THE PICTURE OF THE TAOIST GENII PRINTED ON THE COVER of this book is part of a painted temple scroll, recent but traditional, given to Mr Brian Harland in Szechwan province (1949). Concerning these four divinities, of respectable rank in the Taoist bureaucracy, the following particulars have been handed down. The title of the first of the four signifies 'Heavenly Prince', that of the other three 'Mysterious Commander'.

At the top, on the left, is Liu Thiên Chìn, Comptroller-General of Crops and Weather. Before his dedication (so it was said) he was a rain-making magician and weather forecaster named Liu Chìn, born in the Chin dynasty about 2349. Among his attributes may be seen the sun and moon, and a measuring-rod or carpenter's square. The two great luminaries imply the making of the calendar, so important for a primarily agricultural society, the efforts, ever renewed, to reconcile celestial periodicities. The carpenter's square is no ordinary tool, but the gnomon for measuring the lengths of the sun's sidereal shadows. The Comptroller-General also carries a bell because in ancient and medieval times there was thought to be a close connection between calendrical calculations and the arithmetical acoustics of bells and pitch-pipes.

At the top, on the right, is Wû Yüan Shuai, Intendant of the Spiritual Officials of the Sacred Mountain, T'ai Shan. He was taken to be an incarnation of one of the Hour-Presidents (Chin Shen), i.e. tutelary deities of the twelve cyclical characters (see p. 262). During his earthly pilgrimage his name was Hsu Tiou-Yü and he was a scholar and astronomer in the Later Han (b. + 142). He is seen holding an armillary ring.

Below, on the left, is Ku Tiou-Shuai, Assistant Secretary of State in the Ministry of Thunder. He is therefore a late emanation of a very ancient god, Lei K'ung. Before he became deified he was Hsin Hsing, a poor woodcutter, but no doubt an incarnation of the spirit of the constellation Koa-Chien (the Angular Arranger), part of the group of stars which we know as Ursa Minor. He is equipped with hammer and chisel.

Below, on the right, is Pi Yüan Shuai, Commander of the Lightning, with his flashing sword, a deity with distinct alchemical and cosmological interests. According to tradition, in his earthly life he was a countryman whose name was Thiên Hsin. Together with the colleague on his right, he controlled the Spirits of the Five Directions.

Such is the legendary folklore of common men canonised by popular acclamations. An interesting scroll, of no great artistic merit, destined to decorate a temple wall, to be looked upon by humble people, it symbolises something which this book has to say. Chinese art and literature have been so profound, Chinese mythological imagery so fertile, that the West has often missed other aspects, perhaps more important, of Chinese civilisation. Here the graduated scale of Liu Chìn, at first sight unexpected in this setting, reminds us of the ever-present theme of quantitative measurement in Chinese culture; there were rain-gauges already in the Shang (+ 12th century) and sliding calipers in the Han (+ 140). The armillary ring of Hsu Tiou-Yü bears witness that Naubirnien and Hipparchus, al-Nasqâ and Tycho, had worthy counterparts in China. The tools of Hsin Hsing symbolise that great empirical tradition which informed the work of Chinese artisans and technicians all through the ages.
JOSEPH NEEDHAM
SCIENCE AND CIVILISATION IN CHINA
VOLUME 5
CHEMISTRY AND CHEMICAL TECHNOLOGY
PART I: PAPER AND PRINTING
BY
TSIEN TSUEN-HSUIN, PH.D.
PROFESSOR EMERITUS OF CHINESE LITERATURE AND
LIBRARY SCIENCE AND CURATOR EMERITUS
OF THE FAR EASTERN LIBRARY AT THE
UNIVERSITY OF CHICAGO

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To three eminent scholars who have contributed to our knowledge of the History of Printing

L. CARRINGTON GOODRICH
Dean Ling Professor Emeritus of Chinese
Columbia University

HOWARD W. WINGER
Professor Emeritus of Library Science
The University of Chicago

and

KWANG-TSING WU
Former Head, Chinese and Korean Section
The Library of Congress
Washington, D.C.

this volume is dedicated
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FOREWORD

It was in 1948, some thirty-six years ago, that the writing of this series of volumes began, after I came back from China and from Unesco. My first collaborator was Wang Ling (Wang Ching-Ning); and then eight years later Lu Gwei-Djen came over from Paris to occupy the same position of Adjutant-General of the Project which she still fills. While Wang Ling’s background was rather mathematical and chemical, Lu Gwei-Djen’s is more medical and biological. Then, some fifteen years ago, we found ourselves faced with a great dilemma, whether to peg away alone for the rest of our lives, or whether to associate with ourselves a group of collaborators, who would bring us nearer to seeing the conclusion in our own lifetime. We decided on the latter course. It was a veritable turning-point.

