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The Effect of Brush vs Supercalendar Finishing on the Optical and Surface Properties of Paper

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THE EFFECT OF BRUSH vs. SUPERCALENDER FINISHING ON THE OPTICAL AND SURFACE PROPERTIES OF PAPER

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I. Purpose.

In the demanding and ever changing area of paper finishing a new and relatively unpublicized operation has appeared. The operation is one of brush finishing, where a high speed cylindrical bristle brush is employed continuously against a paper web in order to develop desireable surface properties. The principle involved is a simple low pressure polishing action not unlike shining one's shoes. The performance of this new method, however, is obscure due to the absence of published information on the subject in available literature.

Through local industry a portable, laboratory model brush finisher was made available to the Paper Technology Department of Western Michigan University. Because of the availability of both this apparatus and an existing laboratory supercalender, and because of the complete lack of literature information on the topic of brush finishing, there seemed good reason to conduct an exploratory comparison of the two finishing methods. This investigation will evaluate and compare many common optical and surface characteristics of both brush finished and supercalendered papers and it will especially compare the printing fidelity obtained on each.

II. Description of Apparatus and Techniques.

The laboratory supercalender used in the investigation is a three roll calender having a soft white cotton filled roll, with a twelve inch diameter, interposed between two ten and one half inch diameter steel rolls. The width of all rolls is four-

teen inches. The calender runs at a constant speed and is pneumatically loaded.

In using the supercalender the stack was pneumatically loaded to give approximately 1660 pounds per lineal inch nip pressure. Samples of each paper tested were subjected to one, two, four, eight, and sixteen nips. The sheets were fed through the stack in the machine direction of the paper and the felt side of the sheet always contacted the steel roll. All tests were conducted on the felt side.

The brush finisher (Fig. 1) consists of a twelve and one half inch diameter bristle brush, with an eight inch face, driven by a 1725 rpm one-third horsepower motor. The V-belt drive rotates the bearing mounted brush at approximately 1150 rpm, or at a peripheral speed of about 3765 feet per minute. The motor and brush are mounted in a box constructed of half inch plywood. To facilitate using the brush in this study it was necessary to modify the apparatus as supplied by the manufacturer. The unshaded area in Fig. 1 illustrates the nature of the modification. This arrangement allows the "back-up board" to be moved perpendicular to the brush axis and tangent to its surface. A paper sample is attached to the board and the board is passed across the brush in a direction opposite to that of the brush rotation. This "countercurrent" motion increases the effective peripheral speed of the brush to about 4000 feet per minute.

The brush finisher was employed in a manner similar to that of the supercalender. Samples of each paper tested were brushed by one, two, four, eight, and sixteen passes. The brush pressure was initially adjusted to produce a significant surface

gloss improvement without creating difficulty in manually moving the board across the brush. All sheets were brushed in the machine direction with the felt side receiving the action of the brush. All testing was performed on the felt side of the sheets.

The aforementioned finishing operations were conducted on each of three samples of paper. Sample I was a 100 pound (25x38-500) coated two sides cover stock. The coating was an offset formulation containing clay, $CaCO_3$, and Satin White with a casein and latex adhesive. Sample II was a 70 pound (25x38-500) coated two sides paper having the same coating formula applied as sample I. Sample III was a 47 pound base stock of chemical and secondary fiber content.

The following tests were conducted on the finished and unfinished papers in accordance with standard TAPPI procedures:

1. Caliper - ten sheets
2. Brightness - IPC
3. Opacity - Bausch and Lomb
4. Gloss - Photovolt
5. Vanceometer oil absorbance
6. K&N ink absorbance
7. Dennison wax pick
8. IGT printability

All finishing and testing was performed in a controlled atmosphere at 73 degrees Fahrenheit and 50 per cent relative humidity.

III. Results.

The mean results for all tests are tabulated in Tables 1, 2 and 3. This same data is also presented graphically in

Figures 2 - 13. A convenient common denominator of both brush finishing and supercalendering is gloss development. Gloss, therefore, is used in the graphs as the basis against which the other tests are plotted in comparing the two finishing operations.

IV. Discussion of Results.

The data tables show that in order for the brush to develop as much gloss per pass as the supercalender either higher brush pressures would have to be applied or the brush-paper contact time would have to be increased. For the methods used in this study, however, both of these alternatives are impractical and the results obtained with the brush are considered optimum. As might be expected the brush shows essentially no effect on sheet caliper (Figs. 2, 3) whereas the supercalender causes a typical caliper reduction with each successive nip. This behavior is characteristic for each operation since the brush develops gloss by a low pressure buffing or polishing of the paper surface in contrast to the high pressure "ironing" action of the supercalender.

As the brush develops gloss it also shows a marked tendency to yellow the sheet surface and thus lower the paper brightness by shifting the area of maximum reflectance away from the preferred blue-white region of the spectrum (Figs. 4, 5). This brightness loss due to yellowing is significantly greater than the loss due to blackening inherent in the supercalendering operation.

Since supercalendering works, at least in part, on a high pressure ironing principle it is inevitable that some air

will be squeezed from the sheet and thus reduce the number of air-cellulose refracting interfaces. As the number of these refracting interfaces is decreased the opacity is also decreased, as Figs. 6 and 7 show. The low pressure brush, however, shows little adverse affect on opacity as gloss is developed. Figure 7 indicates that a slight initial opacity loss might be associated with brushing an uncoated paper, although continued brushing reveals no clear trend.

Whether or not a paper is coated is the influencing factor in determining the resistance to ink penetration of brush finished papers. In Fig. 8 high degrees of brushing can be seen to increase the ink penetration resistance of a coated paper to a greater extent than supercalendering. Figure 9 shows that the same amount of brushing on an uncoated paper increases the ink resistance only slightly. The supercalender raises the ink resistance equally well for both coated and uncoated grades. The supercalender develops ink penetration resistance by increasing the sheet density whereas the action of the brush appears to be entirely a surface phenomenon and thus dependent on the nature of the surface. This behavior is further exemplified by measuring the rate of oil penetration into sheets prepared by both finishing operations. Figures 10 and 11 show that by brushing a coated paper surface the rate of oil penetration can be gradually decreased but that this same amount of brushing causes only a slight initial lowering of the oil penetration rate into uncoated paper.

The Dennison wax pick values in Tables 1 - 3 indicate that brushing a coated paper surface tends to reduce the pick

resistance of the paper slightly but that no such reduction is apparent for an uncoated paper surface. The supercalender lowers the pick value of the lighter weight coated paper but it, in turn, raises the surface strength of the uncoated sample by two wax numbers.

The nature of the printing surface produced by both brushing and supercalendering is sharply contrasted in Figs. 12 and 13. This test reveals that the gloss produced on a brushed surface has essentially no bearing on the fidelity of reproduction that can be expected from this surface. On the other hand, the supercalender gloss development shows a corresponding and very significant improvement in printing quality. This behavior is the same for both coated and uncoated grades.

V. Summary and Conclusions.

It has been demonstrated that a brushing operation can be employed to substantially raise the surface gloss of coated and, to a lesser extent, uncoated papers. However, as in any other paper finishing method, a particular effect is achieved along with accompanying desireable and undesireable side effects. This study has revealed some of the side effects of brush finishing. To decide, though, which of these accompanying factors are desireable and which are not is beyond the scope of this investigation. The goal here instead has been to conduct a limited, exploratory comparison between the new brush finishing operation and the presently routine supercalender finishing method.

Based on the techniques described and on the specific

papers tested the following conclusions seem justified :

1. Brushing will develop satisfactory coated paper gloss, although it is somewhat less effective than supercalendering in this respect.

2. Brushing develops uncoated paper gloss much less than does supercalendering.

3. Brushing has little effect on paper caliper whereas supercalendering greatly reduces caliper.

4. For equivalent gloss values the brightness of brushed paper is lower than the brightness of supercalendered paper.

5. Brushing has little effect on paper opacity, in contrast to supercalendering which reduces opacity.

6. Brushing increases oil and ink penetration for coated papers but does little to increase this property of uncoated papers.

7. Supercalendering increases oil and ink penetration resistance of paper independently of surface coating.

8. Brushing coated papers reduces the pick resistance slightly but brushing uncoated paper does not affect this quality.

9. Supercalendering may reduce the pick resistance of coated papers slightly but it tends to increase this property in uncoated paper.

10. Gloss developed by brushing offers no obvious improvement in

the fidelity of reproduction of printed matter.

