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Prediction of Neutral Requirements for Letterpress Printing

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"PREDICTION OF NEUTRAL REQUIREMENTS
FOR LETTERPRESS PRINTING"

BY

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ABSTRACT

This paper compares two systems for neutral requirement predictions in terms of % dot area values of halftone seperation negatives. The systems compared (to note a significant difference in the neutral requirement prediction) were the GATF system using the "GATF Color Reproduction Guide" as control and the RIT system which calculates neutral requirements from empirical second degree equations. A significant difference between calculated values of neutral requirements for each prediction system was concluded.

1. INTRODUCTION:

"Principles of Color Photography" by Evans, Hanson, and Brewer states that-"Experience has shown that one of the prime requirements which a color process must fulfill is that it reproduce a scale of neutrals approximately as neutrals."[1] In photographic color reproduction systems the reproduction of neutrals or color balance is controlled by the original choice of colorants, in this case dyes, and by the amount or concentration of dyes that can be formed in the intregal tripack.[2] In graphic arts color reproduction systems inks are used as colorants and neutral reproduction can be controlled by (a) varying the thickness of ink transferred to the paper or (b) varying the size of the halftone dot area in any or all of the three colored images.[3] In most cases the control is accomplished with a variation in the relative sizes of the yellow, magenta, and cyan halftone dot areas with the ink thickness being constant.[4] To determine these relative halftone sizes for neutrals is what is known as determining the neutral requirements of an ink set.

Necessary - not sufficient

The definition of a perfect ink set is one that will produce neutrals by overprinting equal halftone dot areas of each of the three process inks (yellow, magenta, and cyan). When equal halftone dot areas are overprinted with conventional ink sets a near neutral is produced rather than a neutral. This near neutral will look brown with most ink sets. To produce a better neutral, the halftone dot sizes of one or all of the process color printers must be altered from equal dot sizes. The extent of this alteration in dot sizes depends on several system variables such as the ink set, the paper and the press used.[5] Several methods are available for determining the neutral requirements of the three colorants. One method, a combination of graphical solution and computation is described in a report of the Graphic College of Denmark.[6] This system involves numerous computations and plottings on the G.A.T.F. Color Hexagon diagram.[7] While it is reasonably simple it is too lengthy for the average plant to use. In a paper by I.Pobboravsky, R.I.T.-G.A.R.D.[8] two methods for calculating the colorant amounts that would produce neutrals for any colorant set are described. One method uses the Neugebauer and Murray-Davis equations while the second method uses empirically derived second degree equations. Both methods require the use of a colorimeter and a digital computer which are not usually found in the average printing plant. An alternate method which does not require the use of any unusual instrumentation is noted in a paper from G.A.T.F. by Eljziw and Preucil which uses "The New G.A.T.F. Color Reproduction Guide"(5). In this system a 3 color equal dot overprint representing ink, paper, and press variables is produced by individual plants. This overprint appears brown rather than neutral and is included in the copy to be reproduced when halftone seperations are made. During the making of the seperations the 3 color overprint area of the control guide is exposed to produce equal dot areas in each seperation negative. Subsequently the plates are made and the printing done in the conventional manner. The authors claim that by using this system, neutrals in the copy will be reproduced as neutrals in the reproduction. The G.A.T.F. system is based on the theory of duplication(9) i.e. if the overprint which is brown is reproduced as brown then neutrals will be reproduced as neutral. Duplication by definition is the making of an exact facsimile(10) of the neutrals in the copy. This assumes the same colorants that produced the neutral in the copy will be used to make the neutrals in the reproduction. However using the G.A.T.F. system for neutral reproduction this requirement in most cases will not be accomplished i.e. the colorant or colorants used to prepare the original neutral will not be the same as the colorants used to make the reproduction. Normally the colorants of the original will not be known Therefore on the theory of duplication, this system nay not predict neutral requirements as is claimed.

2. OBJECTIVE:

It is the objective of this paper to determine if a significant difference exists between the G.A.T.F. system and a graphical presentation of I.Pobboravsky's second degree equation system (hereafter called the R.I.T. system) for neutral requirement predictions of % dot area values for halftone seperation negatives.

3. EXPERIMENTAL PROCEDURE

(I) The neutral requirement prediction is based on a calculated % dot area value for each of the 3 inks in an ink set. The % dot area values used to compare the G.A.T.F. system and the R.I.T. system in this experiment were based on values for neutral areas in each of 3 seperation negatives that would be used to prepare printing plates. These % dot area values for both systems were compared to note any difference between systems for each of three letterpress ink sets printed on 80 lb. coated stock. The ink sets used were as follows:

A. Ault & Wiborg Litho Ink -lemon yellow
-rhodamine red
-process blue

B. Canada Printing Ink -L/P process yellow
-L/P process red
-L/P process blue

C. General Printing Ink -L/P fluorescent process yellow
-L/P fluorescent process red
-L/P process blue

(II) In the test copy, neutrals used for dot area calculation were representative of typical copy. These neutrals included (a) a scale of neutrals from premixed cyan, magenta, and yellow printing inks,(b) a silk screen ink neutral scale, (c) a photographic silver neutral scale, and (d) photographic neutral scales prepared from cyan, magenta, and yellow dye sets.

(III)%Dot Area Calculation Using the G.A.T.F. System.

A. The G.A.T.F. Color Reproduction Guide (see appendix) was printed by letterpress methods on a Meile Vertical V-50 press. It was printed using the 3 ink sets noted above.

B. The Guide was included in the test copy and seperation negatives were made on Dupont Cronar High Contrast Seperation Negative film developed in Kodak HC-110 developer. Wratten filters no. 25,58, and 47B were used in making the seperations. The seperation negatives were exposed and developed so as to produce equal density and consequently equal dot areas in the corresponding overprint area of each seperation. The required density of the overprint area of the Guide in each seperation was to be a density that would give the same half-tone dot area as in the negatives used to make plates for the initial printing of the Guide(step A). In achieving this requirement (density) film-dev. data from the manufacturer was used to determine an initial exposure-development combination. Successive exposures approaching the required density consumed considerable time and a density variation of 0.05 between seperations was accepted. This density variation would result in approximately a 2.0 % dot area variation which is not significant.

C. The density of each neutral in each seperation was read with a Macbeth TD102 densitometer.

D. Each density value was converted to % dot area values using a density VS % dot area curve. (see appendix, Graph I)

(IV) <u>% Dot Area Calculation Using the R.I.T. System.</u>

A. The R.I.T. equal dot hexagon pattern (see appendix) was letterpress printed using a Meile Vertical V-50 press. It was printed using the 3 ink sets noted above. This pattern contains 20 individual dot area levels in increments of 5% dot area from 0% to 100% and includes individual cyan, magenta, and yellow areas as well as a 3 color overprint for each level.

B. For the illuminant "C" neutral scale the colormetric values (%R,%G,%B) as well as visual densities corresponding to brightnes levels from 0% to 100% were calculated as follows:

B. Cont'd.

-- Illuminant "C", C.I.E. values

$$x = 0.310$$
$$y = 0.316$$
$$Y = 0\% \text{ to } 100\%$$

-- Convert x,y,Y values to R,G,B values

$$X = 0.748R + 0.196B$$
$$Y = G$$
$$Z = 1.18B$$

also

$$X + Y + Z + sum$$
$$y = Y/sum \; ; \qquad sum = Y/y$$
$$x = X/sum \; ; \qquad X = x(sum)$$
$$Z = sum - X - Y$$

therefore

$$R = (X - o.196B) / 0.784$$
$$G = Y$$
$$B = Z/1.18$$

-- for the same illuminant "C", C.I.E. values calculate visual densities

$$D_r = \log (1.0/R)$$
$$D_g = \log (1.0/G)$$
$$D_b = \log (1.0/B)$$

From this calculated data a plot of visual density vs colormetric reflectance for the 3 colorants corresponding to illuminant "C" neutrals was made. See Figure 1. The values for each colorant differed only in the 4th place decimal and consequently only one curve was plotted.

GRAPH II

C.I.E. Illuminant "C" Neutral

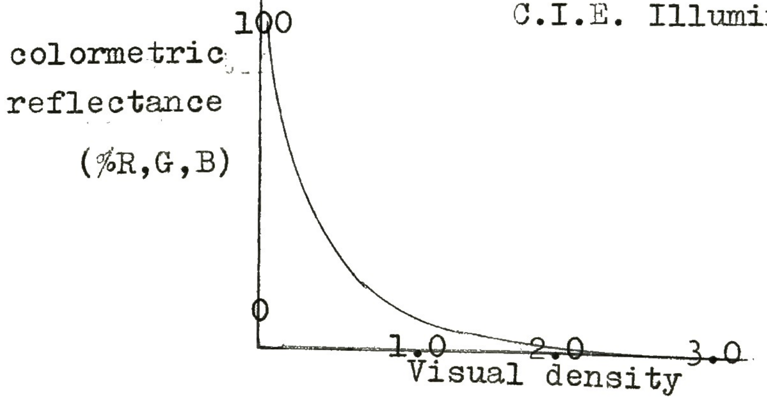


FIG. 1

C. The R.I.T equal dot hexagon pattern that was printed in step A was evaluated colormetrically. Colormetric reflectances (R,G,B,) using a Model IV Colormaster colorimeter were read for (a) the 3 individual colorant amounts used to make the overprint and (b) the near neutral overprint. These values were plotted as follows: (see FIG 2)

- The R value of the cyan colorant VS the R value of the overprint neutral.
- The G value of the magenta colorant Vs the G value of the overprint neutral.
- The B value of the yellow colorant Vs the B value of the overprint neutral.

These curves are produced for each ink set used and tell us the colorant requirements to produce a neutral of specified reflectance.

