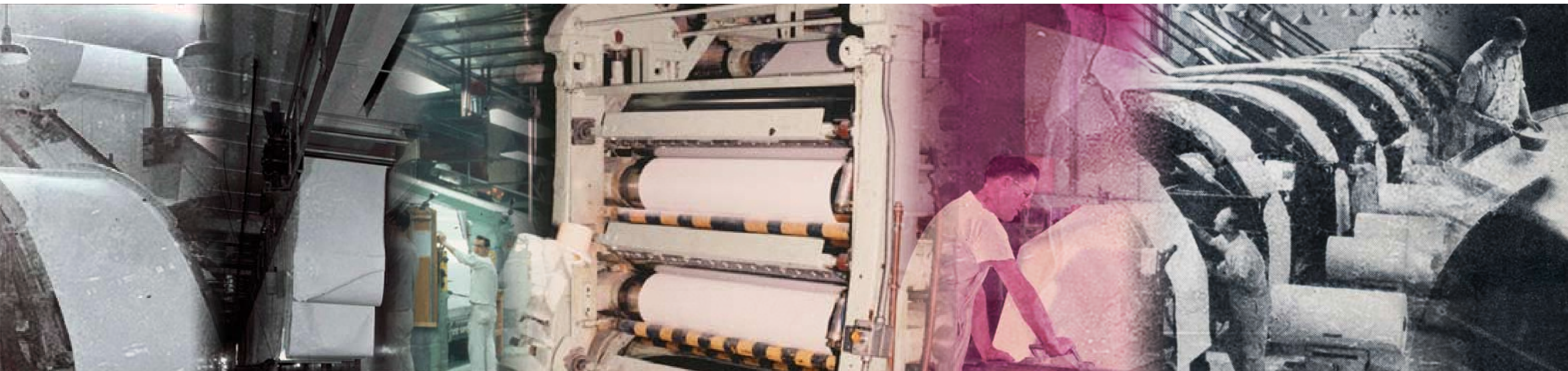


A GUIDE TO THE SURFACE CHARACTERISTICS:

KODAK FIBER BASE BLACK-AND-WHITE PAPERS

KIT FUNDERBURK

CONTENTS:

ACKNOWLEDGEMENTES: Since this Second Edition builds on both the First Edition (2007) and on an earlier work by the same author (History of the Paper Mills at Kodak Park, 2006), continuing thanks go to the many people previously identified who provided assistance, information, and resources for those efforts. As with the earlier works, this edition would not have been possible without the assistance of key people. Thanks to Joe Struble and Todd Gustavson for their assistance in accessing archival information in their respective areas at the George Eastman House. Thanks to Nancy Martin for her support in accessing the archives at the Rush Rhees Library at the University of Rochester. Thanks to Jennifer Curtis for providing the graphic illustrations of my rough drawings of a paper machine, baryta coater, and supercalender and thanks to Bob Achilles who helped with the baryta coater drawings. And finally, special thanks and appreciation go to Sheila Foster and Emily Welch of the George Eastman House who not only encouraged this work to be undertaken but helped with editing, made arrangements for graphic illustrations, and secured photos included in the text.

DESIGN (COVER AND LAYOUT): Jackson Cook
This paper is typeset in Univers and Interstate

Kodak Opal Grade Z photographic paper sample.
"Photographic Papers Manufactured By Eastman Kodak Company"
Rochester, Eastman Kodak Co., circa 1937
10.7 x 16.2 cm.

The history of Kodak fiber base black-and-white papers spanned over 100 years from the 1880s to 2005 leaving behind a rich legacy. Unfortunately, much of the manufacturing history was unrecorded or, along with most of the first-hand knowledge, has now been lost. However, some of the history remains – in archives, libraries, and unpublished documents – like pieces of a puzzle waiting to be put together.

The 2007 edition of *A Guide to the Surface Characteristics, Kodak Fiber Based Black and White Papers* sought to assemble available pieces of this puzzle to fill in missing gaps and to bring back some of the past history. The Introduction to the 2007 edition concluded with the following:

"As the title of this work states, it is a guide, not a definitive technical paper nor an exhaustive examination of all possible resources. … Hopefully, this attempt to recapture the history will aid in the discovery of new information that will provide additional clarity."

New pieces to the puzzle and better information to interpret the available history continue to be found. This new research has prompted the need to revise earlier statements, to adjust assumptions, and, in some cases, correct misinterpretations.

This second edition is not a sign that the search is over. New information has closed some gaps but has opened others. The work to rebuild the history of the fiber base black-and-white papers continues.

Kodak Azo Grade B photographic paper sample.
"Some of our Photographic Papers"
Rochester, Eastman Kodak Co., circa 1910
14 x 20 cm.

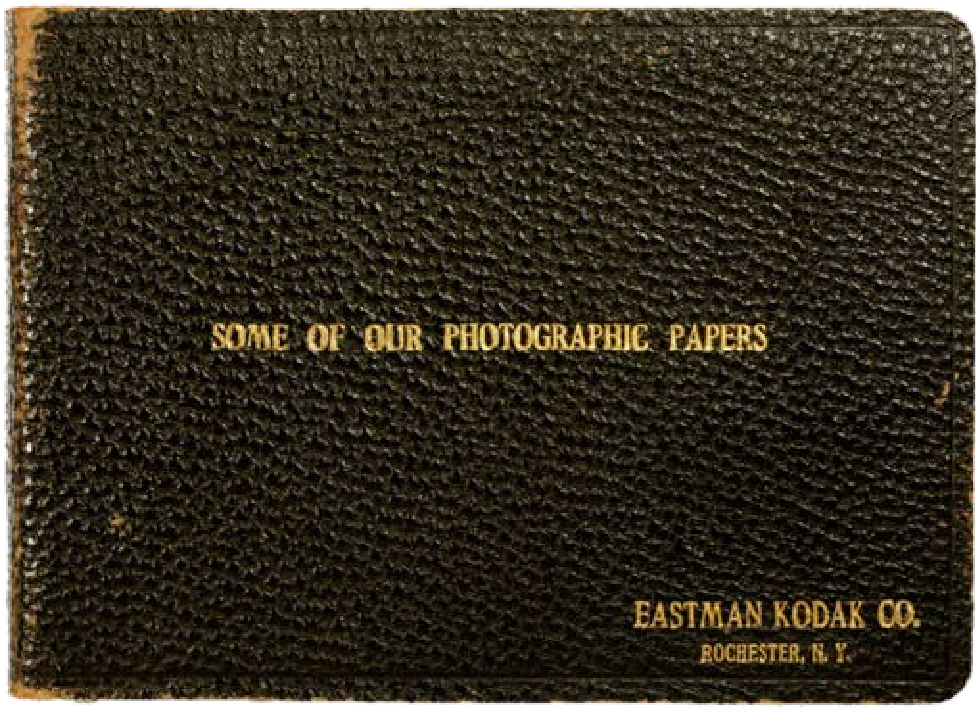
The use of a capital letter added to the product name has been commonly associated with the designation for surface characteristics of Kodak fiber base black-and-white papers. Since the 1940s, the surface descriptions were generally recognized to consist of a specific combination of texture, sheen (also known as gloss), and paper tint. However, this convention was not always in use. The surfaces of the earliest products were identified only by a texture and a weight (or thickness as an indicator of weight). Some products had no specific surface identification and others were identified with numbers rather than capital letters. Until the lettering system was standardized in the 1940s, the use of capital letters was not necessarily consistent across product lines. For example, in 1932, the letter E represented the following surfaces:

Opal E: Rough, matte, old ivory
Azo E: Smooth, semi-matte, white
Eastman Portrait Bromide E: Rough, lustre, buff

It is clear that the lettering system was not always an infallible identifier of surface characteristics. However, the history of how the system was used can provide important information for understanding the differences in the surface characteristics of the products.

THE 1880s TO THE 1910s

The use of a capital letter to identify Kodak products can be traced back to at least 1886 when three varieties of Eastman Permanent Bromide Paper were described as:



Cover, photographic paper sample book. "Some of our Photographic Papers" Rochester, Eastman Kodak Co., circa 1910

A: Smooth surface, thin
B: Smooth surface, heavy
C: Rough surface, heavy

However, the use of capital letters was not consistent nor was it widespread. Eureka Bromide Papers of 1895 were available with the same descriptors as Eastman Permanent Bromide but were identified with numbers:

1: Thin, smooth
2: Heavy, smooth
3: Heavy, rough

In these examples, the descriptors Smooth and Rough refer to the surface texture; Thin and Heavy refer to the thickness or the weight of the paper. One of the early references to sheen (gloss) can be found in 1895 with the product Eureka Enameled, available in both thin and heavy versions, and described as coated on enameled paper giving a glossy appearance. By the late 1890s, a matte surface was identified and by the early 1900s surface texture and sheen were beginning to be used in combination. For example, in a description for Dekko paper, the surface was identified as Rough, Matte. In the early 1900s, P.M.C. Bromide papers were identified as #1, #2, and #3 with the same definitions as the 1895 Eureka Bromide; #4 was identified as Glossy Enameled and #5 as Thin, Matte. Velox papers were assigned neither letters nor numbers but were designated simply as Rough or Glossy, in the first case a reference to the surface texture and in the second case to the sheen. In 1905, a new surface identified as Velvet was added to the Velox products but with no letter designation.

By 1907, multiple capital letters were used to distinguish the weight of the papers with BB representing Smooth, Extra Heavy and CC as Rough, Extra Heavy. Additional surfaces were added at this time to the P.M.C. Bromide papers but the use of numbers instead of letters continued for that product line.

The use of the capital letters seemed to have escalated by about 1910. It is probably not a coincidence that the number of combinations of identified textures and sheens, as well as paper tints, had also expanded. In 1911, the Artura Iris product line had five identified surfaces:

A: Regular weight, Smooth, Semi-matte
B: Double weight, Smooth, Semi-matte
C: Double weight, Smooth, Absolute matte
D: Double weight, Medium rough, Absolute matte
E: Double weight, Buff tint (in both a Medium rough and Smooth)

In the above examples, the letters A through D represent a designation based on weight, texture, and sheen. However, E represents weight and paper tint with the same letter used for two different textures.

Azo had been identified as only one paper in the early 1900s. By 1910 the product line had grown to four different surfaces and by 1911 to six surfaces (A through F). An important feature of the Azo surface identification in 1911 was that paper weight had been separated from texture, sheen, and tint as a surface characteristic. This convention would eventually become the standard for the use of the letter designations.

However, the characteristics of the six Azo surfaces in 1911 were different than the Artura Iris products with the same letter designation. This difference continued as the number of surfaces for each product increased from 1912 through 1918 with sequential letters of the alphabet added so that A through H plus K were in use. It appears that the letter I was never used, perhaps due to possible confusion with the number 1. It is not known why the letter J was skipped at that time since it would be used in later years. During this same time frame, other product lines continued with no letters and the P.M.C. Bromide line continued to identify new combinations of surface features with numbers.

As will be seen in later chapters, the surface textures were produced in the papermaking and/or the baryta coating operations. The first Kodak paper products in the 1880s were emulsion coated on baryta-coated paper from European suppliers. Kodak started its own baryta coating operation in 1900 using raw paper base from the same sources that previously supplied baryta-coated paper. Kodak started its first paper machine in 1914 but supplied only a small portion of the total demand for raw base until 1919 when a paper making expansion to five paper machines was completed. Even though these operations, and later expansions, provided the majority of the paper support required, Kodak continued for many years to purchase specialty paper supports as well as paper supports for operations outside of the United States.

The early history of the Kodak paper mills identified that the first successful photographic raw base, made in 1915, was a 135 gram Buff stock for photocopying (Photostat paper). The number 135 referred to the weight of the paper, 135 grams per square meter, which would have been classified as a Single Weight. Buff was an early tint reference for what was later called Ivory or Old Ivory. The use of the metric system for stating the weight of the raw base was changed sometime prior to 1929 and for the rest of its history the Kodak paper mills used the English measurement system for raw base weight, stated as pounds per thousand square feet. The baryta coating operations used the metric system throughout its history.

Following the initial success with Photostat paper, attention was directed to making the S & C brands of paper. While it was not specifically identified in the archival documents, S & C was probably a reference to Solar and Carbon (Regular Carbon, Special Carbon, and Contrast Carbon) which were early Single Weight products that all used the same raw base.

From 1915 to about 1919, most of the raw bases produced at Kodak Park were smooth texture and used for glossy papers. The glossy products required heavy baryta coatings which was fortunate since the coatings also masked the poor quality of the wood pulp then available. It appears that little, if any, Rough texture raw base was produced at Kodak at that time and early paper mill histories made no mention of how the Rough textures were produced.

In 1921, Kodak published a how-to booklet for the amateur photographer which included descriptions of several grades of Eastman Bromide and Velox papers. Even though this was not a complete list of Kodak papers, there were several different combinations of surface texture, sheen, or paper weight described for the two product lines. In addition to noting whether Velox papers were available in Single, Medium, or Double Weights, surface identifications included Glossy, Semi-gloss, Smooth Matte, Matte, Enameled, and Velvet Matte. For Standard Bromide papers, the letter B was used for heavy smooth, C for heavy rough, and BB and CC for the Double Weight versions.

Another source of information from this same timeframe comes from the personal papers of Reinhold Becker [1] which contained hand annotated descriptions of baryta coating operations with links to raw base and emulsion coating. The links show both letter and number designations for surface characteristics for some of the products:

Letter and Number Designations	Surface
#1	glossy, cream white tinted
A, C, F, #6, #10	glossy, white tinted
E, #9	E smooth & E rough
B, D, #7	rough
#8	rough, buff tinted
H	smooth, buff tinted
K	smooth, cream white tinted

It was commented earlier in this chapter that the convention for surface description would eventually include the texture, sheen, and paper tint. However, up to the 1920s, the surface descriptions rarely included all three features and in many cases added the paper weight or thickness reference as a surface characteristic.

Further clues for black-and-white paper surfaces come from a 1929 pocket notebook that was used as a reference for raw base papers and identified 35 different raw bases. [2] In the Becker papers, some of the raw bases were designated with a three digit number and some with a single number. [3] The raw bases in the pocket notebook were all three digit numbers which implied that the Becker reference pre-dated the notebook since a three digit number became the standard identification for a raw base. However, in 1929, this system was only in the early stages of use and identified the whole range of grades as either Single Weight (100 series numbers) or Double Weight (200 series numbers).

The identification system for raw base papers would later be developed into a three digit number with the following key:

•First digit – weight •Second digit – color (tint) •Third digit – surface (texture)

This system remained in place for many years with relatively strict adherence to the key. The system later became corrupted as the number of grades increased and chemical changes and other product variations were incorporated into the numbering.

Raw base identifications did not include an official link to a final product. One reason was that a single raw base was often used in more than one product line. However, it was common for paper mill reference material to include anecdotal notations that provided a product link and the 1929 notebook contained references to Glossy (smooth), Rough, and Fine grain surface textures. Fine grain and Fine-grained were used interchangeably by Kodak to describe this surface; Fine-grained will be used throughout the rest of this work for consistency.

In 1932, Kodak published a description of Kodak photographic papers with the stated purpose being to acquaint the photographer with the various grades and surfaces of photographic papers. In most of the product lines, surface characteristics were identified by the combined features of texture, sheen, and tint. For example:

Vitava Opal B: Smooth, Semi-matte, White
or
Azo W: Rough, Lustre, Old Ivory

Surface characteristics in a few product lines continued to use the traditional identifiers, such as:

Velox Glossy

The P.M.C. Bromide line continued to use numbers, such as:

No. 8: Rough, Semi-matte, Buff

It is also apparent from this information that by this time a number of new textures, sheens, and tints had been added to the product lines. Across all products, the following descriptors were in use for texture, sheen, and tint:

Texture	Sheen	Tint
smooth	glossy	cream white
rough	matte	white
medium rough	semi-matte	pensé (pearly white)
fine-grained	lustre	buff
linen	absolute matte	old ivory
silk	slight lustre	natural
tapestry	semi-gloss	ivory
	dead-matte	

Every letter of the alphabet was used for the combination of descriptors except I, J, M, N, O, U, and V. M and O had previously been used but the surface had been discontinued prior to 1932. In addition to the single letters, AA, B1, B2, and the numbers 1 through 11 were used in addition to five products with no letter or number.

In some cases, a capital letter had a specific meaning only within a product line which would suggest that the choice of a letter originated within product lines and without a strict requirement that it be consistent across product lines. For instance, other references used the tint descriptors Buff and Ivory interchangeably and it would not seem likely that there was a difference between Absolute Matte and Dead-matte sheen, names which were in use in different product lines.

The 38 different combinations of texture, gloss, and tint had anomalies but this system of surface identification appeared to have provided the basis for the rationalization into what later became a clearer method of product characterization.

Over the years, Kodak prepared loose-bound sample books which contained processed prints on each of the available Kodak products. Some of these still survive and are valuable resources not only as examples of long-ago discontinued products but also to track the introduction of new surface features or combinations of existing features. One of these sample books (original publication estimated as ca. 1937) contained new combinations of texture, sheen, and tint assigned to the unused letters J, M, N, and U. With the new combinations of features, all letters of the alphabet except I and O were in use and the numbering was increased to include a #12 surface. Hints of consolidation and rationalization also appeared. In 1932, the tints Buff, Ivory, and Old Ivory were used in different product lines. As pointed out earlier, Buff and Ivory had been used interchangeably in some earlier references. In the 1937 sample book, these products were all identified as Old Ivory which was either a consolidation to one tint or simply recognition that different names had been used for the same tint.

THE 1940s

In 1940, Kodak published the first edition of the *Kodak Reference Handbook*. In the Photographic Papers section of this handbook, image tone, surface texture, tint, and weight or thickness of the paper support were identified as the most important physical characteristics of the Kodak papers. Image tone referred to the color of the silver deposit in the finished print and will not be discussed here as it was not a function of the paper support but was dependent on the size and condition of the silver grains, emulsion composition, and conditions of development.

The 1940 edition appeared to be the earliest available reference that defined the features used to describe physical characteristics.

•Surface texture was divided into:

•Character of the surface texture: identified as Smooth, Fine-grained (a pebbled surface), or Rough along with special textures called Silk and Tapestry.
•Sheen (also called gloss or brilliance): identified as Glossy, Lustre, Semi-matte, and Matte.

•Tint was identified as White, Natural White (a slight cream tint), Cream White, and Old Ivory (with a notation that it was sometimes called Buff). Pensé was identified as a pearly white available only in a glossy surface.

•Depending on the thickness of the raw paper base, papers were classified as Single Weight, Medium Weight, or Double Weight.

One of the unique features of the Photographic Paper section was a table identified as "Surfaces and Contrasts of Kodak Photographic Papers." (seen on p.11) The most important information for this investigation was the organization of the paper surfaces into 12 different columns each headed by a sample, processed to maximum density, said to have the same surface texture (character of the texture and sheen) as all the papers listed under each sample.

For the first time, it could be seen, for example, that Azo G was categorized as the same surface texture as Kodalure P and P.M.C. Bromide #11. Unfortunately, the samples were identified as representing a surface but no description of the surface was provided in the table. However, the product specifications in another section of the Handbook provided a description for both the character of the texture and the sheen which can be assigned to each column, listed here 1-12 as they appeared from left to right in the table:

1. Smooth / Glossy
2. Smooth / Semi-matte
3. Smooth / Lustre or Semi-matte
4. Fine-grained / Lustre
5. Smooth / Matte
6. Rough / Matte
7. Fine-grained / Matte
8. Medium Rough / Lustre
9. Rough / Lustre or Semi-matte
10. Silk / Semi-matte
11. Tapestry / Lustre
12. Suede / Matte

While the descriptions in the specifications were clear, the match of each paper to its representative surface texture sample was not as clear. It appeared as though surfaces had been assigned based not only on their actual physical characteristics but also on the descriptors previously assigned. For example, Kodabromide E, assigned to column two, had been previously identified as Smooth/Semi-matte but visually it was clear that it had a slightly pebbled surface and was different than other smooth surfaces.

The samples aligned in columns three and nine included both Lustre and Semi-matte product descriptions in the specifications. Lustre and Semi-matte had previously been used as sheen descriptors in different product lines so this seemed to be at least an implication that the Lustre and Semi-matte products had either the same or very similar sheen at that time.

