EVALUATION OF THE EFFECT OF VISCOSITY ON THE CALIBRATIONS OF SEVERAL FLOWMETERS

(Under Contract DEN-57-10195)

by
Fred Videon

conducted for
The Martin Company
Denver Division
Denver, Colorado

through
Colorado State University Research Foundation
Fort Collins, Colorado

February 24, 1958

CER58ARC5

EVALUATION OF THE EFFECT OF VISCOSITY ON THE CALIBRATIONS OF SEVERAL FLOWMETERS

(Under Contract DEN-57-10195)

by
Fred Videon

conducted for
The Martin Company
Denver Division
Denver, Colorado

through
Colorado State University Research Foundation
Fort Collins, Colorado

February 24, 1958

EVALUATION OF THE EFFECT OF VISCOSITY
ON THE CALIBRATIONS OF SEVERAL FLOWMETERS

(Under Contract DEN-57-10195)

by
Fred Videon

Approved: A. R. Chamberlain
A. R. Chamberlain, Chief
Civil Engineering Section

Date: 25 Feb. 1958

INTRODUCTION

As the temperature of a fluid varies, a change in the resistance of the fluid to shearing stress occurs. The tests reported herein were conducted to determine whether or not a large difference in fluid viscosity would affect the calibration of turbine flowmeters. The results of these tests indicate that an increase in the viscosity causes a decrease in cycles per gallon output from the meters.

TESTS

Two calibrations were run on each of six meters using MIL-0-5606 hydraulic fluid. Each meter was calibrated at 60° F. and 120° F. Oil, rather than water, was used for two reasons. First, the test facilities existing for calibration with oil at Colorado State University provide much better temperature control. Second, by reducing the temperature of oil from 120° F. to 60° F., an approximately five-fold increase in the viscosity takes place; whereas, the same temperature reduction of water results in only a two-fold viscosity increase.

Table I

Identification of Meters Tested

Report Code	Description and Manufacturer		
1	3/4-14	5608A3356A5	Fischer and Porter
2	3/4-23	5608A3356A5	Fischer and Porter
3	MT-111	Serial - 2500	1/2" Waugh
4	MT-111	Serial - 2520	1/2" Waugh
5	FL-12S	Serial - 3571	3/4" Waugh
6	1/2-9	5608A3356A9	Fischer and Porter

Since only two fluid viscosities were used, it is impossible to arrive at quantitative conclusions. The data obtained, however, does supply sufficient information to tell qualitatively what the general effect of viscosity will be on flowmeter calibrations.

Table II

Comparison of CPG Output of Flowmeters at 60° F. and 120° F. Showing Percent Increase Caused by Temperature Rise

Results:

Meter No.	Mean CPG @ 60° F.	Mean CPG @ 120° F.	Difference in CPG	% Increase in CPG
1	2244.0	2324.5	80.5	3.59
2	1406.9	1457.8	50.9	3.62
3	6464.4	6667.6	203.2	3.14
4	6370.4	6532.4	162.0	2.48
5	1693.4	1735.7	42.1	2.49
6	3558.4	3711.4	153.0	4.30

Table II compares the average cycles per gallon at 60° F. and 120° F. for each meter tested. In every case the cycles per gallon increased as the temperature increased. This increase is probably due to the fact that the viscosity is lower at the higher temperature and offers less resistance to the rotation of the rotor. Since the rotor can turn more freely in the low viscosity medium, the cycles per gallon will increase.

It can also be noted from Table II that the percent increase in cycles per gallon was not constant among the meters tested. The design of the meters evidently contributes to the magnitude of the viscosity effect.

The error caused by a change in the viscosity is greater at low discharges. This fact is verified by the accompanying graphs, which show the variation in cycles per gallon at 60° F. and 120° F. All of the meters produce curves which diverge at the lower discharge. The degree of this divergence is greater for some meters than others; but nevertheless, the general pattern is the same for all of them.

RECOMMENDATIONS

On the basis of the tests so far completed and bearing in mind that a limited amount of data has been obtained, the following recommendations are made:

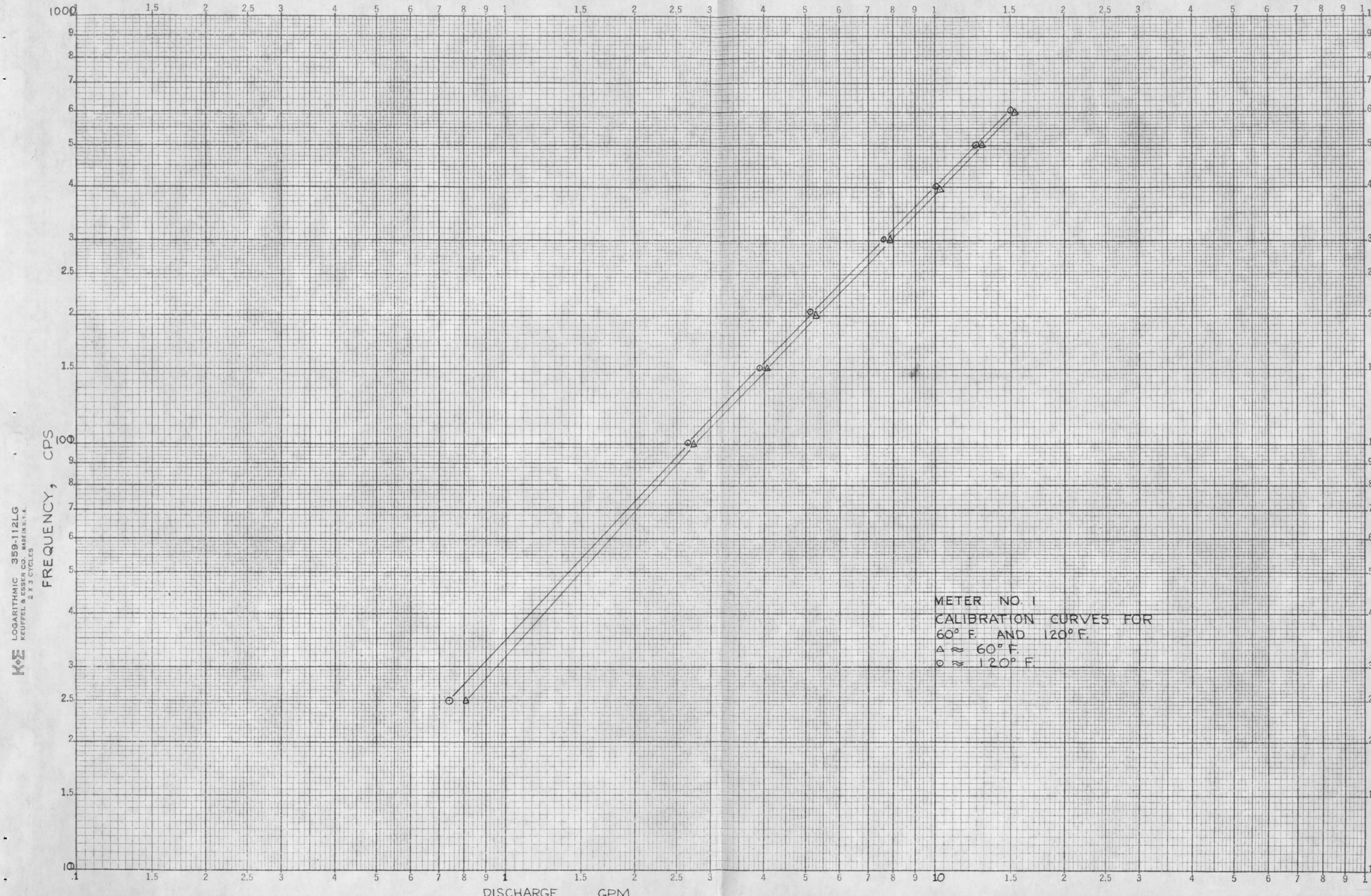
1. When using meters with high viscosity fluids, the viscosity should be held within approximately ± 30 percent of the calibration viscosity. This is based on the approximation from the herein contained data that a five-fold viscosity change will cause a deviation of about five percent in the mean cycles per gallon. Assuming the meter is to be accurate within one-half percent and that no errors are introduced by the instrumentation,

