Some Notes on Paper and Papermaking in Europe from the Fourteenth to the Nineteenth Century

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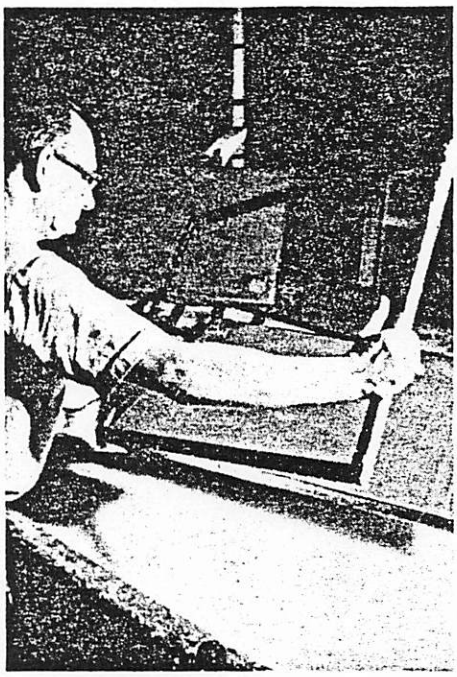
The rapid development and spread of the art of printmaking and printing in the early fifteenth century would not have been possible if a suitable material had not been available. Paper was not produced in large quantities in Europe until the fourteenth century, and it is certainly no coincidence that the great production of woodcuts began at that time.

The early papers were mainly made from linen and cotton rag, whereas the chief source of paper fibers today is wood. It was not until after 1840, when the invention of a wood grinding machine made production of wood pulp economically feasible, that wood-pulp paper was made on a large scale. The basic constituent of both types of paper is cellulose. Paper made of wood pulp is, however, not as durable as that made of rag. The presence of lignin in wood fibers is one of the main causes for the degradation of papers made of such fibers. There are other equally important factors affecting the durability of paper, such as the use of bleaching agents, fillers, and of alum, that are responsible for the lesser quality of modern papers, both machine and handmade.

The sources of papermaking fibers can be divided into four groups: (1) cotton (cotton, linen, ramie, and hemp); (2) woodpulp (mechanical, and chemical sulfite, sulfate soda); (3) grass (including esparto and bamboos); and (4) rope.[1] I shall only discuss the two more common groups, cotton and wood. The fibers of the cotton group are quite long (linen: from 25-30 mm; cotton: from 20-40 mm), and make the strongest and most stable papers. The fibers of the woodpulp group are shorter, their natural full length is about 3 mm.[1] They are poor in strength in comparison to the fibers of the cotton group, and more apt to deteriorate since they are more easily hydrolized and oxidized.[2]

Not only the nature of the fibers, but also the way in which they interlock contribute to the strength of paper. Handmade papers are equally strong in each direction of the sheet, since the fibers are distributed at random. The strength of machine-made papers is much greater in the machine direction than across it, and it is unequal in



1. Vatman about to place deckle on mold, J. Barcham Green, Ltd., Kent, England

stretch. The paper machine was not invented until the last decade of the eighteeenth century, at about the same time that the early experiments with wood pulp were made. As in the case of the wood pulp, this invention did not become popular until after the development of the Foudrinier machine in 1807 made papermaking by machine practical and profitable.

The introduction of new machinery, together with the practice of bleaching and the use of rosin size in the early part of the nineteenth century, created many problems. The papers of this period are usually of poor quality and not suitable for artists' work such as intaglio and relief printing. A paper to be "printable" has to have certain optical and mechanical properties. These are uniformity, smoothness, opacity, and ink receptivity (evenness of absorption of ink),[3] the paper should also be strong and durable. Rag paper, especially when made by hand, is superior to paper made by any other method. Printmakers and artists throughout the centuries have been aware of this fact and have tended to use only rag paper in their work.

