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Pigmented Coating on Unbleached Paper

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PIGMENTED COATING ON UNBLEACHED PAPER

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LITERATURE SURVEY

INTRODUCTION

Much work has been done generally on the coating of paper, but very little literature is available on the coating of unbleached paper or unbleached book stock. Therefore, the covering power of the coating in this study is of the chief interest. Engelnart states that the titanium dioxide in a coating would increase the opacity and hence prevent the original low brightness base from showing through. (1) (2). Other knowledge on general coatings can also be applied to this relatively unknown field of coating.

The literature survey is therefore necessary to cover the areas of:

I. Fundamentals of brightness

II. Compositions of a coating

- A. Pigments
- B. Dispersing agents
- C. Adhesives
- D. Modifiers

FUNDAMENTALS OF BRIGHTNESS

Pigments are the materials used to provide the brightness and opacity required by a coating. However,

adhesives are required to bind the pigments to the paper; and yet, adhesives lower the brightness of pigment, because the refractive index difference between adhesives and pigments is less than that between air and pigments. Therefore, the amount of adhesives should be kept as low as possible.

Some adhesives are brittle and modifiers must be added to provide the flexibility required of the coating. Since modifiers tend to decrease the brightness of the pigments, the addition of modifiers can be overdone.(3)

Solvent is important in a coating solution, as the coating materials have to be diluted for their application. However, a solvent residue in the coating tend to lower the brightness, because the refractive index of the solvent would be higher than that of air.

The surface smoothness of a coating can be improved by running it through a supercalender; but the packing down of the coating decreases the amount of solids and thus decreases the brightness of the coating.

PIGMENTS

The pigments provide brightness and most of the weight of the coating. First, consider clay. Commercial coating clay is purified to consist mainly

of Alumina (Al_2O_3) and Silica (SiO_2). (4) It is one of the first pigments to be employed in the coating industry. (5) It's particle size and shape have been improved since then. A particle size of less than two microns predominates, and hence refractive index is higher, and the hiding power is better. (6) Clay is low in price, and has a brightness of about 85% when dry. (4) Although it's color is never too good, it is characterized for it's uniformity. Willets and Bingham suggested that titanium dioxide is to be blended with the clay to improve showing through. (3)

Lyons recommends that 12-25% of starch be used as the adhesive, and 0.3% of dispersing agent, such as sodium hexametaphosphate or tetrasodium pyrophosphate, is to be used. (7)

Moreover, clay is excellent in gloss, and is best in giving weight to the coating. (8) (3)

Titanium dioxide has a brightness of 98% when dry, and has a refractive index of 2.55-2.70. It has a very high opacity and covering power and can thus be used as a whitening agent. It has a particle size of 0.1-0.5 micron which provides an even and smooth coating. Chemically speaking, it is inert and non-toxic. A commercial grade of water dispersable titanium dioxide is generally used in coating, and a solution can be prepared easily by adding it gradually to the water

with agitation. Willets and Bingham claimed that a 20-30% of chlorinated starch used as adhesive can provide a Dennison Wax Pick test of 9-11. On coating board, the addition of titanium dioxide is able to increase brightness and opacity, and 10-25% of it on total pigment is generally used. (3)

DISPERSING AGENTS

A good dispersion of a coating pigment can be achieved by adding a chemical which protects the pigments in colloidal form. The most common dispersing agents used on a clay or titanium dioxide solution are Calgon (sodium hexametaphosphate) and tetrasodium pyrophosphate. (8) It was found by Leaf that the inorganic polyphosphates are the most effective dispersing agent for $CaCO_3$, clay and TIO_2. (9) (7) However, an excess of the dispersing agent would tend to increase the viscosity of the solution which would decrease the coating speed, delay penetration and produce a less even spreading. Haywood suggests that when tetrasodium pyrophosphate is used, 0.1-0.5% based on the pigments is a sufficient amount.(11)

Other dispersing agents for clay, titanium dioxide and similar pigments are soda ash, sodium

caseinate, sodium silicate, methylcellulose, sulfonated oil or salts and other synthetic dispersing agents. (3)

ADHESIVES

Starch is a commonly used adhesive and is less expensive than casein which is almost equally popular. There are corn, potato, rice, sago, tapioca and wheat starches. General properties of these adhesives cannot be overlooked. Adhesives tend to lower the brightness of the coating, decrease the ink-penetration and increase the smoothness of the coating. (12)

Starch solutions can be prepared by wetting the starch thoroughly with water and heating the solution to 180-210°F at a pH 5.0-8.5; they are then cooled before using.

