	120	9075	75.63	A	7.5	10	320.0	965.0	645.0	47.5	8.3442	77.30	117.4	38.65	20.0
7	910	030	120	12289	102.41	A	10.2	10	181.5	1056.0	874.5	47.5	8.3442	104.8	117.3	52.40	20.0
7'	030	150	120	12300	102.50	A	10.2	10	124.5	1000.0	875.5	47.5	8.3442	104.9	117.3	52.45	20.2
10	390	510	120	21183	176.53	A	17.6	10	137.0	1657.0	1520.0	47.5	8.3442	182.16	116.29	91.08	21.0
11	510	630	120	24172	201.43	B	20.1	10	94.0	1830.5	1736.5	47.5	8.3442	208.11	116.15	104.06	20.0
11'	630	750	120	24058	200.48	B	20.0	10	102.0	1832.5	1730.5	47.5	8.3442	207.39	116.00	103.70	20.2
12	960	160	1200	280173	233.478	B	23.5	10	VOLUMETIC CALIBRATION			47.5	---	2422.0	115.68	121.1	20.5
13	160	300	1140	285565	250.496	B	25.0	10	"	"	"	47.5	---	2459.8	116.09	129.46	19.0
14	300	260	960	290024	302.108	B	30.2	10	"	"	"	47.5	---	2446.0	118.57	152.88	20.0
15	290	410	120	17761	148.01	A	14.9	10	85.0	1369.0	1284.0	50.5	8.3429	153.90	115.41	76.95	20.5
16	530	650	120	14906	124.21	A	12.5	10	95.5	1168.5	1073.0	50.5	8.3429	128.61	115.90	64.30	20.5
17	650	770	120	5985	49.88	B	50.0	1	52.0	482.0	430.0	50.5	8.3429	51.54	116.12	25.77	20.0

Cavitation. - The phenomenon of cavitation may occur in a flowing fluid body where reduction in pressure intensity below a limiting value causes a discontinuity of the flow due to formation of vapor cavities. The formation and collapse of vapor bubbles is almost instantaneous and it can be distinguished only as an opaque blur to the naked eye.

Reduction of pressure intensity at any point in a flowing fluid may be caused by reduction in pressure of the total system, by an increase in elevation with respect to the pressure gradient, by increasing the velocity of flow or by a combination of the three.

In Figures 5 to 12, photographs of the flow conditions within the meter were taken at various flow rates and system pressures. The elevation of the meter was not changed for any of the tests. It will be noted that as the velocity was increased under approximately the same system pressure of 5 p.s.i.g., the amount of cavitation increased. When the system pressure was increased to 20 p.s.i.g. cavitation was eliminated for all but the highest velocity.

The phenomenon of cavitation can be characterized by a dimensionless cavitation number:

$$\sigma = \frac{p_o - p_v}{\rho \frac{v_o^2}{2}}$$

Where σ is the cavitation number

p_o is the pressure in p.s.f. at a reference section in the flow field.

p_v is the vapor pressure of the flowing fluid.

ρ is the fluid density.

v_o is the velocity of the flow at the reference section.

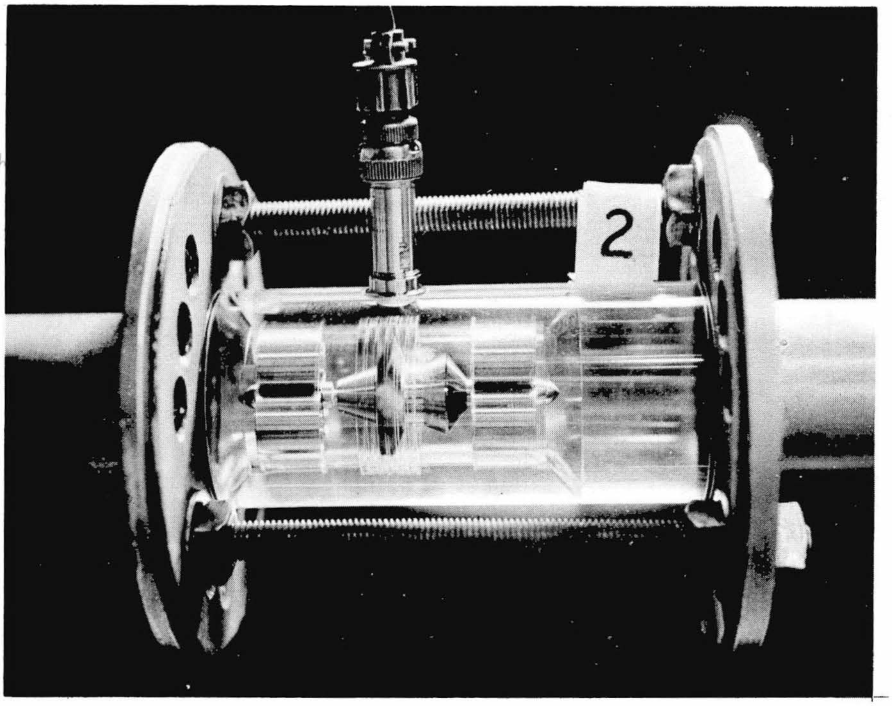


Fig. 5. Flow Rate 93.5 g.p.m.
System Pressure 5 p.s.i.g.
Frequency 180 c.p.s.

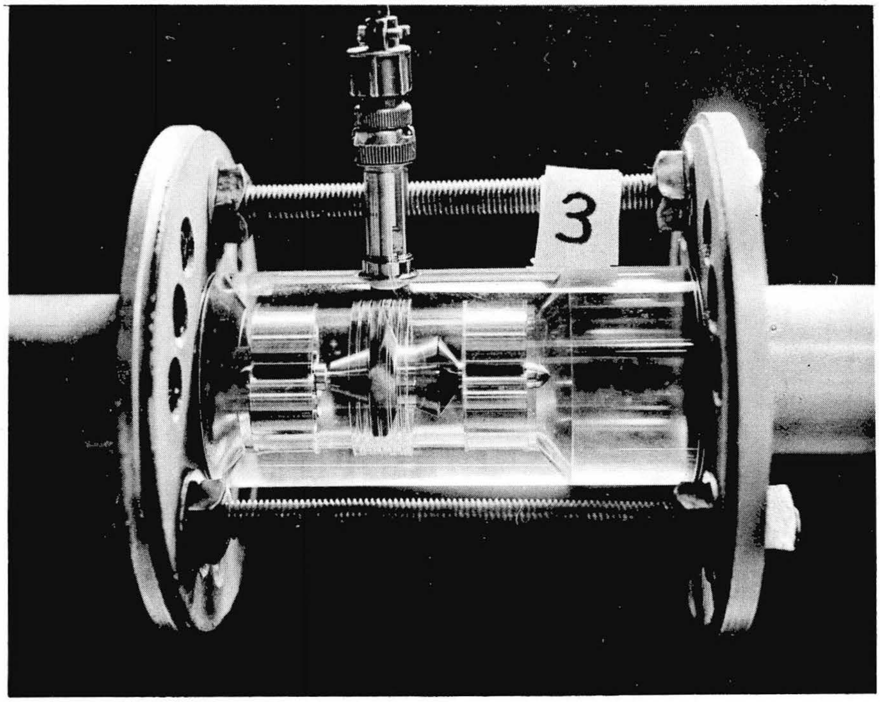


Fig. 6. Flow Rate 93.5 g.p.m.
System Pressure 19 p.s.i.g.
Frequency 180 c.p.s.