The manufacture of handmade rag paper in the fourteenth century and today is essentially the same. The first step is the preparation of the pulp. The raw materials must be reduced to fibers that are then suspended in water and deposited into a thin, compact web. During the early days of papermaking, the rags immersed in water were

2. Vatman dipping mold, J. Barcham Green, Ltd., Kent, England

pounded in log or stone troughs by rows of wooden hammers until they were reduced to pulp. Into this beaten pulp the vatman dipped his mold, a wooden frame with a wire screen which collected the pulp and allowed the water to run off. The vatman then shook the mold from right to left and from back to front. These motions cross and mat the fibers and make the paper equally strong in both directions. A second wooden frame, the deckle, lies on top of the mold and serves to keep the pulp from running off the edges. The uneven edges of handmade paper are a result of the uneven distribution

3. Vatman lifting mold out of vat, J. Barcham Green, Ltd., Kent, England

of the pulp along the sides of the deckle. Once the pulp has dried sufficiently on the mold, the sheet was put on a smooth piece of material, called felt. This process was repeated until a stack of 144 sheets, a post, had accumulated. The post was then taken to be pressed to expel the excess water from the sheets. After pressing, the sheets were hung up to dry, four or five sheets together to prevent warping.

European papers from the thirteenth to the middle of the eighteenth century are characterized by the chain and laid lines. They are a direct result of the construction of the mold. The chain lines are more prominent and usually run parallel to the short side of the paper. They are spaced farther apart than the laid lines, usually at the distance of about an inch. The spacing in paper made prior to 1500 varies from twenty-eight to forty millimeters; thereafter the chain lines were eighteen to twenty-five millimeters apart.[4] The laid lines are caused by fine wires which are laced to the chain wires and run perpendicular to the chain lines. From early times, the number of these wires to the inch was gradually increased. Thus, the paper on which the Gutenberg Bible was printed had only twenty-eight laid lines to the inch.

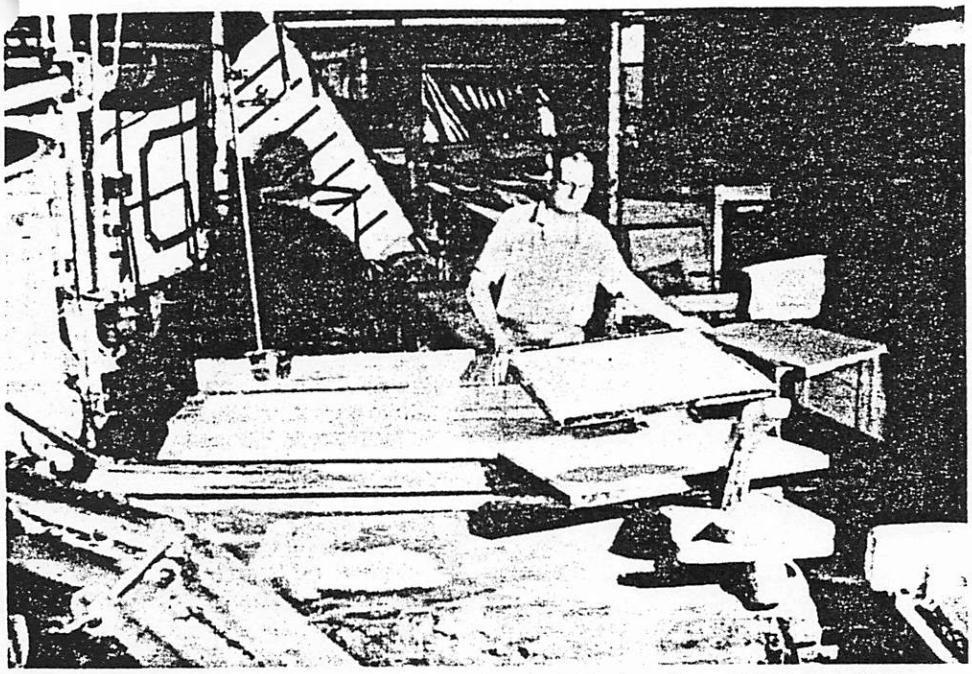
Until the latter part of the eighteenth century the laid wires had been attached directly to the wooden ribs which act as supporting struts or beams for the mold frame. The extra width of the wooden ribs tended to retard the heavy drainage of water on either side of the chain wires so that more pulp collected there. This "antique laid" was eliminated by attaching the laid wires to wires running above and parallel to the wooden supports. After the middle of the eighteenth century another type of screen was introduced by John Baskerville. The laid and chain wires were replaced by a woven screen, similar to modern mosquito screening. This wove type of mold produces a much smoother paper and leaves only a very indistinct, fabriclike impression on the paper. Wove paper was first made in England in the 1750s and in France in 1782.

