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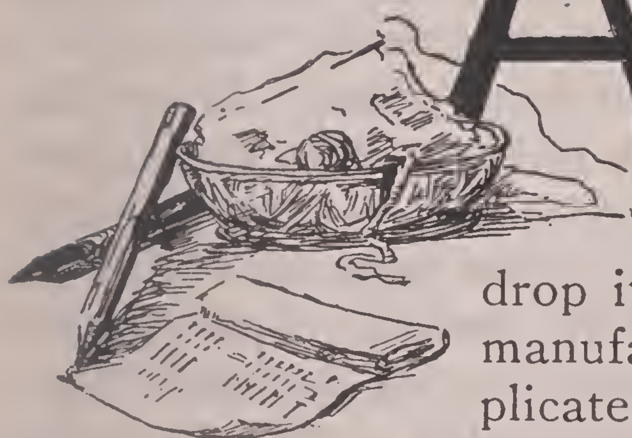
CHICAGO

THE STORY OF PAPER, PENS, PENCILS, ETC.

By W. F. Rocheleau

PINS



A PIN is so common and so cheap that we scarcely think it worth while to waste time in picking one up when we drop it. Nevertheless, its manufacture requires complicated and delicate machinery, and, until within the last few years, every pin passed through the hands of at least fourteen workmen before its completion. At present all pins are machine made.

Common pins are made from brass wire which is coiled upon large spools. The wire is drawn from this coil through a hole in a steel plate, which has the same diameter as the pin. It is seized by a pair of pinchers and thrust through a hole in another plate, where the end is struck by a hammer, which forms the head. The pin is then cut off the required length and falls into a groove where it hangs by the head. On the lower side of this groove, the opposite end of the pin comes in contact with a rapidly revolving cylinder, by which means it is pointed. All this is done so rapidly that an endless stream of pins falls from the machine during its operation. The pins next pass between two grinding wheels which give them a still sharper point. After this they are dipped in a tub of polishing oil, and polished. They are then usually boiled in a solution of tin to make them white. After coating the pins are ready to be stuck in the papers. The machine which does this work is probably the most ingenious invention connected with the manufacture of this little article. The pins fall into a hopper arranged on an inclined plane, and having a number of slits. The pins slide along down these slits point downward. They are then caught and inserted in the paper, ready for market. One of these machines will stick 100,000 pins an hour, and the mechanism is so delicate that the least imperfection in the pin will stop the feeding until the obstruction is removed.

Black pins are sometimes made from steel wire, and sometimes from brass wire and coated with japan, but those made in this way are of an inferior quality, and not generally used.

There are forty-five pin factories in the United States, giving employment to 1,600 persons, and turning out $10,000,000 worth of pins every year. The number of pins manufactured is practically beyond comprehension. A careful estimate made in the city of London a few years ago, showed that Great Britain alone was making 280,000,000 a week; at the same time, 120,000,000 were made in France, and an equal number in Germany, besides 30,000,000 a day made in the United States, and the output of other large countries. It is also estimated that only one pin out of every hundred made is worn out or broken by use, the other ninety-nine being lost.

When pins first came into use, they were very expensive and used only by ladies of wealthy families. When a lady was married, it was customary to give her a sum of money with which to buy pins; this gave rise to the term, "pin money," which now has an altogether different meaning.

NEEDLES

Although tne manufacture of the sewing needle is not properly an American industry, its introduction here is pardonable on account of the interest we all feel in this little piece of pointed steel wire. The use of the needle is very old, and it was probably one of the first tools employed by men. Savage and barbarous nations have been accustomed to using pieces of bone, or even thorns, to aid them in sewing their clothing together; and bone needles with eye holes have been found in the tombs of the ancient Egyptians and among the ruins of old Roman cities.