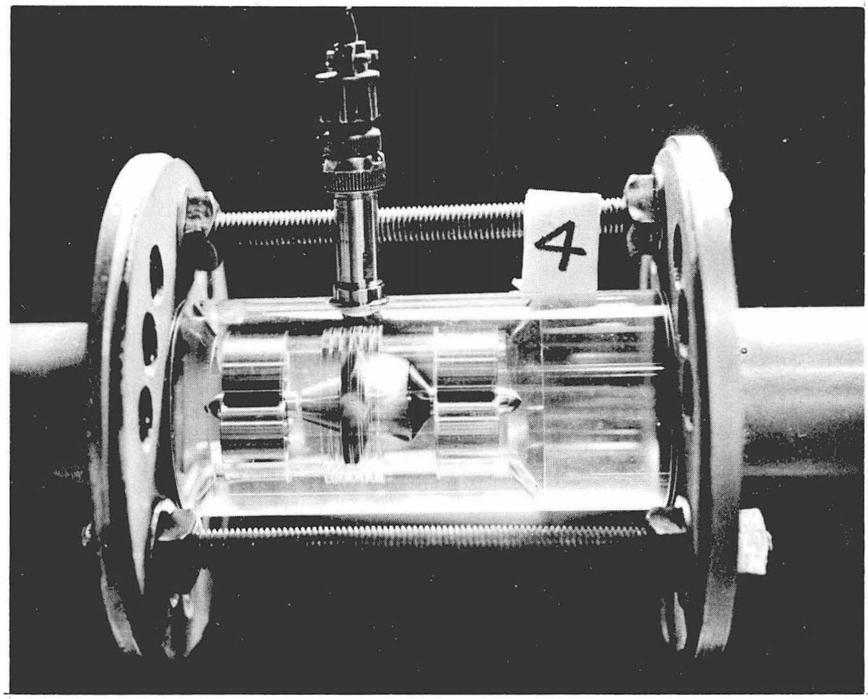


Fig. 7. Flow Rate 104 g.p.m.
System Pressure 5 p.s.i.g.
Frequency 200 c.p.s.

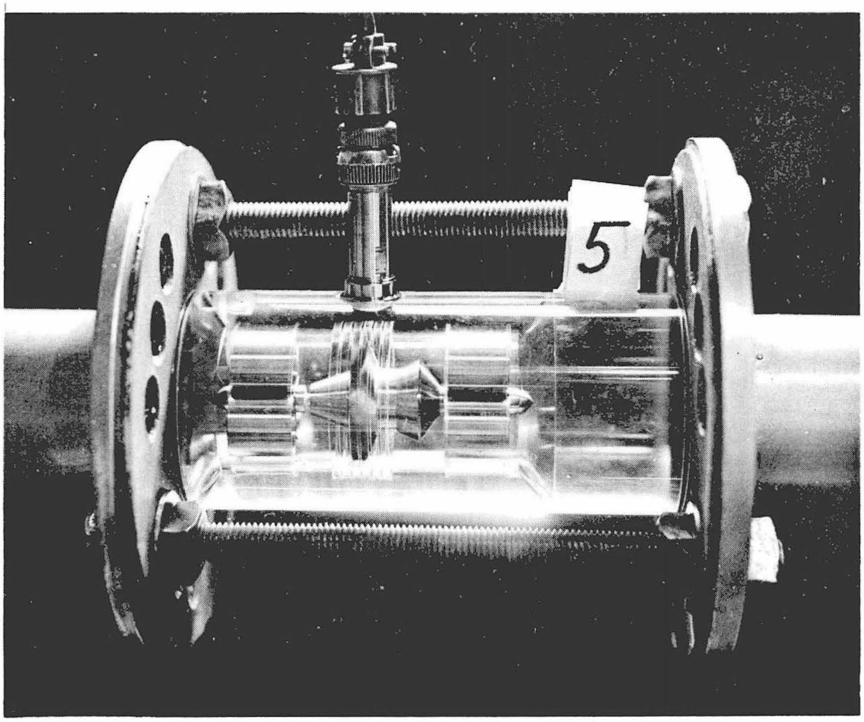


Fig. 8. Flow Rate 104 g.p.m.
System Pressure 20 p.s.i.g.
Frequency 200 c.p.s.

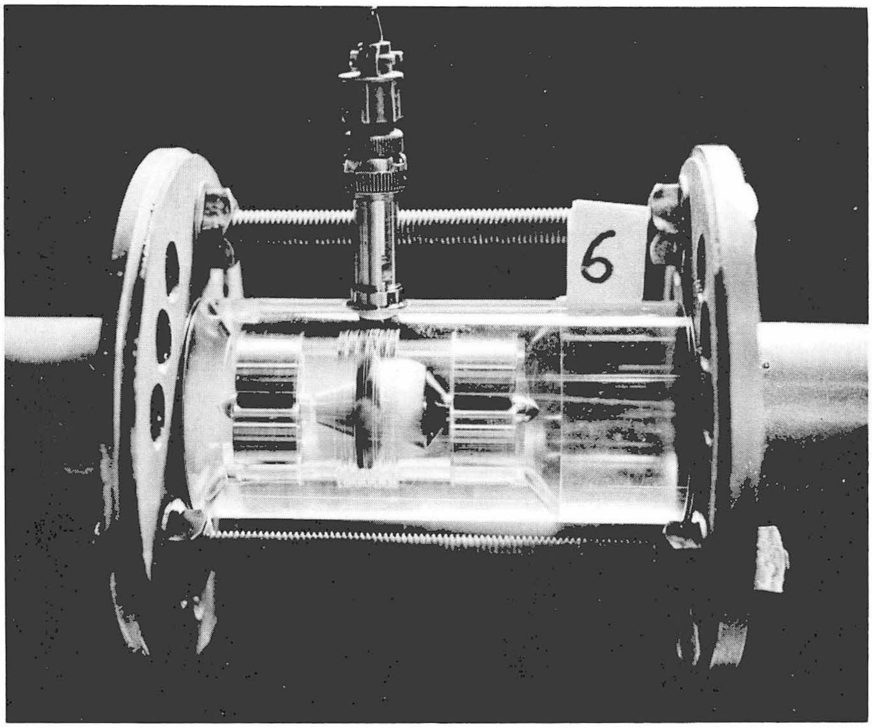


Fig. 9. Flow Rate 119 g.p.m.
System Pressure 7 p.s.i.g.
Frequency 230 c.p.s.