Another variable in the manufacture of paper is the preparation and quality of the pulp used. Until about 1780, paper usually assumed the same tone as the material from which it was made. It varied from a creamy white for high-grade paper to a light coffee tone and even gray in paper made from poor quality rags. With the discovery of chlorine in 1774, it became possible to obtain white paper even from poor materials. Bleaching, which is not absolutely necessary in the preparation of rag pulp, is essential to the preparation of wood pulp. This is a distinct disadvantage, since paper will soon become brittle and perish if traces of the bleaching solution remain in the pulp. The shade or tint of early paper was also affected by the water used in its production, since any impurities contained in it would be imparted to the pulp.

The color of the early papers could also be affected by the process of fermentation, which served to weaken the structure of the rags prior to maceration. In the sixteenth century when printing became more widespread, the demand for paper increased and the treatment of materials was often hur-

4. The sheet as it comes out of the vat, J. Barcham Green, Ltd., Kent, England

Photographs courtesy Andrews, Nelson, Whitehead, New York



5. A view of the vat with sheets draining on the stay, J. Barcham Green, Ltd., Kent, England.

ried up by addition of lime water (lime water had already been in use much earlier). Paper made from rags prepared in this manner is not as strong as naturally fermented paper, and it has been suggested that the yellow tint especially of sixteenth-century paper is a result of the treatment with lime.[5] Another undesirable result of fermentation with lime is the appearance of rust colored spots; these are seldom found on paper made before 1500.[6]

Fermentation with lime water was later abandoned because of better beating methods. The Hollander, which replaced the old pulp stampers by the early eighteenth century, was invented around 1680; it must have existed in a primitive form before 1673. The early Hollander was quite simple, a wooden cylinder with thirty or more blades rotated in an oblong tub that ground the rag material against a stone or metal bedplate. This process eliminated the need to ferment the rags and was also much more efficient than the stampers. The advent of a more mechanized pulping process brought with it other problems. As the teeth of the cylinders disintegrated with time, small particles of metallic iron become embedded in the pulp and eventually cause rust spots to appear on the paper. Furthermore, the fibers of the rags when subjected to Hollander beating were shorter than those produced by the old wooden stampers, and the resulting paper was not as strong as the earlier papers.

The surface texture of fifteenth-century papers was relatively rough, since it received little finishing after it had dried. Impressions of the material of the felts are quite obvious on Italian and Dutch papers made before 1500.[7] Beginning with the sixteenth century, the felts were removed after pressing, and the sheets were pressed again and again until the surface of the paper was of the required finish. This process was called sweating. Most of the paper for printing was also burnished by hand with a smooth stone after it had been sized. Burnishing by hand could result in an uneven streaked surface. After 1600, the pressing hammer replaced the manual process and paper finished by this mechanical method had a more uniform and smooth surface. The paper hammer is an invention of the early sixteenth century, and therefore both types of finishes can be found in early paper. For this reason, the presence of streaks is not useful for the dating of old paper. Later on, the hammer was replaced by the calender roll.

Before paper was burnished it usually was sized to make it less absorbent to ink, especially in the case of writing paper. From the fourteenth century on, animal glue was used in Europe for the sizing of paper. After the sheets had dried, they were dipped into a bath of gelatin and then hung up to dry. A low grade of size may produce discoloration upon exposure to light. Animal size can also aid the development of mold and microorganisms which produce brown stains in paper. Animal size was used in papermaking exclusively until after 1806, when the discovery of rosin sizes made sizing in the vat possible.[8] It seems to be generally agreed that rosin has a bad effect on paper fibers. Most modern papers contain sufficient quantities of rosin to seriously affect their lasting quality.[9]

Rosin is soluble in water; in order to coat the paper fibers and adhere to them it has to be made insoluble. For this purpose alum (aluminum sulphate) is added to the pulp in papermaking. The proportions of alum to rosin must be carefully controlled since an excess of the slightly acidic alum causes paper deterioration. Cellulose is attacked by acid, even under the most favorable conditions, and becomes discolored, fragile, and brittle. This effect is even more pronounced if chlorides are present in the pulp from the bleaching process.