Steel needles were formerly made entirely by hand, but now a great part of the work is done by machinery. The manufacturer buys his wire, (which must be of the best quality of steel), in bundles, each containing several coils. The wire is first cut out into two-needle lengths. The cut wires are called blanks. As these are taken from a round coil, they are slightly bent and must be sraightened. The first process in straightening is to place the blanks in bundles and heat to redness, and then allow them to cool slowly. The actual straightening is now done by rolling them back and forth on an iron plate, with a tool called the smoothing file. The blanks are then pointed in a grinding machine. Only one end is pointed at a time, so the process has to be repeated for the other end. When ground, the needles are drawn from the grinding machine by a rapidly revolving pulley. They are then fed automatically into a machine which marks the place for the eyes; then the eyes are punched and the needles are "spitted," or strung on two wires. The projections caused by the stamping are filed off and the double needles are then divided between the eyes. Each row, still strung on the wire, is placed in a vise-like arrangement and the heads are filed into shape.

Needles are tempered by heating to a red heat and cooling suddenly in oil, then exposing to a slow heat until a blue oxide forms on them, when they are allowed to cool gradually. Each one is then examined by rolling with the fingers on a smooth steel slab, and any that do not roll evenly are cast aside. They are next washed and scoured in soap to remove any coating of oil that may adhere to them. The eyes are then smoothed and polished. While in the cheap grades of needles this work is done by machinery, in all the best grades the eyes are polished by hand. After polishing, the heads are ground, and the points finished on a stone by hand. The final process is polishing the shank, which is done by passing the needle between rollers arranged especially for the purpose. They are then sorted according to size, put up in papers holding twenty-five each, and a dozen of these papers are placed in a package. With all the machinery now in use, the ordinary sewing needle passes through the hands of seventy workmen in the process of its manufacture. The finest needles are made in England, where most of those in use in this country are obtained.

Besides the common sewing needle, we have a great variety of others for as many different purposes, like knitting needles, crochet needles, etc.; but sewing-machine needles are the most numerous and important of all these different kinds. These needles have the eye near the point, and a groove on one side for the thread. Some needles used in machines for sewing the welts on to shoes are in the form of an arc of a circle.

LEAD PENCILS

If we draw a piece of lead across a paper, it leaves a dull black mark. This quality of lead was known to the Romans and other ancient people many centuries ago. It was quite common to use small sticks of it for the purpose of marking. It is altogether probable that we get the name lead pencil from this custom. As you all know, a lead pencil does not contain any lead at all, but the substance which makes the mark, and is generally known as black lead, is a peculiar form of carbon, called graphite. Graphite, like lead, has been used for several centuries to mark with. It is so soft and brittle that it needs to be protected in some kind of a case in order to make it durable, and this led to the invention of the present form of pencils. Graphite is found in veins in rock, like coal, from which it is mined. The most important graphite mines in the United States are at Ticonderoga, N. Y.; others of note are found in England, in Siberia. and in the island of Ceylon.

The first lead pencils were made by sawing graphite of the best quality into little bars and placing these in a case of wood. The German manufacturer, Faber, still continues to use this method. His pencils are known for their fine quality, and can easily be recognized by their square lead.

The American manufacture of lead pencils differs from similar works in Europe, in the method of preparing graphite, and also in the use of machinery. When the graphite is taken from the mines, it is reduced to a powder, and then separated into various grades according to fineness. This separation is effected by running the graphite, with a current of water, through a series of tubs, each one set above the other. The coarsest settles in the first tub, the medium in the second, and the finest (which is used in the best grade of pencils) in the third. The graphite is then mixed with a fine quality of porcelain clay, and the mixture is thoroughly ground between flat stones. It contains enough water to give it about the same thickness as cream. The clay determines the grade of hardness in the pencil; the greater the proportion of clay, the harder the lead. Ordinary writing pencils contain about equal proportions of clay and graphite.

After grinding, the water is forced out of the mixture by hydraulic pressure. It is then made directly into leads. These leads are made by a machine which works on the principle of an old-fashioned force pump. It contains a close fitting iron piston which is forced into a cylinder with a screw. The bottom of the cylinder contains a small round hole, the diameter of the lead desired. As the piston works its way down the cylinder, the lead is forced out and coils up like a wire on a board at the bottom. It must now be handled with skill and dispatch for it dries rapidly. It is quickly cut into lengths sufficient for three pencils and straightened on boards. These leads are then gathered in bundles and baked until they become thoroughly dried and hardened. They are then ready for the cases.

