marking, but to the fact that certain Oriental fibres are not generally available in the Occident, at least not on a scale sufficiently abundant for papermaking.

Upon completion of my last journey in Japan, after I had inspected several hundred handmade and machine paper mills, and I was leaving for Korea and Manchuria, my kind friends the Japanese papermakers arranged a banquet in my honour. I learned that my companions were considering the purchase of an elaborate gift that was to be presented to me on the night of the final dinner.
I was naturally reluctant to accept anything that might be expensive and cause these good people any hardship, as even in 1935 they were complaining about inflation and the excessive cost of living. I suggested that they give me something readily procurable and inexpensive — for instance, some seeds of the mitsumata and gampi plants. This they cheerfully agreed to do. When the rather tiring banquet was at last over and the guests were about to depart, I was ceremoniously presented with a finely made box fitted with two compartments: one side held a number of ounces of the coveted mitsumata seeds and the opposite space was filled with the seeds of the gampi. In all innocence I accepted the token of friendship and told my hosts that I would plant the seeds in my own garden in America. Little did I suspect on that last evening of my visit in beautiful Japan that my kind and obliging Japanese friends had caused every seed that had been given to me to be boiled until all possibility of germination had been destroyed!

The more experienced papermakers of Japan were of the opinion
that the fibres beaten by the hand mallets made better paper than those macerated in the "Hollander" type of beater. This is no doubt true as the hand beating draws out the fibres, leaving them long, strong, and tenacious. To emulate this hand beating the Japanese constructed mechanically operated stampers that very closely duplicate the hand action. In Figures 126 and 127 two types of such a machine are shown, and to a great extent the material reduced to fibre in this manner is superior to that produced in a regulation power beater. The Japanese were adverse to show these machines and I had no little difficulty in procuring the two photographs. For the most part, the large handmade paper mills of Japan are equipped with small beaters of the European style (Figures 128, 129).

When papermaking was first introduced into Europe, the meth-
Fig. 124 Japanese girls picking the specks and foreign matter from the bark after boiling, preliminary to the beating process. In the Imperial paper mill, near Tokyo, Japan.

Fig. 125 The barks of the mulberry, mitsumata, and gampi must undergo a slight boiling, or cooking, before they are ready for beating. After the boiling process the bark is freed of specks as shown in Figure 124. This photograph was made in one of the largest handmade paper mills of Japan.

Fig. 126 A mechanical beating equipment used in Japan that emulates the old hand method of macerating the mulberry, mitsumata, and gampi barks. This machine is less efficient than the more modern set of stampers shown in Figure 127.

Fig. 127 In Japan the handmade papermakers have endeavoured to duplicate the superior qualities of hand beating by mechanical means. This medieval-appearing contrivance, based on the ancient principle of stampers, is thorough and efficient.

Fig. 128 Small Hollander such as used in the large and efficient handmade paper mills of Japan. It is only in the “company” mills that equipment of this modern kind is employed. In many of the small “cottage” mills the material is beaten by hand.

ods of the East were no doubt used for the maceration of the pulp. It did not take the Europeans long, however, to devise a better method of beating, for about 1151 there was invented at Xàtiva (now Játiva or St. Felipe de Játiva), an ancient city of Valencia, Spain, a stamping-mill operated by water-power. At that period linen and cotton were used as material for making paper. For the preliminary treatment well-worn cloth was wetted and pressed into balls, which were left in piles for six weeks or two months, being kept moist. This caused a fermentation, manifested by the increased temperature of the mass, the rags assuming a peculiar colour, not unlike that of the dregs of wine. This method of preparation was wasteful in the extreme, as fully one third of the material was rotted beyond use; but the portion suited for paper was tender and easily beaten, so that the action of the newly invented stamping-mills had immediate effect upon the disintegrated rags.

