business in both flour and paper. Hendrick Onderdonk, who set up
an early paper mill in New York at Roslyn, Long Island, in 1773,
also ground grist and made paper in the same mill. Thirty years
ago I visited a handmade-paper mill in the south of England and
saw in operation a large wooden water-wheel that furnished the
power for operating two Hollanders and two sets of millstones,
both papermaking and the milling of grain being carried on under
the same roof. This mill was later demolished, and as I was present
at the time, much of the old papermaking equipment was acquired
and brought to America, where it was ultimately used in the re-

vival of the handmade-paper industry in Lime Rock, Connecticut.

In the Hollanders of the mid-eighteenth century (Figure 141)
the washing and cleansing of the linen and cotton were accom-
plished by the use of two screens, called “chesses,” which ex-
tended through the hood, or “chapiter,” just in front of the re-
volving roll. The screen nearest the roll was fashioned of coarsely
woven metal wire, and the other of fine cloth made of horsehair.
At the base of these two screens a hole-scupper or “dalot” was
placed, which carried away the unclean water as it was thrown
through both of the screens by the velocity of the revolving roll.
Fresh water was supplied continually to the beater tub during the
washing process, and the mission of the two screens was to pre-
vent the escape and waste of any fibrous material. An engraving in
Groot Volkoren Moolenboek, published in Amsterdam in 1734,
depicting this form of washer, was the first illustration of the Hol-
lander to appear in the country of its invention (Figure 142).

The German papermakers were slow to take advantage of the
newly devised Dutch machine, no doubt thinking, and rightly too,
that the old method of macerating cloth by means of stamping-
mills made the best paper. Both Frederick the Great and Maria
Theresa encouraged the master papermakers to install the im-
proved Dutch beaters and discard the old-time stampers. By the
year 1800 there was but one paper mill in all England where the
stampers remained in use. The French were the last to adopt Hol-
landers exclusively, and until 1861 the French Government in-
sisted that all pulp that was to be used for making paper for
the Stamp Office be beaten by the primitive stamping-mills, thus
assuring long-fibred stock and therefore stronger and more dura-
ble paper. In 1801 Johann Christoph Ludwig recommended that
the German papermakers adopt the Dutch windmills as a means of driving the beating-engines, and he compiled a small pamphlet regarding his observations (Figure 143). As late as 1920 there was a set of the old stampers in operation in the south of the Tyrol, and several Italian and German mills still retain them in their buildings as curiosities. In 1925 I was offered a set of these ancient stampers by the last member of one of the old German papermaking families, the troughs of stone worn by use and the wooden parts almost falling into decay.

In the Hollanders of the present day (Figures 144, 145) a few improvements have been made, but in principle of conception and general construction they are almost identical with the old machine of Dutch invention shown in Sturm’s book of machinery of 1718.
Early Papermaking Processes and Methods

The methods that were used in the making of paper during the early centuries of the craft are naturally vague after a lapse of almost two thousand years. No records indicate to us the manner in which the Chinese first made paper; but as with the ancient arts of the weaver and the potter, the method of hand fabrication in this craft must have changed but little from its inception to the present day. Almost two thousand years ago sheets of paper were made from disintegrated fibre upon flat moulds, and in this fashion paper is still formed, the only difference being in the treatment of the fibre and in the construction of the moulds; in principle the process remains unchanged. The original papermakers of China probably poured the fibrous pulp upon the cloth-covered frames, or moulds, but it was not long before the craftsmen practised the more expedient method of dipping the moulds directly into the macerated liquid material. This change of method was one of the important steps in papermaking technique, as it enabled the artisans not only to form better sheets of paper, but to produce them in greater quantity. There is no way of arriving at the exact period when moulds were first dipped, but it probably did not take the ingenious Chinese a great while to discover the new and more efficient method. The pouring of the fibrous stock upon the moulds is still practised in Tibet, Burmah, Nepal, Bhutan, Siam, and some parts of China. (See Figures 41, 90, 91.)