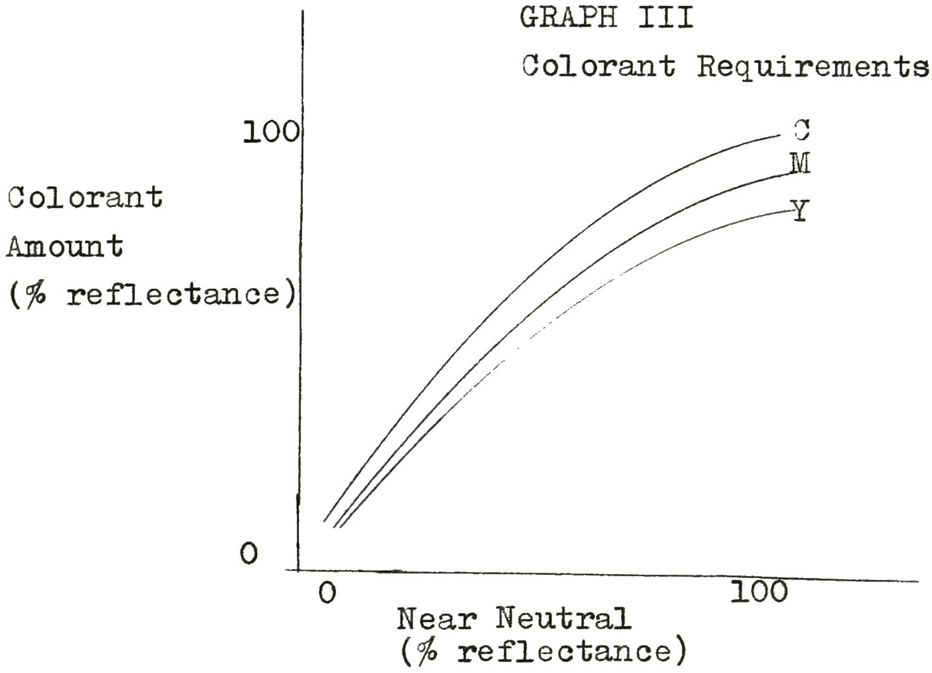


FIG. 2

D. The dot areas of the negatives used to make plates for printing the R.I.T. equal dot hexagon were read with a Densicron % Dot Meter and were plotted Vs the colormetric reflectance of each printed colorant. This was repeated for each ink set. (See FIG. 3)

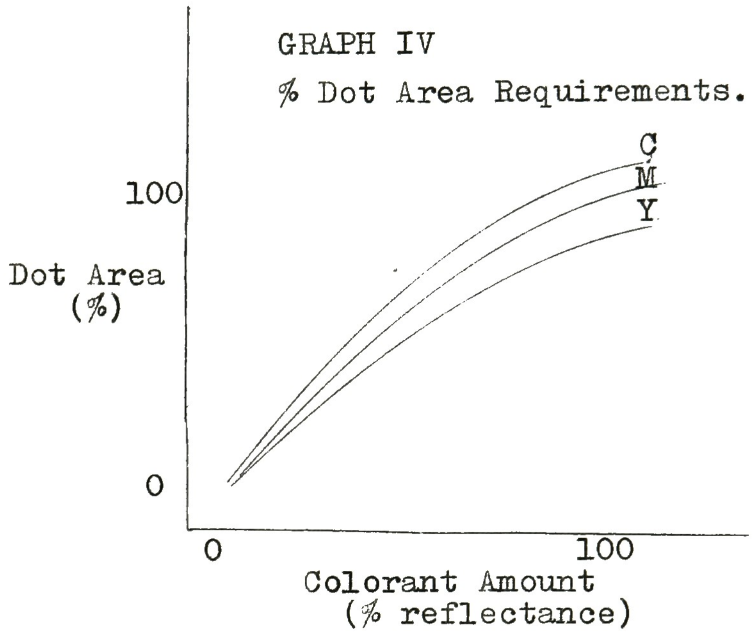


FIG..3

E. To find the calculated % dot area requirements for the neutrals of the copy, the visual density of each neutral was read with a Macbeth RD 100 densitometer. From GRAPH II the 3 colormetric reflectances of the neutral were determined. These values were then used with GRAPH III to find the colorant amounts in terms of reflectance of cyan, magenta, and yellow. Using GRAPH IV these colorant amounts were converted to % dot area values. This graphical computation was repeated for each system as well as each ink set used.

(V) Comparison of The G.A.T.F. system and The R.I.T. system
For each system the calculated % dot area values for the cyan, magenta and yellow colorants were plotted Vs the visual density of the original neutral. This provides three curves on one graph for each prediction system. The curve sets were superimposed with the cyan curve of the G.A.T.F system alligned on the cyan curve for the R.I.T. system (if possible) and any difference in the respective magenta or yellow curves was considered a difference in systems. A difference of more than 4 % dot area between curves was considered a significant difference in systems. The comparison of systems was repeated for each ink set used. This evaluation cannot tell which system is correct but only if a difference in system prediction occurs. The evaluation is independant of tone reproduction and assumes a 1:1 reproduction system.

4. RESULTS:

The results of this experiment are presented in graphical form. The empirically derived graphs used for the calculation of % dot area values for both the G.A.T.F and R.I.T. systems such as GRAPHS I,II,III,IV will be found in the appendix. The bracketed letter after each graph number indicates the ink set used as coded below:

A = Ault & Wiborg Ink
B = Canada Printing Ink
C = General Printing Ink

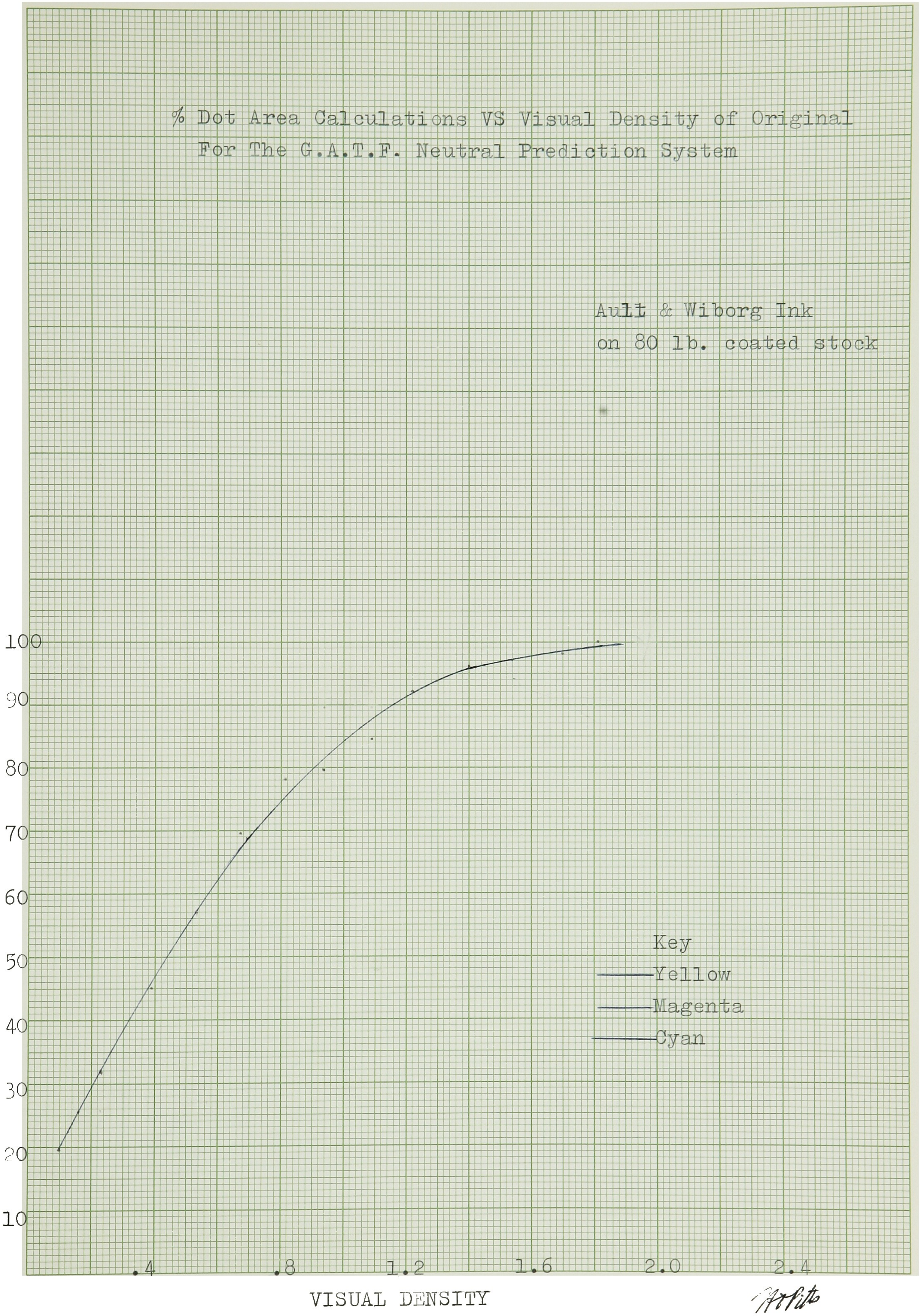
For example GRAPH III(B) is the graph of Colorant Requirements for the Canada Printing Ink Set. The graphs relating the visual density of the original neutrals to the colorant requirements in term of calculated % dot area are at the end of this section. There is a pair of graphs (3 curves each) for each ink set used. Each pair contains one graph representing the G.A.T.F. prediction system and one graph representing the R.I.T. prediction system. The pair of graphs for the General Printing Ink set of inks were not plotted as no % dot area values were calculated. This was due to the fact that this ink set,which contains fluorescent inks, provided ironious information when evaluated colormetrically with the Model IV Colormaster colorimeter. As is noted from GRAPHS III(C) AND IV(C) in the appendix the lowest reflectance value for the fluorescent inks was 60% which was printed from a 5% dot area. Hence the two systems for prediction will not be compared for the fluorescent ink set i.e. the General Printing Ink set.