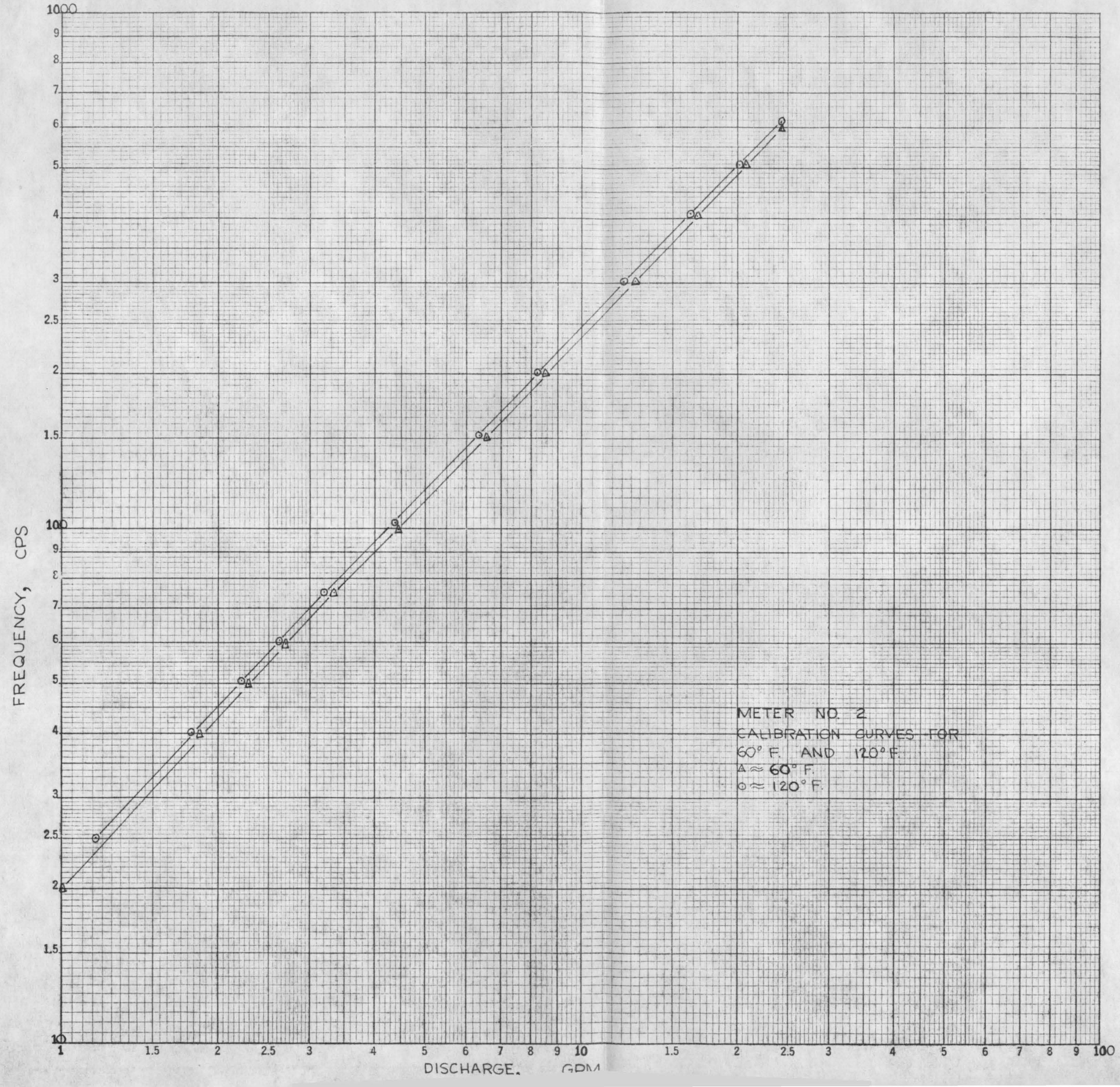
a ±50 percent viscosity change would cause the one-half percent error. For example, when using MIL-0-5606 hydraulic fluid with the meters, the temperature should not deviate more than about five degrees Fahrenheit from the calibration temperature if ±50 percent accuracy is to be maintained. The preceding analysis may or may not hold true for low viscosity fluids. It is hazardous to assume its validity until further tests have been run.

