6-14-1966

The Influence of Refining Upon Stormer Viscosity Values

Louis Wilhelm
Western Michigan University

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June 14, 1966

Advisor: Dr. R. A. Diehm

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ACKNOWLEDGEMENTS:

I give my sincere thanks to the faculty of the Department of Paper Technology at Western Michigan University, and especially to my advispr— Dr. R. A. Diehm. You have been most helpful.

Louis Wilhelm

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ABSTRACT:

In this paper the author has attempted to investigate the influence of refining upon Stormer Viscosity readings. The variables controlled were beating time, consistency, and temperature.

The instruments used were the Valley Beater, the Stormer Viscometer, and the Bauer McNett Fiber Classifier.

Louis Wilhelm
Senior Thesis
Dr. Diehm

-EXPERIMENTAL PROGRAM-

OBJECTIVES: The purpose of the experimental work is to determine if high consistancy pulp viscosity is a good means of predicting the physical and optical characteristics of the final sheet. The relationship between the scattering coefficient (Kubelka and Munk) and the viscosity will be considered in conjunction with the physical and optical sheet tests.

BASIC EXPERIMENTS TO BE PERFORMED:

1. Sulfite pulp at 2.5% consistency will be refined on the Mead refiner or Valley Beater to set viscosity levels. Beating time will be noted.

2. Samples will be removed from the refiner;; and viscosity measurements (on the Stormer viscosimeter), freeness readings (on the Canadian Standard Freeness tester), and hand sheets (on the British Sheet mold) will be made on each sample.

3. Each hand sheet will be tested for tensile, tear, basis weight, brightness, and opacity.

4. The Kubelka and Munk scattering coefficient will be calculated for each sample from the values of brightness, opacity, and basis weight.

5. A graph of scattering coefficient vs. viscosity will be plotted.

SPECIAL EQUIPMENT AND SUPPLIES NEEDED: None.

CHANGES IN PROCEDURE:

The Stormer Viscometer with the "Paint Testing Outfit" attached, showed extreme sensitivity to any change in consistency. It was found very difficult to remove a representative consistency sample from the Mead refiner after the desired beating time. Therefore, the bleached sulfite pulp was beat in a laboratory Valley Beater at 1.56% consistency. If the slurry sample was removed directly after the roll-bedplate nip in the operating Valley Beater, a slurry of constant consistency could be removed, after any desired amount of refining. This change in procedure solved the sampling problem.

Physical and optical tests on various hand sheets were not run—nor were any hand sheets made. The hand sheets and physical and optical tests were orininally included in the experimental procedure as a possible tool to compare the Canadian Standard Freeness test to the Stormer Viscosity readings. However, early experimental data repeatedly showed that that the Stormer Viscosity readings were inferior to C.S.Freeness readings as an approximation of the degree of refining of the pulp. Therefore, the hand sheets were not made. However, Bauer McNett fiber length tests were run to help determine relative fiber length.

LITERATURE SEARCH:

Blakeney showed that the viscosity increased rapidly at concentrations greater than about .0042 which is approximately the "critical" zone for free rotation of fibers as predicted by Mason. (1) At greater than 2% consistancy a plot by Myers of torque vs. Angular vilocity showed the following: (a) The line is concave to the torque axis. (b) A small change in torque in the high torque range will cause a large change in the angular velocity. (c) It took some torque to start the bob initially. (2) Myers also pointed out that the Relative Viscosity = (slope of slurry / slope of suspending solution)

$$\text{Viscosity} = \left(\frac{\text{slope of slurry}}{\text{slope of suspending solution}} \right)$$

-where the "slope" is taken from a torque verses angular velocity plot. And if the L/D ratio is less than 40, the relative viscosity varies directly with the concentration. (2)

The curvature of the fiber seems to be an important factor in determining and explaining the viscosities of fiber slurries. Blakeney found that with nylon fibers a slight curvature (γ = 162-178) had a large effect on the relative viscosity. He also observed that above a certain degree of curvature the ($\frac{\text{intrinsic viscosity}}{\text{relative viscosity}}$) ratio depended ONLY on the CURVATURE--and NOT on the L/D ratio of the fibers. (1) Myers concluded, "curved fibers cause a much greater increase in viscosity than straight fibers of the same axis ratio in suspentions of the same concentration." (2)

Myers pointed out that because of the complexity of fiber interaction forces, little theory on experimental work has been done in this area in relation to viscosity. He noted that

"the fibers would be expected" to spend more time in the flow direction than in other positions. He found that inertial effects for the flow around a cylinder become appreciable at Reynold's Number 1.0. Where $Re = \frac{U\ D}{\gamma} = \frac{(vel.)x(Dia.)}{Kinematic\ Viscosity}$