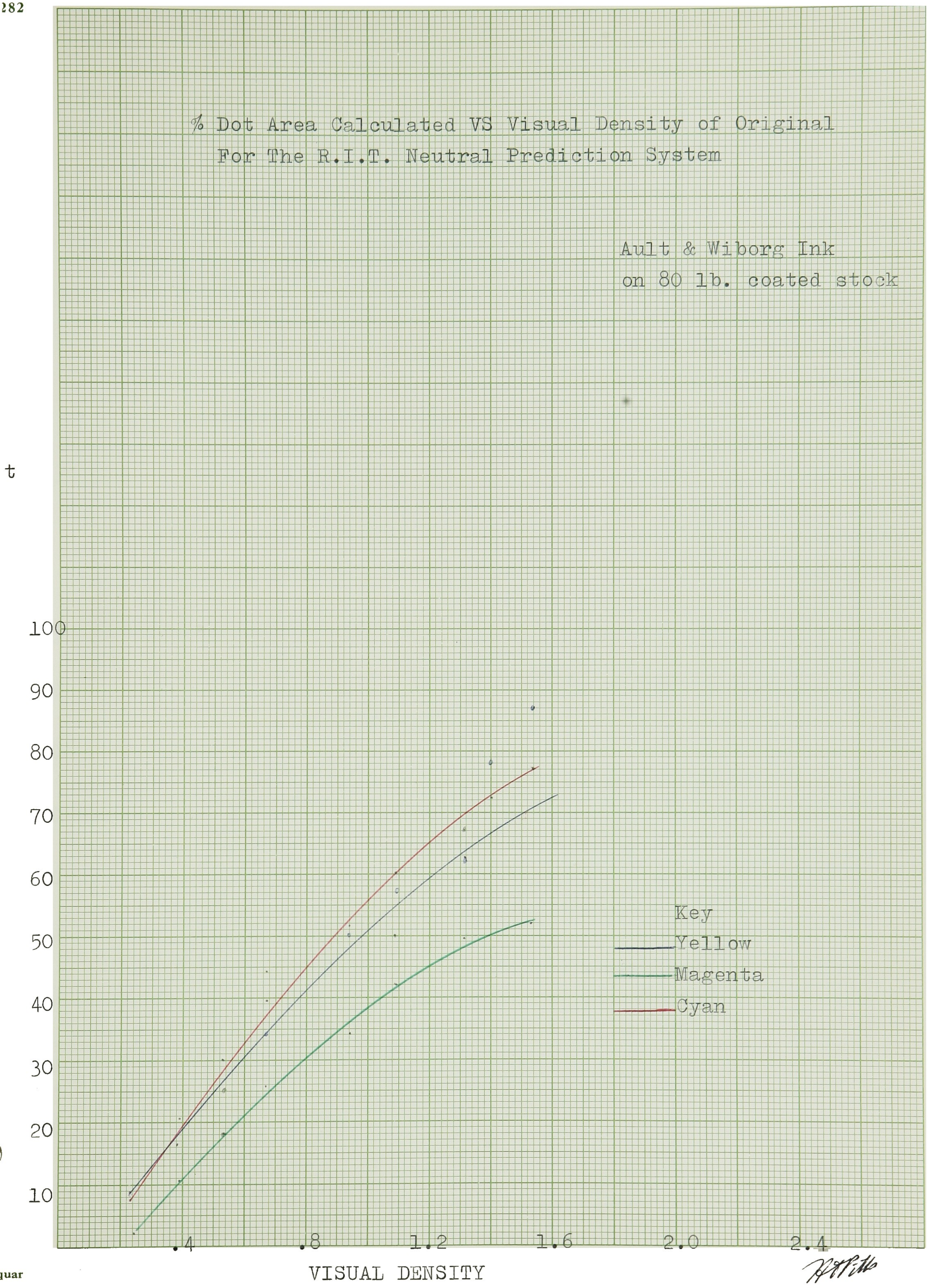
When the graphs relating visual density of the original neutral Vs the calculated % dot area requirements are compared by superposition for both the G.A.T.F. and R.I.T. prediction systems with the Ault & Wiborg Ink set, there was no allignment between the two cyan curves and a considerable variation between both of the magenta curves as well as between both the yellow curves.

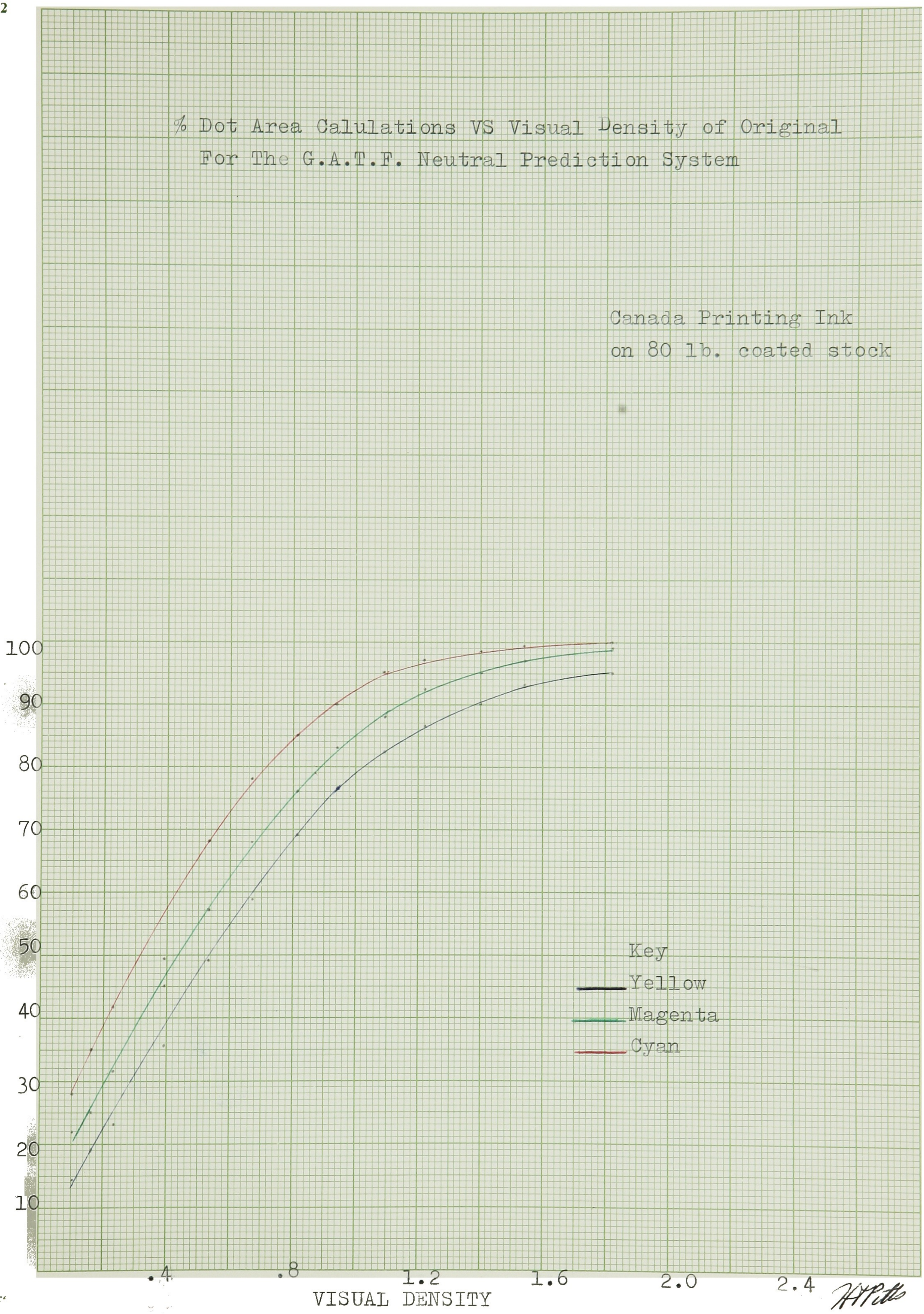
When the same curves for the Canada Printing Ink set were compared for both the G.A.T.F. and R.I.T. prediction systems,the results were similar to the Ault & Wiborg Ink set. No two respective curves alligned and as much as 30% dot area difference was noted between the yellow curves. At no level is the dot area difference less than 10%.

