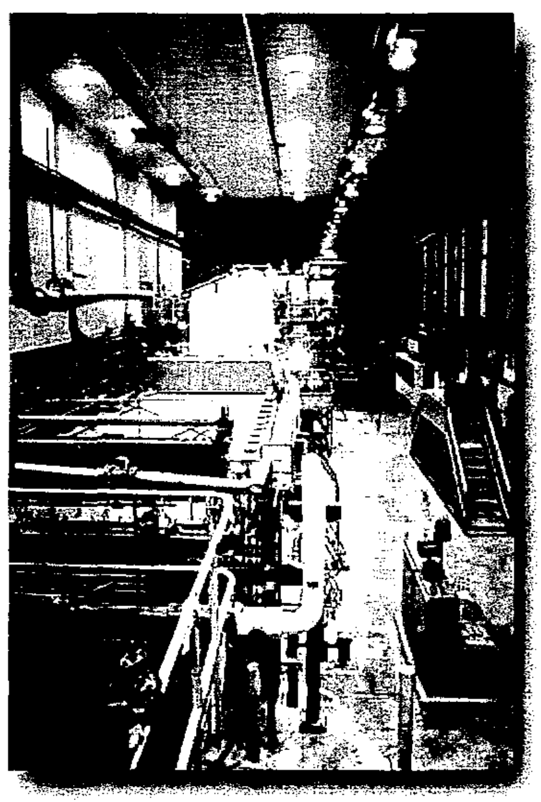
HISTORY
of the
PAPERMILLS
at
KODAK PARK



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Printed courtesy of
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Cover Photo: Courtesy Eastman Kodak
Bldg. 319 paper machine following 1999 rebuild
Overhead view from behind the headbox looking down the machine

To the Kodak papermakers
in honor of their contributions to Kodak
and to the papermaking industry.

May there always be a trace of whitewater in their veins.

Acknowledgments

First, it must be acknowledged that this history would not have been possible at all without the summaries by John Shepheard, Gerould Lane, and Wes Bills who compiled the early history of the paper mills. These papermakers were also the inspiration for this author to complete the story.

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Finally, thanks to all of the Kodak papermakers who lived the history and made it as rich as it is.

Introduction

In July 1919, Mr. John M. Shepheard, at the time a general foreman in the Paper Mill, provided what is the earliest known written account of the early manufacture of base paper at Kodak Park. This summary described the early experiments, the initial paper machine installation, the first commercial production, and the rapid expansion of papermaking capacity from September 1906 to July 1919. Mr. Shepheard (also spelled Shepherd in some documents) had previously been a paper mill superintendent in Scotland and had worked for several years in the film base casting department at Kodak Park prior to being put in charge of the first paper machine.

In April 1932, Mr. Gerould T. Lane described the changes brought about in the manufacture of photographic paper due to the introduction and use of pulp with high alpha cellulose content. The memo also described early work with precipitated sodium stearate internal sizing and issues with fog. Mr. Lane, an experienced papermaker, started work at Kodak in 1918 and was Paper Mill Superintendent until he became part of Kodak Park Management in 1936. In other documents, he is credited with "firmly establishing the paper mills at Kodak Park."

The history of base paper at Kodak actually predates both the Shepheard and Lane summaries. As described in a November 1946 account, again by Mr. Lane, Kodak started sensitizing photographic paper in 1880 using base paper obtained from Germany and France. This 1946 account provided a brief description of the situation leading up to the laboratory work of 1906, then draws heavily from both the 1919 and 1923 accounts to provide an overall summary of the early years of papermaking at Kodak Park. Even though the summary was written in 1946, very little historical information was presented after the mid 1930's. This might have been due to Mr. Lane's move to general management in 1936 in which case he may have had only limited involvement in the day-to-day events in the paper mills.

In January 1976, Mr. Wesley W. Bills, previously Assistant Superintendent of the Paper Mills and then Assistant Superintendent of Paper Support, brought the history up to date. The earlier summaries were narrow slices of certain events but Mr. Bill's account was clearly intended to be a broad historical account of paper mill history including filling in the missing time from the mid 1930's to 1946. This summary covered an exciting time in the paper mills as capacity expanded, new technology was introduced, and Kodak papermaking and papermakers became recognized as leaders in the industry.

The years following 1976 continued to see even greater increases in capacity, greater utilization of technology, and confirmation of Kodak's position as a quality leader in papermaking. The new millennium came just after a significant rebuild and there was much promise for a continuation of the papermaking traditions. However, the demand for conventional photographic products was being overwhelmed by the digital revolution and just a few years later papermaking at Kodak ended. This author, who at the time of the final mill closure was Senior Technical Manager, has attempted to capture significant events and happenings since 1976.

Editor's Comments

The summaries written in 1919, 1932, and 1946 have been edited and consolidated to produce Chapter 1. The main framework for the chapter is the 1946 summary supplemented with additional or clarifying information from the 1919 and 1932 accounts. Much of the work is presented exactly as originally written. It will be obvious that the sentence structure and phrasing, particularly those taken directly from the 1919 and 1932 accounts, would be considered out of date today. However, it is hoped that by preserving the style the reader will be able to see how the original authors captured a slice of history.

An edited version of the 1976 historical account is presented as Chapter 2. As in Chapter 1, much of the work is presented as originally written. *Editor's notes* have been added to both Chapters 1 and 2 to clarify some of the original comments.

For Chapters 3 and 4, the editor becomes the author. Chapter 3 is organized by topic in order to follow similar activities over a longer time period. The short, concluding Chapter 4 covers events leading up to the final mill closure. The information for both chapters is based on the author's notes, discussion with others, and recollections from his 36 year career with Kodak photographic base papers.

For the casual reader, apologies are extended for the use of papermaking terminology which might be difficult to understand. Calendering is not making a date for lunch, the wet end has nothing to do with babies, furnish is not about buying a new couch – but if it's pronounced "cooch," which is a roll on the Fourdrinier -- well, you get the idea. Fortunately, any papermaker will be glad to provide explanations; we all like to talk about paper almost as much as we like making it.

Paper Machine Chronology

Paper Machine	Built	Width	Service
Bldg 46 Experimental	1914	50 inch	Dismantled 1919
Bldg 50 A Machine	1918	50 inch	Dismantled about 1940
Bldg 50 B Machine	1918	50 inch	Shutdown 2000
Bldg 50 C Machine	1918	50 inch	Shutdown about 1980
Bldg 50 D Machine	1919	50 inch	Shutdown 1973
Bldg 50 E Machine	1919	50 inch	Shutdown 1964
			Converted to X Machine 1968
			Shutdown about 1990
Bldg 62 Machine	1931	100 inch	Shutdown early 1980's
			Restarted for recycled pulp 1994
			Shutdown 1995
Bldg 50 F Machine	1934	100 inch	Originally built as RI machine
			Rebuilt as F machine 1938
			Shutdown 2000
Bldg 319 Machine	1962	150 inch	Shutdown 2005

Chapter 1

The Eastman Kodak Company started sensitizing photographic paper in 1880. The base paper for this use was obtained from Germany and France for many years. No raw paper stock was manufactured in this country that was of proper quality for this purpose.

The European mills were family concerns and generally the workers were recruited from the families of the older employees. Papermakers in the United States believed that some very secret process or knowledge was required to make photographic raw paper stock. European manufacturers claimed that purity of water was the major requirement and that there was no water supply in the United States equal to the water used by European mills.

The photographic paper business at Kodak increased to a great extent over the years. Orders had to be placed in Europe a year in advance of the anticipated use of the paper. Various types of grades were made in different mills. The mills making raw paper stock for Kodak were Rives in France, the Schoeller mills in Germany, and the Steinbach mill at Malmady, at the time in Germany and later in France. Most of these mills were represented in this country by an importing concern known as The General Paper Company.

The problem of supply was so complicated that in 1906 Mr. Eastman authorized a study covering the possibilities of the manufacture of photographic raw paper stock in the United States. The Eastman Kodak Company had no research laboratory at that time. The only talent available for the study was in the Industrial Laboratory. This laboratory carried on various testing operations at the Kodak Park Works and was supervised by Mr. David E. Reid. He was given the assignment to carry out the investigation of the manufacture of photographic raw paper stock.

Laboratory work was started in September 1906 and experiments were made with different paper pulps to find out what action they might have on sensitized silver salts. Soon after this, arrangements were made for small commercial experiments to be made at the mill owned and operated by the American Playing Card Company at Middletown, Ohio. Changes were made in the equipment at this mill to aid in the elimination from the raw paper stock of metal, dirt, and other impurities. A testing laboratory was installed at the mill and provided with the necessary equipment for control of the chemicals and pulps used. Small runs of raw paper stock were made and shipped to Kodak Park for testing in comparison with European papers.

Production experiments were continued at Middletown for nearly six months. Although some progress was made during this period, none of the paper made was free enough from defects to be usable for photographic purposes. It was believed by the experimenters that the mill equipment was not suitable for the purpose and the work at Middletown was abandoned. In order to renew experiments at Kodak Park, a small beater, a drier, deckle frame, and suction pump were installed to enable handsheets to be made and thus try different stock and water supplies to see if the paper made would have the necessary keeping qualities.

During this same period, the American Writing Paper Company at Holyoke, Massachusetts, in cooperation with a man named Curtiss, started making photographic raw paper stock at their Hurlburt Division at South Lee, Massachusetts. Mr. Curtiss claimed to have developed a secret process for making photographic paper and he prepared, in a locked room, all the sizing material used. No one else was allowed to enter this room. The Eastman Kodak Company encouraged this work and although the surface of the paper was very coarse and rough, the raw paper stock was purchased and used for one grade, for which smoothness of the surface was not essential.

About this same time, Mr. Reid was sent to Europe to try to find out some of the methods used there in the manufacture of photographic paper. He was allowed a brief inspection of a photo base paper mill but was given much conflicting information or information that later appeared to be false.

As a result of his trip to Germany and his earlier work at Middletown, Mr. Reid recommended building a paper mill at Kodak Park. Since no improvements had been made at the Hurlburt Division, the Kodak management agreed that the only way a satisfactory photographic raw paper stock could be made in this country would be in a mill especially constructed for the purpose. A suitable building had already been constructed in Kodak Park which was not in full use so authorization was given in April 1913 and design work was started with the help of the Black & Clawson Company at Middletown, Ohio. Mr. Reid had recommended that the mill equipment should be built, as far as possible, from copper and bronze, and whenever iron was used, that it should be plated with nickel. This mill was to have a single small paper machine, of conventional design, capable of making paper 42 inches in width, and the necessary beaters and other auxiliary equipment to make 2 tons of paper each 24 hours. The Eastman Kodak Company used probably four or five times as much paper as could be produced on this machine but the main purpose of the installation was for experimental work.

The design work was finished and the order was placed with Black & Clawson in September 1913 and the delivery was in January 1914. The cost of the experimental mill was said to have been $750,000. (*Editor's note: Another account claims that the cost was $137,949.04 but it is believed that this only covered the cost of installation, not the total cost*). The operation of this mill was put in charge of Mr. John M. Shepheard.

The manufacture of paper was started in this mill June 9, 1914 and, at first, ordinary commercial bond paper was made for general use by the Eastman Kodak Company. As soon as the equipment was considered to be properly adjusted, experiments were started to make photographic raw paper stock. Up to January 1915, 225 experimental runs were made but none of these was considered of satisfactory quality for photographic use. All kinds of difficulties were encountered. As soon as one trouble was corrected, other troubles developed. Several hundred rolls of paper were made that were of no use for the purpose intended and were later used for making pads and for record-keeping throughout the company.

All the runs up to this time were experimental and only as an average thing from one to two rolls to a lot. Some experiments would hardly be started and the machine regulation complete when the material would be out. Best results had always been found on a large machine of this kind to be obtained on a continuous run. Therefore, on January 25, 1915, the first continuous run of 3 days was made which produced 49 rolls weighing 12,446 lbs. This paper was inferior to the standard set in many ways as to surface, general appearance and handling, but still showed some improvement on previous runs which demonstrated that continuous running was to our advantage.