11. Gloss developed by supercalendering causes printing fidelity to be greatly improved.

12. There is no significant relationship between gloss alone and fidelity of reproduction in printing.

Table I

100 lb. coated paper

	Unfinished	Brush Passes 1	2	4	8	16	Supercalender Nips 1	2	4	8	16
Caliper	.0765	.0770	.0776	.0767	.0766	.0767	.0562	.0544	.0528	.0512	.0508
Brightness	81.9	80.6	79.4	78.8	78.3	77.4	81.3	80.5	80.2	80.3	80.0
Opacity	97.8	98.0	97.9	97.6	97.8	97.7	97.6	97.8	96.9	96.9	97.0
Gloss	5.5	16.8	21.4	28.1	31.7	36.2	29.8	36.2	44.6	44.4	49.9
K & N Ink	45.5	38.2	35.8	33.5	23.0	17.9	36.5	34.0	31.8	29.7	27.4
Vanceometer	16.4	10.2	9.4	9.4	9.8	7.6	12.8	10.8	7.8	4.8	4.0
Dennison Wax	11	10	10½	10	9½	10	11	11	11	11	11
Printability	652	622	636	616	640	630	276	214	170	114	90

Table II

70 lb. coated paper

	Unfinished	Brush Passes 1	2	4	8	16	Supercalender Nips 1	2	4	8	16
Caliper	.0565	.0555	.0556	.0553	.0553	.0552	.0395	.0381	.0376	.0368	.0362
Brightness	82.1	80.8	80.2	79.1	77.8	77.2	81.4	80.7	80.8	80.1	79.6
Opacity	95.4	95.7	95.4	95.3	95.5	95.0	94.9	94.2	93.6	94.2	92.9
Gloss	5.1	21.1	23.1	28.1	33.1	34.6	29.8	36.8	40.0	48.1	48.5
K & N Ink	58.0	55.0	55.1	51.6	40.7	34.1	47.3	44.6	43.2	47.3	37.8
Vanceometer	49	36	40	36	26	26	17	15	14	15	10
Dennison Wax	11	10	10	10	10	10½	11	11	10½	10	10
Printability	625	654	614	632	616	623	186	143	135	110	78

Table III

47 lb. base stock

	Unfinished	Brush Passes 1	2	4	8	16	Supercalender Nips 1	2	4	8	16
Caliper	.0433	.0432	.0432	.0428	.0427	.0428	.0335	.0319	.0317	.0311	.0300
Brightness	78.7	77.7	77.7	77.5	77.3	77.0	78.1	77.9	77.9	77.7	77.2
Opacity	84.5	83.6	83.6	83.2	83.4	83.6	83.4	82.5	83.1	83.0	82.3
Gloss	6.9	10.3	10.6	11.7	12.5	13.9	14.4	15.4	18.2	19.6	23.3
K & N Ink	54.9	51.5	51.4	51.7	51.4	51.8	47.0	44.6	45.2	45.6	43.1
Vanceometer	104	78	80	80	80	78	16	10	6	6	3
Dennison Wax	14	13	14	14	14	14	16	16	16	16	16
Printability	1235	1209	1079	1144	1040	1061	546	494	487	280	233