As the viscosity of the starch solution varies inversely with the temperature, coating temperatures should be controlled to provide the same or very close coating weight at each application. (11)

MODIFIERS

Some coatings can be too brittle for their intended purpose and others might be too low in ink-penetration. Modifiers are added accordingly to provide the characteristics of the coating required. For

instance, pure resine, as modifiers are able to provide good insulating and grease resistance properties. (8) Other modifiers that are commonly used are pine oil, sulfonated oil, formaldehide, sodium carboxymethylcellulose (sodium CMC) and Zein. (13) (14)

EXPERIMENTAL WORK

The coating was prepared by the dispersion of Hercules Titanox A-W.D. in water to 60% solids in a dough mixer. Similarly, Steller Clay was dispersed with 0.3% tetrasodium pyrophosphate, based on clay, in water in a dough mixer to 60% solids. Low viscosity corn starch M-200 obtained from St. Anthony Starch Co. was put into solution in the following manner: the starch was soaked in water for 10 minutes at 40% solids and heated to a transparent solution.

300 ml of 40% pigment content coating were prepared on each of the following:

0% TiO_2 to 100% clay by weight
25% " " 75% " " "
50% " " 50% " " "
75% " " 25% " " "

These were prepared by 0, 50, 100 and 150 ml. of the 60% TiO_2 dispersion added correspondingly to 200, 150, 100 and 50 ml of the 60% clay dispersion and 20%

of starch based on the pigment, then stirred in at 120 F for each coating color. In each case, 60 ml of the 40% starch solution was added. To each coating color 0.25% phenol on the weight of the pigments was added as a preservative. Each coating was then diluted to 300 ml total volume at 120 F.

Each coating was carefully applied by R.D. Specialties rods numbers 6, 14, 24 and 30 on the base paper at 105 F and was immediately dried in the oven at 212 F. Four sheets were made with each rod, half of which were recoated by the same rod to obtain the double coating.

All the coated sheets were cut to 5" x 7" samples and conditioned according to TAPPI standard method T 402 m-49. The coating weights were calculated from their differences with the average weight of the uncoated sheets, and were calculated into pounds per thousand square feet.

Single coated sheets of about 6 lb/1000 ft. coating weight and double coating sheets of 8-11 lb/1000 ft. coating weight were selected and their brightness values were determined by The Brightness Tester before calendering. After calendering, they were tested with The Brightness Tester, the Hunter Reflectometer, the Photovolt and the Welch Densichron. Calendering was

achieved by four passes through the laboratory supercalender at 35 psig. air pressure on the rolls. The purpose of these tests were to study the effect of calendering on brightness and correlation of the brightness testers used.

All the other sheets were calendered in the same manner and tested for brightness with The Brightness Tester. For each coating, the percent brightness was plotted against the coating weight to study the effect of coating weight on brightness in different coatings. Moreover, the single coatings were plotted in the same graph with the double coatings to study the effects of double and single coating on this coated paper at different TiO_2 contents.