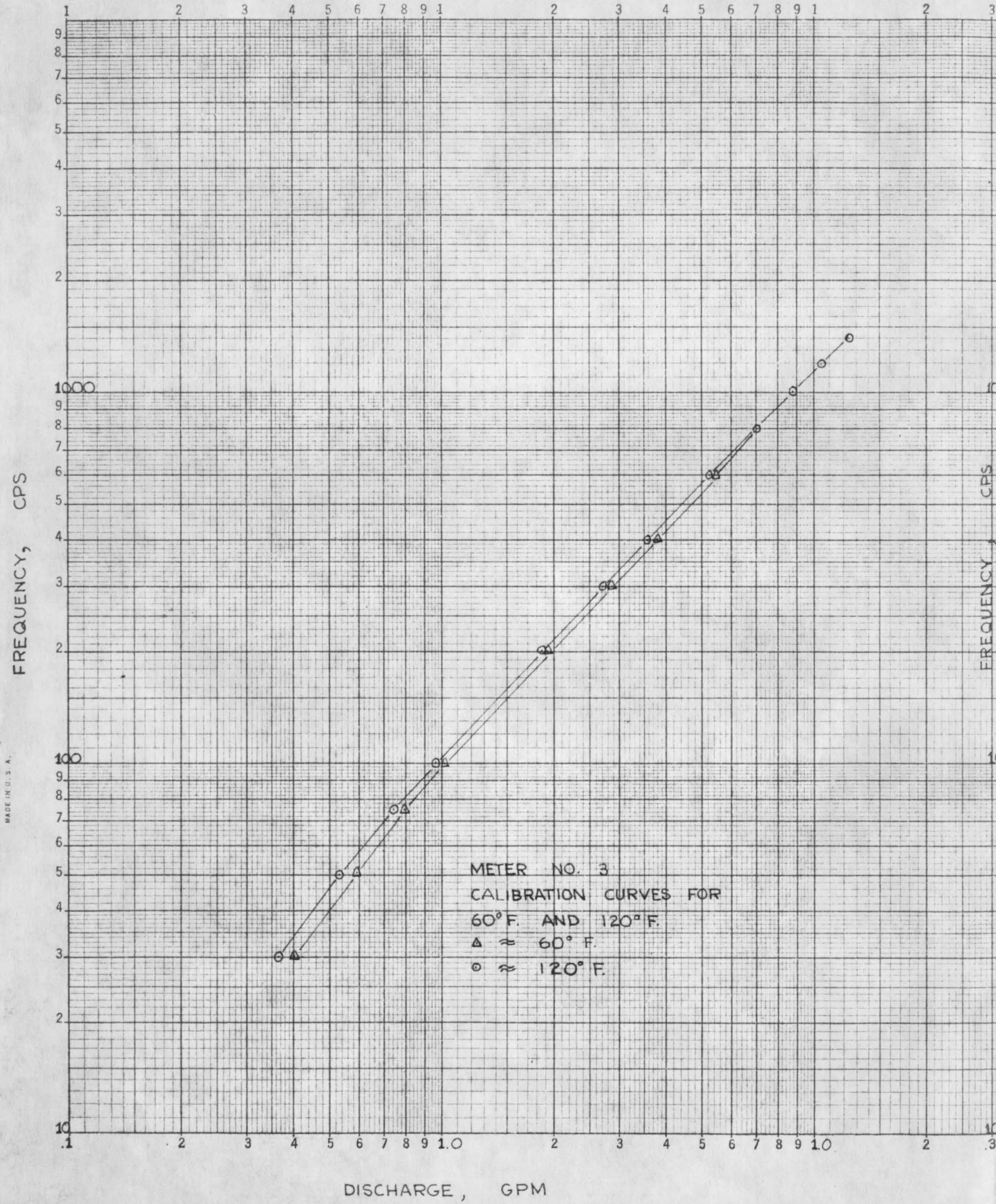
2. Since the viscosity has a greater magnitude of effect at low discharges, the meters should be used if possible at the higher range of discharges. If it is necessary to use them at very low discharges, great care should be taken to utilize them at the calibration temperatures.

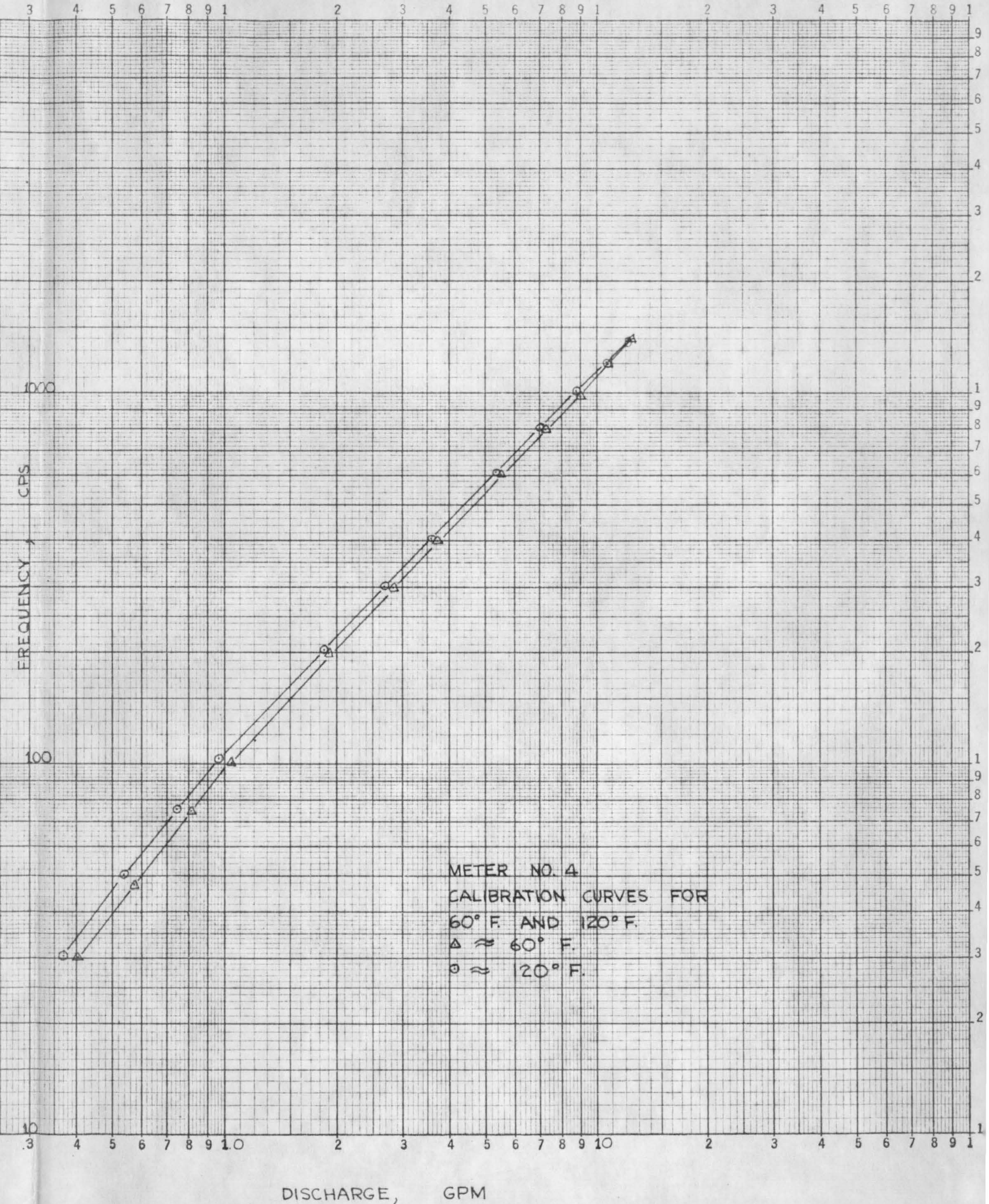
3. Because the tests were run with oil, it is not advisable to apply the results to low viscosity fluids such as water or liquid oxygen. The overall effect will probably be the same with these fluids, but whether the magnitude will be greater or smaller cannot now be determined.