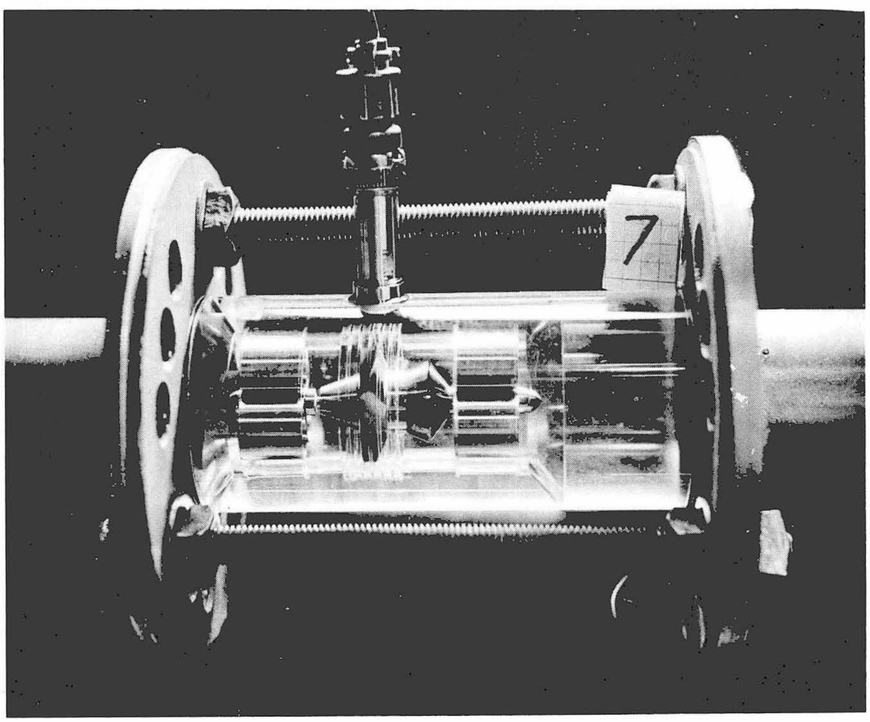


Fig. 10. Flow Rate 119 g.p.m.
System Pressure 19.5 p.s.i.g.
Frequency 230 c.p.s.

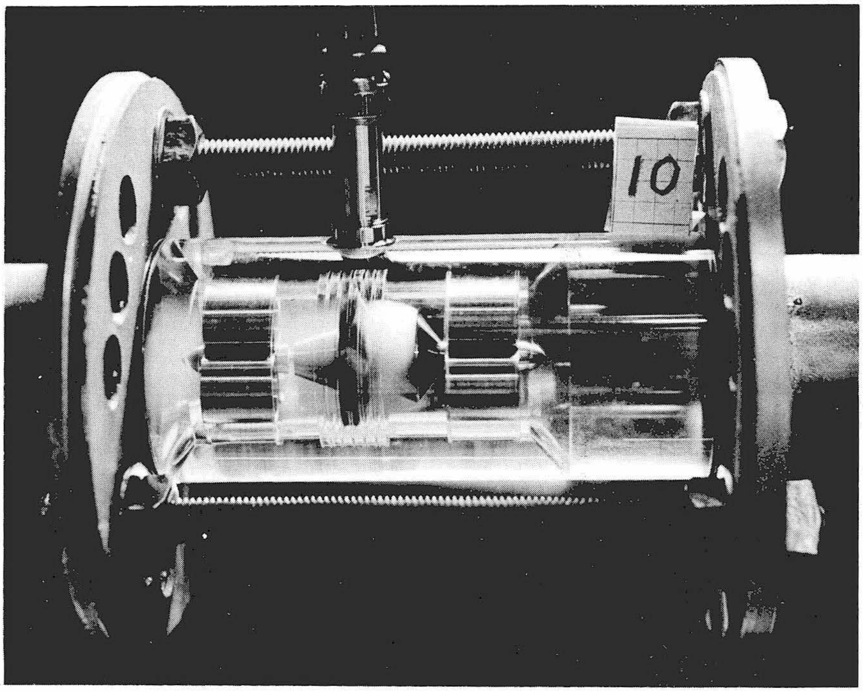


Fig. 11. Flow Rate 145 g.p.m.
System Pressure 4 p.s.i.g.
Frequency 303 c.p.s.

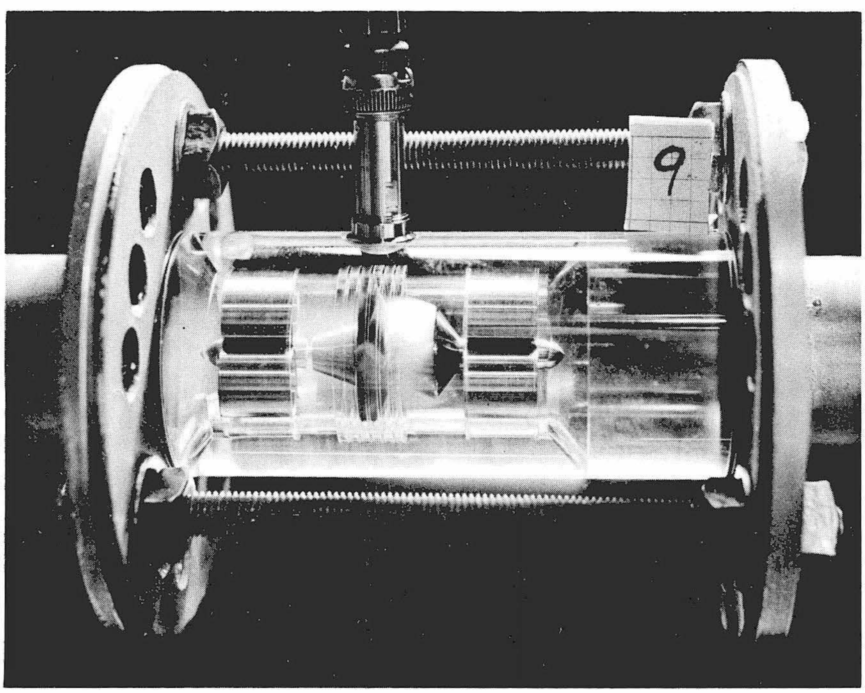


Fig. 12. Flow Rate 145 g.p.m.
System Pressure 20 p.s.i.g.
Frequency 288 c.p.s.

TABLE 2.
CAVITATION NUMBERS.

$\sigma = \frac{p_o - p_v}{\frac{\rho V^2}{2}}$, $V_o = \frac{Q}{A_0}$, $D_o = 2.16''$ $A_o = .0254 \text{ ft}^2$ $\rho = 1.94 \text{ Slugs/ft}^3$

Fig.	G. g.p.m.	p_o* p.s.i.g.	Q c.f.s.	°F Temp.	p_v p.s.f.a.	p_o p.s.f.a.	V_o	$p_o - p_v$	$\rho \frac{V_o^2}{2}$	σ
ORIGINAL METER										
5	93.5	5	.208	47.5	23.4	2447	8.2	2424	65.2	37.2
6	93.5	19	.208	47.5	23.4	4662	8.2	4439	65.2	68.1
7	104	5	.232	47.5	23.4	2447	9.13	2424	80.8	30.0
8	104	20	.232	47.5	23.4	4607	9.13	4584	80.8	56.7
9	119	7	.266	47.5	23.4	2735	10.48	2712	106.3	25.5
10	119	19.5	.266	47.5	23.4	4532	10.48	4509	106.3	42.4
11	145	4	.323	47.5	23.4	2302	12.71	2279	156.8	14.5
12	145	20	.323	47.5	23.4	4607	12.71	4584	156.8	29.2
REVISED METER										
14	103	3	.230	70	52	2159	9.05	2107	79.4	28.0
15	113	3	.252	70	52	2159	9.92	2107	95.5	22.1
16	129	3.5	.288	70	52	2231	11.32	2179	124.4	17.5
17	154	4	.344	70	52	2303	13.54	2251	178.0	12.6
18	140	8	.312	70	52	2879	12.29	2827	146.2	19.4
19	128	12	.285	70	52	3456	11.21	3404	122.1	27.9

* P_o measured 3' downstream from meter.