Whatever the methods employed in the Orient at the inception of papermaking, the method used when the craft was introduced into Spain during the twelfth century was to dip the mould into a vat filled with macerated liquid pulp and bring it to the surface laden with the matted and felted fibre, which, after drying, was paper. In the four centuries following there was little development in papermaking. Before the invention of printing in Europe the use of paper was limited, but with the ushering in of this art the craft of the papermaker had its real impetus. It was during the fifteenth century that the fabrication of paper developed into a notable industry, and present-day interest in old papermaking dates from the infancy of printing rather than from more remote periods.

The precise methods used by papermakers in the days of Gutenberg, Jenson, and Caxton are no more clear to us than are the exact processes employed by the early printers in their type-making. The oldest print in either the Orient or the Occident representing an interior view of a paper mill (Figure 146) is that of Jost Amman, * from the year 1568, but this woodcut throws no more light on the details of papermaking than does the print of the old typefoundry, in the same volume and by the same artist, show us how type was made at that time. It is only by piecing together material from many and varied sources that we are able to arrive at the methods used by the early craftsmen. The art of papermaking was jealously guarded by the old workers, and, there being little intercourse between the different mills, it was natural that the papermakers in each locality should have had their own methods. Even today there is a secrecy among the makers of handmade paper in both the Orient and the Occident, and the various mills show a pronounced variation in equipment and methods of operation.

In an examination of old Asiatic and European paper it may be readily perceived that the sheets were formed upon flat moulds, and from the impressions left in the paper by the material of which these moulds were made, it is not difficult to determine how the moulds were constructed. The moulds differed slightly in work-

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* The print may be found in a book of trades issued in Frankfurt am Main under the title: _Eingentliche Beschreibung aller Stände auf Erden, hoher und niedriger, geistlicher und weltlicher, aller Künsten, Handwerken und Händen_ (1568). In this little book 115 trades or callings are pictured by Jost Amman (1539-91); under each woodcut there is a verse about the particular craft compiled by Hans Sachs (1494-1576), the cobbler-poet of Nürnberg. The woodcut of the papermaker is the eighteenth in the book and follows the illustration depicting the woodcutter at work. A translation of the verse by Hans Sachs reads:

Rags are brought unto my mill
Where much water turns the wheel,
They are cut and torn and shredded,
To the pulp is water added;
Then the sheets 'twixt felts must lie
While I wring them in my press.
Lastly, hang them up to dry
Snow-white in glossy loveliness.
making of the paper have undergone few changes since the original invention by the Chinese.

In all old European paper mills, aside from the appliances that were used in the preparation of the pulp or paper stock (described in Chapter 5), there were four essential utensils used: the vat, the moulds, the felts, and the press. In every antique engraving produced in Europe depicting the papermakers' art these four necessary appliances will be seen. In the fifteenth century the vat for holding the fibrous liquid was simply a round or oblong wooden tub, about five feet in breadth, reaching in height to the worker's waist, and bound with stout hoops. The old vats were probably made from huge wine casks or tunns cut through the centre, as it is not likely that there were special shops where papermaking equipment was manufactured. Doubtless the mills designed and constructed their own appliances to suit their individual needs (Figure 147). The earliest engraving representing papermaking shows no appurtenances to the vats, but during the seventeenth century several inventions were made which greatly facilitated the work. The most important of these was the introduction of the charcoal heater, which was annexed to the back of the vat to warm the stock. By the more rapid evaporation that resulted the workers were enabled to make a greater number of sheets in a day. In France this heater was known as a "pistolet," and it was the practice to place the vat against an outside wall so that the smoke from the heater or grate would not permeate the vat-house and soil the paper during the moulting process.*

In pioneer papermaking in America the vat was heated in much the same manner. The only contemporary description of this old