The second edition of the *Kodak Reference Handbook* was printed in 1943 with some interesting changes in the paper products. Tweed texture was identified for the first time and not-so-smooth E-smooth surface was replaced by E as a Fine-grained surface. Tapestry and Suede surfaces were missing from the list of available products. Both would be available in following years. Were they discontinued and then brought back into use due to customer demand? Perhaps the materials required to produce these textures were unavailable during the war years?

There were also further steps toward consolidation and rationalization of the surface identifications in this edition:

•CF was assigned to an Azo surface previously called C but which had no apparent visual difference from F surface. The CF designation would later be changed to F completing the consolidation for a Smooth / Glossy / White surface.

•The then unused designation C replaced an Azo surface previously called AA eliminating the use of double letters for a tint difference.

•Opal A (a designation for a cream tinted, single weight version of the product) and Opal T (for a medium weight version) were changed to B and G, respectively, which removed the weight distinction from the surface naming for this grade.

•Opal W which had been a designation in this product line for Rough / Lustre / Old Ivory was changed to U matching the use in other product lines and eliminating the overlapping use of W for Suede surface texture.

In June 1944, a revised edition of the Surfaces and Contrasts chart announced a simplified Kodak system of designating paper surfaces. Under this new system, all papers with similar surface – texture, sheen (identified as brilliance), and tint – were assigned a specific capital letter. Gone were the surfaces identified by numbers. Products previously identified only with a product name were assigned a letter designation based on the surface characteristics even if there was only one surface in the product line. However, there were still anomalies in the identifications. For example, there were two different surface categories both described as Fine-grained / Lustre; both F and CF were used to describe Smooth / Glossy / White; and C and M were both used for Smooth / Matte. In total, 10 different combinations of texture and sheen were listed (including the two duplicate Fine-grained / Lustre surfaces).

By 1947, the number of different texture/sheen combinations was back to 12. Tapestry was again listed after an absence of a few years; Suede had been re-listed in 1945. In total, 8 textures (including the double-listed Fine-grained / Lustre) and three levels of sheen were combined to produce 12 texture/sheen combinations, identified as:

- Smooth / Glossy
- Smooth / Lustre
- Smooth / Matte
- Fine-grained / Lustre (1)
- Fine-grained / Lustre (2)
- Fine-grained / Matte
- Rough / Lustre
- Rough / Matte
- Tweed / Lustre
- Suede / Matte
- Silk / Lustre
- Tapestry / Lustre.

(The numbers (1, 2) above were added by the author to highlight the double-listing of Fine-grained / Lustre)

In the 1947 chart, the Opal product line was represented by 8 of the 12 designated texture/sheen combinations. One of the most striking observations, however, was that six of these combinations were offered in only the Opal product line. In addition, of the 15 product lines listed, the next highest number of texture/sheen combinations in a product line was three and that was in only two products – Athena and Platino. The remaining 12 product lines had only one or two surface offerings each. The implication is that even though some of the surfaces existed, and continued for many more years, their exposure in the market was at times relatively small.

It would not be until the 1950s that all Fine-grained / Lustre surfaces would be consolidated into one listing and later Data Books did acknowledge that they were the same texture/sheen with different tints. Also by the 1950s, the title of the table had been changed to Surfaces, Stock Tints, Printing Grades, and Weights of Kodak Papers reflecting the wealth of information contained in this one document.

The seven surface textures (Smooth, Fine-grained, Rough, Tweed, Suede, Silk, Tapestry) described in 1947 represented the range of textures for the Kodak fiber base black-and-white products that would be produced for the next 50 plus years. These seven surface textures were distinctly different in visual appearance and were also unique in that they were produced by different manufacturing processes. A texture identified as Ultra-Smooth was offered for a few years beginning in the late 1980s and discontinued a few years later. While this paper was probably the smoothest ever offered by Kodak, the character of the texture was not different from other papers identified as Smooth and no new manufacturing operations were used in its manufacture.

SURFACES AND CONTRASTS

OF KODAK PHOTOGRAPHIC PAPERS

Surface Texture ➧

KODABROMIDE Fast enlarging paper.	F SW, WH 1, 2, 3, 4 F DW, WH 1, 2, 3, 4	E SW, WH 1, 2, 3, 4 E DW, WH 1, 2, 3, 4	A SW, NAT 1, 2, 3, 4 N SW, WH 1, 2, 3, 4 N DW, WH 1, 2, 3, 4	G DW, NAT 1, 2, 3, 4 P DW, IVR 1, 2, 3, 4				R DW, NAT 1, 2, 3 S DW, IVR 1, 2, 3				V DW, CR (SUEDE) 1,2,3 W DW, IVR (SUEDE) 1,2,3
VITAVA OPAL Slow enlarging or fast contact paper. One contrast only for negatives of normal contrast.	F SW WH		A SW CR B DW CR	G DW NAT P DW IVR T MW NAT	C DW CR	E DW, IVR ROUGH D DW NAT	H DW NAT Q DW IVR		L DW NAT U DW IVR		Z DW, IVR (TAPESTRY)	
KODALURE Slow enlarging or fast contact paper. One contrast only for negatives of normal contrast.			J DW IVR M DW NAT	G DW NAT P DW IVR				R DW NAT S DW IVR				V DW, CR (SUEDE) W DW, IVR (SUEDE)
VITAVA PROJECTION Medium high speed enlarging paper.	F SW, WH 2, 3 F DW, WH 2		A SW, CR 2 B DW, CR 2, 3	G DW, NAT 2, 3 P DW, IVR 2, 3	C DW, CR 2	D DW, NAT 2			L DW, NAT 2 U DW, IVR 2	X DW, IVR (SILK) 2 Y DW, CR (SILK) 2, 3		
P.M.C. BROMIDE Fast enlarging paper.	#1 SW, WH N, C #4 SW, PENSÉ N #10 DW, WH N, M, C, EC	#2 SW, WH N, M, C, EC #9 DW, WH N, M, C EC		#11 DW, NAT N, M, C, EC #12 DW, IVR N, M, C	#5 SW, WH N #6 DW, WH N	#3 SW, WH N, C #7 DW, NAT N, M, C			#8 DW, IVR N, M, C			
AZO All-purpose contact paper.	F SW, WH 0, 1, 2, 3, 4, 5 F DW, WH 0, 1, 2, 3, 4, 5 C SW, WH 0, 1, 2, 3, 4, 5	E SW, WH 0, 1, 2, 3, 4, 5 E DW, WH 0, 1, 2, 3, 4, 5	B DW, CR 1, 2, 3 J DW, IVR 1, 2, 3 K SW, CR 2, 3, 4	G DW, NAT 1, 2, 3, 5 P DW, IVR 1, 2, 3, 5	A SW, WH 2 AA DW, CR 1, 2		A DW, WH 1, 2 H DW, NAT 1, 2 Q DW, IVR 1, 2			X DW, IVR (SILK) 1, 2, 3 Y DW, CR (SILK) 1, 2, 3		
VITAVA ATHENA Contact paper for portraiture. One contrast only for negatives of normal contrast.			A SW CR B DW CR E DW, IVR SEMI-MATTE	G DW NAT P DW IVR	C DW CR E DW, IVR SMOOTH	E DW, IVR ROUGH	H DW NAT Q DW IVR			Y DW, CR (SILK)		
VELOX and OTHER PAPERS	Velox F SW, WH 0,1,2,3,4,5 Velox Rapid F SW & DW WH 0-4 News Brom., SW, WH; N,M,C,EC	Velox E SW, WH 0,1,2,3,4,5 Velox Rapid E SW & DW WH 0-4 Illus. Spec., SW & DW, WH, N	Ad-Type, SW, WH, 0, 1, 2, 3, 4, 5 Kodaline, SW, WH, C Insurance, SW, WH, C Translite, SW, WH, N		Line Solar SW, WH N, C	Solar SW, WH N		Portrait Proof Matte SW, NAT, N Portrait Proof Lustre SW, NAT, N				

TINTS OF KODAK PAPER STOCK

WHITE (WH)	NATURAL WHITE (NAT)	CREAM WHITE (CR)	OLD IVORY (IVR)

APPROXIMATE WARMTH OF TONE OF KODAK PAPERS

WHEN PROCESSED AS RECOMMENDED

KODABROMIDE, P.M.C. BROMIDE, VELOX, AZO *E, C, F*	VITAVA PROJECTION	AZO *Except E, C, F,* VITAVA OPAL, VITAVA ATHENA	KODALURE

Surfaces and Contrasts of Kodak Photographic Papers. "Kodak Reference Handbook" Rochester N.Y., Eastman Kodak Company, 1940

QUESTIONS ABOUT LETTERS AND MEANINGS

It is often asked if the letters chosen for each surface had a specific meaning. There seems to be no record available that lists a definition governing the letter use. The lettering system originally started at the beginning of the alphabet and proceeded sequentially through the alphabet up to the letter H as new surfaces or new combinations of surface features were introduced. As noted earlier, the letter I was never used and J was apparently skipped at that time.

It is often speculated that F may have stood for "ferrotyped." In 1910, the letters in use extended from A through E. F was first used in the Azo product line in 1911 with the description of Glossy. However, C was already in use in the same product line with the same Glossy description and both C and F were identified as being specifically for use on ferrotype plates. The distinction between C and F in the 1930s was that was Azo C was Glossy, Pensé (pearly white) and Azo F was Glossy, White. Also in 1911, #4, and later #8 and #10 were used to identify Glossy paper in the P.M.C. Bromide products. It is true that rationalization did result in the use of the letter F for Smooth / Glossy but this was most likely due to attrition as the Pensé tint had been discontinued and the numbering system was folded into the letters.

There was an indication of at least one specific instance where the choice of the letter may have had product significance. In 1923, a deeply textured portrait paper was offered called Old Master (see Chapter 4 for more details). The product was available in two tints and the letter identification was O (White) and M (Buff). Since O and M are not sequential and it appears that N was not in use at the time, it seems plausible that the O and M also represented Old Master.

There is sometimes the appearance that consecutive letters were used to distinguish tint variations. For example, the R and S papers had the same texture and sheen but different tints. This situation also existed for V-W and X-Y. However, this appears not to have been by design but occurred when a new surface was originally offered in more than one tint at the same time. There are other examples in which different tints in the same surface were not represented by consecutive letters.

The role of tint in the lettering system was noted in several of the Kodak Dataguides but it has sometimes been overlooked that letters designated tint as well as texture and sheen. This has led to some misconceptions that the letter designations for surface changed in meaning. This might occur in a case in which a surface (texture/sheen) in use in a particular product line was added to another product line but in a different tint so it was assigned a different letter. The change of letters was not a change or addition of a new texture or sheen but was a result of the different tint.

There were exceptions. In the early 1970s, Fine-grained / Lustre / White and Fine-grained / Lustre / Warm White had the same letter designation. It may just have been considered unnecessary to assign a new letter for a subtle tint change, from White to Warm White (described as a slightly cream white).

We have already seen that by the late 1930s all of the letters of the alphabet (except I and O) were in use to describe different combinations of texture, sheen, and tint and that starting in 1944 letters were solely used for surface identification. How were products named after that if there were no more letters to use? Since no new textures were produced after 1947, "new" surfaces actually consisted of a change (or rename) in the sheen or tint or by extending an existing surface to a different or new product line. In the latter case, the existing letter would be used for the new product. For example, when the Medalist product line was introduced in the 1950s, the Silk / Lustre / Cream White version was designated Y just as the Silk / Lustre / Cream White version in several other product lines already offered at that time. So there was no need for a new letter designation. This brings up another important point which is that the same support was very often used for different product lines. In this case, Medalist Y was made using the same support as Ektalure Y.

Even though many "new" products were introduced over the years, not many required a new letter designation and, at the same time, many of the texture/sheen/tint combinations were discontinued which made letters available for reuse. There was a fair amount of reuse, or re-assignment, of letters prior to the beginning of the simplified system of 1944. From that time, it appears that nine letters were reused including the letter K which was reused twice. This statement applies only to the fiber base black-and-white products. A lettering system was also used for resin-coated products but the processes for producing the texture/gloss/tint were different from those of the fiber base products.

The letter A was often described as being used to designate a non-baryta-coated paper. This was not always the case as A designated papers in the 1920s were baryta-coated, sometimes with two baryta layers. Later, when A papers were non-baryta-coated, it must be remembered that this meant they were not coated with barium sulfate. It did not mean that there was no coating at all as some grades were coated with a lightweight gel layer but were not designated as A. The A designation was sometimes appended with another letter prior to the 1944 simplification. AA was used to identify Cream tint (A was for White tint), SA for a light weight paper, and XA for extra light weight.

Perhaps the most often asked question is how many surfaces were there? This is not at all easy to answer since it depends on many factors. It was not until the 1940s that a specific surface was identified as consisting of a combination of a texture, a sheen, and a tint. Prior to that, identification of the papers sometimes consisted of only one of the surface features and sometimes included a reference to thickness or weight. We could list all known textures, sheens, and tints but not all combinations were used and many of the individual features did not exist at the same time. In some cases the same sheen or tint had different names in different product lines. Finally, as will be seen in Chapters 4 and 5, there were some papers identified with the same texture name that had very different visual appearances.

Some insight into the breadth of surfaces can be obtained, however, by narrowing the scope of the inquiry. Based on the resources available it is pretty clear that the largest number of distinct surfaces to exist at one time occurred in the 1930s to the very early 1940s. Adjusting for duplications, the 1940 Contrast Chart can be broken down into seven textures, four levels of sheen, and four tints that were combined to make 22 different named surfaces.

As noted earlier in this chapter, some product lines contained only a small number of distinct surface combinations. Other lines, such as the Azo product line, contained many, but not all, of the surface combinations. In the 1940 listing, Azo was represented by 14 of the 22 combinations of texture, sheen, and tint. However, there was a great deal of variability in the offerings; in 1947 Azo was represented by only two surfaces but by 1958 had been expanded back to four surfaces.

Over the years, textures of the fiber base products were discontinued based on changing customer preferences and lack of demand. No unique textures were added after the late 1940s. Rough texture was discontinued in 1966; Suede in 1972; Silk in 1980; Tapestry and Tweed in 1987; and Fine-grained in 1999. These dates are approximate as in some cases product was available for sale from inventory for some time following manufacturing discontinuance. Only Smooth texture was being offered when Kodak stopped producing fiber base black-and-white papers in 2005.

1. Reinhold Becker Papers D.354, Rush Rhees Library, University of Rochester, Rochester, NY. [See chapter 3 of this publication for further information on Reinhold Becker.]
2. [Notebook of Paper Mill grades, 1929], Kodak Historical Collection #003, Rush Rhees Library, University of Rochester, Rochester, NY
3. Reinhold Becker Papers D.354, Rush Rhees Library, University of Rochester, Rochester, NY. [See chapter 3 of this publication for further information on Reinhold Becker.]

PAPERMAKING AT KODAK

Eastman Kodak started applying photographic coatings to paper in the early 1880s using raw base manufactured in Germany and France. At that time, no raw base paper was made in the United States that met the purity, cleanliness, and physical properties required for photo paper. Papermakers in this country believed that a secret process or knowledge was required to make photographic paper base. European manufacturers claimed that purity of the water was the major requirement and that there was no water supply in the United States equal to the water used by European mills.

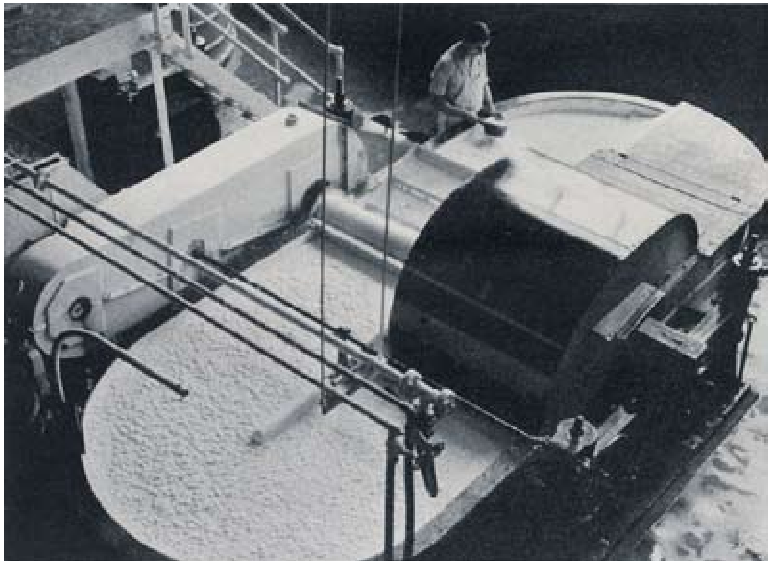
As the photographic paper business at Kodak grew in volume, it became more and more difficult to obtain enough raw base as orders had to be placed as much as a year in advance and at different paper mills for different raw bases. The supply process became so complicated that in 1906 George Eastman authorized a study to investigate finding a domestic source of raw base. There was no research laboratory at Kodak at that time so the investigation was assigned to Kodak's Industrial Laboratory and work was started in September 1906. The main focus was to identify paper pulps that did not have adverse affects on sensitized silver salts.

Soon after this, arrangements were made for small commercial experiments to be made at a paper mill in Ohio. Changes were made in the equipment at this mill to improve the removal of metal, dirt, and other impurities and a testing laboratory was installed for control of the chemicals and pulps. Small runs of raw base paper were made and shipped to Kodak Park for testing and comparison with European papers. Production experiments continued for nearly six months and though some progress was made, none of the paper made was usable for photographic purposes due to physical defects and contamination. It was eventually concluded that the mill equipment was not suitable for photo paper and production was abandoned.

At about that same time, arrangements were made for a trip to Europe to try to find out how photographic raw base was made. The manufacturing processes were closely guarded secrets, however, so only a brief inspection was allowed. In addition, the information provided proved either conflicting or was later determined to have been false. In order to renew experiments at Kodak Park, additional laboratory equipment was installed in order to make handsheets to test different sources of pulp and water.

During this same period, a paper mill in Massachusetts started making photographic raw base paper with the cooperation of an expert who claimed to have developed a secret process for making photographic paper. The chemicals required for this process were prepared by an expert in a locked room with no access allowed to other mill personnel. Kodak encouraged this work and, although the surface of the paper was very coarse and rough, the raw base was purchased for use in product that did not require a smooth surface.

Since there had been little success in securing a domestic source of supply, the decision was made that Kodak should build its own paper mill. Authorization was given in April, 1913 to begin design work for a paper machine to be installed in an existing building at Kodak Park in Rochester, NY. It was to be capable of making paper 42 inches in width. The total capacity would be less than 25% of the Kodak demand for raw base paper but the main reason for this installation was for experimental purposes. The machine was to be of conventional design for that time period with one exception. Based on the trial work, the decision was made that, wherever possible, it should be constructed from copper and bronze. If iron was necessary it was to be plated with nickel. The purpose for this was to minimize the opportunity for iron contamination in the raw base under the belief at that time that iron was the only metal that was harmful to photographic emulsions. The design work was finished and the order was placed in September 1913. By January 1914 the paper machine had been delivered to Kodak Park. The cost was said to have been $750,000. Another account claims that the cost was $137,949.04 but it is likely that was the cost of installation, not the total cost.



(Fig. 2.1) One of the many beaters used in the Kodak Park paper mills.

Kodak Historical Collection #003, Department of Rare Books and Special Collections, University of Rochester Library.

(Fig. 2.2) The forming section of a 50-inch (wide) Kodak papermachine (1986). The pulp/water mixture is moving toward the camera position.

Kodak Historical Collection #003, Department of Rare Books and Special Collections, University of Rochester Library.