Table 2 gives the values of σ for each of the test conditions from Figures 5 to 12. It was noted in the test of Fig. 5 that a small vapor pocket formed and dissipated intermittently, indicating a condition of insipient cavitation. A close view of Fig. 5 indicates a small vapor pocket above the cone.

Cavitation numbers greater than that for Fig. 5 would therefore, indicate stable conditions while smaller numbers would signify that cavitation occurs. Compare the cavitation numbers of the table with the respective figures.

Reduction in pressure or increase in velocity of flow beyond the point of incipient cavitation will only serve to enlarge the size of the vapor pocket, which in turn can be expected to change the flow pattern and the pressure distribution along the boundary. In this flowmeter the calibration curve of frequency vs flow rate was affected for the very large discharge. Thus, in Fig. 4, the frequency at 153 g.p.m. and 20 p.s.i.g. deviates approximately 2.1 % from the average. Also in Fig. 11, for a low cavitation number, there is deviation from the average calibration curve.

THE REVISED DESIGN

Performance - The performance characteristics of the revised Potter flowmeter 2-353A are given in Fig. 13 by three separate calibrations. Only one curve of frequency vs flow rate is given because on this scale, the three curves plot almost as a single line. Expressed in terms of cycles per gallon, however, there are some deviations in the three calibrations.

Curve A is the result of a calibration of the new meter, curve B, the result after head loss tests were made and curve C, the result after the bearing-life test. The linearity of the three curves may be expressed as:

Curve A. F = 116.84G within $\pm$ 0.5% from 15 - 153 g.p.m.

Curve B. F = 116.60G within $\pm$ 0.5 % from 16 - 150 g.p.m.

Curve C. F = 117.15G within $\pm$ 0.5% from 37 - 153 g.p.m.

where: F = Frequency in cycles per second.

G = flow rate in gallons per minute.

The value of 117.15 is larger than Curve A or B because of the higher values for discharges less than 37 g.p.m. For the flow range from 37 g.p.m. to 154 g.p.m. the linearity of the flowmeter can be adequately described as:

F = 116.84G within $\pm$ 0.5 %.

There is considerable improvement in performance from the original meter and although it cannot be stated conclusively on the basis of this one meter, the improvement must be due in part to the redesigned rotor. The accuracy of the meter and repeatability of measurement within 100 hours at any discharge between 37 and 154 g.p.m. are within $\pm$ 0.5 %.

Cavitation - The primary improvement of the redesigned meter was the reduced cavitation at the upstream stationary cone. This was accomplished by making the rotor shaft diameter the same as that of the stationary cone and reducing the diameter of the stationary cone. The pressure differential and upstream force on the rotor was effected by a reduction in the size of the rotor shaft downstream of the impellers.

Figures 14 through 19 photographically show effects of the redesigned rotor on cavitation. Comparisons can be made with the photographs of the original design, Figs. 5 to 12. By a comparison of cavitation numbers in Table 2 the redesigned meter gives a smaller critical cavitation number, indicating improvement in design.

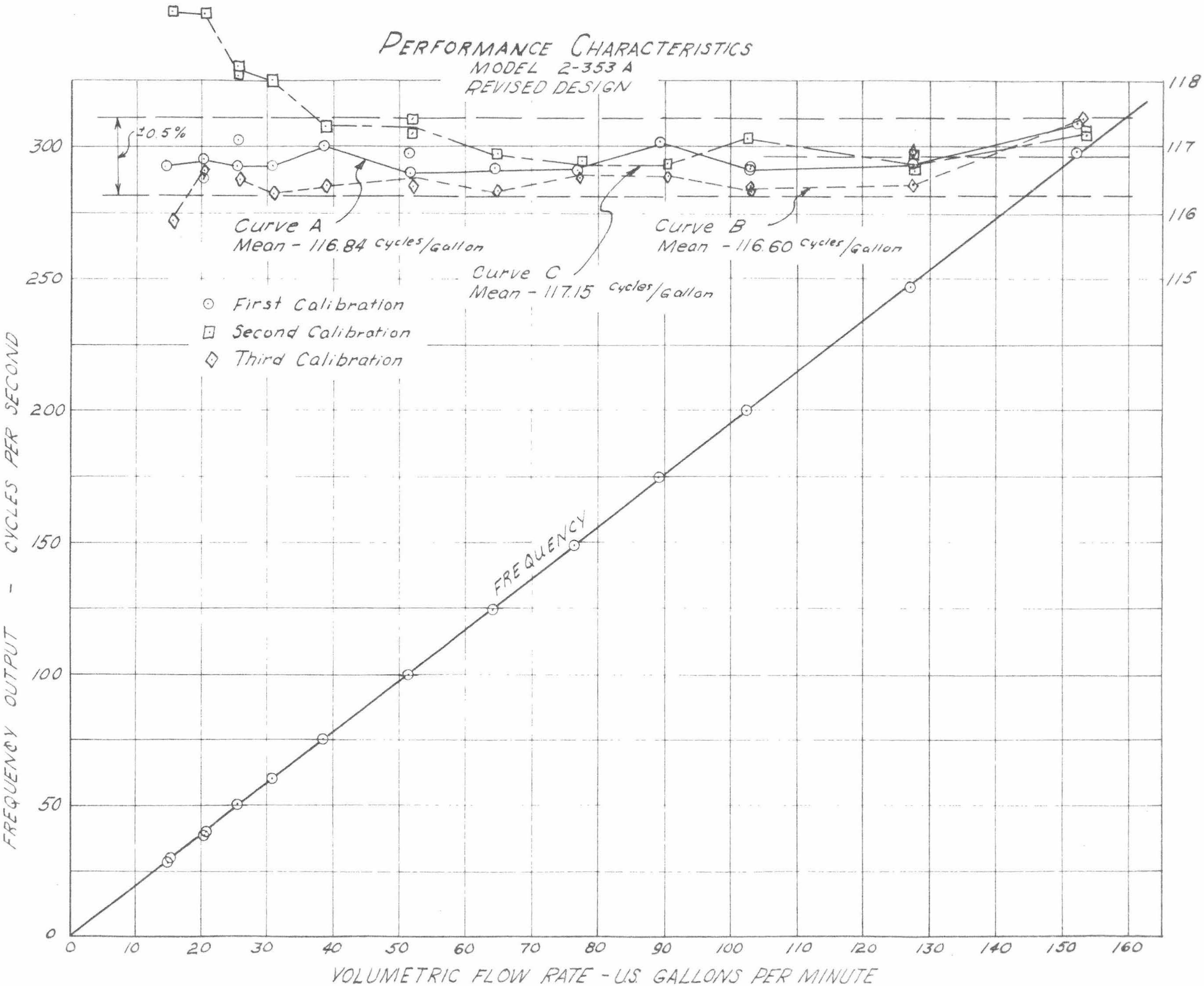

PERFORMANCE CHARACTERISTICS
MODEL 2-353 A
REVISED DESIGN
±0.5%
Curve A
Mean - 116.84 cycles/Gallon
Curve B
Mean - 116.60 cycles/Gallon
Curve C
Mean - 117.15 cycles/Gallon
First Calibration
Second Calibration
Third Calibration
FREQUENCY
FREQUENCY OUTPUT - CYCLES PER SECOND
CYCLES PER U.S. GALLON
VOLUMETRIC FLOW RATE - U.S. GALLONS PER MINUTE
0
50
100
150
200
250
300
115
116
117
118
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160