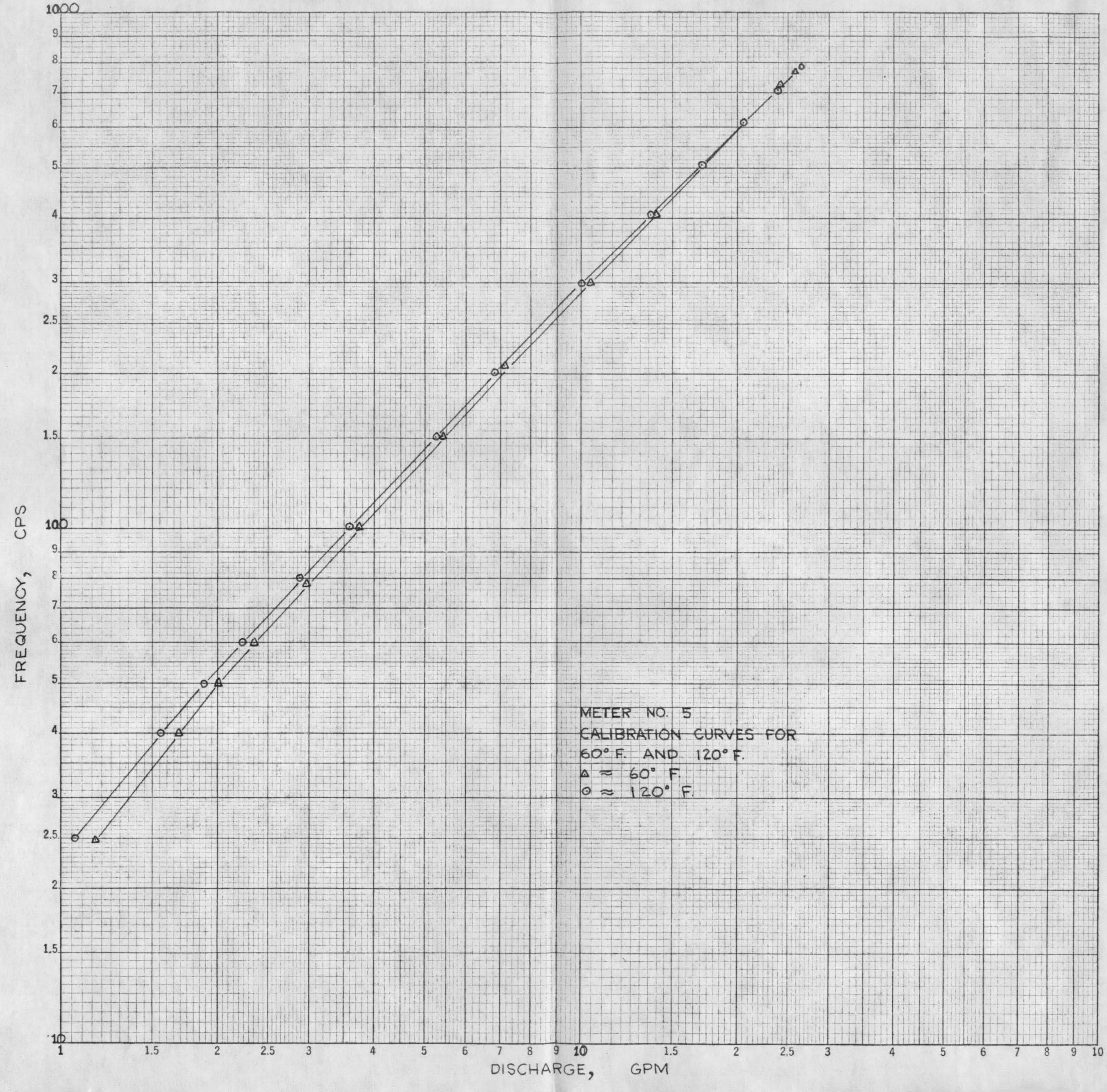
4. Further tests should be run using low viscosity fluids so that quantitative conclusions can be made and a method devised to accurately convert the meter calibrations provided to various viscosities.


METER NO. 1
CALIBRATION CURVES FOR
60° F. AND 120° F.
△ ≈ 60° F.
○ ≈ 120° F.
FREQUENCY, CPS
DISCHARGE, GPM
1000
100
10
.1
1
10
LOGARITHMIC 359-112LG
KEUFFEL & ESSER CO. MADE IN U.S.A.
2 X 3 CYCLES