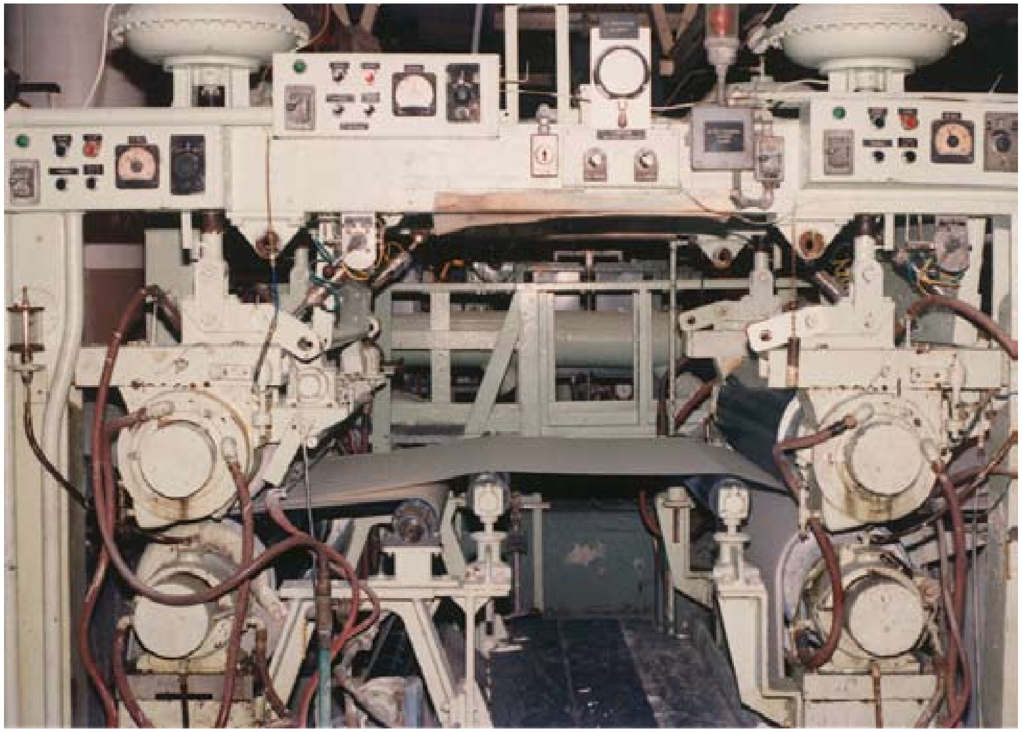
THE PAPERMAKING PROCESS

Prior to the late 1700s, paper was made by draining a suspension of fibers in water through a screen attached to a wooden frame. The single sheet of still wet paper was then removed from the screen, pressed to remove excess water, and then dried, often by hanging so that air could circulate around the sheet. The patent for the first paper machine capable of making a continuous roll of paper was granted in France in the late 1790s. In the early 1800s, the Fourdrinier brothers patented improvements and their name became synonymous with paper machine design in which the sheet was formed on a flat continuous screen. The first Fourdrinier paper machine was installed in this country in the late 1820s. By the time Kodak installed the first experimental machine, Fourdrinier paper machines were the conventional design.

While the description of a paper machine as a Fourdrinier machine actually only applies to the web forming part of the machine, the entire process had become standardized into well recognized sections such as:

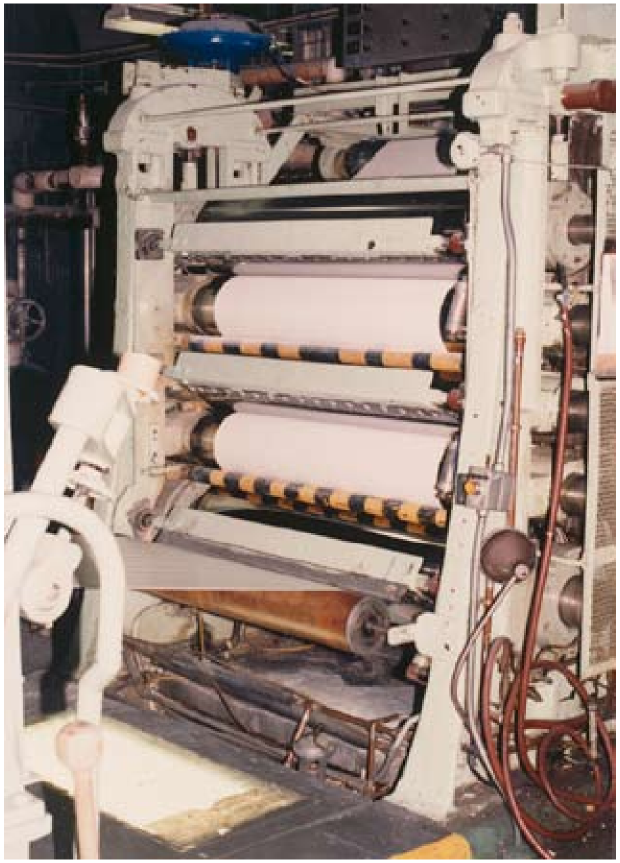
• Stock Preparation - separation of pulp fibers in water followed by beating and refining of the pulp fibers (brushing and cutting operations)
(see Fig. 2.1)
• Chemical Addition - addition of sizing agents (for water resistance), fillers, strength additives, dyes, etc.
• Screening - removal of dirt, fiber bundles, contamination, etc.
• Sheet Forming - the dilute fiber, chemical, water mixture is deposited on the endless moving screen to allow water to be removed by drainage and/or suction (see Fig. 2.2)
• Wet Pressing - the formed paper web is carried through press rolls to further remove water and to consolidate the fiber web (see Fig 2.3)
• Drying - evaporation of most of the water from the web by contact with steam-heated cylinders
• Surface Treatments - further application of chemicals to improve sizing and physical properties, followed by additional drying
• Calendering - passing the dried web between a series of metal rollers to smooth the surface and reduce the thickness (see Fig. 2.4)
• Reeling - winding the full width of paper on a large spool
• Winding - slitting the full width of paper to the desired roll widths and winding on a core

Several editions of the Kodak Reference Handbooks for black-and-white papers, as well as other Kodak publications, have provided descriptions of the paper making process. The level of detail varies by publication but none of them ever mention the wet pressing section of the paper machine. This was probably not an oversight as several of the textured surfaces for black-and-white papers were produced in the Wet Press section. This technology would have been well known within the paper industry so the intent was probably to hold as trade secrets the detailed information about the materials and processes. The use of the Wet Presses to produce textured surfaces will be described in Chapter 4.



(Fig. 2.3) The wet press section of a 50-inch (wide) Kodak papermachine(1986). The paper web is moving right to left, exiting the first press, and entering the second press supported by the wet felt.

Kodak Historical Collection #003, Department of Rare Books and Special Collections, University of Rochester Library.

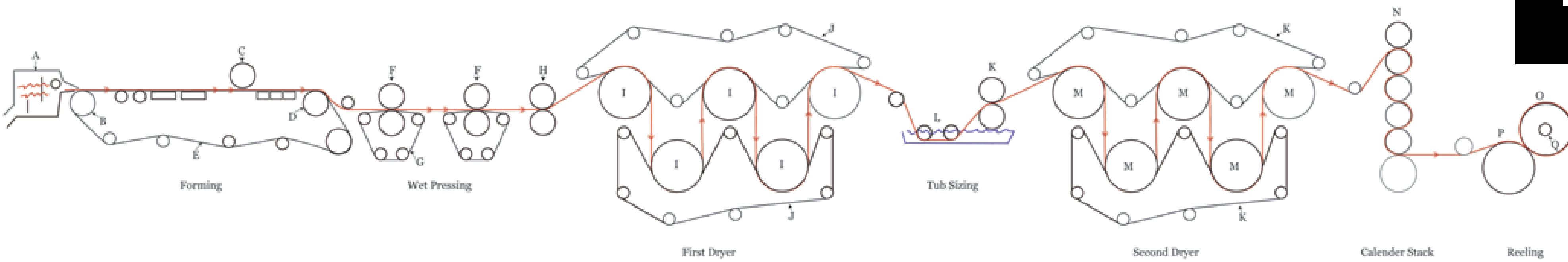


(Fig. 2.4) The calender stack of a 50-inch (wide) Kodak papermachine (1986). The dried sheet of paper is entering the calender at top/right, exiting at bottom/left.

Kodak Historical Collection #003, Department of Rare Books and Special Collections, University of Rochester Library.

ILLUSTRATION ONE: THE PAPERMAKING PROCESS

Original Drawing by Kit Funderburk. Graphic Illustration by Jennifer Curtis.



A. Headbox: distributed the fiber-water slurry (stock) onto the wire.

B. Breast Roll: support roll for the wire, point at which the stock was discharged onto the wire.

C. Dandy Roll: wire covered cylinder that smoothed the top of the sheet.

D. Couch Roll: main drive roll for the wire, point where the formed paper web was removed from the wire.

E. Wire: metal or synthetic mesh on which the sheet was formed.

F. Wet Presses: in this illustration there are 2 but there could be more. There are many different configurations but this one is a simple depiction of the type on the Kodak black-and-white paper machines. They would have been referred to as First Wet Press and Second Wet Press.

G. Wet Felts: woolen or synthetic fabrics that carried water away from the sheet; the wet felt on the Second Wet Press was the position for the marking felts if used.

H. Smoothing Press: sometimes referred to as the Third Press or as an unfelted press. The normal operation was with a smooth top roll used to make the sheet smoother. For press marking, the top roll was textured.

I. Dryer Drums: hollow, internal steam heated rolls used to dry the paper. In this illustration only 5 driers are shown. There were many more depending on the size of the machine and groups of dryers would be organized into first sections dryers and second section dryers.

J. Dryer Felts: woolen or synthetics fabrics that held the sheet in close contact with the drier drums in order to get efficient heat transfer to the paper web.

K. Size Press Rolls: Size refers to gelatin or starch treatment of the sheet. The illustration shows what was called a "tub size" operation in which the sheet was immersed in the size and then passed through the press rolls. This is an old style method but was the one used for photo paper at Kodak up until about the 80s.

L. Size Tub and Immersion Rolls: pan that held the sizing material; the immersion rolls were lowered into the size to submerge the sheet into the size.

M. Dryer Drums: This section of dryers (the third section in Kodak reference) was used to dry the moisture that had been put back into the sheet in the size press. It was sometimes referred to as the "after dryers" since they dried the sheet after the size had been applied.

N. Machine Calender: smoothly ground metal rolls, stacked vertically, that reduced and unified the sheet thickness and improved the smoothness. There were different roll configurations used on different Kodak paper machines. The one shown in this illustration is a very simplified design.

O. Paper Reel: the full width, large-diameter roll of paper wound up at the end of the paper machine. For a Kodak black-and-white paper machine, the reel of paper was about 43 inches or 86 inches wide by a multiple of 2 to 3 times the final roll length. For example, a reel 86 inches wide by 60,000 feet long would have been slit down on another machine to 6 – 43 inch wide rolls, each 20,000 feet long (there are no allowances for waste or edge trim in this example).

P. Reel Drum: large diameter roll used to maintain tension on the sheet while the paper reel is formed.

Q. Reel Spool: core onto which the paper reel was formed. When a paper reel was completed to the desired length, a fresh reel spool was moved into position next to the paper reel, accelerated to sheet speed, and a transfer was made to the fresh spool. There were many means used for the transfer but they are beyond the scope of this simple illustration.

LEARNING TO MAKE PHOTO RAW BASE PAPER

The manufacture of paper was started in the new mill on June 9, 1914 and, at first, ordinary commercial bond paper was made for general use within Kodak. As soon as the equipment was considered to be properly adjusted, experiments were started to make photographic raw base paper. Throughout the rest of 1914, 225 experimental runs were made. Many operational issues and quality problems were encountered and several hundred rolls of paper were made that were of no photographic use. These rolls were later used for making writing pads for use throughout the company. In some experiments, by the time the machine operation was stabilized, the supply of raw materials was exhausted and no paper at all would be made.

It became obvious that attempting small trials would not allow sufficient time to reach stable operation. Therefore, it was decided that a large, continuous trial was needed to obtain the best results. On January 25, 1915, the first continuous run of three days was made which produced 49 rolls of raw base. This paper was still inferior for surface properties, general appearance, and handling but did show improvement over previous experiments.

The start of WW I in Europe had by this time shut down the supply of photographic raw base and Kodak was solely dependent on what was in stock plus the small amounts of inferior quality paper available from domestic sources. Therefore, it was decided that despite considerable losses and high costs, the experimental paper machine would have to be put on continuous production with the best paper samples to be selected for photographic use regardless of inferior quality and defects. In the next several months, more than 1000 rolls of unacceptable paper were produced. These rolls were stored and later sold to another company for use as photo postcards.

The first roll of usable paper was produced on March 30, 1915. There were still many problems but by June 17 a run of 18 rolls was made that was considered usable in an emergency. By September, more improvements were made and for the first time there was considerable optimism that acceptable raw base could be made. Therefore, it was decided to install additional equipment to increase the capacity and to operate 24 hours per day and seven days per week.

In the early 1900s, European photographic raw base was made almost entirely from white rags (a description of white rags is given later in this chapter). This could not be duplicated since the Kodak paper made from 100% white rags caused excessive curl and absorption of developing and fixing chemicals in the print making process. The best formula to avoid these problems was found to be 30% white rags, 20% sulfite wood pulp, and 50% soda wood pulp.

The sulfite pulp (predominately spruce and balsam fir) was a standard grade supplied to many paper mills. The soda pulp produced paper of low expansion when wet which was needed in order to coat the paper without excessive curl. There were many problems with this formula as the soda wood pulp contained wood slivers in addition to dirt and iron particles which reacted with the photographic emulsion causing black spots in the photographic prints. Even though these raw materials produced paper of inferior quality, they were the best available at the time.

It would not have been possible to use this paper at all without the discovery of a sizing formula in Henley's Book of Formulae which had been published in 1891. This formula covered coating both sides of paper with glue or gelatin and then dipping the coated paper in a formaldehyde solution. The formaldehyde reacted with the gelatin producing a water resistant layer on each side of the paper and to some extent between the fibers. This water resistant layer kept the emulsion from penetrating the paper and reacting with the iron and dirt. Some of the impurities on the surface of the paper reacted with the emulsion but the black spots on the finished prints were sufficiently reduced in number that the paper, when baryta-coated, was considered usable under the circumstances. See Chapter 3 for a description of baryta coating.

Since the raw base intended for glossy photographic paper was always baryta-coated, it was decided to use most of the paper made at Kodak Park for the production of glossy paper. This was desirable, not only to make Kodak paper usable, but also because the supply of European raw base used for glossy paper had been completely exhausted.

There was still some stock on hand of rough surface paper from Europe and the paper mill in Massachusetts continued to supply rough surfaced paper. This paper was very inferior to the European paper but could be used with the less sensitive emulsions. Even so, the Massachusetts company was persuaded to make photographic paper at another of their mill sites which helped to supply more of the rough surface paper but there was still a shortage of glossy paper.

Kodak made a survey of all of the manufacturers of high grade paper in the United States and requested them to make photographic raw base paper. Samples were made at several mills in the east and mid-west. The samples from one of the mills which had developed raw base for blueprint paper were promising enough to justify production trials and several carloads of paper were made and shipped to Kodak Park. All of this paper showed a large number of black spots when coated with the less sensitive silver chloride emulsions and white spots in the dark areas of the prints when sensitized with the higher speed silver bromide emulsions. The source of these spots was not known as there was no visible impurity and the spots showed only after processing. The supplier did not believe that their paper was at fault but Kodak did not experience the same number of defects with other papers that were emulsion coated at the same time. Due to this disagreement, no more paper was made at this mill. The cause of the problem was later identified by Kodak chemists as microscopic spots of bronze on the paper surface.

EXPANSION AND CRISIS

The demand for photographic paper had increased so much that on August 1, 1916 it was decided to build another paper mill with six paper machines and to attempt to make all the brands of raw paper base. Construction was started on a new building to house the paper machines in late 1916.

The equipment for the first of five 50-inch paper machines for the new mill, all based on the same design as the experimental machine, began to arrive in March, 1918. The first machine began production on June 22 and the first delivery of paper was made on July 1. The second machine was ready for operation and delivered paper in August followed by the third machine in October. The fourth and fifth machines were completed in July, 1919. The original plan had been to rebuild the experimental machine in the new mill as the sixth paper machine but that was not done and the experimental machine was dismantled.

It was soon realized that the formula which was acceptable for glossy paper could not be used for the other grades since the degraded color of the wood pulp could only be masked by a heavy baryta coating which destroyed all signs of the texture of the paper. This texture was highly prized by portrait photographers and many beautiful surfaces had been available in the European papers.

The only fiber white enough to match the European papers was that prepared from white rags, preferably those from the cuttings made in the manufacture of white shirts, bed sheets, and other uncolored cotton materials. Therefore Kodak had to increase the use of rags. However, doing so brought about new problems in addition to those previously described.

The processing of white rags involved sorting, cooking in alkaline conditions, washing, and then tearing apart the rags and cutting the individual fibers to the proper length by knives in a beater. The knives in these beaters had all been made from bronze in order to prevent iron contamination. However, when the knives were set closely together to get good cutting of the fibers, the soft bronze material was worn away. Bronze particles ended up in the raw base paper and reacted with the silver salts in the emulsion causing black spots. This problem was understood only after many weeks of study and research and came as quite a surprise since the bronze had been used to avoid the black spots previously thought to be caused only by iron.

The only solution at the time was to set the knives so they did not touch. This resulted in poor cutting efficiency requiring prolonged processing. The protracted agitation with water in the beaters caused the fibers to swell and become slimy, preventing the water from properly draining out on the paper machine. This caused unevenness in the paper and high waste from excessive curling during the subsequent coating operations. The finished paper also curled so much that it broke the boxes in which it was packed. In addition, the finished print, if dried by the customer in the very dry air of heated rooms in the winter time, would curl and roll up in the shape of a lead pencil.

Therefore, it was necessary to compromise and set the knives so that the fibers would be cut in a reasonable time without wearing away too many bronze particles. This made it possible to increase the use of rag fiber to 75%. However, it was very difficult to establish an acceptable process under these conditions and waste was very high from both black spots and paper curl problems.

After WWI, raw base paper was again available from Europe and was being supplied to Kodak competitors. This paper was superior to that being made by Kodak and customers were complaining about the poor quality of the Kodak papers. A recommendation was made to abandon raw base manufacture at Kodak and to resume purchasing from European suppliers. However, a case was made to make one more attempt by replacing all of the bronze knives in the beaters with recently invented stainless steel material. This resulted in significant improvements in both the black spot and paper curl problems. The Kodak paper still had deficiencies but the shutdown of the Kodak paper mills had been averted.

FROM WHITE RAGS TO HIGH ALPHA WOOD PULP

In 1923, the Brown Company developed a new wood pulp with a 93% alpha cellulose content compared to 88% for the regular sulfite pulp. Manufacture of this pulp was being considered as a regular item for high grade paper mills to replace rags. At that time, Kodak photographic paper was made using 75% rag fiber and 25% sulfite pulp manufactured by the Brown Company. The use of pulp made by the sulfite process helped to overcome many of the troubles caused by the use of rags. However, due to the dull color of the pulp and to the dirt it contained, its use was limited to no more than 25%. Kodak was very interested in this new pulp not only because it might help to improve paper quality, but also because white shirt cuttings were becoming very scarce. Shirt makers were using more silk cloth and were using silk and colored stripes in cotton cloth. Dyes were much more permanent and the papermakers could not bleach the colors. Rubber was also being woven into white cloth and showed up as dirt specks in the paper.

At Kodak's suggestion, the Brown Company made a mill trial of this pulp of which the first carload to be manufactured was sent to Kodak Park. While this new fiber had many defects, it was considerably superior to the regular sulfite. The Brown Company introduced this new pulp to the paper trade in 1924 and Kodak soon replaced the 25% regular sulfite with the new high alpha pulp.

Other makers of high grade paper resisted the use of this pulp. The Rag Paper Association retained experts to lecture and write articles on the lack of permanence of wood pulp. They included this new pulp with pulps such as groundwood that was used in the manufacture of newsprint. It was pointed out that newsprint, up to 1866, was made from rags and that newspaper files previous to that date were still in excellent condition. However, files of newsprint made after 1866 from wood pulp had shown discoloration and signs of disintegration after only a few years.

These statements were true and Kodak began to have complaints from customers about the wood content of its papers. This was especially important in the case of insurance companies who made large quantities of photographic copies of policies. They kept life insurance records for 95 years and wanted a guarantee from Kodak that photographic copies on wood pulp paper would last that long.