At a consistancy of 2.8% using nylon fibers, Myers noted the following torque-fiber characteristics: (a) At low torque the fibers touched the bob. (b) At medium torque only a few fibers moved. (c) At a high torque a clear-fluid anulus developed between the bob and fiber phase. Mason and Manley showed that an apparent collision between two fibers greatly change their rotation orbits. Such collisions do not occur at very low concentrations. (2)

Blakeney found that the degree of flocculation had a big effect on the relative viscosity. He found that the relative viscosity at any concentration was higher for flocculated suspentions than for the well-dispersed suspentions. (1) Myers noted that the type of liquid in the slurry was an important factor in determining the degree of flocculation.

He found that for nylon fibers in a sucrose solution flocculation and fiber net works formed at much lower consistancies (.08-.6%) than in organic solvents. He thought this could be explained via physico- chemical factors. He also noted that in the sucrose solution, the flocculation increased as the pH decreased down to two.

The wall effects using a bob and cylinder type Viscometer, seemed to have only a negligable effect on the relative viscosity even for L/D fiber ratios equal to 0.358. (2)

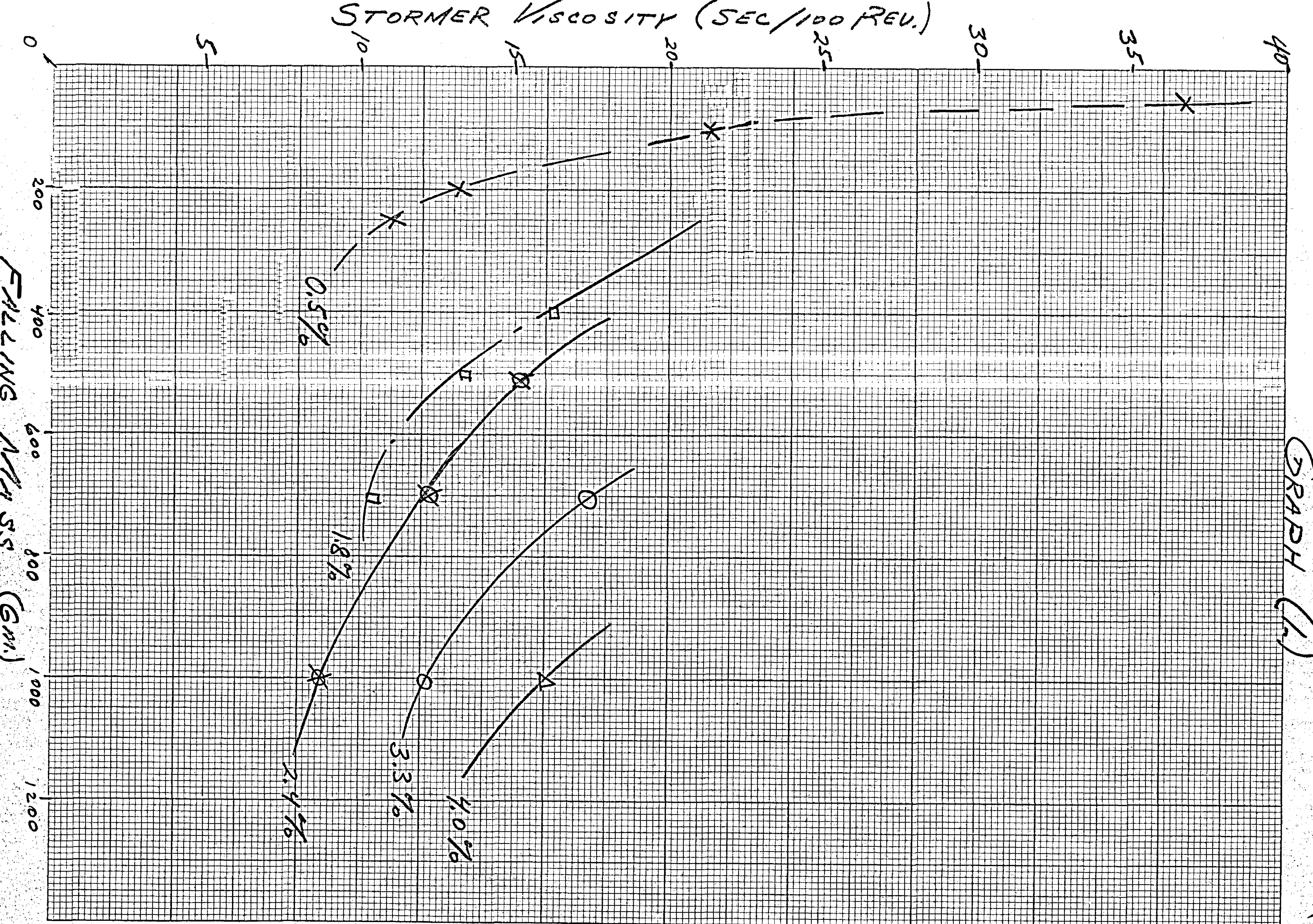
The DeZurik Corporation manufactures a consistency sensing device which works on the same principle as the Stormer viscometer. However their research department had the following comment: "At the present time we have not conducted extensive tests to determine the amount of or direction of change in transmitted signal when the freeness is changed. We do know the affect exists and that it differs with different types of paper stock and that the affect is proportionally more prominent at higher consistencies and freeness." (3)