Another cause for paper deterioration is the use of fillers, a common practice in the early nineteenth century when paper began to be sold by weight.[10] Fillers used were chalk, china clay, and gypsum. This practice, as so many others of early nineteenth-century papermaking, can be detrimental to the strength and quality of the paper, since an excess of filler in paper weakens its fibrous structure. Fortunately the use of fillers in handmade paper is rare.

The presence of chlorides, rosin, filler, and alum in paper can be chemically tested. Such tests might be helpful in detecting forgeries, at least in cases where the print in question was made before the first use of the respective substances in papermaking. However, they would not furnish conclusive proof, since most old prints are likely to have been treated with one or the other substance to conserve, repair, or clean them.

Most of the inherent faults in early paper are due not so much to chemical reactions, as to mechanical factors. Old paper when held up to the light often reveals round semitransparent spots about the size of a dime. They were caused by drops of water falling from the worker's hands onto the moist sheet after dipping. These spots usually occur along the sides of the sheet and can also be found in modern handmade paper. There can also be seen in old papers ruffled or blurred chain and laid lines; they occurred if the coucher had let the mold slip with its thin, still moist deposit of pulp. Sometimes a fine line shows across the middle of a fifteenth- or sixteenth-century sheet. These lines were caused by the hair ropes on which the paper was hung to dry. Another de-

fect, encountered usually in old paper, is a peppered appearance throughout the sheet; it is due to the knotting of certain of the fibers. It is also not uncommon to find hairs, wood, silk, and other fine extraneous matter embedded in handmade paper.

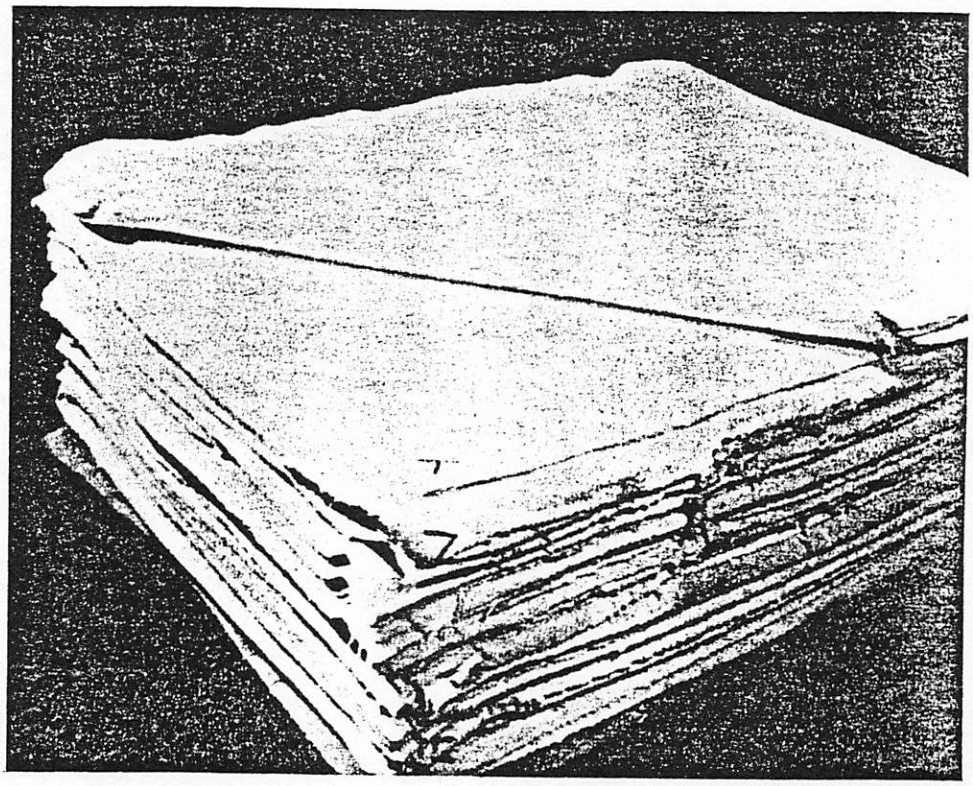
Yet another means to identify old and new paper is the watermark. Its first documented appearance in Europe is in Italian papers of the late thirteenth century; by the fifteenth century it appears on most of the paper produced in Europe. There is evidence that in Switzerland, paper without watermarks was quite common until the 1540s,[11] and this may be the case for other countries. Whatever their origin, it seems that by the sixteenth century watermarks served solely to indicate the quality and/or size of the paper they marked.[12] On paper dating after the middle of the sixteenth century, a subsidiary watermark, the countermark, can be found. It was placed in the middle of the sheet, but opposite the main mark. As a rule, it shows the name or initials of the maker. Venetian paper is one early exception; by 1483, the initials were separated from the main mark and put on the bottom or top corner of the sheet.[13]