Kodak could not give this guarantee and was especially worried because, several years before this, attempts had been made to purify and whiten sulphite pulp by means of a strong, hot acid bleach. The pulp was thought to be a very great improvement, as white as rag pulp, and had been used in all Kodak paper for several months. However, after the paper was six months old, it started to turn yellow very rapidly. All the sensitized paper had to be called back from the trade and all the paper in process and the raw base on hand had to be scrapped. This resulted in a large financial loss and a great loss of prestige with customers. It was later learned that the bleaching action had formed oxidized cellulose which was very unstable. Due to the publicity given to wood pulp by the Rag Paper Association and because of this disastrous experience, Kodak delayed the program of substituting the new wood pulp for rags.

The Brown Company faced this issue with many customers. While there was a market for this pulp for rayon and acetate fibers, the only sales to paper mills were to those already using wood pulp and who did not make claims about the permanence of their paper. The new pulp cost much more to make and the high price limited sales to those mills that made lower price wood pulp papers.

The Brown Company had made an extensive study of the permanence of their new pulp but felt that any statements made by them would not be given much weight. Therefore, they asked the National Bureau of Standards to devise an accelerated aging test and to make comparative tests between rag papers and paper made from the new pulp. Government departments supported this as they had always been large purchasers of 100% rag papers and the use of this new pulp for permanent papers would result in significant cost reductions.

After several months work, the Bureau approved a rapid aging test and issued a bulletin giving the results of all the tests that they had made. They determined that paper made from the new pulp was as permanent as paper made from rags and more permanent than paper made from used rags. The Bureau recommended that paper should no longer be judged by its rag content but by its performance in a rapid aging test. This publication by the Bureau of Standards enabled Kodak to continue its program of substituting the new high alpha pulp for rags.

In 1925, trials were run to increase the high alpha pulp content in the paper from 25% to 50%. However, this was not successful due to increased cockle in the paper caused by high wet expansion of the fiber. In addition, the pulp contained high levels of copper and iron contamination which caused an increase in the number of black spots in the final photographic product.

The Brown Company made experiments to produce a softer, more pure fiber and by the fall of 1926 it was possible to go into production on a paper containing 50% of this improved high alpha pulp. A great improvement was immediately found in the mottle that had always been characteristic of the Kodak Park paper. However, the high alpha pulp still contained contamination that caused black spots.

Sizing (the process) or size (the material) refers to the addition of chemicals that provide the paper with resistance to penetration by fluids. The materials can be added either to the dilute fiber/water slurry before the sheet is formed (referred to as wet-end sizing) or by surface application (surface sizing) during the manufacturing process. The traditional wet end sizing material was rosin, a natural resin derived from the sap of southern pine trees, or later from tall oil, a by-product of the manufacture of pine wood pulp. The rosin was added to the paper fiber along with aluminum sulfate which reacted with the rosin to form an aluminum complex that attached to the fiber.

It had been recognized for some time that Kodak papers (whether made from rags or from wood pulp) had an interaction with the photographic emulsions that caused poor keeping characteristics. An intensive study of the cause of this deterioration found that it was caused by the slow oxidation of the rosin used for sizing. This oxidation formed peroxide which disseminated into the emulsion layer and caused the emulsion to develop chemical fog (photographic density, in negative working products, without light exposure due to chemical reaction with silver salts). Efforts were then directed at how to use rosin size more efficiently so as to use only the minimum amount required. Papers made this way were known as the 1927 and 1928 papers.

Studies to find a replacement for rosin lead to the discovery that stearic acid, reacted with sodium hydroxide, could be attached to the fibers with aluminum sulfate, just as with rosin, to develop sizing in the paper. But the sizing effect when using the 50% white rag fiber/50% high alpha wood pulp was not sufficient to hold out the baryta coating nor was it enough to keep the paper from picking up excessive water. However, when the rag fiber was replaced with the high alpha (100% high alpha pulp content paper), the stearic acid size provided a well-sized paper, free from excessive water absorption, and non-fogging to the emulsion. It was also found that paper sized in this manner did not turn yellow with age as papers sized with rosin did. However, this discovery could not be used, since the high alpha pulp was not satisfactory for use at 100% due to the presence of the metallic contaminates which caused black spots and the excessive wet expansion of the fibers.

The Brown Company, therefore, agreed to install a large chrome plating plant and to plate all the exposed metallic parts of their equipment used in the manufacture of high alpha pulp. They installed new equipment and ran trials to further increase the purity of the alpha fiber. The result of these efforts was a high alpha wood pulp free from contamination that could be used at 100%. In 1929, Kodak introduced the first paper made from 100% high alpha wood pulp along with stearic acid sizing.

Though the 100% high alpha wood pulp paper was highly successful, the paper still had cockle. To address this problem, Brown Company made a series of experiments to manufacture a pulp from poplar which had been chosen after an evaluation of 15 different wood species. Paper made from this pulp had very low expansion due, at least partly, to the short fiber length of poplar. However, use of this pulp was restricted to no more than 25% due to loss of strength caused by the shorter fiber length. This pulp was introduced at Kodak in 1930 and was very successful in reducing cockle.

By 1931, all raw paper bases, with one exception, had been converted to 100% high alpha wood pulp and stearic acid sizing. The exception was Photostat papers as some local governments continued to mandate that rag fiber be used for photocopying papers.

A sixth paper machine was installed in 1931 in an adjoining building to make what was referred to as non-photo grades of paper such as interleaving, film backing, and duplex papers. Manufacture of these papers was made possible when the use of the stearic acid with high alpha wood pulp was shown to have no fogging action on film products even under harsh heat and moisture conditions. This machine had a traditional Fourdrinier section and a separate cylinder former. The cylinder former (invented in the early 1800s) formed a web on a horizontal screen covered hollow roll (the cylinder) rotating in a vat of diluted paper fiber. To make the duplex paper (black on one side, yellow on the other) separate sheets were formed on the Fourdrinier and the cylinder and then pressed together in the wet presses. Traditional grades of black-and-white paper were never made on this machine.

In 1932, a new method for handling of high alpha pulp was developed making it possible to eliminate cockle and excessive warp in Kodak papers. In this process, the high alpha pulp was furnished to a beater, lightly beaten, formed into a web, and then rapidly dried. The objective was to destroy some of the bonding sites on the cellulose molecule and thus reduce its later reaction with water. After drying, the reprocessed pulp was cut into sheets and supplied back to the beaters along with regular pulp for paper production. The process was referred to within Kodak as dehydration or reverse imbibition (RI).

In 1934, a 100-inch wide paper machine with a cylinder forming process was installed in the same building as the first five paper machines. This machine was originally built to pre-process pulp (the RI process) but was rebuilt as a photo paper machine in 1938. The forming section of the rebuilt machine contained a special Kodak design that combined Fourdrinier and cylinder forming methods. This method had previously been installed on one of the other paper machines and was considered to be the state of the art design combining the sheet characteristics made possible with a cylinder former with the flexibility of a Fourdrinier machine. This type of forming device proved to be very speed limited and difficult to control and was later replaced with conventional Fourdriniers.

PROCESS AND IMPROVEMENT

From the earliest days of Kodak paper making, the raw base was tub-sized with gelatin and then with formaldehyde to harden the gelatin. This process had been used to reduce black spots by creating a water resistant layer isolating the emulsion from contaminants in the raw paper base. The process also imparted some wet strength to the sheet so that it would withstand handling during print processing.

Tub sizing was a surface treatment in which the sheet of paper was immersed in a bath containing, in this case, a solution of gelatin and then passed through the nip of two rollers to force gelatin into the sheet and to remove the excess. This was followed by a formaldehyde treatment until the mid-1930s when formaldehyde was replaced by chromium chloride.

Paper made from rags was generally more absorbent and the gelatin in this tub sizing operation penetrated the rag stock paper to some extent. With the wood pulp paper, especially when the fibers were sized with the water repellant stearic acid, the gelatin did not penetrate the paper to help bond the fibers together. This led to separation of the fibers causing a void area in the raw base of the paper when the photographic print was processed by the customer in the developing, fixing, and washing operations. This trouble persisted to some extent until 1935 when Kodak developed a method of penetrating the paper with gelatin by steaming the paper before immersing it in the gelatin solution (the process was referred to as steam sizing). The fiber separation problem was cured by this method but at a very high cost for gelatin. This process also brought about a need to increase the drying capacity after the tub sizing operation.

Melamine formaldehyde resin was introduced to the paper industry in the early 1940s as a wet strength agent. In 1943, following trials, a system was installed at Kodak to supply melamine formaldehyde resin to all the paper machines. This was the first successful continuous addition of a chemical to the papermaking system. Up to that time, all of the chemicals had been added to the beaters in a batch process.

The introduction of melamine formaldehyde was so successful in developing wet strength in the raw base that for the first time the photographic paper was strong enough to withstand continuous roll processing in photographic processing machines. One of the first continuous photographic processing machines was the V-Mail process used during WWII. This small start grew to the point where sheet handling of photographic papers eventually became relatively small in comparison to papers that were developed, fixed, washed, and dried in one continuous process. One disadvantage, however, was that the resin continued to release formaldehyde from the paper sheet for up to two years which caused problems with the shelf life of some photographic emulsions.

In addition to the product benefit, the wet strength system was so efficient that steam sizing was very rapidly discontinued since it was no longer necessary to try to get large amounts of gelatin impregnated into the raw base. This created an imbalance in the drying systems since there was no longer a need for large amounts of drying capacity after tub sizing. However, additional drying was needed ahead of the tub sizing operation in order to heat cure the wet strength resin. Therefore, the drier systems were rearranged and the separate hardener tubs were eliminated in favor of hardener added directly to the gelatin.

In the 1930s, a recovery system for both fiber and silver was installed in the paper mill. All sensitized, undeveloped waste from the paper manufacturing organization was collected, sorted for contaminant materials, chopped into small pieces, and then dropped into a trough containing sodium hypochlorite (bleach) which dissolved the silver halides. The hypo was then pumped through plating cells and the silver was deposited on stainless steel plates. The paper chips were washed and then added to the paper mill broke for recovery. This system was dismantled in 1966 largely because it was almost impossible to keep resin-coated paper out of the system, which made reuse of the fiber impossible. A better system of incineration of the scrap to recover the silver was available and the economics favored burning the silver bearing waste.

In the late 1930s, screening equipment was installed in order to remove heavy dirt particles from the dilute fiber/water mixture before the web was formed. These screens replaced rifflers which were long troughs with cleats fastened to the bottom. The fiber slurry flowed down this trough and heavy dirt was caught ahead of the cleats. Kaolin clay was a common ingredient of most of the raw bases at that time. It had always been a problem that some of the clay was removed by the rifflers along with the dirt but this problem increased with the more efficient screens which eventually lead to the removal of clay from the raw bases.

The Kodak photo paper business continued to grow through the 1930s requiring more capacity from the paper machines. By 1940 additional driers had been added to most of the machines and the average paper machine speed had been increased from well below 100 feet per minute (fpm) to 105 fpm. This was not enough to keep up with demand during WW II and further increases were necessary. In 1944 and 1945, more than 2-1/2 times as much paper was made as in 1940. This required further drying capacity to increase the average speed to 170 fpm as well as going to seven days of operation.

Beating, alternately known as refining (see fig. 2.1), was traditionally a batch process in which pulp, diluted in water in an oval vat, was passed between a revolving roll and a fixed bedplate. Both the roll and bedplate were fitted with metal bars. The mechanical action created between the bedplate and the bars separated the pulp into individual fibers or small fiber bundles, then hydrated, fibrillated, and shortened the fiber length through cutting. Depending on the type of fiber, the condition of the bars, and the process parameters, it could take several hours to accomplish the desired amount of fiber treatment.

This batch process was replaced by a continuous process in which the diluted pulp was continuously pumped through a refiner consisting of a cone shaped rotor rotating within a conical shell (Jordan refiner). The bars where placed lengthwise down both the rotor and the shell and the positioning of the rotor versus the shell controlled the amount of fiber treatment. For this process, it was necessary to first mix the pulp with water and then to use mechanical action to break up the pulp into small fiber clumps. This was the role of the pulper which in this case was a large tank with a rotor in the bottom.

The first pulper (trade name Hydrapulper) was installed in the paper mill in 1944. While this was the beginning of the end for the beaters, it would be many years before all of the 32 – 600 pound beaters were completely replaced. One operational difficulty with the conical refiners was uneven bar wear and this caused problems when refining fiber for lightweight papers. Therefore, a new, modern pulper was installed in 1945 for the refining on critical paper grades. Pulp was first slurried in the Hydrapulper then pumped to the new beater for refining. This beater was eventually taken out of service as the process knowledge for operation of the Jordons increased.

The initial installation of the Hydrapulper in 1944 was such an overall improvement however that another Hydrapulper was installed in 1947 and mixing chests were also installed to mix the chemicals with the fiber. Automatic controls were becoming more commonplace and the mixing chests were equipped with level control measuring tanks and a sequence timer to add the chemicals in the proper order.

By the late 1940s, paper machine speeds had continued to increase and many capital expenditures had been made to break bottlenecks. Basis weight control was a serious problem due to stratification in the chests and increased sheet agitation was not the complete answer. A consistency regulator, which was new to the industry at the time, was installed on one machine in 1946 and on all machines by 1948. These early regulators were crude but were a big step forward in making more uniform basis weight.

The control of wet expansion of the photographic papers had always been a problem. Experimental work had shown that wet expansion could be reduced by restricting shrinkage of the raw base during drying. To accomplish this in production a Yankee dryer was installed on one paper machine in May 1945. The Yankee dryer also had the advantage of making a somewhat smoother surface on the raw base. This Yankee dryer was unlike any other in the paper industry in that the top side of the sheet was pressed onto the dryer. This made the machine thread-up more difficult. In addition, this dryer was chrome plated and doctoring the surface was a problem that was never completely solved. A long learning period was required to successfully operate the Yankee but by May 1947 most of the problems had been overcome. All of the Photostat papers were dried on the Yankee for quite a few years but it finally fell into disuse and was eventually removed in 1971, the result of limited drying capacity, mechanical and thread-up problems, and general control issues.

The cost of gelatin for tub sizing and the presence in the market of new thin boiling starches prompted trials in 1945 which eventually resulted in the installation of equipment to cook and supply starch to the size tubs on the paper machines. Over several years, gelatin was replaced in most of the grades with starch. However, gelatin surface sizing was never completely replaced and was being used in one grade family when the mill making black-and-white paper closed in 2000.

By 1945, it had been found that aluminum chloride could be used to replace the aluminum sulfate used to precipitate the stearic acid size. It has been reported that the change was introduced since only one-half as much melamine formaldehyde was required to obtain acceptable wet strength. Other claims have been made that the benefit of aluminum chloride was that it formed a smaller floc size with stearic acid and improved the sizing in the sheet.

By 1950, paper machine speeds averaged a little over 200 fpm and work was still progressing in breaking bottlenecks in drying, refining capacity, and screening. Dissolved and entrained air in the system caused a serious problem with foam in the sheet. The Deculator, an industry development that provided vacuum removal of entrained air, had been successfully installed on a Canadian newsprint machine. The first Deculator at Kodak was installed on one machine in 1953 and the improvement was so dramatic that Deculators were installed on all machines by 1959.

Most of the paper machines were running at their drive capacity so the old belt driven mechanical drives were replaced starting in 1953. This continued until all machines were using electric drives by 1957.

In 1956, a scanning beta gauge to measure basis weight was installed. This was an important improvement as it provided real time measurement of weight. Eventually all of the machines were so equipped.

The introduction of melamine formaldehyde for wet strength, while a great benefit, came with problems since the resin made the wool of the wet press felts resistant to water. Continuous felt conditioning with pH controlled water was installed to clean the felts as they ran and this was successful in extending felt life.

By the mid-1950s, refining capacity was a constraint and somewhat different refining techniques were necessary for the raw bases for Verifax. While a lot had been learned about refining, the problem of uneven wear in the Jordans had never been completely resolved and it was theorized that disc refiners would help solve that problem. Consequently, a double disc refiner was installed on one machine in 1956 followed by two others in 1957 and 1958. A great deal of development effort was placed on plate design as it was speculated that by changing plates it would be possible to refine specifically for the needs of different paper grades. The long term goal was to replace the jordans; however, it was determined that discs were not suitable for cutting the fiber but were very effective for hydration. The long term refining capacity was solved by the use of both Jordans and disc refiners in series on the paper machines and eventually every paper machine was so equipped. This combination gave much more flexibility and control of the final sheet characteristics.

From 1929 to 1939, the Brown Company had been the sole supplier of high alpha sulfite pulp. It was the feeling at that time that wood pulp needed to be aged for two years before it was fit for photographic papers. The pulp for Kodak was made only during the winter when the water was the cleanest and shipped to Kodak for storage prior to use. Part of the large inventory was due to the two-year storage requirement but part was also due to having only one source of supply.

EXPANSION IN THE USE OF WOOD PULPS

In 1939, Kodak began looking for other sources of high alpha wood pulp. It took some time to develop an acceptable supply but by the early 1940s Kodak was using small amounts of a western high alpha pulp made from 100% hemlock. At the same time, another source of northeastern softwood sulfite (a mix of northeastern spruce and fir) had been found and gradually replaced the original supplier so that by 1971 it comprised over 50% of the pulp used by Kodak.

Advances in the bleaching of wood pulp using chlorine dioxide in the 1940s made it possible to produce white, strong, bleached sulfate (kraft) pulp and eventually made it possible (ca. 1955) to produce regular sulfite pulps with the desired paper making characteristics that were less expensive than the high alpha pulps. By the late 1950s, Kodak was using 10 different pulps from a variety of wood species. The softwood bleached kraft pulps were mainly used in the production of the non-photo grades where their strength properties were important.

At this same time, trials were underway using northern hardwood bleached kraft (blends of maple, beech, birch, and poplar) and these pulps were introduced during the 1960s to replace small amounts of both hardwood and softwood bleached sulfites.

During the 1950s, Kodak had started placing radioactivity monitoring stations at several of its manufacturing sites around the world in order to detect effects caused by atmospheric nuclear testing. Tests sites were also installed at several pulp mills in the United States and Canada. In 1959, the air and water were found to contain so much radioactivity that it began to affect the photographic acceptability of some of the non-photo papers produced for film packaging. It was necessary to install absolute air filters and water filters and seal the building so that radioactivity did not leak in. Pulp manufacturing sites were also affected and the suppliers making the pulps for the non-photo papers took measures to close up their mills.

As new pulp suppliers were added so were new testing stations and these were maintained even after atmospheric testing ceased. On May 18, 1980, Mount St. Helens erupted sending millions of tons of volcanic ash into the atmosphere. Kodak's major softwood sulfite pulp supplier at that time was located 200 miles from Mount St. Helens. A large amount of the wood supply for that mill was directly impacted by ash fallout. The ash cloud also spread across North America jeopardizing other pulps as well. The radioactivity monitoring stations were used to track the ash cloud and data was cooperatively shared with U.S. government agencies. As the ash cloud passed the mill locations of Kodak pulp suppliers, manufacturing for Kodak was suspended in order to avoid any contamination that could impact photographic properties.

In the early 1970s, a market shortage of softwood sulfite pulp led to an increased use of hardwood kraft pulp and by 1976 northern hardwood bleached kraft pulp made up about 35% of the total pulp purchased by Kodak. Only very small amounts of alpha softwood sulfite pulp were still being used for some double weight black-and-white papers.

In 1980, 13 different wood pulps were being used by Kodak to manufacture black-and-white, color, and non-photographic papers. Most of the hardwood kraft pulp was used for color paper. In 1990, small amounts of tropical hardwood kraft were introduced (plantation grown eucalyptus). Another major shift in pulp usage occurred in 1994 when hardwood bleached kraft pulp replaced all of the softwood bleached sulfite in color raw base.

Conversion of pulps in the fiber base black-and-white papers proceeded more slowly and cautiously as there was considerable resistance to change from both customers and from within Kodak. Northern hardwood bleached kraft was incorporated in some black-and-white fiber base grades but was never used at 100% in these grades in Kodak's paper mills. When the last fiber base black-and-white raw bases were made at Kodak in 2000, the major pulps in use were softwood bleached sulfite and hardwood bleached sulfite with northern bleached hardwood kraft in use at only 15% to 30% for some grades.