Now, with the present Volume, we see the first-fruits of this plan. We were able to persuade our dear friend Professor T. H. Hsien (Chhiien T’ien-Hsin), of the University of Chicago, and one of the world’s most eminent authorities on the subject, to accomplish this task in our series. We greatly admire what he has done. Of course, the book of T. F. Carter (1) has long been a classic, but it is now quite old, having seen the light first in 1923 and not revised since 1955; since then many archaeological finds, and many literary perspectives, have intervened, so that a new synthesis was urgently necessary.

We expect that in due course other Volumes not written personally by us will be appearing in our series; notably Vol. 6, pt. 2, on the ‘History of Agriculture in China’, which has been written by Ms. Francesca Bray. This again deals with a subject of the highest importance for the general theme of the history of science and technology in China, and we feel fortunate that her work for some ten years past on our staff has proved so successful. We now anticipate that still further Volumes will be contributed by our collaborators.

I suppose that no theme could be more important for the history of all human civilisation than the development of paper and printing. Francis Bacon, ‘the bell that call’d the wise together’, fully recognised this. In the present Volume readers will be able to follow all the vicissitudes of paper and printing during those Chinese centuries when Europe knew nothing of such arts. I always suspected that the Chinese Buddhists may have had something to do with the technique of documentary reproduction, because of their mania for the infinite repetition of images, as I had plenty of opportunity to observe on the walls of the Thang cave-temples at Chihien-to-fung (Tunhuang).2

3. 王大年
4. 王餘
5. 董文
6. 董直
7. 董余
8. 董文
9. 董直
10. 董文
11. 董直
12. 董文
13. 董直
14. 董文
15. 董直
16. 董文
It has always been extremely hard to believe that Johann Gutenberg about + 1454 knew nothing (even by hearsay) of the Chinese printed books which had been circulating in large numbers in China for five previous centuries—and there are some sources fairly contemporary which aver that he did. It seems perhaps less likely that he ever knew of his predecessor Pi Shêng, the artisan who had anticipated him as the inventor of movable type by some four centuries. We have already alluded to the celebrated passage about Pi Shêng in the Mêng Chhi Pi Thuê, and we have illustrated a rotating 'case' for the type sorts depicted by Wang Chên later.

Many printers in Korea as well as China, subsequently made use of this invention, but of course it was much more inviting to use movable type for the alphabetic languages needing only twenty-six letters, than for the ideographic ones where as many as 33,500 characters, with some 400 radicals, would be involved.

Be that as it may, however, there is plenty of evidence that Chinese printing and book-production were the envy of the whole world that knew about them before Gutenberg's time. Even long afterwards we have Jesuit relations which show their great admiration for the books of China, which enshrined so much of human learning and knowledge. True it is that, as Francis Bacon again said: 'The wits and knowledge of men remain in books, exempted from the wrong of time, and capable of perpetual renovation.' Let us pray that no evil fire-storm will be let loose upon the world to destroy in an instant much, if not all, of the accumulated culture of the ages, and put an end to that most glorious of human achievements, printing and the paper on which it may be done. So let us wish all success to this story told by Tsien Tsuen-Hsuin.

Joseph Needham

Cambridge
January 1954

FOUNDER

AUTHOR'S NOTE

This volume is devoted to the study of the origin and development of papermaking and printing in Chinese culture from their earliest known beginnings to the end of the 19th century, when both handicrafts had gradually been replaced by modern technology. It is intended to be a comprehensive study, covering all periods in their history and all aspects of their techniques, aesthetics, applications, and worldwide spread and influence, based on extensive investigation of literary records, archaeological discoveries, scientific reports, as well as artifacts available for examination. Previous contributions to the field are either limited in scope or outdated in many respects. Numerous Chinese documents concerning paper had not been explored and many important topics had not been covered in Western scholarship. Details of printing, on the other hand, are rarely documented in Chinese literature, but hundreds and thousands of items printed from the + 8th century onward are available for investigation. The present work tries to bring up to date or fill gaps in previous studies; it also offers new interpretations based on fresh data and new evidence. An attempt in this direction is briefly explained at the end of the Introduction.