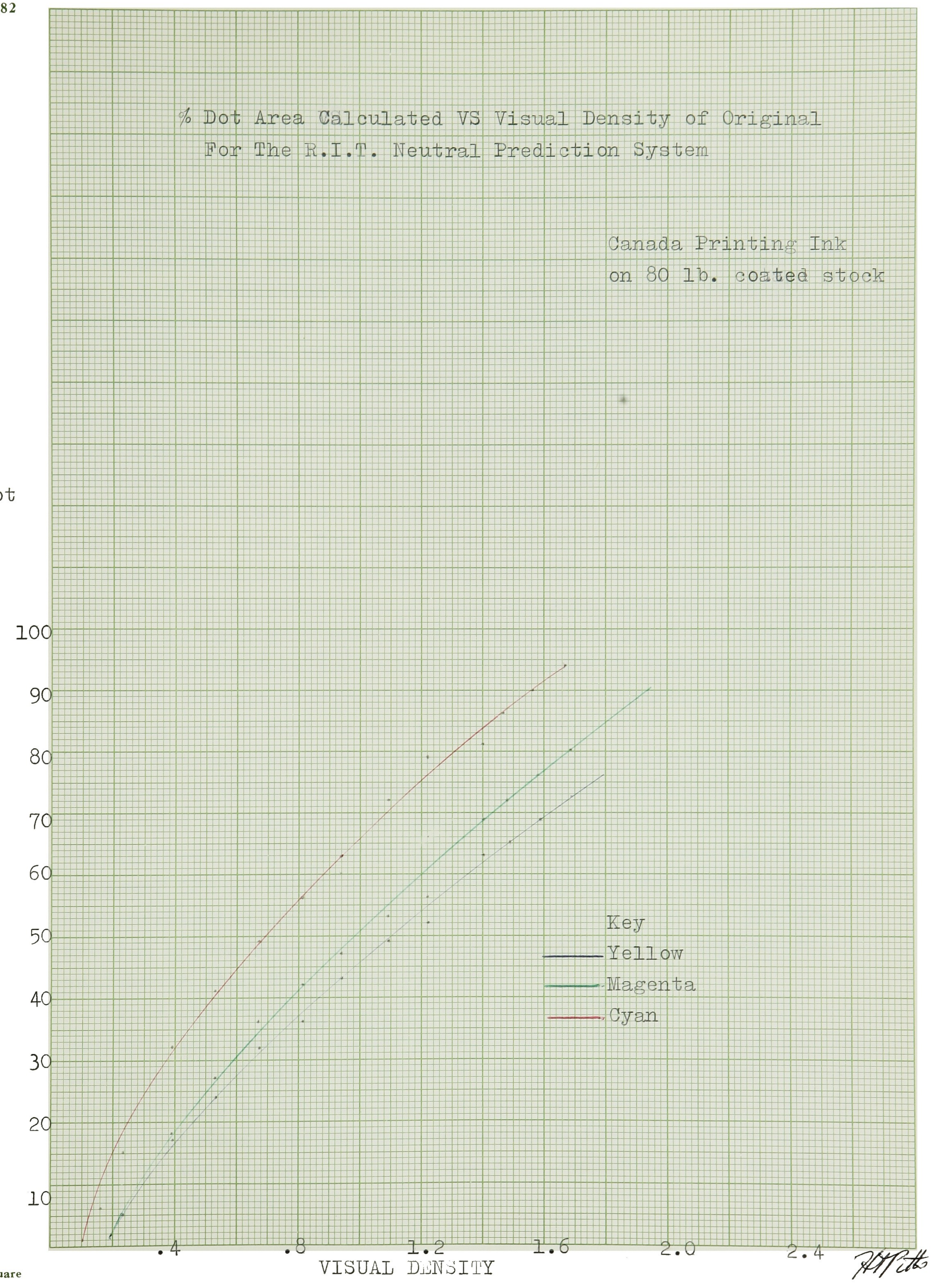
For the Ault & Wiborg Ink set and the G.A.T.F. prediction system there was no difference in the % dot area values of the cyan, magenta, or yellow curves. This indicates that the G.A.T.F. system predicted neutral requirements of equal dot overprints to reproduce the neutrals in the copy for this ink set. This is impossible as we note the equal dot overprint in the G.A.T.F. Color Reproduction Guide for this ink set was a near neutral that looked brown.

The graphs relating the visual density of the original neutrals to the colorant requirements predicted for seperation negatives in terms of % dot area values(there is one graph of 3 curves each for each ink set-prediction system) follow as pages 10 through 13 of this report.


% Dot Area Calculations VS Visual Density of Original
For The G.A.T.F. Neutral Prediction System
Ault & Wiborg Ink
on 80 lb. coated stock
Key
Yellow
Magenta
Cyan
100
90
80
70
60
50
40
30
20
10
.4
.8
1.2
1.6
2.0
2.4
VISUAL DENSITY


% Dot Area Calculated VS Visual Density of Original
For The R.I.T. Neutral Prediction System
Ault & Wiborg Ink
on 80 lb. coated stock
100
90
80
70
60
50
40
30
20
10
.4
.8
1.2
1.6
2.0
2.4
Key
Yellow
Magenta
Cyan
VISUAL DENSITY


% Dot Area Calulations VS Visual Density of Original
For The G.A.T.F. Neutral Prediction System
Canada Printing Ink
on 80 lb. coated stock
Key
Yellow
Magenta
Cyan
100
90
80
70
60
50
40
30
20
10
.4
.8
1.2
1.6
2.0
2.4
VISUAL DENSITY


% Dot Area Calculated VS Visual Density of Original
For The R.I.T. Neutral Prediction System
Canada Printing Ink
on 80 lb. coated stock
Key
Yellow
Magenta
Cyan
100
90
80
70
60
50
40
30
20
10
.4
.8
1.2
1.6
2.0
2.4
VISUAL DENSITY

5. CONCLUSION:

From the results of the preceeding research using two ink sets it is evident that a significant difference exists between the G.A.T.F. and the R.I.T. systems for neutral requirement prediction of % dot area values in halftone seperation negatives.

6. DISCUSSION:

To gain more reliable information for comparing the G.A.T.F. and R.I.T. prediction systems, the printing of the colorant amounts predicted,as separation negative % dot area values, must be completed. This would entail making the halftone seperations, followed by platemaking, and subsequent printing. The printing must be accomplished as nearly as possible under the same conditions that prevailed when the G.A.T.F. Color Reproduction Guide and the R.I.T. equal dot hexagon pattern were printed. This would include the use of the same ink sets,the same paper, and the same press. The reproduced neutrals based on prediction of each system could then be compared with the original neutrals and a practical comparison of systems made. This is necessary because it is highly unlikly that the identical % dot areas would be printed as were predicted. Differences in each system could be noted through measured differences in colormetric values for the original as well as the reproduction.

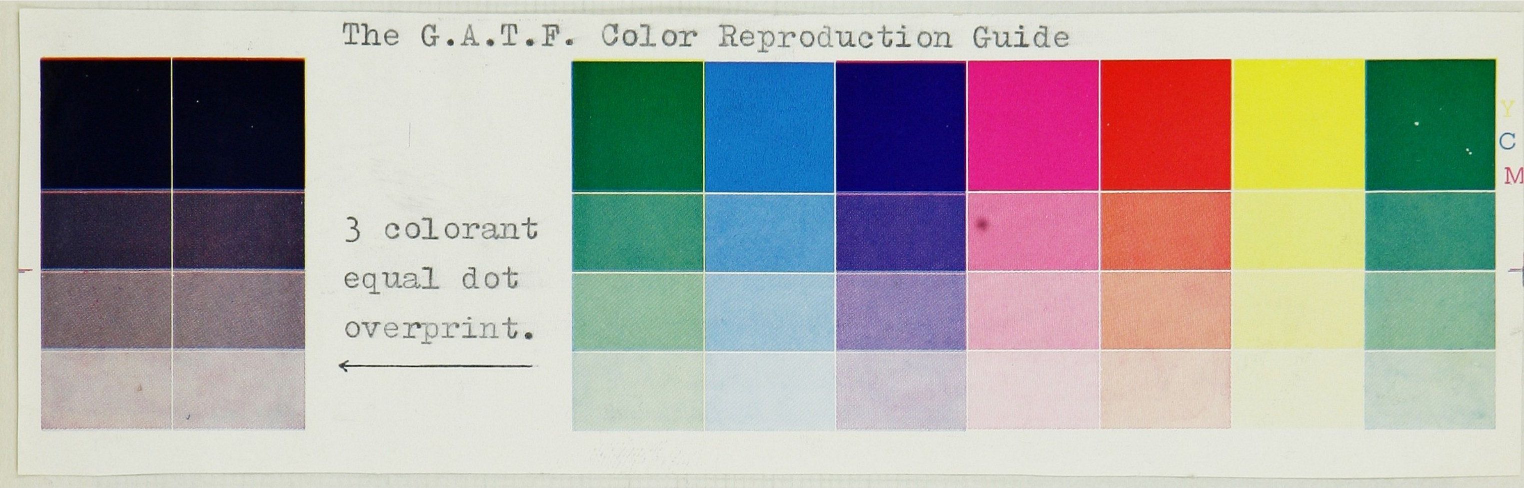
The accuracy of each system could also be determined from actual printed material, based on the systems prediction. This would then provide us with answers to the questions(1) Is there any difference in the neutral requirement prediction between systems? (2) Is there any difference between the neutral requirement prediction and what was actually printed? (3) Is one prediction system more accurate in its prediction of neutral requirements than the second system?

It is important to know if the seperation film material responds the same when exposed to a near neutral as it does to a neutral. This is important because the G.A.T.F. system depends on equal response or metamers. An investigation in this area as well as metamerism of neutrals to be reproduced may provide information for corrective application if the G.A.T.F. system does not predict neutral requirements accurately.

This refers to difference between eye and film response, applied to metameric pairs, especially neutral