The start of World War I in 1914 had by this time shut off the supply of photographic raw paper stock from Europe and Kodak was dependent upon what was in stock and such small amounts of inferior grade paper that could be made at the Hurlburt Division of the American Writing Paper Company. It was decided the experimental mill would have to be put on continuous production and the best raw paper stock selected and used for photographic use. In all, more than 1000 rolls of unusable paper were made. These rolls were stored and later sold to another company for use as photo postcards.

On March 30, 1915 the first paper was made that was used by Kodak for photographic products. This was 135 gram buff stock and was made and surfaced here and sent to Canada. (*Editor's note: Surfaced refers to being coated with barium sulfate, commonly called baryta or blanc fixe. Until 1897, when baryta coating had been started at Kodak Park, photographic paper had been purchased from European mills with the coating already applied*). Between March 30 and June 17, 1915, continued experiments were made to eliminate blister trouble. At this time, attempts were being made to make Photostat paper. While the quality and general characteristics of the paper were satisfactory, still when it came to be coated and handled in the usual manner, numbers of the sheets would show separation which was termed blisters. This caused considerable trouble and it was necessary to make many changes in the methods of making this paper. On June 17, satisfactory results for this difficulty were obtained and the first 18 rolls were shipped to the Baryta Dept. for their coating.

In addition to these experiments on Photostat paper, it was decided that attempts should be endeavored to make the S & C brands of paper. Experiments were run for this purpose. This covered the time between June and September 1915. During this time, any number of changes in our rolls and felts were tried, having felts from about every manufacturer that could make one that showed an appearance of producing a surface like that which our requirements needed. On September 26, 1915, batch #1026 was finished. Experimental rolls taken from this lot were reported as being very fair, in fact, the best that had been made up to date. This paper was the first encouragement given on this particular brand of paper. Between September 26, 1915 and January 1, 1916, production continued making S & C brand same as batch #1026 and some double weight of the same class of stock was also made. Production continued making this type paper with most of it used at Kodak Park and shipping some to Canada and Australia. From time to time, experiments were made on other grades with some success.

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European photographic raw paper stock had been made almost entirely from white rags which gave it a very bright clear appearance. Kodak paper made from rags was not as firm or compact as that made in Europe. It also absorbed too much water in the developing and fixing baths used by photographers. This problem also caused excessive curl when the paper was wet by the later coating operations. Therefore, Kodak had not been able to make paper with more than 35% rags. The best formula had been found to be 30% white rags, 20% sulphite wood pulp made by the Brown Company at Berlin, New Hampshire, and 50% soda wood pulp made by the New York and Pennsylvania Company at Wolfboro, New York. The Brown Company sulphite pulp was a standard grade supplied to paper mills under the trade name Burgess Selected Sulphite Pulp. It was chosen as being of the best quality available. Swedish sulphite was used to some extent but it was not equal to the Burgess pulp. Soda pulp was used because it produced paper with a very low expansion when wet. It was possible to coat paper made by this formula without excessive curl but the wood pulps contained wood slivers, cinder, iron particles, and other dirt and were dull and yellow in color.

Kodak would not have used paper of such inferior quality if any better paper had been available. The iron and dirt particles reacted with the sensitized silver salts of the emulsion showing as black spots in the lighter areas of the photographic prints. The use of this paper was made possible by the finding 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 waterproof layer on each side of the paper and to some extent between the fibers. This waterproofing 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 reduced in number to such an extent that the paper when baryta coated was considered usable under the circumstances.

Glossy photographic paper is always coated with a suspension of barium sulfate. This material is a very white, fine grained insoluble material and when suspended in a gelatin solution can be coated as a surface layer on paper to form a more even surface and the brilliant white color improves the brilliance of the paper. It was, therefore, 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 glossy paper from the Steinbach mill in Germany was completely exhausted.

There was still some stock on hand of rough surface paper from the Rives mill in France and the American Writing Paper Company continued to supply rough surfaced paper from their mill at South Lee, Massachusetts. This paper was very inferior to the Rives paper but could be used with the less sensitive emulsions.

The American Writing Paper Company was persuaded also to make photographic paper in their Riverside Division at Holyoke, Massachusetts. This helped to supply more of the rough surfaces but there was still a shortage of glossy paper.

Kodak made a survey of all of the manufactures of high grade paper in the United States and requested them to make photographic raw paper stock. Samples were made at the B. D. Rising Paper Company at Woronoco, Massachusetts and at several mills in the middle west. The Rising and Strathmore mills were the most promising as they had developed raw stock paper for blueprint paper which was formerly, for the most part, imported from Europe.

The experiments at the Strathmore Paper Company were promising enough to justify production trials and several carloads of paper were made and shipped to Kodak Park. This paper all showed a great number of black spots when coated with the lower 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 could not be discovered. There was no visible impurity, the spots showing only after reaction with the silver salts in the emulsion. The Strathmore people could not believe that the fault was in their paper but Kodak did not have this trouble to the same extent with the other paper. Due to this disagreement, no more paper was made at the Strathmore mill. The trouble was later identified by Kodak chemists as microscopic spots of bronze on the surface of the paper.

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The demand for photographic paper had increased to such an extent that, on August 1, 1916, it was decided to build another mill with six times the capacity of the experimental mill and attempt to make all the brands of raw paper stock. The equipment for this mill was to be of the conventional type and similar to that in the experimental mill with a few minor exceptions, such as even further elimination of the use of iron in the equipment. An expenditure of $3,100,00 was authorized and building started in the latter part of the year. (*Editor's note: The total cost also included additional capacity for baryta coating.*). The new mill was to concentrate on grades other than the glossy type that was being made in the original mill.

In the meantime, the stock of raw paper had become dangerously low as demand continued to increase on account of the war in Europe. Therefore, it was decided to install additional equipment to increase the capacity of the existing mill as quickly as possible. This limit of capacity was largely due to lack of beaters so an order was placed for a large copper lined washer, 2 large tile lined beaters, one Kollargang, a third press and 4 dryers which were installed and in use by February 1917. Production continued this way until June 1917 when more of this quality was wanted and sufficient help was added to run this machine 7 days per week. Even with the added capacity there was still a shortage of stock and in the early part of 1918 output was further increased. However, the quality was not quite as good as at the lower rate of production.

The first machine in the new mill was started on June 22, 1918. The second machine was started on August 26, 1918 and the third machine on October 23, 1918. The fourth and fifth machines were not ready for production until July, 1919. The sixth machine, which was to have been rebuilt from the experimental machine in the other mill, was never installed. (*Editor's note: All of the paper machines were installed in Bldg. 50 and would later be identified with a letter. The first 5 machines were designated A, B, C, D, and E.*)

It was soon realized that the formula used 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 coating of barium sulfate which destroyed all signs of the texture of the paper. (*Editor's note: This refers to the 30% white rag formula described earlier in this chapter.*) This texture was highly prized by portrait photographers and many beautiful surfaces had been available in the European papers.

The only fiber that was white enough to match the brilliance of European papers was that prepared from white rages, 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 but that brought about new problems in addition to those previously described.

The rags or cuttings had to be sorted, cooked with alkali to remove oils from the cotton, thoroughly washed, and then torn apart and the fibers cut to the proper length by knives in a machine known as a paper beater. This was done by standard methods common in papermaking practice.

These knives had all been made from manganese bronze in the belief that iron was the only metal that was harmful to the photographic emulsions. The bronze was quite soft and when the blades were set closely so that they would cut the fibers well, millions of invisible microscopic particles were worn off in the pulp. These particles reacted with the sensitized silver emulsion causing black and white spots. This was understood only after many weeks of study and research.

To eliminate the trouble from the bronze, it was necessary to set the knives so they could not touch. This gave poor cutting efficiency and required fourteen hours cutting time for each batch of pulp of 600 lbs. This prolonged cutting, while being agitated with water in the beaters, made the fibers swell and become slimy, so that the water would not drain out well on the paper machine. This caused unevenness in the paper and also high waste from curling during the subsequent coating operations. The finished paper also curled to such an extent 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 form of a lead pencil.

To avoid an excess of each of these troubles, 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 from the knives. It was very difficult to maintain this close adjustment and the waste continued very high from both black spots and poor formation with subsequent curling.

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By this time, European raw paper stock was again available to our competitors in this country and to manufactures of sensitized photographic paper in Europe, who were again importing their finished product into the United States. Kodak customers, now that they again could purchase the better European product, were complaining of the quality of Kodak papers and the Sales Department stated that we could no longer compete in the photographic paper market. They advised that raw paper stock manufacture be abandoned at Kodak Park and European paper again be purchased.

A meeting was called of those concerned with management, production, and sales of photographic paper. The only suggestion that the production people could offer was to scrap all the bronze equipment in the beaters and replace it with knives made from a new type of hard steel with a high chromium content. (*Editor's note: The new type of hard steel was stainless steel*). The original bronze bars had cost several hundred thousand dollars and the cost of the new steel knives would be very great. It was decided that this one last attempt should be given a fair trial before changing back to European paper.

The installation of these hard steel knives showed a great improvement and produced paper nearly equal to that made in Europe. There was still considerable criticism of Kodak paper but the period of great emergency had passed.

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In 1923, the Brown Company of Berlin, New Hampshire developed a new pulp that had a content of 93% alpha cellulose compared to 88% for the regular sulfite pulp. They were considering manufacturing this pulp as a regular item for high grade paper mills to replace rags. At this time, Kodak was using in their photographic paper 75% rag fiber and 25% Burgess Sulfite manufactured by the Brown Company. The use of wood pulp made by the sulfite process helped to overcome, to a considerable extent, the troubles caused by the use of rags. However, due to the dull color of the wood pulp and to the dirt it contained, an addition of more than 25% could not be made to the rags. The Burgess Sulfite pulp was considered to be the best sulfite pulp produced at that time, although a very similar quality to the sulfite pulp manufactured before the war. Therefore, Kodak showed great interest in this new pulp not only because such a pulp might improve the quality, but also because white shirt cuttings were becoming very scarce. The shirt makers were using more silk cloth and were using silk and colored stripes in cotton cloth. The 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 sulfite and gave considerable improvement to our photographic paper. The Brown Company introduced this new pulp to the paper trade in 1924 and Kodak at once started trials and replaced the 25% Burgess Sulfite with the new Alpha Fiber.

Other makers of high grade paper resisted the introduction and use of this pulp. The Rag Paper Association retained scientific experts to lecture and write articles on the lack of permanence of wood pulp. They included this new pulp with other pulps such as groundwood pulp that was used in the manufacture of newsprint. Attention was called to the fact that newsprint, up to 1866, was made from rags and that newspaper files previous to that date were still in an excellent state of preservation. Since that date, newsprint had been made of wood and the newsprint files, a few years old, showed bad discoloration and had disintegrated from storage and handling.

These statements were true and Kodak began to have complaints from customers regarding 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 as white as rag pulp and was used in all Kodak paper for a period of months and thought to be a very great improvement. 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 paper on hand had to be scrapped. This caused a large financial loss and also a great loss of prestige with customers. It was later learned that the bleaching action had formed oxidized cellulose which was very unstable. Kodak, because of the publicity given to wood pulp by the Rag Paper Association and because of its disastrous experience, felt that it would be wise to delay the program of substituting this new wood pulp for rags.

This decision was told to the Brown Company. They also had to face this same publicity with other customers. The only sales they had been able to make were to paper mills that already used wood pulp and did not make paper claimed to be permanent. The new pulp cost much more to make and the high price was not interesting to those mills that made lower price wood pulp papers. Considerable quantities, however, were sold to other companies for making rayon and acetate yarn.

The Brown Company had made an extensive study of the permanence of this new pulp but felt that any statements made by them would not be given much weight. They asked the National Bureau of Standards at Washington to devise an accelerated aging test and to make comparative tests between rag papers and paper made from this new pulp. Work on this problem was carried on at the Bureau of Standards for many months. Government departments were interested as they had always been large purchasers of 100% rag papers for permanent filing and the use of this new pulp for permanent papers would reduce government costs to a considerable extent.

The Bureau of Standards did approve a rapid aging test and issued a bulletin giving the results of all the tests that they had made. The paper made from this 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 undergoing a rapid aging test. This publication by the Bureau of Standards enabled Kodak to continue with its program of substituting this new alpha fiber for rags.