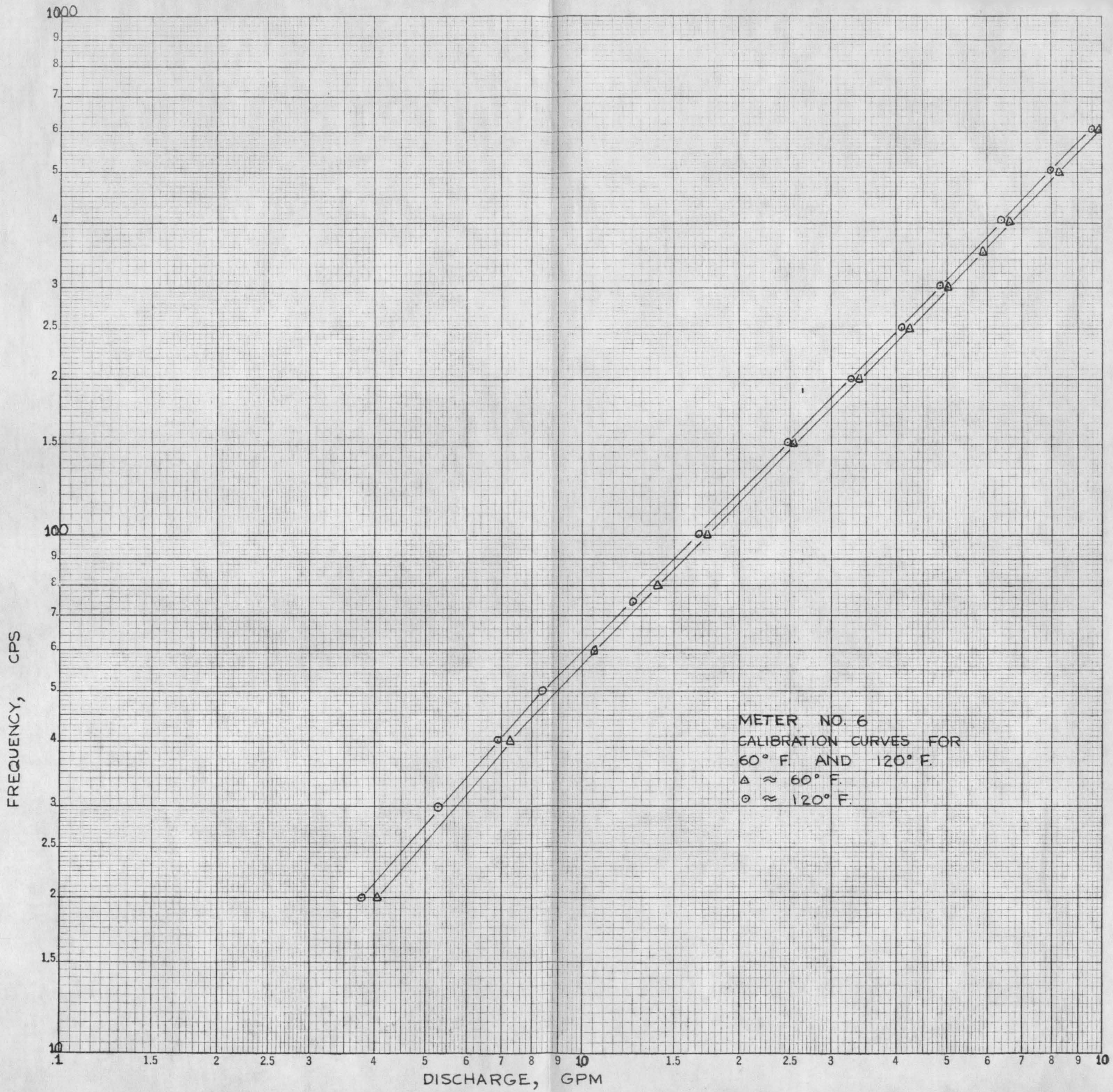

FREQUENCY, CPS
DISCHARGE. GPM
METER NO. 2
CALIBRATION CURVES FOR
60° F. AND 120° F.
△ ≈ 60° F.
○ ≈ 120° F.