EXPERIMENTAL RESULTS

Single Coating

Coating Pigments	Coating Weight #/1000	Brightness Tester " Brightness	
		Non-calendered	Calendered
All Clay	5.4	70.8	61.4
75% clay 25% TiO_2	5.7	73.5	69.0
50% clay 50% TiO_2	6.8	75.5	73.2
25% clay 75% TiO_2	8.8	78.5	78.2
	Double Coating		
All Clay	7.8	77.6	75.5
75% clay 25% TiO_2	9.7	81.4	79.2
50% clay 50% TiO_2	11.0	84.0	82.0
25% clay 75% TiO_2	11.1	87.0	85.2

Single Coating Calendered

Coating Pigments	Coating Weight #/1000ft.^{2}	Brightness Test (%) Photovolt	Densichron	The Brightness Tester	Hunter's
All Clay	7.0	67.0	75.0	66.2	67.1
+75% clay 25% TiO_2	6.6	70.5	79.0	70.2	71.4
+50% clay 50% TiO_2	5.2	73.5	82.0	71.5	72.4
+25% clay 75% TiO_2	4.1	75.5	82.5	76.7	77.5
	Double Coating Calendered				
All clay	9.6	72.5	81.5	73.9	72.8
+75% clay 25% TiO_2	11.5	77.5	85.5	78.9	78.4
+50% clay 50% TiO_2	11.1	80.5	91.0	82.8	80.9
+25% clay 75% TiO_2	10.4	82.5	91.0	85.6	85.0
Base Stock	65.5 Base Wt.	34.5	34.0	31.4	29.4

Single Coating -- Calendered

Coating Pigments	Coating Weight #/1000ft^2	% Brightness by Brightness Tester
All Clay	3.76	59.7
	5.40	61.4
	7.00	66.2
	10.40	71.8
75% Clay and 25% TiO_2	5.50	61.4
	5.70	69.8
	8.18	75.0
	10.42	77.1
	11.18	77.6
50% Clay and 50% TiO_2	3.90	73.6
	5.31	79.0
	9.60	80.3
25% Clay and 75% TiO_2	4.10	76.7
	5.62	81.5
	6.71	81.3
	9.16	82.3
	9.71	86.5

Double Coating -- Calendered

Coating Pigments	Coating Weight #/1000ft^2	% Brightness by Brightness Tester
All Clay	5.30	68.6
	7.59	68.2
	9.60	73.9
75% Clay +25% TiO_2	5.36	73.6
	6.60	70.2
	6.97	71.2
	9.7	79.2
	11.5	78.9
50% Clay +50% TiO_2	11.0	82.2
	11.1	82.8
	12.65	83.2
25% Clay +75% TiO_2	6.01	82.6
	10.4	85.6
	11.1	85.2

Conclusion:

As the unbleached paper chosen for the coating base of this work was aimed at about 30% reflectance, the brightness readings would be directly related to the opacity of the coatings. TiO^2 was found to be very good in raising the brightness, and hence, good covering power. It can be seen from Graph I that up to 75% TiO_2 and 25% clay for pigments, the brightness increase was almost a straight line for both single and double coatings. The double coating has a higher brightness than single coating for the same coating weight in all cases, until coverage is reached. From Graphs II and III, in order to achieve a 75% reflectance on The Brightness Tester for the 25% TiO_2 per 75% clay pigments, about 7.5 pounds/ 1000 ft^2 coating weight had to be used in a single coating as compared with 5.5 pounds/1000 ft^2 coating weight in a double coating. All other brightness levels can be studied the same way from attached graphs.