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The use of this material (Alpha Fiber) in the percentage of 25% was continued until 1925 when the amount was increased to 50% in some large production trials. This increased amount, however, caused considerable trouble in the paper due to the increase in cockle due to the high expansion and harshness of the fiber and also due to the large number of particles of copper and iron that were present in the pulp. These particles caused considerable increase in the black spot experience after sensitizing. Work was continued on the use of 50% Alpha Fiber in the papers but no success was had during that or the early part of the next year.

In 1926, the Brown Company made experiments to produce a softer and purer fiber and by the fall of 1926 it was possible to go into production on a paper containing 50% of the improved Alpha Fiber. A great improvement was immediately found in the mottle that had always been characteristic of the Kodak Park paper. There were still problems with black spots and with poor keeping of the emulsion due to the influence of the raw base so an intensive study of the cause of this deterioration or fog was started.

Kodak papers, whether made from rags or from wood pulp, had always had an effect on the keeping properties of the sensitized photographic emulsions. The work on the study of fog developed the fact that it was caused by the slow oxidation of the rosin used for sizing in the beater. This was due to the fact that this rosin was an unsaturated compound containing carbon atoms connected by a double bond making it very readily oxidized. This oxidation formed a peroxide gas which disseminated into the emulsion layer and caused what was commonly known as peroxide spots. The next problem was to handle the rosin in such a manner as to get a minimum amount of trouble from it. The papers that were made under what was known as the 1927 and the 1928 formulas represented the single weight and double weight papers with as perfect a balance as could be obtained. (*Editor's note: The perfect balance is believed to be a reference to using only the minimum amount of rosin necessary for adequate sizing.*). Even with this perfect balance, the keeping quality of the paper was not satisfactory. Studies were started to find some material that would size as well or better than rosin but would not oxidize and, therefore, fog the emulsion layer.

The work on the search for a new sizing pointed towards various types of precipitated soap. The very best results were obtained with a sizing produced by the precipitation of a saponified solution of stearic acid. Stearic acid gave some sizing effect but on the furnish then in use it was not enough to keep the baryta coating and the emulsion layer from sinking into the paper and causing very bad mottle, nor enough to keep the paper from water-soaking.

The photographic tests on the paper sized with stearic acid showed that at last a sizing material had been obtained that did not cause spots in the sensitized layer of emulsion. It was also found that paper sized in this manner did not turn yellow with age as papers sized with rosin size always did. So work continued along this line with the feeling that this problem of low sizing must be solved to obtain the results required.

The next experiment was to attempt the use of 100% Alpha Fiber with stearic acid as a sizing agent and, very surprisingly, it was found that the result was a perfectly sized sheet of paper free from water-soaking and non-fogging to the emulsion. However, it was not possible to take advantage of this discovery owing to the fact that the Alpha Fiber then produced was not of a quality satisfactory for use alone in the photographic paper due to the still excessive expansion and contraction of the material and also due to the large number of metallic impurities.

The Brown Company, at Kodak's suggestion, agreed to install a large chromium plating plant at Berlin, New Hampshire and to chromium plate all the exposed metallic parts of their equipment used in the manufacture of Alpha Fiber. They also agreed to produce an even higher grade of fiber than they had in the past and installed new apparatus and equipment to carry on a treatment of the fiber beyond anything that they had heretofore attempted.

The chromium plating of the exposed metallic parts of the manufacturing equipment eliminated the trouble from metal and soon an Alpha Fiber was available that was as free from iron and cooper, or freer, than any rag pulp Kodak could produce. The Brown Company was also successful in their efforts to produce a softer pulp and produced what was known as their No. 30 Alpha Fiber.

And so in 1929, with the use of stearic acid as a sizing material, Kodak produced its first paper from 100% Alpha pulp in what was known as the 1929 stock. A patent for the use of stearic acid, the first patent that Kodak made for papermaking, was granted in January 1932. This method enabled Kodak to size paper fibers without the use of the excessive amounts of rosin and thus made Kodak papers, in this respect, equal to those of European manufacture.

The 1929 paper was very superior in keeping quality, very free from water-soaking, had excellent handling all through the manufacturing processes, and had excellent handling through the developing and fixing and washing. But it had several very serious defects. One of these was still an amount of cockle more than desirable. The other was a tendency to more readily blister when given excessive treatment in the developing and fixing bath. The tendency to blister was overcome by changes in the balance of chemicals increasing them to points which had not been possible previously and by a proper adjustment of the surface sizing to eliminate, as far as possible, the type of membrane that would cause blisters due to osmotic pressure.

The tendency to cockle was again referred to the Brown Company and they carried on a series of experiments in the production of a new type of fiber from poplar wood. This wood was chosen from a series of experiments they made on 15 different types of wood to obtain the one with the lowest expansion. This Alpha Fiber from poplar wood was produced for Kodak and was called Alpha Fiber No. 51. It had very low expansion but due to the short nature of the fibers the amount that could be used in the furnish was limited to a maximum of 25%. This amount enabled production of what was known as the 1930 paper which was very successful in reducing cockle.

In 1932, a new method for handling of Alpha Fiber was developed which made it possible to entirely eliminate cockle and excessive warp in Kodak papers. Alpha Fiber, with this new treatment called "dehydration," gave almost the theoretical perfect fiber for photographic paper manufacture. (*Editor's note: The process originally referred to as dehydration was later referred to as reverse imbibition and is explained in Chapter 2.*).

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Photographic raw paper stock was tub-sized on the paper machine by immersion in a gelatin solution. 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 caused a separation of the layers of the paper when the photographic print was processed by the customer in the developing, fixing, and washing operations. This defect caused many complaints from customers. This trouble persisted to some extent until 1935 when Kodak developed a method (later patented) of penetrating the paper with gelatin by forming a vacuum within the paper before immersing it in the gelatin solution. The layer separation trouble was cured by this method but at a very high cost for gelatin.

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The1931 installation of the Bldg. 62 paper machine for the manufacture of the duplex papers and interleaving papers for the Film was made possible by the preliminary tests made with the use of stearic acid and Alpha Fiber. These experiments demonstrated that a paper could be produced that could be used in the Roll Film and would have no fogging action on this film no matter what age the film nor no matter what conditions of heat and moisture the roll of film was subjected to.

Chapter 2

The period 1930-1935 was concerned with firmly establishing the use of high alpha bleached sulfite pulp from the Brown Company and the use of sodium stearate precipitated with alum as the sizing material. All photographic papers were used as sheets at that time and the major base related problem was blisters in the print during some of the photographic processes. The control of wet expansion of the paper and the resultant curl was a problem to the papermaker and to help reduce this, F Machine was built and started in operation in 1934 as the RI (reverse imbibition) machine. Pulp was furnished to a beater, lightly Jordaned, formed into a web, and then hard dried. The object was to destroy some of the bonding sites on the cellulose molecule and thus reduce its later reaction with water. This pulp was then sheet cut and furnished to the beaters for paper production.

In 1935 the paper mill was operating 5 – 50" paper machines in Building 50 (A, B, C, D, and E), the RI machine (F), and the duplex machine in Building 62. All of the stock was furnished to beaters and each beater doped with all the chemicals. Paper machine speeds were somewhat less than 100 fpm. The wet ends of the 50" paper machines, with the exception of E machine, were essentially the same as they were built in 1918 and 1919. Incidentally, some of the drawings from the builder, Black Clawson, were dated in the 1880's. The Fourdriniers had adjustable deckles (for width), square deckle straps, two slices of two-piece construction, wooden headboxes, and jacketed top couch rolls.

The wet end of E machine in 1935 was a "Lanefield" wet end. This was invented by Mr. Lane and Mr. Wendell Butterfield and consisted of a wire running around a cylinder and then out on a table. Its progenitors were the Sonbert wet end installed on A machine in 1933 and a narrow width experimental machine on the west side of the beater room balcony. The object of this style wet end was to try to combine the sheet characteristics of cylinder-made paper and Fourdrinier paper with the flexibility of a Fourdrinier machine. Unfortunately, the machine operated like a cylinder machine and was speed limited for formation and very difficult to control.

All of the photographic papers were tub sized with gelatin, run through a cage to allow the gel to soak in and then through a hardener bath of chromium chloride, through another cage, and then dried. The drives on the 50" paper machines were cone pulley drives from a line shaft in the basement which was driven by an electric motor.

Papermaking was a real art at the time and each machine tender had his own way of doing things. The skilled jobs were learned by observation and then by trial and error because no one would tell someone else anything and if they did it would generally be wrong. It was during this period that standard conditions of manufacture were being formulated and some process control testing was being done. There were essentially no automatic controls and the only instrumentation was recording thermometers and a few Type P regulators.

Bldg. 62 was making duplex papers at that time and the mill had its own staff, did its own hiring, and reported directly to the superintendent. It took some time to integrate the Bldg. 62 operations into the Paper Mills Division and it was not really accomplished until World War II.

The Bldg. 62 paper machine was originally designed with a Fourdrinier on the ground floor and a three cylinder board wet end in the pit. It is probable that this was never used to make board but duplex papers were made with the black side on one of the cylinders and the colored side on the Fourdrinier. The other two cylinders were eventually removed. The two wet sheets were then pressed together in the first press, thereby making a duplex paper. The colored side of Kodak's duplex papers was always brighter than those made at Knowlton Bros. in Watertown, New York because our colored side was on top. At Knowlton Bros., the black side was on top and the black water was pressed through the colored side on the bottom in the presses. (*Editor's note: Some duplex papers were being purchased from Knowlton as well as being made in Bldg. 62.*). The drive for the Bldg. 62 machine had a steam turbine prime mover operating Oil Gear section drives. It is alleged that this was the first installation of an Oil Gear drive on a paper machine.

There were several decisions made in the design and construction of Bldg. 62 that were problems for succeeding generations of papermakers. The installation of the paper machine on the ground floor required a pit under the machine for the dryer felt runs, the cylinder wet end, and pumps. With the pit below ground level, water in the pit had to be pumped out and with any failure in this system a flooded pit was a certainty. In addition, any removal or addition of equipment required a lot of rigging. It was also decided to run the paper machine from north to south and because the south end was on Hanford Landing Road, any expansion of the drying capacity of that machine was economically unfeasible. It is alleged that a few thousand dollars were saved in the design of the building by decreasing the width of the paper machine front side aisle a couple of feet. This prevented removing any roll from the paper machine straight-out. Therefore it was necessary to cock the paper machine rolls which required more time and care especially on the wet end.

While the paper machine crews were essentially the same as today (1976), the beater room crews were much larger. Pulp was handled one bale at a time with hand baggage trucks. The first electric pulp handling truck was purchased in 1933 and was used mainly for piling pulp in storage. In the beater room of Bldg. 50, there was a beaterman for each machine who put the pulp in the beater a couple of sheets at a time, a chemical man to measure and add the chemicals, a man making cooked starch and gel, and a beater boss, making a total of 8 per shift. All of the size was made during the day shift by one man. Color control left something to be desired because each beater had its own characteristics and retained more or less dye on the paper machine. At one time there were 32 – 600 lb. beaters in the Bldg. 50 beater room. The Bldg. 62 beater room had four beaters and two pulpers with a shift crew of 4 – two beatermen, a chemical man, and a handler. They were assisted at times by a spare man who helped with pulp and shipped finished paper.

The paper mill also built and operated at this time a recovery system for both fiber and silver. All sensitized, undeveloped waste from the paper manufacturing organization was collected, sorted for deleterious materials, chopped into small pieces, and then dropped into a trough containing hypo which dissolved the silver halides. The hypo was then pumped through plating cells and the silver 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. (*Editor's note: Resin coated paper is discussed later in this chapter*). A better system of incineration of the scrap to recover the silver was available and the economics of the whole situation dictated burning the silver bearing waste.

As stated earlier, blisters were a continuing problem during this period and steam sizing was invented in 1935 to help cure this condition. (*Editor's note: This process was earlier referred to as vacuum sizing.*). This created a need for more drying capacity on the paper machines as the after-size-press moisture content was increased by this system. It was at this time that vapor absorption systems were beginning to be installed in the dryer sections.

Also during this period, centrifiners were being installed on the paper machines to remove heavy dirt. They replaced rifflers, which were long troughs with cleats fastened to the bottom. The thin stock flowed down this trough and any heavy dirt was caught ahead of one of the cleats. As clay was a common ingredient of most of the papers, the rifflers, and later the centrifiners, were full of clay. Because of dirt problems, clay was eventually eliminated in the furnishes.