THE GLORY DAYS

By the late 1950s, the paper mill was running at full capacity and even then it was necessary to purchase some of the Verifax papers from other paper mills. A new paper machine had been discussed several times but in 1958 approval was given for a new 150-inch paper machine to be constructed in Kodak Park. This created the need to investigate the capability of some of the newer machinery advances in the paper industry for possible use on the new machine. During the design phase, inspection trips were made to many new installations in the paper industry in order to assess the capability for making photo paper. Besides investing in proven technologies, several innovative steps were taken as well. The fiber and chemical blending systems and adjustable vapor adsorption systems were jointly designed by Kodak and supplier engineers and both became industry standards.

The existing machines also became test sites for new equipment and a machine was equipped in 1959 with a new dirt removal system and in 1960 with a pressure screen. These were eventually included in the design for the new machine and gradually put in use on the other paper machines.

As paper machine speeds had increased through the years, the old wooden headboxes became inadequate. For a long period following WWII, a considerable amount of experimentation was done on headbox design and the wooden headboxes were gradually replaced with stainless steel. As machine speeds had increased, increased hydraulic head became more of a problem so that in 1959 a new pressure/vacuum headbox was installed on the non-photo paper machine. While some improvement was made, performance was not completely satisfactory so plans were made to install a very flexible headbox design on one machine in order to investigate headbox design parameters. This was installed in 1961 and lead to the model for the new machine and later headbox upgrades on the existing machines.

Upon completion, the new paper machine was one of the most modern fine paper machines in the world. Production began on September 4, 1962 and though some risks had been taken in the machinery design and process, all of them proved successful.

The paper machine had been justified by and designed to make Verifax copy paper and Verifax matrix base. Just before construction of the machine was completed, however, the Xerographic process was introduced and quickly gained market acceptance which would eventually make the Verifax process obsolete. However, in the meantime, sales of color papers were increasing at such a rate that it was necessary to expand production of the color raw base paper to the new machine. Fortunately, the width of the new machine had been determined by the maximum roll width of any paper made in the mill, which at the time was color raw base paper.

This paper machine continued to make raw base for the Verifax process until 1974, replacing the declining volume with color raw base and a few other black-and-white raw bases primarily for Graphic Arts and Phototypesetting papers. However, the demand for color raw base soon required the total capacity and black-and-white raw bases were no longer made on the new machine.

There was great excitement about the new paper machine, the rapidly increasing demand for color papers, and the development and introduction of resin-coated papers. However, investments continued to be made in the black-and-white paper machines and the products.

Lighter weight photographic papers for instrumentation products were being demanded by the market so in the early 1960s one of the paper machines was refurbished especially to make light weight papers. These products required a base paper with very good dimensional stability under changes in relative humidity. The development of an acetylated cellulose fiber made this possible. The pulp fibers were acetylated at Tennessee Eastman, dried, and sent to Kodak Park. This was a very difficult fiber to handle since its water resistant properties made it very difficult to wet in the Hydrapulper. The fiber produced very low strength papers so its use was limited to small amounts in the pulp blend. As process improvements were made to improve dimensional stability, the fiber became obsolete and was discontinued in the early 1970s.

Even though the advent of melamine formaldehyde wet strength resin had been a tremendous advantage in manufacturing photographic papers, the formaldehyde given off in minute quantities was a serious problem for some products. In the late 1950s, a formaldehyde-free wet strength resin was introduced into the paper industry. This brought about a significant change in the manufacture of photo paper. By the mid-1960s many of the raw bases had been converted to the new wet strength resin which made possible much longer product shelf life. Eventually all raw bases were converted to the new resin.

For many years, gelatin and then starch had been added to the fiber mix in order to increase the strength of the raw base. In the mid-1960s, dry strength resins became available which provided a means of attaining fiber-to-fiber bonding strength. Along about this same time, articles were beginning to appear in the technical journals about the electrokinetic theory of sizing paper. The application of this theory, in conjunction with the new dry strength resins, took several years to perfect but finally resulted in the early 1970s in much better sized photographic base papers with a significant decrease in the amount of chemicals needed and a tremendous reduction in the organic material discharged to the sewer.

During the mid-1960s, many large computers were installed on paper machines in the United States to control the process. None of these were successful because papermakers did not know enough about all of the factors necessary to control a certain machine or paper base parameter. However, these installations were of considerable interest and it was decided to install a small data logger with the necessary instrumentation on one of the black-and-white paper machines to study the process in relation to sheet characteristics and paper machine operation. This installation was made in 1968 and the study proceeded for several years. As a result, a small black box was installed with closed loop controls for those parameters which were clearly understood rather than a single large computer. One such black box installation was made on the new paper machine in 1973 and resulted in, it is believed, the first operating system on a paper machine to control both machine direction and cross direction basis weight and moisture content.

The last major change for black-and-white papers at Kodak was the conversion to alkaline sizing using synthetic sizes which did not require a source of alumina (from aluminum sulfate or aluminum chloride) to attach to the fiber. The conversion was made in response to a serious edge penetration problem with a black-and-white graphic arts paper. The problem was not controllable by the normal means of adjusting the stearic acid size or using other sizing materials in the tub size. Kodak scientists had previously investigated alkaline sizing and believed that this could improve the edge penetration resistance. In 1985, a very rapid development project was undertaken to change the sizing system. At first, the conversion was made for the critical raw base for graphic arts made on one of the paper machines. It was then expanded to all black-and-white grades made on that machine and finally expanded to all black-and-white raw base papers.

By 1935, the paper mill operations had grown from the original 50-inch paper machine to five 50-inch paper machines. One building housed five 50-inch paper machines and one 100-inch RI machine. Another building housed the 100-inch non-photo paper machine. By 1938, the RI machine had been converted to photo paper manufacture and in 1962, the 150-inch paper machine had been installed in yet a third building.

On October 31, 1978 a milestone was reached when the combined year-to-date output of all Kodak paper machines exceeded one billion linear feet. This total had never before been accomplished even in a full year. It is interesting to note, however, on that day in October, only four of five operating paper machines were running. Kodak had built nine paper machines; the original experimental machine had been dismantled in 1919, a 50-inch machine had been dismantled in about 1940 following the conversion of the RI machine to photo papers and two other 50-inch machines had been shutdown in 1964 and 1973. Of the four paper machines in operation that day, one (150-inch) was making raw base for color products, one (100-inch) was making roll film backing paper, and two (100-inch, 50-inch) were making traditional fiber base black-and-white raw bases.

THE END OF AN ERA

At the time, this was a celebration of the increasing volume of paper being made. In retrospect, it foretold the future for the fiber base black-and-white papers. The volume growth was in color products and in resin-coated papers for black-and-white products. In the early 1980s, the 100-inch non-photo paper machine was shutdown and the products were outsourced to other paper mills. This machine had a brief second-life in 1984 when it was restarted to make recycled pulp for outside sale but this venture was short-lived and the machine was again shutdown in 1985. The closure of another 50-inch machine followed in 1986 as the demand for the fiber base black-and-white papers declined.

During this time, the total volume of Kodak-made raw base continued to increase but the growth was in color products and all of the black-and-white products were in decline. In the mid-1990s, only two machines were still making raw base for black-and-white papers. By the late 1990s, demand for traditional fiber base black-and-white products had dropped so significantly that it represented less than 1% of the total photo raw base produced at Kodak Park. The production was highly inefficient as it was spread across two paper machines, with only one operating at a time, and accounted for only 3% of the volume being made on those two machines.

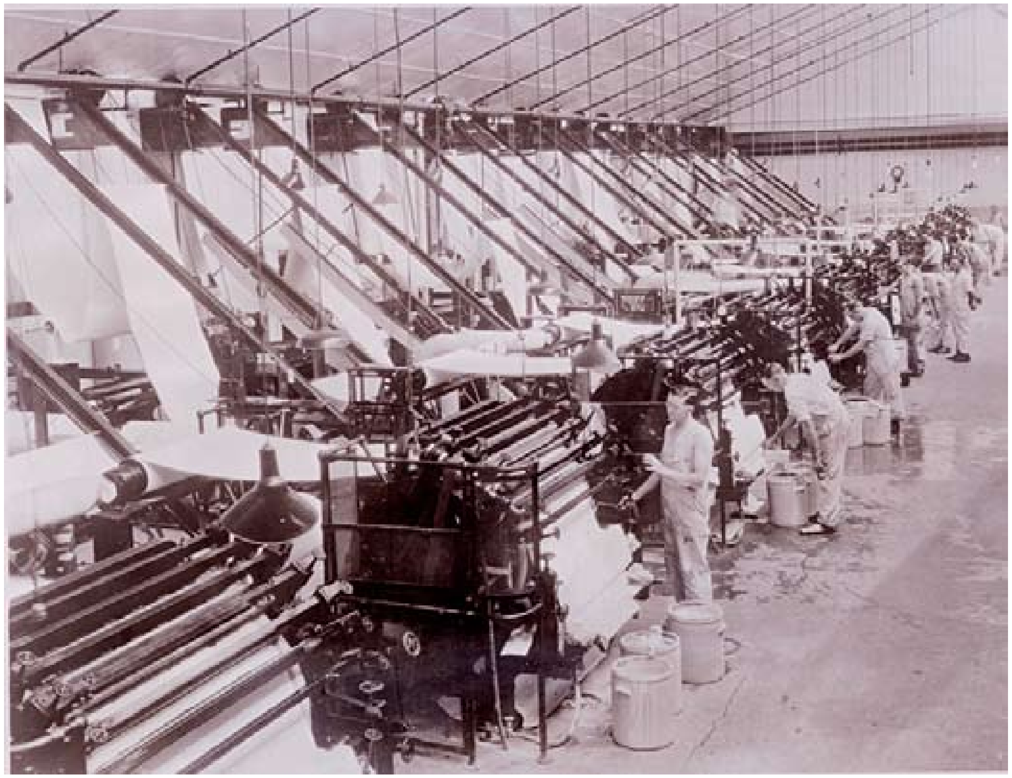
In order to try to manage manufacturing cost for the remainder of product life, a project was started in 1999 to outsource the remaining black-and-white raw bases. This project was completed in 2000 and the two remaining paper machines making black-and-white raw bases were shutdown.

The last of the textured papers, Fine-grained, was discontinued so that upon transfer of manufacturing in 2000 only the Smooth paper was still in production. However, the life-span of the remaining grades was very short as Kodak announced in 2005 that it was ending production of black-and-white papers by the end of that year.

When the shutdown of the two paper machines making black-and-white raw base took place in 2000, the last remaining paper machine at Kodak had just undergone a major rebuild and was posed to continue to meet the demand for color products. However, the rapid growth of digital photography impacted the demand for traditional color products and by 2005 it was operating at less than full capacity. On March 17, 2005, Kodak announced that it too would be shutdown. The manufacture of color raw base was outsourced and on May 12, 2005, the last Kodak paper machine was shutdown and soon after dismantled. The building that housed the paper machine was converted to other operations and by 2007 the buildings that housed the other paper machines and baryta coaters, as well as the buildings of the support staffs,

BARYTA COATING COMES TO KODAK

When Kodak started making photographic coatings on paper in the early 1880s, the raw base was supplied with the baryta coating already applied. In 1897, Kodak decided to undertake the baryta coating part of the paper support production. Baryta coating production, with 12 employees, started at Kodak Park in 1900 pre-dating the manufacture of photo raw base at Kodak by about 15 years. During the early 1900s, baryta coatings were applied to raw base that was still imported from Europe.



The coating application sections of several Kodak baryta coaters (1932) showing the brush coating process.

Kodak Historical Collection #003, Department of Rare Books and Special Collections, University of Rochester Library.

The original two coating machines were also imported from Europe. Both were brush coaters, a process in which the coating material was applied to the surface of the raw base and then smoothed out by oscillating brushes made from badger hair. In 1909, the operation was moved to a different building and expanded to eight brush coaters. In 1918, the operation moved again, this time to the same building that was constructed for the paper mill expansion. Company history was that when the construction firm in charge of the new building went on strike George Eastman hired their foreman and formed his own company to complete the work. This construction company later became a division of Kodak and continued to carry out capital projects for the company.

The expertise required to start a baryta coating operation was imported as well when George Eastman hired Dr. Reinhold Becker of Mannheim, Germany to set up the operation. Dr. Becker's first employment contract was negotiated directly with Mr. Eastman in 1898 and stated that it would be Dr. Becker's responsibility to supply all the baryta-coated paper that was required.

In 1903, Dr. Becker's contract was renewed making him the superintendent of the Baryta Coating Department. Historical records from this time indicate that the baryta operation was very secretive and the formulas were closely guarded. This was not surprising since a clause in Dr. Becker's 1903 contract stated that he could not "disclose or divulge any information, formulae, machine, patents, or inventions of his department" to anyone other than George Eastman or other specifically designated persons. Dr. Becker's contract was renewed several times and he remained with the company until about 1935.

The term "baryta" was derived from barite or barytes, the crystalline mineral ore of barium sulfate. In the context of photo paper, baryta (or baryta coating) was used to describe barium sulfate pigment which was coated along with a gelatin binder and other additives onto raw paper base.

Barium sulfate was prepared by a precipitation process and the resulting wet barium sulfate paste was referred to as blanc fixe. The precipitated barium sulfate was a very white pigment which was chemically inert and had excellent resistance to color change from heat and light. The main function of baryta coating for photo paper was to provide a smooth, white layer to cover the paper fibers and prevent the emulsion coating from penetrating into the raw base. As such, the baryta coating was applied only to the side of the paper that was to be coated with the emulsion.

Kodak initially imported all of the blanc fixe from Europe. When this supply was cut off by the U.S. entry into WWI, a facility was set up at Kodak Park to precipitate barium sulfate from the reaction of barium chloride and sulfuric acid. The process used started with dissolving 1100 pounds of barium chloride in 400 gallons of hot water in a 1000 gallon tank. This was done by suspending 11 flannel bags, each containing 100 lbs of barium chloride, in hot water. After being left overnight to dissolve, sulfuric acid was added from drums hoisted over the rim of the tank. After reacting for 2-3 hours, the acid was drawn off the top and the tank was then topped off with water to bring the total volume to 1000 gallons. This was repeated four times. Then the batch was further diluted into three smaller tanks. After mixing overnight, the batch was run through a filter press to concentrate the blanc fixe. The entire process took more than two days to complete.

This process was used until 1927 but it was recognized that the blanc fixe was inferior in quality to that previously obtained from Europe. Therefore, importation was resumed and the blanc fixe plant at Kodak Park was idled. The blanc fixe from Europe was shipped at 28% water content but dried out during shipping to about 25%. During the depression years, large inventories of imported blanc fixe accumulated. Over the long storage time, bacterial action degraded the blanc fixe, causing photoactive sulfide compounds to form.

WHAT IS BARYTA AND HOW IS IT MADE?

Therefore, in 1930, a new production facility for blanc fixe was installed to replace the earlier system. This time the process used barium chloride and sodium sulfate. The barium chloride was purchased but the sodium sulfate was manufactured at Kodak Park by reacting niter cake (sodium nitrate) with soda ash (anhydrous sodium carbonate).
The barium chloride was first stirred into water then filtered to remove barium carbonate that formed from the minerals in the water. After the barium chloride and sodium sulfate reaction, more soda ash was added to hydrolyze excess sodium sulfate to form sodium hydroxide which reacted with the iron from the niter cake so that it could be removed.

This process was used until 1954 when the blanc fixe plant was again rebuilt and the precipitation process was carried out with barium carbonate, sulfuric acid, and a small amount of hydrochloric acid. Barium carbonate was purchased in 2000 lb. boxes under specifications that allowed no more than 12 parts per million (ppm) iron and 4 ppm of reducible sulfur. The hydrochloric acid was also a commercial product, the by-product of the manufacture of triphenyl phosphate; sulfuric acid was supplied by the Kodak Park acid plant. In the first of two reactors, the barium carbonate and acids were blended at a pH of 4.0 along with a sufficient flow of water to produce a final output of 10% solids of barium sulfate. In the second reactor, a small amount of additional sulfuric acid was added to achieve conversion to a purity of 99.9% barium sulfate at a pH of about 1.5. Following the reactors, the slurry was washed and processed through two stages of centrifuges, with an intermediate screening, to arrive at a final concentration containing about 43% water.

The barium carbonate process, which proved to be more economical and much easier to control, was used until about 1996 when the blanc fixe facility was shut down for the last time and the conversion was made to purchased barium sulfate. From 1954 to 1996, there were several changes made in the source of supply of barium carbonate as the market for this raw material fluctuated. The basic process remained much the same during this time though the equipment was continually upgraded.

The demand for baryta-coated paper grew quickly following the start-up in 1900 and by 1927 the operation had expanded to 10 coaters. By 1935, the number of coaters had increased to 12. In the mid-1930s, the air knife coater was invented by S. D. Warren Company and quickly found application at Kodak, eventually replacing all of the brush coaters. In the air knife method, the coating material was applied to the surface of the sheet in the same manner as in brush coating. Following the application of coating, the sheet wrapped around a backing roll where a sharp jet of air smoothed the coated surface. A unique feature of both brush and air knife coating was that the coating layer applied was relatively uniform in thickness and followed the contour of the paper surface on which it was coated. This was important since an uneven coating might cover up or obscure any texture feature in the raw base.

It was normal practice to add milk to the baryta coating to act as a defoamer. Unpasturized milk was delivered from the Big Elm Dairy in 8 gallon ceramic crocks. The crocks were hauled to the machine and the milk was dipped out and added to the coating through filter bags. The handling of the crocks resulted in cracks to the rims which caused cuts and became a serious safety issue.

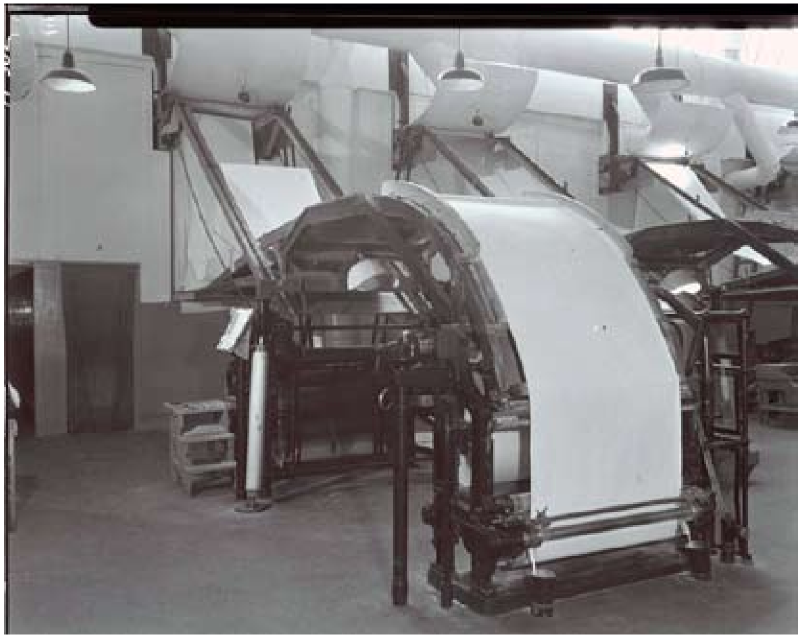
The milk was also the source of a quality issue as it sometimes caused grease-like spots in the coating due to separation of the butterfat. A technique utilized by one employee to prevent this, obviously in the name of quality control, was to skim off the cream and drink it. Apparently several employees must have done this since there are reports from the time of undulant fever caused by drinking unpasteurized milk.

The new air knife method had the disadvantage of creating more foam in the coating than could be controlled by the addition of milk, so isobutyl alcohol became the standard defoamer. The use of alcohol would not have been possible without the conversion, in 1929, to stearic acid sizing in the raw base. The rosin-sized raw base used previously was not resistant to alcohol.

The blanc fixe was the starting point but there was obviously more to the baryta formulas. Gelatin, a colorless, water soluble protein obtained from animal hides and bones, was the sole binder used for baryta coating. The source for gelatin was from outside manufacturers, from a gelatin manufacturing plant in Kodak Park, or from Eastman Gelatin Corporation in Massachusetts which was formed in 1930 from the purchase of a gelatin manufacturer. Over the years, several attempts were made to replace the gelatin with other natural or synthetic binders but none were successful.

In preparing a typical coating mixture, the blanc fixe was first mixed with water to make it free-flowing. Then dyes and optical brighteners (if being used) were added to produce the specific tint desired in the final product. In the early days, dye was added to only a portion of the blanc fixe in order to make a concentrated dye batch that was later blended with un-dyed batches to obtain a variety of tints. When applying multiple baryta layers, the top baryta layer sometimes had a different amount of dye than the other layers.