FIG. 13

TABLE 3

CALIBRATION DATA FOR REVISED METER

SHEET 1 NEW METER

METER NO. 2-353 A NO. OF PULSES / REV - 2

TYPE OF FLUID USED FOR CALIBRATION — WATER DATE 7-30-59

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.	C.P.G.	G.P.M.	BACK PR.
1'	600	690	90	26777	297.52	B	29.8	10	23.0	1924.0	1901.0	69.0	8.3296	228.22	117.33	152.15	21.5
2	690	780	90	22265	247.39	B	24.7	10	78.0	1667.0	1589.0	69.0	8.3296	190.76	116.72	127.17	20.5
3	780	900	120	24015	200.12	B	20.0	10	93.0	1808.5	1715.5	69.0	8.3296	205.95	116.60	102.98	20.0
3'	900	20	120	24026	200.22	B	20.0	10	77.0	1792.0	1715.0	69.0	8.3296	205.89	116.69	102.94	20.0
4	20	140	120	20912	174.27	A	17.4	10	97.5	1585.5	1488.0	69.0	8.3296	178.64	117.06	89.320	18.00
5	140	260	120	17886	149.05	A	14.9	10	97.0	1374.0	1277.0	69.0	8.3296	153.31	116.67	76.655	19.0
6	380	500	120	15010	125.08	A	12.5	10	102.5	1174.5	1072.0	69.0	8.3296	128.70	116.63	64.350	20.0
7	500	620	120	12017	100.14	A	10.0	10	87.0	943.0	856.0	69.0	8.3296	102.8	116.9	51.40	21.0
7'	620	750	130	13015	100.12	A	10.0	10	943.0	1872.5	929.5	69.0	8.3296	111.6	116.6	51.51	21.0
8	750	870	120	9013	75.11	A	7.51	10	91.0	732.5	641.5	69.0	8.3296	77.01	117.0	38.50	21.0
9	870	990	120	7215	60.12	A	6.01	10	732.5	1247.5	515.0	69.0	8.3296	61.83	116.7	30.92	23.0
10	990	130	140	7018	50.13	B	50.1	1	1247.5	1746.5	499.0	69.0	8.3296	59.91	117.1	25.68	23.0
10'	130	250	120	6001	50.01	B	50.0	1	75.5	504.0	428.5	69.0	8.3296	51.44	116.7	25.72	23.0
11	250	370	120	4795	39.96	B	40.0	1	504.0	846.0	342.0	69.0	8.3296	41.06	116.8	20.53	23.0
12	370	550	180	5197	28.87	B	29.0	1	846.0	1217.0	371.0	69.0	8,3296	44.54	116.7	14.85	23.0
11'	550	670	120	4755	39.62	B	39.6	1	1217.0	1557.0	340.0	69.5	8.3291	40.82	116.5	20.41	23.0

TABLE 3
CALIBRATION DATA FOR REVISED METER
SHEET 2 – AFTER PRESSURE TESTS

METER NO. 2-353 A
TYPE OF FLUID USED FOR CALIBRATION – WATER

NO. OF PULSES/REV – 2
DATE: 7-31-59

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	891	981	90	26953	299.48	B	30.0	10	24.5	1936.0	1911.5	70.0	8.3286	229.51	117.44	153.01	19
2	981	71	90	22470	249.67	B	25.0	10	52.0	1659.5	1607.5	70.0	8.3286	193.01	116.42	128.67	22
3	71	191	120	23984	199.87	B	20.0	10	60.0	1776.0	1716.0	70.0	8.3286	206.04	116.40	103.02	20
3'	191	311	120	23988	199.90	B	20.0	10	85.0	1802.5	1717.5	70.0	8.3286	206.22	116.32	103.11	20
4	311	431	120	21035	175.29	A	17.45	10	80.5	1584.0	1503.5	70.0	8.3286	180.52	116.52	90.260	18.5
5	431	551	120	18084	150.70	A	15.0	10	54.5	1346.0	1291.5	70.0	8.3286	155.07	116.62	77.535	17.0
5'	551	671	120	18104	150.87	A	15.0	10	79.5	1373.0	1293.5	70.0	8.3286	155.31	116.57	77.655	17.5
6	671	791	120	15075	125.62	A	12.5	10	75.0	1154.5	1079.5	70.0	8.3286	129.61	116.31	64.805	19
7	791	911	120	12038	100.32	A	10.0	10	70.0	929.0	859.0	70.0	8.3286	103.1	116.8	51.55	20
7'	911	31	120	12030	100.25	A	10.0	10	929.0	1789.5	860.5	70.0	8.3286	103.3	116.4	51.65	20
8	31	151	120	9036	75.30	A	7.53	10	60.0	706.5	646.5	70.0	8.3286	77.62	116.4	38.81	21
9	151	271	120	7178	59.82	B	60.0	1	706.5	1220.5	514.0	70.0	8.3286	61.72	116.3	30.86	21
10	271	391	120	6015	50.12	B	50.1	1	1220.5	1650.5	430.0	70.0	8.3286	51.63	116.5	25.82	22
10'	391	511	120	6006	50.05	B	50.1	1	92.0	521.0	429.0	70.0	8.3286	51.51	116.6	25.76	22
11	511	631	120	4806	40.05	B	40.0	1	521.0	864.0	343.0	70.0	8.3286	41.18	116.7	20.59	22
12	631	811	180	5406	30.03	B	30.0	1	864.0	1252.5	388.5	70.5	8.3281	46.65	115.9	15.55	23