Appendix

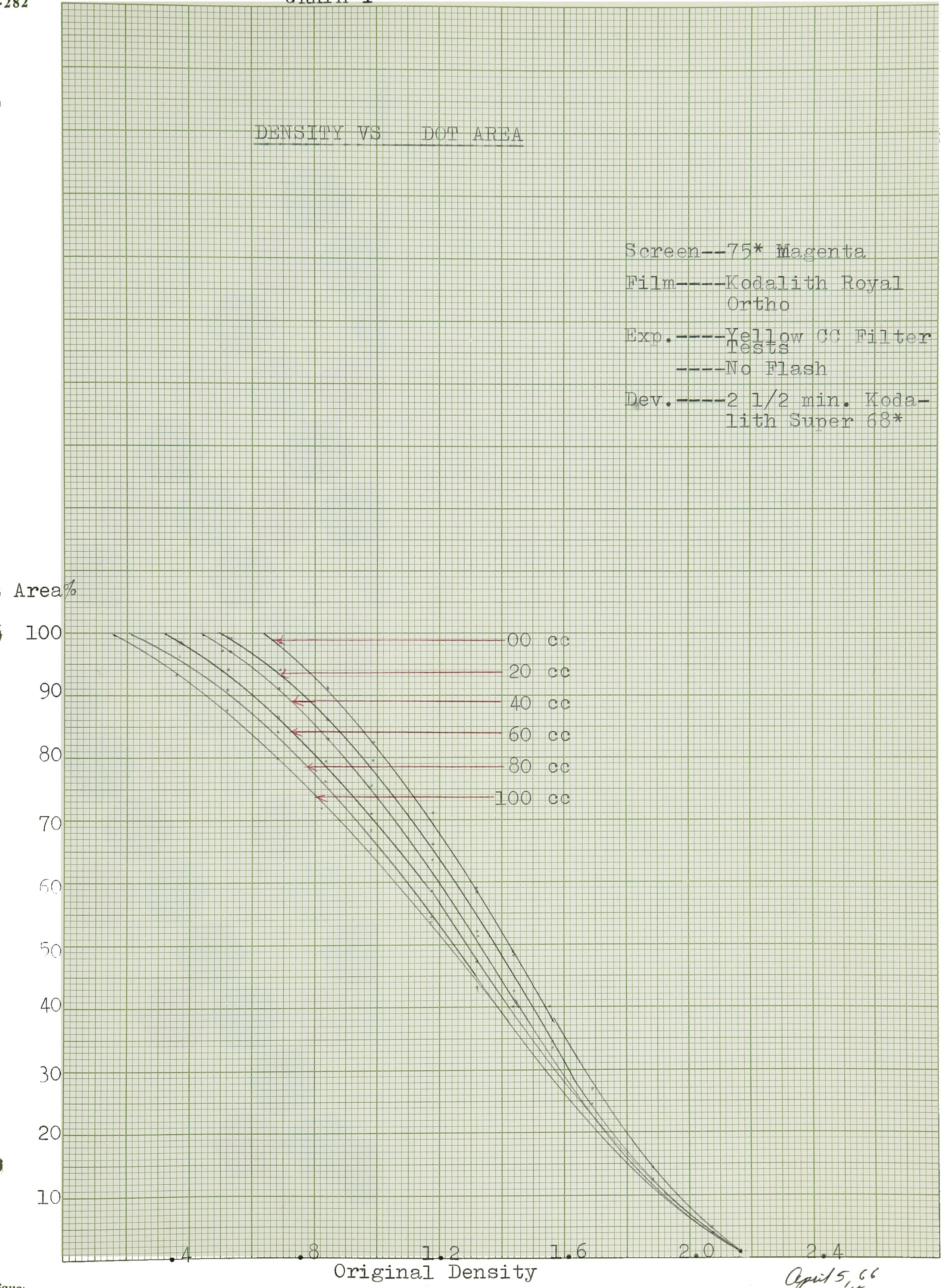
1. Below is a sample printing of the G.A.T.F. Color Reproduction Guide. This sample was printed by letterpress on a Meile V-50 press using Ault and Wiborg Ink.



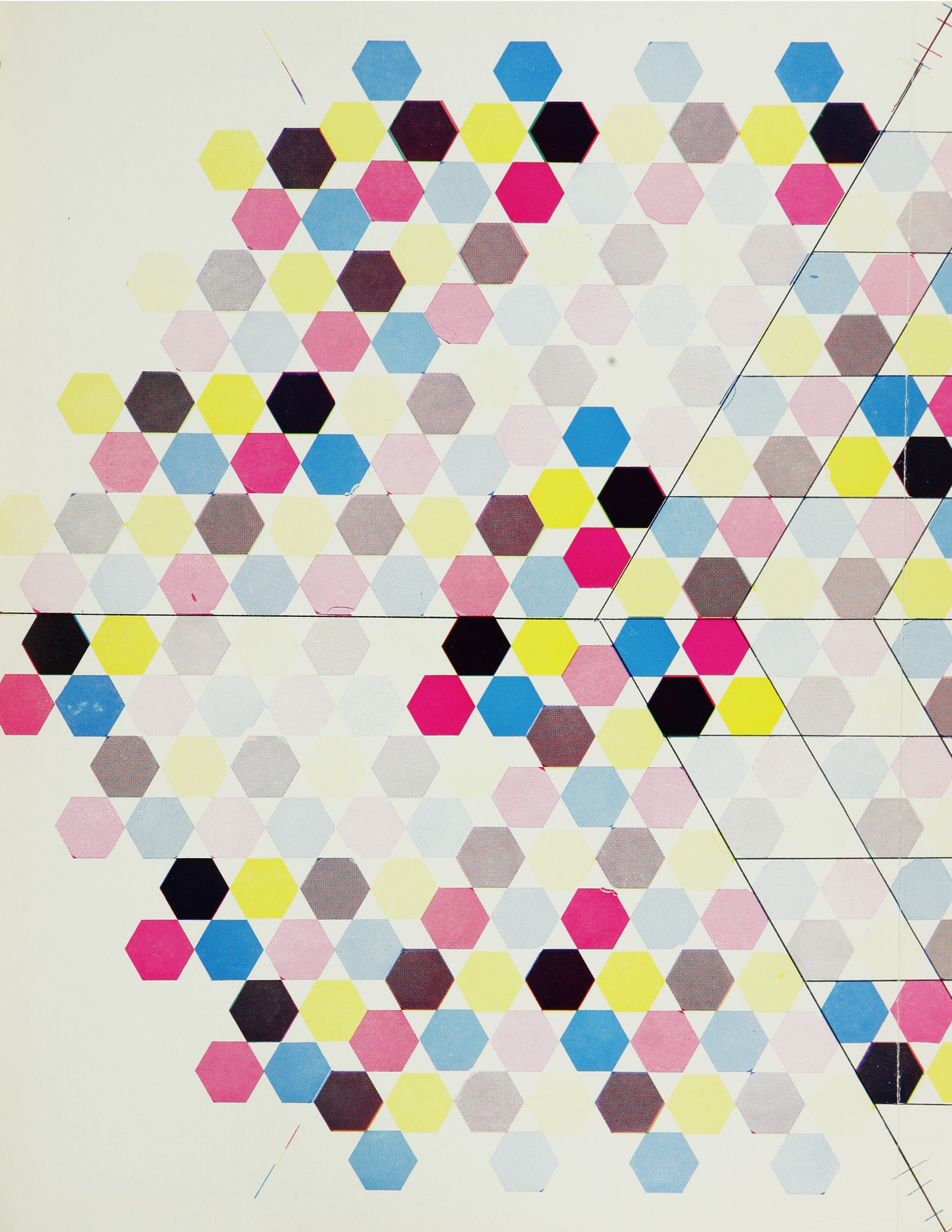
2. On page 16 the density vs dot area curve -GRAPH I- will be found.
3. On page 17 a sample print of the R.I.T. equal dot hexagon will be found. This pattern was devised by B. Archer of R.I.T.-G.A.R.D. It contains 20 levels as outlined by heavy black lines. Within each level there is one overprint (3 color) area as well as areas representing the individual colorant amounts per overprint.

4. On page 18 is GRAPH II.
5. On pages 19 through 24 are GRAPHS III(A), III(B), III(C), IV(A), IV(B), and IV(C) RESPECTIVELY.