Gelatin, after soaking in water and melted to 160° F, was then added at a precise amount, most commonly in a 9.6:1 barium sulfate to gelatin ratio but for some specific grades at a 14.0:1 ratio. Next, the gelatin hardener(s) were added over a 10-15 minute period to prevent localized coagulation. The original material used for hardening was formaldehyde. Chrome chloride was used starting in the mid-1930s; for some formulas, a mixture of chrome chloride and formaldehyde was used. Following this, isobutyl alcohol was added along with other additives (surfactants, spreading agents, etc.) as required.



One of the Kodak baryta-coated paper winding mechanisms (1932).

Kodak Historical Collection #003, Department of Rare Books and Special Collections, University of Rochester Library.

In the early 1900s, after mixing together the blanc fixe, gelatin, and additives, the formula was ready to be coated. Colloid mills were used at some point, probably about the 1930s, to further emulsify the mixture to reduce the particle size of the barium sulfate. The colloid mills did their work by the high hydraulic shear created between a rotor and a stator. The colloid mills were later replaced by homogenizers which also reduced the particle size but the shearing force was created by high pressure pumping through special valves. The batch was then placed in a holding tank for delivery to the coating machine.

THE BARYTA COATING PROCESS

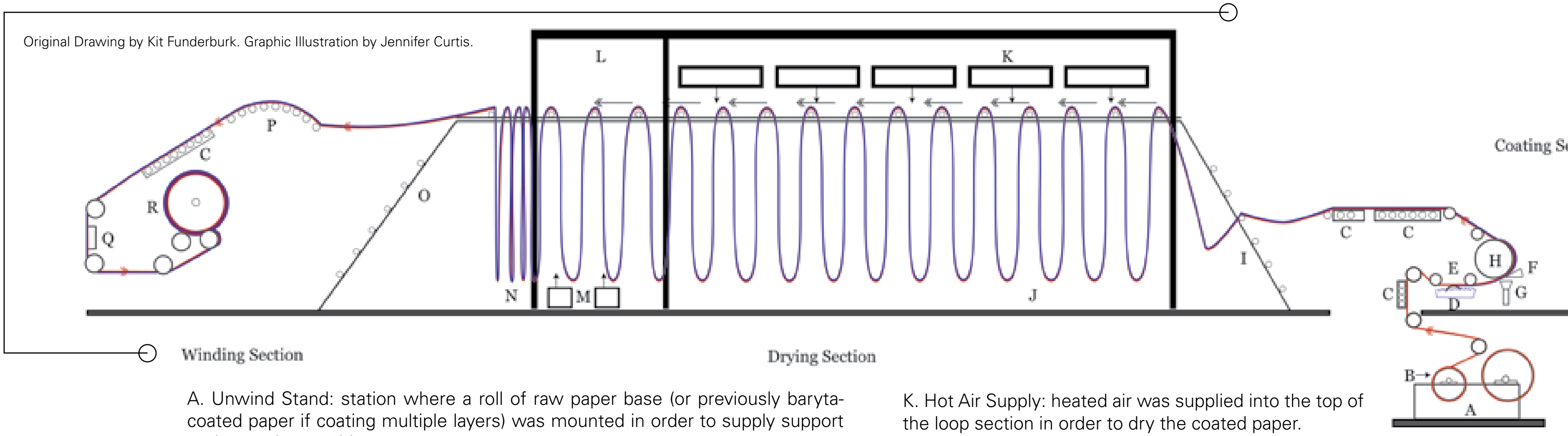
The coating process began with the delivery of rolls of paper to be coated to the unwind section of the coating machine (see illustration p.37). The rolls of paper would have been raw base receiving the first baryta coating or baryta-coated paper returning for application of additional baryta layers or gelatin overcoats. Gelatin overcoats were sometimes used as protective layers on top of the baryta coatings or to prevent penetration and/or interaction between the baryta layers and subsequent emulsion coatings. In a small number of cases, gelatin was also coated on the raw base to prevent penetration of subsequent coatings or as an alternative to a baryta coating for textured papers where the heavier baryta layers might cover up the surface characteristics. In the later case, the products were often referred to as having been “baryta” coated since they were coated in the baryta operations even though there was no barium sulfate present.

The first unwind stations had limited capability for splicing a new roll to an expiring roll. Depending on which side of the paper was to be coated, the coating machine sometimes had to be shutdown in order to make a splice. Later, the machines were equipped with unwinds which allowed for roll transfers without shutting down regardless of the winding orientation of the starting roll.

It should be noted that up to at least the 1930s, and probably for much longer, the rolls of raw base paper did not come directly from the paper mill. After the required testing and quality inspections, as well as any rewinding necessary to remove defects or to improve roll condition, the raw base rolls were stored to season for at least several weeks prior to coating. The most likely explanation for this aging process was to allow time for volatile components to dissipate. At this same time, pulp was stored for two years also presumably to allow for dissipation of unwanted organic compounds. After melamine formaldehyde was introduced as a wet strength agent in the raw base in the early 1940s, it was well documented that formaldehyde continued to volatize from the raw base for long periods of time. It is not clear when these storage times were reduced but over the years it became increasingly important to reduce inventories and this led, at least in part, to the rapid turnaround time between papermaking and baryta coating. In the late 1990s, rolls from the paper mill would have been baryta-coated almost immediately after production.

From the unwind stand, the paper to be coated was transported to the coating station. The baryta coating was applied to the paper by transfer from a roll rotating in a pan filled with the baryta formula. The original applicator rolls were felt covered. With this process, the coating speed was limited by the uniformity of the transfer of the coating formula to the paper. The replacement of the felt covered rolls with smooth, metal rolls in the early 1950s improved the transfer and allowed the speed to be increased. These applicator rolls were wider than the paper to be coated so wipers were used on the edge of the roll to remove excess coating and to leave an uncoated edge on the paper which was later trimmed off.

ILLUSTRATION TWO: BARYTA COATING DETAIL



Original Drawing by Kit Funderburk. Graphic Illustration by Jennifer Curtis.

A. Unwind Stand: station where a roll of raw paper base (or previously baryta-coated paper if coating multiple layers) was mounted in order to supply support to the coating machine.

B. Expiring Roll: the roll of paper being drawn to the coating machine.

C. Suction Box(es): there were several locations on the coating machine where suction was applied to the web of paper in order to keep it flat and to control the tension.

D. Back Pan: held the baryta coating mix to be applied to the paper.

E. Applicator Roll: this roll picked up baryta coating mix from the Back Pan and applied it to the bottom side of the paper web.

F. Air Knife: a high velocity stream of air was directed through a narrow slot tangentially onto the coated paper surface in order to blow off excess coating.

G. Front Pan: collected the excess baryta coating mix.

H. Coating Roll: supported the paper web as the excess baryta coating mix was blown off.

I. Stick Supply Conveyor: chain drive which brought the loop sticks into contact with the coated paper web. The paper loop was formed by controlling the speed of the paper web with the suction boxes relative to the speed at which the conveyor supplied the loop sticks.

J. Drying Section: the coated paper hung in loops from the loop sticks to be dried with hot air. This section was approximately 150 feet long.

K. Hot Air Supply: heated air was supplied into the top of the loop section in order to dry the coated paper.

L. Conditioning Section: damp warm air was supplied to this section in order to increase the moisture content of the dried coated paper. This section was approximately 50 feet long.

M. Conditioned Air Supply: damp warm air was supplied from the bottom of the Conditioning section.

N. Dead Rack: the loop sticks were disengaged from the chain drive in order to accumulate coated paper so that a roll change could be made without stopping the machine. This section was approximately 10 feet long.

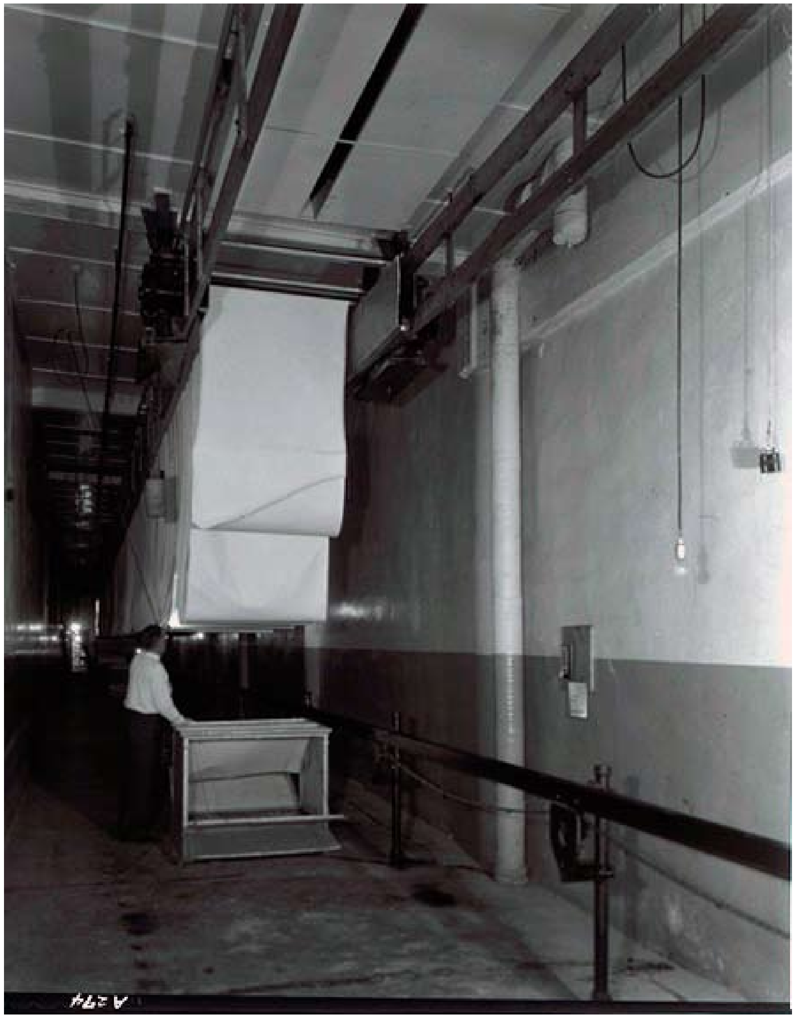
O. Stick Return Conveyor: the disengaged loop sticks were returned by chain drive to the supply conveyor.

P. Winder Arch: the coated web was guided into alignment for winding up into a coated roll.

Q. Inspection Light and Sample Cutting Board: the coated paper web was inspected for defects via transmitted light. The coated paper web could be stopped at this location so that samples could be taken.

R. Winder: the coated paper web was wound into a roll which would be transported to the next operation.

All 12 of the baryta coating machines originally had loop dryers (also known as festoon dryers) in which the coated web was transported through a heated drying tunnel while suspended from wooden sticks with the web hanging in a "loop" from each stick. The wooden sticks were carried along by a chain drive to the end of the drying tunnel where the web was "de-looped." The wooden sticks were very popular for tomato stakes for the home gardeners and some never made the return trip to the other end of the machine.



The inside of a baryta coater dryer section showing the paper hanging from the loop sticks.

Kodak Historical Collection #003, Department of Rare Books and Special Collections, University of Rochester Library.

De-looping was a speed limiting step as taking up the tension in the web and accumulating the sticks was a source of edge tears so the coater could not be run over 200 feet per minute (fpm). This was not an issue with the brush coater speeds since the coating speed was much less than 100 fpm. With the air knife coater, it was possible to increase the speed to about 125 fpm, and with changes from felt application rolls to smooth metal rolls the air knife coater speed could be increased to 175 fpm. By the late 1950s speed was increased to over 200 fpm with light coat weights.

The loop drying process did not have much control and the main focus was simply to dry the paper as thoroughly as possible. This caused a number of accommodations. Paper that received the heaviest coat weights could only be produced between June 15 and September 1 due to high humidity affecting the drying. Also, it was normal to coat the first layer at night and then let the paper "rest" until the next day for the following coating layers. The later addition of a conditioning section to the machines made it possible to control the amount of moisture in the coated paper. After the coated paper was thoroughly dried, the conditioning section added damp, hot air in order to meet the moisture content requirements for the paper (usually about 5-6%). The length of the loop section and conditioning section was about 200 feet total. However, since the paper hung in loops the total length of paper in the drying sections could be as much as 3000 feet.

The winding sections of several Kodak baryta coaters (ca.1970) showing modernization of the operation. (Compare to image on p. 35 of the same process)

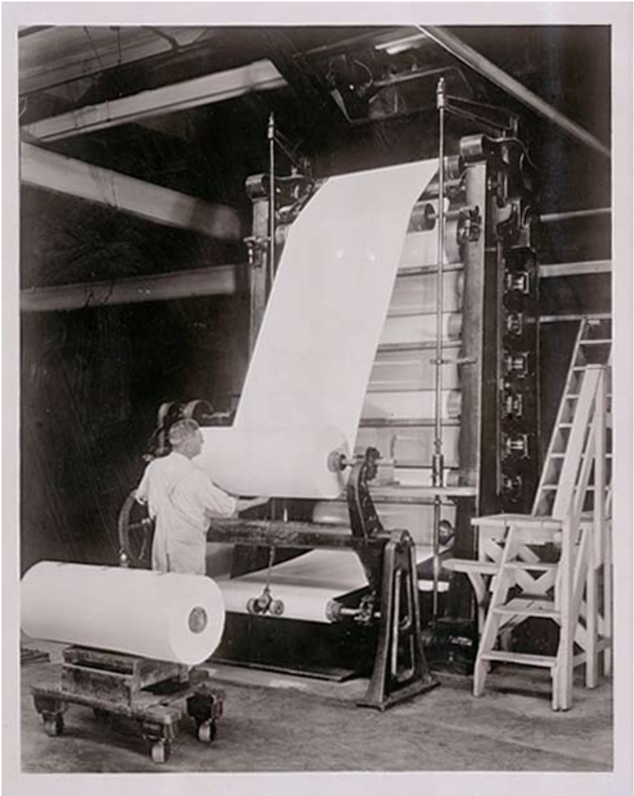
Kodak Historical Collection #003, Department of Rare Books and Special Collections, University of Rochester Library.

After coating and drying, the baryta-coated paper was wound up into a roll of coated paper (paper width varied slightly but on average was about 43 inches wide). The early winders could only accommodate relatively small rolls of about 18-inch diameter. In the 1950s, some of the winders were improved so that two rolls could be combined in order to produce one roll of about 32-inch diameter. Most often the baryta-coated paper would be put through the machine again in order to apply another baryta layer. In the early 1900s, as many as six separate baryta coatings were applied with the combined weight of the coating totaling about 60 grams/m2. The total coat weight and the number of passes through the machine were dependent upon the product; the smoothest, double weight papers having the heaviest coverages and the rough textured, single weight products having the lowest coverages.

Over the years, as both the raw base and coating operations improved, coat weights and the number of passes through the coating machine were reduced. Even so, in 1957, 70% of the baryta-coated products still received at least two passes through the machine and it was 1975 before some of the single weight baryta-coated papers would be reduced to only one layer. Reductions in coat weight were most often taken in steps as can be seen in the following example for the support made for Velox Unicontrast F (smooth, glossy, single weight):

Year	First baryta coat grams/m2	Second baryta coat grams/m2
1950	30	30
1960	24	28
1965	22	23
1975	33	0

The next step in the baryta-coated paper process was calendering. This step was similar to the calendering step on the paper machine except that here the calendering operation was separate from the coating operation and two different types of calenders were used. The first type was a supercalender with alternating steel and cotton filled rollers. A supercalender was used to impart a high degree of finish to the coated paper. The application of load on the metal rollers caused a depression in the cotton filled rollers. During rotation, the cotton started to flow as it tried to return to its normal state. This plastic flow caused a relative motion of the metal roller surface against the filled roller imparting a polishing action to the surface of the coated paper. The second type of supercalender, identified as matte calendars, had the same alternating metal and cotton rollers but the metal rollers were less highly polished and were used on the rougher texture or matte papers.

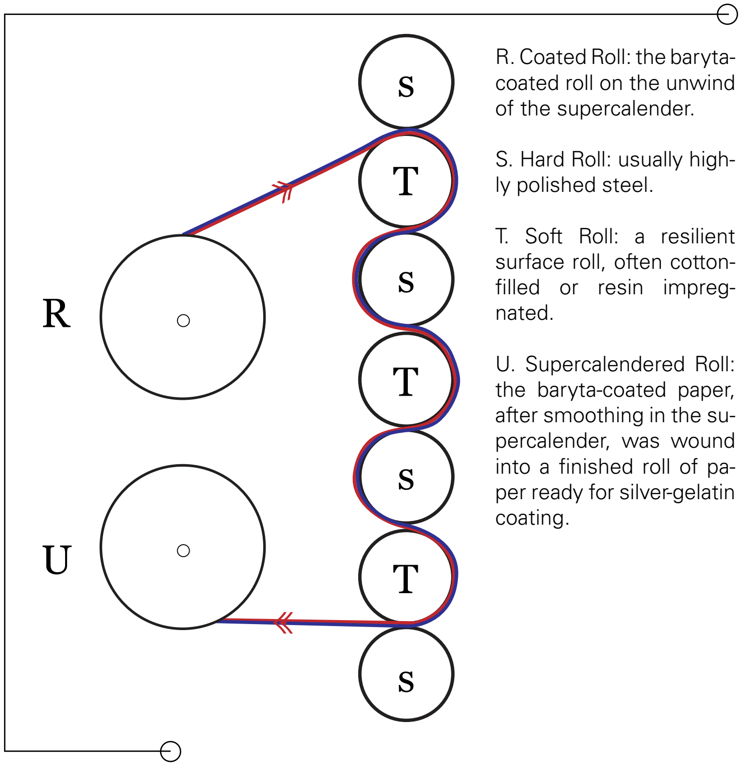


One of several Kodak supercalenders used to calender baryta-coated paper (1932).

Kodak Historical Collection #003, Department of Rare Books and Special Collections, University of Rochester Library.

In the paper mill, all raw base received some amount of calendering. Some of the raw bases were later supercalendered prior to baryta coating. For the coated papers, depending on the specific product application, calendering might be done after each, some, or none of the baryta coatings. Generally, the smooth, glossy grades received the highest amount of calendering with the rougher textured grades receiving less (so as not to destroy the texture).

ILLUSTRATION THREE: THE SUPERCALENDERING PROCESS



R. Coated Roll: the baryta-coated roll on the unwind of the supercalender.

S. Hard Roll: usually highly polished steel.

T. Soft Roll: a resilient surface roll, often cotton-filled or resin impregnated.

U. Supercalendered Roll: the baryta-coated paper, after smoothing in the supercalender, was wound into a finished roll of paper ready for silver-gelatin coating.

Original Drawing by Kit Funderburk. Graphic Illustration by Jennifer Curtis.

In about 1962, calenders with all metal rollers (like those in the paper mill) came into use for baryta-coated papers as a means to produce more uniform sheet thickness. By 1972, more baryta-coated papers were steel-to-steel calendered than were supercalendered, a treatment reserved for only the smoothest, high gloss papers. Beginning in the early 1920s, several of the black-and-white paper supports were printed on the backside (non-baryta side) with an identifying logo. The first product printed was Velox but over the years the papers for other product lines were printed with distinctive logos including Velox Rapid, Kodabromide, Unicontrast, and Illustrator's Azo as well as others.

From at least the 1960s, the printing process used was rotogravure but based on some early accounts it is likely that the first printing was done by the offset process. Records indicate that the earliest inks were formulated from lamp black and linseed oil.

Another operation performed on some baryta-coated paper was embossing. This will be discussed in more detail in Chapter 4.

While not used for traditional baryta-coated paper, another coating method was used in the 1940s and 1950s to produce waterproof papers primarily for the military. These papers were made by hot melt coating cellulose derivatives on the raw base. The first waterproof papers were made in the early 1940s by hot melt coating cellulose acetate butyrate. This paper was replaced soon after the war by cellulose acetate butyrate coated from solvent rather than by the hot melt method.

One of the Kodak baryta coaters showing an air knife coating process.

Kodak Historical Collection #003, Department of Rare Books and Special Collections, University of Rochester Library.

