

INDUSTRIAL AND SPECIALTY PAPERS

INDUSTRIAL AND SPECIALTY PAPERS

Volume I—Technology

Prepared by a Staff of Specialists
Under the Editorship of

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Foreword

The publication of *Specialty Papers* in 1950, followed by *The Technology of Coated and Processed Papers* in 1952, presented information on these subjects in book form for the first time in the English language. The paper industry is a broad and complex one and this is especially true of paper converting. No one man or organization is in a position to cover completely the many facets of specialty papers. Editor Robert H. Mosher therefore chose a group of well-qualified men, each a specialist in his own field, to prepare chapters on specific subjects. The results were two informative volumes that have served as general reference works.

Since the appearance of these two volumes, substantial advances have been made in the technology of specialty papers. Numerous new synthetic polymers have reached commercial production and some of these are of value in coatings. Several of the longer-established materials have been greatly reduced in price, offering new opportunities in specialty papers. At the same time, the availability of unsupported plastic film in large quantities at relatively low prices has drastically affected some markets for coated papers. Growth of metal foils has also offered both an opportunity and a challenge. Advances in machinery for preparing and using coated papers have kept pace with the new materials. This combination of new and improved materials and machinery has made possible an ever-expanding opportunity for specialty papers.

To bring this information up to date, Mr. Mosher has again obtained the aid of specialists to handle capably each of the many phases of the industry. Their efforts are combined in *Industrial and Specialty Papers—Their Technology, Manufacture, and Use* in three volumes.

These comprehensive books should serve as valuable references to a wide audience. While they cover the technology of specialty papers, the language of the chapters is not highly technical but is written along practical lines for more general understanding. These volumes should be helpful to the student as a text on this varied and relatively com-

plex subject. They should be a source of information and background to the marketing man. To the laboratory researcher, they should serve as a reference and source of ideas for new products. Others may find them of general interest.

The editors and their authors are to be congratulated on bringing up to date the extensive information in this field.

New York, N.Y.
August 1967

Wm. H. Aiken
*Vice President, Research,
Union-Camp Corporation
President, Technical Association
of the Pulp and Paper Industry*

Preface

The paper industry represents a dynamic and ever expanding technology. Probably in no other areas have there been more developments in products and attendant techniques and machinery than in the fields of specialty papers and the allied coated and processed papers, particularly since 1950.

This period has seen the explosion in the office copying field, the evolving requirements of electronic data processing equipment, the insatiable demand for business forms, and tremendous advances in the graphic arts industry.

These developments have made necessary a complete revision of *Specialty Papers* (1950) and of *Technology of Coated and Processed Papers* (1952) to bring them up to date. As before, the purpose of this new series is to assemble, digest, and concentrate the best available information on each subject and to interpret this knowledge in the light of sound operating practice. Together with the host of carefully selected entries in the bibliographies, the series should serve as an auxiliary text to the standard volumes used in the leading schools of pulp and paper technology and as an authoritative technical and marketing reference work.

To attain these objectives properly, the editors have closely examined the earlier books in the light of their own experiences and those of their associates. Several chapters required only minor revision to bring the descriptions of certain techniques into conformity with existing improved procedures. The great majority required complete rewriting to achieve adequate coverage of technology and equipment that were entirely unknown fifteen years ago. Several new areas that were in their infancy at that time have been added.

As far as possible the editors have depended upon the original authors to revise and rewrite in their fields of interest and experience. Some have passed on, however, and several have left the industry. In choosing replacements, as well as the experts to cover new subjects,

the editors again sought practical, successful men, rather than mere theoreticians, who had contributed extensively to recent developments and could write about them in a lucid manner. Sound, demonstrated practice has been the approach, yet adequate theory has been provided where it will shed light on the techniques used in this particular phase of the paper industry. The present work is definitely *not* the result of an academic and unimaginative search of the literature.

Many recent references appear where they support the wide experience of the authors. The reader will notice a certain amount of overlapping in the coverage of some of the topics—an intentional feature that reflects the inherent nature of the industry. There has been a deliberate orientation toward the end use and marketing aspects of each product, in comparison with the earlier, more limited technical approach.