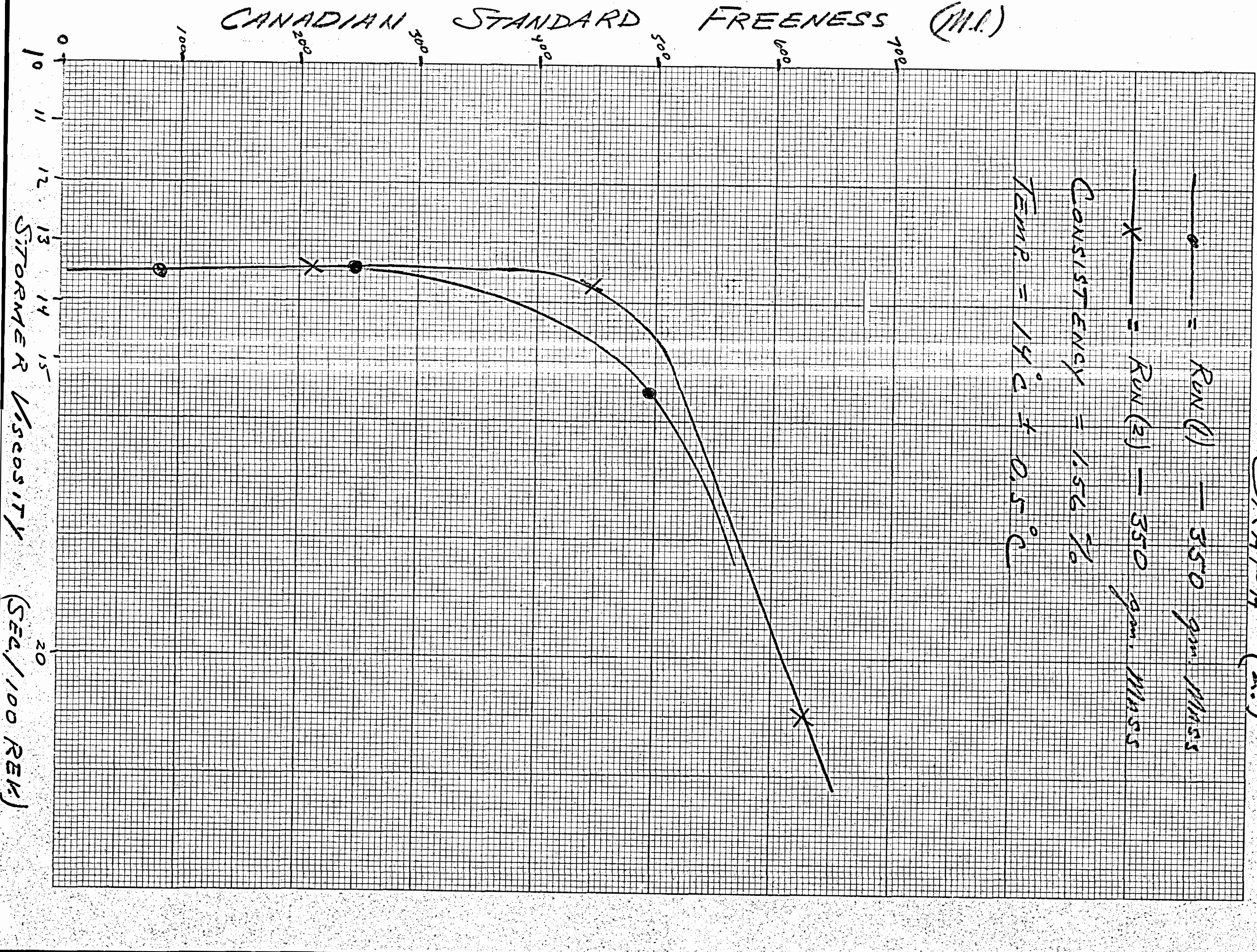
— DATA TABLE — (1.)