The value of watermarks in the authentication of prints is limited, and most writers who have dealt with the problem agree that they are of little help in the exact dating of prints. Nor are watermarks useful in determining the place of origin of a given print. The reasons are obvious: watermarks can and were easily imitated, old molds are known to have been reused,[14] and, even if one could establish the date of a paper through its watermark, there is no guarantee that it was used for printing at the time and place of its manufacture, especially since often the paper was imported and not locally produced. We know that Rembrandt, for example, used paper from Germany, Switzerland, and France, he even used oriental paper.[15] This kind of knowledge is meaningful only if one could establish exactly who imported paper of a given kind, as well as where and when it was made and sold.

There is little published on the paper trade in Europe from the fifteenth to the seventeenth century. The following is a rough outline of the general trends of European paper trade during that period. The first documented paper mill in Europe, outside of Spain, is that of Fabriano, Italy, in 1268. By the middle of the fourteenth century, France had its own papermills,[16] and at about the same time the first mills appeared in south Germany.[17] The first documented papermill in Germany is that of Ulmer Stromer in 1390 at Nuremberg.[18] Blum in his *Origin of Paper* states that Germany was one of the greatest paper producers in the fifteenth century.[19] However, at Augsburg the majority of incunables of the early part of the century was still printed on Italian paper.[20] This practice seems to me to contradict Blum's observation. It is reasonable to assume that German paper mills could meet the demands of the local markets by the end of the century, since export to Switzerland begins early in the following century.[21]

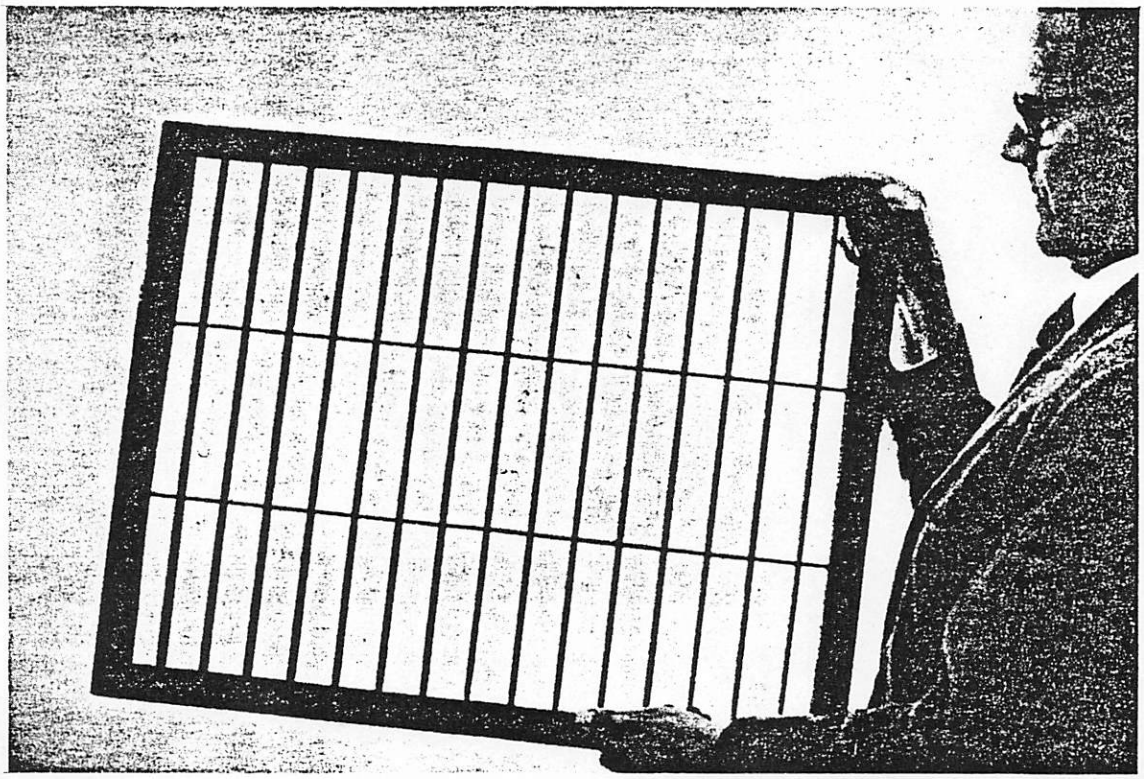
By the second half of the seventeenth century, German papermakers were organized in guilds; their laws, however, were kept secret, and they seem to have kept themselves apart from other trades. There are some parallels to German customs in Holland in the rules pertaining to the conduct of apprentices. In other respects, the development of guilds in the various European countries probably followed local patterns. The tendency towards secrecy, especially in Germany, seems to have stemmed from the early days of the trade when few people outside Italy knew how to make paper.[22]