The editors wish to thank the thirty-seven authors who deemed it worthwhile to take time from their busy schedules to present current practice authoritatively. Thanks are due a number of industrial concerns for permission to use photographs and tables not available elsewhere. The efforts of Mrs. Bairnsfather and others of the staff of the Hayden and Engineering Libraries of Massachusetts Institute of Technology aided considerably, as did the painstaking work of Mrs. Dixie Merson and Marguerite S. Davis in reading proof.

August 1967

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chapter 1

Introduction

R. H. MOSHER

EARLY HISTORY OF SPECIALTY PAPERS

Modern development, techniques, and materials of specialty papers can best be highlighted against a background of early history.

Prior to 1800, when paper was produced by hand and limited to single sheets, printing and coating operations were simple and as primitive as the paper-making technique.

This hand-made paper, which was produced in small volume in Europe beginning in the 12th century, was used from the earliest days of its development as a base for printing. All books and documents were of course hand written or printed prior to the development in 1456 of movable block type by Johann Gutenberg at Mainz, Germany. Previously, the use of woodcuts or engravings was the only method of commercial printing. The early inks were formulated from carbon black and vegetable oil and later from carbon black and mixtures of vegetable and mineral oils. Colored inks were made with vermilion, cinnabar, indigo, cobalt, and copper oxide as the pigmenting or coloring medium.

The printing of the surface of hand-made paper was a problem with the shallow wood cuts and even shallower wood engravings available at that time, because the surface of the paper was relatively coarse. This difficulty was overcome to a certain extent by burnishing the surface of each sheet with some sort of smooth, glossy stone, but the process was slow and cumbersome. About 1540, the glazing hammer was developed; this improvement caused a feud between the stone glazers and hammer glazers that lasted for more than 150 years, but as in most cases, the mechanically-operated device finally won out. This process in turn was superseded about 1720 when the Dutch developed a method of calendering the sheets with a pair of polished

copper rolls, a technique that led to the invention of the sheet plating machine.

The main object of all these processes was to smooth down the surface of the paper so that fine engravings and letter press block printing could be produced with the paper available at the time. The printed paper was used for its traditional pictorial value and could not be considered as a part of the specialty paper industry as we think of it today.

The real start of the paper-converting industry began with the development of wallpaper, or paper "hangings" as they were then termed. This development must apparently be credited to the Chinese, who also invented paper, but it was brought to the western world about 1620 when paper hangings were first made in France. The sheet was produced in its earliest stages by block printing on plain paper, but artisans soon felt the need for some sort of "grounding" or base coating that would be capable of holding up the color and preserving the brilliancy of its hues. A coating was developed from glue and pigments and this was applied with a brush to supply a "ground" or "color" for the printing process. Later, someone discovered that the coated surface could be smoothed mechanically and used as a base for other types of printing operations.³ This was the first purely decorative application of paper, other than as an artists' medium, and marked the beginning of the specialty paper industry, even though the paper was still only available in sheet form.

MODERN DEVELOPMENTS

About 1800, the basic invention that changed the paper-making industry appeared—a machine for the production of paper in a continuous sheet. The first machine, invented by Louis Robert in 1798, was developed by Henry and Sealy Fourdrinier and involved the same fundamentals that had been in use for 2000 years. The machine, which bears the name of the two brothers who lost a fortune in its exploitation, was based on an endless wire screen that allowed the water to run through and form a felt or sheet of paper on its surface. This sheet was continuously stripped off the end of the wire and either cut into strips, which were hung up to dry, or wound up in a partially-dried state and later redried. A second type of paper-making unit, the cylinder machine, was independently developed in 1806. It contained a wire covered cylinder that rotated in a vat of stock, with the water again running through the screen and the fiber mat remaining

on the surface. The two types were introduced to this country in 1816 and 1827 respectively, and soon both were in production. Machines of the same type, although modified, enlarged, and speeded up, are still used today, although the early papermakers would scarcely believe their eyes if they could see them in their present form.^{4,5,6}