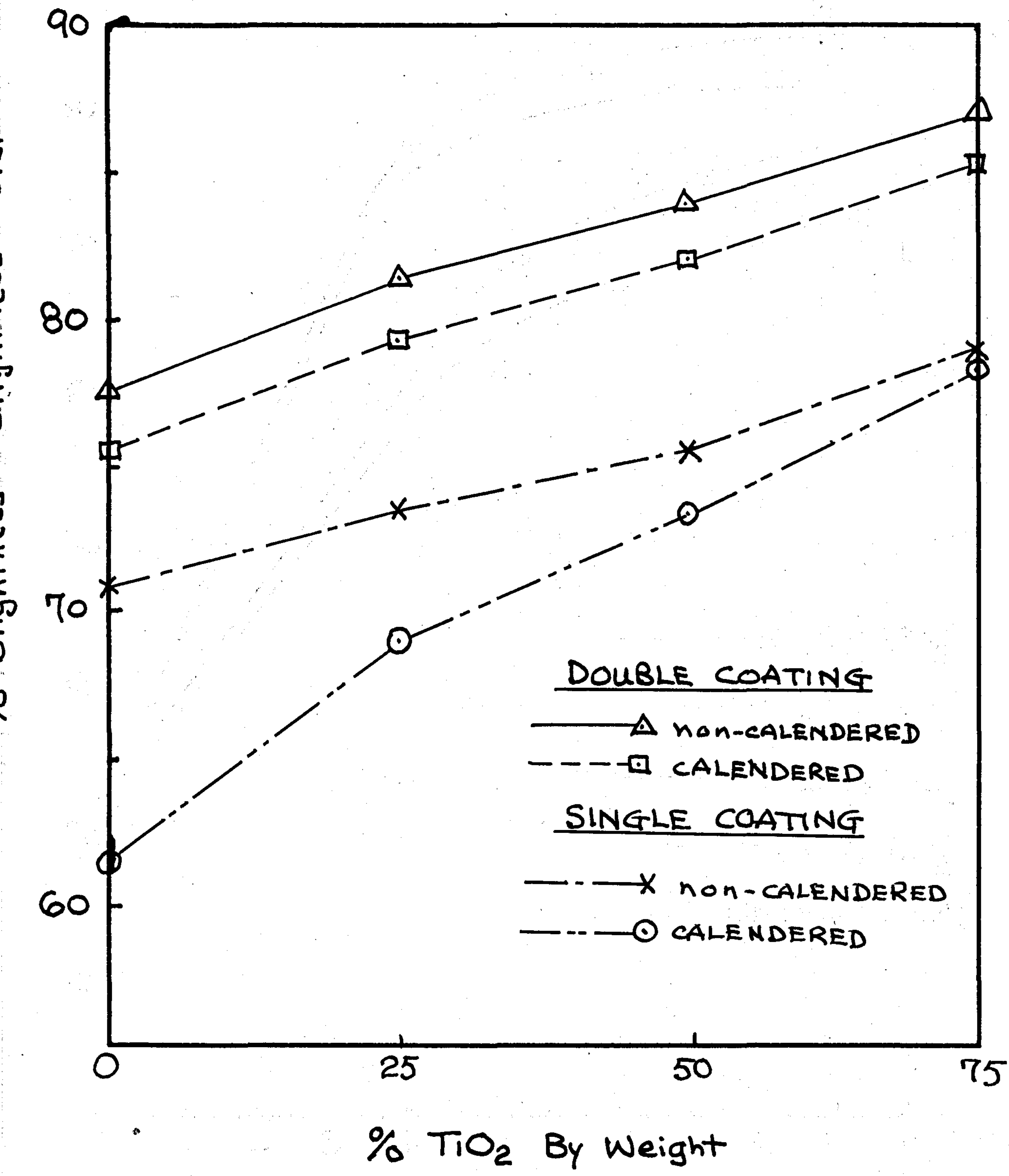
The coating weight change had little effect on brightness after about 6 pounds/1000 ft^2 in single coating sheet and after about 5 pounds/1000 ft^2 in double coating sheets. Therefore, the coating weights chosen to compare the brightness of TiO_2 content increase were justified.

The study on the brightness tests correlation on Graph IV and V showed that they correlated fairly well within the tests, but did not give the same reading for