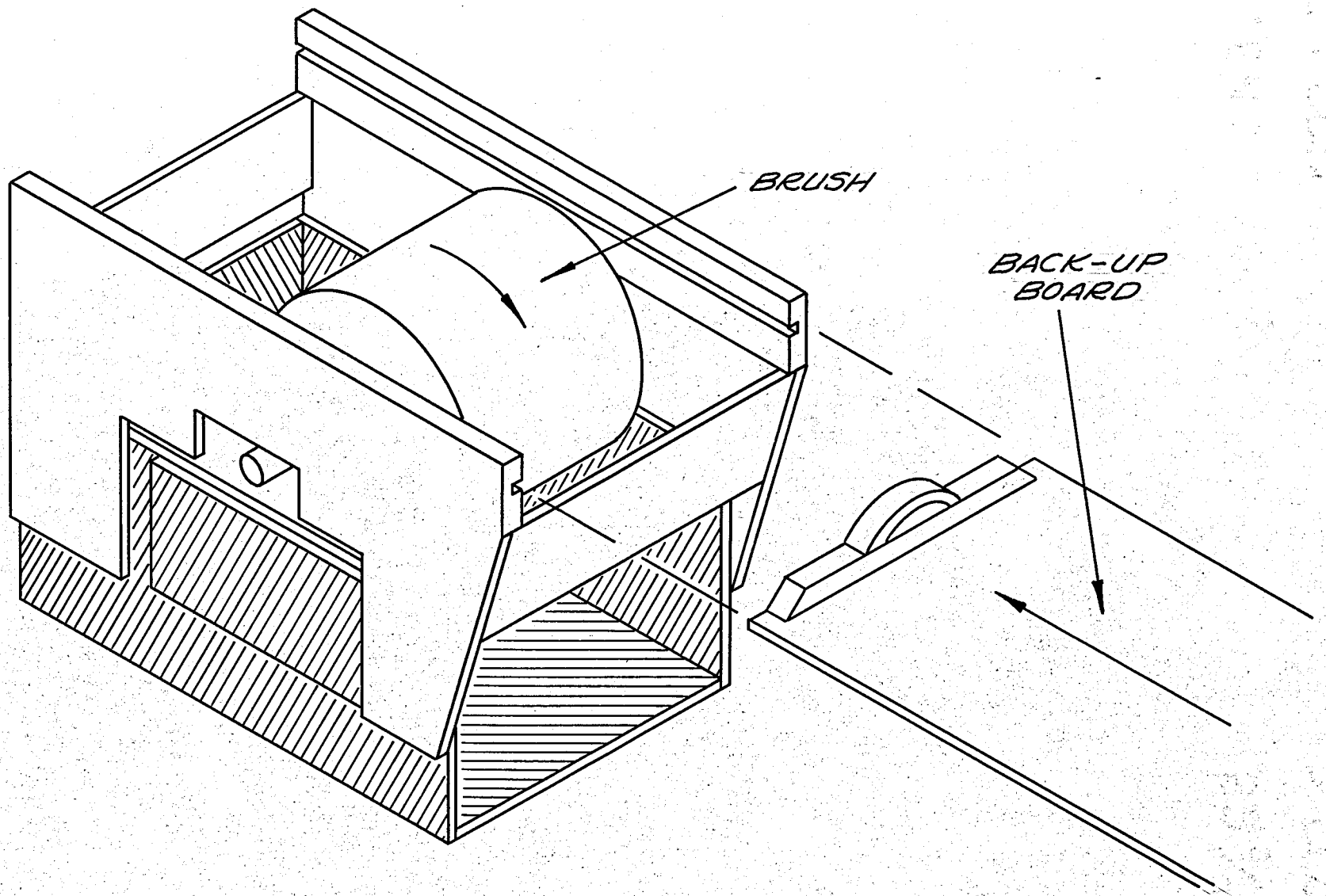


FIGURE 1

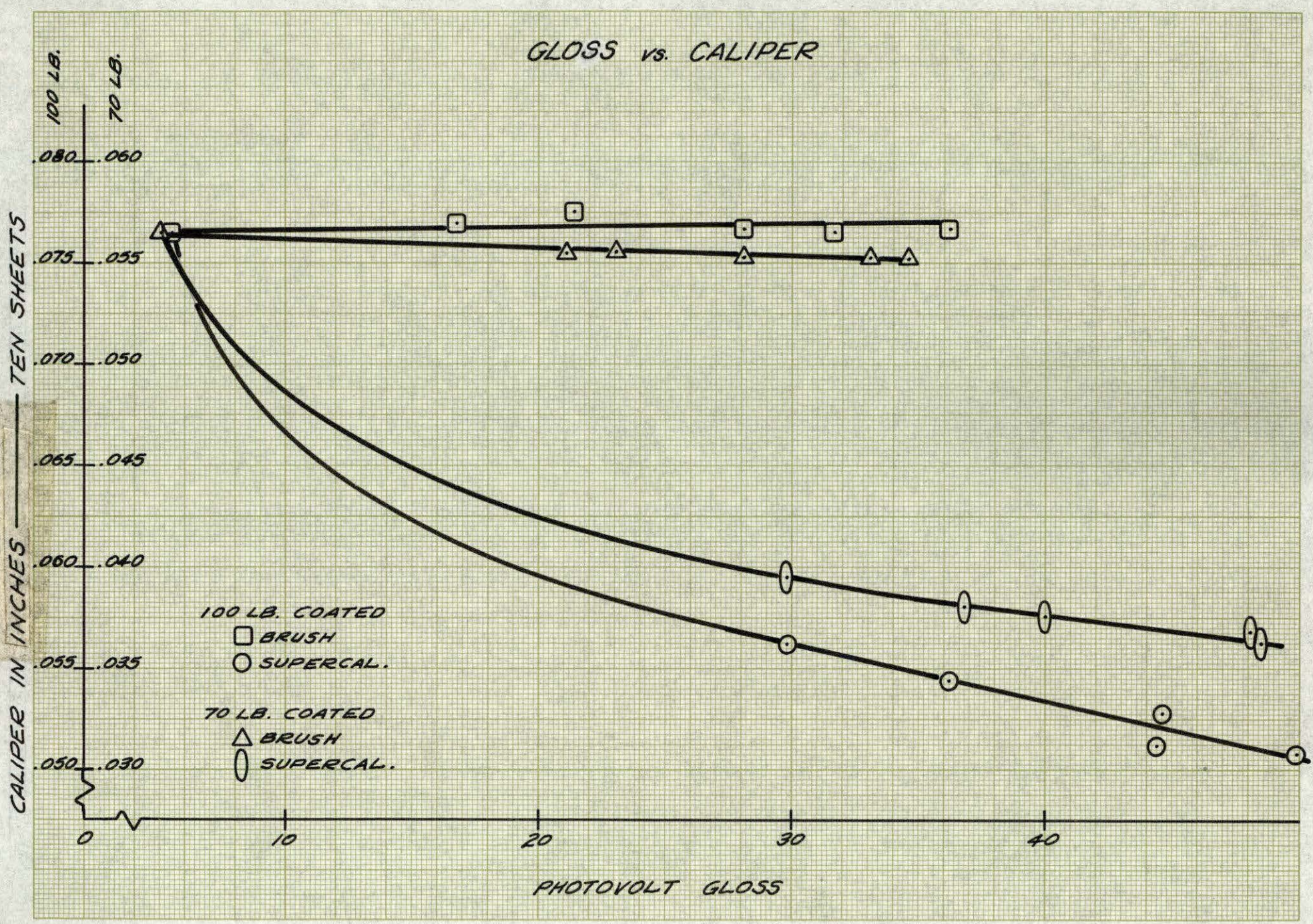
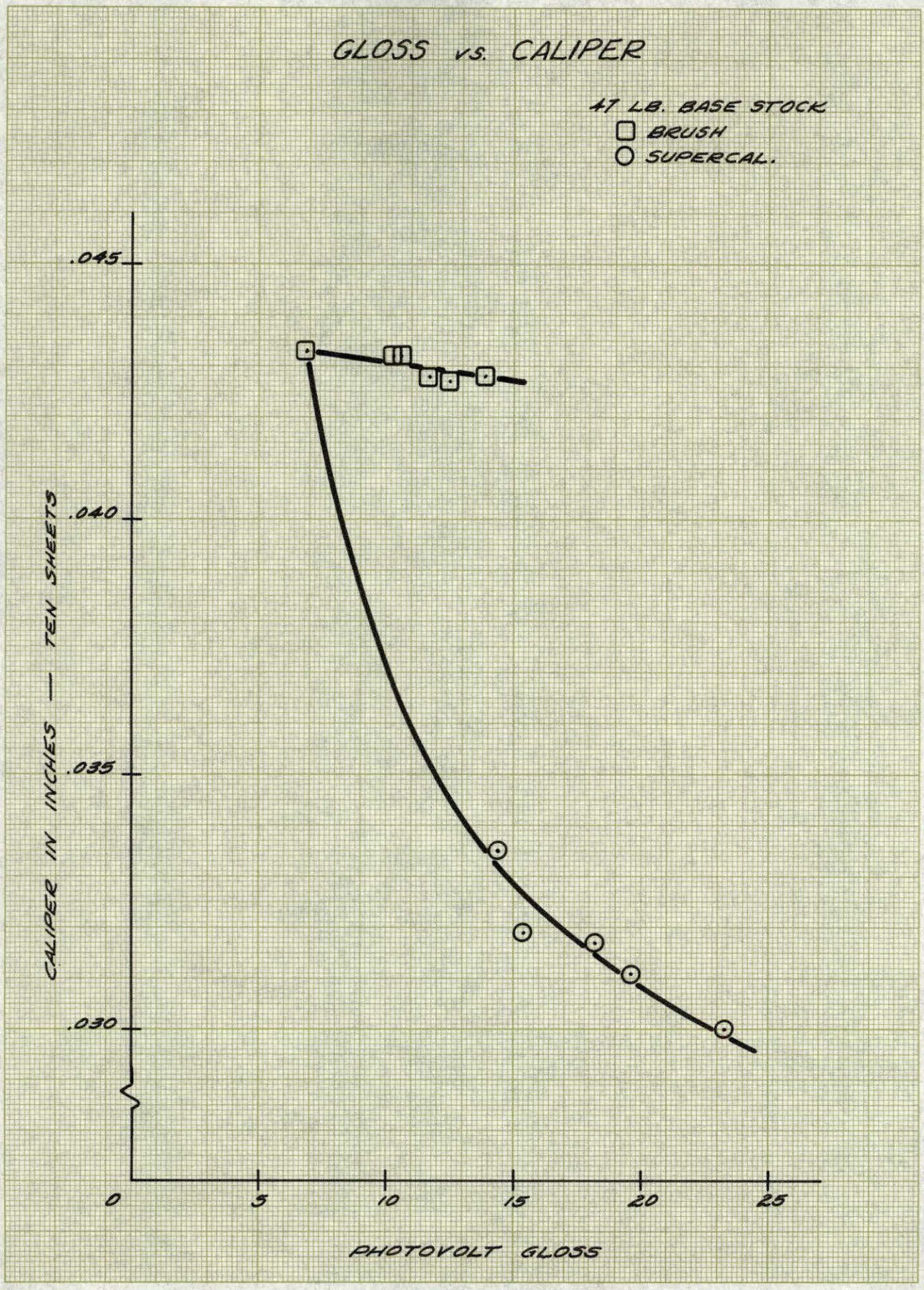