GRAPH I

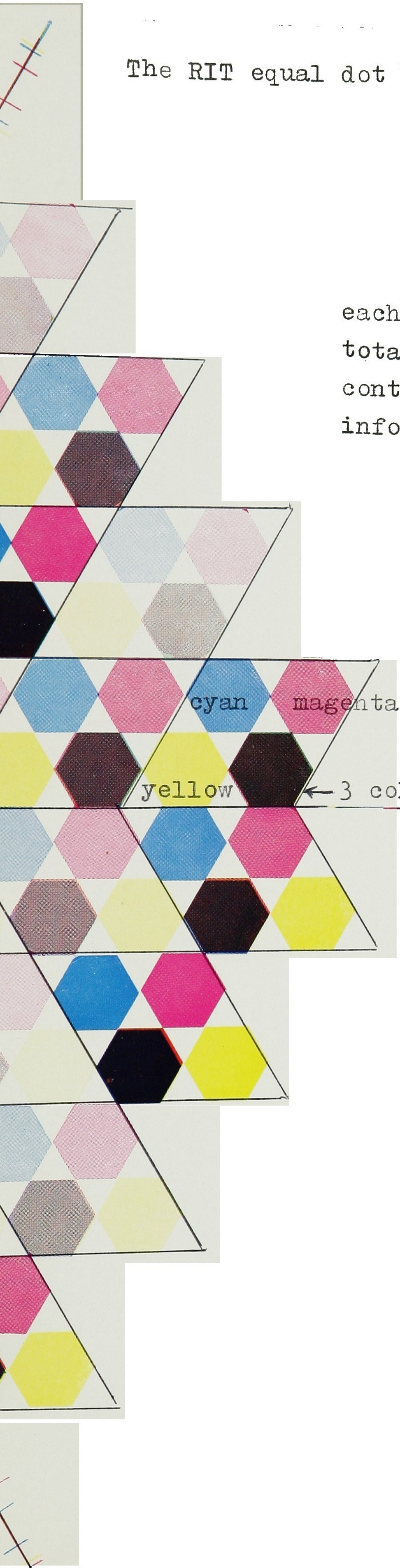


April 5, 66

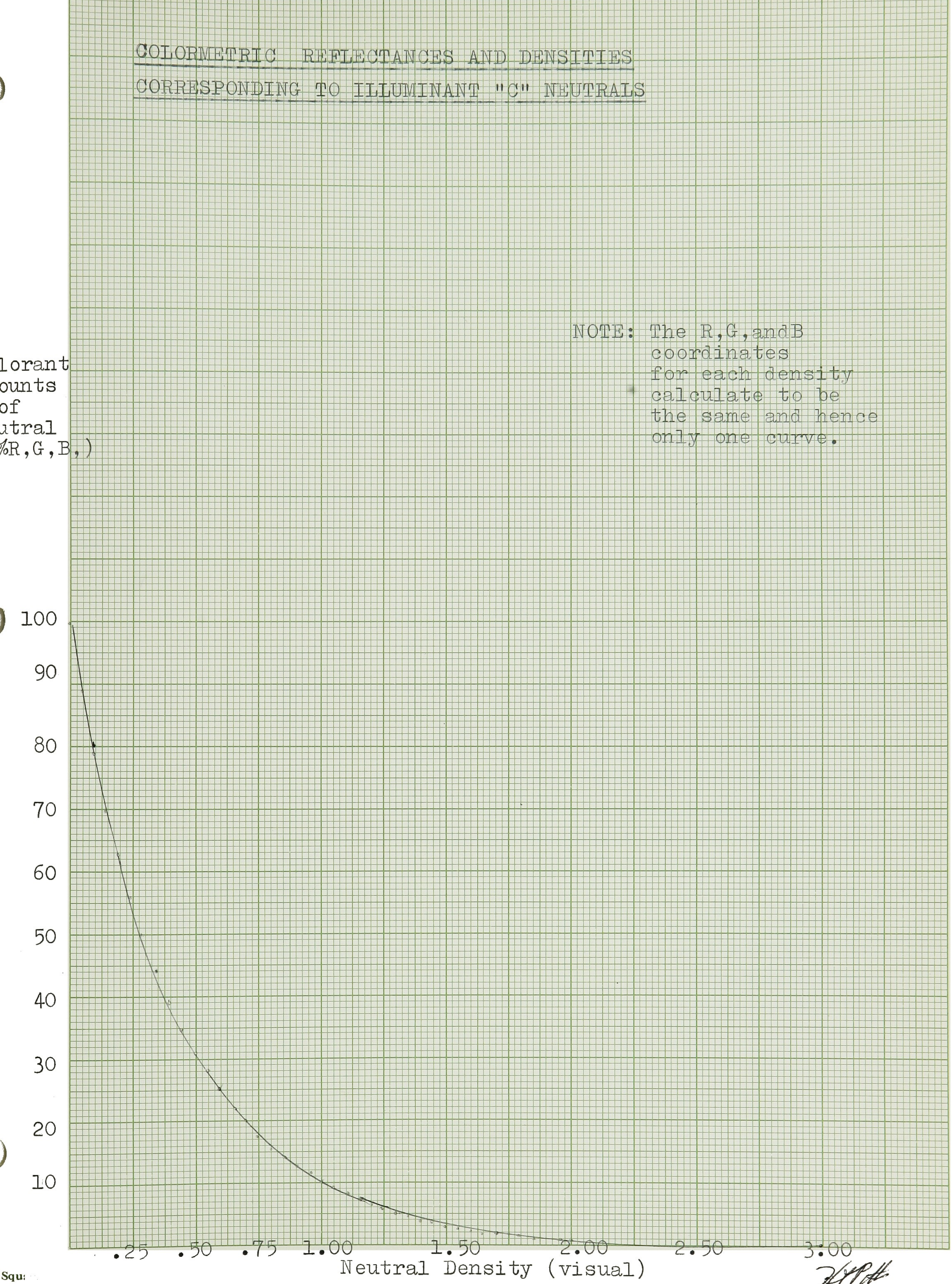


The RIT equal dot Hexagon

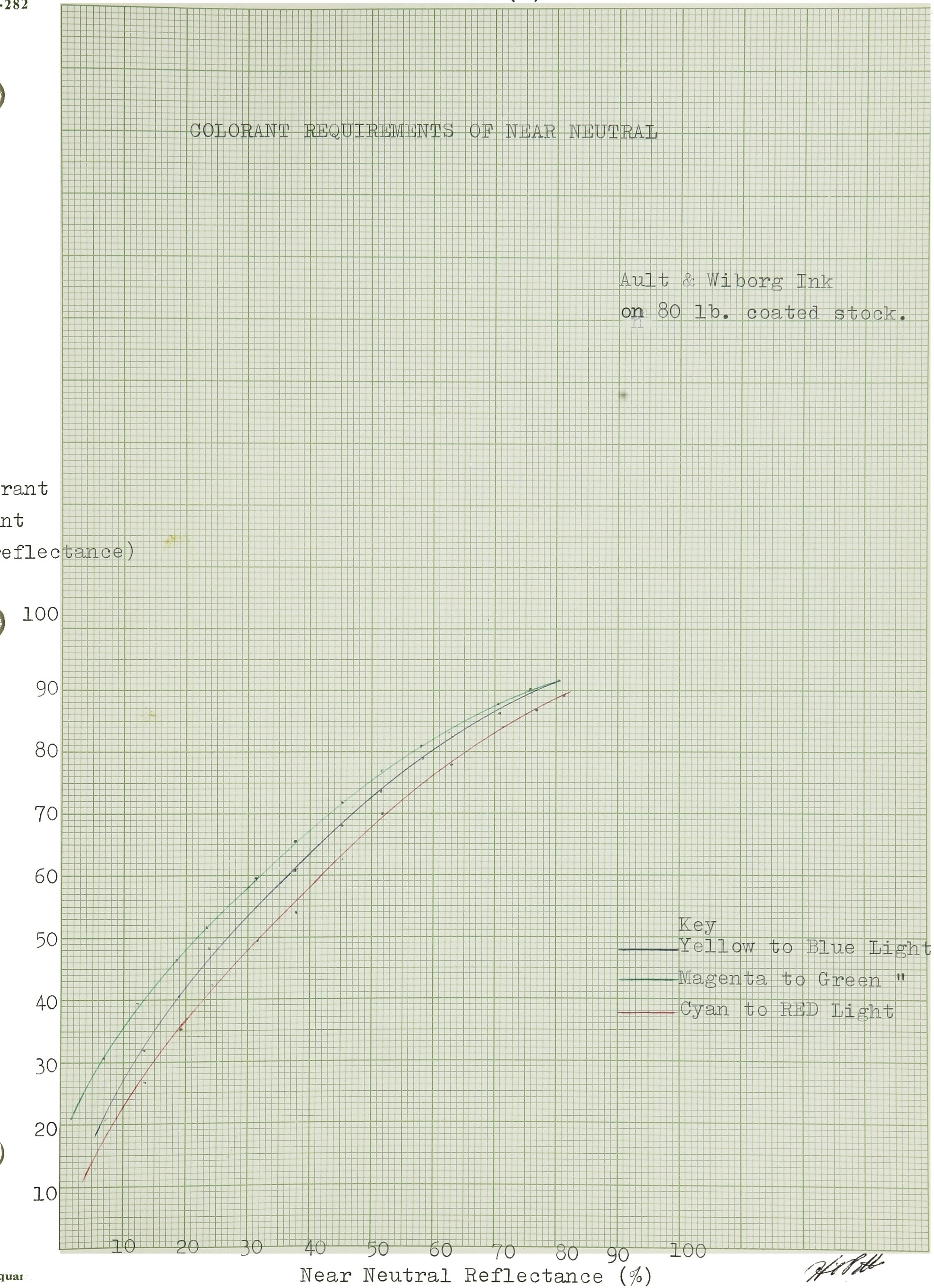
each 1/3 of the total hexagon contains the same information.



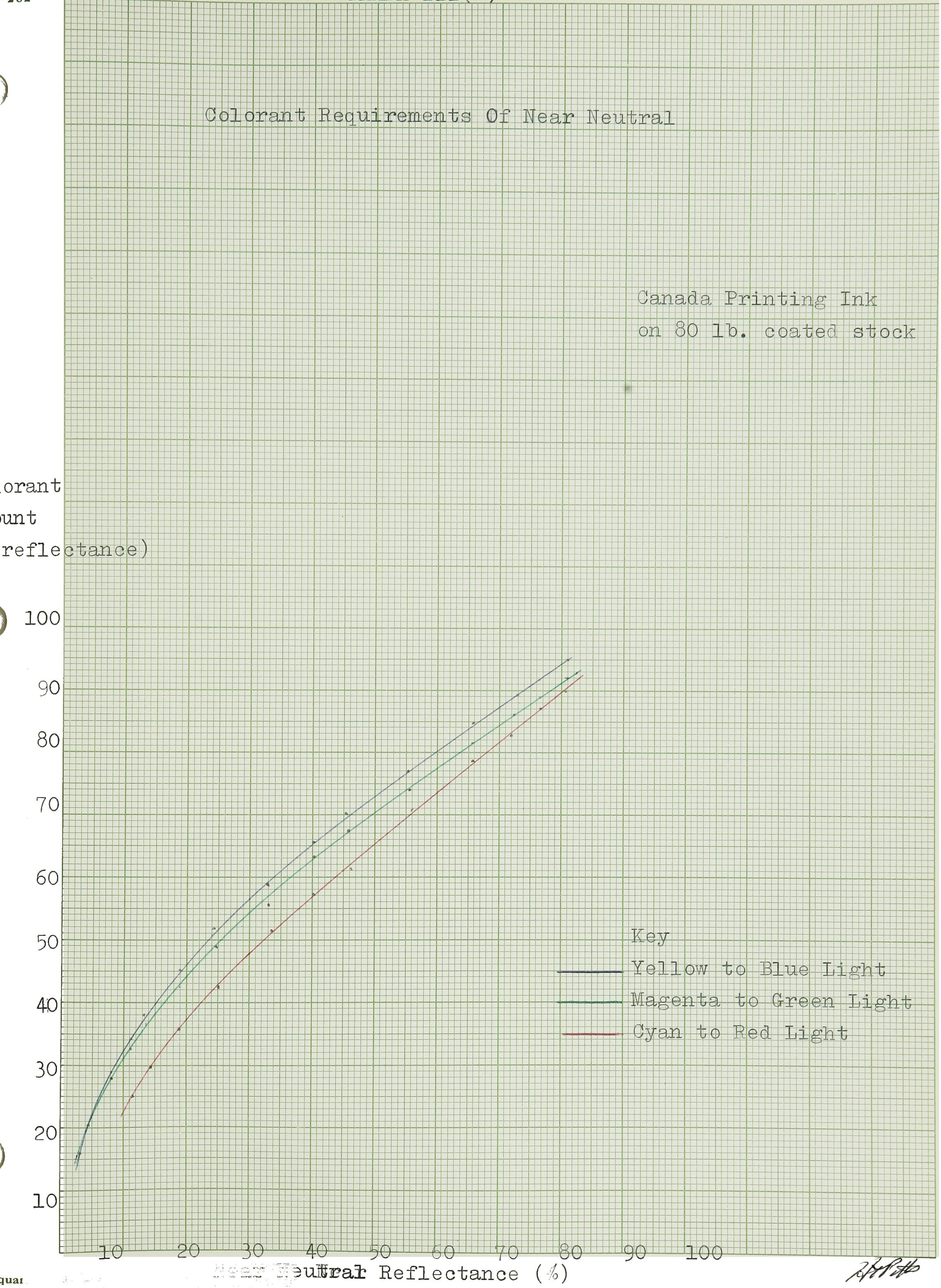
GRAPH II


COLORMETRIC REFLECTANCES AND DENSITIES
CORRESPONDING TO ILLUMINANT "C" NEUTRALS
NOTE: The R,G,andB coordinates for each density calculate to be the same and hence only one curve.
lorant
ounts
of
utral
%R,G,B,)
100
90
80
70
60
50
40
30
20
10
.25
.50
.75
1.00
1.50
2.00
2.50
3.00
Neutral Density (visual)