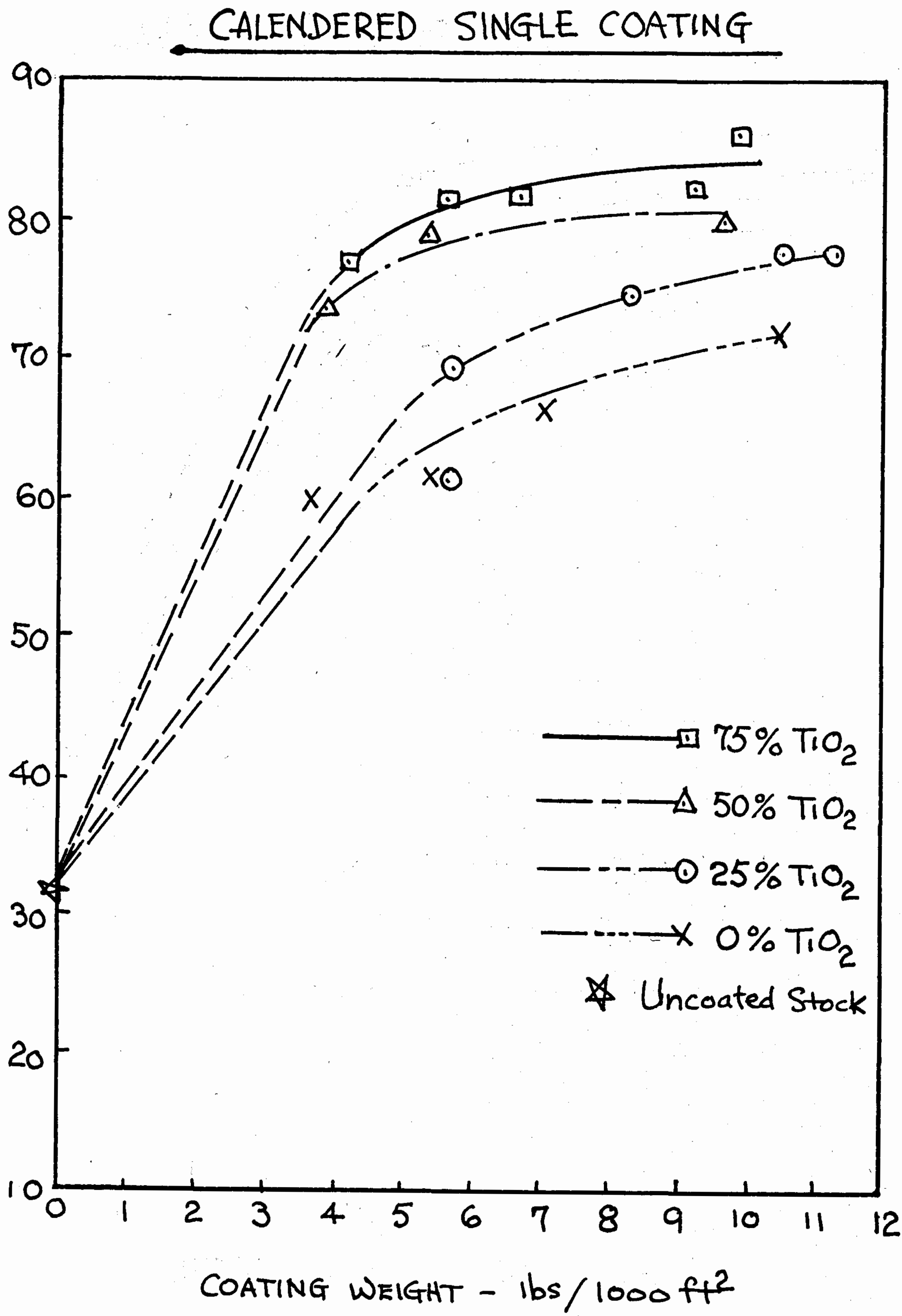
the same paper.

Finally, Graph I showed that the calendering decreased the brightness of all the coated samples used.

Graph I.


90
80
70
60
0
25
50
75
% TiO2 By Weight
DOUBLE COATING
non-CALENDERED
CALENDERED
SINGLE COATING
non-CALENDERED
CALENDERED