TABLE 3
CALIBRATION DATA FOR REVISED METER
SHEET 3 - AFTER BEARING LIFE TEST

METER NO. 2-353 A
TYPE OF FLUID USED FOR CALIBRATION - WATER

NO OF PULSES / REV. - 2
DATE: 8-4-59

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	840	20	180	5400	30.00	B	30.0	1	24.5	402.5	378.0	67.5	8.3310	45.37	119.0	15.12	22
2	20	140	120	4799	39.99	B	40.0	1	402.5	738.5	336.0	67.5	8.3310	40.33	119.0	20.16	21
3	140	260	120	5996	49.97	B	50.0	1	738.5	1161.0	422.5	67.5	8.3310	50.71	118.2	25.36	20
3'	260	380	120	5996	49.97	B	50.0	1	1161.0	1584.0	423.0	67.5	8.3310	50.77	118.1	25.38	20
4	380	500	120	7209	60.08	B	60.0	1	61.5	570.5	509.0	67.5	8.3310	61.10	118.0	30.55	20
5	500	620	120	9020	75.17	A	7.52	10	570.5	1211.0	640.5	67.5	8.3310	76.88	117.3	38.44	18
6	620	740	120	12065	100.54	A	10.0	10	80.0	936.5	856.5	67.5	8.3310	102.8	117.4	51.40	16.5
6'	740	860	120	12072	100.60	A	10.0	10	936.5	1795.0	858.5	67.5	8.3310	103.0	117.2	51.50	16.5
7	860	980	120	15068	125.57	A	12.5	10	95.0	1169.0	1074.0	67.5	8.3310	128.92	116.88	64.460	14
8	980	100	120	18101	150.84	A	15.0	10	192.0	1485.0	1293.0	67.5	8.3310	155.20	116.63	77.600	11
8'	100	220	120	18112	150.93	A	15.0	10	109.0	1401.5	1292.5	67.5	8.3310	155.14	116.75	77.570	11
9	220	340	120	21157	176.31	A	17.55	10	99.0	1609.0	1510.0	67.5	8.3310	181.25	116.73	90.625	8
10	340	460	120	23965	199.71	A	20.0	10	85.5	1790.0	1704.5	69.0	8.3296	204.63	117.11	102.32	15
11	460	580	120	30008	250.07	B	25.0	10	64.0	2203.0	2139.0	69.0	8.3296	256.80	116.85	128.40	23
11'	580	670	90	22515	250.17	B	25.0	10	43.5	1651.0	1607.5	69.0	8.3296	192.99	116.66	128.66	23
12	670	760	90	27039	300.43	B	30.0	10	63.5	1986.0	1922.5	69.0	8.3296	230.80	117.15	153.87	18
12'	760	850	90	27032	300.36	B	30.0	10	56.5	1977.5	1921.0	69.0	8.3296	230.62	117.21	153.75	18

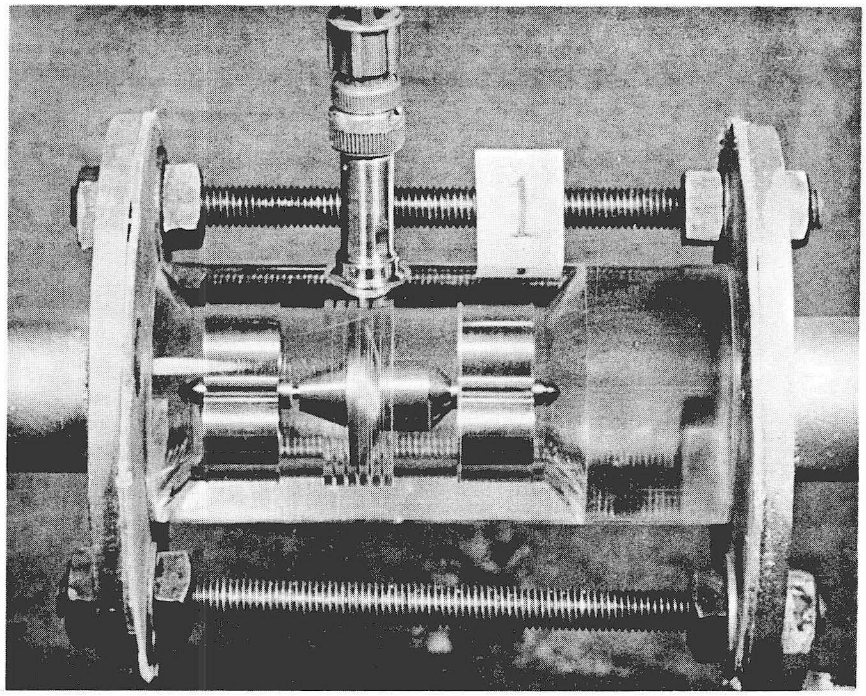


Fig. 14. Flow Rate 103 g.p.m.
System Pressure 3 p.s.i.g.
Frequency 202 c.p.s.

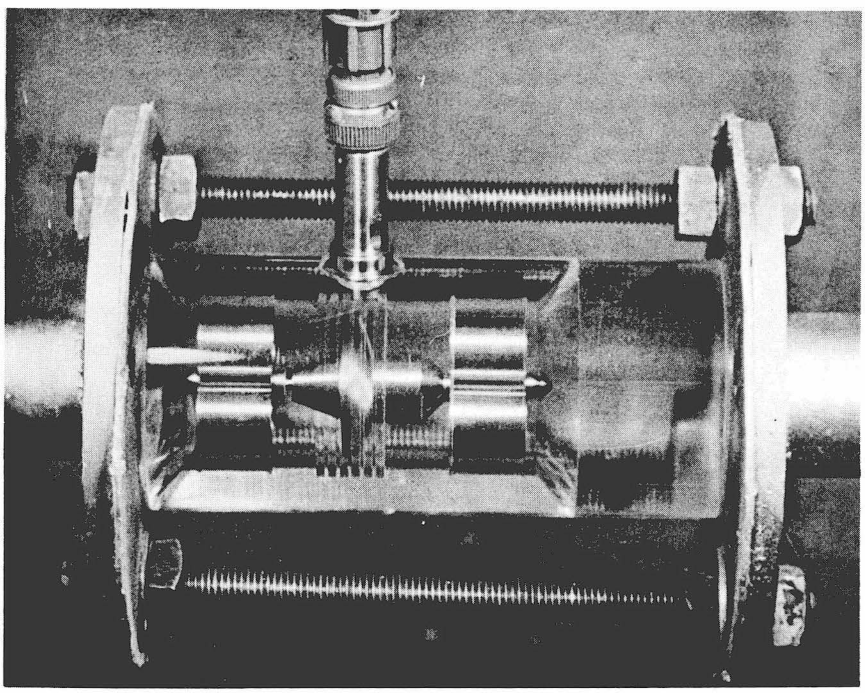


Fig. 15. Flow Rate 113 g.p.m.
System Pressure 3 p.s.i.g.
Frequency 227 c.p.s.

300 c.p.s. 154 g.p.m. BP = 4 p.s.i.

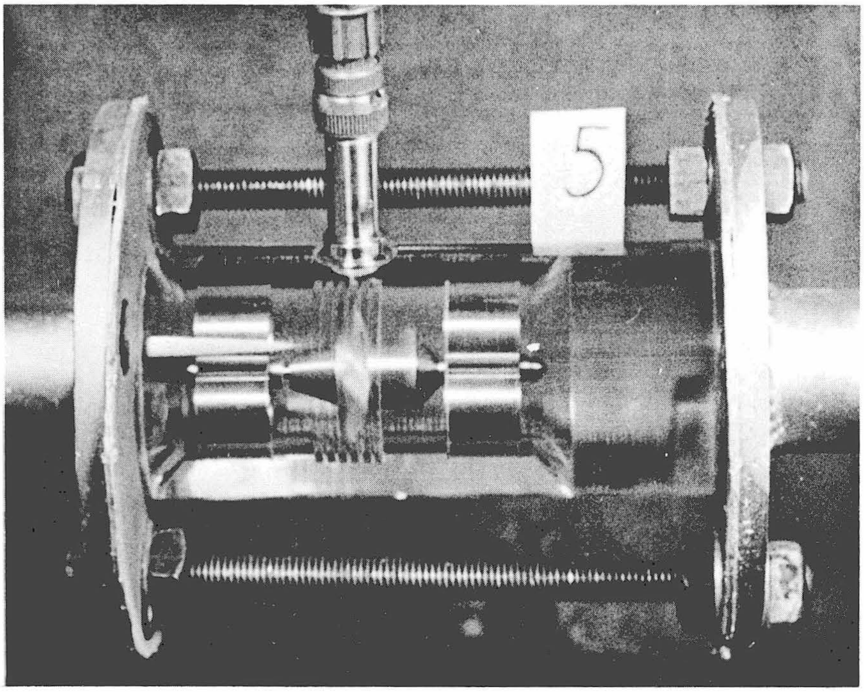


Fig. 16. Flow Rate 129 g.p.m.
System Pressure 3.5 p.s.i.g.
Frequency 253 c.p.s.

