6-1963

A Study of the Comparative Effects of Titanium Dioxide on Paper Brightness and Opacity When Used as Filler versus Its Use as a Coating Mineral

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A STUDY OF THE COMPARATIVE EFFECTS OF TITANIUM DIOXIDE ON PAPER BRIGHTNESS AND OPACITY WHEN USED AS FILLER VERSUS ITS USE AS A COATING MINERAL

SENIOR STUDENT THESIS

Submitted as a portion of the requirements
for the degree of Bachelor of Science
in Paper Technology

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JUNE, 1963

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INTRODUCTION

Because of the fact, that advertisements printed on bright papers have the most appeal, and papers printed on both sides must have absence of show-through, brightness and opacity have become important variables in paper making.

Titanium dioxide used as a filler or as a coating mineral will cause an increase in paper opacity and brightness. Because titanium dioxide is expensive, it is important to know how it can be used (as filler or coating) to the best advantage.

OBJECTIVE

The purpose of this project is to compare the optical gains (opacity and brightness) imparted to paper by using titanium dioxide as a filler versus its use as a coating mineral.

LITERATURE SURVEY

In the literature it was found that extensive research has been carried out comparing titanium dioxide to other coating and filler minerals. However there is not any published literature making a direct comparison of titanium dioxide used as a filler versus its use as a coating mineral, for the purpose of increasing paper brightness and opacity.

Therefore I believe this project will be of value.

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EXPERIMENTAL WORK

EXPERIMENTAL PROCEDURE

Stock Preparation

The pulp used in this project was Astracel, which is a black gum fully bleached kraft pulp.

It was developed to a 360 Canadian Standard freeness using a Valley laboratory beater in accordance with Tappi Standards. A small amount of formaldehyde was added as a preservative.

Titanium Dioxide Dispersion

Anitase titanium dioxide was used. The dispersion was prepared in a J. H. Day laboratory two sigma blade kneader. It was worked for twenty minutes at 79.0% solids with .5% tetra sodium pyro phosphate (based on the mineral weight) added as a dispersing agent.

This "mud" was used as filler for the filled hand sheets, and as coating mineral for the coated hand sheets.

Preparation of Handsheets

All hand sheets were prepared using the Noble and Wood sheet mold equipment in accordance with Tappi Standards. The desired sheet weight was 2.80 gm.,

which is equivlent to a 46 lb./25x38 - 500 basis weight.

Demineralized water was used to prevent a color change due to rust and other impurities in tap water. One-hundred and twenty handsheets were prepared for coating.

In preparing the filled sheets it was decided to use no alum or size. A 20% solids, titanium dioxide dispersion was made in a Weyering blender, using the previously prepared titanium dioxide "mud". It was experimentally determined that the handsheet filler retention was about 15% for sheets containing 5% mineral, and 5% retention for sheets containing more than 5% mineral.

Handsheet Coating

A coating dispersion was made up to 50% solids, using the titanium dioxide "mud" and 6% starch (based on the mineral weight). The adhesive used was medium viscosity oxidized potato starch, M-27 X St. Anthony Starch Company. It was dispersed in cooled water, then heated to 85° C for fifteen minutes.

Before coating, the handsheets were calendered, 1 nip, at a pressure of 1000. lb./linear inch, on the W. M. U. laboratory super calender. This was found

necessary to prevent the coating from diffusing into the sheet during application. A number eight drawdown rod was used for applying the coating.

Nine sheets were coated with the 50% solids dispersion. Then the coating dispersion was progressively diluted, coating a series of nine sheets at each dilution. By diluting, or cuting the percent solids, the coat weight became progressively less.

Percent Titanium Dioxide as Filler or Coating

The percent titanium dioxide was determined by running an ash on the paper in accordance with Tappi Standards.

Brightness and Opacity Determination

All handsheets were calendered, 4 nips at a pressure of 1935 lb./linear inch, on the W. M. U. laboratory super calander.

Brightness and opacity values were determined according to Tappi Standards, using the I. P. C. brightness tester, and the Bausch and Lomb opacity tester.

PRESENTATION
AND DISCUSSION OF RESULTS

Data Table I shows the brightness and opacity obtained by varying the percent titanium dioxide (based on sheet weight) as filler.