METER NO. 3
CALIBRATION CURVES FOR
60° F. AND 120° F.
Δ ≈ 60° F.
⊙ ≈ 120° F.
FREQUENCY, CPS
DISCHARGE, GPM

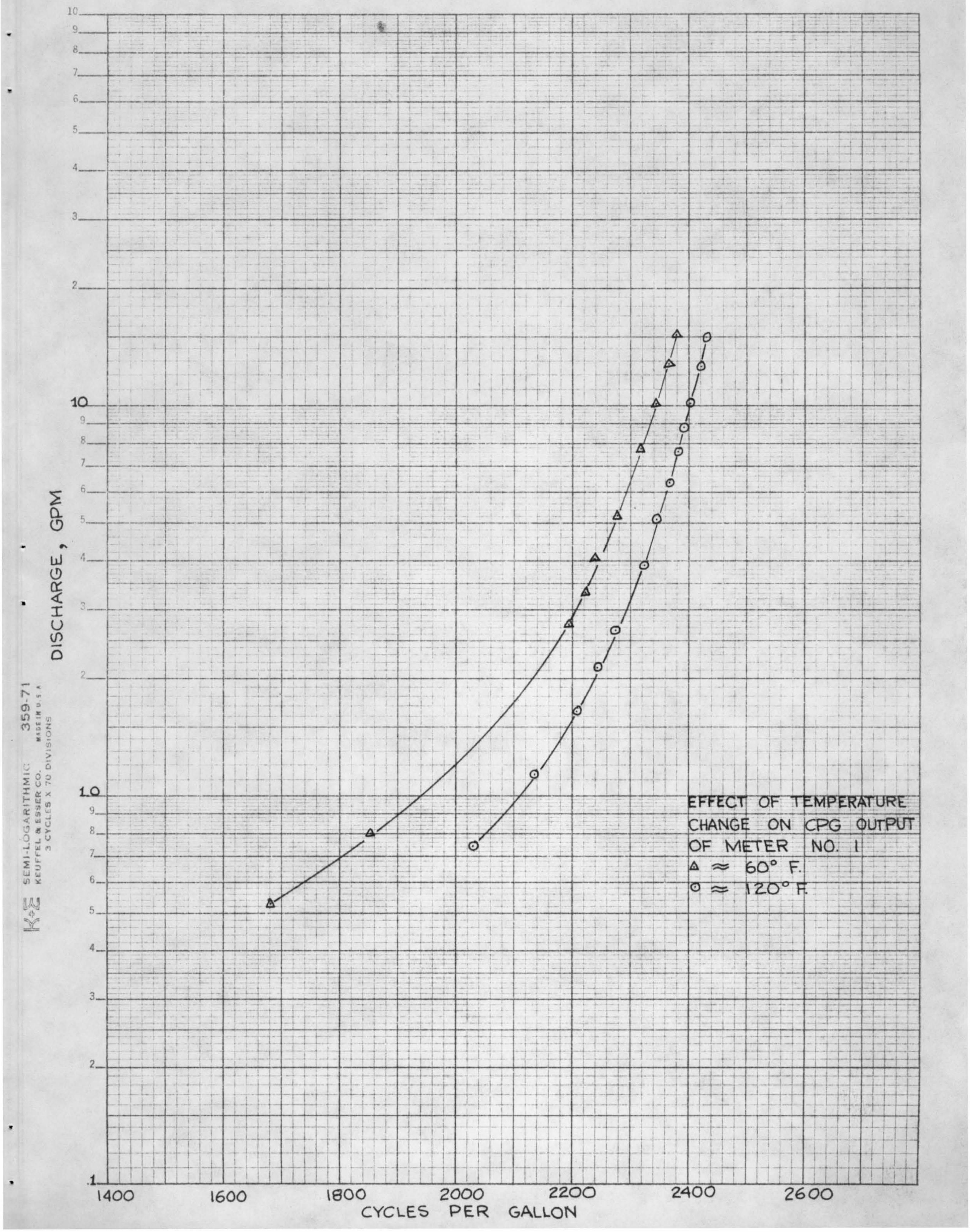

METER NO. 4
CALIBRATION CURVES FOR
60° F. AND 120° F.
Δ ≈ 60° F.
⊙ ≈ 120° F.
FREQUENCY, CPS
DISCHARGE, GPM

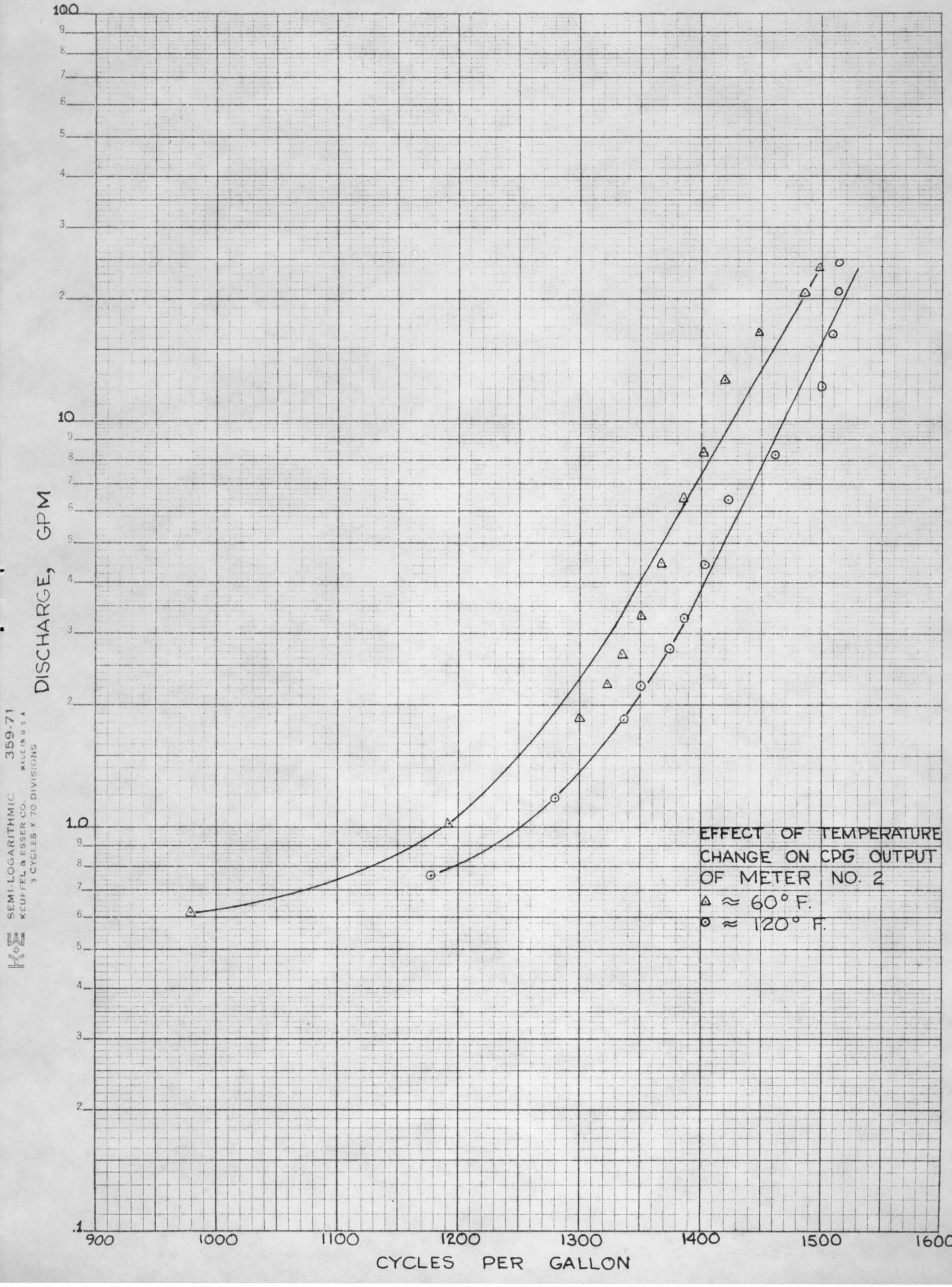


359-110L KEUFFEL & ESSER CO.
Logarithmic, 2 X 2 Cycles.
MADE IN U.S.A.

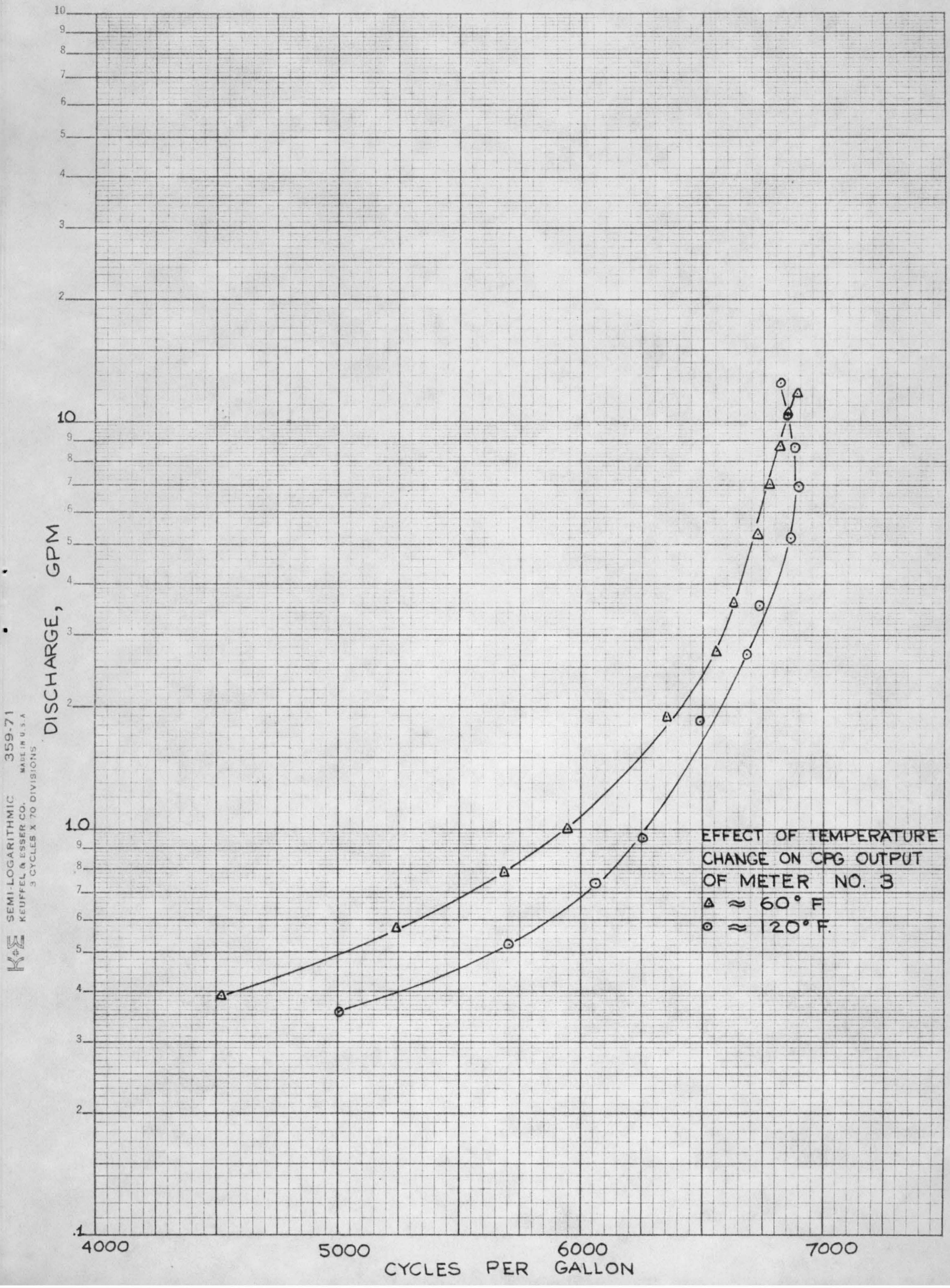


FREQUENCY, CPS
DISCHARGE, GPM
METER NO. 6
CALIBRATION CURVES FOR
60° F. AND 120° F.
△ ≈ 60° F.
⊙ ≈ 120° F.