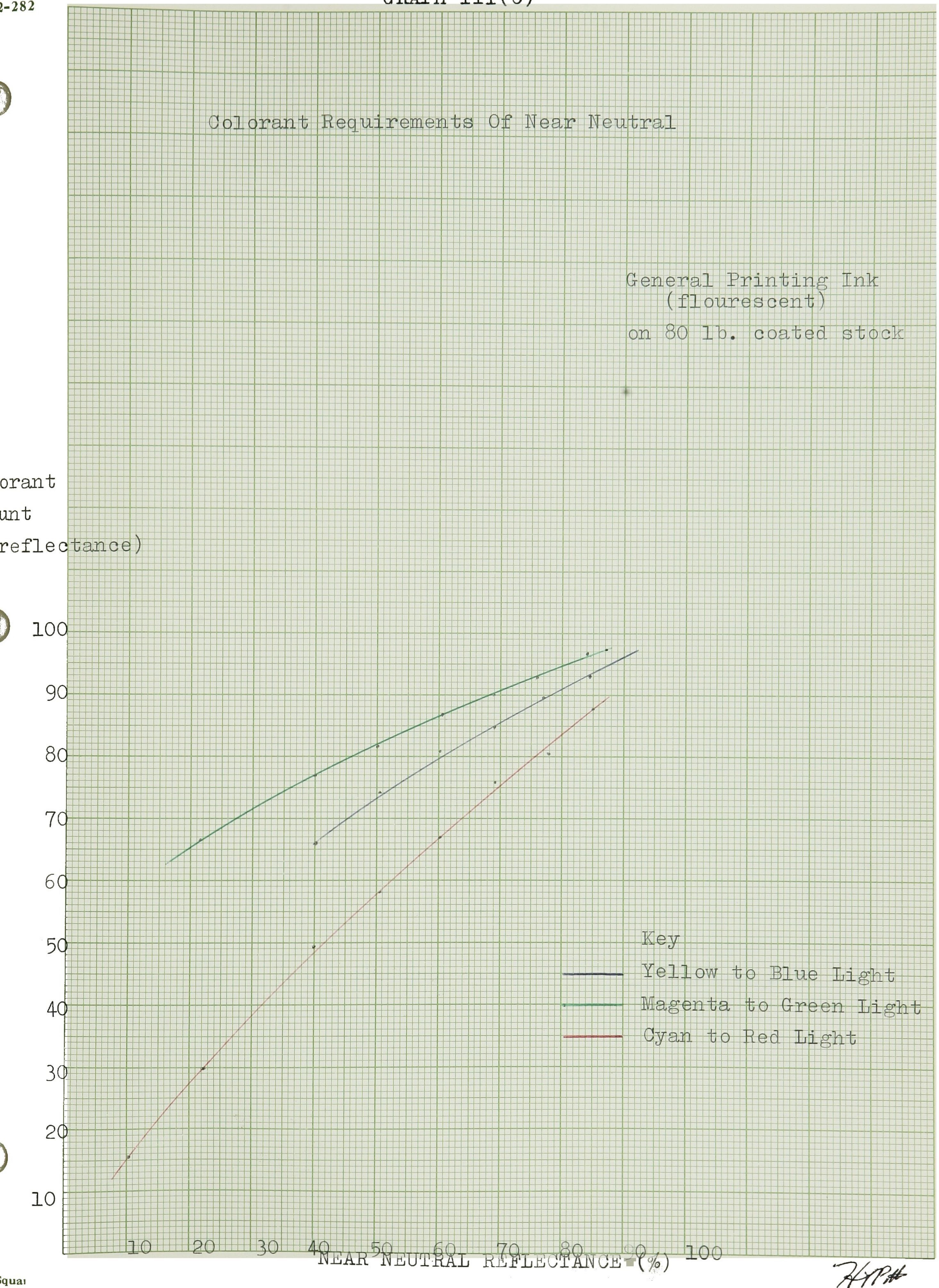
GRAPH III(A)


COLORANT REQUIREMENTS OF NEAR NEUTRAL
Ault & Wiborg Ink
on 80 lb. coated stock.
rant
nt
eflectance)
100
90
80
70
60
50
40
30
20
10
10
20
30
40
50
60
70
80
90
100
Near Neutral Reflectance (%)
Key
Yellow to Blue Light
Magenta to Green "
Cyan to RED Light

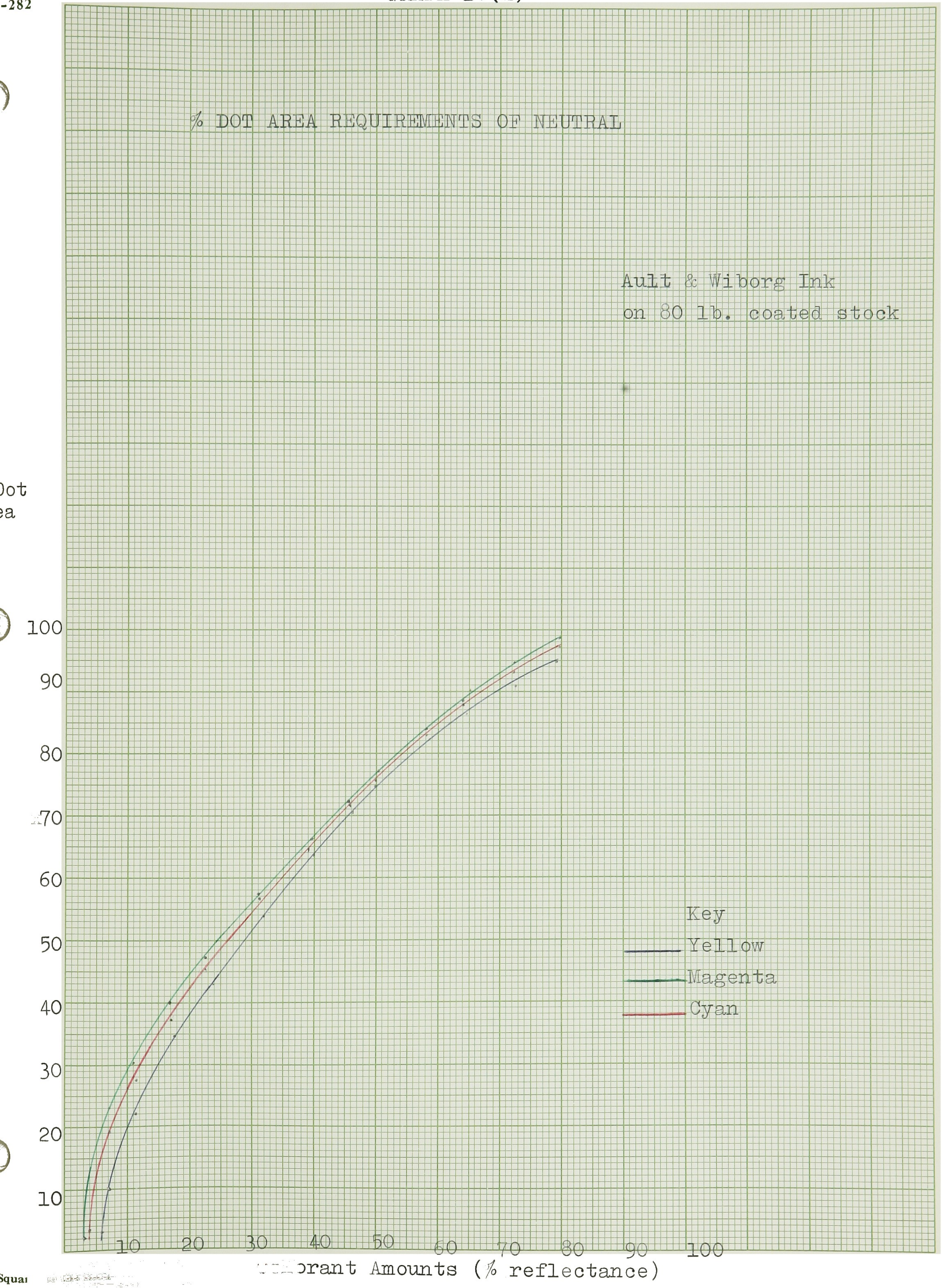
GRAPH III(B)


Colorant Requirements Of Near Neutral
Canada Printing Ink
on 80 lb. coated stock
lorant
ount
reflectance)
100
90
80
70
60
50
40
30
20
10
10
20
30
40
50
60
70
80
90
100
Near Neutral Reflectance (%)
Key
Yellow to Blue Light
Magenta to Green Light
Cyan to Red Light