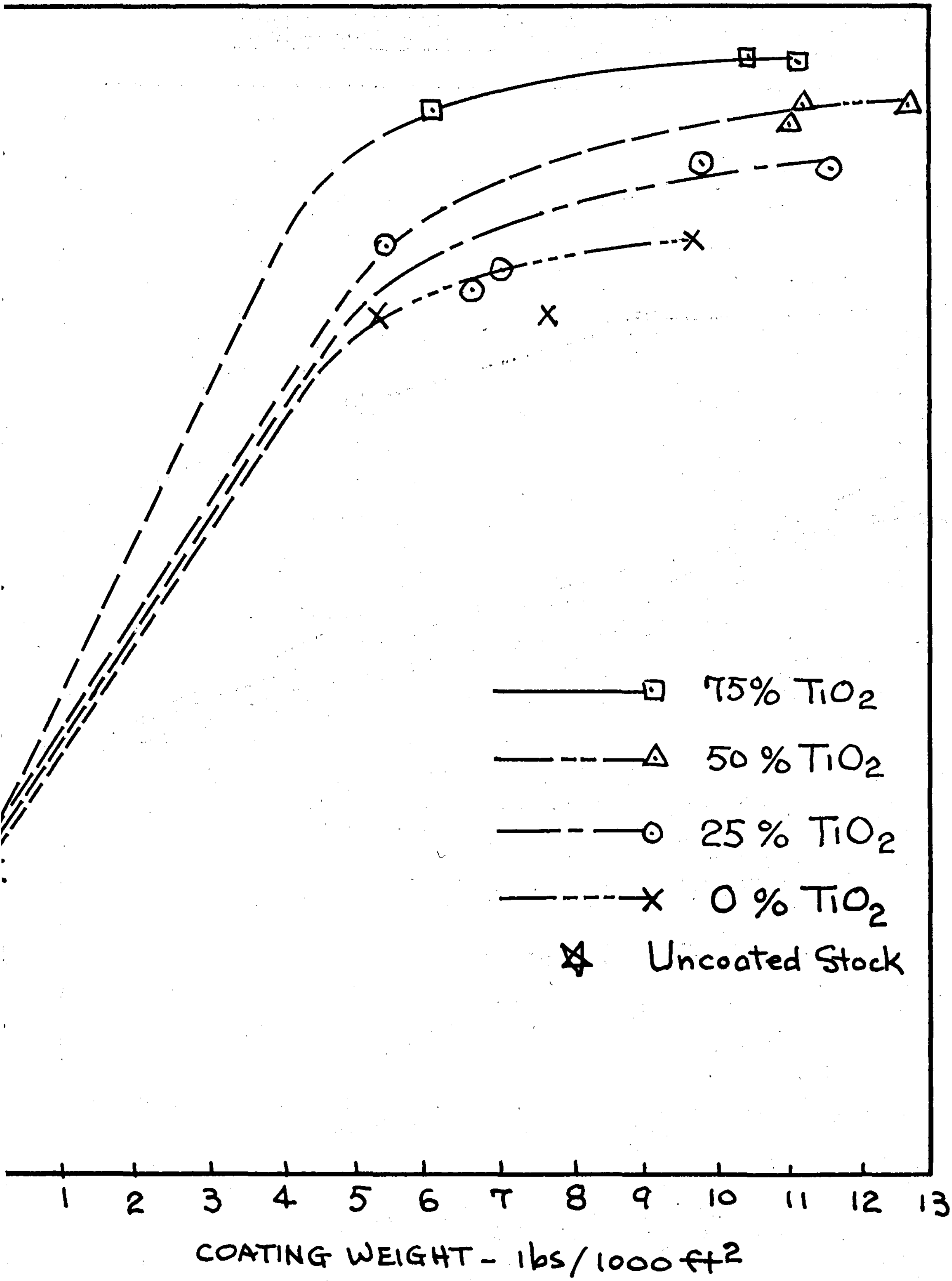
Graph II.