FIGURE 2

FIGURE 3



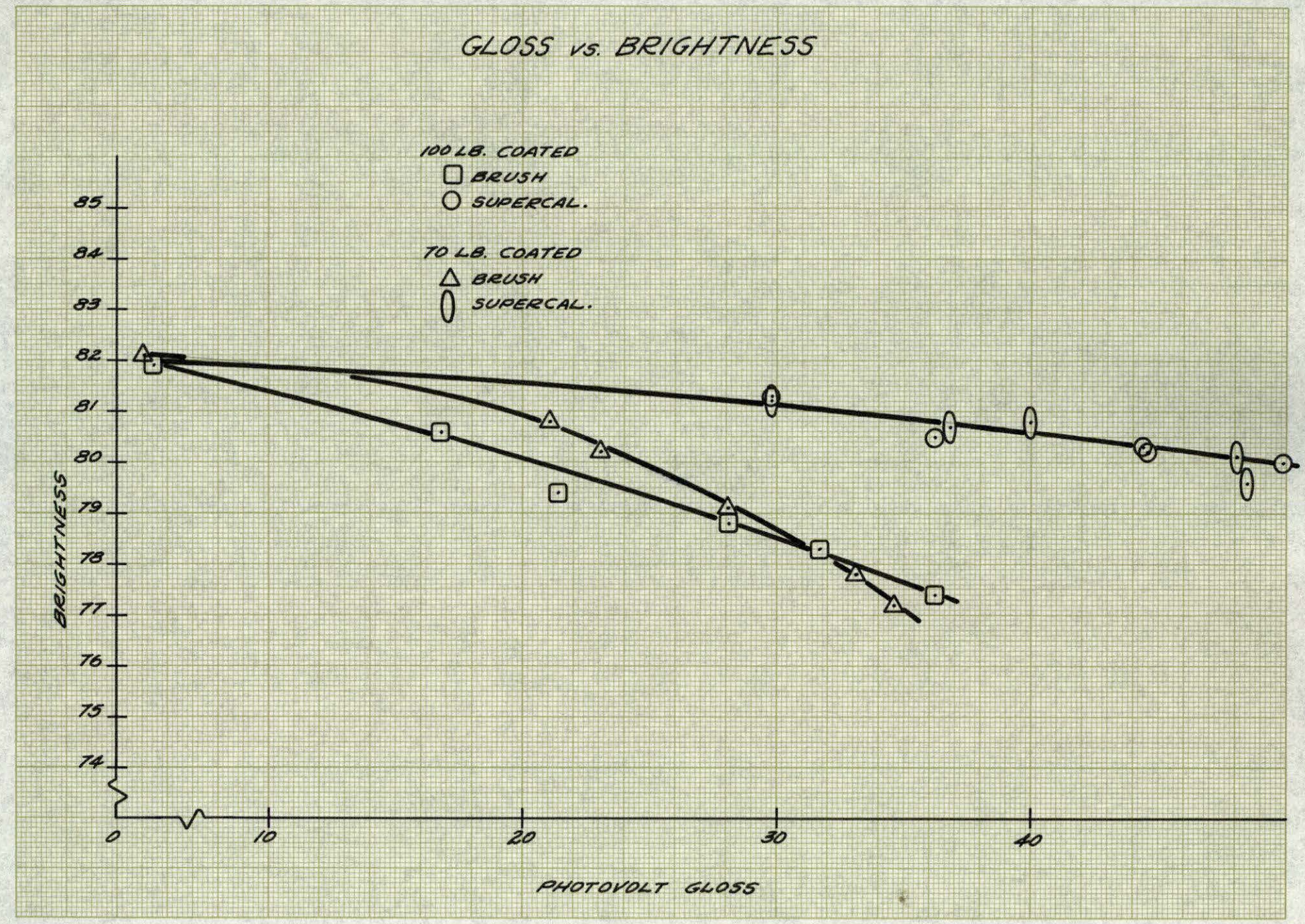
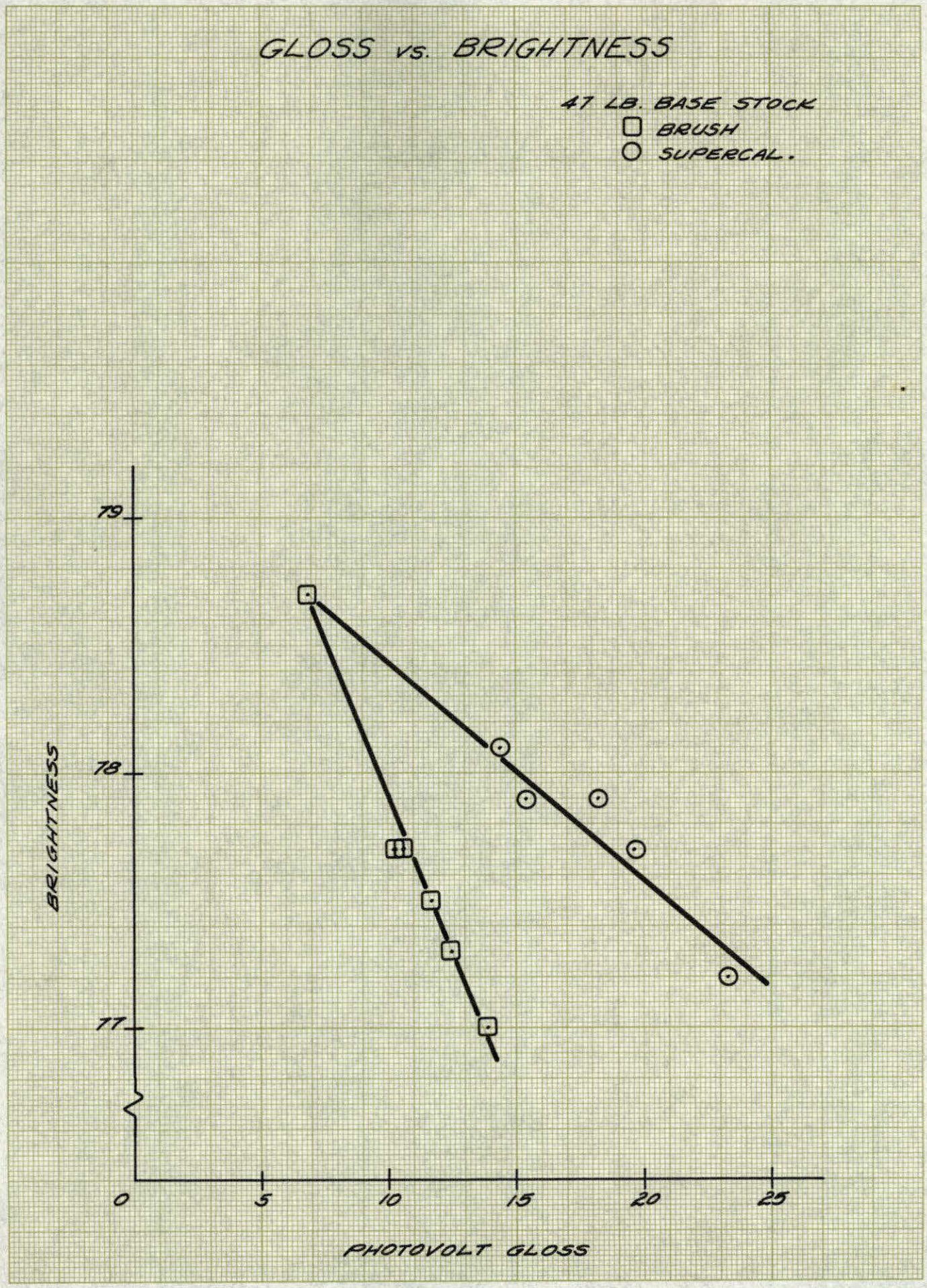