* The earliest British patent pertaining to the heating of vats for papermaking was issued to William Scott and George Gregory on August 16, 1793. The specification reads: "Their invention is for heating water and other stuff in vats for making paper by introducing steam. . . . The common and ordinary method now used for heating water and other stuff in vats for making paper is by introducing fuel into a pan placed within the vat, which not only consumes a large quantity of coal, but is likewise uncertain and irregular in the heat. . . . the new method causes the paper to be free from a great part of the dust and nastiness which unavoidably mix with it from heating the vats by fuel." The specification is accompanied by a plate which shows the steam introduced into the vats by means of coils of pipe protruding directly into the dipping-vats. This is the same method of heating the paper stock as is employed at the present time in the commercial handmade-paper mills of Europe.

Fig. 146 The earliest picture of papermaking. The woodcut is by Jost Amman, the poem by Hans Sachs.
method of warming the stock in the vat is that given in the manuscript diary of Ebenezer Hiram Stedman, who was born in Dorchester, Massachusetts, November 11, 1808. In 1816 young Stedman and his father, a Massachusetts papermaker, migrated to Kentucky to work in a paper mill in Lexington. The account of young Stedman’s trials with the “pistolet” is taken from this exceedingly interesting old diary. Stedman wrote: “From January till May I would have to get up in the mornings at 2 o’clock, the first thing was to make a fire to warm the water in the vat, where they dip up the pulp to form the sheets of paper. I had to go into a hole in my hands and knees, ten feet long, by three feet square, to make a fire in what was called a pot. The smoke came out of the hole I went in and this was on the outside of the mill. Exposed to the weather in winter no one will ever realize how much I suffered with cold, snow, rain, and smoke. Many times I have had to hold my breath while making the fire and dodge in for a chance to put in a stick of wood, then back out for the place was too small to turn around. After making the fire then I would have to wake up the vatman and the coucher and the other workmen in the paper mill.”

Another improvement in the equipment was a platform or bridge which extended from one side of the vat to the other. This bridge, as shown in the old engravings, supported the “horn,” against which the mould with its newly formed sheet was placed to drain. The bridge does not appear in the woodcut of 1568 by Jost Amman, nor in the illustration of 1662 by Georg Andreae Böckler (Figures 136 and 146), but in as much as a bridge is partially discernible in a very crude woodcut of 1658, it may have been in use as early as Böckler’s time in some parts of Europe.

During the process of moulding the sheets of paper it was essential that the fibrous material be kept from settling to the bottom of the dipping-vat. Originally this was accomplished by the action of a pole in the hands of a workman, a means of agitation still used in most Oriental mills. A slight improvement was later made by placing on the end of the pole a wooden disk pierced with holes, which increased the effectiveness of the stirring. Suggestions for more efficient work came slowly in the early mills, and each step, which now seems trivial, was no doubt welcomed as an ingenious invention by the old craftsmen. It was not until the latter part of the eighteenth century that a mechanical agitator was
The first European method of supplying the vat was by transferring the macerated stock from the storage chest by means of hand buckets, a most tedious procedure. It was not until the seventeenth century that a supply by gravity was devised. I once visited a paper mill in Europe that had been equipped in the late eighteenth century, where the fibrous liquid had been conveyed to the vat from a large stone cistern by means of a long winding wooden trough; the stock or pulp had been lifted and thrown into this trough by a huge wooden wheel fitted with copper buckets.

After the vat had been filled to within a few inches of its brim with the diluted linen and cotton fibres that had been macerated under the stamping-mills, the fibrous material was ready to be formed into sheets of paper. A workman (Figures 148, 149), called a vatman, stood on a platform in front of the vat, holding a mould firmly by the two narrow sides; around this mould was a removable deckle or frame, which acted in the manner of a shallow fence around its edges. (Moulds and deckles are described in detail in Chapter iv.) The vatman plunged the mould, at an almost perpendicular angle, into the fibrous liquid substance, and when the mould was well submerged he turned it face upwards and lifted it horizontally from the vat. By this action the mould was evenly covered with the macerated linen and cotton, and the stock not needed for the particular weight or thickness of paper being moulded was allowed to run over the far edge of the mould into the vat, to be used again. The vatman then shook the newly formed sheet on the surface of the mould, first from right to left, then from back to front. These motions crossed and matted the fibres, making the sheets of paper almost equally strong in both directions, and at the same time expelling considerable water from the sheet. The wires of the mould retained the fibres, but allowed the water to drain through as in a sieve. The vatman then removed