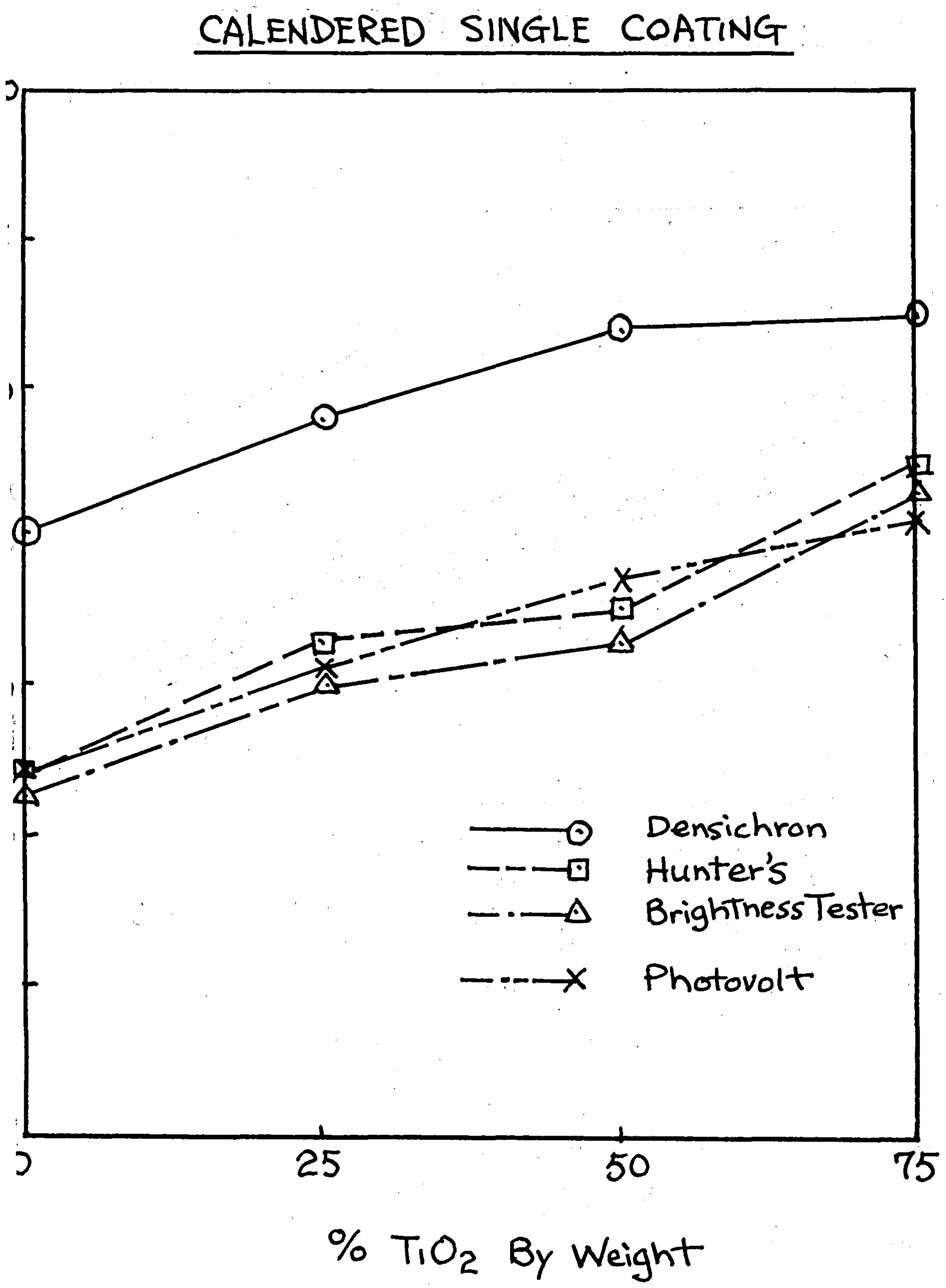
CALENDERED SINGLE COATING
90
80
70
60
50
40
30
20
10
0
1
2
3
4
5
6
7
8
9
10
11
12
75% TiO_2
50% TiO_2
25% TiO_2
0% TiO_2
Uncoated Stock
COATING WEIGHT - lbs/1000 ft²

Graph III.

CALENDERED DOUBLE COATING



Graph IV.


CALENDERED SINGLE COATING
Densichron
Hunter's
Brightness Tester
Photovolt
25
50
75
% TiO_2 By Weight

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