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The Paper Industry

BY ERIC A. PULLAN

The uses of paper are now widespread, but in days long gone by it was manufactured solely for use as a vehicle for the transcription of human thoughts and for the record of events. It is this use of paper which gives it historical significance. Paper has given the world of today its knowledge of the world of yesterday; it has allowed people virtually to converse with their ancestors. The mummy in his Egyptian coffin still enlarges our historical knowledge by means of the papyrus buried with him.

It is from the word "papyrus" that "paper" is derived. Papyrus was the Latin name of an Egyptian reed, from the inner bark of which a kind of writing paper was made in ancient Egypt. The name papyrus was in turn applied to the writing material thus made. The material consisted of strips of the stem of the papyrus plant pasted evenly across similar strips in thin layers and dried under pressure. It was made by the Egyptians, the Greeks and the Romans. Papyrus was, therefore, the forerunner of modern paper, although paper, as we speak of it now, is as much in advance of papyrus as papyrus was in advance of brick, stone, lead, copper, brass, leaves, bark, wood and skins, which preceded it. The following definition of paper appears in the *Paper Trade Journal*, August 16, 1923: "A compacted web or felting, commonly in the form of a thin flexible sheet, formed from an aqueous suspension of fibers, usually vegetable in origin, used for writing, printing and for various other purposes. If a web or sheet is made by felting the dry fibers, it is felt or bat and not paper, while if the sheet is spongy and felt-like but is made from a suspension of fibers in water, it is paper and not felt, as these terms apply specifically."

No one has definitely established the exact date when paper-making originated, although certain historians have traced its first appearance to the second century, B. C. China seems to have been the cradle of the paper industry, and the Arabs introduced paper making into Europe in the eighth century A. D. The industry developed first in Spain and, later, to a greater extent in the south of France. Gradually it crept northward to Germany, to Holland, and finally to England, which for many years had imported all of its paper. The first paper mill in the

United States was started on the Wissahickon river near Philadelphia in 1690, by a man, whose anglicized name was William Rittenhouse. According to records this was the only American mill for some time. Later on other paper mills arose in other eastern sections of the continent. A quaint but interesting poem anent this first paper mill of William Rittenhouse appears in Richard Frame's, *A Short Description of Pennsylvania*:

"The German-town, of which I spoke before,
Which is, at least, in length one mile and more,
Where lives High German People, and Low Dutch,
Whose trade in weaving linnin cloth is much,
There grows the flax, as also you may know,
That from the same they do divide the tow;
Their trade fits well within their habitation,
We find conveniences for their occupation,
One trade brings in employment for another,
So that we may suppose each trade a brother;
From linnin rags good paper doth derive,
The first trade keeps the second trade alive;
Without the first the second cannot be,
Therefore, since these two can so well agree,
Convenience doth approve to place them nigh,
One in the German-town, 'tother hard by.

"A paper mill near German-town doth stand,
So that the flax, which first springs from the land,
First flax, then yarn, and then they must begin,
To weave the same, which they took pains to spin,
Also when on our backs it is well worn,
Some of the same remains, ragged and torn;
Then of those rags our paper it is made,
Which in process of time doth waste and fade;
So what comes from the Earth, appeareth plain,
The same in time returns to Earth again."

At this time the machinery used was of the simplest kind—a mortar and pestle to grind the rags to pulp, a small container for the paper "stuff," a mould and a device for squeezing water from the sheets. Inventions of new machinery were not rapid, and it was not until the latter part of the eighteenth century that the forerunner of the modern beater was invented in Holland. Not only was the machinery of crude design in these early stages, but the materials used were of the simplest, mainly consisting of cotton and linen rags. It was after the invention of machinery which could produce in large quantities and after the discovery of additional raw materials which could enter into the making of