The availability of paper in continuous form instead of sheets soon led to the development of web calenders for smoothing the paper to produce good printing surfaces, but it was not until the middle 1800's that equipment was developed for coating the paper by means of a continuous operation. The use of coated papers had been increasing, and coated labels, fancy papers, and wallpapers were gradually attaining reasonable volume. Gravure printing that employed copper plates had been introduced about 1650 with the mezzotint process, and lithography was developed by Alois Senefelder in the early 1800's. Coated and printed playing cards were developed prior to 1500. All these products and processes had previously been limited by the lack of continuous machinery for their production.²

One of the first companies formed for the express purpose of coating fancy and box papers was the firm of Alois Dessauer, which was set up in 1810. By 1865 it had grown so that the employment had risen to 300 and a sizable volume of paper was being handled. The continuous coating process was brought into Germany in 1866 at the plant of E. Kretschmar in Dresden by a Frenchman named Möglin. A similar machine appeared in England at approximately the same time and in apparent independence of the French development.

The first machines faithfully reproduced hand brushing by the use of the so-called "sun and planets" smoothing unit in which the coating was smoothed out by brushes that revolved in a motion that imitated the manual operation. These machines had obvious disadvantages, however, and in 1874 a cam-driven oscillating-brush unit, similar to those used through the 1940's in the paper converting industry, was developed at the Kretschmar plant. The evolution of the method of making paper in a continuous web and the subsequent adaption of the hand coating technique to the continuous machine-coating operation was the basis for the specialty paper industry of today. Continuous methods of printing, staining, embossing, brushing and otherwise decorating paper for the fancy and decorative trade followed in relatively short time.^{1,2,4}

The development of the specialty paper industry in the United

States followed along the same lines, but with a time lag of several years subsequent to the European evolution. As noted previously, the first Fourdrinier paper-making machine was set up in this country in 1816 and the first cylinder machine in 1827. The wallpaper industry was a going business at that time as the first factories had been set up in 1775, and by 1795 mills were producing this type of decorative sheet in Pennsylvania, New Jersey, and Massachusetts. The early papers were made in sheets about 30 inches long.³ As early as 1824, a wallpaper with a coated and glazed background for the usual block printing was manufactured and the development was rapidly picked up by producers of fancy papers. Aside from wallpapers, two other growing industries—label printing and paper box manufacturing—were rapidly perfecting the art of coloring, glazing, and printing paper for both decorative and traditional applications.

In 1839, the firm of Pollack and Doty was formed in Philadelphia for the express purpose of producing coated label papers. These papers were coated and plated and then printed in the form of labels for print works, cotton mills, and proprietary medicines. According to Wheelwright,³ "The paper was coated sheet by sheet, the color being brushed on it by girls whose aprons were covered with blotches of all sorts of colors; the sheets were then hung on laths which rested

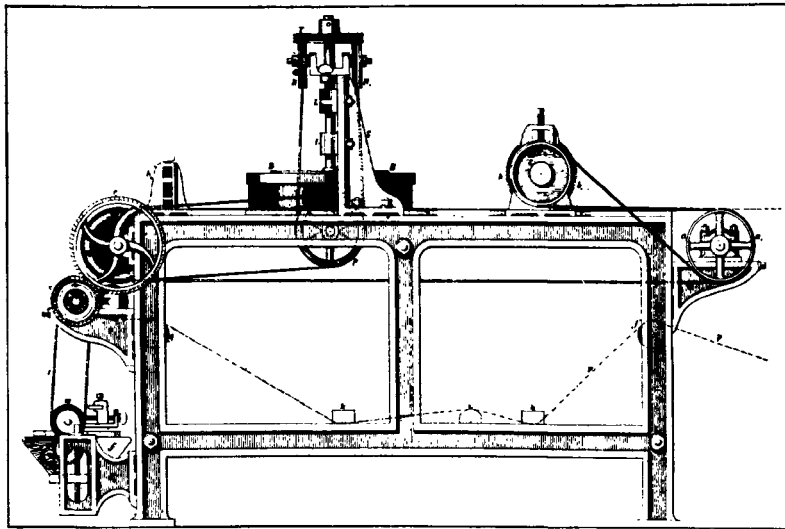


Fig. 1-1. Wall paper coating — about 1860 (Courtesy of Paper Museum of M.I.T.).

on wooden racks, where they remained overnight—sometimes longer—to dry.”