In 1936, E machine with its Lanefield wet end was the show piece in the paper mills and any new equipment was installed on that machine first. All of the paper machines were equipped with LaMorte screens which were eventually replaced with modern inflow screens. E machine was also equipped with two size tubs with the steam sizing equipment.

There was tremendous enthusiasm for the new Lanefield wet end, business was increasing, and the RI process seemed to be losing favor. So on December 8, 1936 an order was placed to convert the RI machine with its cylinder wet end into a paper machine with a Lanefield wet end. F machine started up as a paper machine in 1938 and A machine was shut down and eventually dismantled. It is of interest that the first in-line addition of any chemical was on F machine shortly after its startup when a continuous starch cooker was installed. This was accomplished by metering both a starch suspension and hot water with gear pumps in such a proportion that when the two were mixed, the resulting temperature was at the maximum viscosity of the starch. This system was not very long-lived as the raw starch wore out the gear pumps.

As the business continued to grow, additional paper dryers were added to most of the machines so that by 1940 the average paper machine speed was 105 fpm. With the advent of World War II, the demand for photographic papers increased considerably so that in 1944 and 1945 more than two and one half times as much paper was made as in 1940. This required essentially 7-day operation and an increase in average paper machine speed to 170 fpm. This required additional drying capacity and many new larger capacity pumps and other auxiliary equipment.

In the early 1940's, American Cyanamid invented melamine formaldehyde resin to be used as a wet strength agent for paper. After some initial trials, a system was built in late 1943 to supply the resin to all of the machines. This was the first truly successful continuous addition of a chemical to the papermaking system. This wet strength system was so successful that steam sizing was very rapidly discontinued and blisters were essentially a thing of the past. This created an imbalance in the paper machine drying system. The large drying capacity in the 3rd section dryers, necessitated by the steam sizing process, was not needed. A lot of capacity was needed in the 2nd section as the wet strength needed to be baked before the size tub. Therefore, dryers were rearranged to accomplish this. At some time during this period, the separate hardener tub and press were eliminated in favor of hardener added to the gel and the cages were eliminated.

The introduction of melamine formaldehyde wet strength resin had a tremendous beneficial impact upon the processing of photographic materials because for the first time photographic paper was strong enough when wet to withstand continuous photographic processing. The first continuous photographic processing machine was the V Mail process used during the war. This small start grew to the point where sheet handling of photographic papers became relatively small in comparison to the photographic papers that were developed, fixed, washed and dried in one machine.

While some pulp was coming from Rayonier at Port Angeles, Washington, the main supplier of the high alpha bleached sulfite was still the Brown Company. There was considerable feeling in those days that it was necessary to age pulp for two years before it was fit to make photographic base paper. The Brown Company pulp was made during the winter when the water was the cleanest and with the increasing business and a two year inventory, large quantities of pulp needed warehousing. Building 203 was built in 1942 to store most of this pulp.

The first Hydrapulper was installed in the beater room in 1944 and this sounded the death knell for the Hollander beaters even though it would require many years to completely eliminate them. Beaters were not going to be replaced without a struggle, however, and because there were refining problems with the Jordans, a new modern Bertrams beater was installed in 1945. This was furnished from the new Hydrapulper and was used for many years on lightweight papers on B machine. It was eventually taken out of service as the knowledge of refining increased.

It will be of interest to engineers to learn that as late as 1945 papermakers had little confidence in centrifugal pumps for good control as new triplex positive displacement stock pumps were installed on both C and D machines.

The control of wet expansion of the photographic papers had always been a problem and, after some experimental work, a Yankee dryer was ordered from Beloit Iron Works in May 1945. This also had the advantage of making a "ferrotyped" surface on the raw stock. This Yankee dryer was unlike any other one in the paper industry in that the top side of the sheet was pressed onto the dryer. This made the machine threadup 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 control of many parameters, the limited capacity of the dryer, and the mechanical and threadup problems precluded its continued use.

The cost of gelatin for tub sizing and the presence in the market of new thin boiling starches prompted some trials in 1945 which eventually resulted in the installation of equipment to cook and supply starch to the size tubs on the paper machines. While the gel tub size was never replaced for all grades, most of the production today is starch tub sized. (*Editor's note: Starch sizing did eventually replace all of the gel sizing*).

It certainly should be noted that during the war many females were working in the mill. They did all of the lab work, the dry and wet testing, and all of the rewinding and roll handling. They were gradually replaced by men returning from the services but a few remained for quite a few years working in the sorting room, sorting paper for the silver recovery. It would have been difficult to operate during the war without their help.

The initial installation of the Hydrapulper in 1944 was particularly successful so that in 1947 another Hydrapulper was installed and mixing chests installed on B, C and D machines 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. All of these new installations in the stock preparation area reduced labor but this reduction was accomplished without upsetting too many people.

By the late 1940's, paper machine speeds had continued to increase and many capital expenditures had been made to break bottlenecks. Sheet weight control was a serious problem due to stratification in the chests and increased sheet agitation was not the complete answer. A Brammer consistency regulator, which was new to the industry at the time, was installed on F machine in 1946 and on B, C, D, and E machines in 1948 and in Bldg. 62 in 1951. These regulators did not give the control that we have today but they were a giant step forward in making more uniform basis weight with its attendant advantages all down the machine.

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. The Fourdriniers on C machine and in Bldg. 62 were lengthened to increase the wet end drainage. Foam in the sheet was a real bottleneck in this period of time because of all of the dissolved and entrained air in the system coupled with all of the chemicals that were being used. The Deculator, an industry development that provided vacuum removal of entrained air, had been successfully installed on a Canadian International Paper Company newsprint machine. A Deculator was installed on C machine in 1953 and the improvement was so dramatic that Deculators were installed on B in 1956, D in 1957, F in 1954, and Bldg. 62 in 1959.

The manufacture of duplex papers for roll film backing and many other uses within the company occupied a considerable part of the production capability of the Bldg. 62 paper machine during the 1930's and 1940's. The optical opacity of the film backing papers was a constant concern for the papermakers. The desire to use lighter weight, thinner backing papers eventually resulted in the use of a bleached kraft sheet that was subsequently coated black on one side for opacity and yellow on the other for Kodak's trade dress. Many other new packing methods were being developed and gradually all of the duplex papers were supplanted by other papers or other materials. The last run of duplex in Bldg. 62 was made in August 1955. The cylinder was removed and the space was used for better felt runs.

The paper machine speed of Bldg. 62 was quite limited while making duplex papers so the elimination of these grades resulted in a large increase in the capacity of that machine. During the learning and bottleneck breaking period following the demise of duplex papers, the demand for other colored papers was such that it was necessary to make Yellow Interleaving for x-ray film on D machine for a short time.

By the mid-1950's, most of the machines were running at their drive capacity so the old cone and pulley drives were replaced on B machine in 1953 with the Oil Gear drive and in 1964 with an electric drive, C machine piecemeal with electric drives from 1952 until 1957, and D machine some time after that. The F machine Oil Gear drive was replaced with an electric drive in 1956. The Bldg. 62 drive was replaced in 1957.

Probably the next important improvement was the installation of a scanning beta gauge to measure basis weight on C machine in 1956. For the first time, machine tenders knew their basis weight while the paper was being made. Eventually all of the machines were so equipped.

The advent of melamine formaldehyde resin was a mixed blessing to the papermaker in that the resin reacted with the wool of the press felts and they quickly became impregnable to water. Continuous felt conditioning with pH controlled water was installed on the machines between 1955 and 1957. This was enough of an improvement so that it was generally possible to fun a felt for a full week without changing it.

The late 1950's were exciting times in the paper mills. The Verifax system was firmly established in the market place, the mill was working overtime, and even then we couldn't produce all of the paper that was needed. For several years, Verifax copy paper was purchased from the International Paper Company mill in Niagara Falls and some matrix stock was purchased from the Lee Paper Company in Vicksburg, Michigan.

The temperature in the machine rooms was so high during the summer that totally enclosed hoods were installed on all of the machines with the exception of E. While a Fourdrinier had been installed on F in 1955 to replace the Lanefield wet end, E machine was still struggling at about 200 fpm.

By the middle 1950's, refining capacity was a constraint and somewhat different refining techniques were necessary for the two Verifax sheets that we were making,. 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 Jones Double Disc refiner was installed on D machine in 1956, followed by F in 1957, and C in 1958. Much effort was expended in plate design so that by changing plates it would be possible to do exactly the kind of refining desired for the particular paper grade. The long term goal was to replace the

Jordans. Eventually it was determined that discs were not suitable for cutting but were admirable for hydration. The long term refining capacity was solved by the use of both discs and Jordans on the paper machine and eventually every paper machine was equipped. This combination gave much more flexibility and control of the final sheet characteristics.

Papermakers began to dream about a new paper machine for about the third or fourth time and management gave approval in 1958 for a new 150" paper machine in West 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. B machine was equipped in 1959 with a Cyclean dirt removal system and in 1960 with a pressure screen. These were eventually included in the Bldg. 319 design and were gradually put into use in Bldg. 50 and Bldg. 62.

As paper machine speeds increased through the years, the old wooden headboxes with their two piece slices became inadequate. For a long period following the war, a considerable amount of experimentation was done with flexible lip single slices, rectifier rolls, and replacing the wooden headboxes with stainless steel. The increasing hydraulic head behind the slice became more of a problem so that in 1959 a new Beloit pressure/vacuum headbox was installed in Bldg. 62. While some improvement was made, performance was not completely satisfactory so plans were made to install a very flexible headbox on B machine in order to investigate headbox design parameters. This was installed during the Easter week of 1961. In the meantime, the headbox design for the new Bldg. 319 machine was completed. A new pressure headbox was installed on F machine in 1963.

In 1959, due to large scale atmospheric nuclear device testing, the air and water contained so much radioactivity that it began to affect the photographic acceptability of some of the papers produced in Bldg. 62 for film packaging. It was necessary to install absolute air filters and water filters in Bldg. 62 and button-up the building so that radioactivity did not leak in. Pulp supplies were also affected and Weyerhaeuser at Cosmopolis, Washington and Rayonier at Port Angles buttoned-up their pulp mills so that we could have radioactive free pulp for film wrapping papers.

The Bldg. 319 paper machine started in production on September 4, 1962. The mill was designed to make Verifax copy paper and 42 lb. Verifax matrix base. Fortunately, the width of the machine was determined by the maximum width of any paper made in the mill, which at the time was color base paper. During the design phase of Bldg. 319, inspection trips were made to many new installations in the paper industry with the result that only the latest proven technologies or designs were used. Even then several innovative schemes were used. The proportional stock and chemical blending system was designed by the joint effort of Kodak's instrument engineers and papermakers and Foxboro and eventually became the way to do it in the industry. The crosswise adjustable vapor absorption system in the third section dryers was designed by the joint effort of Kodak people and Ross Engineering and this, too, was eventually used extensively in the industry.

The recovery of wet strength broke in Bldg. 50 was a batch type operation and required much hand labor. It was inconceivable that the wide sheet in Bldg. 319 could be handled the same way so a continuous wet strength broke recovery system was designed with the help of Black Clawson and this, too, became a first in the industry.

Upon completion, the Bldg. 319 installation was the most modern fine paper mill in the world. Even though some risks were taken in the machinery design and process, all of them proved successful. This, coupled with Kodak's hospitality, made Bldg. 319 a mecca for papermakers and literally hundreds of papermakers from all over the world have visited this installation. (*Editor's note: In the 1980's, Bldg. 319 was on the regular Kodak Park visitor tours so many thousands of visitors have seen the operation which always had the reputation of being one of the cleanest paper mills in the world*).

While everyone was excited about the new paper machine, the east mills, as Bldg. 50 and 62 were dubbed at the time, were not forgotten. Lighter weight photographic papers for instrumentation purposes were being demanded by the market place and B machine in the early 1960's was equipped with a new reel and winder, suction couch, calender stack and eventually a new Fourdrinier.

The lightweight papers made on B machine, especially those for instrumentation grades, 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, baled, 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 it was limited to use at low percentages of the furnish. As process improvements were made to improve dimensional stability, the fiber became obsolete and was discontinued in the early 1970's.