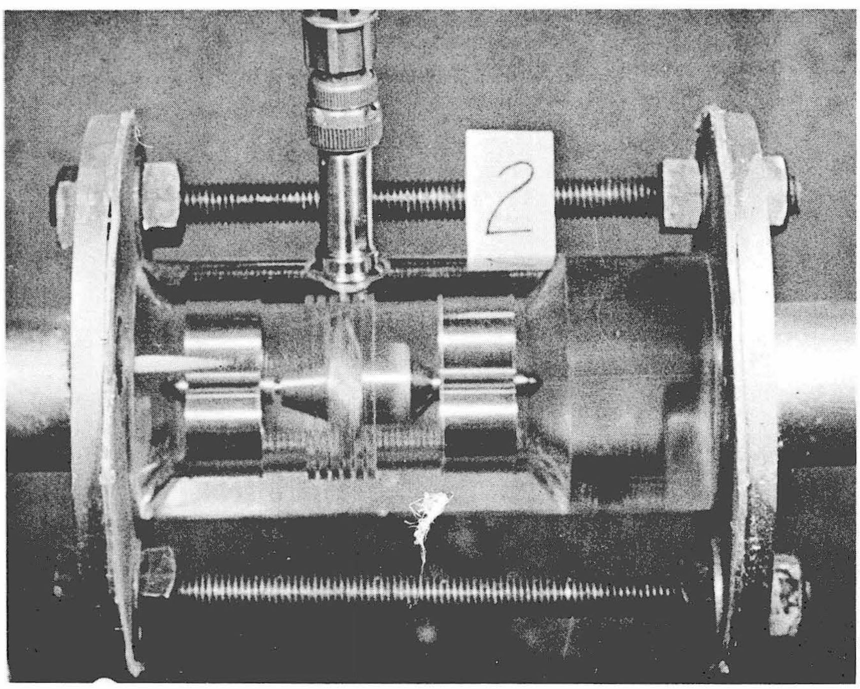


Fig. 17. Flow Rate 154 g.p.m.
System Pressure 4 p.s.i.g.
Frequency 300 c.p.s.

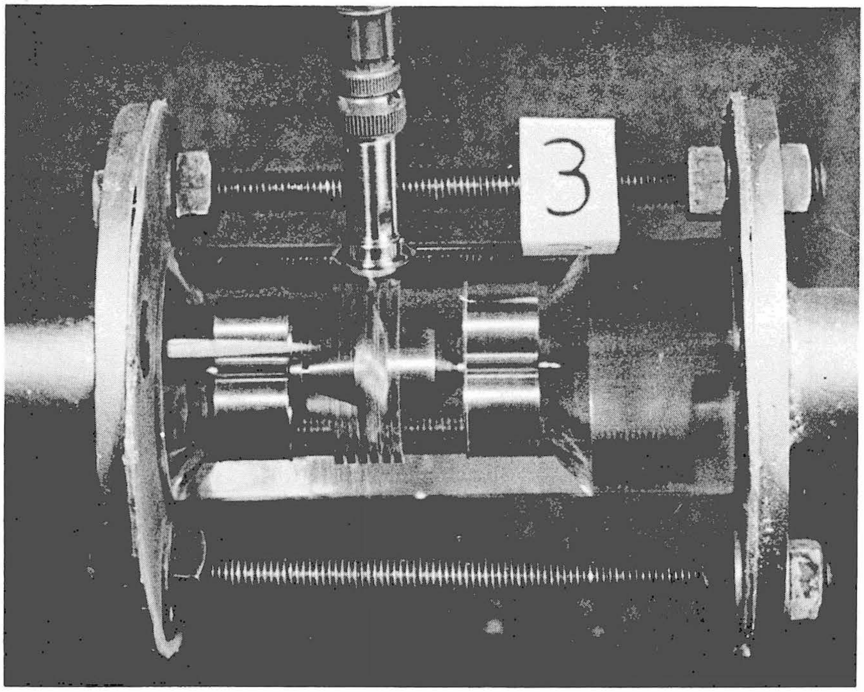


Fig. 18. Flow Rate 140 g.p.m.
System Pressure 8 p.s.i.g.
Frequency 275 c.p.s.

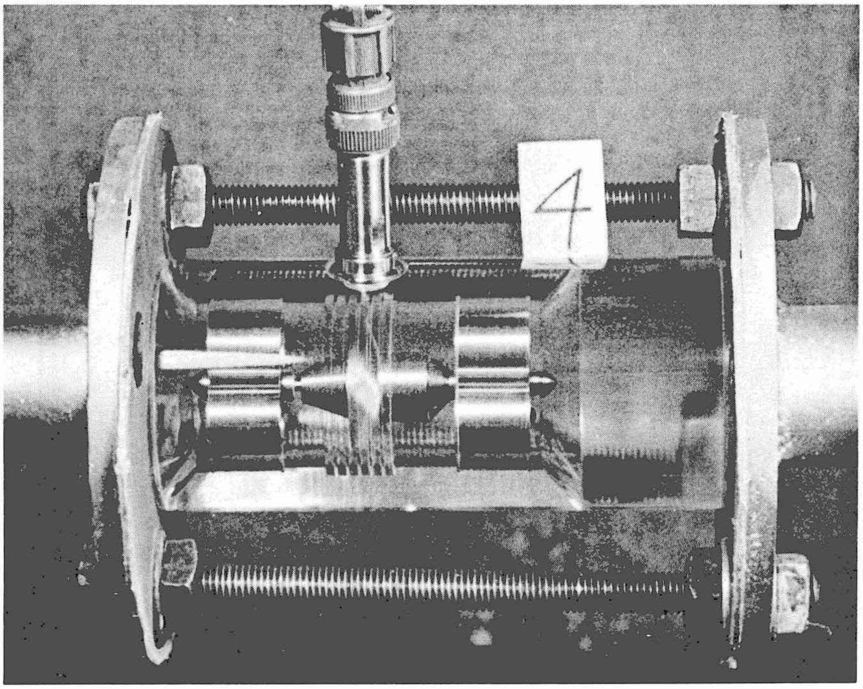


Fig. 19. Flow Rate 128 g.p.m.
System Pressure 12 p.s.i.g.
Frequency 250 c.p.s.

Pressure Distribution and Head Loss - Distribution of pressure along the length of the Potter Flowmeter is given in Table 4. The locations of the piezometers made for the pressure readings are shown in Fig. 3. The apparent gain of pressure at piezometer 2, and the lower pressure measured at piezometer 3 than at piezometer 4 is due to the sharp break in the geometry of the flow boundary. The pressure differential between piezometer 6 and 7 provides the upstream thrust, and the gain in pressure head from 7 to 0 is due to the flow section at 7 not being as fully effective as the section where piezometer 0 is located.

