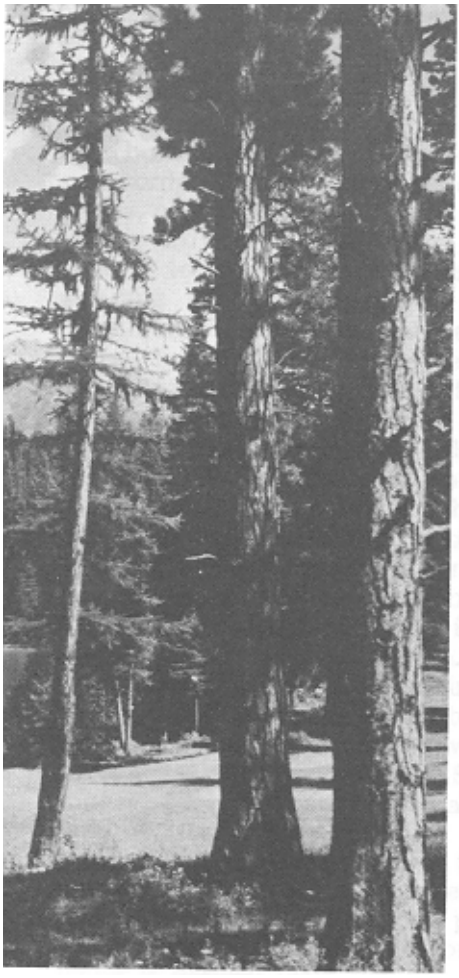
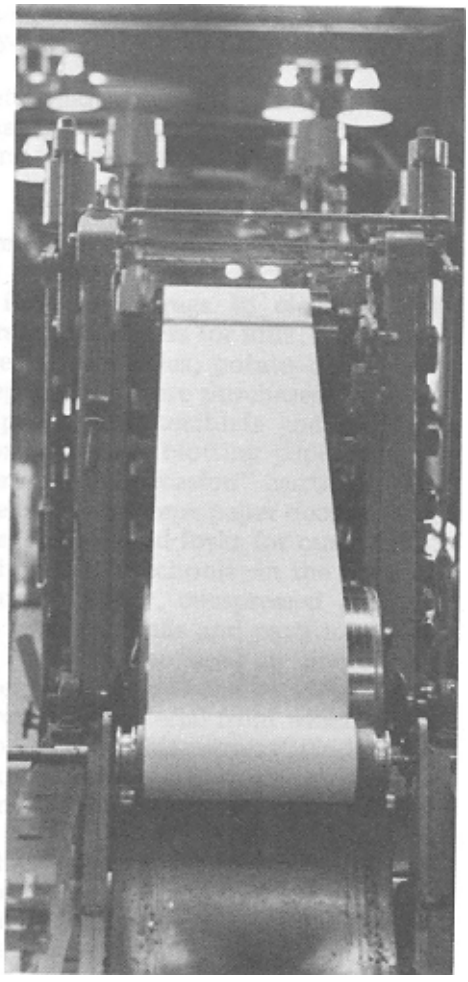
Making Paper from Trees





Forest Service
U.S. Department
of Agriculture
FS-2

MAKING PAPER FROM TREES

Paper has been a key factor in the progress of civilization, especially during the past 100 years. Paper is indispensable in our daily life for many purposes.

It conveys a fantastic variety and volume of messages and information of all kinds via its use in printing and writing—personal and business letters, newspapers, pamphlets, posters, magazines, mail order catalogs, telephone directories, comic books, school books, novels, etc.

It is difficult to imagine the modern world without paper. Paper is used to wrap packages. It is also used to make containers for shipping goods ranging from food and drugs to clothing and machinery. We use it as wrappers or containers for milk, ice cream, bread, butter, meat, fruits, cereals, vegetables, potato chips, and candy; to carry our food and department store purchases home in; for paper towels, cellophane, paper handkerchiefs and sanitary tissues; for our notebooks, coloring books, blotting paper, memo pads, holiday greeting and other "special occasion'' cards, playing cards, library index cards; for the toy hats, crepe paper decorations, paper napkins, paper cups, plates, spoons, and forks for our parties.