In cheaper grades of pencils the cases are made from pine; in medium grades, of common red cedar, but the best grades have their cases of the finest quality of red cedar, obtained in the Florida Keys. The wood is prepared for the pencils where it is cut and comes to the factory in the form of little blocks, seven inches long, three and a half inches wide, and three-eighths of an inch thick.

When the blocks reach the factory, they pass through a peculiar planer which cuts and polishes the grooves for the lead. Each block contains grooves for six pencils. They are then passed to a bench, where the filling is done. One workman places the lead in the grooves, another glues them and a third places the blocks together. The filled blocks are placed in a strong press where they remain until the glue is thoroughly dried. The ends are then smoothed and they are passed through another peculiar planer which cuts them into individual pencils.

The best grades of pencils are usually stained and varnished, all of which is done by machinery. As the pencils pass from one department to another, they are counted to see that no loss occurs. The counting is done by dropping them on to a board having grooves or notches. Each board is made to hold 144 pencils. By filling his hands with pencils and running them rapidly over this board, a workman can count a gross in five seconds of time.

The Joseph Dixon Crucible Co., and the Eagle Pencil Co., are the two greatest pencil manufacturers in the United States. Nearly all the pencils of note or value which we use are made by one or the other of these firms. In style of finish and degrees of hardness, they have varieties sufficient to meet all demands. The degree of perfection to which the lead pencil has been brought makes it the cheapest, pleasantest, and most convenient writing instrument in use.

Colored pencils are made by coloring clay and making it into a composition which can be used as lead in the common lead pencils. Nearly all shades and colors can be obtained if one desires them. Another peculiar pencil made by these firms is one used in marking on glass and china. What we call the lead, consists of a mixture of lampblack, graphite, and wax. When these pencils get cold they become so brittle that they can not be used.

PENS

Before the invention of pens, reeds, the stylus, and brushes were used for instruments of writing. The first pens were undoubtedly made from turtle shells, bone, and similar material. It was found later that quills of certain birds, like the goose and crow, were better adapted to this purpose, and quill pens came into general use. It is from the Latin word meaning feather that we get the word pen. The quill pen was the favorite writing instrument for several centuries. While it may seem to us that only coarse writing can be done with it, we find specimens of beautiful work made with these pens in the hands of skillful writers who lived in the 12th and 13th centuries. Many of the books written before the invention of printing were done with quill pens. The writer manufactured his own pens, using a knife with a small, sharp blade for this purpose. The beauty of his work depended very largely upon his skill in making his pen.

The metal pens were undoubtedly made by rolling metal in the form of a tube and then pointing and shaping it at one end in the form of a pen; the remainder of the tube served as a handle or holder. Later the handles were made of different materials and the pen was of sufficient length to insert in the holder. The invention of the steel pen as it is now known, is uncertain. It is claimed by several manufacturers, but no one has been able to prove which claimant produced his invention first.

As the pen is a delicate instrument, its manufacture requires care and skill. Steel used for this purpose is rolled into sheets about six feet long and seventeen inches wide. These sheets are cut in strips and placed in air-tight boxes, where they are heated to a dull red and then allowed to cool gradually before being taken out. As the heating forms blisters on the surface, the pieces are washed in a weak solution of sulphuric acid to make them smooth again. After the washing, they are rolled in a barrel with pebbles and water. The strips are again rolled to the required thickness for the pen. This work must be delicately done since the variation of one thousandth of an inch in thickness spoils a plate.

The plates are now prepared for making pens. The first process is stamping or cutting. This is done by dies which cut the pens from the strips. The pieces cut out, called blanks, are shaped like a pen, but are still flat. They are then stamped with the name and grade at the same time that the points are hammered. From the stamping machine they pass to the press where the pen is punched. The little opening thus formed near the point is necessary to make the pen elastic, and also enable it to hold ink well. After again washing, to remove dust and grease, the blanks are heated once more in iron boxes to a dull red. When cool, they are rounded into the shape of the pen by pressing in dies.