Data Table II shows the brightness and opacity obtained by varying the percent titanium dioxide (based on sheet weight) applied as coating.

All numbers recorded in Tables I and II are averages of nine experimental values.

Graphs I and II were plotted using the values from tables I and II.

Graph I shows that for equal amounts of titanium dioxide retained as filler or as coating, a substantially higher opacity is obtained with the filler. The following values are from Graph I.

% Titanium Dioxide	Opacity TiO_2 used as coating	Opacity TiO_2 used as filler
2	79.0	80.8
8	83.8	88.2
16	86.7	93.2
28	93.7	96.7

TABLE I

Percent Titanium Dioxide in the Sheet, as Filler Versus Brightness and Opacity

% TiO_2 (Based on sheet weight) as Filler	Brightness	Opacity
0	78.1	77.0
.88	78.9	78.0
1.21	79.3	79.0
1.50	79.5	79.5
2.42	80.1	81.5
3.10	80.5	83.0
4.71	81.7	85.0
5.10	81.9	85.5
6.63	82.7	87.0
8.29	83.7	88.5
12.50	85.8	91.5
15.47	87.1	93.0
16.58	87.5	93.0
18.10	88.2	94.0
22.6	89.8	95.5
24.5	90.4	96.0
27.2	90.6	96.5

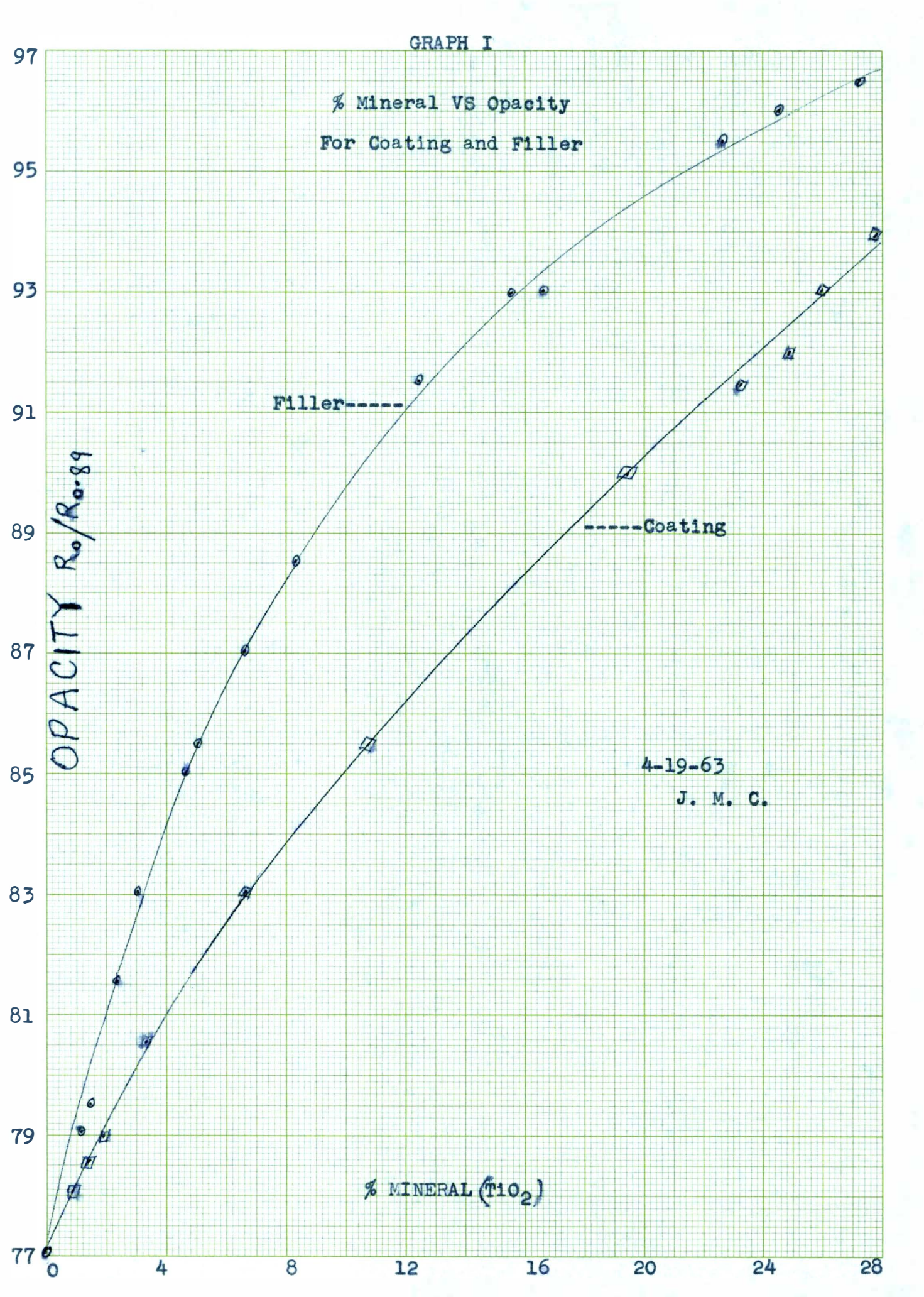
Sheet weight equals 2.8 gm. 6" x 6"
or 46 lb./25x38-500.