The head loss through the meter is shown graphically in Fig. 20. The head loss between piezometer locations 1 and 0 does not include the head loss at the conical expansion at the end of the meter. Assuming that the coefficient for head loss, f_e , at a 38° conical expansion in a pipe line is .58* in the equation

$$H_e = f_e \frac{(v_1^2 - v_2^2)}{2g},$$

where:

H_e = Head loss due to expansion,

f_e = Coefficient of head loss,

v_1 = Velocity in the smaller pipe,

v_2 = Velocity in the larger pipe,

the total head loss through the meter is represented by the dashed line.

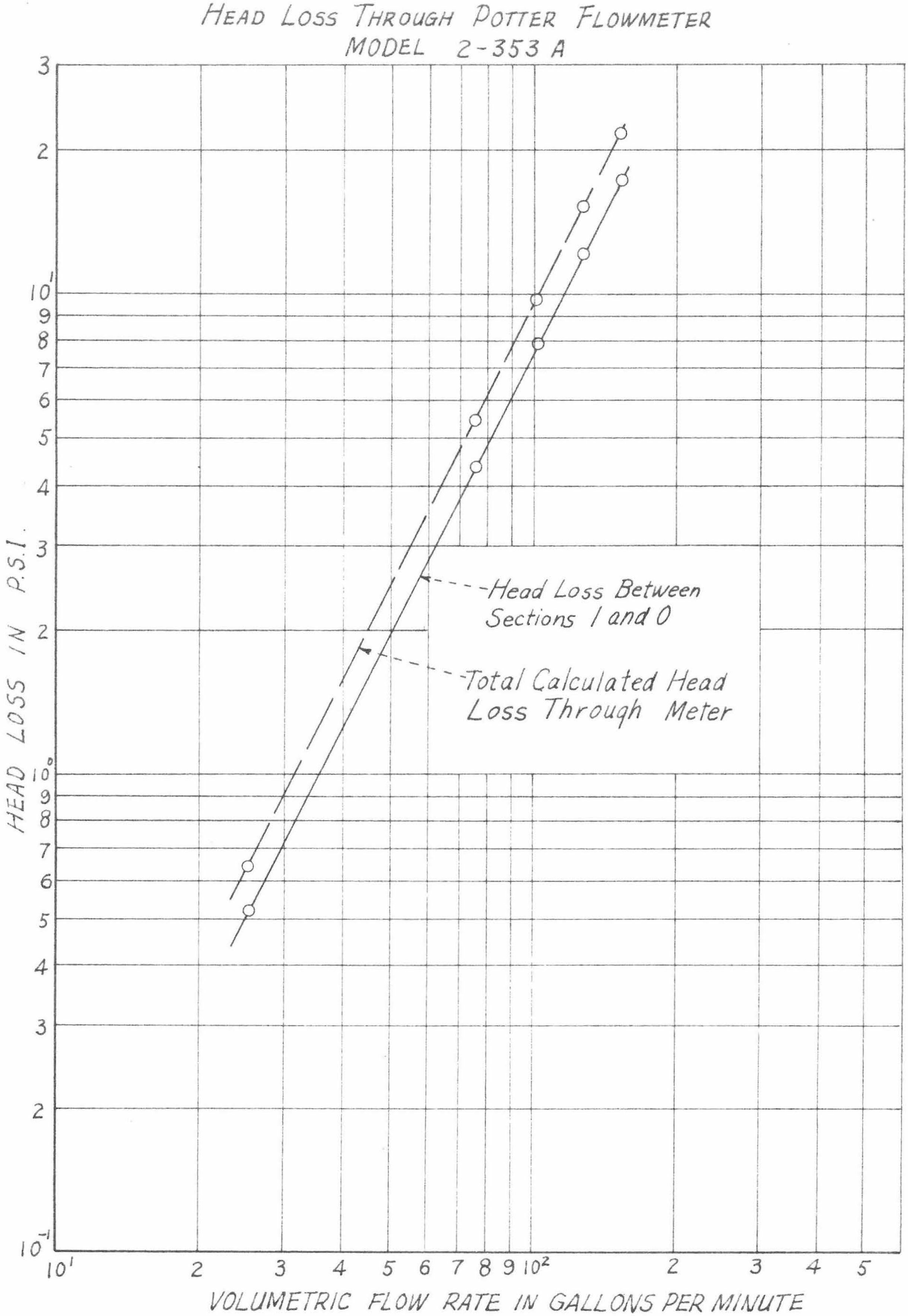
* King, H. W., Handbook of Hydraulics, 4th Ed. McGraw Hill Book Company. 1954 p. 6-16.

TABLE 4.

PRESSURES, GRADIENTS AND HEAD LOSSES IN THE REVISED METER.

Q	Pressure At Piez. O.	ΔH							v_1	v_2	H_e	H_L	H_L
		O-1	O-2	O-3	O-4	O-5	O-6	O-7					
g.p.m.	ft. Water	ft.	ft.	ft.	ft.	ft.	ft.	ft.	ft/Sec.	ft/Sec.	ft.	ft.	p.s.i.
25.25	30.03	1.21	1.22	0.26	0.64	0.05	-0.32	0	2.21	5.93	.27	1.48	0.64
25.50	14.68	1.21	1.21	0.19	0.69	0.03	-0.32	0	2.23	5.98	.28	1.49	0.65
75.93	28.95	10.12	10.44	3.61	6.07	-0.25	-2.77	-0.23	6.65	17.81	2.46	12.58	5.45
76.25	14.39	10.11	10.33	3.58	6.04	-0.26	-2.65	-0.21	6.68	17.90	2.48	12.59	5.45
102.38	27.60	18.16	18.52	6.15	10.61	-0.67	-4.86	-0.37	8.96	24.00	4.47	22.63	9.80
102.01	13.39	17.89	17.95	6.23	10.44	-0.82	-4.57	-0.38	8.93	23.90	4.43	22.32	9.66
127.49	27.30	27.83	28.40	9.26	16.49	-1.26	-7.59	-0.62	11.16	29.90	6.94	34.77	15.05
128.42	11.57	28.32	28.68	9.43	16.71	-1.41	-7.52	-0.68	11.24	30.10	7.02	35.34	15.31
152.28	24.96	40.04	40.76	11.80	23.77	-2.17	-10.81	-0.88	13.33	35.70	9.88	49.92	21.60

FIG. 20


HEAD LOSS THROUGH POTTER FLOWMETER
MODEL 2-353 A
HEAD LOSS IN P.S.I.
VOLUMETRIC FLOW RATE IN GALLONS PER MINUTE
Head Loss Between Sections 1 and 0
Total Calculated Head Loss Through Meter

V. SUMMARY AND CONCLUSIONS.

The original design of the Potter Flowmeter Model 2-353A presented cavitation problems at the upstream stationary cone. The cavitation in turn caused some inaccuracies in flow measurement at high discharges.

The revised design improved the performance of the meter, particularly with regard to cavitation. This was accomplished by making the rotor of the shaft the same diameter as the stationary cone, and reducing the size of the stationary cone from that of the original design. The meter output frequency is linear with respect to discharge and is accurate to within $\pm$ 0.5 per cent in a flow range of 37 to 154 g.p.m. After about 100 hours use, the meter became inaccurate for measuring flows less than 37 g.p.m., due possibly to minor wear of the guide bushings; the frequency output was too high at the low discharges.