Paper is used in building our homes and schools—in the form of roofing paper, and as paperboard- heavy, compressed product made from wood pulp-which is used for walls and partitions, and in such products as furniture. Paper is also used in linerboard, "cardboard," and similar containers.

Wood pulp is the principal fibrous raw material from which paper is made, and over half of the wood cut in this country winds up in some form of paper products. So essential is paper in our daily life that we probably could not maintain our civilization at its present level without wood pulp.

Ancient civilizations carved their laws and history in stone and imprinted them on bricks. Lead, copper, and brass successively carried the written word. Less permanent materials, such as leaves, bark, wood, and skins, were predecessors of paper. The name of paper is derived from papyrus, a tall reed that grows in the Nile Valley in Egypt. The use of slim strips of this reed laid side by side was the nearest approach the ancients made to paper as we know it. The first person to make paper by "felting" wood fibers was Ts'ai-Lun nearly 2,000 years ago in China. He used the fibers in the inner bark of the mulberry tree, with some scraps of linen and hemp. (Felting is the interlocking or matting of loose fibers to form a sheet of paper.)

The Mayan Indians of Central America around A.D. 500 invented a kind of paper made from the bark of the fig tree. The Aztecs later improved the process. The Pacific South Sea Islanders also learned independently how to make paper from bark.

The Muslims learned the Chinese secret of papermaking when they captured some Chinese papermakers during a battle at Samarkand in Central Asia in A.D. 751. The first papermill in Europe was set up in Spain just 400 years later, by the Moorish (Muslim) invaders from North Africa. The first papermill in the United States was built in Philadelphia in 1690.

Reamur, an 18th century French physicist, after examining the fibrous nests made by wasps from finely chewed wood, suggested that paper might possibly be made from wood. In 1750 paper was made from the bark, leaves, and wood of various trees in France. A paper machine was invented about 1800 by Nicholas-Louis Robert of France and was improved for volume production later, in England, by the Fourdrinier brothers. During the 19th century much progress was made in the production of wood pulp for paper. Previously, paper had been made almost entirely from cotton and linen rags.

Wood pulp was first made in the United States in 1869, but only 2,000 cords of wood were used that year along with other raw materials to make paper. Within the next 20 years, however, the great growth of the American papermaking industry was in full swing. By 1974, 77 million cords of wood were being used annually in the manufacture of wood pulp.

PULPING PROCESSES

In 1974, 61 million tons of paper and paperboard were produced in the United States, having a sale value of $32 billion. The paper consumed in that year was equivalent to over 614 pounds for each American. The average number of production workers was nearly 700,000 and the total wages and salaries paid amounted to $8 billion. More than nine-tenths of today's paper comes from wood pulp. Paper, as an indispensable commodity of modern life, has emphasized anew our dependence on forests.

Wood consists primarily of cellulose (mostly from fibers which give strength and support to the tree) and lignin, which cements the fibers together. Cellulose makes up roughly 65 to 80 percent, and lignin about 20 to 35 percent of the weight of wood. Wood is reduced to a mass of tiny, individual fibers for papermaking by chemical or mechanical pulping processes, or by a combination of the two. Fibers of conifers (softwoods) are 3.60 mm long and 0.035 mm wide (0.143-inch-long and 0.0014-inch-wide). Fibers of hardwoods (broad-leaved trees) are even shorter and narrower. In the mechanical or groundwood process, short logs are held against the rough surface of a rotating grindstone made of sandstone or synthetic abrasive material. A shower of water cools the stone and carries away the shredded wood fibers (pulp).