FIGURE 4

FIGURE 5



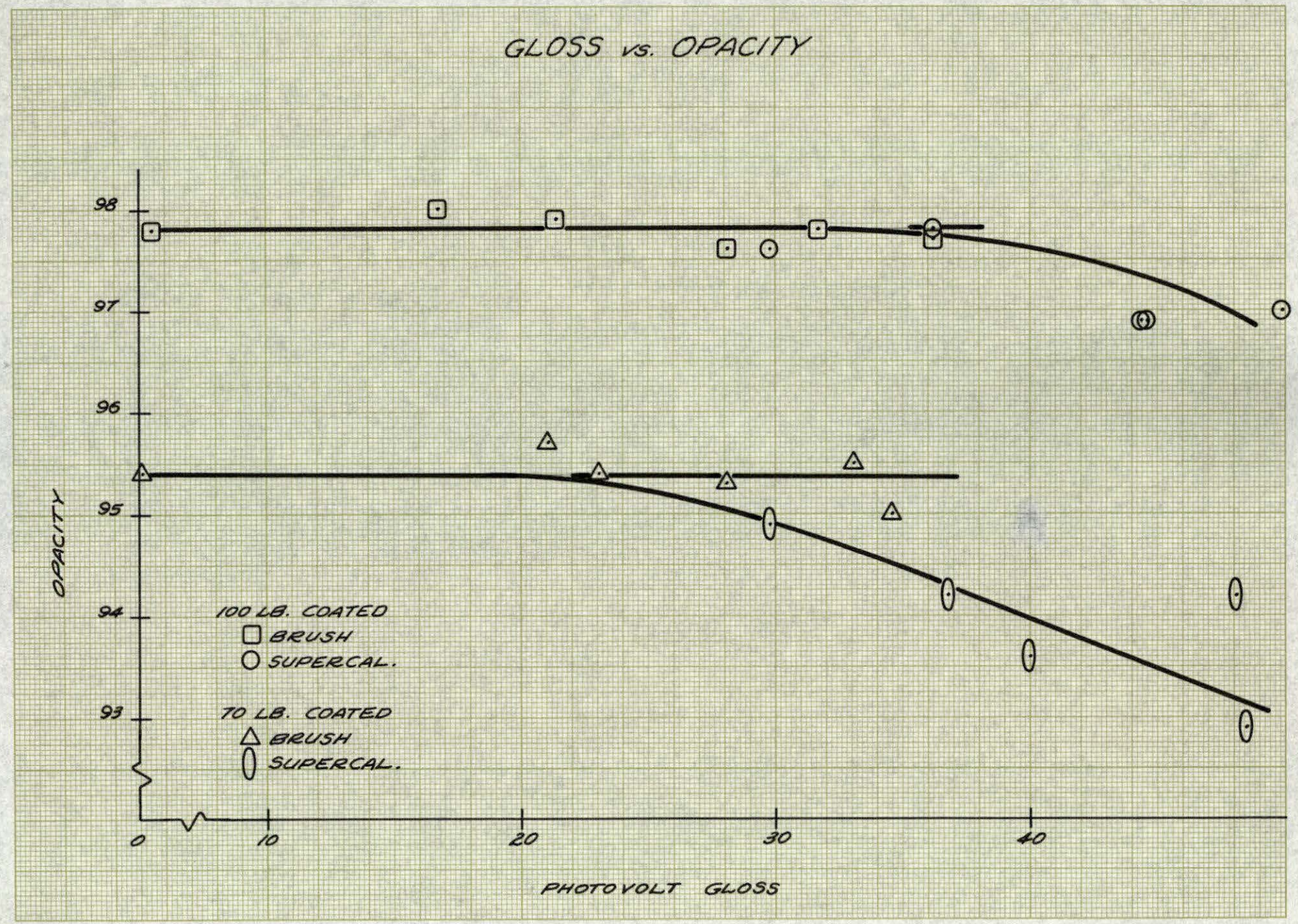
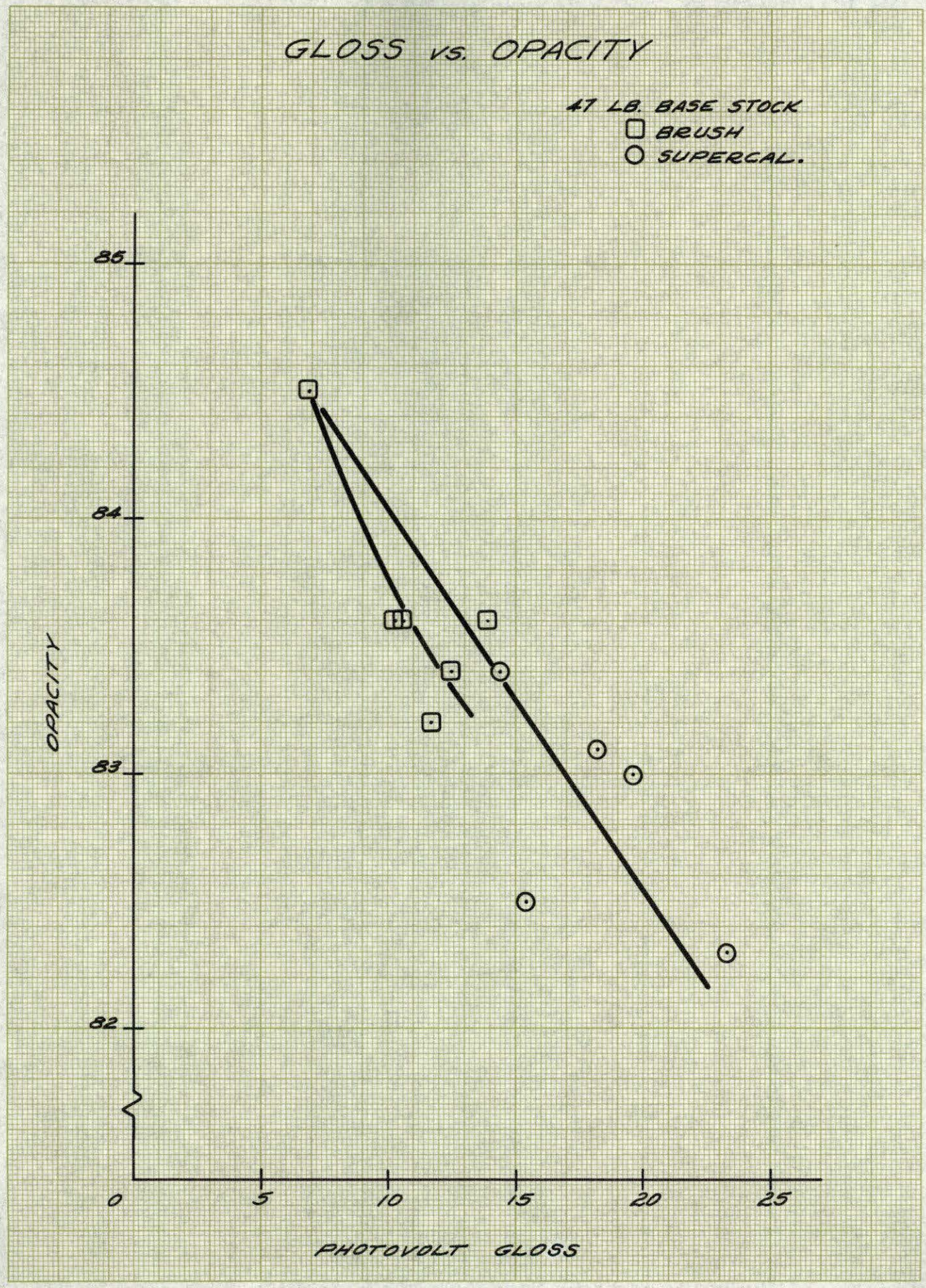