Beating Time (Min.)	Stormer Viscosity (Sec./100 Rev.)		Corrected Freeness (Ml.)	Bauer McNett Fiber Classification (%)				
	350 gm.	400 gm.		28 Mesh	48 Mesh	65 Mesh	150 Mesh	Sewer
Run (1.)								
0	—	30.0	715	90	3.0	1.5	0.4	5.1
20	15.5	13.3	490	66	7.3	5.0	5.0	16.7
40	13.4	11.8	240	54	15.5	6.3	14.0	10.2
60	13.5	12.2	80	44	29.0	10.0	13.0	4.0
Run (2.)								
0	—	23.0	700	89	2.7	2.0	2.0	4.3
10	21.0	16.0	625	80	5.0	2.7	1.3	11.0
30	13.7	11.8	440	66	8.7	6.6	6.7	12.0
50	13.5	11.8	210	50	13.4	8.0	8.6	20.0

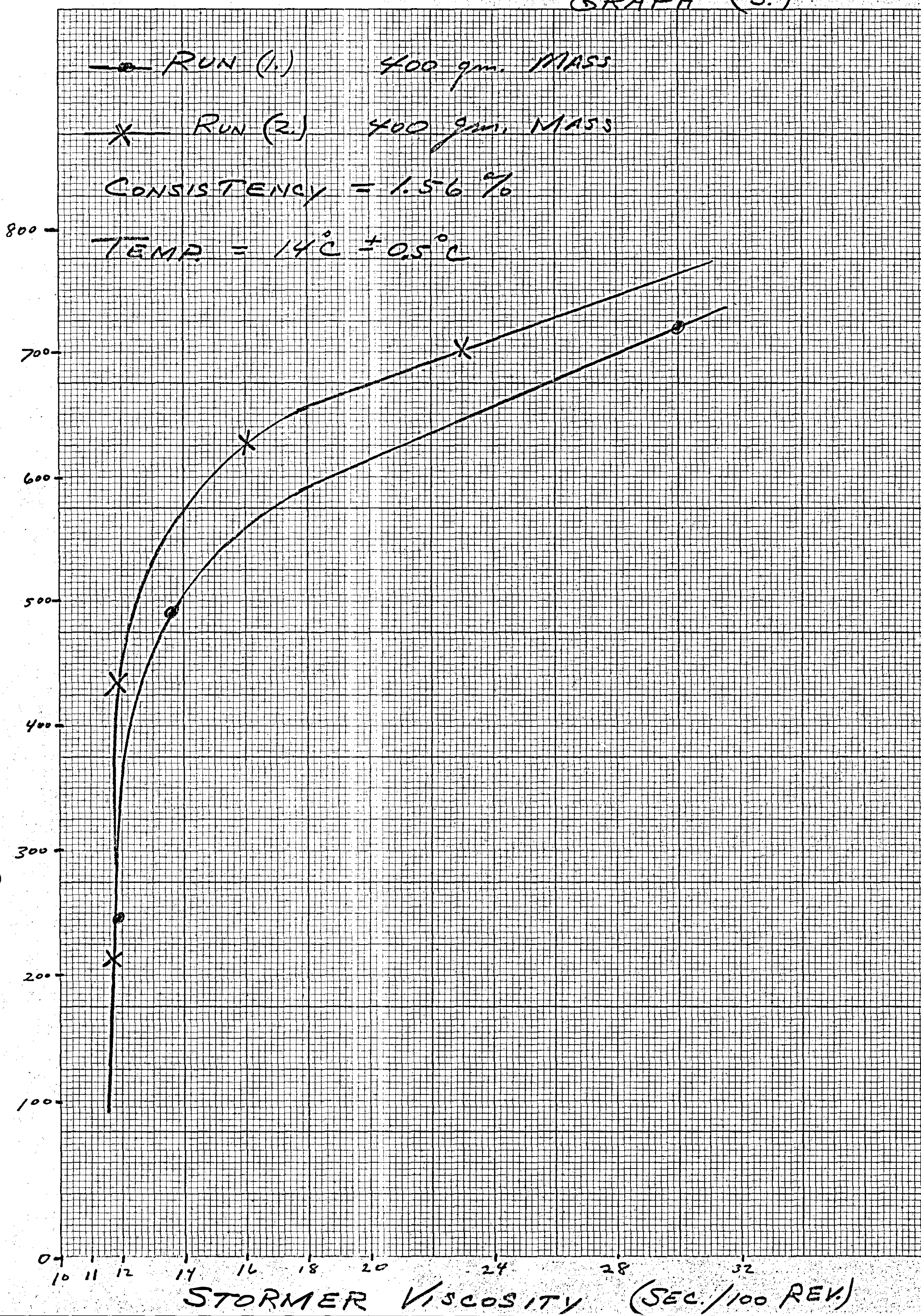
— DATA TABLE — (2)