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* The various prints depicting papermaking appliances before the year 1800 do not show the mechanical agitator, so it may be assumed that this means of preventing the paper stock from settling in the vat was not employed on the Continent previous to this date. The earliest mention of this form of agitation that can be located appears in an article entitled "Sur les papeteries et fabrication de papier-paille en Angleterre" in Annales des arts et manufactures, ou Mémoires technologiques, October-November 1809. The article relates to a visit of a French papermaker to the Matthias Knoops paper mills, Mill Bank, Westminster, England. The description reads: "The vats in nearly all the English paper mills are fitted with agitators placed near the bottom, to which is given a slow motion. This agitator, or paddle-wheel, which the English have given the name "hog," keeps the macerated stock in the vat in constant movement and prevents it from settling to the bottom of the vat.

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* This method of supplying the vats with stock is practised in the Orient; even in the most efficient handmade-paper mills of Japan the pulp is placed in the vats without the help of mechanical means.
the wooden deckle, which left the moist sheet of paper, cut sharply along its four edges, upon the mould. The next operation of the vatman was to pass the mould along the bridge to the second artisan, known as the "coucher," and proceed to form another sheet with a second mould, using the same deckle. The coucher placed the mould, with its thin moist sheet, against the inclined drainage-horn, or "asp," which allowed the surplus water to drain back into the vat. When the wet sheet of paper had solidified upon the mould to the proper extent—a stage determined by a distinctive lustre over its surface—the coucher turned the mould completely over and deposited the wet sheet of paper upon a piece of felting (Figure 150). The cousing was done with a quick, deft motion, rocking the mould from one long edge to the other, leaving the sheet, flat and unwrinkled, upon the woollen cloth. These processes were repeated over and over, the vatman and coucher working together, until a pile of 144 sheets of paper had been formed and couched, each sheet of wet paper separated from the next by a piece of felt somewhat larger than the size of the paper. The pile of six quires was termed a "post," and the next operation was to place the post in a press to expel the excess water.*

In the earliest form of Chinese papermaking, the sheets were dried directly upon the woven textile moulds upon which they had been formed, so that couching, or removing the paper from the mould while wet, was not required (Figure 151; see also Figures 42–46). After the introduction in China of the "laid" bamboo mould, when dipping was used, it was the practice to couch each sheet as it was formed, one upon another without interleaving cloths. This method is in use at the present time in many parts of Asia, including China, Japan, Korea, Indo-China, and India.  

At the introduction of papermaking into Europe, felt of some kind was in all probability used as a material for the couching of paper. It is not likely that the old craftsmen employed woven wool cloth such as the makers of handmade paper use at present, but a more compact, matted substance of hair or wool. The woven material that is used by modern papermakers is called felt, but the name is a misnomer, as felt is a compressed mass and does not necessarily consist of warp and weft. Years ago in Catholic countries the feltmakers celebrated the 23rd of November, St. Clement's Day, with a great festival. It is stated that this saint, when on a pilgrimage, placed carded wool between his feet and the soles

* The term "post" was used for any pile of wet sheets interleaved by felts; the origin of the word is obscure. While the usual number of newly moulded sheets in a post was six quires, the amount would vary according to the size of the paper being made; with paper of large dimensions the post would be made up of as many sheets as could be handled and pressed conveniently. The term "post" may have been introduced into England by German or Italian workers as the word probably came originally from the German Posten or Italian posto, which in turn were derived from the Latin positum.