During the first centuries of papermaking in Europe the demand for paper was slight, but after the advent of printing from movable types in the middle of the fifteenth century the demand became greater, and by the close of the century the art of papermaking on the Continent had assumed considerable proportions and had spread to many places where the craft had not hitherto
been practised. During this period linen was used in wastefully large quantities, as there was considerable loss of the material during the fermenting process and also in the actual stamping of the rags into fibre. In the fifteenth century in Europe there was not of course the great variety of cloth that there is at present, so that the sorting of the rags was not a difficult problem as it is today. The linen and cotton fabrics of that period were naturally all woven by hand and, being free from chemicals and bleaching agents, were ideal materials from which to fabricate paper. Linen of the whitest kind was desired, but cotton was not rejected. When materials of different weights and substances were used, they were, in the best mills, pounded or stamped separately and mixed after beating, for without this precaution much of the fibre would have been lost, the finer particles escaping with the water during the lengthy process of reducing the tougher and coarser fabrics.

In the mills of less importance, where the rags were fewer, they were left to decompose for longer periods as the heaps, being smaller, did not heat so rapidly. The length of time for this process also depended upon the quality of the rags; the finest linen did not break down so quickly as the coarse, and linen that had been worn as clothing required more time than new material, because the internal humidity that disposed the fibres to fermentation was more considerable in new or coarse than in worn or fine linen. When slight traces of fungi appeared on the heaps or piles of rags it was considered that the process was well under way. In some

* It is possible that the treatment of the rags has caused much of the “foxing” prevalent in books from the beginning of the sixteenth century on to about the middle of the nineteenth century. The descriptive term “foxing” was probably applied to the reddish-brown spots on paper account of the resemblance to the rusty-brown coat of the fox. According to Flans and Beckwith writing in the Library Quarterly under the title of “Notes on the Causes and Prevention of ‘Foxing’ in Books” (October 1933, Volume V, No. 4, pages 407-18): “... One seldom finds examples of ‘foxing’ in incunabula, or books printed before 1501. On the other hand, very often titles issued from the Baskerville press during the third quarter of the eighteenth century show signs of discoloration.” The European papers of the fifteenth and previous centuries give evidence that the papermakers exercised extreme care in the preparation of the rags, but after this period, when printing became more general, the demand for paper increased tremendously and to speed the process the makers of paper were forced to hurry the treatment of the material. They did not use sufficient water or allow enough time for the proper cleansing of the fibres. There is opportunity for study of the cause and prevention of “foxing,” so disfiguring in the papers of many valuable books.

mills lime was thrown upon the rags to assist in the disintegration, but this was detrimental to the material, and paper made from material so treated was never so strong or lasting as that which had been allowed to ferment naturally. In the eighteenth century the use of lime was absolutely prohibited in France. After the fermentation process the rags were washed and rubbed by hand, for during the fermentation the material acquired a saddened yellow tone which the workers endeavoured to eliminate. This step was accomplished only with difficulty; in fact, most of the paper from the early mills shows a pleasing creamy tint, to a great extent the result of the fermenting process.

After the cloth had been reduced to a broken and flaccid state by the mild form of disintegration and had been at least partially cleansed by washing, it was ready to be triturated into pulp for forming the actual sheets of paper. The stamping-mills that were originated in Spain consisted of rows of great wooden hammers, or mallets, which were caused to rise and fall by means of a series of cams on a stout axis or axle (Figure 130). These hammers, or pestles, operated up and down in troughs into which the rags were thrown; the troughs or “vat-holes,” as they were termed, were
the Oriental artisans the principles of papermaking, it was not long before they had put to use their own methods in the entire operation—the rigid, metal-covered mould was devised, a better and less laborious process of beating was adopted, and streams and rivers were put to work to turn their paper mills. Yet after these innovations were brought into use the craft experienced but few changes over a period of several hundred years; in the fifteenth and sixteenth centuries European paper was made very much as it had been in the twelfth.