In the chemical pulping processes, the natural plant fibers are separated by dissolving the lignin and other cementing material from wood chips. The lignin is dissolved by heating the chips and

cooking liquor at high temperatures and pressures in large pressure vessels called digesters. The three chemical processes commonly used for pulping are the sulfate or kraft, the soda, and the sulfite. Alkaline liquors are used in the sulfate and soda processes; and acid liquor is used in the sulfite process.

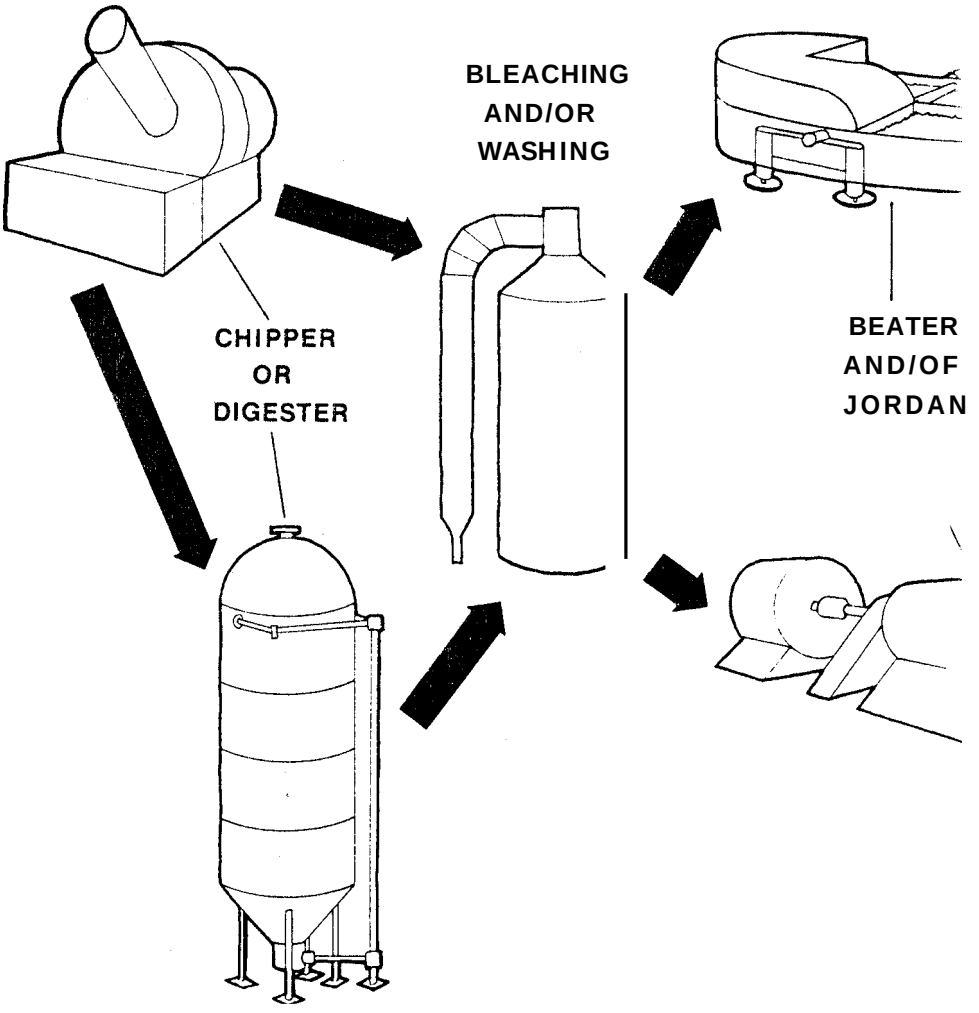
The semichemical processes employ both chemical and mechanical actions. In these processes, the chips are first given a mild softening treatment with a chemical; then they are reduced to a pulp by mechanical treatment in an "attrition" or "disk" mill. The semichemical processes were developed for pulping hardwoods and they are especially suitable for this purpose; also they increase the yields of pulp from both softwoods and hardwoods. This process was developed by the staff of the Forest Products Laboratory, Forest Service, U.S. Department of Agriculture.