The pens are tempered by heating them to a bright red, and immersing in vats of oil. The immersion is done with buckets which are perforated in the bottom. As the bucket rises from the vat, the oil rapidly drains out. This cools the pens so rapidly, however, that they would be altogether too brittle for use, so they are again washed in boiling soda water and tempered by being rolled in cylinders over a charcoal fire.

After annealing, the pens are rolled for several hours in a barrel of ground iron and then in another of dry saw-dust. This completes the polishing process, and leaves them a bright silvery color. The points are now ground and finished, and the pens are ready for the last process, which is slitting the point. We notice how perfectly the edges of this slit fit together, and how easily the pen spreads when we bear upon it, but we seldom think that this result is brought about by polishing the edges of this slit.

This polishing is done by tumbling the pens for several hours with powdered iron. Those pens that have a brown color are bronzed to prevent them from rusting. All those of the first quality are carefully examined by girls, who become very expert in their work. All imperfect pens are rejected. Those suitable for use are packed in boxes holding one gross each.

There are only six important pen manufacturers in the United States, but the pens from these are found in the stores of all stationers. Varieties and styles are sufficiently numerous to meet all demands and cater to all tastes. England is the leading nation in the world for the manufacture of steel pens. In the city of Birmingham, nearly 50,000 persons are employed in pen factories, producing on an average 25,000 gross of pens each week. It requires at least a ton of steel of the best quality to make 1,000,000 pens; and, strange as it may seem, it is nevertheless true, that more steel is used every year in making pens, than is consumed by all the gun, sword, and needle factories of the world. This plainly shows us that the "pen is mightier than the sword" in more senses than one.

Steel pens of excellent quality can be purchased at any stationery store, at from fifty to seventy-five cents a gross, but the first gross of steel pens sold in England in 1820 cost the buyer a sum equal to $36.00 in our money. The quality of those pens was not as good as that of pens to-day, which can be bought for thirty-six cents a gross. This improvement in quality and cheapening in price is all due to the invention and perfection of machinery now used in pen manufactories.

While England is the leading nation in the production of steel pens, we find the United States stands at the head as the producer of gold pens. Most of the gold pens made in this country are sold in Great Britian, France, and Germany. As the gold, even with the alloy, is so soft that the points wear rapidly, they are protected by what is called the diamond point. This simply means that a small quantity of harder metal, usually iridium, is inserted at the point of the pen.

PAPER

THE wasp was the first papermaker, and his material was the same as that employed by the largest paper mills of today, namely, wood fiber. The celebrated Egyptian scholar, Dr. Ebers, tells us that our word paper is derived from *papyrus;* our word Bible from *byblos*, the Greek name for the papyrus plant and the writing material prepared from it, and that the Greek word *bybleon* is applied to both.

There are several varieties of the papyrus plant, but that from which a substitute for paper was first made is the Papyrus Antiquorum, and is of genuine African origin. The plant was abundant on the banks of the lower Nile during the days of the Pharaohs, but it is now found only in the regions of the upper Nile, in the country of Abyssinia, and still further inland. It grows in dense thickets, and often attains a height of twelve or fifteen feet.

Authorities differ about the method of treatment this plant was subjected to by the ancient Egyptians in making what was their paper. Some say that they took the thin inner bark and laid the strips together so they would overlap. Then, by rubbing, the sap would cement these strips into a sheet, which when dry would retain its form. Others think the leaf of the plant was used instead of the bark, and treated in a similar manner. Probably both methods were used, and in this way the papyrus rolls were made, upon which were written in hieroglyphics the biographies of the kings of this ancient people. Many of these rolls have been discovered and translated in recent times and have revealed many interesting facts about the Egyptians and their government.

The Chinese are supposed to be the inventors of paper as we know it. Cotton was the material which they used. Paper made from linen rags is first known in an Arabic manuscript bearing the date of 1100 A.D. It seems that the Persians and Arabians learned the art from the Chinese, and later gave it to the nations of Europe. The first paper mill in Europe was established in Germany late in the 13th century, and during the next three hundred years paper-making became general over the continent.

France and Holland taking the lead in the industry. But little paper was made in England previous to the reign of Elizabeth. The Dutch were the first to make use of machinery to macerate the rags into pulp.