The project started in late 1958 at the request of Dr Joseph Needham to contribute a section on 'Paper and Printing' to his great series of volumes Science and Civilization in China. His proposal actually suggested a sequel to my previous work on pre-paper and pre-printing records of China. A travel grant from the American Council of Learned Societies for 1958–9 enabled me to visit Cambridge and many libraries and museums in Europe and America for a preliminary exploration of opportunities. During the next few years, basic sources were collected and screened, a series of lecture-discussion sessions was held on several university campuses, and three sections on paper were then drafted. To pursue further the study of printing, a seminar was set up at the University of Chicago in 1972 and again in 1973 for a systematic examination of the sources and a discussion of various problems involved. But the actual writing of subsequent sections was interrupted by the increasing load of my duties at the University. With the generous support of the U. S. National Science Foundation and National Endowment for the Humanities from 1977 to 1980, I was relieved of part of my teaching and administrative responsibilities at the University. This allowed me to devote more time to research. Additional support from the East Asian History of Science Trust in Cambridge made it possible for me to complete the entire work by the end of 1982.

The original plan was to write a section of about 100 pages, but subsequent studies...
went deeply into the sources, and this resulted in a volume much broader in scope and size and one which consumed more time than originally planned.

The present work consists of ten sections, with a bibliography of nearly 2000 entries and about 200 plates and figures for illustration. Three sections each deal separately with paper, printing (including inkmaking and bookbinding), and their worldwide spread and influence, in addition to an Introduction as a summary and orientation. The last section on the contributions of paper and printing to World civilization serves as a conclusion. Each part on paper and printing is treated both chronologically and topically. Special attention is given to technical and artistic aspects of each subject as well as to their role in society. Where previous studies are available, a brief description of the topic or event is usually given; where gaps exist in earlier scholarship, fuller discussion is provided. For special editions of works in Chinese and Japanese cited in this volume, their publisher, date, or inclusion in a series are given in parentheses following the specific title in the footnotes and bibliographies. Abbreviations for titles of journals, large collections, symposia, and t'ang-shu are found in a list preceding the bibliography.

In the preparation of this volume, many of my friends, colleagues, and former students have contributed significantly. I am especially indebted to three eminent scholars and specialists in the field who served as consultants of the project, Professor L. Carrington Goodrich, Professor Howard W. Winger, and Dr K. T. Wu, for their constant advice, reading and criticism of the entire manuscript. Professor and Mrs H. G. Creel also gave generously of their time to read over the final draft. All their comments from different perspectives have been most useful in improving this work. I wish also to express my gratitude for the valuable help in many ways from Dr Poon Ming-Sun, Mr. James K. M. Cheng, Mr. Ma Tai-Loi, Mr John Gubowiski, Dr Michael Finegan, and Miss June Work, who served at one time or another as research assistants in the project.

To all my colleagues at the University of Chicago, especially in the Center for Far Eastern Studies, the Department of Far Eastern Languages and Civilizations, the Graduate Library School, and the University Library, I am grateful for advice and continuing support. In the course of my writing, I made use of several excellent papers and theses developed in my seminars by Miss Constance Miller, Mr. Edward Martineau, Mrs Lily Chia Jen Keeckes, and Dr Poon Ming-Sun, whose contributions are acknowledged at various points in the book with reference to their respective works in the bibliography.

For supply of materials for my study and photographs for illustrations, I am indebted to the librarians and curators of the British Museum and British Library, the Cambridge and Oxford University Libraries, the Bibliothèque Nationale, the Musée Guimet, the Austrian National Library, the Museum für Völkerkunde, the Royal Ontario Museum, the Dard Hunter Paper Museum, the Field Museum of Natural History, the Metropolitan Museum of Art, the Fogg Art Museum, the

Printing Department of Newberry Library, the Asian Division of the Library of Congress, the Spencer Collection of New York Public Library, the Harvard-Yenching Library, and the East Asian Library of Columbia University. However, the basic sources of information for my study were drawn largely from the Far Eastern Library of the University of Chicago. All credits to figures in this volume are acknowledged.