In Switzerland, too, the "secret" of papermaking was obtained from Italy. The mills of the early fifteenth century were established near the borders and depended largely on Italian labor. Interestingly enough, most of the major Swiss mills of the sixteenth century still had at least one Italian working for them. Before the national production in Switzerland, paper was imported



6. A post of felts and paper after pressing, J. Barcham Green, Ltd., Kent, England

7. A layer throwing felt over a sheet of newly-made paper.
J. Barcham Green, Ltd., Kent England



8. An antique laid mold with watermarks, J. Barcham Green, Ltd., Kent, England

from Italy and France, and in the early sixteenth century some paper was obtained from the mills of south Germany. With the growth of its own paper industry, Switzerland began to export paper, and by the seventeenth century Basel had become an important supplier of paper for the Dutch.[23]

In Holland, papermaking on a larger scale began in 1586 when Jan Luipart and Hans van Aelst were authorized to manufacture paper near Dordrecht. Until then, paper had been mainly imported from France, but also Italy, Switzerland, and Germany. The wars from 1568-1648 curtailed these relations, and the Dutch had to look for paper elsewhere. They began to import their paper from Basel, and until the first half of the seventeenth century the greater quantities of paper were imported from there.[24] It is also in this period that Indian and Japanese papers were first imported into Europe via the Dutch ports.[25]

Paper was also imported from Germany; the German mills were, however, mostly destroyed during the Thirty Years' War (1618-48). By the middle of the century, the Dutch import of Swiss and German paper declined, and paper was again imported from France, where it was made expressly for the Dutch. By this time, the invention of the Hollander had boosted the national paper production, and Holland became famous for its fine, white paper. The Dutch were the chief suppliers of fine white paper for England until the eighteenth century; they also supplied blue, gray, and brown paper for the English market.[26] England's first paper mill had been established in 1495 by John Tate and John Spillman's was established by 1588. But it wasn't until the middle of the eighteeenth century when the Whatmans began making paper that English paper production became really significant.

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9. The antique method of macerating paper at the Musée Historique du Papier Au Moulin Richard-de-Bas, Ambert, France (founded 1326 A.D.)

[1] H. N. Lee, "Established Methods for the Examination of Paper," *Technical Studies*, IV, October 1921, p. 4.
[2] R. J. Gettens and George L. Stout, *Painting Materials*, New York, 1942, pp. 242-243.
[3] J. P. Casey, *Pulp and Paper Chemistry and Chemical Technology*, London, 1961, II, p. 1768.

[4] E. J. Labarre, *Dictionary and Encyclopedia of Paper and Papermaking*, Amsterdam, 1952, p. 44.

[5] D. Hunter, *Papermaking*, New York, 1947, pp. 154-55; Charles Singer et at., eds., *A History of Technology*, Oxford, 1957, III, p. 413.

[6] Hunter, p. 154.