The sketch on pages 4 and 5 shows in simplified form the papermaking process. Starting from left, either wood chips are poured into the chemical digester ("cooker") or else debarked short pulpwood logs (bolts) are fed into the mechanical grinder. For papers that must be whitened, the next step is the bleaching process. The loose fibers suspended in water (pulp) then go through a washer, where the pulp is sprayed with water as it revolves on large drums. From there it goes into the beater or into the refiner (jordan), or it may go into the beater first and then into the refiner as well.

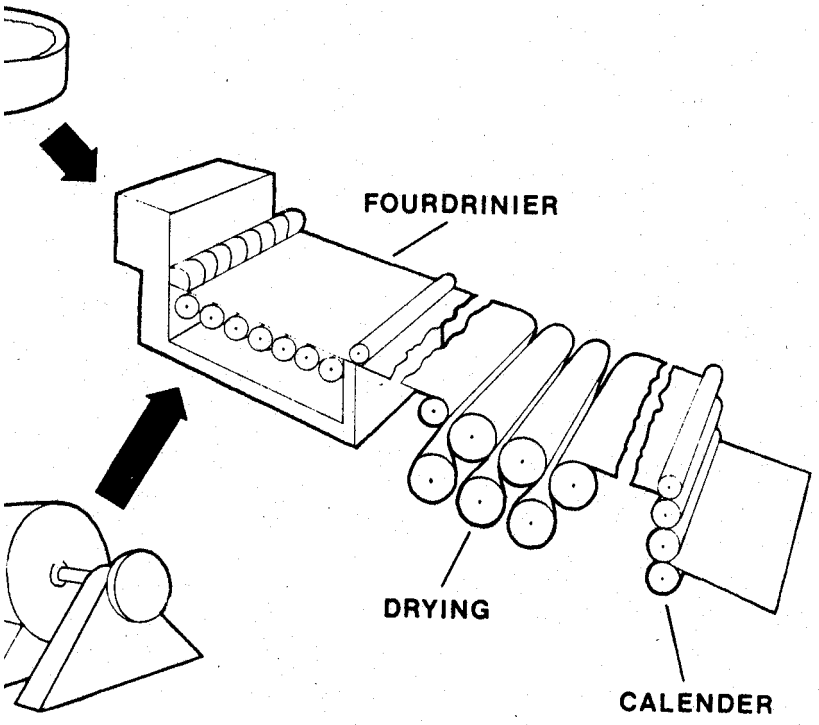
In the beater the fibers are subjected to rubbing or brushing action which cuts, splits, bruises, and frays them in varying degree. The fibers are then more flexible, and have more surface area exposed for fiber bonding. These characteristics result in strong, well-formed paper. For the finer grades of paper, a sizing solution (starch or animal glue) is added to seal pores in the paper and give it a good writing surface. Coloring, if necessary, is also done at this point. In the refiner long fibers are mechanically treated to improve the formation and strength of the sheet. The treatment may also be done by the beater alone.

From here the wet mass of pulp is further diluted with water and fed into a long, broad wire screen where part of the water is drained off and the wet pulp sheet is formed. The wet sheet of pulp is then deposited onto a porous felt cushion which carries it through a series of roller presses which squeeze out more of the water.

The final drying is accomplished by winding the paper through a series of steam-heated rotating drums. Then it is passed through a series of chilled steel rolls to smooth it out and give it uniform thickness. Finally it is wound into large rolls and cut to the required sizes.


BLEACHING
AND/OR
WASHING
CHIPPER
OR
DIGESTER
BEATER
AND/OF
JORDAN

SIMPLIFIED FORM OF PAPERMAKING PROCESS



AMERICAN WOODS FOR PAPERMAKING

Pine, spruce, fir, hemlock, and a few other softwoods furnish 80 to 85 percent of all the wood used in the United States for papermaking; 20 or more hardwood species make up the remainder. Numerous experiments at the U.S. Forest Products Laboratory have shown that with slight modifications in the standard processes, many other species can be used.