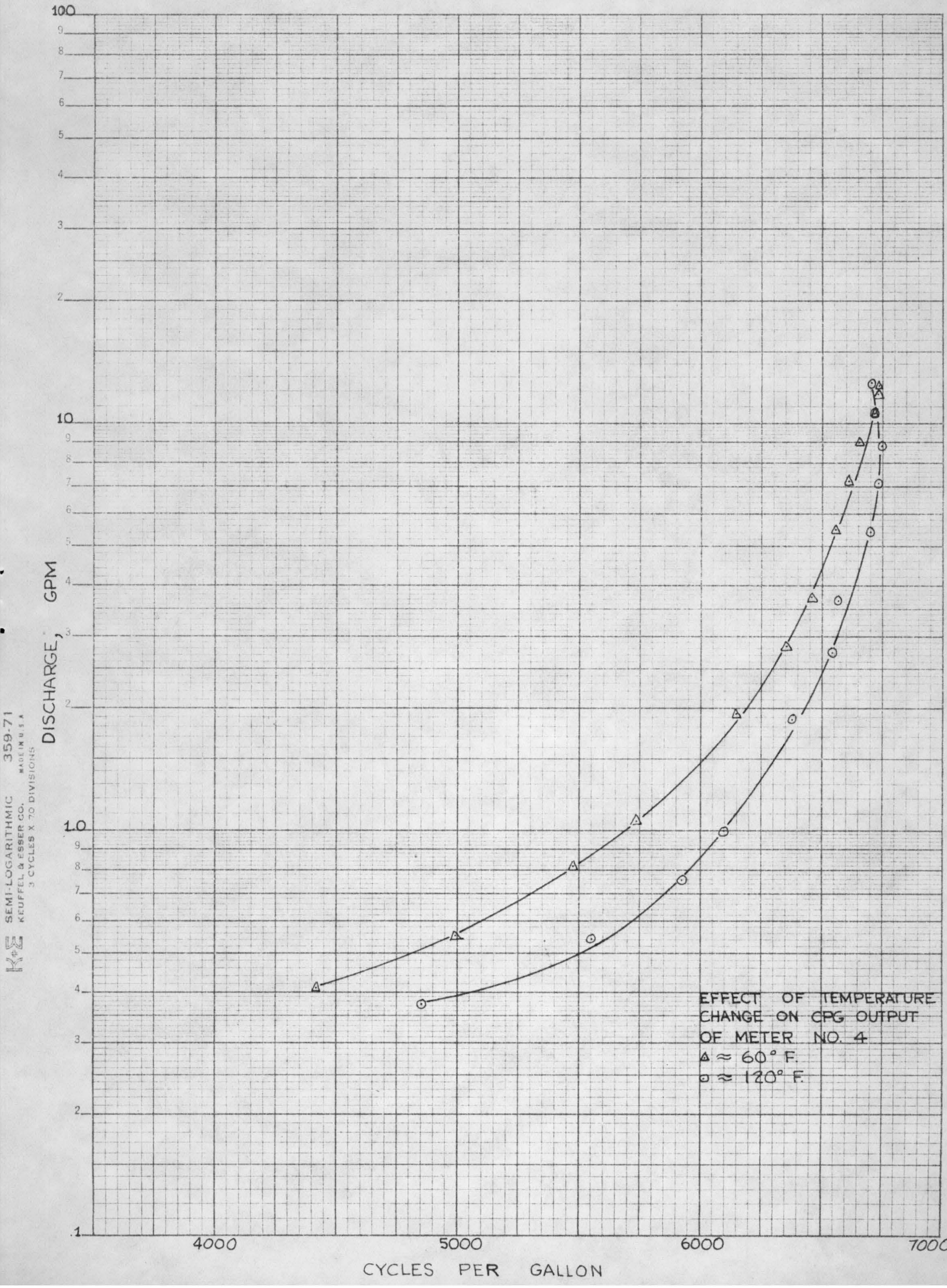

DISCHARGE, GPM
CYCLES PER GALLON
1400
1600
1800
2000
2200
2400
2600
10
1.0
.1
EFFECT OF TEMPERATURE
CHANGE ON CPG OUTPUT
OF METER NO. 1
△ ≈ 60° F.
⊙ ≈ 120° F.
SEMI-LOGARITHMIC 359-71
KEUFFEL & ESSER CO. MADE IN U.S.A.
3 CYCLES X 70 DIVISIONS



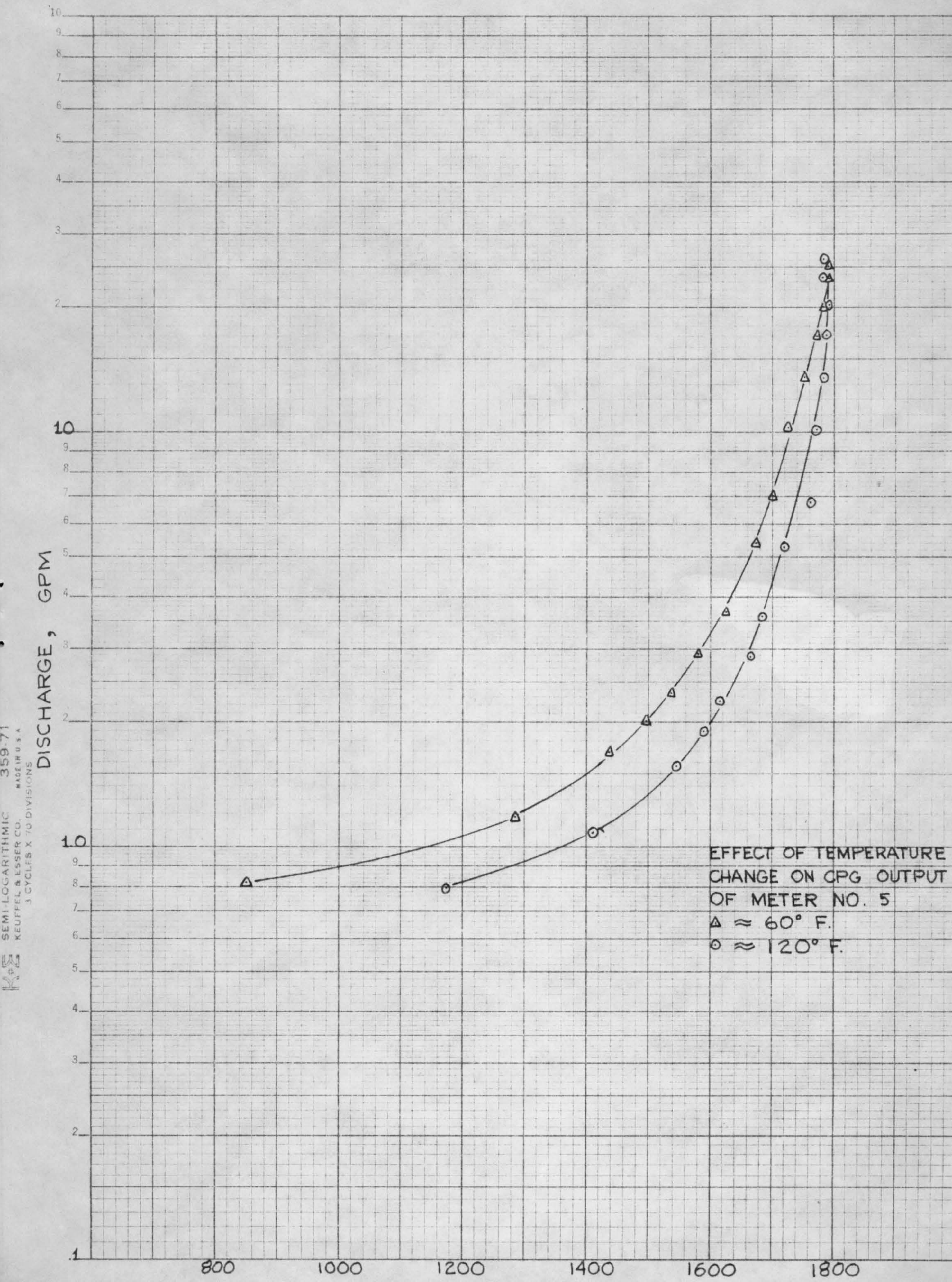
EFFECT OF TEMPERATURE CHANGE ON CPG OUTPUT OF METER NO. 2
△ ≈ 60° F.
⊙ ≈ 120° F.
DISCHARGE, GPM
CYCLES PER GALLON
900
1000
1100
1200
1300
1400
1500
1600
100
10
1.0
.1
SEMI-LOGARITHMIC 359-71
KEUFFEL & ESSER CO. MADE IN U.S.A.
3 CYCLES X 70 DIVISIONS