Toward the seventeenth century the mills did show slight changes, but the principle of the *modus operandi* remained unaltered. At this period the stampers were constructed on a larger scale and were a little more developed in their capacity, the stamps being divided into three classes. The first set of stampers or pestles were shod with rough iron teeth or spikes, which frayed the cloth while a stream of pure water ran into each stone or wooden trough and cleansed the rags, the discarded dirty water flowing off through holes in the sides of the receptacles, over which was placed woven horsehair screening to prevent the escape of any material that had already been beaten to fine fibre. This procedure replaced the more laborious method of hand washing used at the inception of papermaking in Europe. When the rags were partially cleansed and somewhat mangled, they were bailed out of the first set of troughs and placed under the next set of stamps, which were less heavily shod. In the second operation the stream of pure water was continued to complete the washing process. The fresh water was supplied through a wooden leader to each trough or vat-hole, either by gravity from a mountain spring or from the stream that furnished the locomotion for the stampers. The water was usually filtered through a series of large wooden reservoirs, each having an opening covered with iron bars placed closely together, which eliminated the gravel and the larger particles of dirt and vegetable matter from the water (*Figure 132*). The final treatment of the partly beaten rags, or half-stuff, was given by the third and last set of stampers, which were usually made of plain wood, without iron or steel facing. At this stage running water was excluded, for by this time the rags had become so macerated that much of the fibre would have been lost through the strainers or washing screens.
It is recorded that Ulman Stromer, who established a paper mill in Nürnberg about 1390, "employed two rollers (axes) which set eighteen stampers in motion." In an illustration in the Italian book on machinery by Vittorio Zonca, printed in Padua in 1607, the engraver depicts for the first time a set of these water-driven stampers (Figure 135). In this engraving there are eight stampers to one receptacle, while in the volume by Georg Andreas Böckler, published in Germany and dated 1662, three stampers are shown to each trough (Figure 136). According to the three-volume work by Sung Ying-hsing, this same type of power stamper (Figure 137) was in use in China for other purposes than papermaking as early as 1634, when the book was issued. The Chinese probably used the machine previous to this date; perhaps they were the first artisans to employ this mode of beating and the Europeans de-
developed the stampers for papermaking purposes from the Chinese machine. It is not possible to answer this question, but we do know that a water-power stamping-machine was first delineated in the Orient in 1634 and in the Occident in 1607. The Chinese stampers show four sets of cams and pounders. According to illustrations in the work by Leonhardt Christoph Sturm, published in 1718, there were in Europe at that time five sets of stampers to each stone or wooden trough and four troughs at each side of one axis, the axis and its cams actuating forty separate stamps, and one water-wheel turning the entire apparatus. The stamping-mills were slowly developed from the crude and cumbersome machine such as Zonca pictured, until a good German mill had as many as twenty-five troughs with four individual stampers to each trough, while French machines had from three to five stampers to each receptacle (Figure 138). These stamping-mills were used for the

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* In England during the latter part of the seventeenth century four patents were issued pertaining to the maceration of papermaking materials:
  
  A.D. 1682 to Nathaniel Bladen, of Inner Temple, London. "An Engine, Method, and Mill, whereby Hemp, Flax, Linen, Cotton, Cordage, Silk, Woolen, and all Sorts of Material thereof manner Pastebord and of Paper for Writing, Printing, and for all other Sorts of Uses, hath been or may be made, are Prepared and wrought into Paper and Pasteboard much Speedier and cheaper than by the Mills now used, being a New Invention, never yet Practised in any of our Kingdoms or Dominions, and of great Advantage to all our loving Subjects."

  A.D. 1684 to Christopher Jackson, of Rither, in our County of Kent. "A Mill or Engine, either for Wind or Water, which dissolves, Whitens, and Grindeth Raggs, and Prepareth all other Materials of Paper and Pasteboard hath been or may be made, in farre les Tyme than the Mills hitherto in use do."

  A.D. 1691 to John Tizard, of Wapping, in our County of Middlesex. "A Way by an Engine to be worked by one or more Men for the well and more easy pounding and bruising of raggs fitt to make paper, which said engine has never been used in England before."