STORMER VISCOSITY (SEC/100 REV)	FALLING MASS (GM.)	CONSISTENCY (%)
37	100	0.5
22	150	0.5
17	400	1.8
14	500	1.8
16	400	2.4
15	500	2.4
18	700	3.3
16	1000	4.0

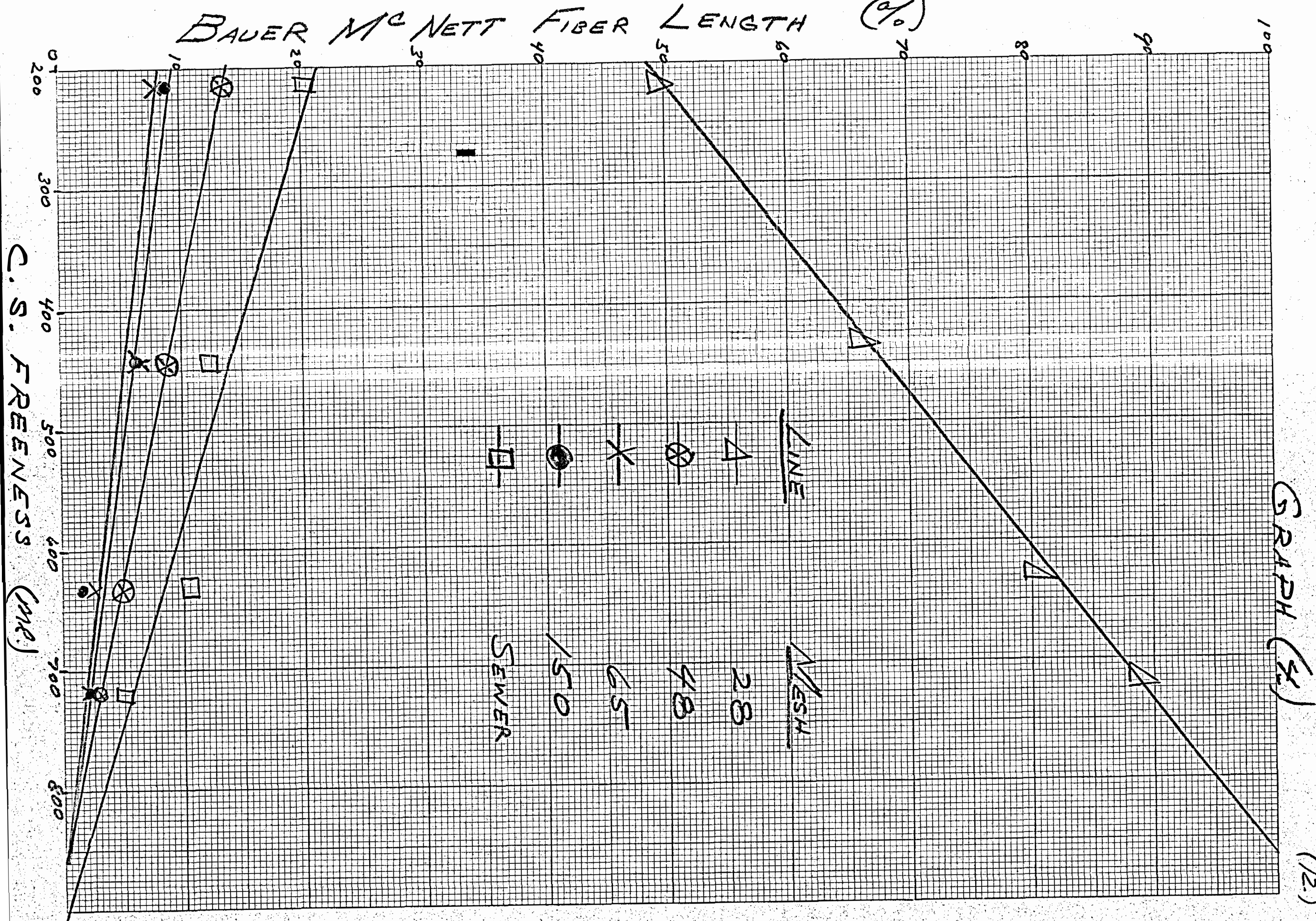

STORMER VISCOSITY (SEC/100 REV.)
0
5
10
15
20
25
30
35
40
FALLING MASS (GM.)
200
400
600
800
1000
1200
0.5%
1.8%
2.4%
3.3%
4.0%
GRAPH (1.)