FIGURE 6

FIGURE 7



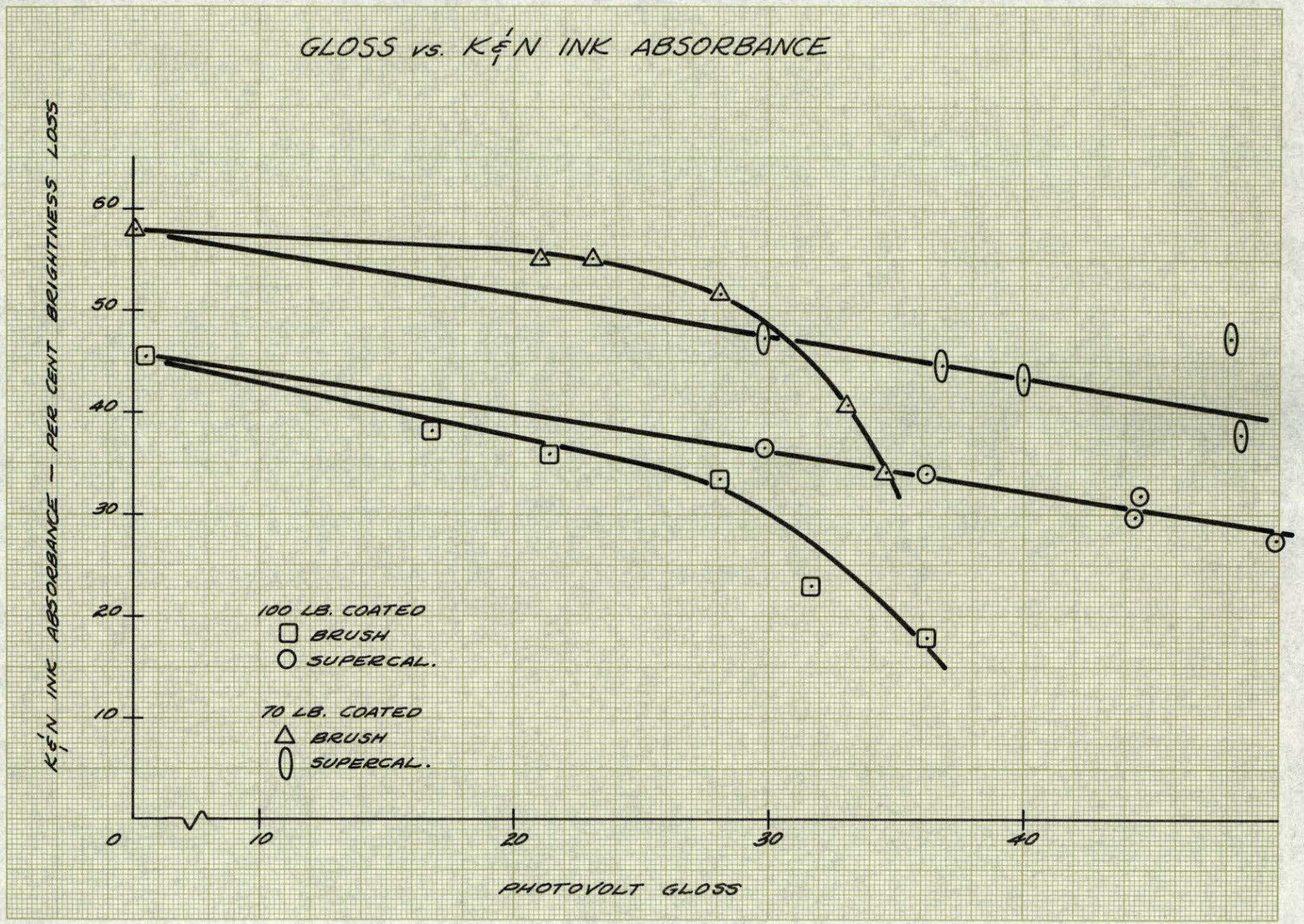
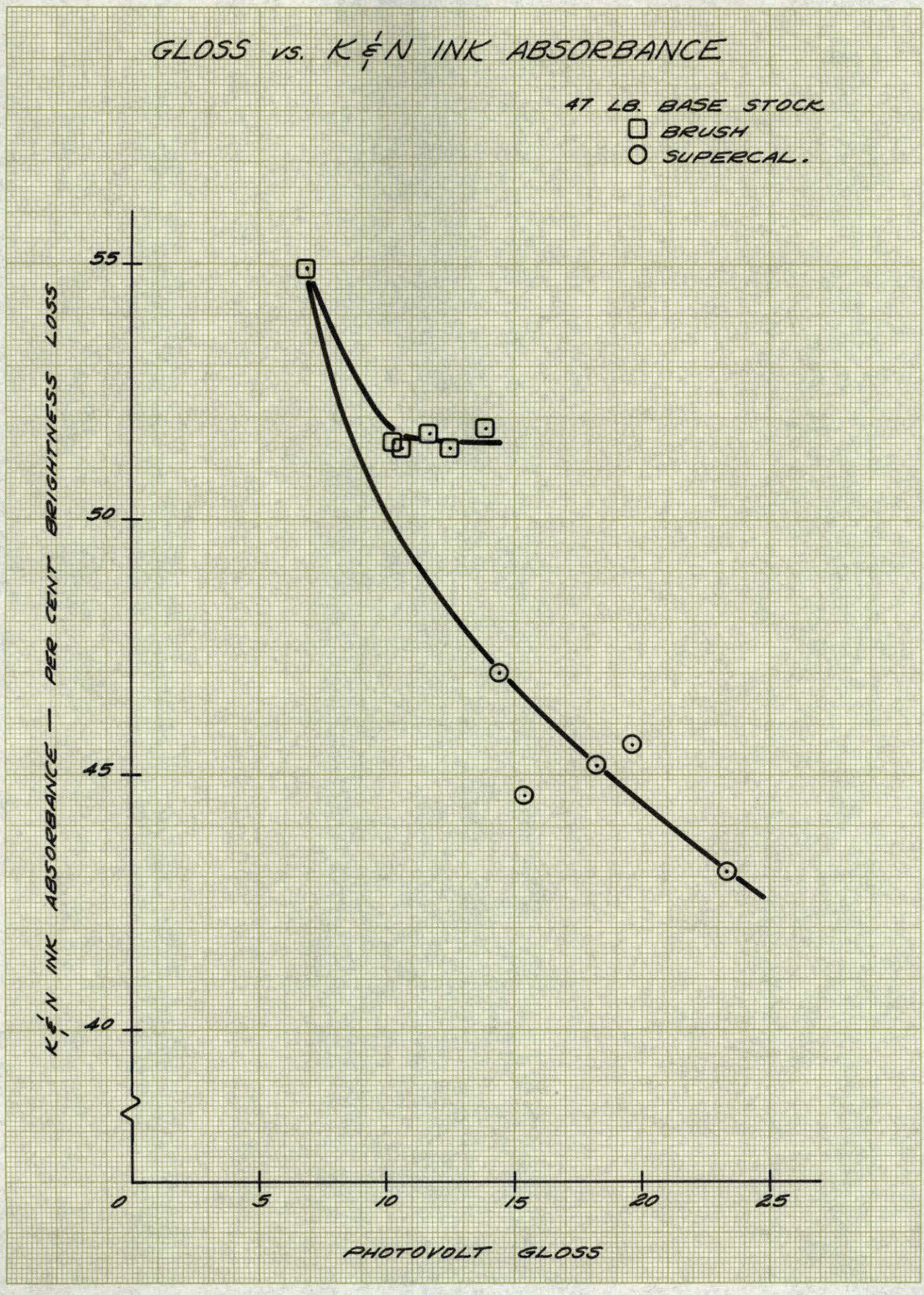


FIGURE 8.

FIGURE 9



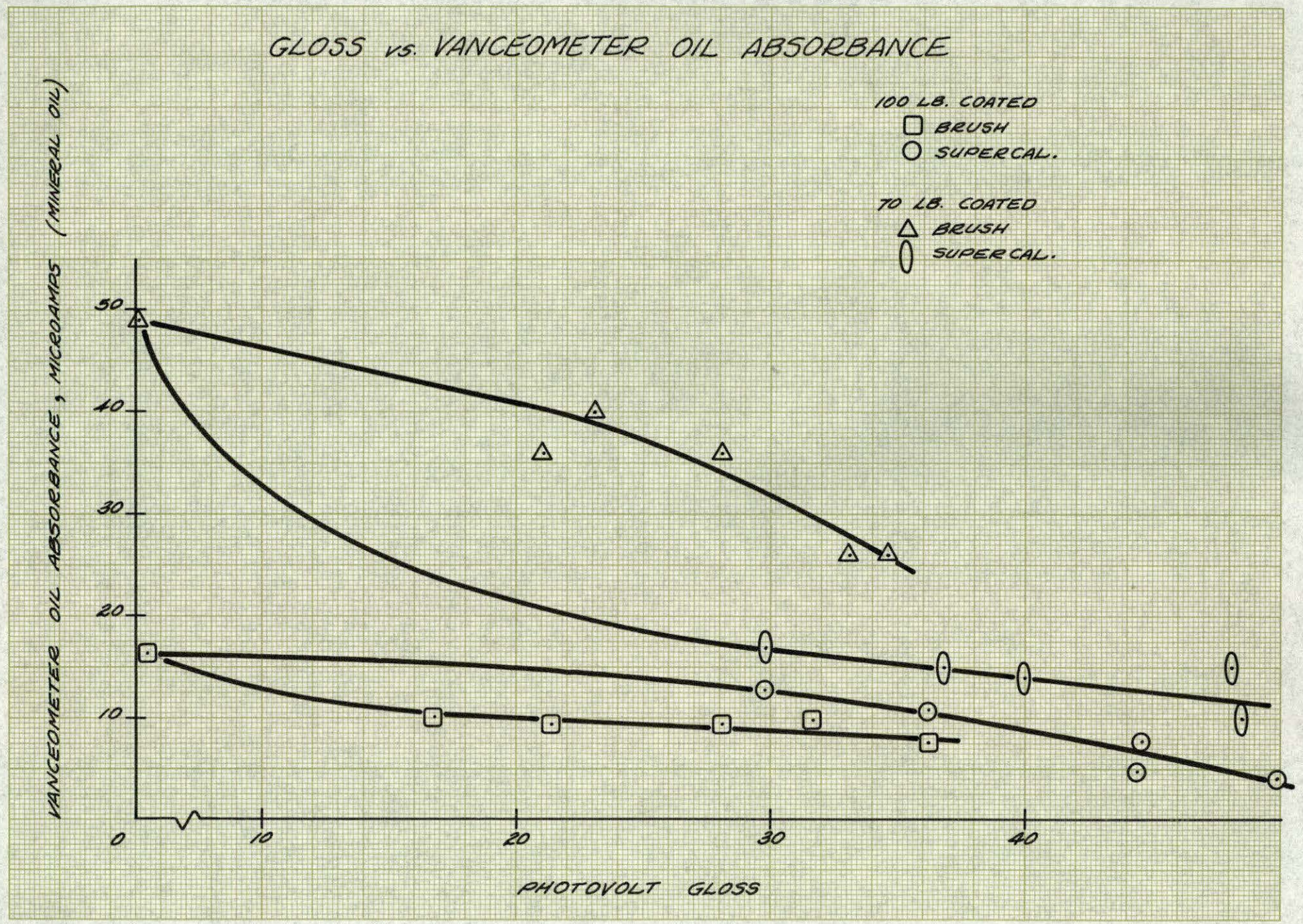
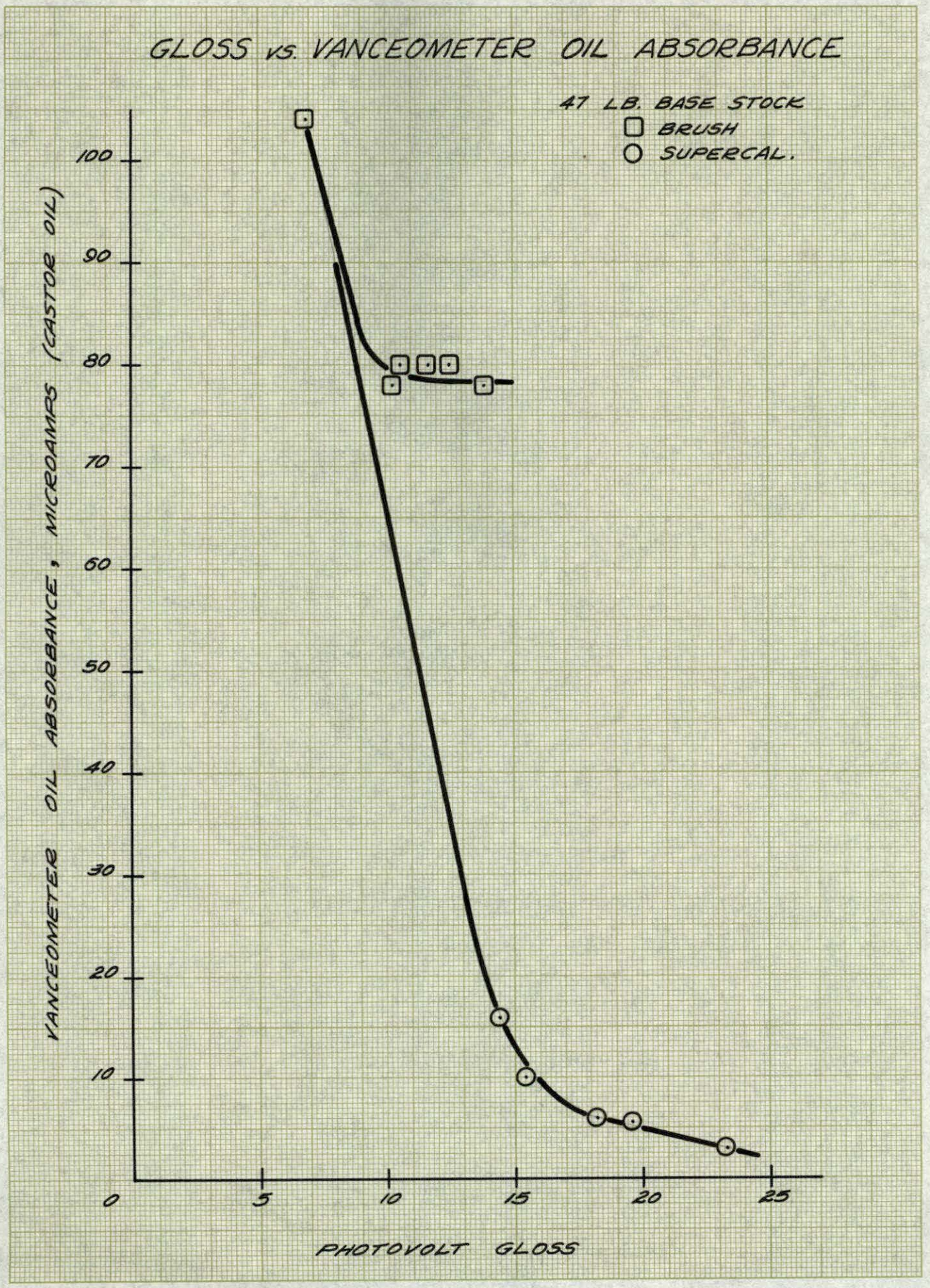