During my travel to the Far East in 1979, I benefited greatly from visiting libraries and museums, meeting and discussing with specialists, and collecting additional materials for my final revision of the draft. Certain old paper specimens and samples of rare printing were examined in China and Japan. Valuable experience was gained by my visits to the printing shops of Jung-Pao-Chai in Peking and Yo-Yun-Hsien in Shanghai, where woodblock cutters and printers were interviewed and tools and accessories collected. I am grateful to Mr Ku Thing-Lung, Director of Shanghai Library, for his advice and cooperation in making a series of photographs and drawings, based on my interviews, showing step-by-step procedures for carving and printing. My thanks are also due to Mr Phan Chi-Hsing of the Institute of the History of Science, Academia Sinica, for his expert advice and reading of the three sections on paper, to Mr Cheng Hsiu-Min formerly of the Peking Library and Mr Hu Tao-Ching of Shanghai, for their counsel and information; and to Mr Chhang Pi-T'e of the Palace Museum in Taipei for his generous assistance in sending me many photographs of old and rare samples of printing now kept in Taiwan.

I feel particularly fortunate to have been associated with the East Asian History of Science Library in the Needham Research Institute at Cambridge, where my hardworking friends have been patiently watching the slow progress of my study. My gratitude goes to Dr Lu Gwei-Djen for her gracious advice, Dr Michael Salt for sending me useful materials, Dr Colin Ronan for his skilled editing of the manuscript, and Mr Peter Burbridge and the staff of the Cambridge University Press for their helpful advice in the publication of this volume. My deepest debt is due to the architect of the project, Dr Joseph Needham, who provided timely help and advice on many problems in the process of my writing. Without his inspiration, guidance, and constant support, this enterprise would not have been accomplished.

Finally, I owe a debt of gratitude to my wife, Esiu Wen-Chin, who has not only given her encouragement and support to my study over many long years, but also contributed a piece of her calligraphy for the oldest poem on 'Paper' appearing in Figure 1290, which adds a special feature to this volume. To many others who cannot be named here, I wish to offer my thanks for help of various kinds.

The University of Chicago
October 1983

T. H. Tsien

1 吳光浩 2 潘補使 3 黨偉文 4 蘭泰來

1 梁薰薰 2 藤原秀 3 阿明德 4 曾月南 5 張秀民
32. PAPER AND PRINTING

(a) INTRODUCTION

Or all the products from the ancient world, few can compare in significance with the Chinese inventions of paper and printing. Both have played a profound role in shaping world civilisations; and both have exerted a far-reaching impact for a very long time on the intellectual as well as the daily lives of countless people everywhere. Paper has proved to be the most satisfactory material on which human thoughts are committed to writing, and when printing came to be allied to it, the idea of one individual could be communicated to a multitude of others separated across great stretches of space and time. In short, the printed message has brought about changes in the intellectual mode of the human mind, and paper has provided the most economical and convenient means for its transmission. But of course paper has other uses than for writing and publishing; it has penetrated into every corner of ancient and contemporary society to become an indispensable article in daily life. Even though new media of communication have developed in recent times, the unique combination of paper, ink and printing are still the basic, permanent, portable, and perhaps the least expensive and most accessible communication device known to us today.

(i) ORIGIN, DEVELOPMENT, AND MIGRATION OF PAPER AND PRINTING

It is common knowledge that paper was invented in China some time before the Christian era. From early in the 2nd century its manufacture became improved, using new materials and superior techniques. By the 3rd century it had become widely used in China itself and had begun to migrate across the Chinese borders; it reached the Western world only just prior to the modern age. Printing from woodblocks was first practised by the Chinese around +700, and movable type several centuries earlier than Gutenberg. Even the indelible ink of lampblack, prized by scholars and artists throughout the centuries in the East as well as the West, and which has been manufactured in the West under the misnomer ‘Indian Ink’, can be traced back to antiquity in Chinese civilisation. It was the introduction of these ingenious elements that made possible mass production of written records for wide circulation. Of the materials and techniques for the modern book, printed with black ink on white paper, the Chinese have contributed most to its development.