The first paper mill in America was built by William Bradford and William Rittinghuyser on the banks of a little stream, still known as "Paper Mill Run," near Philadelphia, in 1690. The structure was of coarse unhewn logs, after the style of the buildings of that time.

"As paper has been the medium by which learning and culture were transmitted, so was the idea of the manufacture of paper borne on the winds of commerce, so have the highest art and skill entered into its manufacture." From the old mill on the banks of Paper Mill Run the industry has continued to grow during the three centuries of its existence, until paper-making now holds the fifth place among the industries of the country.

For several centuries all paper was made by hand labor. The process was very slow, and the product a paper of very inferior quality. The paper used for making books during the 16th century was of a much poorer quality than most of that now used by grocers and other merchants for the purpose of wrapping their goods.

The rags were shredded and churned until they were reduced to pulp which could be made into paper. The pulp was kept floating in large vats from which it was dipped as needed. The pulp was dipped out by a square dipper, called the "mold." This dipper had a long handle and a bottom of wire cloth. It was also fitted with a thin frame called the "deckle." The deckle was just the size of the sheet of paper. The workman put this on the mold and dipped them into the vat. A thin layer of pulp covered the mold inside the deckle, and by gently shaking the dipper this was evenly distributed over the wire cloth. As the dipper was raised from the vat the water drained off, and the mold was taken from the deckle and passed to another workman called the "coucher." The coucher spread a sheet of felt cloth and turned the mold over so as to lay the pulp flat upon it. As these formative sheets of paper were taken from the mold they were laid upon felt and piled upon one another until the pile contained 130 sheets.

The pile was then placed under a hand press which squeezed out most of the remaining water. The felts were then taken out, and the sheets of paper pressed again by themselves. They were then separated and pressed a third time, after which they were hung on lines to dry, very much after the manner of hanging the washing in the backyard. After drying, the sheets were sized by dipping them in a thin solution of glue and alum. Then they needed to be pressed again, after which they were dried for several days. The final finishing was done by passing them between hot metal rollers which were highly polished, or by pressing them between glazed pasteboard and hot metallic plates. The surface of this early paper was uneven and difficult to work on. The process seems to us very crude, and we may wonder that paper could have been made by it at all. Still, however complex the process of paper-making may seem to-day with the elaborate and expensive machinery employed, the modern paper mill is only a device for carrying on the old process of the hand mill on a larger scale and in a more perfect manner.

Any vegetable fiber which can be reduced to a pulp can be made into paper, but the quality of the product will depend very largely upon the material used. Straw, hemp, jute, etc., when used alone, will make the coarse heavy paper used in wrapping merchandise, while linen and cotton rags make the finest grades of writing and printing paper.

The best grades of paper are made entirely of rags, but most of the ordinary grades contain other and cheaper material, such as wood pulp, straw, and hemp. The best quality of rag paper must contain a fair proportion of linen, but it is not all linen. In fact, the only pure linen paper used is found in bonds and bank notes. Linen paper writes well, but is stiff, crackly, and difficult to fold, as well as expensive. For these reasons a mixture of cotton and linen makes a more desirable writing paper. The proportions are usually two parts cotton to one linen.

The first step in making rags into paper is to shred them. All buttons must be taken off, and all seams ripped out in order that they may be thoroughly cleaned. After shredding, the rags are treated to a quantity of chloride of lime and steamed for several hours at a high temperature in a closed boiler. The chloride of lime serves the double purpose of a bleaching and a cleansing agent. When the rags emerge from this process, they are white and clean. They are then thoroughly washed and taken to the beating engine, which does the grinding, or reduces them to pulp. These engines consist of a rapidly revolving axis filled with sharp knives, and encased in an oval-shaped vat. The shaft containing the knives extends about half way across the vat in the direction of its shortest diameter. On the other part of the shaft is a drum cylinder covered with wire gauze. A stream of water is admitted at one end of the oval, and carries the rags under the knives. After they have passed through, the cylinder hurries them around the vat for a second grinding, and so on as long as the process is continued. In course of the grinding the pulp usually passes through three engines, each reducing it finer than the other. In its final stage the pulp bears a close resemblance to rice and milk. From six to eight hours are required to complete the grinding, and the pulp passes from the last engine directly to the storage vats, from whence it is pumped to the machine that converts it into paper.