The industry showed a slow but steady development and growth with the formation of new converting companies at Albany, N.Y. and Nashua, N.H., both of which did large and prosperous business. In 1845, the firm of Doty and Bergen was started in New York; it later changed to Doty and Scrimgour and the plant moved to Reading, Pa. In 1846, the firm of J. & L. Dejonge was formed at Staten Island and was set up to produce glazed fancy papers. This firm in 1852 bought a coating machine from the firm of John Waldron Co. (which had been producing coating machines since 1832 for the wallpaper industry) for the purpose of making glazed paper on a continuous basis—an art that was to revolutionize this phase of the industry. The machine, which was of the “sun and planet” design, was bought for \$225.00.³ The web of paper was coated and festoon-dried before being rolled up. The rolls were then friction-calendered or flint-glazed, and sold, either plain or embossed, for labels and box coverings. In time, rotary brushes for applying color and oscillating brushes for smoothing the surface gradually supplemented and replaced the older designs, but the flinting and friction-calendering operations remained practically the same as when they were first developed.

In 1875, a new field of application of coated papers was developed when Theodore Low Devinne conceived the idea of using such paper for printing purposes where good color reproduction was desired.³ Up to this time, paper had only been coated on one side, but for such an application two-side coating was a necessity. Charles M. Gage, who was manufacturing one-side coated and glazed paper in Springfield, Mass., accepted the challenge and produced 100 reams as an initial order. The resulting paper was printed from fine wood engravings and the results were very satisfactory. The idea was then temporarily dropped until 1881 when Gage, then associated with the S.D. Warren Company at Cumberland Mills, Me., again accepted the challenge and produced another quantity of the paper. The resulting printing work was so superior to the supercalendered paper then in use for gravure printing that soon afterward, when the photoengraving process was developed, it became the standard paper for fine half-tone printing.

NEW TECHNIQUES

In more recent years many further developments have been forthcoming in this industry. Improved adhesives that employ starch, casein, soya protein, and synthetic resins and rubbers have been advanced to take the place of the glue that was used in early work. Better and more light-fast dyes and pigments, as well as specialized chemical additives, have been constantly introduced and have raised the standards of the resulting coatings.

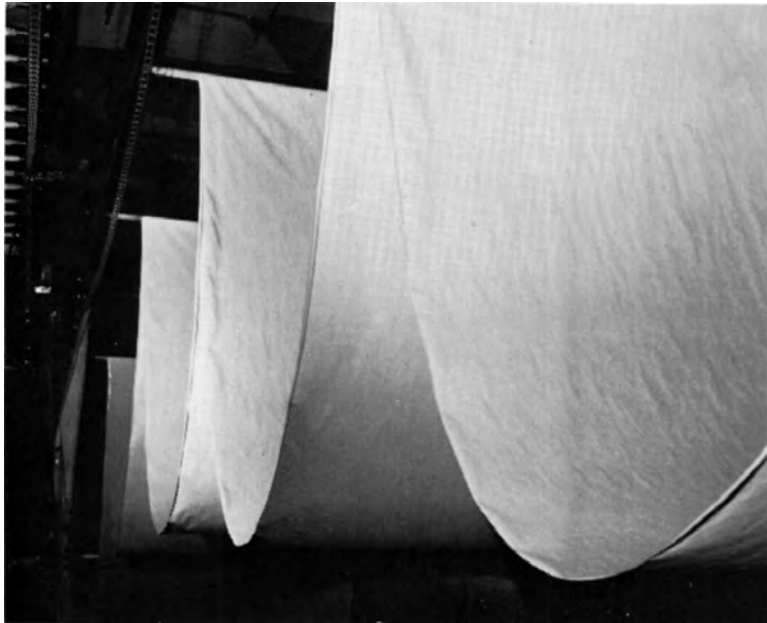


Fig. 1-2. View inside festoon drier (*Courtesy of Watervliet Paper Co.*).