Paper is a felted sheet of fibres formed from a water suspension process using a sieve-like screen. When the water escapes and dries, the layer of intertwined fibres becomes a thin matted sheet which is called paper. Over the span of the two millennia which have elapsed since the inception of the idea of papermaking, the
craft has changed and the tools have become more complex, yet the basic principles and processes remain the same.

Traditionally, the invention of paper was attributed to Ts'ai Lun early in the +2nd century, but recent discoveries of very ancient paper fragments in North and Northwest China have pushed back the date of this invention at least some two to three centuries before him. Indeed, as we shall see, the invention of paper in China is now believed to have originated from a process of pounding and stirring rags in water several centuries before the start of our Era. It is very likely that an accidental placing of fibres from the rags on a mat with water draining away, may have suggested the idea of making a thin sheet of paper. But paper was not invented expressly for writing, as has often been presumed. It was extensively used in China in the fine and decorative arts, at ceremonies and festivals, for business transactions and records, monetary credit and exchange, personal attire, household furnishings, sanitary and medical purposes, recreations and entertainments, and so on. What is more, all these non-literary applications were common in Chinese society before paper was introduced into Europe in the +9th century.

Paper was not used for writing until perhaps early in the +1st century, and even then did not entirely replace the more cumbersome bamboo and wood slips as the chief materials for making books until the +3rd century. But when it came, the use of paper enabled books to be cheaper and more portable, though their extensive production and wide distribution was not possible until the invention of printing. It is uncertain when and where the first book was printed in China and who was the earliest printer, but probably the process developed gradually.

There is a long history of pre-printing techniques in China, including the use of seals for stamping on clays and later on silk and paper, of stencils to duplicate designs on textiles and paper, and of the inked impressions taken from stone inscriptions. All these processes gradually led to more efficient methods of the mechanical multiplication of copies and, as archaeological and literary evidence indicates, by the +7th century or around +700, printing began in China. Movable type was introduced by the middle of the +11th century and multi-colour printing some time in or before the +12th century. The movable type was first made of earthenware, but later various other materials, including wood, metal, and a variety of ceramics, were also adopted repeatedly and intermittently in the following centuries.

Because of the great number of characters in written Chinese, woodblock printing was used far more often than movable type for book production in China until recent times. Wood blocks were simpler and more economical, and could be stored easily and were readily available when a reprint was needed; movable type was preferred only for large-scale production of voluminous books. Nevertheless, both wood blocks and movable type have gradually given way, since the mid-19th century, to the modern printing press.

After papermaking was perfected, it not only became popular in China but spread in all directions throughout the world, first eastwards in the +2nd century, then westward during the +3rd century. However, it did not reach India until the +7th century, and only became popular there in the +12th. Paper arrived in Western Asia in the middle of the +8th century, and to Africa in the +10th. The Arabs monopolised paper-making in the West for some five centuries. Only in the +12th century was it manufactured in Europe, and it did not reach America until the +16th century and Australia in the +19th. Thus it took more than fifteen hundred years for paper to spread from China to almost every part of the world.

Whether or not typography in Europe was influenced by the Chinese is controversial, but it is certain that Chinese printing and printed materials from China were known in Europe before printing began there. As might be expected, there are many theories about how printing reached Europe. Some suggest that it travelled from China to Europe along routes similar to those taken by paper, others, emphasising the differences between European and Chinese printing, suggest that European typography was independent in origin. However, there is strong evidence from cultural considerations of a close connection between them. Certainly there is no doubt that paper-making originated in China, and was already a fully developed craft before it spread over the rest of the world. It is probably the most complete of all the inventions China has given to civilisation.

(2) Factors Contributing to the Early Invention of Paper and Printing in China

The prerequisites for a useful invention include both the physical and the mental readiness for the event; besides a creative mind and a popular demand, proper materials and the essential basic techniques must be available. Since all the material facilities for the invention were present in Europe as well as in China, several questions arise. Why did the invention occur in one civilisation but not the other? What were the factors responsible for such development? What was it that made these two great inventions appear very early in Chinese culture but only after a long delay in the West, at least a thousand years for paper, six hundred years for wood-block printing and four centuries for movable type? In an attempt to find the answer, we shall discuss and compare the conditions that led to these developments.