CANADIAN STANDARD FREENESS (M.I.)
0
100
200
300
400
500
600
700
10
11
12
13
14
15
20
STORMER VISCOSITY (SEC./100 REV.)
GRAPH (2.)
= RUN (1) — 350 gm. MASS
= RUN (2) — 350 gm. MASS
CONSISTENCY = 1.56 %
TEMP. = 14°C ± 0.5°C

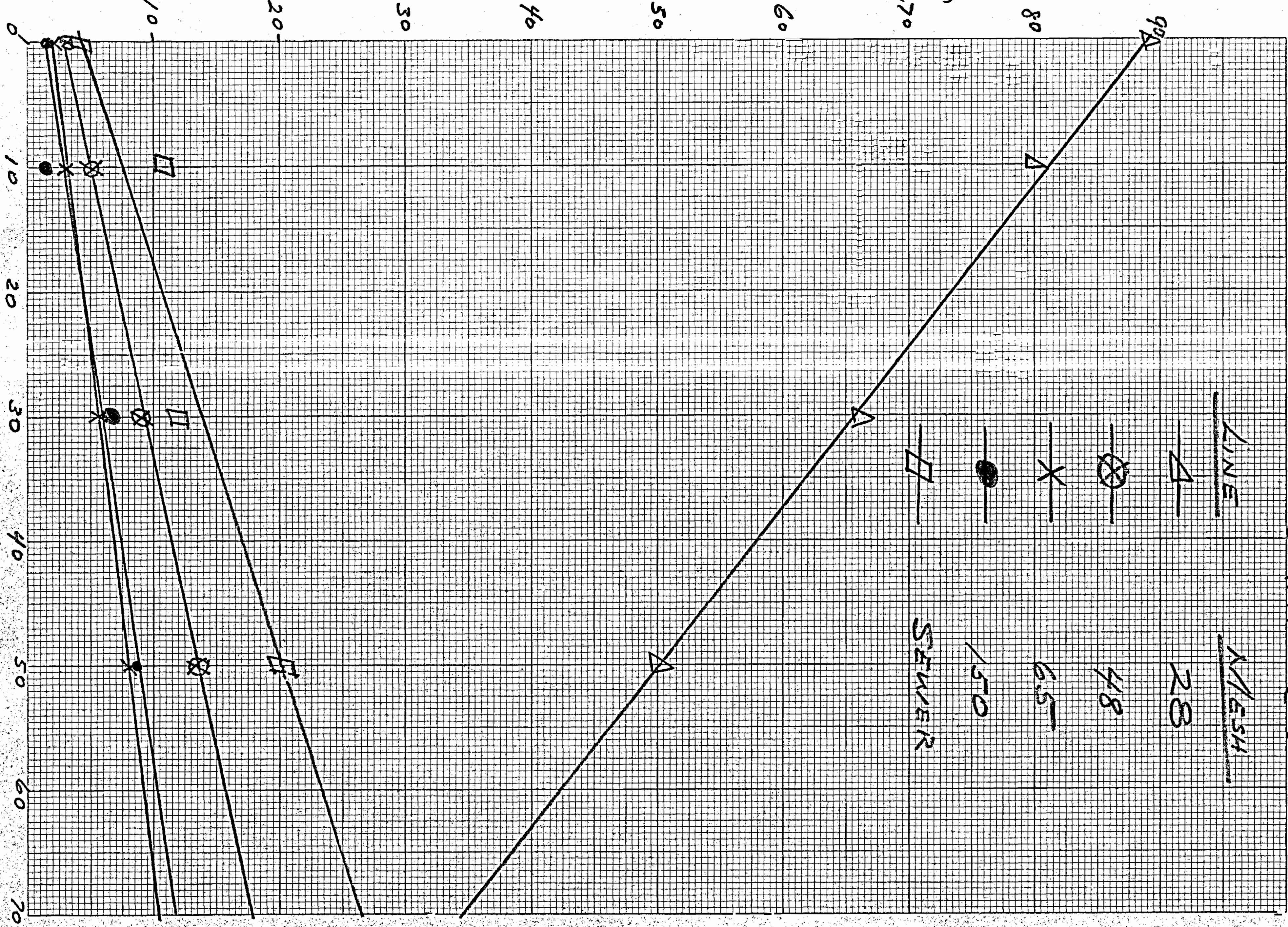
GRAPH (3.)