Softwoods or Conifers

Pines.—The standard process for the pulping of pines is the sulfate or kraft process. Sulfate pulps are the raw materials for the manufacture of corrugated boxes, multiwall bags, wrapping papers, and as part of the mix or "furnish" for the manufacture of book papers, publication paper grades, and sanitary papers. The sulfate or kraft pulps can be bleached satisfactorily under proper conditions. For mechanical or groundwood pulps, the young, fast-growth southern yellow pines, and lodgepole, ponderosa, sugar, limber, eastern white, and jack pines are all suitable. However, the groundwood pulps obtained from all pines cause trouble in papermaking because they contain pitch, which limits the proportion in which some of them can be used. For making light-colored unbleached groundwood pulp, the pine used must contain very little heartwood.

Spruces.—All spruces are suitable for pulping by any of the processes, and make highquality pulp.

Hemlocks.—Western hemlock is similar to the spruces in pulping quality, although in grinding the wood, more power must be applied with hemlock to produce pulp of equal quality. Eastern hemlock is not so suitable for groundwood. Chemical pulps made from it are darker, require more bleach to lighten their color, and are weaker than spruce pulps.

Firs.—All true firs are as readily pulped by any process as are the spruces. With the exception of California red fir, they are comparable with spruce in pulp quality. California red fir gives a rather dark groundwood pulp, and the sulfite and sulfate pulps made from it are harder to bleach than those of spruce.

Baldcypress, Douglas-fir, larches, redcedar, and redwood.—These are not suitable for the better grades of groundwood pulp. Douglas-fir, after a pretreatment with steam or hot dilute alkali, can be ground for pulp suitable for container boards. The sulfite process digests these woods with difficulty, but with modifications it may be used. All these woods may be pulped satisfactorily by alkaline (sulfate or soda) processes. The strength of the papers made from the pulps of these woods varies greatly with the species. Various mixtures can be used to obtain desired combinations of color,

strength, and texture in the paper. The yields of pulp from redcedar and redwood are rather low.

White cedars.—The white cedars are converted easily by all processes to fairly acceptable pulps. In comparison with other woods, white cedars give lower yields per cord, because the wood is less dense.

Hardwoods or Broad-Leaved Species

Poplars—Several hardwood species are classified as "poplars" by the pulp industry because they react similarly to pulping treatments although some of the species are not closely related. The group includes such true poplars as aspen, cottonwood, and balsam poplar; also yellow-poplar, which is not a poplar but a kind of magnolia. All can be pulped by the groundwood or chemical processes to yield short-fibered pulps, lower in strength than those obtained from the wood of conifers. The bleached chemical pulps are used in the higher grades of printing papers. The groundwood pulps are used in book and magazine papers, newsprint, sanitary tissues, and heavy structural boards.

Birch, maple, beech, sweetgum, and tupelo.—This group, including the several varieties of each species, is used in substantial quantities for paper pulp. Like the "poplars," they can be pulped by the chemical and semichemical processes and yield pulps somewhat similar in quality. Pulps from these woods are being used in blends for the manufacture of book, toweling, linerboard, wrapping, and many specialty papers.

Other hardwoods.—Miscellaneous hardwoods used for papermaking include principally ash, chestnut, elm, oak, willow, and such less used species as alder, basswood, buckeye, butternut (white walnut), catalpa, sugarberry, magnolia, mangrove, hickory, locust, sassafras, and sycamore. All may be pulped by the soda, sulfate, and semichemical processes. The lighter colored species are, in general, acceptable for groundwood pulps. Their principal use is in the manufacture of corrugated board for shipping boxes. In small quantities, pulps from some of these woods are being used in writing and printing grades of paper, and in hardboards.