[7] Ibid., p. 186.

[8] A Renker, "Moritz Friedrich Illig 1777-1845, Inventor of Rosin Sizing," *Papermaker*, XXX, 2, 1961, p. 38.

[9] Lee, p. 4.

[10] Hunter, p. 490.

[11] Peter Tschudin, "The Old Mills of Switzerland and their History," part 11, *Papermaker*, XXXI, 1, 1963, p. 6.

[12] By 1540, the small coat of arms of Zurich indicated that the paper was for writing, and the best paper had the lion as mark. Ibid., part III, XXXII, 2, 1963, p. 31. At about the same time, a statute in Troyes sets down rules for the making of paper, and fixes the watermark to indicate the size and quality of the paper. André Blum, *On the Origin of Paper*, trans. H. M. Lydenberg, New York, 1934, p. 412. In Ravensburg, watermarks also indicate the quality of paper. Ibid., p. 41.

[13] Labarre, p. 60; countermarks did not become common in France until after 1567.

[14] Hunter, p. 224; books of the fifteenth and sixteenth century often contain paper with different watermarks and of varying thickness. This indicates that printers had to get their paper from various sources to meet the growing demand for printed material.

[15] *Rembrandt: Experimental Etcher*, exhibition catalogue, Boston, Museum of Fine Arts, 1969, pp. 178, 180. Indian paper has a thin texture, a white dull surface, and prints clearly; Japanese paper is very absorbent and needs to be printed from a plate with little ink; it has a rich yellow tone. A. M. Hind, *A History of Engraving and Etching*, New York, 1963, pp. 16-17.

[16] Hunter, p. 475.

[17] Blum, p. 320.

[18] Hunter, p. 233. Spain, first mill at Xativa, 1150, Germany, there were probably mills at Cologne, Augsburg, and Mainz by 1320; Flanders, 1405; Switzerland, ca. 1433 at Basle; England, 1495; U. S. A., 1690 (Klaus Ritten house).

[19] Blum, p. 331. A. Renker, "Some Curious Customs of Old Time Papermaking in Germany," *Papermaker*, XXX, 1, 1961, p. 3.

[20] H. H. Schmid, *Augsburger Einzelformschnitt und Buchillustration im 15ten Jahrhundert*, Baden-Baden, 1958, p. 12.

[21] This is also confirmed by Dürer's remark to Pirckheimer in a letter from Venice in 1506: "Item lasst mich wissen, was Papiers Ihr meint dass ich kaufen soll. Wann ich weiss kein subtillers denn als wir doheim kauft hand." E. Heidrich, ed., *Albrecht Dürers Schriftlicher Nachlass*, Berlin, p. 138.

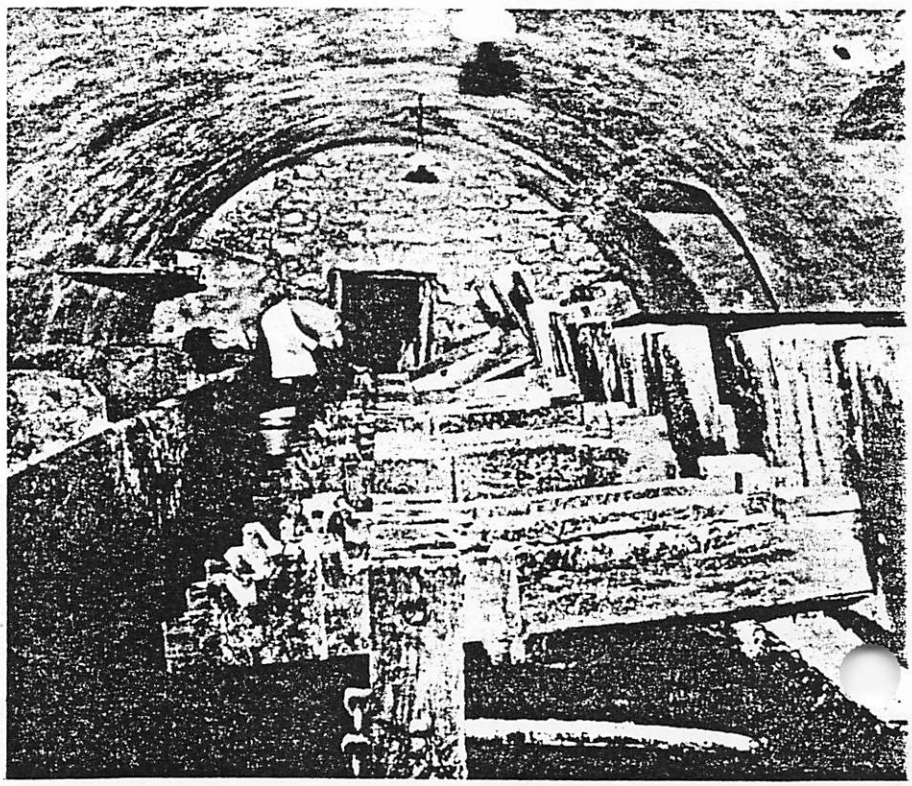
[22] Stromer in 1390 had Italians working in his mill and went so far as to imprison them to keep the "secret" of papermaking from his fellow citizens.