E machine was abandoned in 1964 and this brought to an end the Lanefield wet end. Much new equipment was added to the east mill machines as increasing productivity demanded. The success of the continuous chemical addition to Bldg. 319 resulted in the installation of the necessary equipment in Bldg. 50 between 1963 and 1966.

Foils replaced the table rolls on the Fourdriniers on B in 1969, F in 1970, Bldg. 62 in 1972, and Bldg. 319 in 1973 with resulting improvements in formation, increased water removal, and decreased maintenance costs. Suction couch rolls were installed in Bldg. 62 in 1970 and on C machine in 1972. The C machine installation permitted the production of the wet felt marked papers on C machine by marking the sheet on the wire side and thus allowed the mothballing of D machine in 1973.

While the advent of melamine formaldehyde wet strength resin was a tremendous advantage in manufacturing photographic papers, the formaldehyde given off in minute quantities was a serious problem to emulsion makers especially those concerned with color papers, Verifax matrix, and lithographic plate emulsions. Kymene, a non-formaldehyde wet strength resin was introduced by Hercules in the late 1950's and was of interest to the paper mill. While it took some time to learn how to use it and emulsions had to be adjusted to get full advantage of the absence of formaldehyde, by the mid 1960's, many of our photographic base papers, especially color base, were being made with Kymene. Along about this same time, articles were beginning to appear in the technical journals about the electrokinetic theory of sizing paper and additional polymers were appearing on the market which, in the final analysis, allowed for better control of the electrokinetics of the sizing system. Understanding this system, along with many unsuccessful trials, took some time but finally resulted in 1970 and 1971 in much better sized photographic base papers with a significant decrease in the amount of chemicals needed and a tremendous reduction in the BOD load to the sewer.

Bldg. 319 was justified and designed to make papers for the Verifax process and it was good business for a few years. But just before construction of the machine was completed, Xerox introduced their first office copier which gained immediate market acceptance. This was the beginning of the end for Verifax. Bldg. 319 made its last papers for Verifax in 1974. However, in the meantime, sales of color papers were increasing at such a rate that it was necessary to make the base paper in Bldg. 319 rather than in Bldg. 50. Because of the formation requirements for these papers and the fact that there was never success in making a double disc refiner cut the fiber, Jordans were installed in Bldg. 319 in1967, 1973 and 1975.

In the early 1960's, polyethylene coating of photographic papers was started and the commonly held idea at the time was that any piece of paper could be coated with poly and it would make good photographic paper. This idea was soon dispelled as the technical requirements for these base papers became more complicated that ever.

During the mid 1960's, 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 B machine 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. Out of the learning experience, it was decided to install small black box closed loop controls for those parameters which were clearly understood rather than a single large computer.

One such black box installation was the downstream and crosswise weight control operating on the Bldg. 319 machine which was developed by the Taylor Instrument Company. During the design phase of this system, it was decided that the same algorithm used to control crosswise basis weight could be used to control crosswise final moisture content with the crosswise adjustable vapor absorption system. This was eventually done and the whole system, while it was installed in early 1973, did not have all of the bugs out of it until January 1974. At that time, to the best of our knowledge, this was the only operating system in the world controlling both basis weight and moisture in both directions.

The late 1960's and early 1970's saw a virtual revolution in the machine clothing industry as synthetic materials found increasing use. The use of plastic forming fabrics to replace bronze Fourdrinier wires resulted in increasing the life of the wires from a few weeks to a year in some cases. The old fashioned woven, fulled, and napped woolen felts were replaced by felts made of large percentages of synthetic fibers that were made by a needling technique. Increased water removal in the presses and a tremendous increase in felt life allowed these felts to replace the conventional woven type. New dryer felt fabrics were also designed which allowed higher dryer rates. All of these industry developments found acceptance in the mill.

Much of the initial development work on new materials and paper bases was done on X machine. A narrow width wet end and press section were constructed in the location of the Lanefield wet end on E machine and modifications were made in the dryer sections. In addition, a full width hot calender stack was installed to investigate relatively high temperature calendering. X machine was a very valuable tool to the development papermakers.

Since the mid 1960's, the paper mills were engaged in a program to significantly increase productivity. During 1964, the mills produced 811 million linear feet of paper. (*Editor's note: The million linear feet measure is based on 43 inch equivalent width*). During 1974, production was 895 million linear feet at twice the rate of product per person per hour. This was particularly significant because in 1964 Verifax Copy Paper constituted a large share of the production in Bldg. 319 and by 1974 it was non-existent. Machine speeds increased over the years from less than 100 fpm in 1935 to an average of 400 fpm for B machine, 250 fpm for C which was dryer limited, close to 400 fpm on F, up to 600 fpm in Bldg. 62, and up to 750 fpm in Bldg. 319. The comparison of production rates for color base was particularly significant. The production rate in Bldg. 319 was about eight times that of either C or D machine.

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Since the advent of high alpha bleached sulfite pulp, significant changes took place over the years which had a distinct impact upon the pulp furnishes. Prior to World War II, hypochlorite was the primary bleaching agent for wood pulp. High brightness required quite strong treatment with the result that the pulp produced was fast beating and made poor photographic paper. The alpha process which consisted of dissolving some of the degraded cellulose in caustic made this pulp suitable for Kodak. In the early 1950's, chlorine dioxide bleaching in conjunction with the hypochlorite bleach produced bright pulps with more desirable papermaking characteristics which were considerably less expensive than alpha pulps. These pulps eventually replaced all of the high alpha pulps and at the present time (1976) only relatively small quantities of a medium alpha pulp are used for C machine double weight grades.

Chlorine dioxide bleaching also produced a much better softwood bleached kraft pulp which had been used to augment the strength of the photographic base papers. During the 1960's, the pulp companies began to produce hardwood kraft pulps that were quite good and at a considerable reduction in price from the softwood pulps. While it took time to learn to use these pulps, by 1976, hardwood kraft constituted about 35% of the pulp purchases even though prices were then similar.

This account would be remiss if it didn't summarize the pulp supply problems that were faced between 1970 and 1975. Because of the wood species, northeastern softwood bleached sulfite pulp was the preferred fiber. The Brown Company had been the principle supplier of this pulp for many years. Small quantities of a similar pulp from the Kipawa mill of the Canadian International Paper Company at Temiskaming, Quebec were also used. Over the years, the quality of the Brown Company pulp deteriorated to such an extent that the pulp could not be used. With the decline of Brown Company pulp, the volume of Kipawa eventually increased significantly so that by 1971 this mill supplied 50% of the total pulp requirements. While the Kipawa mill was old, it made perfectly acceptable pulp. During the late 1960's, Kodak was informed that the operations at the Kipawa mill were marginal and that there was a distinct possibility that the mill would be closed within 5 years. Environmental problems hastened this decision and the mill was shut down in June 1972.

In the meantime, relatively small quantities of softwood sulfites were used from the Bellingham, Washington mill of Georgia Pacific, the Cosmopolis, Washington mill of Weyerhaeuser and the Rayonier, Port Angeles, Washington mill. These pulps did not make suitable direct replacement for the Kipawa pulp as the surface of the paper was not quite as smooth. It was determined, however, that a blend of the western softwood sulfite and a northeastern hardwood kraft would make a satisfactory sheet. So in 1972, a major shift took place in the furnishes and Georgia Pacific and Weyerhaeuser became major suppliers of softwood sulfite and Penobscot and Consolidated Pontiac became major suppliers of hardwood kraft.

The pulp supply problem seemed to be solved until Weyerhaeuser announced in early 1973 that, because of pollution problems, their Everett, Washington mill was to be shut down in 1974 and all of the dissolving pulps made there would be made in Cosmopolis. This precluded making paper pulps at Cosmopolis and no pulp would be supplied from Cosmopolis after 1973. And then to add insult to injury, the real tight worldwide wood pulp supply shortage struck in mid 1973. During this year, five other pulps became unavailable to Kodak. This created almost a crisis situation but by the efforts of the purchasing department and with the real cooperation of Georgia Pacific, Rayonier, Consolidated Pontiac, and a newcomer to our pulp stable, Lake Superior, pulp supplies were assured for 1974. For the first time in the history of the mills, long term supply contracts were negotiated in late 1973 with Georgia Pacific for softwood sulfite and hardwood kraft and with Lake Superior for softwood kraft. By early 1975, with the help of a business recession, the pulp inventories were back to normal.

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Since 1916, the paper mills at Kodak Park have advanced from learning the business from scratch to being worldwide leaders in photographic base manufacture. While there have been a great many accomplished papermakers, paper mill leaders also contributed in other ways. In the 1930's, most superintendents and managers in Kodak Park were quite autocratic and manufacturing costs were very confidential. It became apparent to the Manager of Paper Manufacturing in the mid-1960's that if Kodak was to remain in the photographic paper business a greater effort needed to be placed on better control and reduction of manufacturing costs. It was also recognized that the managers and superintendents could not do it alone so the confidential cost curtain was opened a little to supervisors in paper manufacturing. This was to have far-reaching effects as the curtain was opened wider and wider so that after several years the people who had the primary control of any particular cost set the budget and were responsible for it.

In 1972, the Paper Mill Division and the Baryta Division were merged into one organization. It seemed that the major problem remaining after the decision was made to merge was the name of the new division. After many suggestions were considered, it was decided to call it the Paper Support Division. The individual departments represented where the Paper Mills, Poly/Baryta, and Solvent Coating.

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The most significant technical advances in photographic paper base manufacture during the past 30-40 years were as follows:

1. The invention of wet strength resins which eventually allowed the photographer to get out of trays and onto a web processing machine.
2. The development of chlorine dioxide bleached pulps which allowed significant cost reduction and superior color stability.
3. The invention of deculators which removed the foam generation bottleneck on the wet end of the machine and allowed increased paper machine speeds.
4. The advances in instrumentation which allowed more efficient mill operation and a better understanding of the process.
5. Continuous chemical addition to the papermaking system which made better control possible and the eventual use of more modern sizing procedures.
6. The invention of new polymers, which in conjunction with electrokinetic control, allowed the papermaker to make a better sized paper with fewer chemicals. This also produced the virtual elimination of internal starch with the resultant advantage of better drying rates on the paper machine, thus allowing increased machine speeds.
7. Polyethylene coating of many photographic base papers, while not strictly a paper mill operation, did allow wider use of photographic processes.
8. Much better sheet uniformity crosswise, lengthwise, roll to roll, and batch to batch which resulted from many of the things mentioned here and possibly hundreds of others. With these improvements, the base paper worked better in subsequent Kodak Park manufacturing operations than it did many years ago.

For many years, Kodak Park papermakers had studied the possibility of coating on the paper machine. Quite recently, an on-machine coater appeared on the market which seemed to have many advantages for us. After many trials on two experimental coaters outside of Kodak Park, management approved the installation of a coater on B machine during the summer of 1976. It is likely that this will open a whole new era in the manufacture of photographic base paper.

And so the history of the paper mills at Kodak Park has been brought up to date. There are still many things to learn about the craft and new generations of people with white water in their veins and the enthusiasm to solve some of the old mysteries and to develop new techniques so that the photographic base paper produced in the mills at Kodak Park will remain the world standard for excellence.

Chapter 3

In 1976, the paper mill was about to enter the on-machine coating era. The concept for on-machine coating was a cost reduction measure driven by the pulp supply issues of the early 1970's. Development work had demonstrated that basis weight could be reduced by a combination of a special flat surface coating along with reduced calendering on the paper machine. A coater was installed on B machine to further test the concept and to serve as the prototype for an installation in Bldg. 319. However, the pulp crisis was resolved as described in Chapter 2, pulp cost was down, and the re-calculated cost saving was not enough to justify capital for Bldg. 319. Attempts followed for several years to find another use for the on-machine coater but there was no success and the coater was never used for commercial products.