FIGURE 10

FIGURE 11



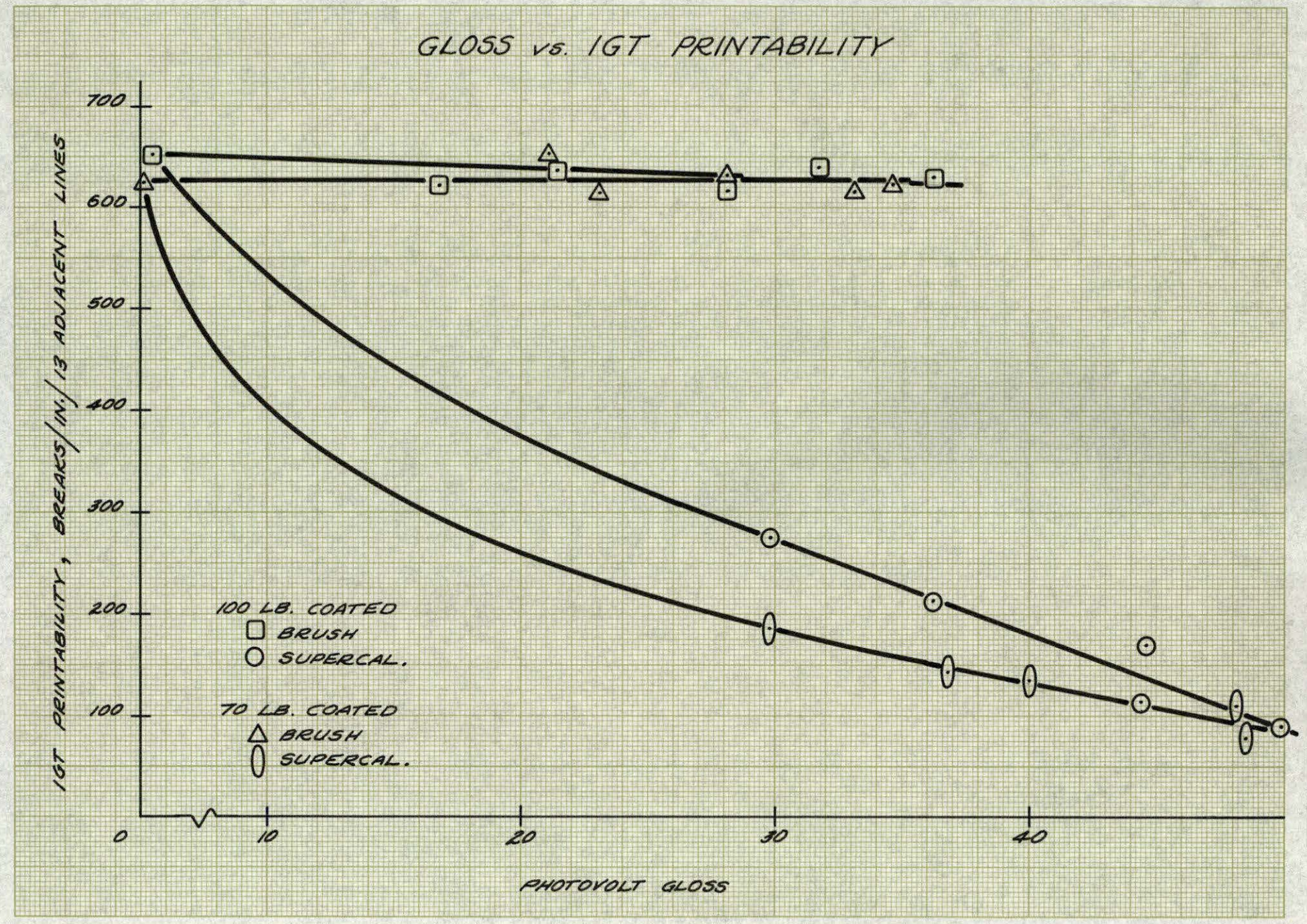
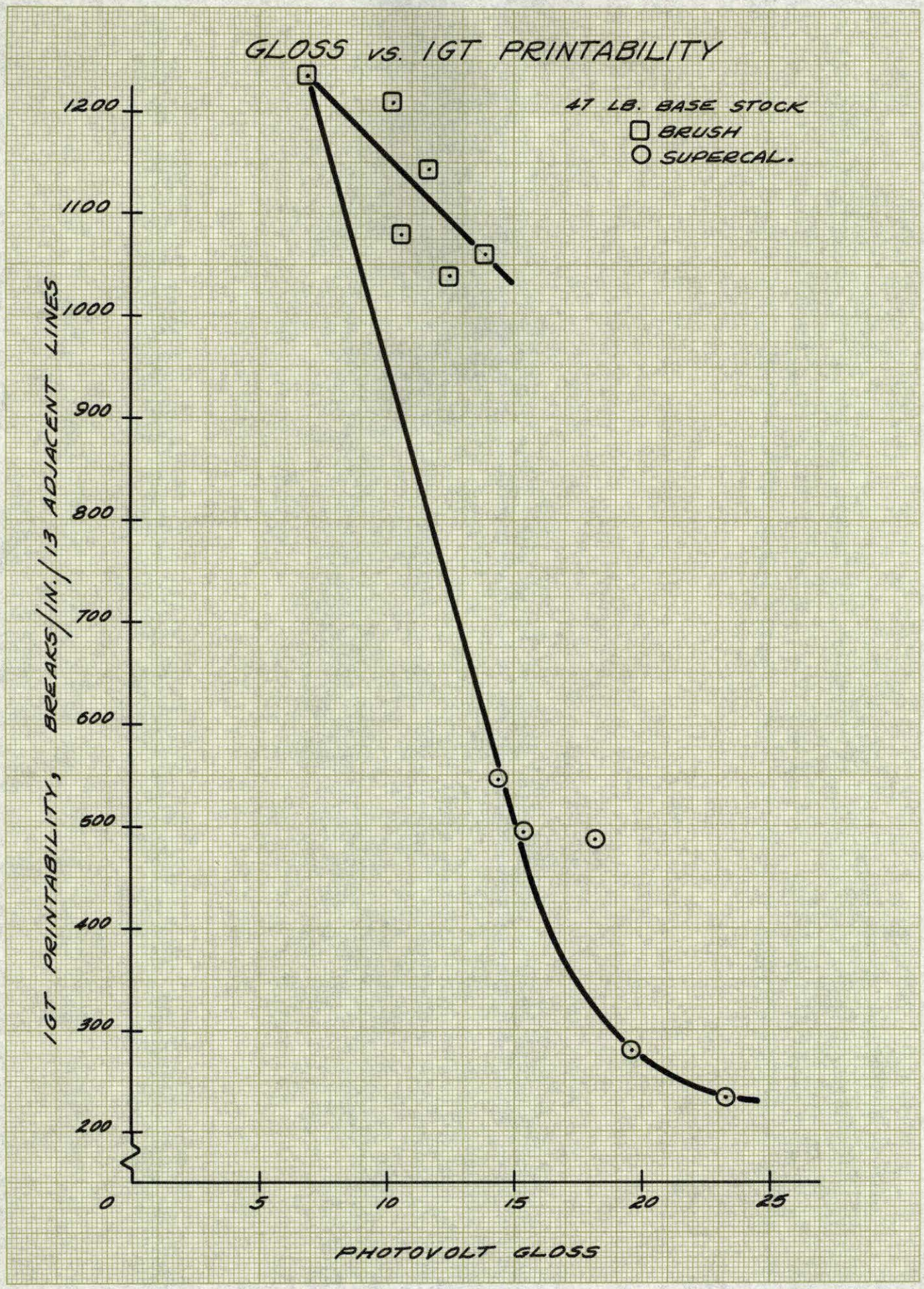