paper, that the industry began to flourish and to assume larger proportions. It was in 1798 that a Frenchman by the name of Robert gave out to the world that he "had discovered a way to make, with one man, and without fire, by means of machines, sheets of paper of a very large size, even twelve feet wide and fifty feet long." The French government realized how important was the invention and gave Robert eight thousand francs, a patent for fifteen years and granted him permission to go to England with his model for the purpose of obtaining English capital. The machine had been tried in a French mill and the owner of this mill, becoming interested, bought the patent and proceeded to England where he secured the services of an English mechanic to construct a machine. Lack of capital necessitated the calling in of two rich London stationers, the Fourdrinier brothers, who, with Donkin (the mechanic), worked on the machine until they became bankrupt. However, the English government came to their assistance and voted them seven thousand pounds to help them out of their financial troubles. The machine, therefore, which revolutionized the paper industry was named after the Fourdrinier brothers, but no less credit is due to Robert, the original inventor, and to Donkin, the mechanic. In addition to these pioneers there were others: John Dickinson, inventor of the "cylinder" type of machine; T. B. Crompton, inventor of driers; M. Causon, inventor of suction boxes; John Wilks, inventor of the dandy roll, and so on, each inventor contributing something necessary to the perfection of machines which today turn out millions of tons of paper a year in the United States alone. With the new machinery producing paper so much more rapidly than the old methods, people began to look for new sources of supply of raw material. In 1719, Reamur noticed how wasps made their nests from wood and told paper makers of his discovery, but it was not until over one hundred years later, in 1840, that ground wood pulp was produced. To sum up, then, we have Robert's invention in 1798 and the invention of wood pulp in 1840, a space of about forty years wherein the paper industry advanced at a tremendous pace, after dragging along for about eighteen hundred years.

The following description of the making of paper is, of course, a general statement and does not cover the various technicalities of manufacture. It presents merely the underlying principle of what might be termed the formation of paper.

Small cellulose fibers derived from various raw materials (which will be discussed later) are held in suspension in water. The water containing these fibers is carried over a wire cloth, which allows the bulk of the water to pass through, leaving a deposit of the pulpy mass of fibers. Evaporation and expulsion of more water from this pulpy mass produces a sheet of paper. As already explained, the original raw materials from which the fibers were derived consisted principally, almost entirely one might say, of rags. At the time when the machine age came into its own and replaced the handicraft or small-tool age most industries grew rapidly, but the paper industry did not. It was still handicapped by the lack of raw materials, from which the essential fibers could be obtained. Rags were exceedingly scarce. Many and diverse were the methods used to acquire rags. Advertisements appeared in the papers; premiums were offered; suggestions were made to keep "rag-bags," and even the bards were called on to make appeals for rags. For instance the following poetic appeal appearing on an advertisement is quoted in *The Black River Gazette* of November 9, 1907, in an article entitled "A history of Lewis County in the State of New York" by Franklin B. Hough.

"Sweet ladies, pray be not offended,
Nor mind the jest of sneering wags;
No harm, believe us, is intended,
When humbly we request your rags.

"The scraps, which you reject, unfit
To clothe the tenant of a hovel,
May shine in sentiment and wit,
And help to make a charming novel.

"The cap exalted thoughts will raise,
The ruffle in description flourish;
Whilst on the glowing work we gaze,
The thought will love, excite and nourish.

"Each beau in study will engage,
His fancy doubtless will be warmer,
When writing on the milk-white page,
Which once, perhaps, adorn'd his charmer.

"Though foreigners may sneer and vapor,
We no longer forc'd their books to buy,
Our gentle belles will furnish paper,
Our sighing beau will wit supply."

For many years the lack of raw materials hindered and even endangered the paper industry, and the demand for paper outgrew the supply of rags. The old colonists were frugal people and they wore their clothes for a long time. No doubt the modesty of the ladies prevented them from selling certain of their old clothes to the paper mills, even though good money or other barter was offered. It was not until certain events occurred that the urgency of the appeals for rags diminished:

- (1) Invention of ground wood in 1840.
- (2) Work on esparto grass and wood by soda process in 1854.
- (3) Invention of the sulphite process in 1866.