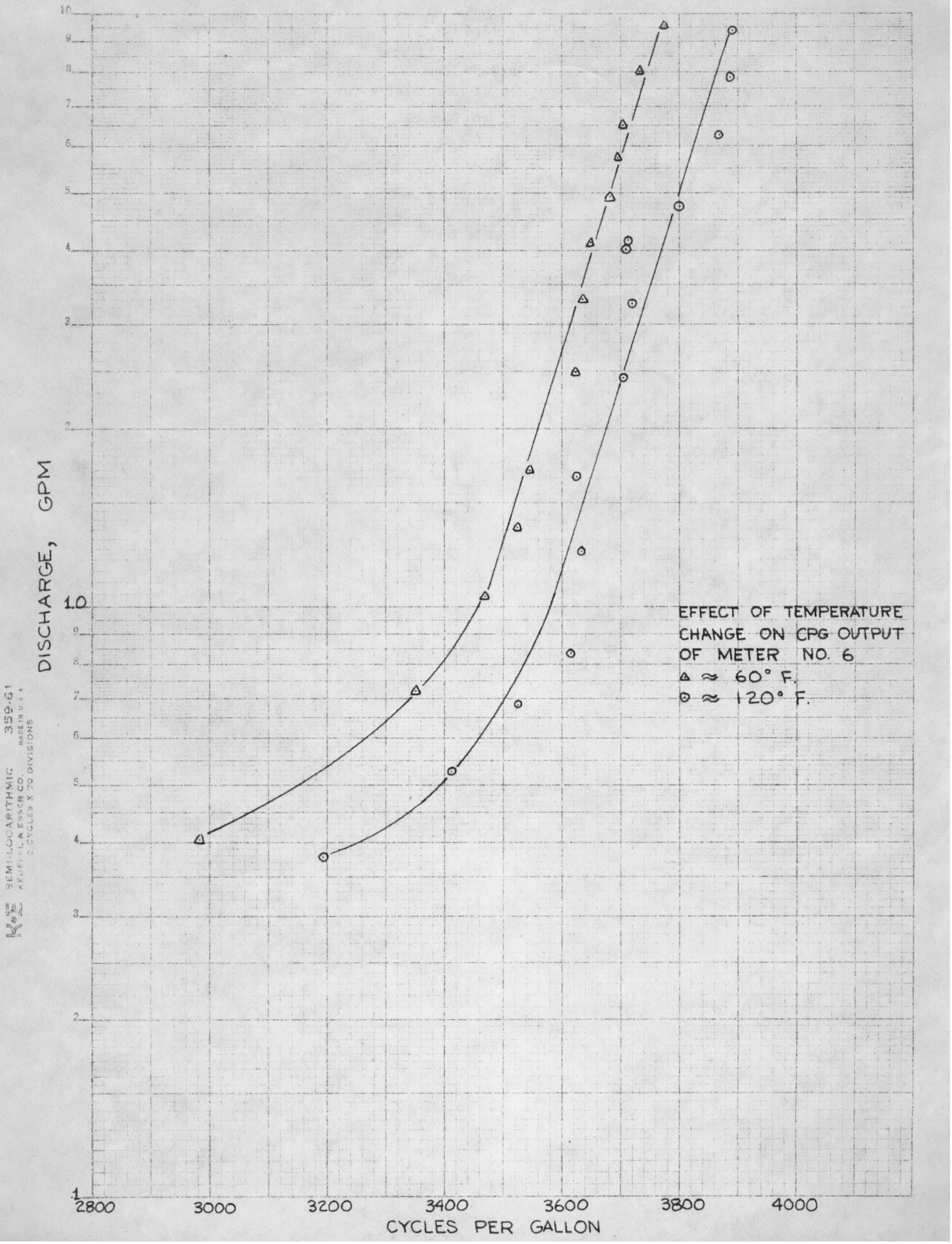
EFFECT OF TEMPERATURE
CHANGE ON CPG OUTPUT
OF METER NO. 3
Δ ≈ 60° F.
⊙ ≈ 120° F.
DISCHARGE, GPM
CYCLES PER GALLON
4000
5000
6000
7000
10
1.0
.1
SEMI-LOGARITHMIC 359-71
KEUFFEL & ESSER CO. MADE IN U.S.A.
3 CYCLES X 70 DIVISIONS



DISCHARGE, GPM
CYCLES PER GALLON
4000
5000
6000
7000
100
10
1.0
.1
EFFECT OF TEMPERATURE
CHANGE ON CPG OUTPUT
OF METER NO. 4
Δ ≈ 60° F.
⊙ ≈ 120° F.
SEMI-LOGARITHMIC 359-71
KEUFFEL & ESSER CO. MADE IN U.S.A.
3 CYCLES X 70 DIVISIONS



EFFECT OF TEMPERATURE CHANGE ON CPG OUTPUT OF METER NO. 5
Δ ≈ 60° F.
⊙ ≈ 120° F.
DISCHARGE, GPM
CYCLES PER GALLON
800
1000
1200
1400
1600
1800
.1
1.0
10
SEMI-LOGARITHMIC 359-71
KEUFFEL & ESSER CO. MADE IN U.S.A.
3 CYCLES X 70 DIVISIONS



DISCHARGE, GPM
CYCLES PER GALLON
2800
3000
3200
3400
3600
3800
4000
1.0
EFFECT OF TEMPERATURE CHANGE ON CPG OUTPUT OF METER NO. 6
△ ≈ 60° F.
⊙ ≈ 120° F.
SEMI-LOGARITHMIC 359-61
KEUFFEL & ESSER CO. MADE IN U.S.A.
2 CYCLES X 70 DIVISIONS