  A.D. 1692 to Thomas Hutton. "A New Way of Makeing Paper in Great Quantities and with less Charge and Labour and more Advantage than ever hath been yet practiced in England or elsewhere, by a Mill or Engine to be Driven either by Windle, Sails, or Water Wheeles, and to work as Eighty or more Stampers at once, different from all other Mills now used."

The specifications of these four patents are meagre, so that it is not possible to determine the type of "engine" designated, but it may be supposed the inventions did not embody any of the principles of the "Holland." In 1696 the beating of papermaking materials is mentioned in an English book for the first time: in a book on machinery by Venturi Mandev, published in London under the title Mechanick Powers; or, the Mystery of Nature and
maceration of rags by the early American papermakers, but their use was discontinued in this country a number of years before they were entirely abandoned in Europe. The Wilcox mill of Pennsylvania was not established until 1729, but it is recorded that its first method of reducing rags to pulp was by the use of a stamping-mill. This was the third paper mill set up in America. It is not known when the stampers were discarded in this country, but it is thought that they remained in use until about the year 1780. With the use of these old machines the fibres of the cloth were slowly drawn out, almost to full length, which is one of the reasons the papers of the stamping-mill period show such remarkable strength and endurance. By making a study of old paper it is possible to tell by the peculiarities of the fibres in what manner they were reduced to pulp. The stampers did not cut or lacerate the delicate fibres; the action of these machines was rather to rub and fray the material.

The papermakers of Holland with their windmills found it difficult to compete with the mills of Germany, where there was plenty of water-power. The ingenious Dutch therefore tried to devise a method of macerating rags that would require less power than the stamping-mills and at the same time be more productive than the ancient method. In the latter part of the seventeenth century a Dutchman, whose name has been lost to posterity, conceived the idea of the cylinder beater for reducing rags to fibres suitable for the making of paper. This machine is known to this day as the “Hollander,” after the country of its invention. It consisted of an oblong wooden tub, rounded at both ends, in which revolved a solid wooden roll made from the trunk of a tree and fitted with about thirty iron knives. The linen and cotton rags circulated around the tub and were lacerated by the action of the metal bars of the roll revolving over a metal or stone bed-plate set in the bottom of the tub directly under the roll. The material was kept in constant motion by the impetus given by a backfall and by the rotation of the roll. With the invention of the Hollander the putrefaction of the rags ceased in some mills, the cloth being washed and beaten without preliminary treatment.

The Hollander was naturally first used in the country of its origin, but it is known that the invention was in use in Germany as early as 1710. In 1725 the papermaker Kelerstein in Saxony wrote: “The Hollander in Freiburg furnishes in one day as much pulp as eight stumper-holes do in eight days.” Even after the introduction of the Dutch beating-engine many mills in Germany and France, as well as in Italy, retained the old stampers for the breaking of rags, and employed the Hollanders to complete the beating. In 1716 one of the largest paper mills in Germany operated twenty-five sets of stampers, of four each, which supplied three dipping-vats with paper stock. This same mill in 1777 had thirteen sets of stampers and three Hollanders, which macerated sufficient stock for workmen to make paper from four dipping-vats. In 1829 this mill reduced the number of stampers to eight sets and increased the Hollanders to four. This equipment furnished the beaten stock to the same four vats. As early as 1760 one of the largest paper mills in France had discarded the stampers altogether, but operated twelve of the Dutch beaters, which supplied the beaten fibre for forming the sheets of paper from twenty vats. A mill of this magnitude would have had a capacity of about seventy-five reams of finished paper a day.

The first paper mill in central Massachusetts was established by Abijah Burbank in 1775 and was considered at the time one of the best-equipped mills in this country. This establishment operated two Hollanders, with rolls two feet in length and twenty-six inches in diameter, which produced the required amount of stock for two vats. A mill of this size would have had a capacity of from four to five thousand sheets of demy paper a day.