From this point, the supply of raw materials was sufficient to meet demand for the finished products and the industry advanced by leaps.

In spite of the fact that by far the largest percentage of fibers used comes from wood, this does not mean that the demand for rags has diminished. And there may come a time again, although this seems to be a long way off, when it will be necessary to find a substitute for wood pulp to supply the fibers to make paper, as it was necessary to find a substitute for rags. Paper is now being used for innumerable purposes. The demand increases, and the unavoidable law of supply and demand again comes to the fore. The supply is not increasing in proportion.

There seems to be a division of opinion among paper experts as to the adequacy of the future supply of wood pulps. For many years to come, however, there should be no need to worry. In the history of paper making in the United States, there has never been a year when the number of cords of wood used for paper manufacture has exceeded seven and one-half million. On the other hand, the United States lost a large portion of its newsprint production in the last two decades. The greatest amount is now imported from Canada.

There seems to be no question, however, that a more far-reaching policy of reforestation, similar to that adopted in Canada, France, Germany and other countries is necessary.

MANUFACTURE

In the manufacture of paper there are five general processes, viz.:

- (1) Separation of fibers from raw material.
- (2) Formation of pulp from fibers.

- (3) Beating and refining of fiber and intermingling it with other constituents.
- (4) Formation of paper from the "stuff."
- (5) Finishing and preparation for sale.

There are two distinct classes of wood pulps, mechanical and chemical. Mechanical wood pulp or ground wood is used principally in the manufacture of newsprint; it is also used in making cheap cardboards, pie plates, etc. The cost of manufacture is low compared with that of other papers and the paper produced has no permanent qualities. In order to strengthen it, sulphite pulp is used. Most people know that newspapers are made from wood pulp and are inclined to think that all paper made from wood must be of a flimsy nature. The idea is erroneous, as wood cellulose chemically treated can produce some very fine grades of paper.

The principal chemicals used in making chemical wood pulp are caustic soda, sulphide of soda, sulphate of soda and bisulphite of lime. Caustic soda is used in the preparation of soda pulp. Caustic soda, sulphide of soda and sulphate of soda are used in the preparation of sulphate pulp. Bisulphite of lime serves in the preparation of sulphite pulp. Mitscherlich pulp is produced by a special method of making sulphite pulp. In the soda-pulp process the wood used consists mainly of poplar, gum, chestnut, etc. To make sulphate pulp, spruce wood is largely used, although this pulp can be made from various woods. Spruce wood with the wood of other conifers also enters considerably into the making of sulphite pulp.

The paper manufactured from the different pulps may be generally classified as follows:

From soda pulp:

Blotting

Book

Cover

From sulphate pulp:

Kraft (brown wrapping paper)

Kraft bag paper (paper bags)

Kraft board (known also as jute board)

Kraft waterleaf (used mainly for towelling)

Sulphate wrapping (brown wrapping paper)

From sulphite pulp:

Sulphite bond (paper of bond type)

Sulphite manila (wrapping paper colored like manila)

Sulphite board (pulp board)

Sulphite bag paper

This classification does not include all the kinds of paper made from the various pulps, but it serves as a general index. The term "sulphate pulp" is now used loosely to define an admixture of sulphate pulp and other chemical pulps. In fact, few papers are made from one kind of material only—most of them contain various fibers with the addition of non-fibrous constituents. Of the chemical wood pulps, sulphate pulp supplies the largest and most varied supply of papers.