The key elements for the manufacture of paper are water, fibres, and a mould. The first was present almost everywhere and fibres were available from rags or hemp or linen just as soon as textiles were woven in the ancient world. The use of the two together was common enough, but not so the process of turning rags into separate fibres through maceration, and using a screen mould to hold these fibres while allowing the water to drain away. Perhaps, as will become evident later, the Chinese tradition of washing rags in water and allowing the fibres to form a felted sheet on the mat was responsible for this discovery in ancient times. The earliest

* See pp. 96 ff. below.
mould is believed to have been made of a piece of cloth stretched with frames to support the macerated fibres and to let the water escape through its meshes.

The invention of paper-making was, of course, a continuing process rather than a single event. An important step came with the introduction of new and fresh raw fibres, allowing unlimited production. Here the discovery of the suitability of the paper mulberry (Broussonetia papyrifera) was certainly significant. It is a plant that is native to China, though it has been cultivated extensively in many other temperate and tropical zones throughout the world. Its bark, after being beaten into a cloth, was used for clothing in China as well as in other regions along the equator, and ancient Chinese literature provides evidence that it was manufactured and traded by native tribes in the southern part of China, as we shall see. The invention of paper-making with tree bark attributed to Ts'ai Lun in the early 2nd century was possibly influenced by the acquaintance of the people in his area with the paper mulberry. Ts'ai Lun was a native of Lei-yang in what is now Hunan province, and it was here that the bark was made into cloth by beating and then into bark paper after maceration. Since then, the maceration process of turning rags into pulp was already known in China, it was very likely that the people in the south of the country were the first to convert paper mulberry bark into a pulp for paper-making. Neither paper mulberry nor bark cloth was, it seems, used in Europe, where its cultivation appears to have been unknown, even in the 18th century; indeed among the numerous kinds of plant tested for paper-making by European scientists at this time, paper mulberry was not included. Furthermore, it was described with curiosity by the early Jesuit missionaries to China, and they suggested its transplantation to France.

The popular demand for a better writing material was another important factor leading towards the invention and utilisation of paper. In China, paper was a much cheaper and more ideal writing medium than expensive silk and the chumier bamboo or wood. But in Europe, paper did not have too many advantages over papyrus or parchment. Papyrus was plentiful, simple to prepare, inexpensive, and perhaps as light and convenient as paper. Parchment, although it cost more, had a smoother surface and was more durable than paper. Indeed, in the early days, paper was not much cheaper than parchment, in contrast to silk, and not any more portable than papyrus, in contrast to bamboo and wood. Because of its fragility,

[Note: The text continues discussing the historical context and development of paper-making in Europe, referencing various sources and events.]

Seal impressions in a mirror image, from which a correct position was obtained by translating on clay and later on paper, embody the technique closest to that which eventually led to the invention of printing. The use of seals began in antiquity in both Chinese and Western civilisations. In China, seals cast in bronze with designs and inscriptions in relief survived from the Shang dynasty. Other seals were generally made from wood.

Paper was first used for official use by King Roger of Sicily in 1145 and again by Emperor Frederick II of Germany in 1221; cf. Blum (1), pp. 73-30.

See further discussion on pp. 73-30, below.


The specific references cited in the text are as follows:

- See pp. 76-77, below.
- See Jiang Shou-Sung (2), pp. 7-8.
- Lu Chi of the 1st century AD stated that the bark of paper mulberry was used by the people south of the Yangtze River to make cloth or was pounded for making paper; see discussion of silk and paper clothing, pp. 129 below.
- Searching for new materials for paper-making, Dr. Jacob Schade (1) noted that he had tried over thirty kinds of raw material, including bamboo, canon, paper, wood, and various other plants, for use in paper-making to be mentioned in his six-volume work published between 1765 and 1771, but he did not include paper mulberry or handkerchief, which had been major raw materials used in paper-making in China and other nations in east and south Asia; see Hunter (1), pp. 100-101.
- In 1797, 31 quires of parchment, each containing three dozen sheets, cost £2 5s. 0d. in Florence, 5 marks, 8schillings in Tournai; in 1599, two quires of paper cost 8 deniers; and in 1796, four quires of paper cost 2 shillings, 4 deniers; see Blum (1), pp. 60-61, note 8.