The machine known as the "Fourdrinier Papermaking Machine" is the most complete and perfect apparatus yet invented for the manufacture of paper. The machine is very large, sometimes having a length of 150 feet. It is also a complicated structure, and difficult to understand without seeing it in operation. So perfect is the adjustment of the parts, and their adaptability to the work in hand, that one of these machines seems to exercise almost human understanding in performing its task. This is to receive the pulp at one end as it comes from the storage vat, and turn out at the other end the paper finished and ready for use. Let us try to follow the pulp as it passes through the machine in its transformation to paper.

The pulp is pumped from the storage vat into a long narrow box at one end of the machine. From this box it flows through a pipe and spreads itself over a frame set with horizontal slats about an inch in depth. The grooves between these slats catch any sand or pieces of metal that may have followed along. Next comes a sieve of brass wire which removes any threads or knots that may have escaped the engine. From a box beneath this sieve the pulp falls upon an endless belt of wire gauze. This belt is about thirty feet long, and is supported on numerous rollers. It also has a lateral as well as a longitudinal motion. This is for the double purpose of keeping the pulp evenly distributed over its surface and weaving the fiber together so as to give greater strength to the paper. Running along each side of the gauze belt are two rubber straps, supported in a frame known as the "deckle frame." These straps perform a function similar to that of the original deckle in the old hand mill: viz., to confine the pulp between them and determine the width of the sheet.

As the pulp passes along over the gauze, most of the water is drained off. Just before it leaves the wire it passes over a vacuum box from which the air is partially exhausted by pumps, and this serves to remove more moisture, and make the substance firmer. As the sheet leaves the deckle, it passes over a wire roller known as the "dandy roll." This serves to still further press out the water, and to stamp any impression which the manufacturer may desire to place upon the paper as a trade-mark. This impression is known as the "water mark," and can be readily seen by holding the sheet between the observer and the light. It is found only upon paper of good quality, and is a guaranty of its grade. The design is made of wire, and fastened upon the roller, so that an impression is made at each revolution. If no impression is desired, the roller is left plain. This arrangement strengthens the impression made by the wire gauze, and the paper is known as "wove." "Laid" paper is distinguished by having parallel lines running through it at equal distances. These are made by fastening wire around the surface of the dandy roll. Some of the devices stamped in this way have given different kinds of paper their names. Foolscap was so named because when that kind of paper was first made it bore the water mark of the iester and his bells.

Between the dandy roll and the end of the belt of gauze there are several suction boxes which still further remove the moisture and strengthen the sheet. After passing these boxes the paper leaves the belt of gauze and passes to one of felt, and known as the "wet felt." This belt takes it between the first "press rolls." From these the paper is carried to the second "press," where it is transferred to another endless felt which takes it on its way to the driers. The paper is now practically made. The further work of the machine consists of drying, sizing, and finishing.

The driers are large iron cylinders about two and one-half feet in diameter. They have highly polished surfaces, and are heated by steam which enters through the trunnions upon which they revolve. The machine is so constructed that the number of these cylinders can be increased indefinitely, and their number depends to quite an extent upon the grade of paper which the machine is to make. On its way over the driers the paper passes through a vat of sizing, and again between a pair of press rolls, to have the unnecessary sizing removed. The best grades of paper are obtained by allowing it to dry slowly after sizing, so the entire fiber may receive a portion of the finishing solution. For this purpose a large number of driers at a low temperature is required.

After being thoroughly dried the paper is passed over and between a set of press rolls each of which is about a foot in diameter, and placed one above the other. This part of the machine is known as the "stack," and its work is to polish and finish the surface. Paper made by a machine having this attachment is known as "calendered" paper.

From the stack the paper goes to the reel or cutters as desired. That used by the great newspaper houses is rolled and printed directly from the roll. That used in printing most books and magazines is cut into sheets and put up in quires. This style of marketing is used with all paper of high grade, such as stationery and the best qualities of printing paper.