VARIOUS TYPES OF PAPER AND PAPERBOARD

Paper and paperboard differ primarily in the thickness of the products. The U.S. Department of Commerce classifies several categories within each field. Among them:

Newsprint.—Newsprint is used for newspapers. Made mainly from unbleachable groundwood pulp, it also contains about 20 percent chemical pulp. Because the paper has a high lignin content (the substance that binds the fibers together in the tree), it turns yellow and brittle in a relatively short time.

Printing papers.—Uncoated groundwood, book and coated papers are often grouped together as printed papers. Uncoated groundwood papers contain groundwood and chemical pulps as does newsprint, but there the similarity ends. The groundwood grades contain less groundwood and more chemical pulps than newsprint. The groundwood grades of pulps are frequently bleached and are of a higher quality than those used in newsprint. In addition, the sheets are often sized, supercalendered, clay filled, or otherwise treated for special purposes. Major uses include: directories, magazines, commercial printing, and catalogs. Coated papers are used largely in magazines. Paper coated on only one side is used for can labels. Book papers go into books, magazines, and pamphlets, and are used in commercial printing, as well as in business stationery and envelopes.

Fine papers are among the highest grades of paper made. Some grades are made largely, or entirely, from cotton fiber and found in the more expensive writing papers and envelopes, stock and bond certificates, and for the money we use every day. Most fine papers, however, are made from chemical wood pulp.

Business and industry uses fine papers—both cotton fiber and chemical wood pulp content—for check papers; writing paper; ledger and mimeograph papers; for maps and charts; and for blueprint and other sensitized papers. Many of the greeting cards used today are made from this grade of paper.

Coarse papers—These are the heavy duty papers used to wrap and package products. Grocers' bags, and the gaily colored notion and specialty bags, are all made of coarse papers, as are paper shipping sacks, such as those used for cement, sugar, and flour. Coarse papers may be converted into a great many special products, including envelopes, gumming paper, asphalting paper, and coin wraps.

Special industrial papers—These are made for industrial uses. The surface pulp content, strength, and other characteristics vary according to the specific need. Just a very few of the more important types include: abrasive paper; electrical insulation paper; gasket paper; tabulating card stock; filter papers; and absorbent papers.

Sanitary and other tissue papers—Major uses include paper towels; toilet tissue; paper napkins; and facial tissues or paper handkerchiefs. Other tissue papers are used for wrapping tissue, fruit and vegetable wraps, salesbook tissues, pattern tissues, and similar products.

Containerboard—This is the largest single grade of paper made. There are two major kinds: linerboard and corrugating material. Liner and corrugating materials are made into paperboard corrugated shipping containers, also called fiber boxes. Corrugating materials were once made largely from straw, but today are made mainly from hardwood pulp.

Folding boxboard—Most of the cartons holding dry cereals, toothpaste, soap powders, and other common household products

are made from folding boxboard. It is usually made on a cylinder machine, where outer surface of this board is designed to take a fine printing, while the inner part gives the bulk, rigidity, and protection necessary for a carton.

Special food board.—This is a type of boxboard made from bleached kraft wood pulp on the Fourdrinier. It is used to package moist and oily foods. Milk cartons, frozen food packages, ice cream cartons, and paper plates are made from this type of board.

Set-up boxboard.—Made mainly from waste paper, it's much thicker than folding boxboard. Shoe boxes, candy boxes, and jewelry boxes are common products made from set-up boxboard.

Other paperboard—In this group are such boards as fiber can, tube and drum stock, liners for the gypsum board that may be used as walls in the home, and cardboard, a relatively small grade of paperboard.

Wet machine board is so thick it cannot pass through the dryers of the papermaking machine, and must be taken off while still wet. Uses include shoeboard and bindings for books.

Construction.—Grades include roofing, floor coverings, automotive felts, and insulating boards.

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