FIGURE 12

FIGURE 13



SAMPLE I
100# (25 x 38 - 500)
C2S

UNFINISHED

SIXTEEN BRUSH PASSES

SIXTEEN SUPERCALENDER NIPS

SAMPLE II
70# (25 x 38 - 500)
C2S

UNFINISHED

SIXTEEN BRUSH PASSES

SIXTEEN SUPERCALENDER NIPS

SAMPLE III
47# (25 x 38 - 500)
BASE STOCK

UNFINISHED

SIXTEEN BRUSH PASSES

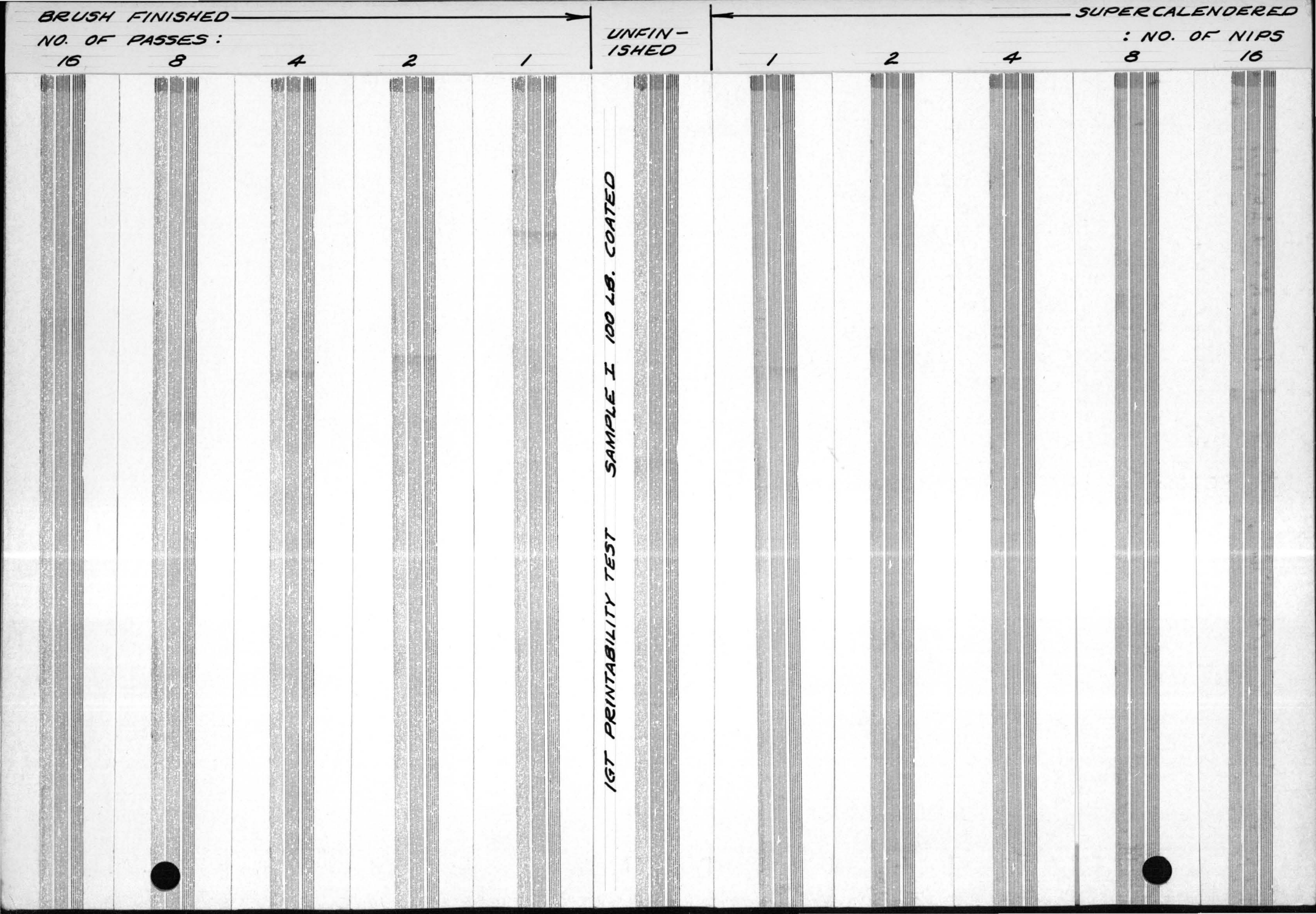
SIXTEEN SUPERCALENDER NIPS

BRUSH FINISHED
NO. OF PASSES:
16
8
4
2
1

UNFIN-
ISHED

1
2
4
8
16
: NO. OF NIPS
SUPERCALENDERED

IGT PRINTABILITY TEST SAMPLE III 47 LB. RAW STOCK


BRUSH FINISHED
NO. OF PASSES :
16
8
4
2
1
UNFIN-
ISHED
SUPERCALENDERED
: NO. OF NIPS
1
2
4
8
16
IGT PRINTABILITY TEST SAMPLE I 100 LB. COATED

IGT PRINTABILITY TEST SAMPLE II 70 LB. COATED

BRUSH FINISHED — NO. OF PASSES :

16

8

4

2

1

UNFIN-ISHED

SUPERCALENDERED — : NO. OF NIPS

1

2

4

8

16