From this description it will be seen that the Fourdrinier machine does on a large scale, and in a better way, what the mold, the deckle, and the press did in the old hand mill. Each machine is constructed for the particular kind of paper which it is to make, and can not make any other economically. The part of the machine which requires great skill in adjusting and tending is that over which the pulp passes before reaching the driers. Any fault in the flow of the pulp at once destroys the symmetry of the sheet, and usually causes it to break and run to waste. The machine is seldom stopped when an accident of this kind occurs. The attendant soon effects the necessary adjustment, and the paper ribbon rolls on. One of these machines will run thirty feet of ordinary newspaper a minute, and sixty tons a week by working twenty-four hours to the day.

The Civil War put a stop to the importation of rags for several years, and, for a time, paper-makers were unable to supply the demand for their product. Finally, someone conceived the idea of treating rye straw to the same process as rags in the manufacture of the pulp. The experiment was so successful that nearly all the newspapers during the four years of the war were printed on straw paper. Wood gradually came to take the place of straw. The inner bark of the basswood had been used to a limited extent in paper-making for a number of years, and this led to the use of the wood itself.

At first, basswood was the only sort considered suitable for pulp, but now the processes of manufacturing wood pulp have been brought to such a degree of perfection that pine and spruce are very generally used. The wood is prepared for paper by two processes. The pulp is made by grinding, and what is known as "fiber" by chemical action.

In the manufacture of pulp, the wood is first stripped of its bark, after which it is cut and split into blocks resembling stove wood. The knots are removed from these blocks, and they are then ready for the grinder, which is a large grindstone revolving on a horizontal axis. The stones revolve at a high rate of speed, and the wood is pressed against them by the action of a screw which is operated from the axis. A stream of water flows over the stone, and carries away the pulp as fast as it is ground. The pulp passes over a wire screen which removes all splinters and knots, the fine pulp being sucked through the screen by a bellows-like arrangement attached to a box underneath.

After screening, the pulp, as a rule, is pumped to the "wet machine," where it is gathered on an endless woolen felt, and pressed into layers, or "laps." The laps are about two-thirds water, but make quite a compact sheet, having the thickness of ordinary pasteboard. If the paper is made in a separate mill, the laps are shipped to the consumer. Most large mills, however, grind their own pulp, and thus save a good deal of freight.

Spruce is considered the best wood for pulp. A cord of good spruce will produce a ton of pulp, dry weight. About 200 horse power is required to grind three tons of pulp in twenty-four hours. The development of pulp machinery during the past few years has been extensive, and has engaged the attention of some of the most competent inventors and designers.

It was soon discovered that there was not enough fiber in wood pulp to give paper sufficient strength to withstand the strain of the printing press, and a proportion of rag pulp had to be added. A process of treating wood has now been perfected by which the fiber is preserved so that paper can be made wholly from wood, and contain the necessary qualities for successful printing. Wood fiber is prepared by cutting the wood into chips and packing these in a large boiler, called the "digester." A solution of caustic soda or sulphate of soda is added. The digesters are then closed and the contents cooked for eight or ten hours under a steam pressure of ninety or one hundred pounds.

When the "cook" is completed, the contents of the boiler are washed and made into laps the same as those from the pulp. In making the paper the fiber and the pulp laps are mixed in proper proportion in the engine.

Nearly all the paper used by the large newspapers is made from wood, and more or less wood enters into the composition of that used in printing books. But paper containing any considerable amount of wood turns yellow or brown when exposed to the light, and should not be used for printing matter which is to be preserved for any length of time. The rapidity of the process of making paper from wood is astonishing. Excepting the chemical process necessary for making the fiber, a tree could be converted into paper in an hour.

The coarsest kinds of wrapping paper, and the board used in the manufacture of paper boxes, are made from wheat straw. The pulp is prepared by first boiling the straw with quicklime, then washing and reducing in the beating engine. This paper is finished in a cylinder machine working on the same plan as that already described, though of much simpler construction.