TABLE II

Percent Titanium Dioxide on the Sheet as Coating, Versus Brightness and Opacity

% TiO_2 (Based on sheet weight) as coating mineral	Brightness	Opacity
0	78.1	77
.91	79.4	78.0
1.50	79.8	78.5
1.92	80.2	79.0
3.38	81.4	80.5
6.63	83.4	83.0
10.8	85.6	85.5
19.4	88.8	90.0
23.2	90.5	91.5
24.8	90.9	92.0
25.9	91.2	93.0
27.8	91.9	94.0

Sheet weight equals 2.8 gm. 6" x 6" or 46 lb./25x38-500.


GRAPH I
% Mineral VS Opacity
For Coating and Filler
Filler-----
-----Coating
OPACITY $R_o/R_{o\text{-}89}$
% MINERAL (TiO_2)
4-19-63
J. M. C.
97
95
93
91
89
87
85
83
81
79
77
0
4
8
12
16
20
24
28

It takes about half as much titanium dioxide retained as a filler, to give the same opacity as when the titanium dioxide is used as a coating. The following examples are from Graph I.

Opacity	% TiO_2 as Filler	% TiO_2 as Coating
78	0.5	1.0
80	1.5	3.0
84	4.0	8.3
88	7.9	15.6
90	10.2	19.5
92	13.8	24.0