The earliest volume to mention the Dutch invention of the Hollander was a small book by Johann Joachim Becher, a German

Art Unwalled. The paragraph (page 71) reads: “Also Engines to make Paper, in which a wooden Cylinder of sufficient magnitude standing out, furnishes with little trouble, takes up wooden Mallots, which bruise and break whatsoever is laid under them to powder.” No illustrations of stampers were given in any English books of the seventeenth century except the small, somewhat obscure woodcut in the Visible World (London, 1658).
writer on mechanics. This book was issued in 1682. Dr. Becher writes (page 68): "One does not know who conceived the art of papermaking, but it is a fine and wonderful invention. In the ordinary method the rags are beaten with many stampers and much rattling. I have seen, however, a new kind of paper mill, in Serndamm in Holland, which operates, not with the crude stampers, but by the use of a Roll, and within a short time and without difficulty the rags are macerated to a pulp."

The earliest engraving of the Dutch beating-engine (Figure 140) is shown in the book by Leonhardt Christoph Sturm * dealing with mill machinery which was printed in Augsburg in 1718, the title being Vollständige Mühlen Baukunst. In this volume one of the engravings shows the Hollander placed in a circle, so that four or five of the machines could have been actuated by one huge wooden cog-wheel, which in turn was operated by a windmill or sche und Mercurialiske Concepten und Propositionen. The description given by Becher is definitely that of the newly invented beater, so it may be assumed that this machine was in use in Holland some time previous to Becher's visit. A second edition of this book appeared in 1706 and in this edition the same passage relative to the Serndamm machine may be found on page 69, another edition was issued in 1729.

Dr. Johann Joachim Becher was born in Speyer in 1635, the son of a Lutheran minister who died during Becher's infancy. Becher was a student of theology, mathematics, medicine, chemistry, philosophy, economics, and art. At twenty he began his writings, which embrace these subjects. Becher evidently visited Holland previous to 1680, for in that year he left Germany for England and it is recorded that owing to storms he was twenty-eight days in a sailing ship before he finally arrived in the British Isles. During this long voyage he compiled the little book that is of so much interest to the historian of papermaking. Evidently Dr. Becher returned to his native land for the publication of his book, since later that same year he went back to England, where he died in his forty-seventh year.

* Sturm's researches in Dutch paper mills, where he drew for the first time a picture of a beater, occurred almost forty years after the eventual visit of Dr. Becher and his original description of this important machine. Sturm and his original background as Dr. Becher, and the two men recorded one in writing, the other in illustration, the origin of a papermaking appliance that has undergone few changes to the present day. Sturm was born in Aldorf in 1669, the son of a professor of mathematics and physics in the Aldorf he was entered in the university as a student of theology; at eighteen he received a Master of Arts degree. Finding theology distasteful, he relinquished this subject so that he might become a student of architecture. He eventually was chosen as building director for the Duke Ludwig Rudolf at Blankenburg in Braunschweig. Sturm died in 1719, the year following the publication of his important work on the subject of mill machinery.

Fig. 140 The first delineation of the Hollander as pictured in the volume on machinery by Leonhardt Christoph Sturm (Augsburg, 1718).

Fig. 139 Five Hollander for the maceration of rags for papermaking and two millstones for the grinding of flour, all operated by one water-wheel. (From Sturm's Vollständige Mühlen Baukunst, Augsburg, 1718.)

water-wheel — in Holland by the power of the wind, and in Germany and France by the weight and force of water. In another of the prints in Sturm's book there are illustrated five Dutch beaters in combination with two millstones (Figure 139), the stones grinding flour at the same time the beaters reduced rags to a fibrous pulp for papermaking. This combination of making flour and paper in the same mill was not usually practised, and some writers have advanced the thought that the placing of the millstones in the engraving was nothing more than a fancy of the author, who produced the book after a journey through Holland, where he had visited mills used for various industries. It is recorded that Nicholas Hasselbaughe, who was operating the former De Wees mill in Pennsylvania in the late eighteenth century, had a pair of stones in connection with the paper mill and carried on an extensive