[23] Tschudin, part III, XXXII, 2, p. 45. At that time, the prices for rags were rather high; the Swiss government therefore regulated the prices for paper, which were kept low.

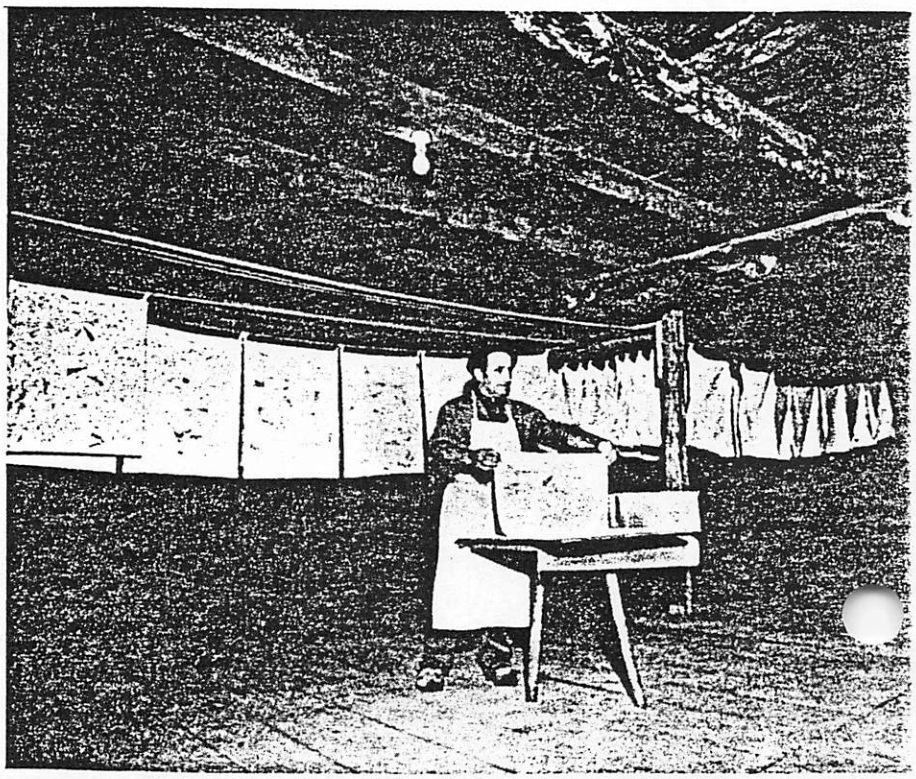
[24] H. Voorn, "Some Notes on the History of Dutch Paper Commerce," *Papermaker*, XXXII, 2, 1963, p. 3.

[25] See note 15, above.

[26] In 1586, the mill in Dordrecht had been granted the privilege to make blue paper, and in the early 1600s, 800-1000 reams annually were imported by the English. Labarre, p. 84; Voorn, XXXII, 2, pp. 4, 12.



10. The antique vat showing a sheet just removed at the Musée Historique du Papier Au Moulin Richard-de-Bas, Ambert, France



11. The drying room with newly formed sheets hanging on lines. Musée Historique du Papier Au Moulin Richard-de-Bas, Ambert, France