The term "quire" (Middle English quaver, quair; Old French quaver, quair, cayer, cayer; French cahier; Low Latin quaternus, quaternum, from the Latin quattuor) denotes four sheets of paper or parchment folded together into eight leaves; hence any set of folded sheets fitting one within another, as the sheets of a book. The modern use of the term quire is usually applied to twenty-four sheets of paper, either folded or unfolded. A "ream" of paper is made up of twenty quires, or 480 sheets. This term comes from the Arabic word razmeh, meaning a bundle, especially of paper. The term was probably introduced into Spain along with the craft of papermaking in the twelfth century, where the word became reisma or resma. The Middle English term was reme; Old French rayme; French rame. According to Webster, a regulation ream is 480 sheets, but sometimes 472 of drawing or handmade paper, 300 sheets of news or book paper, and a printer's "perfect ream" 516 sheets.
of his sandals, and at the end of his journey found that the wool had been converted into felt. However, the invention of felt by St. Clement is to be questioned, as this material was in use long before his time. The Greeks manufactured true felt as early as 900 B.C., long before the art of papermaking. Papyrus was made before this period, it is true, but this is a laminated substance, not made from macerated and disintegrated fibre as is true paper. Both the Greeks and the Romans made use of matted felt for caps, blankets, and the lining of helmets. Since the material was thicker than common cloth, it presented a more effectual obstacle to missile weapons; hence when the soldiers under Julius Caesar were annoyed by Pompey’s archers, they made shirts of heavy felt and wore them for defence. The Scythians, who from the most remote time roamed the lands of northern Asia, as did the Tatars, their successors, used felt for both clothing and material for making tents. It is therefore quite evident that had the early papermakers, even the original Chinese, desired felt for the couching of their paper, it could have been readily procured.

It is not known when felt came into use as a material for receiving the wet sheets of paper as they were couched from the moulds, nor is it known when woven wool cloth was substituted for matted felting for the couching of paper, but it is probable that some sort of woven material was in use for the purpose as early as the thirteenth century. No special wool cloths were fabricated for papermaking until the eighteenth century, although there was an incorporated company of feltmakers in England as early as 1604. These artisans made felt for hats, but it is not recorded that they attempted any woven or matted material especially for papermakers. The material used for the making of felt was not only wool, but the hair of the seal, rabbit, monkey, goat, and camel.

The best description of woven cloth such as was used in the eighteenth century by the makers of paper is furnished by Nicolas Desmares in *Traité de l’art de fabriquer le papier*, published in Paris in 1788:

The felts have two surfaces furnished with different naps. That side which has the longest nap is applied to the couched sheets, and on the side with the shortest the fresh leaves are laid. If this arrangement of the felting was changed, and the sheets laid upon the surface with a long nap, not only would they not apply themselves accurately to the felt, but the long stiff hairs would pierce the paper or cause depressions, which would injure the texture. On the contrary, the leaves fit themselves evenly to the side with a short nap, which absorbs the surplus water and gives a sufficient consistency for the coucher. It is also from this side that the layman detaches the sheets after the press has passed through the press so that the different character of these surfaces is an assistance to the layman as well as to the coucher. The material of which the felting is made requires great care on the part of the papermakers, and much attention and knowledge of the art of papermaking on the part of the manufacturer who prepares them. They should be firm enough to spread evenly upon the leaves without wrinkling or needing to be displaced. Also, they should be supple enough to adapt themselves to the work of the coucher, who applies the mould successively from one edge of the felt to the other upon every intermediate point. As the felts have to resist the reiterated efforts of the coucher and the press, it is necessary that the warp of these cloths should be very strong and therefore made of combed and well-twisted wool. And as they should be clean and quickly absorb and give up again a certain
amount of water, their weft should be of carded wool quite loosely spun and woven in about the same manner as light cloth. It results from this that the weft abundantly fills the stuff and covers the warp in such a way that the texture is not marked upon the paper, which would injure its grain by the irregular impression of an uncovered warp and weft, as is often observed in establishments where folis not woven upon these principles are used, which does not denote a great deal of talent upon the part of the papermaker. If the material were too closely woven, like ordinary clothes, or even the finest kinds, it would not absorb the water enough to enable the sheets to adhere and assume a certain consistency. It is for this reason that Carcassonne cloths are very well adapted to this purpose, and that those of Louviers, of which the texture is very close, would not take the leaves of paper covered upon them in experiments several times repeated, because the water could not sufficiently penetrate them. It is very essential that the warp of the stuff intended to be made into felts should be strong and tough, so that they may be of good service and wear well.