Dull- or matte-finished papers, gummed papers, mica-coated papers, and finally, the varnished and lacquered or plastic-coated papers, were developed. New methods of coating, which eliminate the need of the brush coater and based on roll or spray applications, and the use of an air knife, rolls, or various types of doctor instead of brushes for smoothing the coated surface, have been introduced and brought to a high degree of efficiency. The old festoon lines have been modernized and gradually replaced by enclosed tunnel driers that increase the speed and efficiency of drying. All these developments

have tended to improve the variety and quality and to reduce the unit cost of coated papers.

By 1950 the paper converting industry had only begun to emerge from its self-sufficient and self-imposed shell. Specialty products were still being manufactured in a series of small unit processes by operators with narrow interests. They were truly converters in that the wide variety of base papers, boards, films and foils were made elsewhere by other organizations and shipped to them for processing and finishing. Major exceptions were those that made machine-coated publication printing papers directly on the paper machine. This group, however, was a closely-knit club, because its highly specialized technology required heavy capital investment in large paper machines.

High grade printing papers as a rule were still manufactured by means of off-the-machine conversion techniques. The development



Fig. 1-3. Asphalt laminated aluminum foil nursery wraps (*Courtesy of Thilmany Pulp & Paper Co.*).

and commercialization of high-speed blade, off-the-machine coaters later enabled not only producers of routine publication paper to upgrade their products, but also opened the door to the smaller manufacturer who could pass the production of several paper machines through one piece of high speed, off-the-machine coating equipment. By 1960 numerous versions of such coaters became readily available from several of the large machine manufacturers who were also in a position to recommend coating formulations and know-how where these were necessary. The expansion in the commercial printing industry and the growth of markets for specialty coated paper were reflected directly by expansion of the coated paper industry.

A second major factor and one that altered the profile of the industry was the trend toward mergers of the smaller companies and the acquisition of the smaller by the larger ones. Over a period of years this tendency has eliminated most of the specialty converters as corporate entities, but in the process it has introduced the knowledge and technology of these highly specialized organizations into fertile ground for growth of the large corporation. This situation quickly made possible long-needed expansion of the specialty organization through the infusion of readily available capital and the broad technical and engineering capabilities already present in the large organizations. The market research and efficient marketing and sales efforts of the combined organizations have made possible the expansion of the industry in terms of total production as well as the broader range of markets serviced.

A list of the specific areas where the converting industry has expanded and where other industries are now invading the paper field would touch practically any of us in our daily lives. Papers of distinctive appearance or unique characteristics are constantly sought by the package designers and others who create the appealing products and packages that are demanded by a quality-minded purchasing public. The more useful and specially designed papers have often replaced cloth, coated fabrics, leather, or wood. The market for papers with unusual properties is most lucrative.⁸ A look at the diversified utility of paper and paper-based products is persuasive evidence that they represent a rare combination of potential characteristics whose commercial acceptance is the result of a similar pattern in each instance—the most practical way to achieve a group of difficult specifications, unusual features, or special properties.

SYNTHETIC MATERIALS

Another feature that has revolutionized the paper-converting industry is the development and practical exploitation of synthetic resins, rubbers, and plastics. Nitrocellulose lacquers were found to be ideal coatings for paper and made possible decorative and functional effects that could not be obtained with the previously available substances. Other cellulose derivatives and the synthetic resins and natural and synthetic rubbers, which were developed with startling speed, opened new fields where paper was a definite winner, or at least a very close competitor instead of a poor substitute for more expensive materials. As the new plastics and chemicals were generally insoluble in water, an entirely new application technology had to be worked out. However, this time the development was mainly in the hands



Fig. 1-4. Typical fancy wrapped candy package (Courtesy of Sylvania Division of American Viscose Corp.).

of the machine builders and the large chemical companies that were responsible for the discovery and exploitation of the plastics. These large and relatively wealthy companies, instead of the paper companies with their more limited facilities, evaluated the new products and in cooperation with progressive paper converters soon developed new combinations of paper and plastic as well as economical methods for their manufacture.