The improved chemical system that had been introduced in the 1970's continued as a success but there was still room for important improvement. Stearic acid sizing is sodium stearate precipitated onto the fiber by alumina ions. Alum (aluminum sulfate) was originally used as the source of alumina but it was replaced by aluminum chloride since it formed a finer precipitate. The aluminum chloride was not only the source of alumina ion, it was also the chemical used to control pH, so as pH was adjusted the amount of alumina present changed. An important discovery was made when research showed that the trivalent form of alumina was preferred and that it was also pH dependent. It was recognized that with independent control of pH by hydrochloric acid, a fixed ratio of alumina to stearate could be maintained with the preferred alumina specie. This brought about a significant improvement in the stability and performance of the sizing system. Further optimization work showed that the performance was further improved when the aluminum chloride was added before the sodium stearate (known as reverse sizing). This system was further fine-tuned but the fundamental system remained unchanged in Bldg. 319 for many years.

However, other changes would be needed in the chemical components of the base paper. Polyethylene (resin) coated paper had been introduced with great success for photo products in the early 1960's. By the 1970's, it had become apparent that there was a problem with stability of the polyethylene layer. When prints on resin coated paper were exposed to light for long periods of time, the polyethylene layer developed cracks. This was discovered to be due to oxidation of the polyethylene. After many experiments, an effective antioxidant was found that could be added to the base paper. Wet end addition was very difficult since the material did not disperse well in water. A pre-emulsified version of the same material was later located which made addition much easier. Continued development work found other ways to prevent the oxidation from within the polyethylene layer and the use of antioxidant in the base paper for color products was later discontinued. However, the use of antioxidant continued in black & white products since it was found to prevent red spots caused by the silver image oxidizing to colloidal silver. Another unique product requirement for black & white papers required the addition of sodium formaldehyde bisulfite to the starch surface size. This was found to be necessary to prevent yellowing caused by the oxidation of incorporated developer in the emulsion layer of Phototypesetting grades.

Internal pigment addition had been used only infrequently but a project to improve sensitized product D-min required that titanium dioxide be added to the color base paper. This increased both the opacity and lightness of the base paper which carried over to an improved product D-min. While the use of titanium dioxide brought about a very significant improvement in product quality, its use on the paper machine through wet end addition presented problems for years to come as it was a major contributor to contamination which resulted in spot defects in the base paper.

In the early 1980's, penetration of developing chemicals into the edges of color prints became a major problem. This was initially attributed to the increased hydrostatic head caused by the new deep tank photo processing equipment. When increasing the amount of internal sizing was not effective in reducing the edge penetration, it was discovered that another factor was that the stearate sizing provided relatively poor resistance to the butyl alcohol in the developing solutions. This problem was solved by the addition of Quilon, a chromium complex material, to the surface size which provided the appropriate amount of edge penetration resistance. This method was used for several years until the butyl alcohol was removed in a later generation of processing chemistry.

The most significant change in internal chemistry addition, however, was made in the east mills. Serious issues with edge penetration had been discovered in a black & white base paper made on F machine. The mechanism for penetration was different than for color paper and the stearate sizing system, even with Quilon in the surface size, was not able to correct the defect. Kodak scientists had previously investigated alkaline sizing and believed that this could improve the edge penetration resistance of the base paper. Alkaline sizing systems had been developed by the chemical suppliers and were increasing in use in the general paper industry. The sizing chemicals were self-reacting with cellulose and therefore did not need a source of alumina which is what made acid systems acid. Consequently, in 1985, a very rapid development project was started to change the sizing system from acid to alkaline. The project was successful and alkaline sizing was introduced on F machine in a very short time. However, one problem remained. Paper machines that switched back and forth between acid and alkaline systems had very severe problems with contamination since each system became a cleaning process for the previous system. The solution was to be either acid or alkaline, but not both. Therefore, all of the grades in Bldg. 50 were converted to alkaline, not because the product characteristics demanded it but in order to prevent cross contamination between acid and alkaline systems.

While the alkaline sizing system was very effective for the critical black & white paper bases, earlier trials in Bldg. 319 on color base paper had never been completely successful. At best, equivalent performance was obtained but at much higher cost. While this issue was revisited many times, there was never a case made for conversion in Bldg. 319.

However, another change would be needed with the Bldg. 319 base paper. During one of the projects to evaluate alkaline sizing in Bldg. 319, it was found that the sensitized color product keeping characteristics were improved. It was originally thought that this must be due to a beneficial interaction between the alkaline sizing materials and the emulsion. It was discovered, however, that the improvement in sensitized keeping characteristics was due to the increase in the extractable pH of the base paper. Since the alkaline sizing experiments for Bldg. 319 conversion were not going well, the focus shifted to changing the extractable pH of the base paper by adding sodium bisulfite to the starch surface size. This was successful so the wet end process remained acid but the finished base paper had a neutral extractable pH.

During the next 20 years, the Bldg. 319 chemistry system was continually fine-tuned by altering addition points, diluting the concentrations of the chemicals prior to addition, and improving filtering. The result was significant reductions in cost and improvements in spot defects and the cleanliness of the system.

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In the late 1950's, Kodak had started placing radioactivity monitoring stations at several pulp mills in the United States and Canada to detect effects caused by atmospheric nuclear testing. New stations were added over the years as new pulp suppliers were added and the stations were maintained even after atmospheric testing ceased. In 1980, they were used for an incident caused by a natural disaster. On May 18 of that year, Mount St. Helens erupted sending million of tons of volcanic ash into the atmosphere. Kodak's major softwood sulfite supplier at that time was located in Bellingham, Washington, 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 activated 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. The effects of this major natural disaster also showed how important it was to be able to rapidly shift to changes in supply and this become an important consideration in designing future pulp furnishes.

In 1980, thirteen different pulps were accredited for use between the east and west mills. All of them were in use to some extent in the east mills in order to make the wide range of grades. Bldg. 319 used eight of the pulps in different blends for color base paper. Softwood sulfite pulp had been preferred for color paper base but hardwood kraft pulp had made in-roads due to lower cost. As more had been learned about pulp properties and refining control, the mix had shifted so that the furnish for color base paper had become 65% hardwood kraft and 35% softwood sulfite. The eight pulps used in Bldg. 319 represented three high brightness softwood sulfites, two high brightness hardwood krafts, and three regular brightness hardwood krafts. At any given time, the pulps in use would be dependent upon the pulp inventory and using a blend that met the brightness aim while maintaining the 65%-35% overall mix. It was recognized that the pulps did not refine the same so guidelines had been developed to change the refining to accommodate specific pulps and pulp blends.

In one of the early process control efforts in Bldg. 319, it was recognized that process and product variability could be reduced by limiting the number of pulps and using them in a permanently fixed ratio. Five pulps were selected for the fixed ratio based on maintaining the overall 65%-35% mix, meeting the product brightness requirements, and accommodating the pulp purchase contracts. What caused a lot of intense discussion beforehand, but seemed relatively simple in retrospect, was very successful for both process and product characteristics.

By the mid 1980's, titanium dioxide was being used in the color base paper which had a significant effect on brightness and other improvements in resin coating and sensitizing had reduced the need for the very high brightness pulps. A thorough investigation of pulp properties and how they affected base paper properties lead to a new pulp furnish for color base paper. The new furnish used only one high brightness softwood sulfite pulp (from Georgia-Pacific in Bellingham, Washington) and two regular brightness hardwood kraft pulps (from St. Anne in Nackawic, New Brunswick and from Pontiac in Portage-du-Fort, Quebec). Cost reduction would continue to drive more changes for both softwood sulfite and hardwood kraft.

Each of the two hardwood kraft pulps was a proprietary blend of maple, beech, poplar, and birch wood species. The price for these pulps included a premium for "special" properties that made them suitable for photo base paper. An investigation was started to find a pulp without "special" properties that could be used for photo base paper so as to bring leverage on the price of hardwood kraft pulp.

That pulp turned out to be a tropical hardwood kraft (eucalyptus) from the Aracruz mill in Brazil. The high growth rate eucalyptus trees came from managed plantations and could be harvested every 7 years which were significant factors in the lower cost of eucalyptus pulp. Eucalyptus had found widespread demand for use in tissue products due to the bulky nature of the fiber. This was not a characteristic that was favored for dense photo paper but after many trials the engineers and papermakers found out how to handle the refining to produce color base paper with up to about 25% eucalyptus with properties equal to northern hardwood kraft. In 1991, eucalyptus was added at 10% of the total furnish replacing some of the northern hardwood. The lower cost of the eucalyptus brought pressure on northern hardwood kraft and the photo premium was reduced and later eliminated. Even though the eucalyptus had been successful at 25% of the total furnish, it was introduced at 10% and would never be used at more than 15%.

The lower price of eucalyptus and the elimination of the premium on northern hardwood kraft widened the gap between the hardwood and softwood prices. When it became apparent that this gap was unlikely to be closed, trials were started to determine if the softwood could be completely replaced with hardwood. Not only did the trials demonstrate that replacement was possible but there was an improvement in process and product uniformity since refining could be better optimized for a blend of hardwoods than for a blend including softwood. In 1994, the softwood sulfite was replaced with northern hardwood kraft and for the first time the furnish for color base paper became 100% hardwood with a mix of 90% northern hardwood kraft and 10% tropical hardwood kraft (eucalyptus).

Even though the special premium pricing for "photo pulp" had been eliminated, the price of the northern hardwood kraft pulps was still higher than standard grades of pulp. The maple, beech, poplar, and birch blend of the Pontiac and St. Anne pulps was referred to as the "market basket" since these were the wood species that grew naturally in the northeastern forests. The preferred specie for photo base paper was maple due to its fiber characteristics which gave excellent surface smoothness with moderate strength. The poplar specie had been the least preferred since the rigid fiber structure made a rougher surface base paper. In the 1980's, trials had been made with western Canadian 100% aspen pulp, which had similar properties to eastern poplar, but they were not successful due to the poor base paper surface. However, much progress had been made in refining and the Alberta-Pacific mill in Alberta, Canada had also made many improvements and was a world class operation. Again the engineers and papermakers found ways to control the process so that aspen pulp could be used successfully and its use was approved in 1998. Initial use was small at 5% of the total furnish but this was later increased.

In 1997, the Thurso mill in Quebec approached Kodak with an interest in providing a standard northern hardwood kraft pulp. The first samples were unacceptable due to low brightness, heavy dirt, and some photoactive response but the mill was committed to providing an acceptable pulp. Many improvements were made and the pulp was continually improved.

In the meantime, eucalyptus continued to enjoy worldwide success and, in tissue and fine paper markets, it was preferred over northern pulps. The result was that the eucalyptus price increased so that it became more expensive than the northern hardwood.

Since Kodak was a very small user of this pulp compared to the rest of the world, it was not possible to negotiate acceptable pricing. With the aspen pulp accredited and the Thurso pulp trials well underway, the eucalyptus was eliminated in 1999. The Thurso trials continued but the pulp was not fully accredited until 2002 although significant volumes had been used in 2001 in the later stages of the accreditation trials. For a brief time in 2002, the color base paper furnish in Bldg. 319 was a mix of Pontiac, St. Anne, Alberta-Pacific, and Thurso but St. Anne was soon eliminated due to high price.

By 2003, the furnish mix of Pontiac, Thurso, and Alberta-Pacific pulps was often changed in order to balance the contracted volumes with declining color base paper demand while maintaining the lowest furnish cost possible. Development of the papermaking technology had provided the capability to vary the mix of the pulps and maintain both process and product uniformity. In 2003 and 2004, the furnish was changed more than 10 times each year.

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In 1972, the Paper Mill and Baryta Divisions had been consolidated to form the Paper Support Division. In this organizational structure, an assistant superintendent had responsibility for both east and west paper mills. Production, development, and engineering supervisors also had responsibility for both east and west. Within the paper mills, this structure was the same as it had been. It would continued for another 10 years with no change in the cooperation and mutual support that already existed between the east and west paper mills.

However, in 1982, another re-organization took place which was to have lasting impact on the paper mills. A management decision was made that the Paper Support Division should be re-aligned into East and West operations, combining the paper mill and coating operations in each geographical location. It was made clear that the separation was to be more than an organizational formality when instructions were given to "build a brick wall" between the east and west paper mills. No longer would crew members train in both locations, reassignments were restricted, and separate staff functions were assigned to each location. During this same time, a shift of emphasis away from the east mills and to the west was taking place since the growth was in color products and that base paper was made in Bldg. 319 where more potential capacity existed.