The next raw material is waste paper, the second largest supplier of fibers. It consists of old newspapers, magazines, books, paper shavings, binders' waste and a heterogeneous mass of anything that has ever seen the inside of a paper mill. This material must first be graded. The lowest grade, which contains miscellaneous papers of all kinds and colors, is used only in the production of coarse papers. By graduation of colored papers, papers made of ground wood, etc., are eliminated until the highest grade, consisting of old writing and ledger papers, is reached. Sorting of the waste paper removes foreign material; boiling in a solution of soda ash removes ink; and from this point the stock is washed and bleached in much the same manner as rags. Some of the processes which I have described are employed only in the manufacture of fine papers. In the manufacture of coarse papers and boards, the waste paper, after being dusted and sorted, is merely hydrated before going into the beaters.

Rags should be of cotton or linen and should be generally free of silk threads, oil, grease, leather, rubber, etc. The first process is similar to that for waste paper, but it is more thorough. The rags are cut, dusted, sorted, seams are opened up, buttons, hooks and eyes are removed. Then the rags are ready for boiling, or "cooking." This removes dyes and grease. After the boiling comes washing and then bleaching.

Esparto grass, which is not used to a great extent in this country, but is one of the principal raw materials entering into paper making in England and other European countries, is made into pulp by the soda process.

After the stock has been worked up by one or other method, depending on the nature of the raw material, the next step is to mingle the non-fibrous components with the stock. These consist

mainly of mineral fillers, sizing materials and coloring matters. The fillers add smoothness to the paper. The most common filler is China clay. Others are certain silicates of magnesia and a preparation of barium sulphate. Sizing materials give resisting qualities to paper against ink or water; they consist of glutinous or viscid substances such as starch, gelatine, resin, glue, etc. The coloring matters consist of various dyes, the purpose of which is obvious.

Mixing of the filling, sizing and coloring matters with the stock is done usually at the same time as the "beating." Beating consists in comminuting the fibers, and of such importance is the treatment accorded the "stuff" in the beaters, that it has been truly said "the paper is made in the beaters." Quick beating with keen knives results in absorbent paper. Slow beating with blunt knives gives paper of the opposite kind. This illustrates how important a place the beating machine takes in determining the quality of the paper finally produced. It is the usual custom in a paper mill for the man in charge of the beaters to be given a formula directing him how to mix the raw materials in his machine, and these are placed in the machine as directed, with a lot of water. After the "stuff" has passed through the beaters it goes to the "Jordan" where it is further refined. It passes through at least one of these machines and then passes over a "sand settler." After traversing the sand settler it reaches a screen or series of screens, the object of which is to make the stock uniform and to exclude foreign substances. After leaving the unwanted stock on the screens the "stuff" which has passed through is ready for the paper machine. (The screens previously mentioned are usually considered as part of the wet end of the paper machine itself.) There are three general processes in a paper machine:

- (1) Forming and pressing
- (2) Drying
- (3) Cutting and binding

The paper machine, then, might be said to have three distinct parts: the wet end, the middle and the dry end. There are two distinct kinds of paper machines, Fourdrinier and cylinder. The difference between the two lies in the "wet end" of the machine. However, the function of the wet end of both machines is the same, namely, to bind the fibers in the pulp together. This is accomplished by passing the stock, which at this point contains

almost 99 per cent. water, over wire meshed screens or cylinders. Pressure is exerted by means of squeeze rolls, and the paper is carried through between endless felts.

The drying is done in the "middle" of the machine, and the various cutting knives, calender stocks, binding rolls, etc., are in the "dry end."

Other machines are used for making specific kinds of paper, such as gummed papers, high finished papers, etc.

FINISHED PRODUCT

The principal tests of finished paper are for weight per unit, thickness, bursting strength, tensile strength, folding strength, expansion, absorption, chemical constituents, nature and kinds of fibers, color, opacity, etc. Although the processes of paper manufacturing appear to be simple, great care is essential in order to turn out a finished product of the highest standard. Defects arise which have to be remedied. Sometimes the paper is not uniform—this may be caused by lack of control of the "stock" as it passes through the machine or, by tracing the cause further back it may be attributed to negligence on the part of the man controlling the beaters. Again the finish may be defective, usually caused by non-uniformity of dampness in passing through the calenders. Holes in the paper, dirt, etc., are generally attributable to careless handling of rags and old paper stock and to accumulation of dirt or grease on the machines themselves. Defects in coloring, coating, packing, etc., appear at various times.