For pressing the water from the piles of paper and felts a wooden screw press such as was portrayed by Jost Amman in 1568 and Georg Andreas Böckler in 1662 was employed in the old mills (Figures 136, 146, 152, 153, 154, 155). As these presses had to yield an immense pressure, they were massive and cumbersome, and constituted one of the most expensive appliances of the old paper mills. After the post had been placed under the platen of the press, all of the workers in the various parts of the mill were summoned together by the ringing of a bell to exert their strength in turning down the screw of the press by means of a long wooden lever. *

* In the Ebenizer Hiram Stedman diary the following account of the method used in pressing the posts in an early nineteenth-century paper mill in Kentucky is given, and it will be noted that the procedure is not unlike that practiced in Europe. Stedman wrote: "It was my duty when Layboy to
As the platen of the press closed downward upon the felts and newly formed paper, an abundance of water was forced from the mass, the post being reduced from about two feet in thickness to barely six inches. In later years a device called a “Samson” or “sampson” was brought into use in the larger mills (Figure 156). This device acted as a windlass, and with the power of six men the pressing was more efficient than had been previously possible, giving the paper a more compact texture. To ensure a uniform pressure on the pile of paper and felting the workmen placed thin bevelled boards around the top of the post, for without this precaution the centre would have received more pressure than the edges. The results of these apparently simple innovations are reflected in the old papers, and without a knowledge of the different methods of working it is not possible to determine the age or origin of antique papers.

After pressing, the weight of the paper and felts from the loss of the water had been reduced tenfold, and the fibres of the sheets of paper had been so matted and felted together by the great pressure that the sheets were lifted from the woolen cloths without tearing, each sheet being a homogeneous piece of paper, although far from being entirely dry. The third workman in the process of old papermaking was known as the “layman,” and it was his duty to free each sheet of paper from the interleaving felts and to place the sheets in a neat and even pile, one upon another, on an inclined stool or bench (Figures 157, 158, 159). The felts were returned to the concher to be used in making the following post. These pure wool cloths were expensive, and the old mills had but one set for each size of paper that they made. By long hours and diligent work it was possible for the three workmen to make twenty posts, or about five and one half reams of paper, a day. Had but a single mould been used, one man acting as both vatman and concher, scarcely one fourth of this amount would have been made.

After the sheets had been placed directly one upon another by the layman, the pile was again subjected to pressure. This procedure, although the pressure was light, brought out a little more water, which formed in drops upon the edges of the sheets. After this second pressing the sheets of paper were separated, again built into a pile, but in a different rotation, and subjected to a little
Fig. 157 The workers are taking the semi-dry paper from the felts after the initial pressing. The paper will be stacked in a neat pile, ready for the second pressing in the "dry" press, as shown in Figure 153.

Fig. 158 These two companion photographs were made in 1936 in one of the remaining seventeenth-century paper mills of Auvergne, an old province of France. Both photographs were made by Georges Degaast, French bibliographer.

Heavier pressure than could have been given before, owing to the tendency of the sheets to stick together. This rearrangement of the sheets was repeated until the paper acquired the desired smoothness of finish. The roughness of much of this paper previous to the sixteenth century would indicate that before that time the exchanging or parting was not in practice in some localities, the paper evidently having received no finishing after removal from the woollen felts. In an examination of old paper, especially Italian and Dutch, it will be noticed that many of the sheets retain the impressions left by the material upon which they were couched. The early American papermakers did not devote much time or labour to the exchanging, although this procedure was, and still is, the secret of giving to handmade paper a beautiful finish and texture.