Other substances which can be used to advantage in the manufacture of paper are bamboo, corn husks, and esparto grass. This grass grows in the southeastern part of Europe, and has an excellent fiber. It is cheap and abundant, and is extensively used in the paper mills of England and the United States. One of the most important considerations in the manufacture of material is that of the selection of the fiber. The most perfect spinning fibers, and the best for paper-making, are cotton and flax. Next to these are shea, the fiber of the so-called China grass, cultivated extensively in the East Indies, hemp, jute, and, after these we may rank the fibers used in twine and rope-making, but not adapted to spinning. The poorer the fiber, the poorer the quality of paper. The chemical composition of the fiber, or its capacity for withstanding the natural agencies of destruction, is also an important requisite of the material used. In this respect cotton and linen rags are the best, and wood fiber is the poorest.

There are many special kinds of paper bearing distinct names, such as India paper, Japan paper, etc. Some of these names indicate the place of manufacture, while others refer only to the quality or use. The delicate operations necessary to the manufacture of some of these brands is especially noticeable in connection with silver tissue paper. This is so thin that we can scarcely measure its thickness, yet it is quite strong. Much of our tissue paper is made from old rope, which shows the good use that can be made of what we might at first consider worth-less material. On account of the strength of its fiber, rope is especially adapted to the manufacture of thin paper. Many of the smooth papers have their pores filled with a preparation of fine porcelain clay, or talc. Glazing and polishing give such papers or boards a smooth, glossy surface, especially suited to certain kinds of writing and printing. For engravings a paper with a fine fiber but slightly rough surface is usually preferred, as this brings out the details of the picture in clear relief.

There are many sorts and grades of paper. These have different names in different countries, and each class has its numerous subdivisions which are recognized in trade. All these, however, can practically be classed under the following heads: printing, writing, wrapping, and boards.

The following sizes are among the most common, and are in general use. The sizes are given in inches.

Billet note	6x8
Cap	12¾x16½, and 13x17
Commercial letter	11x17
Commercial note	8x10
Letter	10x16
Octavo note	7x9
Packet note	9x11½
Small flat cap	13x16

The size of the pages of a book or pamphlet is frequently denoted by the number of folds in the sheet, showing the number of leaves.

Folio, folded once	2 leaves, 4 pages.
Quarto, folded twice	4 leaves, 8 pages.
Octavo, folded four times	8 leaves, 16 pages.
Duodecimo, folded six times	12 leaves, 24 pages.

Sixteen is the highest number of folds usually made in book-making; this gives 64 pages, and is styled a 32mo. This book is an octavo, having 16 pages to the sheet.

We are all familiar with common uses of paper, and they do not need any special mention in this work; but, if the new discoveries of the uses of this article are any index to advancement in civilization, we must be making progress very fast. Some of the most recent and novel uses to which paper pulp has been put are making window panes, flower pots, wagon wheels, horseshoes, barrels, tubs, pails, pulleys, etc. Flower pots are made from 85 parts wood and 15 parts rag pulp. The pot is shaped to the desired form in a mold. After drying, it is subjected to the treatment of a composition consisting of a petroleum, paraffin, and linseed oil. The liquid is put on hot, and permeates the entire substance and renders it water-proof. Paper is also used in the construction of canoes, and in building portable houses. It is light, strong, and durable, which qualities adapt it to the construction of portable hospitals, and such other buildings as are necessary to the field outfit of an army.

The older paper mills are located in the New England and other eastern States. The most noted mills of the country are at Holyoke, Mass., Bellows Falls, Vt., and Ticonderoga, N. Y.; but the use of wood in the manufacture has caused the erection of many large mills in the vicinity of the forest regions, as it is much cheaper to freight the paper than the raw material. The perfection of machinery by which the expense of manufacture has been greatly reduced has proportionately extended the use of paper, as it has enabled publishers to reduce the price of books and periodicals to such an extent as to make it possible for everyone to purchase them. This, with the new uses for paper which are being continually discovered, cause such a demand for it that the United States has become the largest paper-producing country in the world. The annual output at the present time exceeds 1,200,000 tons, and the value of the paper and pulp manufactured now exceeds $500,000,000 per year. The next largest producer is England. Then follow France, Germany, Austria, and Italy.

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