The overall east - west structure did not function well, primarily due to the combination of coating and papermaking responsibilities, and a year later the organization was divided into 4 operations – east and west paper mills and east and west coating departments. Papermaking operations and staff functions in each location were then under the same supervision but the separation of east and west paper mills continued. The paper mills were never recombined. In later reorganizations some of the staff functions were partially combined but the damage had been done. The combination of factors caused more competition than cooperation between the east and west mills, a situation that would last for many years. Despite efforts to change this, the brick wall concept proved easier to erect than to take down.

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In 1984, the manager of paper manufacturing met with the local supervision of Bldg. 319 to lay the groundwork for an inquiry into the concepts embodied in the Toyota Production System. Reduced inventory was the early interest but this quickly became seen as an end result that would only be possible from a dramatic change in total operations. At the heart of the new concept was a commitment to manufacturing quality defined as 100% conformance to specifications with manufacturing operating in process control. Six key points were identified as necessary to achieve this vision: process & product uniformity, operator responsibility and authority, raw material quality, smoothed production scheduling, fully defined product fitness for use, and equipment reliability.

One of the first issues addressed was the routine practice of producing non-conforming product while trying to find a solution to a manufacturing or quality problem. This was possible since the non-conforming product could usually be used in restricted sizes or markets but this was choking the system with slow moving product. An approach was implemented that called for shutting down the paper machine at the first sign of a problem in order to fix problems before they got out of hand or before making large stocks of non-conforming product while deciding on corrective action. In 1983, 73% of product had been fully conforming. In the first four months under the new procedure, conforming product was at 88% and increased to more than 90% by the end of 1984 with no loss in total productivity.

In 1980, an outside consultant had been hired to assist in preparing a training manual that went beyond normal training tools of the day. It took 2 years to complete this manual but the result was a practical and technical explanation of not only what to do, but why, and how processes interacted. This concept aligned very well with the idea of increasing operator responsibility and authority.

In 1984, each shift in Bldg. 319 had a shift supervisor – there were 4 shifts since Bldg. 319 had been on 7-day operation since January 1980. The shift supervisor was usually an experienced papermaker who had progressed through the ranks of all papermaking positions. Having this level of expertise on each shift was normal both within the paper industry and within Kodak. Even so, it was also normal for a shift supervisor to call on management to approve decisions. This changed one night when a shift supervisor called a manager for approval to cut off a damaged wire that had the potential to create non-conforming product. The manager told the shift supervisor that he had the authority to make the decision himself. The wire was cut off. The major impact of this event was that it created a heightened sense of responsibility which spread through the workforce. Within a relatively short time, shift supervisors were given a new role working as a team on day shift with each having primary responsibility for a part of the operation. Crews were aligned into groups, with their own group leaders, and were responsible for their own on-shift supervision.

The testers and inspectors who evaluated the base paper and made decisions on its quality had always been part of the Paper Service Division – sort of like not having the fox guard the hen house. The new idea was that making this function part of the mill responsibility would improve ownership of quality and a project was started called Self-Inspect - Self-Release. In this project, papermakers were trained to do the testing and evaluation of the base paper and when completed, testing, inspection, and release functions became a paper mill responsibility. The papermakers became much stronger advocates for quality, often were more critical in the quality assessments, and were more pro-active about making improvements.

As the improvement and fine-tuning work with the chemical systems advanced, it had become apparent that the variability of in-coming raw materials was a problem. A program had already been started with suppliers to rewrite chemical specs and to require supplier certification that shipments met the specs before being shipped. This was expanded to all chemicals and pulps and was highly successful not only in improving raw material quality but also in building relationships with suppliers as they in turn saw the benefit of not having to take returned material. A short time later, Purchasing formally began a company-wide Supplier Quality Program (Q1) based on the same concepts and Bldg. 319 was one of the first to adopt the official program. The official program was changed several times, mostly to have a more direct impact on cost reduction, but the paper mill retained the original quality concepts and expanded the mill-supplier teams with much success.

In Chapter 2, we saw how a data-logger on B machine became the foundation for closed loop control for both machine and cross direction weight and moisture control in Bldg. 319. When it was discovered that there was a relationship between moisture variability in the base paper and sensitometric properties of color products, more stringent moisture specifications were placed on the base paper. With the closed loop control and the cross direction vapor control system, it was believed that Bldg. 319 would be in good shape to meet the tighter specs. Waste due to moisture variability did increase slightly with the tighter specs but was not a major issue at the time.

The original control system was developed by Taylor Instruments but other companies had made more progress in on-machine computer control and this system was eventually replaced. It was quickly discovered that the moisture gauging capabilities had also been improved with the result that the moisture variability was much greater than measured by the previous gauges. Waste due to unacceptable (out of spec) moisture variability tripled. The control of moisture variability would become a never-ending struggle and always a significant cause of waste.

An old papermaker's saying is that "paper is made in the beaters." The meaning is that many sheet problems can be traced to variability in beating (refining) which is an inherently difficult process to control due both to the variability in pulp fibers and to the continual wear of the refining tackle. A Refining Team working on this problem found that by applying fundamental refining theory regarding the control of specific net refining power and refining intensity, hydration and cutting could be controlled while stabilizing Jordon tackle wear. Monitoring methods were implemented to track performance. The variable couch broke addition was re-routed to by-pass refining to better control refiner through-put and to eliminate over-refining of the couch broke. It was also necessary to decrease machine speed in order to control within the optimal refining window.

Control of refining and machine speed had long been practiced as an art by papermakers as they monitored and made machine adjustments. This could have been a difficult adjustment for the papermakers but with the focus shifting to process control the transition was readily made. An improvement was seen in refiner wear, in improved variability in sheet properties, and in an unexpected but significant reduction in waste due to moisture variability. Additional improvements in refining process, recovered fiber by-pass, and the addition of a Duo-flo refiner in 1988 would allow the speed loss to be recovered and provide for further speed increases.

One of the causes for moisture variability was found to be that the Jordans were over-hydrating the fibers as the tackle wore and the normal routine of reversing the Jordans to resharpen the tackle was not effective. Within a few months, as the control parameters were fine-tuned, moisture waste was halved. Further significant improvements in moisture control would also be made by installing a closed loop re-moisturizing spray (VIB system) and later a closed loop infrared drying system (Impact). These systems plus dedicated work on control systems by the operators, technicians, and engineers would bring about a continued lowering of moisture waste.

At this same time, the need for cost reduction for color base paper became a major requirement and one that would be continuously pursued. Bldg. 319 was in a good position from the development and process control work and over the next 10 years cost reductions previously thought impossible would almost routinely be implemented. The base paper was redesigned several times, pulp and chemical work lead to material reductions, waste was reduced, runtime improved, and downtime and maintenance efficiency were improved with the result that Bldg. 319 clearly became the low cost leader for color base paper.

The six key points had originally been given an official name - the Paper Mill Operating Strategy – and had been introduced in the summer of 1984 with some fanfare with the general manager providing visible support. For the next 4 years, the key points were the basis for very successful paper mill operations. In 1988, the general manager was in a new position in Kodak and Paper Support management was pursuing concepts that did not have room for a separate paper mill strategy. Reference to the Strategy faded away but a continuing commitment to the principles behind the six key points would remain firmly in place.

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Development work in the 1970's had shown that improved smoothness could be achieved by heating the calender rolls. The original calender in Bldg. 319 was a closed frame 10-roll stack with pneumatic loading and relieving for each roll except the king roll. After much discussion on how to test hot calendering in production, a decision was made to drill out the Bldg. 319 intermediate calender rolls so that they could be heated with hot water. In order to maintain strength, the rolls still had very thick walls which did not allow for uniform heat transfer. This resulted in uneven thermal expansion of the rolls which made caliper control impossible. It would be several more years before the technology could catch up.

In 1983 a new calender stack was installed with top and bottom 5-zone NIPCO rolls, fixed queen roll, and one intermediate. Extra intermediate rolls were purchased since it was not sure if 4 rolls would be sufficient – if they were not needed they would have become spares. The 4 roll stack did not give enough total load capability and 2 extra intermediates were added within about a week. The intermediate rolls were tri-pass drilled which allowed hot water (up to about 210 degree F) to pass in channels within the rolls. This design made it possible to uniformly heat the rolls. Development work on finding the optimum temperature continued for some time. High temperature was good for paper surface but was bad for moisture variability since the base paper rolls cooled non-uniformly in storage. This resulted in unacceptable moisture variability. It was found that the most effective procedure was to match the sheet temperature in the top nip and graduate the temperature down in each successive nip. This calender stack was replaced in a later machine upgrade but the fundamental technology remained the same. The same technology was also used for a new calender on F machine in 1990.

The work with temperature control and moisture variability also lead to attempts to lower the temperature of the sheet entering the calender stack. By the late 1980's, improvement work on drying, moisture control, and surface sizing had resulted in excess drying capacity in the third section. So in 1988, the last three dryers in the third section were converted to cooling drums. This was effective in lowering the sheet temperature but condensation and water drops prevented long term use. The solution would have been to isolate the cooling drums from the third section hood but this could never be cost justified.

Bldg. 319 was originally equipped with a 24 inch dandy roll. As machine speeds increased, the dandy became less effective at improving formation and had problems with throwing water back on the sheet. Process improvements had also improved formation so the dandy was removed in the 1970's with little affect on product performance. As machine speeds continued to increase, formation again became an issue. In 1982, a 48 inch dandy with an external pan and shower system was installed on the Fourdrinier. It took some time to find the right positioning into the wire and to optimize showering but the new dandy was successful in improving formation and surface. However, the dandy would continue to be a source of operating and cleaning problems.

In 1968, an analysis had been made of what should have been done differently in the Bldg. 319 construction. One of the issues identified was that the grout used for the machine sole plates and drive pedestal bed plates had been found to be unstable. Moisture and rust within the grout were causing non-uniform expansion of the grout causing the machine frames to tilt. By the early 1980's, the tilt had increased so much that it was necessary to replace the entire machine grouting. In 1981, the third section was removed, the sole plates were re-grouted, and the section was reinstalled and realigned. Based on this successful project, in a 13-week shutdown in 1982, the first and second sections were successfully re-grouted.

In the late 1970's, Noble & Wood beaters in the east mill were still being used for fiber recovery but the equipment was obsolete and replacement parts were not available. The process was also very time-consuming as roll broke was fed directly into the vat with a long cycle time required to break up the wet strength in the sheet.

The Pandia system (a unique broke recovery process using a chemical pulping concept) that was originally installed in Bldg. 319 had its own operational problems, including degradation of the optical properties of the pulps, so it was not a candidate for installation in the east mill. Therefore, an investigation was made into using different types of high consistency or high intensity hydrapulpers. It was found that by using a special rotor & plate design (called a Barracuda), along with elevated temperature and sodium hydroxide to break up the wet strength, that good defibering could be accomplished. A production size unit was installed in the east mill and was successful. Meanwhile, in Bldg. 319, changes in trim width resulted in more fiber for recovery than the Pandia system could process. The Barracuda offered the opportunity to provide the needed fiber recovery capacity and to reduce the pulp degradation so a short time later a unit was installed in Bldg. 319 to replace the Pandia.

The original headbox in Bldg. 319 was an air pressurized rectifier roll design. This headbox had good flexibility in handling different weights over a wide range of machine speeds and optimization work had resulted in very dependable performance. Except for slice modifications for cross direction weight control in 1973, only minor operational changes were made for many years. Repeated polishing gradually reduced the thickness of the stainless steel walls and in 1989 it was replaced with a modern hydraulic headbox. This installation was made with some apprehension since an hydraulic headbox would have a narrower operating window. An extensive test plan was developed and after a 4 day debug of equipment and controls and a 4 day test cycle through resin coating and sensitizing the headbox was certified for regular production. However, the narrower process control window provided limited capability to control "wormy" surface and this would prove to be a continuing quality issue.

In the mid 1990's, base paper for thermal products was developed in the east mill. The first generation of raw base was successful because of a unique furnish that provided a very smooth but also uniformly compressible surface. The blend of a high maple content hardwood kraft with an alpha hardwood sulfite was granted an EK patent. Later generations of thermal receiver required even better surface which was achieved by installing a steam foil ahead of the calender on F machine.