The next process was the drying of the paper, which was one of the most particular operations of the mill. The paper was taken from the pile, after the last pressing, in "spurs" of four or five sheets, as in this moist state they adhered together. Had the sheets been dried separately they would have wrinkled, but when taken in spur the paper dried smoothly and without excessive curling. The drying-lofts of the old paper mills were situated in the top storeys of the buildings, where the air was reasonably free from...
particles of dirt and soot. The walls of these lofts were fitted with sliding wooden shutters which could be shifted to let in or exclude the air. The spurs of paper were hung over ropes that had been woven from cow- or horse-hair, coated with beeswax. These heavy ropes, supported by horizontal wooden frames called “tribbles” or “trebles,” were stretched throughout the loft, and the entrance of the air was arranged so that it came in contact with the full breadth of the sheets and not against the edges of the paper. Ropes are still used in European mills for drying handmade paper, but the paper mills of America in the days of loft drying employed round or half-round wooden poles for this purpose.

In the fifteenth- and sixteenth-century mills the drying was carried on in the most primitive manner, and it is not unusual in paper from this period to find stains through the middle of the sheets caused by the hair ropes upon which they had been hung to dry (Figures 160, 161). During the development of papermaking in America some of the mills transported their paper to the printers before it had dried thoroughly, as the makers were not able to supply the demand with sufficient rapidity. In many folio volumes, particularly from the seventeenth century, the pages bulged in the centres, causing the leaves to lie in ridges, somewhat in the shape of a diamond. While this defect is more noticeable in folios, it may be found in smaller books also. It was caused by the paper not having been exchanged or pressed sufficiently. During the drying the weight of the paper stretched the sheets, causing them to bulge in the centres. The Oriental papers were dried in various ways: upon the moulds on which they had been formed (Figures 42, 43, 46, 172); or spread flat against boards (Figures 162, 163, 164, 166, 177); or brushed against smooth masonry walls in the sun (Figures 167, 168, 170); also, upon ropes or poles (Figures 169, 178), and spread upon the ground (as shown in Figures 165 and 171). In drying paper against plaster walls the sheets were held rigid and flat, so that many of the Oriental papers are unusually smooth, especially on one side.

* The wooden “trebles” were pierced with holes at evenly spaced intervals for the support of the hair ropes, which were known as “treble-lines.” The word “treble” may have come originally from the ropes having been formed of three strands, but this is uncertain; the precise origin of the word remains obscure.

Fig. 160 The drying-loft of a paper mill. The “spurs” of paper are being hung upon ropes by means of the “T,” shown in Fig. 5 in the plate. This same method of drying paper is in use in Europe at the present time. From the engraving in the work (1774) by Nicolas Desmaretas.
Fig. 161  The drying-loft of a seventeenth-century French paper mill. The paper was hung upon hair ropes; the shutters for the entrance or exclusion of air appear at the right of the picture. Photograph by Georges Degaast.

Fig. 162  The Japanese paper-makers brush their paper upon smooth wooden boards for drying. A coir-fibre brush used in "pasting" the paper to the boards is shown in Figure 107. Photograph made in 1933 in Ogawa-Machi, Saitama Prefecture, Japan.

Fig. 163  In Japan the moist sheets of paper are "pasted" against boards for drying.

Fig. 164  In southern Korea the paper is dried upon wooden boards, in the same manner as in Japan. This method originated in China and was introduced into Japan from Korea.

Fig. 165  Drying paper in the village of Ompet, central Korea. This paper would eventually be laminated and used on the floors of native Korean houses. The boy would think nothing of carrying his burden to Seoul, a distance of eight or ten miles.

Fig. 166  Drying paper in India. The individual sheets of newly made paper are "pasted" against a smooth metal plate. This is an improvement on the old method of placing the sheets against plaster walls. Autshai, Bengal, India.