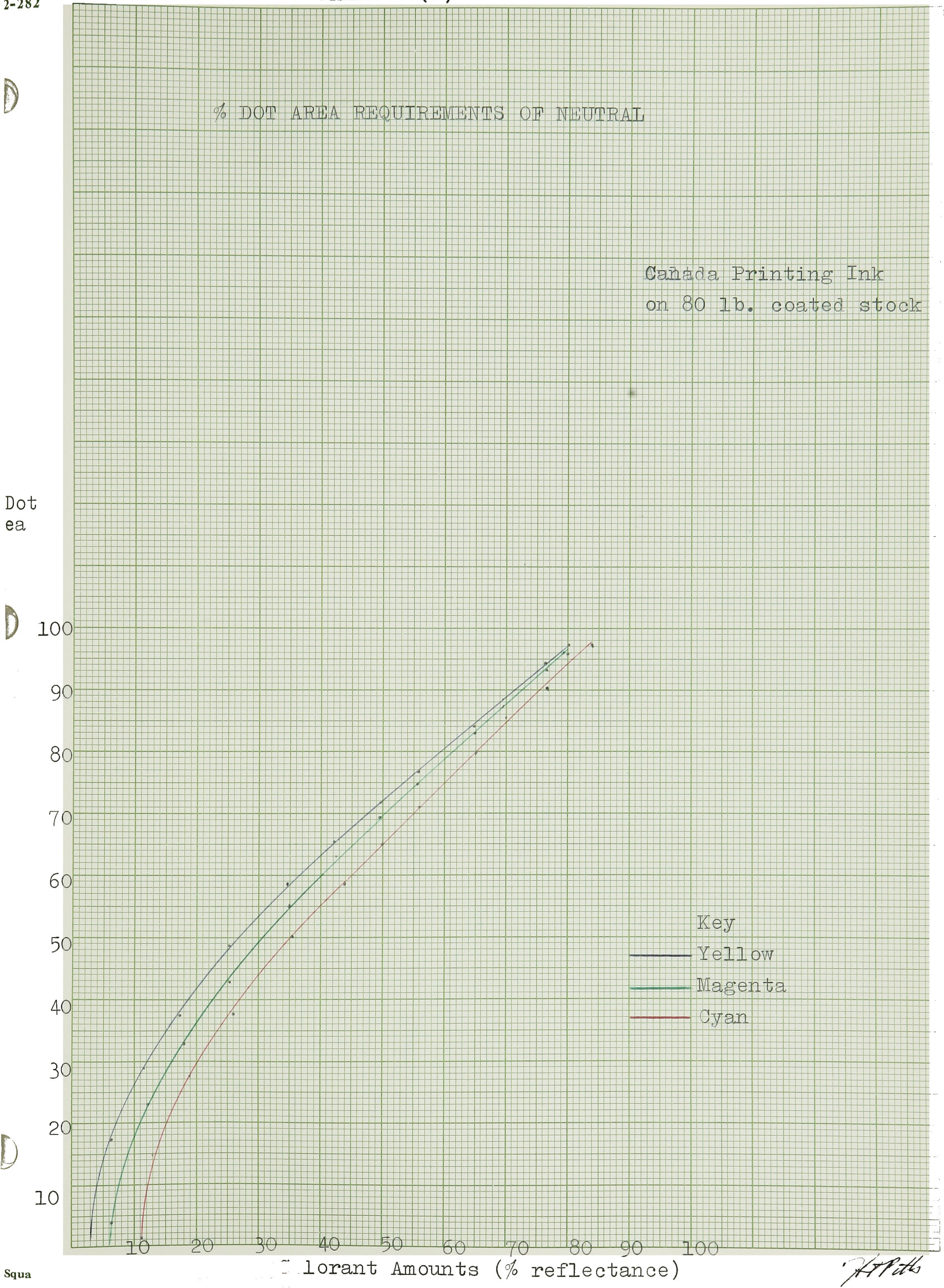
GRAPH III(C)


Colorant Requirements Of Near Neutral
General Printing Ink
(flourescent)
on 80 lb. coated stock
orant
unt
reflectance)
100
90
80
70
60
50
40
30
20
10
10
20
30
40
50
60
70
80
90
100
NEAR NEUTRAL REFLECTANCE (%)
Key
Yellow to Blue Light
Magenta to Green Light
Cyan to Red Light

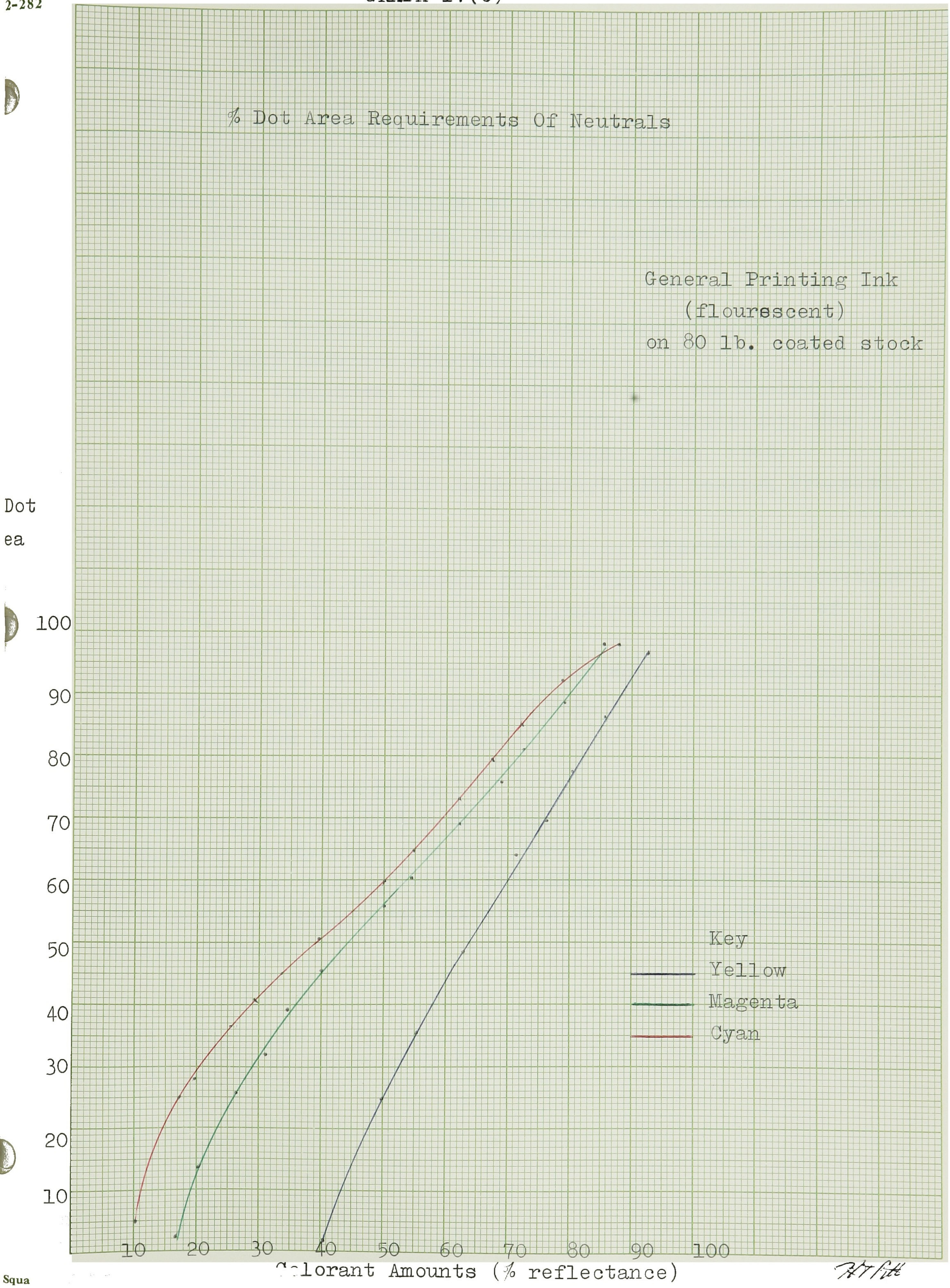
GRAPH IV(A)


% DOT AREA REQUIREMENTS OF NEUTRAL
Ault & Wiborg Ink
on 80 lb. coated stock
Dot
Area
100
90
80
70
60
50
40
30
20
10
10
20
30
40
50
60
70
80
90
100
Key
Yellow
Magenta
Cyan
...orant Amounts (% reflectance)

GRAPH IV(B)


% DOT AREA REQUIREMENTS OF NEUTRAL
Canada Printing Ink
on 80 lb. coated stock
Dot
ea
100
90
80
70
60
50
40
30
20
10
Key
Yellow
Magenta
Cyan
10
20
30
40
50
60
70
80
90
100
lorant Amounts (% reflectance)

GRAPH IV(C)


% Dot Area Requirements Of Neutrals
General Printing Ink
(flourescent)
on 80 lb. coated stock
Dot
ea
100
90
80
70
60
50
40
30
20
10
10
20
30
40
50
60
70
80
90
100
Key
Yellow
Magenta
Cyan
Colorant Amounts (% reflectance)

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(2) Neblette, C.B., "Photography,It's Materials & Processes", 6th edition, Chapter 33.

(3) Archer,H.B., "Reproduction of Gray with Halftones",Graphic Arts Information Service, Rochester Institute of Technology, pp. 2.

(4) Ibid,pp. 3.

(5) Elyjiw,Z., Preucil,F., "The New GATF Color Reproduction Guide" GATF Research Progress No. 67.

(6) Wulff,A., Jorgensen, H.O., "An analysis of the Controllability of the Seperation Stages in Multi-Color Production", The Graphic College of Denmark, Copenhagen, July, 1964.

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(8) Pobboravsky, I., "Methods of Computing Colorant Amounts to Produce a Scale of Neutrals for Photomechanical Reproduction", Graphic Arts Information Service,Rochester Institute of Technology.

(9) Archer, H.B., Graphic Arts Research Dept.,Rochester Institute of Technology,Private Communication.

(10)Websters New World Dictionary.

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