MARKETING

The two principal methods of disposing of paper are through jobbers and direct sales to the consumer. The jobber usually handles the majority of writing and wrapping paper and, to a less extent, book paper. Of course, other papers are also sold in this manner. Newsprint is almost always sold direct to the consumer. It may be said, as a general statement, that the large consumers buy direct; others buy through jobbers. There is a considerable amount of re-manufacture to be done by some consumers, such as manufacturers of stationery, tags, books, boxes, toilet accessories, etc.

Paper manufacturers and also paper jobbers have formed associations for the purpose of gathering statistics relative to production, consumption, etc., for the purpose of producing uniformity

in trade customs, and for sundry other purposes, both technical and educational.

ACCOUNTING

It seems to be agreed among progressive manufacturers, whether they manufacture paper or some other product, that they must have some accounting system, which indicates to them the cost of their product. In the process of compiling costs other data are accumulated and statistics are obtained. The benefits of a cost system are, therefore, not entirely confined to the resulting ability to determine a product's cost.

In obtaining costs of a product one is serving at least two main purposes. The first is to use the information in the general accounting of the industry; the second is to provide a medium for calculating selling prices. An ideal cost system is one which is controlled in the general ledger, or in a subsidiary ledger, and is in turn controlled through the general accounting system. Many kinds of paper are manufactured under different conditions. It is obvious therefore that no fixed system will be suitable for all mills; nevertheless a certain approach to uniformity can be obtained.

The following list shows generally the derivation of the mill cost of a paper product:

Rough paper cost:	Finishing:
Material cost:	Rewinding
Purchased raw material	Cutting
Handling and storage	Calendering
Prepared materials:	Plating
Half stuffs:	Sorting
Material	Etc.
Handling and storage	Packing and shipping:
Preparation	Wrapping
Sizing—material, labor and burden	Crates, etc.
Conversion cost:	Labor and burden
Converting labor and burden:	
Beaters	
Chests	
Jordans	
Paper machine	
General mill burden:	
Administrative expense	
Research expense	

In costs in a paper mill there is one important feature which must be observed closely—that is the change in weight of material

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as it passes from one department to another. At one time it was customary to estimate the shrinkage; but more satisfactory results can be obtained by keeping records of the number of containers obtained from a given quantity of raw material and establishing a value rate per container.

Another factor to be remembered in costing is that the expenses for repairs in a paper mill usually run fairly high, and are not consistent enough to indicate accurate monthly costs. To obviate this one may include, as a fixed monthly charge, an average allowance for repairs, and the offsetting credit may be to an account "reserve for repairs." The actual cost of repairs can then be debited to the reserve account.

It is comparatively easy to make a physical inventory of the stock in a paper mill, and it is advisable to do so at the end of each month, or at any rate at the end of three months, so as to keep a close check on the perpetual-inventory records.

There is little to be said of the general accounting records of a paper mill which can not be said of any other manufacturing concern. A list of suggested balance-sheet accounts follows:

<i>Assets</i>	<i>Liabilities and net worth</i>
Current assets:	Current liabilities:
Cash	Notes payable
Notes receivable	Accounts payable
Accounts receivable	Accrued liabilities (various)
Reserve for bad debts (valuation account)	Reserve for income taxes
Inventories:	Bonded indebtedness
Raw material	Capital and surplus:
Prepared material	Preferred stock
Finishing material	Common stock
Maintenance material	Surplus
Supplies	
Work in process	
Finish product	
Prepaid expenses (various)	
Property, plant and equipment:	
Land	
Buildings	
Manufacturing equipment	
Steam equipment	
Maintenance equipment	
Office furniture and fixtures	
Reserve for depreciation (valuation account)	
Deferred charges	