THE RISE AND FALL OF BARYTA COATED PAPERS

There were many more baryta products produced than there were raw bases since it was common to use one raw base for several different products. In 1930 there were 30 different designs used for raw base. In this case, design includes the specific combination of fiber, chemicals, physical properties, and process parameters used to produce the raw base. While the differences were sometimes very subtle, each raw base was distinctly different and intended for a different use. However, the number of unique papers increased to 80 different papers after baryta coating. In one case, a single raw base -- a double weight, white tinted raw base -- was used to produce seven different baryta-coated papers, each with distinctive properties for different product applications.

In 1968, the number of distinctive raw base papers had increased to 72. These 72 were turned into 150 different baryta-coated papers. The increase in number of papers since 1930 was due to new sensitized paper products being added, such as instrumentation, graphic arts, document copying, and industrial papers. In addition, the numbers also included color products that were still produced on baryta-coated papers. In fact, the new papers mentioned above had outpaced in volume the more traditional fiber base black-and-white papers commonly used in what was known as the commercial and professional markets. In addition, the rapidly increasing demand for color products outpaced all of the products and the growth of resin-coated papers for many products meant that by the early 1970s about 70% of the products were resin-coated rather than baryta-coated.

From 1912 to 1924, production of Kodak baryta-coated papers more than doubled in volume and from 1924 to 1936 increased by an additional 20%. The peak however came just before the end of WWII with an additional increase over 1936 of an amazing 300%. This volume decreased after the war but rose again to the same high level during the Korean Conflict of the 1950s and continued at that level on into the late 1950s. However, by 1985 the volume of black-and-white products, including both resin-coated and baryta-coated papers, was 11% lower than the 1944 peak and even then most of the products were resin-coated papers, not baryta.

In 1972, of the original 12 baryta coaters, only 9 were still in operation. The first of the coaters to be taken out of production was shut down in the late 1930s. Another was taken out in the late 1950s/early 1960s and a third was dismantled in the late 1960s. In addition, of the nine coaters still remaining, only five were configured as loop dryer machines and used for baryta coating. The other coaters had been converted to flat, air impingement dryers, and were not used for making traditional baryta-coated papers but were producing specialized coatings including anti-stat, anti-curl, lithographic, etc. By 1974, only six coaters remained, three loop dryer machines doing baryta coating and three flat dryer machines making other products.

The last of the loop dryers was taken out of service in the mid-1980s and the baryta-coated papers remaining were transferred to the three flat dryer coaters. Baryta papers that had been converted to single baryta layers in the 1970s were converted back to double layer coatings (two - 17 gram/m2 coatings). When the last of the baryta-coated grades were made at Kodak Park in 2000, only two baryta coating machines remained and they were run only on a partial schedule.

1. Reinhold Becker Papers D.354, Rush Rhees Library, University of Rochester, Rochester, NY

WEIGHT (THICKNESS)

Many Kodak publications stated that Kodak papers were classified as Single, Medium, or Double Weight depending on the thickness of the paper stock. It would seem that the weight would be a rather straightforward property but the classifications were not associated with exact measurements nor was there a strict relationship between weight and thickness. The publications noted that the weight was in reference to the "paper stock" but it may not have always been clear that this meant the weight of the raw base and did not include the weight of any baryta coating(s) or the emulsion layer(s).

In the late 1800s, photographic papers were referred to as heavy or either light or thin. The term Double Weight did not appear until 1902 when it was used to describe a Velox paper that was 25% heavier than regular Velox. In 1906, Double Weight was used for an Azo paper that was 20% heavier than Single Weight Azo (which may the first use of the term Single Weight). The use of regular weight, heavy, and extra heavy continued in other product lines until well into the 1920s.

In the 1929 pocket notebook of paper mill grades, all grades were classified as either Single Weight or Double Weight and included the following range of weights. [1]

Weight Classification	lb/1000 ft2
Single Weight	14 to 31
Double Weight	46 to 54

While it does not appear to have ever been published, there was an internal guide within Kodak that grouped raw base weights. This listing was a general reference tool that was used in the 1970s – 1980s and covered all products, not just the fiber base black-and-white papers.

Weight Classification	lb/1000 ft2
Extra Thin	10-12
Light Weight	20-22
Single Weight	25-28
Medium Weight	35-38
Double Weight	50-55

For a few years in the 1980s a paper with a weight of 60 lb/1000 ft2 was offered as a Premium Weight in one product line.

The following example from a ca. 1979 listing of paper mill grades shows weight and thickness differences for some raw paper bases that were all classified as Double Weight.

Paper mill grade number	Target weight (lbs/1000 ft2)	Target thicknes (1/1000 inch)	Texture
203	55	11.0	Smooth
256	54	12.8	Fine-grained
258	50	14.5	Tweed
259	51	14.5	Tapestry

Each of the above raw paper bases received different amounts of baryta coating and different levels of calendering. Of the four raw base papers, the heaviest coating weight (> 7 lbs/1000 ft2) was applied to the smooth surface raw base paper which also received the highest level of calendering thereby further distorting the thickness–weight relationship.

Does all of this mean that the weight (thickness) classifications were irrelevant? Not at all! The weight classifications were not intended as a definition for an exact thickness or weight but as a guide to group suggested product use characteristics, such as Single Weight for small prints, Double Weight for larger prints, Light Weight for applications requiring folding, etc. Measuring the weight or thickness of a paper today provides little more than being able to confirm the weight classification of that paper.

TEXTURE

In Chapter 1, seven textures were identified as representing the post-1940s range of textures for Kodak fiber base black-and-white papers and the different manufacturing methods used to produce them. These textures are described below along with the approximate dates of manufacture.

Smooth (mid-1880s – 2005)

In 1940, Kodak described Smooth texture has having no noticeable surface pattern to interfere with the rendition of fine detail. However, based on prints from sample books from the early part of the 1900s, not all Smooth texture papers were the same and some had considerably more surface irregularity than others. In at least one case, the Smooth paper in one product line had more surface irregularity than did Rough paper in another product line. Therefore, it might be more appropriate to describe Smooth papers as those made with no intentional surface irregularity. The word "intentional" is key since it appeared that the variation in smoothness of some early Smooth papers resulted from the inability of the manufacturing processes to produce a flat surface.

A smooth paper is a relatively straightforward concept; however, it was probably the most difficult to produce considering that the ultimate goal was to duplicate the surface of glass. In manufacturing, the papermakers assessed surface flatness by first using transmitted light to "look through" the sheet to assess the formation (the uniformity of the fiber distribution). The first step to make a paper surface smooth was to make good formation since it was the non-uniform distribution of fibers and fiber flocs that resulted in an uneven paper surface. Every step in the paper making process affected making a flat, smooth sheet – fiber selection, refining, forming, wet pressing, surface treatment, drying, and calendering but the vital steps were fiber selection, refining, and forming since the later steps could not make bad formation any better. The calendering step in the paper mill was responsible for smoothing and leveling the sheet to uniform thickness but it did not improve the formation. In fact, heavy calendering of a poorly formed sheet made the ultimate surface worse since the highly compressed sheet expanded non-uniformly in baryta and emulsion coating operations which could lead to mottle in the black-and-white print (non-uniform print density).

The next step for making a smooth surface was the baryta coating. Sometimes, the raw base would be supercalendered prior to the first of what were usually several baryta coats with supercalendering done between each coating and after the last one. As discussed previously, in the early days, there were as many as six baryta coatings applied with a total weight of about 60 gram/m2. Mulitple layers were needed to provide the required surface smoothness. A side benefit was that the high total coating weight covered up the low quality wood pulp available at the time.


(1)


(2)


(3)

The highest standard for smoothness was for the smooth baryta-coated paper used for Glossy products. The smooth baryta-coated paper used for Matte or lower gloss papers was not as critical though was often made to the same standards as that for Glossy products.

Baryta coating weights were reduced as improvements were made in the raw base and as the air knife coating method improved the quality of the baryta layer by creating a more uniform coating. Drying, calendering, re-conditioning, etc. also played a role in these improvements. By the 1990s, the baryta coating weight for Double Weight, Smooth, Glossy paper had been reduced to 35 gram/m2 applied in two coatings with supercalendering after each coating.

In the 1980s, Kodak produced a premium paper referred to as Ultra-Smooth. This support had raw base weight greater than other double weights and increased baryta coating weight but the manufacturing techniques were the same as those of the standard support.

(1) Kodak Eastman Bromide Standard A photographic paper sample
One of the early papers called smooth but that shows some broad roughness.
Rochester, Eastman Kodak Co., circa 1910

(2) Kodak Artura Iris E Smooth photographic paper sample
Another early paper identified as smooth that shows some roughness of texture.
"Some of our Photographic Papers"
Rochester, Eastman Kodak Co., circa 1910

(3) Kodak Kodabromide Paper F photographic paper sample
An example of a smooth paper with no noticeable surface pattern.
"Kodak Master Darkroom Dataguide R-20"
Eastman Kodak Company, 1965.

Tweed (1942 – 1987) and Tapestry (1932 – 1987)

Kodak described Tweed paper, appropriately enough, as having a tweed-like appearance which was effective in minimizing the need for fine retouching and good for breaking up large areas. Tapestry paper was described has being extremely coarse-textured and canvas-like. Visually, Tweed gave the impression of a woven, cloth-like surface. The most remarkable visual feature of Tapestry was that it had the appearance of a plowed field with deep furrows when viewed in the machine direction (the direction the web moves through the paper machine; cross direction is 90 degrees to machine direction).

Both of these surface textures were produced in the paper mill using a wet felt marking technique. As noted previously, Kodak descriptions of the paper making process left out mention of the wet press section of the paper machine apparently in order to protect the nature of the sheet marking process.

After the fiber web was formed on the continuously moving wire screen, the still very wet sheet of paper was transferred to a felted blanket and was carried into the wet press section the main function of which was to remove water and to consolidate the fiber structure within the web. While there are many designs of wet presses, the Kodak paper machines were equipped with straight-through presses each consisting of a top and bottom roll with the tensioned felt strung over the bottom roll so that it contacted the paper in the nip of the press rolls where water was pressed out of the sheet and flowed into the felt. The wet felt marking process was carried out in the second press which was the optimum position based on the amount of water remaining in the sheet at that point.

The felts were originally woven woolen fabrics which were later replaced by synthetic materials. In papermaking the intended use of the felt was to carry away water from the paper sheet (among other functions). One of the requirements of a felt would have been that it not mark the surface of the sheet contacting the felt. However, the potential to mark the sheet to produce surface texture was utilized for both the Tweed and Tapestry textures. This created an interesting conflict in that the felt suppliers were trying to prevent felt marking while Kodak was trying to use it to produce textured surfaces. What made it even more complicated was that Kodak papermakers did not tell the felt suppliers that a felt was chosen because it would produce a certain mark. Once a specific style of felt was found that would give the desired mark several were ordered at one time. Since these papers were infrequently made, the inventory of felts would last for a long time ensuring that a marked paper could be reproduced for many years.

Kodak Opal Grade Z [Tapestry] photographic paper sample and micrograph.
"Photographic Papers Manufactured By Eastman Kodak Company"
Rochester, Eastman Kodak Company., circa 1937
10.7 x 16.2 cm.

Kodak Kodabromide Grade R [Tweed] photographic paper sample and micrograph. "Photographic Papers Manufactured By Eastman Kodak Company" Rochester, Eastman Kodak Company., circa 1937
10.7 x 16.2 cm.

A description of a particular kind of felt marking defect has been described (Paper Machine Felts and Fabrics, Chapter 5-26, Albany International Corp., 1976) in which the mark occurred due to the felt not providing enough cushioning which resulted in machine direction marks appearing as uniformly spaced, continuous ridges and valleys – just like the texture of Tapestry paper. Part of the Kodak manufacturing history was that some wet felts were turned inside out in order to produce the required mark (a feature not divulged to the felt suppliers). Since the ridge and valley defect would have been more severe on the reverse side of the felt, it is likely that the Tapestry texture was produced by the inside-out felt technique.

The Tweed texture was produced with a rough felt that was not intended for fine-paper (smooth surface). The cloth-like texture of the felt surface was impressed into the paper surface. The main control for uniformity of the depth of the impression was the moisture content of the web and the pressure of the nip rolls.

The paper mill calendering on both of the felt marked surfaces was done with reduced pressure so as not to destroy the texture. The effect of lower calender pressure on the thickness of these papers can be seen in the table in this chapter under the heading Weight (thickness).

The manufacture of the felt-marked grades was particularly difficult since there were many variables. The assessment of acceptability of the texture, during manufacture in the paper mill, was made by a visual comparison against five numbered standard samples -- #1 was the lightest mark and #5 was the deepest mark. The difference between the standard samples was very subtle and it took a well-trained inspector to make the evaluation. In normal operation, #3 standard sample was the target, #2 and #4 were acceptable but adjustments would be made in order to get to the target; #1 and #5 were unacceptable.

At the start of a production run, a sample would be taken for assessment. If needed, adjustments would be made in the process until the depth of the mark was acceptable. Since the total volume requirement was relatively small for the felt marked grades, it was not unusual to produce as much as one to two years anticipated demand once an acceptable texture was achieved. At times, a #5 mark would be made intentionally. In this case, the character of the texture was the same but the depth of the mark was deeper. This would have been done as a special order for a specific customer request.

It was explained earlier that the baryta coating applied by either a brush or air knife coater provided a relatively uniform layer that followed the contour of the raw base. Multiple baryta layers would erode the texture detail so Tweed and Tapestry papers were coated with lower weights of baryta and mostly with only one layer or in some cases with only a lightweight gel layer with no barium sulfate pigment. The latter case is an example of the situation previously explained in which a coating was applied in the Baryta Department so the grade was called baryta-coated even though there was no baryta (barium sulfate) in the coating formula.

(1)

(2)

(3)

Rough (mid-1880s – 1966)

Kodak described Rough paper has having a noticeable texture which tended to subdue fine detail and emphasize the larger areas of the subject. However, there was considerable variability in the very early papers and it was obvious that some Rough papers had much more noticeable texture than others. This was most likely due to manufacturing variability in the early papers and to the use of raw base which was reclassified to Rough texture when found unacceptable for Smooth texture.

Little information was found that specifically described the early manufacture of this texture. It is clear, however, that the Rough textured raw base of the 1960s was produced by wet felt marking and, with the exception of the reclassified raw base, this technique was probably in use throughout its manufacture.

Wet felt marking as practiced for Tweed and Tapestry texture was based on using wet felts with specific surface features to provide cloth-like characteristics in the raw base. Rough texture paper, however, was produced with a felt that had a course surface finish which gave randomness to the texture not unlike naturally appearing roughness in a paper surface.

It appears that Rough texture became less "rough" over the years. This might have been due to customer preference but was probably also influenced by less variability in the manufacturing processes and with improvements in wet felt design and manufacture.

As with other textured papers, it was necessary to preserve the roughness after baryta coating. Therefore, the coating weights on this paper were low (3 – 11 grams/m2 depending on the product line), applied in only one layer, and were not calendered after coating.

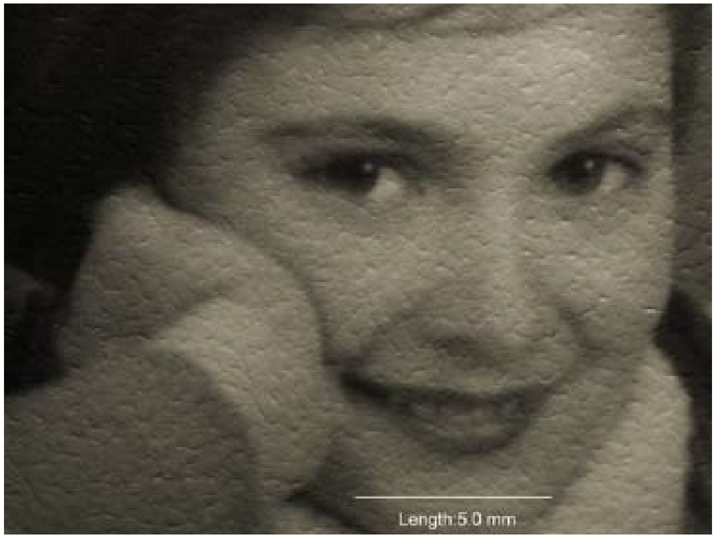
(1) Kodak Eastman Bromide Royal Rough photographic paper sample.
An example of a broad roughness.
"Some of our Photographic Papers"
Rochester, Eastman Kodak Co., circa 1910

(2) Eastman Bromide Standard C.C. photographic paper sample.
An example of a paper with a less broad roughness.
"Photographic Papers Manufactured by Eastman Kodak Company"
Rochester, Eastman Kodak Co., circa. 1925.

(3) Kodak Opal L photographic paper sample.
This more 'modern' rough texture has more regularity in it.
"Kodak Master Darkroom Dataguide R-20"
Rochester, Eastman Kodak Company., 1965.

Fine-grained (1929 in mfg, 1932 in product – 1999)

Kodak Ektalure Paper E [Fine grain] photographic paper sample and micrograph. "Kodak Master Darkroom Dataguide R-20" Eastman Kodak Company, 1968.



Kodak described Fine-grained paper has having a slightly pebbled surface which added richness to a print without loss of definition. The "pebble" reference closely reflects the visual appearance and "pebbled grades" was the most common reference used in the Paper Mill and Baryta Coating Department.

The origins of this texture are not entirely clear. The term Fine-grained can in found in paper mill records by at least 1929 but did not exist as a named texture in product information until 1932. In 1931 product information, these grades were identified by sheen and tint with no reference to the texture although manufacturing records indicated that the raw base was the one referred to as Fine-grained.

As discussed in Chapter 1, the representative sample for Column 2 in the 1940 Surfaces and Contrasts chart was identified as Smooth, Semi-matte but its visual appearance showed a pebble texture. The parentage of this texture appeared to have come from a texture which began in 1913 identified as E semi-matte, part of a group of textures which included E rough, and E smooth. The E semi-matte, in turn, appeared to have origins in one of several different papers identified as Medium Rough.

If this speculation is correct, then Fine-grained texture began as a slightly rough surface that evolved into Fine-grained. Throughout the 1940s, two separate Fine-grained / Lustre categories were shown in the Surfaces and Contrasts chart but there was no apparent visual difference in texture. It was not until the 1950s that these two categories were merged.

While the product identification history for Fine-grained texture is speculative, the paper mill manufacturing records are clear that it was produced in the press section of the paper machine. Unlike Tweed and Tapestry textures which were produced by felt marking, the Fine-grained texture was produced by roll marking.

Immediately following the wet presses and prior to entering the dryer section, the paper machines had an un-felted plain press to smooth the surface of the sheet and provide for further sheet consolidation. The press consisted of a hard, metal top roll and a rubber covered bottom roll. To make Fine-grained texture, the top roll was replaced with a roll that had been ground to a rough surface instead of the normal smooth surface.

The calendering and baryta coating for Fine-grained texture papers was the same as for the Tweed and Tapestry textures.

Silk (1929 – 1980)

Kodak described Silk paper simply as simulating silk and an attractive surface for expressing brightness in snow scenes and seascapes. It was also a popular surface for wedding photography.

This surface texture was produced by the method known as embossing which was mentioned in Chapter 3. In this operation, an engraved steel roll running against a paper-filled backing roll was used to impart a special texture to the baryta-coated surface. A hexagonal pattern engraved into the top metal roll of the embosser produced the characteristic feature of Silk paper. The paper support used for Silk was a smooth, baryta-coated paper except that the final baryta calendering operation had light pressure since the intent was to smooth the surface only enough to make a flat surface for the embossing operation.

Kodak Polylure Paper Y [Silk] photographic paper sample and micrograph.
"Kodak Master Darkroom Dataguide R-20"
Eastman Kodak Company, 1968.

Kodak Opal Paper V [Suede] photographic paper sample and micrograph.
"Kodak Master Darkroom Dataguide R-20"
Eastman Kodak Company, 1968.

Suede (1940 – 1972)

Kodak described Suede paper as simulating the appearance of suede leather with a smooth, extremely matte surface which toned down some detail and added depth to subjects. Visually, the characteristic feature of Suede paper was the reflection free surface. On handling, it was obvious that the surface had a toothy feel.

The Suede "texture" was not created in either the raw paper base or the baryta coating but was produced by adding a matting agent to the emulsion just as was done to control the surface characteristic of sheen (gloss). Therefore, this surface will be described in the next section of this chapter.