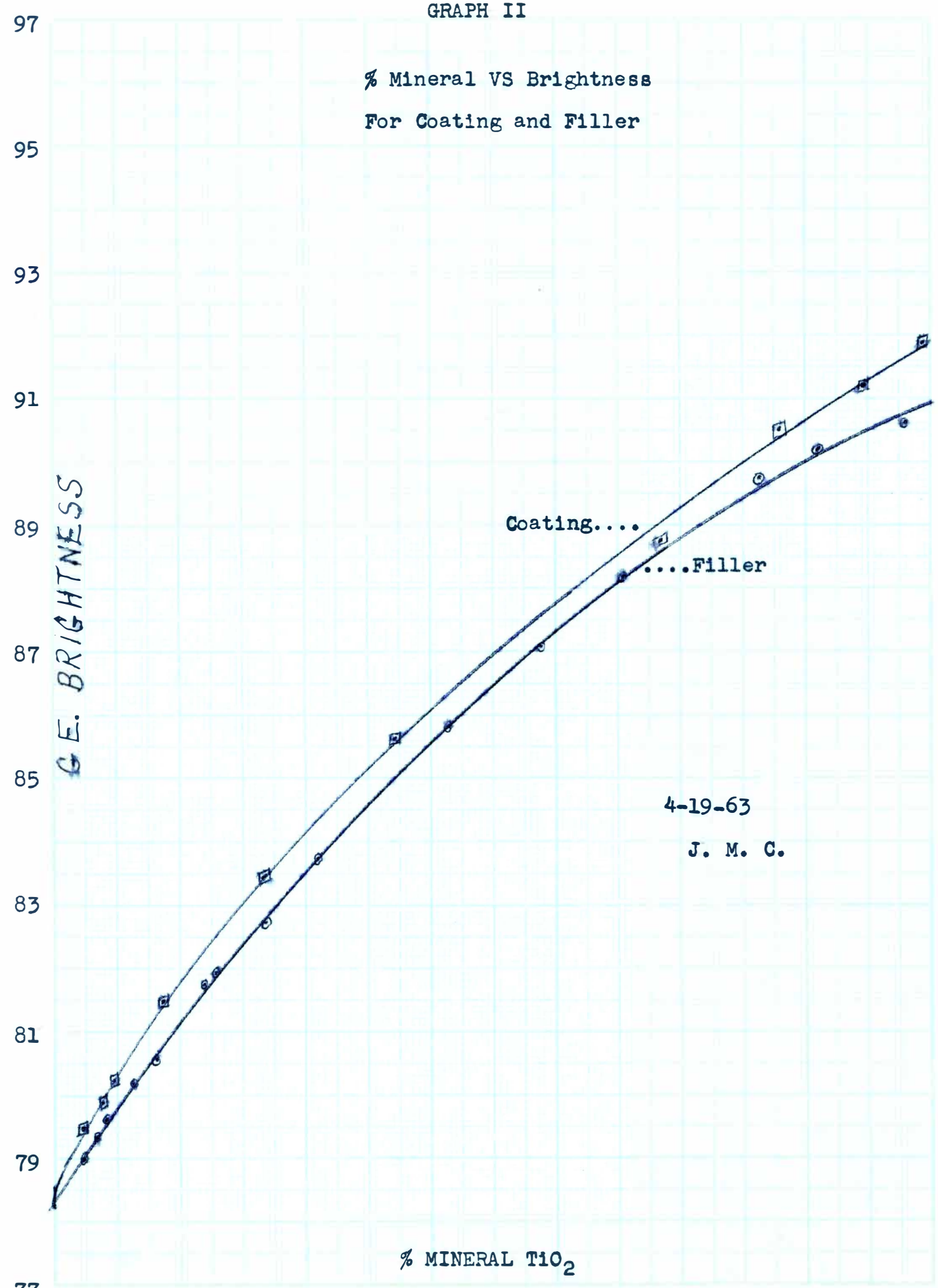
From this one can see, if the overall filler retention was only 50%, there would have to be 100% total usage of the coating mineral to obtain the same opacity. Since one never gets 100% total usage of coating mineral, and practically always gets higher than 50% overall retention of filler, it would be more economical to use titanium dioxide as a filler than as a coating mineral to gain opacity.

Graph II shows that for equal amounts of titanium dioxide retained as filler or coating, a slightly higher brightness can be achieved with the coating. The following values are from graph II.

GRAPH II

% Mineral VS Brightness

For Coating and Filler



% Titanium Dioxide	Brightness TiO_2 used as filler	Brightness TiO_2 used as coating
4	81.0	81.6
12	85.5	86.0
20	88.8	89.3
24	90.0	90.6

From the above it is evident that paper samples containing equal amounts of titanium dioxide are slightly brighter when the titanium dioxide is used as coating, rather than filler.

However one cannot say whether coating or filling would be the most economical without knowing the mineral retentions of each.

In view of the fact that one can gain paper brightness cheaper per unit weight by using brighter pulps, or other high brightness minerals in place of titanium dioxide, the above relationship was brought out only as a side issue during the investigation of how one can gain the greatest amount of opacity (by coating or filling) with titanium dioxide.

FACTUAL AND THEORETICAL CONCLUSIONS

1. From the experimental data one can conclude that when starting with a 78 brightness pulp, a substantially higher opacity can be achieved by using titanium dioxide as a filler rather than a coating.

2. As a side issue in connection with using titanium dioxide to increase opacity, one will obtain, a little more brightness with the coating than the filler, for the same percent of titanium dioxide in the sheet.

3. One theoretical explanation for the greater opacifying power of titanium dioxide when used as a filler rather than a coating could be, because the coating adhesive tends to seal or fill some of the interstices of the medium, thus leaving less air, mineral, fiber, interfaces which are necessary in bending the light waves and preventing transmittance.

As a final remark I would like to say it may be a combination of filler and coating that would give the greatest gain in opacity when using titanium dioxide. This would be an interesting problem for a future project.