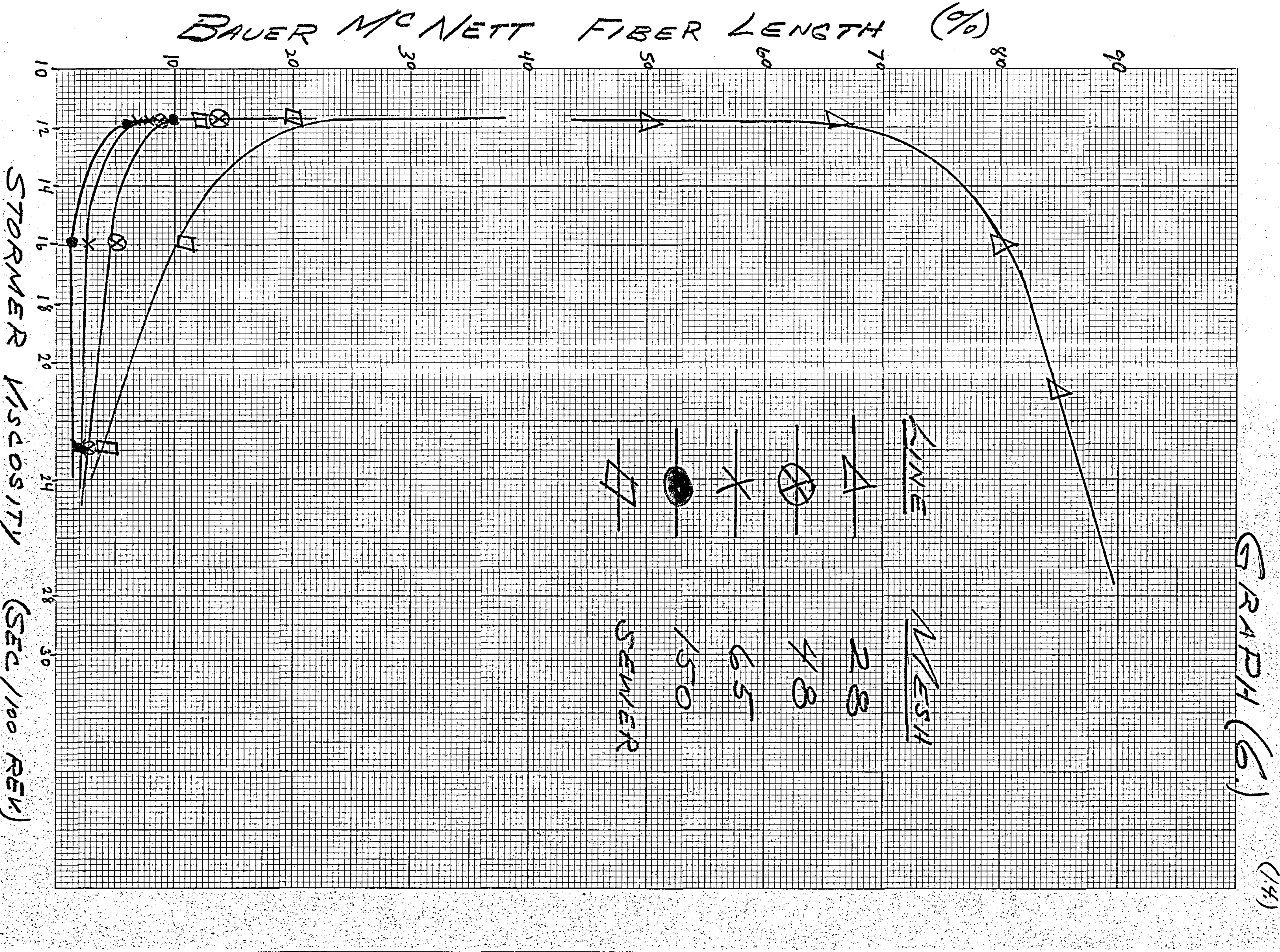
RUN (1.) 400 gm. MASS
RUN (2.) 400 gm. MASS
CONSISTENCY = 1.56 %
TEMP = 14°C ± 0.5°C
800
700
600
500
400
300
200
100
0
10
11
12
14
16
18
20
24
28
32
STORMER VISCOSITY (SEC./100 REV.)
C. S. FREENESS


BAUER McNETT FIBER LENGTH (%)
0
10
20
30
40
50
60
70
80
90
100
C. S. FREENESS (ml.)
200
300
400
500
600
700
800
LINE
MESH
28
48
65
150
SEWER
GRAPH (5)
(12.)

BAUER McNETT FIBER LENGTH (%)



GRAPH (5.)


BAUER McNETT FIBER LENGTH (%)
10
20
30
40
50
60
70
80
90
STORMER VISCOSITY (SEC/100 REV.)
10
12
14
16
18
20
24
28
30
MESH
LINE
28
48
65
150
SEWER
GRAPH (6.)