Fig. 167  In India the moist sheets of newly made paper are spread with a brush against plaster walls for drying. Photograph made near the ancient paper centre of Salkot, Punjab, northern India.
Fig. 168  Drying paper in China in the seventeenth century by placing the newly formed, moist sheets against a heated wall. This same method is in use in both China and Indo-China at the present time. (From T'ien kung k'ai wu, by Sung Ying-hsing, 1634.)

Fig. 169  Drying paper over cow-hair ropes. Salkot, Punjab, India.

Fig. 170  After the moist sheets of paper have dried they fall to the ground from the smooth plaster walls. In India the paper is spread against the walls by the use of brushes, shown in Figure 176. Photograph made in 1937 in the papermaking district of Salkot, Punjab, India.

Fig. 171  Drying paper in China. In the papermaking districts it is not unusual to see whole hillsides literally covered with drying paper.

Fig. 172  In Siam the paper is dried upon the moulds on which it was formed, in the manner used in China in the second century. The long, narrow moulds form paper that is suitable in shape for the folding books of Siam. The elderly papermaker is Tym Niltongkam, now deceased, Bangsoom, Siam.
The drying completed, the old European papermakers dipped their paper into an animal size that had been made from the parings of hides, which they procured from the parchment-makers. It was necessary to size the paper so that it would be impervious to ink, but sizing was more needed in writing than in printing papers. Many books of the fifteenth century were printed upon paper that had not been sized, this extra treatment not being essential for a type impression. The sizing was accomplished by a worker holding a number of sheets with the aid of two wooden sticks and dipping the paper into the warm glutinous liquid. The sheets were then pressed to extract the superfluous gelatine. This crude method of sizing the paper was extremely wasteful, as many sheets were torn and bruised beyond use. The sizing room of the early Occidental paper mills was for this reason known as the "slaughter house." One of the earliest Oriental methods of sizing paper consisted in covering the surface of the sheets with a thin coating of gypsum. The next improvement was to render the body of the paper, as well as the surface, impermeable to ink by the use of lichen, starch, or rice flour (Figure 173). The Chinese used starch as a size for paper as early as A.D. 788.

In an examination of more than a hundred different volumes of incunabula (books printed in Europe before 1501) I have found that the papermakers of the fifteenth century followed no definite formula as to the sizing of their papers; many of the sheets are heavily sized, others contain a limited amount of sizing, and a small number no sizing at all. Most of the modern European hand-made papers, like some papers used in the early centuries of printing, are sized too densely and give the printer who employs the old traditional hand press no end of difficulty in his work. The earliest European book to mention the actual sizing of paper is the small volume entitled *Papyrus sive Ars conficiendae Papyri*, compiled by J. Imberdis, Claromont, and issued in 1693. This was the first treatise on the art of papermaking to be published in France. Father Imberdis was a Jesuit, and being a native of Ambert in Auvergne, he was familiar with the paper mills of that district, a very old seat of French papermaking; some historians contend that the first paper mills of France were set up in Auvergne. Judging from his detailed account of papermaking, Father Imberdis must have possessed a most observant and inquisitive mind. The entire treatise is in the nature of a descriptive poem giving a semi-technical version of papermaking as it was then practised in France. He states, with keen insight and knowledge uncommon in the layman, that the sheets of paper are far from perfect when they leave the mould, for even after being formed thereon the paper must pass through numerous hands and be subjected to a thousand manipulations before it is ready to leave the mill. No one but a maker of handmade paper can truly appreciate the significance of this statement. The author of the poem gives two methods of testing paper for its writing qualities. The first is to crumple the paper in the hands; if the sound resembles that of parchment under the same treatment the paper should prove satisfactory, as this shows it is well sized with animal glue. The second test is to wet the paper with the tongue; if the saliva penetrates through the sheet, showing that there is little or no sizing, the paper is unfit for the application of fluid writing ink. In men-