Kodak Reference Handbooks noted that certain chemicals were added to the photographic emulsion to obtain variations in physical characteristics and among those chemicals were matting agents. The matting agents were used to vary the property alternately referred to as Sheen, Gloss, or Brilliance. These names were used interchangeably so for simplicity this property has been referred to in this work as Sheen.

Sheen is a reference to the amount of light reflected from the surface which gives the appearance of being shiny (high surface reflectance) or dull (low surface reflectance). For photographic papers, sheen also had a major impact on print density scale – the greater the surface reflection, the blacker the maximum density, and the greater the possible range of tones in the print. This characteristic could be seen in the Surface and Contrasts chart where the sample at the head of each column was representative of the maximum density attainable by the products in each column.

The sheen of the paper surface was dependent on both the texture (more pronounced texture features gave lower sheen) and the amount and type of matting agent added to the emulsion. Since the texture and matting agent use could be controlled separately it was possible to produce papers with the same texture but with different sheen.

The most extreme case of matting agent use was Suede paper. Suede was characterized as a texture but was actually a smooth texture paper with a special matting agent – ground glass – in the emulsion.

The ground glass was prepared at Kodak by washing Pyrex glass cutlets in hydrochloric acid to remove iron contamination. The glass was then washed with water and dried in an oven followed by grinding for 48 hours in a ball mill. Iron particles released in the grinding process were removed by passing the ground glass two times over a set of magnets. The ground glass was then classified through a 105 mesh screen in a vibratory shaker. The ground glass that passed through the 105 mesh screen was slurried in water and continuously stirred to prevent settling until drawn down for use.

SHEEN

Little history has been found to describe the manipulation of sheen. The most widely used matting agent was barium sulfate from the same blanc fixe as used in baryta coating. In manufacturing records, it was most often referred to as "paste." In this use, the blanc fixe (paste) was simply diluted with water and continuously agitated to prevent settling. Other matting agents used were rice starch (slurried in water and then heated) and pearl (unmodified) corn starch (processed through a colloid mill to reduce the particle size). Silica has often been mentioned as a matting agent but it was rarely used in the fiber base black-and-white products (perhaps only in E: Fine-grained / Lustre, during the 1980s). Silica was often used in the resin-coated papers where it was added to the overcoats, not directly to the emulsion.

Over the years there were many sheen descriptions. The descriptions were, however, relative terms and were not defined by a specific level of sheen. There were many examples in which papers identified with the same sheen had different visual surface reflection. Below is a listing of some of the sheen descriptors that were in use:

- Glossy
- Semi-gloss
- High Lustre
- Lustre
- Slight Lustre
- Semi-matte
- Matte
- Absolute matte / Dead matte

TINT

Tint, simply stated, referred to the color of the paper stock on which the emulsion was coated. The tint was either the natural color of the raw base and baryta coating or was altered by dyes added to the baryta formulation and/or to the raw base.

Blue dye or sometimes mixtures of blue and red or violet dyes were added to enhance the whiteness of the raw base. The dyes were added to the fiber slurry before the web was formed on the paper machine.

Blue dye and sometimes violet were also added to the baryta coating formulation for White tint papers. However, some of the White tint papers were dyed only in the raw base and not in the baryta layers or vice versa depending on the desired tint and the baryta coating weight and number of coating applications.

The historical record is not entirely clear about the use of dyes for the warm tint papers. Manufacturing records show that from at least the early 1970s, Cream White tint was made by adding yellow and red dyes only to the raw base, not the baryta coating. Old Ivory tint was discontinued in the late 1960s to early 1970s but samples from the 1930s and 1950s clearly show that the raw base was dyed. This was possible since the barium sulfate did not have a high refractive index and the color of the raw base was visible through the baryta layer.

Some accounts imply that at times the dyes may have been added to the baryta coating to make either Cream White or Old Ivory tints. Two pieces of evidence were found that might support this premise. One was a 1945 Standard Material List for the paper mill which identified the dye usage for Cream White but showed no formula for Old Ivory. Since Old Ivory was available during this time, it may be that the dying was done in the baryta layer, coated on a Cream White raw base. The second piece of evidence comes from the Becker papers in which "Cream" and "Buff" (Old Ivory) are included in the baryta formula names.[2] However, the same tint names are used in the raw base name so it may be that the dye was added to both the raw base and baryta coating or it may simply have been an indication that the baryta coating was on a raw base that was Cream or Buff tinted.

Other manufacturers did make warm tinted papers by adding the dyes only to the baryta coating. When the Kodak baryta operation was shut down in 2000, one Cream White tint product remained and its supply was outsourced to a manufacturer who produced the tint by adding dyes only to the baryta layer.

Like Sheen, a variety of descriptors were used at different times for the support tint. Below is a list of some of the tint descriptions.

- Snow White
- White
- Pensé (pearly white)
- Natural White
- Warm White
- Cream White
- Old Ivory / Ivory / Buff

There has been uncertainty about when and to what extent optical brightening agents (OBA) were used in Kodak fiber base black-and-white papers. While the use of a letter designation aligned with the support Tint, there was no separate designation for an optically brightened support.

An internal Kodak report from 1951 noted that an investigation had been going on for some time studying the use of fluorescent dye in the raw base, baryta, emulsion, and processing solutions to brighten photographic prints. This report recommended that fluorescent dye not be used based on evaluations which showed no preference for brightened prints. In this experiment, the fluorescent dye was added to either the emulsion or the developer. Later, preference for adding fluorescent dyes shifted to adding them to either or both the raw base and the baryta coating. Apparently the recommendation of the 1951 report was followed since none of the samples in the 1952 Kodak Professional Handbook were optically brightened.

Customer input may have started to shift, however, since by the late 1950s optical brighteners can be found in Kodak fiber base black-and-white papers. Of the 11 samples in the 1958 Kodak Master Darkroom Dataguide, 1 was coated on an optically brightened support. It seems as though customer requirements were still being sorted out in the 1960s as that same sample in the 1965 Dataguide was on an un-brightened support while another paper, un-brightened in 1958, was coated on a brightened support in 1965.

During the 1970s, the use of resin-coated (RC) supports for black-and-white products brought with it an increase in the number of black-and-white RC papers with optical brighteners. However, the variability in the use of OB in fiber base black-and-white products continued as evidenced by a comparison of the samples in the Dataguides from 1972 and 1974 which showed OB being used in different grades and in different amounts. Not only was their use variable from year to year but was also variable within a product line. In the late 1970s, manufacturing records show that OB was used in a specific product for the Latin and South American markets but not for the same product in the North American market where there was a different customer preference.

By the late 1990s, 95% of the volume of Kodak black-and-white papers was on resin-coated supports and most of these contained optical brighteners. Optical brightener use in the small volume that remained on traditional baryta-coated papers was just as variable as it had been 30 years earlier. The following table is offered as an example of how dyes and optical brightener were used to produce the few remaining fiber base black-and-white supports in 1999.

Note: high, medium, and low for the dye used in the baryta formula refers to the relative amount of dye used. The information used to prepare this table made no reference to the relative amount of OB or dye used in the raw base but it should not be assumed that it was the same in all grades.

Support Texture / Tint / Weight	Raw Base OB / dye	Baryta Coating OB / dye
Smooth / White / DW	yes / no	no / blue-high
Smooth / Cream White / DW	no / yellow & red	no / no
*Smooth / White / SW	yes / no	no / blue-low
*Smooth / White / SW	yes / no	no / blue-medium
*Smooth / White / SW	yes / no	no / blue-high
*Smooth / White / SW	yes / no	yes / blue-high
Fine-grained / Cream White / DW	no / yellow & red	no / no
Fine-grained / White / SW	no / blue	no / blue-low

(For Smooth / White / SW: Four differently tinted baryta-coated papers were produced from one raw base tint)

PRE-1940 SURFACES

Listed below (with approximate dates of manufacture) are several pre-1940s textures along with comments on their manufacture and use.

Enameled (1895 – 1931)

This texture was originally used to describe a product which was coated on an enameled paper giving a glossy appearance. The general definition for Enameled even today is a paper with a very smooth, high gloss surface. As such, Enameled can be considered to be an early name for what would later become Smooth / Glossy surface. The manufacture of this paper would also be similar to Smooth / Glossy with multiple coatings of baryta and heavy calendering to produce a very smooth paper.

Velvet (1905 – 1937)

Velvet papers were single baryta-coated and were not calendered after coating. The raw base used was smooth surface but the lack of calendering after baryta coating provided a somewhat undulating surface profile. Velvet texture was originally offered with no further description but at different times was offered as matte, semi-matte or semi-gloss.

Medium Rough (1906 – 1943)

Medium Rough texture appeared sporadically, apparently as a means to identify a texture in a given product line that was between Smooth and Rough. It may also have been used for paper that was intended to be Smooth texture but was not acceptable. There is some evidence that one or more such textures might have evolved into Fine-grained.

Linen (1921 – 1935)

There are no available manufacturing records that describe this texture but its visual appearance strongly suggests that it was made by embossing (as with Silk texture). Under low magnification (7x – 10x), the embossed pattern looks like a window screen or a waffle pattern.

Old Master (1923 – 1932)

Old Master was described in a 1928 Kodak catalogue as a "half canvas surface." It is not known if this was meant as a comparison with some other canvas-like texture. The Old Master texture was very rough and apparently intended for close-up portrait work. The visual appearance of the texture is not unlike the random appearing pattern of weathered barn wood. The texture appearance suggested that it was produced by felt marking.

Parchment (1925 – 1928)

Parchment refers to a kind of paper rather than a texture; although the name was used by Kodak in the Athena product line as a texture reference describing thin translucent parchmentized stock. Today the term "parchment paper" is applied to a wide range of products from imitation sheepskin to baking papers. In its simplest form, it is a paper that has been impregnated with, for example, acids to dissolve some of the cellulose, wax to make the paper grease-proof, silicon to give it release properties, etc.

Paper mill records mention a "parchment" paper from the 1920s but there was nothing unique about it as produced in the paper mill. Therefore, it was likely that the translucentizing was an operation, either by coating or impregnation, in the baryta coating department.

Photostat Paper

Chapter 1 notes that the first successful production in the first Kodak paper mill was a raw base for photocopying paper. Photocopying papers were rarely mentioned as a fiber base black-and-white paper since most of them were produced for other companies that made photocopying machines. It was common to refer to the papers as Photostat, since the original papers were made for the Photostat Corporation. However, Kodak also made photocopying papers for other companies and also manufactured raw base for companies who supplied the final emulsion coated photocopying papers.

Within Kodak, a variety of product names were used for these papers including Insurance, Ledger, and Reflex Copy. A 1937 Kodak catalogue listed the following:

Insurance Bromide SW, smooth, matte, white

* A: 75 grams
* B: 95 grams
* R: 100 grams

There was no connection between the use of letters for these papers and the traditional fiber base black-and-white papers.

During the 1950s, there were as many as 21 different grades of photocopying paper. They were generally not baryta-coated and the main differences between the papers were in weight and sheen. Many of the raw base papers were the same as used in traditional product lines such as Azo, Velox, and Kodabromide. At least two of the papers were emulsion coated on both sides for two-sided copying. Some were also coated on purchased rag paper.

1. ([Notebook of Paper Mill grades, 1929], Kodak Historical Collection #003, Rush Rhees Library, University of Rochester, Rochester, NY
2. Reinhold Becker Papers D.354, Rush Rhees Library, University of Rochester, Rochester, NY.

Modern quantitative methods provide the ability to analyze fiber base black-and-white papers and there are many different interests in furthering the capability to characterize these papers. The characteristics of Kodak papers were not always strictly defined so caution is necessary in interpreting current analytical data.

It has already been discussed how the classification of weight (Double Weight, Single Weight, etc.) was based on ranges of raw base weights and did not account for the weight of subsequent baryta coating layers. Not all Double Weight papers, for instance, were intended to be the same weight, nor the same thickness, and the weights and thicknesses changed over time and sometimes independently.

Like weight classifications, descriptions used for texture, gloss, and tint were also not precise. The comments below are offered to provide some background on "differences" that might be expected to show up under analytical analysis.

TEXTURE

The first edition of the Kodak Reference Handbook (1940) referred to the "character" of the texture which was described as relating to visual appearance and impact on the intended use of the photographic print.

The seven different textures used as the baseline in this guide were visually distinctive and the character of each texture was relatively consistent from at least the 1940s to its discontinuance. Therefore, one of these specific textures would not generally be mistaken for one of the other six textures.

This does not hold, however, for some of the textures of the early 1900s. As pointed out in Chapter 4, the early papers identified as either Smooth or Rough textured were sometimes not consistent in visual appearance and, in at least one case, a Rough paper appeared to have a smoother surface than a Smooth texture paper and neither would be considered to be a smooth paper by later standards.

While a Smooth / Glossy paper is relatively easy to identify, a Smooth texture with another level of sheen (for example, Semi-matte or Matte) can be mistaken for a different texture. The Velvet texture can also be difficult to identify since it is only slightly less smooth than Smooth textures of its time.

It is important to clarify that the visual nature of the character was apparent under normal viewing. It was not necessary to magnify or enlarge the texture detail in order to observe the differences. In fact, enlargement tends to mask the character of the rougher textures (Tweed, Tapestry) and high magnification can make the Smooth textures appear to have surface irregularities. Low magnification of the embossed textures does clearly reveal the pattern of the texture but magnification is not required to see that it is a unique surface.

Does this mean that any particular texture, measured today by modern analytical equipment, would be found to be identical to samples from, say, different years? Absolutely not! It is highly likely that measurement differences would be found as a result of manufacturing variability as well as texture differences due to different raw base weights. For example, the depth of the Tweed texture on a Single Weight paper would have been slightly different than on a Double Weight paper due to compressibility differences during the felt marking process. But Single Weight Tweed and Double Weight Tweed both had the same character and both would have been recognizable as Tweed. In instances noted where a particular texture might have been adjusted to meet a specific customer demand, the change would have been visually subtle.

SHEEN

While the character of the texture did not change (with the exception of some of the early Smooth and Rough papers), the sheen descriptions appeared to have been more often based on a relative positioning compared to other surfaces offered at the same time than on an absolute level of reflectance. At any given time, it was apparent that the hierarchy from highest sheen (highest surface reflection) to lowest sheen was as follows:

- Glossy
- High Lustre
- Lustre
- Semi-matte
- Matte

However, all grades identified with the same sheen description did not always have the same visual appearance and would not have the same measured sheen if analyzed today. For example, in the 1952 Kodak Professional Handbook, a sample of Rough / Lustre paper had higher visual surface reflection than did a sample of Tweed / Lustre. An even greater difference was apparent in 1963 samples in which Silk / Lustre had much higher visual sheen than did Tapestry / Lustre.

Besides the impacts on surface reflection and the maximum photographic density, the sheen also influenced the perception of texture. In the case of Fine-grained texture, the apparent depth of the texture appeared to be greater on High Lustre papers than on Lustre papers. However, manufacturing records show that the texture was not different as the same support was used for both High Lustre and Lustre products.

TINT

Tint descriptions appeared to have had more to do with describing the impact on the tone of the final print than on describing an exact color of the support. Based on samples in the guide books, it was obvious, for example, that all products identified as White were not visually identical. What White papers had in common was a blue-white (cold) appearance but the formulas for "white" papers were not all the same and those differences were recognizable even before instruments were available to assign a precise color measurement. An example can be seen in the table in the Tint section of Chapter 4 which showed that one raw base was coated with 4 differently tinted baryta formulas yet all were in the general classification of White tinted.

Like other surface characteristics, the Tint categories represented visual differences. Some of those differences can best be assessed by a side-by-side evaluation. While White would not be confused with Old Ivory, the difference between White and Natural is sometimes difficult to see especially if the samples are old. The difference between Cream White and Old Ivory can usually be identified in side-by-side comparisons but as a single stimulus each can be mistaken for the other especially in older samples that have faded.

GLOSSARY:

A

Alpla Cellulose: The highly oriented (crystalline) component of the cellulose molecule.

B

Baryta: Barium sulfate pigment coated along with a gelatin binder and other additives onto raw paper base.

Basis Weight: Weight per unit area of paper.

Beater: An oval tank in which a circulating fiber and water mixture undergoes mechanical action between a steel roll revolving against a bedplate.

Blueprint Paper: A paper coated or soaked in a light sensitive solution which will react with bright light to form an insoluble blue pigment. Commonly used for copies of architectural drawings.

Broke: The waste (wet or dry paper) that is created during manufacture; broke is recovered and reused in place of pulp.

C

Chemical Fog: Photographic density, in negative working products, without light exposure due to chemical reaction with silver salts.

Consistancy Regulator: Instrument that controls the addition of water to achieve a specific weight percentage of pulp in a pulp/water mixture.

D

Disc Refiners: Pulp processing machinery that provides modification of the fibers by the mechanical work done by passing the fiber/water slurry through rotating plates surfaced with cutting bars.

E

Edge Penetration: The intrusion of photographic processing chemicals into the cut edges of a photographic print.

Electrokinetic: Electrical charges on materials (fiber and chemicals) in water suspensions; motion (attraction or repulsion) of the materials based on the charge differences.

F

Fibrillate: Mechanical action that unravels small filaments from the wood fiber.

H

Handsheets: Paper made in the laboratory one sheet at a time; used for experimental purposes.

Headbox: Large chamber that distributes the fiber/water slurry onto the screen used to form the paper web.

Hot Melt Coating: Process in which the material to be coated is melted and applied to the coating substrate while still molten.

H (cont.)

Hydrate: Mechanical action on the pulp fibers which opens the structure and increases the water holding capacity.

K

Kaolin Clay: A fine white pigment used as a filler in paper; primarily hydrous aluminum silicate.

M

Mottle: Non–uniform photographic image density.

O

Offset Process: a printing method in which ink is transferred from a plate roller to a rubber covered roller (offset roll), then to the paper surface.

Optical Brightner: a dye that improves the visual whiteness (blue-white appearance) by absorbing light in the ultra-violent spectrum and re-emitting in the blue spectrum.

P

Photostat: a photocopying method in which a large camera photographed the image to be copied directly onto a photo paper which was processed and then dried in order to obtain a reverse image of the original (a negative if the original was a positive image). The reverse (negative) image could then be reprocessed multiple times in order to produce positive copies on photo paper.

Pressure Screen: Equipment to remove oversized particles from the pulp/water slurry.

R

Raw Base: The fiber support (paper) onto which the other layers (baryta, gelatin, emulsion) are coated.

Resin-coated Paper: Paper which has been coated with a plastic resin, in this case with polyethylene.

Roll Processing: Photographic processing of a roll of paper which has been exposed with many individual images. The individual images are cut from the roll after processing.

Rotogravure: a printing method in which ink is deposited in engraved cells of a metal roller from which it is transferred to the paper surface.

S

Scanning Beta Gauge: A device that continuously traverses the paper web during manufacture to measure the weight of the paper. Beta rays are high-speed electrons emitted by radioactive isotopes which are absorbed or reflective by the paper web dependent upon the mass.

Sizing: Sizing (the process) or size (the material) refers to the addition of chemicals that provide the paper with resistance to penetration by fluids.

Soda Pulp: Pulping process using sodium hydroxide as the major component of the pulping chemicals.

Sulfate Pulp: Pulping process using sodium hydroxide and sodium sulfide as the pulping chemicals. Also known as the Kraft process from the German and Swedish word for strong.

Sulfite Pulp: Pulping process using alkaline bisulfite plus sulfurous acid as the pulping chemicals.

V

V Mail: V (victory) Mail was a process in which wartime (WW II) correspondence was transferred to microfilm which was then sent to various destinations to be printed out on lightweight photographic paper.

Verifax: a Kodak transfer method for making copies in which an intermediate negative image (from a positive original) was created on a donor sheet (also called a matrix) which had been coated with gelatin, silver salts, dyes, and a developer and then transferred to a receiver sheet. The transfer process could be repeated in order to make multiple copies.

W

Warp: In papermaking it is curl at an angle to the axis of the paper.

Wet Press Felts: Woolen or synthetic fiber blanket that transports the wet sheet and provides a medium for water removal in the press section of a paper machine.

Y

Yankee Dryer: Large diameter steam filled drying cylinder; the wet sheet is pressed against the polished surface.

PAPER WEIGHT

SURFACE TEXTURE

STOCK TINTS