Because the same resinous coating could often be applied by means of several different techniques, similar yet competitive products could frequently be obtained. Solvent coatings were the first developed and exploited, closely followed by the hot melts. As plastics technology and chemical process development advanced to the stage where emulsion polymerization became a commercial reality, water dispersion coatings were produced. These made possible the application of plastic films from an aqueous system.

The most recent advance in the field is the development of paste dispersion as well as extrusion coatings, and with them the possibility of laying down thick films with a minimum effort. The use of encapsulation techniques offers an additional approach to the application of coatings with specialized purposes. The development of various plastic films and the possibility of utilizing metal foils and vacuum metallizing techniques for decorative and functional products now permit specialty converters to produce sheets with appearances and properties that were not even imagined two decades ago. The products of the paper converter do not merely compete with wood, metals, glass, and other materials, but have often replaced them in their own fields.

STATE OF THE INDUSTRY

Considerable technical and marketing information is available in the plastics-treating field, inasmuch as every machine and chemical company that attempts to merchandise its products has available technically trained sales and service men and maintains customer-service laboratories for the solution of specific converter problems. The result has been that the basic information necessary to enter almost any phase of the paper converting industry is now available in many places, but the "know-how" on specific sheets is still mainly, as it should be, in the hands of the individual manufacturers. The purpose of this series is to concentrate the available information on the various phases of the industry, to temper this knowledge with operating

“know-how”, and to condense the subject so that along with the listed references these volumes can be used as a starting point to study any specific phase of the speciality converting field.

The many available processes, along with an extremely wide range of suitable raw materials, make possible the manufacture of a similar (or even identical) product by different processes from different raw materials. For example, a greaseproof decorative wrapper can be made from a saturated or plasticized base sheet that can be coated, printed, laminated, and calendered or embossed. If it has a pigment coating, it may have been made on a brush, doctor, roll, spray or air-knife coating unit. If it is a plastic-type sheet, any one of the several dozen base resins or rubbers could have been used in the coating formulation and the coating could have been laid down from a solvent, water dispersion, hot melt, organosol, plastisol, or extrusion applicator. The printing may have been done on an aniline press, or by the gravure, letterpress, electrostatic, or surface technique. If the paper is embossed, it may have been handled on a geared, flat-back, or meshed-roll machine. The costs and rate of production vary widely with differing equipment or even with the same type of machine in different mills. The specialty-paper industry is fairly unique in the variety of its manufacturing operations, and every mill unit has developed its own modification of the usual practice.

To date this growth seems to show that the future will continue to offer great promise to the specialty paper and converting industry. According to Macdonald,⁷ however, great resourcefulness on the part of the paper-use promoters will be required. The enormously expanding field of plastics products can become predominantly a branch of the chemical or the paper industry depending upon which makes the greater product development and promotional efforts. The opportunity for development and promotion is further dependent on the quality and intensity of technical effort. Between these two industries is the converter who takes paper and additive materials and combines them to create products that have a specific market value.⁷ The ultimate user buys the best product designs available at a given price and cares little about how, or of what, they are made. If the independent converter can direct his efforts along similar lines he will be able to create products to meet the insatiable demand of the consuming public.

Against the production of specialties can be contrasted the more standard pigment-coated papers of the glossy and matte type for the

fancy paper field, and the enormous quantities of coated stock for the printing-paper industry. In these areas only a limited number of adhesives are available, relatively few standard pigments, and only a half-dozen methods of economic application. This part of the industry attempts to be as secretive with its coating formulations and technology as are the highly specialized portions.

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