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We saw in Chapter 2 that the capacity of the paper machines was continuously increased throughout the 1970's. 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 been accomplished in a full year and now it was achieved with 2 months remaining. It is interesting to note that on that day only 4 of 6 paper machines were running. D machine had been shutdown in 1973 and C machine was reserved for only a few special grades and did not operate on a full schedule. Within a few years, C machine would also be permanently shutdown.

In response to long range forecasts for increasing color base paper demand, studies for investment in new papermaking capacity and significant speed-ups were carried out almost continually for the next 20 years.

In 1979, a feasibility study was made for a new 250 inch paper machine next to Bldg. 319. No action was taken but the concern for future capacity for color raw base never went away and neither did the search for options.

In 1981and 1982, major investigations were made examining the feasibility of rebuilding Bldg. 62 to make photo base paper, rebuilding F machine to speed up, removing the idled C and D machines and replacing with a new 90 inch paper machine, building a twin machine next to Bldg. 319, and constructing a Bldg. 319 twin at a greenfield site.

In 1985 a new study was underway for upgrading F machine for color base paper (with a speed increase from 275 fpm to 550 fpm) and for upgrading Bldg. 62 for photo base paper. This was the second time for this study on Bldg. 62 but it would be the last. Bldg. 62 had made what was referred to as non-photo grades (interleaving and film packaging papers) but these grades had been outsourced and the mill idled in the early 1980's. The engineering firm that was retained to do the study on Bldg. 62 included the following comment in the final report: "Bldg. 62 paper machine has served Eastman Kodak well, its tour of duty and practical service life are over, and any attempts to recondition Bldg. 62 paper machine would be difficult if not impossible to justify."

However, Bldg. 62 was not yet ready to be forgotten. In the early 1990's, there was a paper industry-wide interest in the use of recycled fiber both for environmental reasons and for lower cost. Recycled fiber had been investigated for use at low levels in color base paper but was unacceptable due to the adverse reaction to spot contamination in customer evaluations. The new idea was to use the idled Bldg. 62 machine to produce recycled pulp for outside sale. The source of the recycled feed stock would be office waste both from Kodak and outside sources. Much of the office waste was copy paper so a process was installed to remove toner by a chemical agglomeration of the toner followed by screening. In May 1994, Bldg. 62 was re-opened for business. The recycled pulp was sold in rolls and there was demand for the entire capacity. However, the on-going operational costs were high and the general market price for recycled fiber was in decline. In January 1995, Bldg. 62 was shutdown for the last time. The entire building was later dismantled and the space used as a marshalling area for trucks.

The experimental paper machine in the east mill was also shutdown. X machine had been very successful for development work on internal chemistry, new paper grades, and hot calendering. While X machine had some unique capabilities for developing concepts, it was relatively unsophisticated in ability to produce consistent product. The level of process and product control that was in place in production could not be duplicated. Except for major equipment like the hot calender, most of the improvement and maintenance for X machine had come out of small development budgets. In order for X machine to remain useful, significant improvements and upgrades were necessary but it was not possible to provide a cost justification since there were several pilot facilities outside of Kodak that were available for trials on a rental basis.

In 1988, the capacity options would be recycled with slightly different twists from previous ones. This time a second machine would be installed next to Bldg. 319 but Bldg. 319 would also be rebuilt to make black & white base papers which would be moved from the east mill. In a 1990 study, the second machine would be wider, Bldg. 319 would be shutdown, and a greenfield site was again considered. In 1991, a study was again made for a new 90 inch machine in the east mill. In 1991 and 1992, a 172 inch machine proposal for the west was reconsidered. In 1995, a twin for Bldg. 319 was again considered and in 1997 the proposal was brought forward yet again with updated costs.

Even though the demand for color base paper kept increasing, the capital costs could never be justified for any of the new capacity options. A major reason was that new capacity was very expensive and came in very large increments which could not be filled in the short term. Even though the demand for color base paper was growing, there was uncertainty about the very long range demand due to the potential impact of alternate technologies. The end result was that a business case could never be made for the large investment needed for a capacity expansion.

In the meantime, the focus shifted to increasing capacity by speed increases and improved efficiency in operations. During the mid to late 1980's, the aggressive quality program in Bldg. 319 had resulted in significant improvements in efficiency which translated to increased production. In 1980, Bldg. 319 was running at 1000 fpm. An immediate impact of the process control work on refining was the need to lower speed to

975 fpm in order to better control the process. This actually created more production volume as the improvements resulted in lower waste and improved runtime. De-bottlenecking continued and Bldg. 319 was at 1050 fpm in 1987, 1100 fpm in 1990, 1150 fpm in 1993, and 1225 fpm in 1995. One important factor that made the speed increases possible was that the manufacturing strategy included providing equipment that was sized to operate at higher than standard speed each time a new piece of equipment was replaced or a small upgrade made. This resulted in several of the systems being sized to support speeds up to 1500 fpm.

In 1989, discussions started on making color base paper on F machine without a rebuild but this was seen as unlikely to be successful. Shortly after this, improvements were made to F machine to support a development program for a new product. Upgrades to the moisture and process control system, the addition of IR drying, and the new calender that was installed in 1990 had made color base paper feasible. In addition, black & white base paper volumes had been decreasing and F machine had extra capacity for color base paper. An accreditation was started in late 1992 and finished in September, 1993. The formula was similar to Bldg. 319 except that F machine color base paper was made with alkaline sizing.

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During the 1980's, Bldg. 319 was supplying all of the worldwide demand for color base paper except for that required by Kodak Limited at Harrow, England which was sourced from Germany. The supply of base paper was recognized as a worldwide issue and papermaking technical exchange was implemented in order to provide support for Kodak Limited. This expanded into detailed benchmarking which re-enforced the need to continually improve manufacturing competitiveness. Most of this effort was directed at cost reduction to achieve the lowest possible cost at acceptable quality, continuing the cost reduction emphasis that had begun in the early 1980's.

During the 1990's, demand for color base paper increased dramatically resulting in significant shortfalls in Kodak base paper capacity. We have already seen how the capacity options studied during this time could not be cost justified and the result was that base paper was imported from Germany to meet the shortfall.

It had become clear that with capacity available in Germany, large papermaking expansions in Kodak Park were unlikely. It had also become clear that Bldg. 319 had achieved the advantage of being the low cost producer so effectively filling the available capacity was very important. However, the years of cost reduction and restricted capital had not been kind to Bldg. 319 and while the paper machine was in good mechanical condition it was in need of modernization and replacement of functional but obsolete equipment.

Two items which needed immediate attention were the drives and the winder which was the original Beloit 2-drum design from 1962. In order to get a broad perspective on what else was needed, a paper machine engineering company was retained in 1994 to perform a full mill assessment. One of the outcomes of the assessment was a confirmation of the need to replace the drives and the winder and plans were made for a drive replacement in 1995 and for a new winder in 1996. The total need for capital and expense was estimated to exceed $20M. Therefore, a 10 year capital plan was laid out for the other necessary improvements.

Worldwide benchmarking also showed that some base paper features were in need of improvement. Development work had identified that closing these feature gaps would cause a large loss in Bldg. 319 capacity. In March 1996, it was recognized that an opportunity existed to install the new winder in a different location so that space could be created to add additional dryers to recover lost capacity if the feature improvements were implemented. A plan was quickly drawn up to rebuild and expand the bridge between Bldg. 319 and Bldg. 350 and to install the new winder there. This would cost an additional $1M but the idea was quickly accepted by senior management and the new winder was installed just a few months later on the rebuilt bridge.

By early 1997, it was acknowledged that maintaining Bldg. 319 as a world class papermaking facility could not be accomplished if the necessary improvements and upgrades were carried out over 10 years. Instead a bold plan was prepared for a major rebuild of Bldg. 319 and in April final approval was given for an $84.5M capital project that would improve manufacturing performance, enable improved product features, and would increase machine speed to 1500 fpm. The world was quickly changing, however, and later that same year the project scope came under review due to pressure on availability of funding for capital projects, questions on the value of the improved product features, and the need and value of increased capacity from the speed increase.

The result was that the project was redefined to focus only on improved manufacturing performance and in April 1998, one year after the original project was approved, a new project was approved for $40M for completion in July, 1999.

Even with the reduction in scope, the $40M upgrade for Bldg. 319 was the largest and most significant upgrade ever for Kodak papermaking. By the time it was completed in 1999, many of the major parts of the machine would be replaced, including a new headbox, new breast roll and shake, new 5-stage cleaners, double-felted first press and rebuild of the rest of the press section, new slant size press, a new reel with water jet turn-up, and major upgrades of support systems including HVAC, stock chests with efficient mixing equipment, machine threading, a new reel pulper, distributed control systems, and space for a new drop-in defect scanner.

In the months leading up to the 1999 rebuild in Bldg. 319, much effort was put into inspections at vendor sites for equipment acceptability, planning for the capital work and for the debug after start-up, and for the product evaluation. Nearly all of the new equipment was selected based on demonstrated performance in photo base paper manufacturing. When benchmarking was not available, back-up plans were employed. Base paper had been stockpiled for the downtime and for lower than normal production during the learning curve after start-up. The learning curve was estimated based on the experience with the headbox replacement in 1989. However, this rebuild would change most of the major process equipment and there was uncertainty about the rate for returning to full production.

The start-up in August went well with most de-bug issues being quickly addressed. The new reverse cleaning system and the double-felted first press had been targeted as potential problem areas but both performed very well from the beginning. There were some start-up issues due to faulty design, manufacturing, or installation that could have been serious but contingency planning and the ability to construct or alter equipment on-site minimized the issues.

However, several pieces of equipment did not perform as expected and would cause operational and product problems over the next two years. The new headbox was found to have a manufacturing defect of misaligned tubes which caused a skewed fiber alignment across the sheet and resulted in product curl problems. It took many trials to determine the source of the problem and to convince the supplier that their tolerances for tube alignment were not acceptable. In the end, the supplier provided a new block with properly aligned tubes.

The new size press caused release marks in the sheet that formed between the press and the third dryer section. After trying many process adjustments, it was determined that the sheet path exiting the nip had been designed incorrectly by the supplier. This was finally corrected by changing the exiting sheet path. The new reel worked well and it was possible to make triple length rolls without cinching defects but the water jet turn-up system was not reliable and needed a lot of optimization work.

Despite these issues, the rebuild was successful and runtime improved, waste was reduced, and the number of machine breaks decreased.

Chapter 4

Even as the immediate future for Bldg. 319 looked bright, there were dark clouds on the horizon for the east mill. Demand for traditional black & white products was in steady decline. Even with some increase in demand for thermal base paper, F and B machines were not fully loaded and had been operating since 1997 on a one-machine schedule with crews moving between the two machines. While capital had been limited for Bldg. 319, it had been practically non-existent in the east mills except for modest routine maintenance. While capable of manufacturing current products, neither F nor B machine was world class in total cost of manufacture and the gap was expected to increase in the future. Therefore, in 1999, a project was started to transfer manufacture of the east mill grades to outside source of supply where better asset utilization could contain costs for the remaining years of product life. This project was completed grade by grade and by the end of 2000 all remaining east mill base paper grades had been outsourced and the east mill was permanently closed.

Following the 1999 rebuild of Bldg. 319 machine, production performance continued to improve but the demand for color base paper did not. Even with base paper for ink jet products being made in Bldg. 319, the demand was far short of capacity. In 2004, a project was started to accredit thermal base paper in Bldg. 319. This was a major stretch as the machine capability was not a good match for the thermal requirements but by early 2005 the accreditation was successfully completed. However, the total demand for color, ink jet, and thermal base papers was still much lower than available capacity and options were being studied for how Bldg. 319 would be scheduled in 2005.

The March 17, 2005 headline in the local newspaper reported the answer – **"Kodak Closing Paper Mill** – Eastman Kodak Co. will stop making raw paper at Kodak Park later this year as digital photography continues to change the way photographers take and print pictures."

During the next two months, the Kodak papermakers would continue their long tradition of excellence. Production output exceeded expectations and machine performance was at record levels.

At 7:02 am on May 12, 2005, the crews and staff assembled on the machine floor in Bldg. 319 for the last reel of base paper that Kodak would make. The American flag hanging on the wall above the winder was taken down and presented to the Kodak Vietnam Veterans association.

Papermaking at Kodak had come to a close.