RESULTS AND CONCLUSIONS:

The sensitivity of the Stormer Viscometer toward consistency is shown on Graph (1.). Here the TIME in seconds per 100 revolutions is plotted against the falling mass in grams. If one follows an immaginary horizontal line from left to right at a time of 15 seconds, five intersections—one at each consistency level—will be noted. The first intersection shows that a 0.5% consistency pulp sample required a falling mass of only 175 grams to "spin" the submerged "paddle wheel" on the viscometer in the pulp slurry 100 revolutions in 15 seconds. The final intersection, on the far right, shows that at a pulp consistency of 4%, a falling mass of about 1025 grams is required to spin the paddle wheel 100 revolutions in the same time interval—15 seconds.

This shows that at a low consistency of pulp, the viscosity (resistance to flow) is low; and at a higher consistency the viscosity is much greater.

Graph (1.) emphasizes the demand for a constant consistency if one is trying to measure the change in Stormer Viscosity with refining time.

Graph (2.) shows the Canadian Standard Freeness (measured in milliliters) versus the Stormer Viscosity readings measured in seconds per 100 revolutions. A falling mass of 350 grams was used, and two "identical" runs are shown. Graph (3.) illustrates

the same trend as graph(2.)—the only difference being in the mass of the falling body used, which was 400 grams instead of 350 grams. In both graphs the temperature and consistency are constant at 14^0 centigrade and 1.56% consistency.

Graph (2.) shows that as the C.S. Freeness decreases (with beating) from about 650 ml. to 450 ml., the Stormer Viscosity decreases from about 23 (sec./100 rev.) to 14 (sec/100 rev.). But a further decrease in freeness (with increased beating) from 450 ml. to 100 ml. (or lower) does not change the Stormer Viscosity values—they remain constant at about 13.5 (sec./100 rev.).

The second "stage" of this graph—values below 450 ml. freeness—shows that the Stormer Viscometer is definitely inferior to the C.S. Freeness Tester as a tool to aid in measuring the degree of refining or beating of a pulp slurry at 1.56% consistency. This is quite obvious, since the Stormer Viscometer recorded no change while the freeness decreased 350 ml.—due to approximately 40 minutes of "roll-down time" on the Valley Beater. The graphs (4.) and (5.) show that there was a good deal of fiber length shortening during both "stages"; but the decrease in fiber length evidently had no affect on the Stormer Viscosity readings in the second stage.

Graph (3.) shows the same trend, and the four runs—although the two runs at each weight do not coinside exactly—show the validity of the trend.

Graphs (2.) and (3.) indicate a decrease in Stormer Viscosity as the freeness decreases for values above 450 ml. Below a 450 ml. freeness, the Stormer Viscosity remains constant with changing freeness values. Graph (4.) shows that the Bauer McNett fiber length decreases linearly as the freeness decreases over the entire range, (from 700 ml. to 200 ml.).

This data tends to show that fiber length is not an important variable to Stormer Viscosity measurements when the "Paint Testing Outfit" type rotor is employed. Perhaps with a differently designed rotor, fiber length could become an important factor. However, with this particular rotor, the results indicate that fiber length is not an important factor.

If fiber length is not an important factor, what is? This leads to an area of speculation. It would seem that fiber wetting is an important factor to Stormer Viscosity values—where increased wetting would decrease the Stormer Viscosity.

Graphs (2.) and (3.) would indicate that the fiber is wetted as the freeness drops from 650 ml. to 450 ml. However, below a 450 ml. freeness, continued beating does not tend to wet the fiber to a greater degree. And the Stormer Viscosity remains constant.

This would be a good area of future study—to see how a fiber is wetted with beating.

APPLICATIONS:

The information and the ideas brought forth in this paper might be of value to paper mills using "paddle-wheel-type" consistency regulators or "transmitters". A paddle-wheel-type consistency regulator and the Paint-Tester-rotor used in this experiment seem to be based on the same principles, and their operation is probably affected by the same variables.

If the above assumption is true, the paddle-wheel-type consistency regulator is affected by freeness changes—as well as the consistency changes for which it was installed.

If a single paper machine produces a variety of grades of paper—especially ranging from a dense sheet (a low freeness stock) to a free sheet (a high freeness stock)—the paddle-wheel-type consistency regulator error due to viscosity changes of the pulp could become an important factor.

Further work along the line of this experiment could perhaps produce a viscosity correction factor for the consistency readings transmitted form the paddle-wheel-type consistency sensing device.

A correction factor of this type could be of utmost importance to a wet-end, in-line computor installation on a paper machine. The computor must be fed accurate, exact percent-solids values inorder to utilize its full potential.

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