[Note: The text concludes by summarising the development and significance of paper-making in China and Europe, noting its role in communication and record-keeping.]
made of metals or carved on stone, jade, ivory, horn, earthenware, and wood have continued in use until this day. They are characterized in general by a flat surface, square, oblong, or occasionally in other shapes, bearing inscriptions of characters in relief or intaglio of personal names or official titles, always in reverse. They have been used always to indicate ownership, authenticate documents, and establish authority. The use of seals in Western culture began and flourished in Mesopotamia and Egypt, perhaps even before the invention of writing. These seals made of stone, ivory, shell, or metals were of two principal types, cylinders and stamps. The cylindrical type was used in Mesopotamia and in areas under Babylonian influence. Their designs, primarily of deities, heroes, animals, celestial bodies, instruments, and emblems, were impressed by rolling the cylinder over a flat surface of clay, mortar, cement, or wax. The stamp seals have a variety of shapes. Those used in Egypt were of scaraboid form with a beetle on the back, a sacred symbol of resurrection and immortality. Their bases are flat and engraved with designs or inscriptions of motifs, personal names and titles of officials. These had strong religious overtones as well as practical functions. Both the cylindrical and stamp forms of seals were also used in Asia Minor, Syria, and Palestine. Their use was discontinued after the fall of the Western Roman Empire but revived in the second half of the 8th century. Since then, round or oval seals engraved with designs and legends have been employed in the West until modern times.

Generally speaking, the seals developed in Chinese and Western cultures bear some similarities and differences. They were both made of the same kinds of materials, impressed originally on the same kind of surfaces, and used primarily for the same purposes. But there were some major diversities which led perhaps to development in different directions. Chinese seals were mostly made in a square or rectangular shape with a flat base, inscribed with characters in reverse, and used to stamp on paper. These characteristics are very close to those of block printing. Although the surface and inscriptions of most seals were small or limited, some wooden seals were as large as printing blocks and were inscribed with texts more than one hundred characters long. The seals of the West, on the other hand, were cylindrical or scaraboid, round or oval, and inscribed primarily with pictures or designs and only occasionally with writing. The cylindrical seals used to roll over clay had no potential to develop into a printing surface. While the scaraboid seals were flat-based, their primarily religious nature was predominant over their functional aspects as a tool of multiple functions. Furthermore, seal inscriptions always took a positive position, the impressions being made primarily on stiff material such as wax, rather than on a flexible medium such as parchment or paper. Such different usage discouraged any development in the West of the idea of printing from seals. The use of seals as symbols of authority and authenticity was similar in standing to that accorded to coins. In ancient times, the circulation and acceptance of metal money depended upon official sponsorship, which was usually indicated by marking on the coins their value, place of minting and, sometimes, the official symbol of approval. These numismatic inscriptions were made either by casting in a mould, or by stamping or punching the face of the coins. From very early times in China, coins in spade, knife, plate, and circular shapes were cast from moulds. But in the West, they were first made by stamping and later by casting, a technique which was subsequently borrowed by bookbinders, who cast separate metal characters for stamping titles on a book. This craft was eventually adopted by printers to cast metal type and thus was the forerunner of typography in the West.

The technique of engraving on stone tablets is close to that of carving on wood blocks, and taking inked squizes or rubbings from stone inscriptions is very similar to the process of block printing. Inscribing on stone was developed very early in both China and the West. Chinese inscriptions on stone survive from the Chou dynasty, and subsequently stone became the most popular medium for commemorative and sacred writings, and for the preservation and standardisation of the canonical texts. The Mesopotamians also used stone in addition to clay tablets for writing. The Egyptians used it for tomb inscriptions and it was adopted for monuments by the Romans as well as other peoples in the ancient world, but inscriptions in the West were neither as extensive nor as refined as they were in China, and were never in scale with those of the Chinese, where hundreds of thousands of characters of Buddhist, Taoist, and Confucian texts were carved on stone throughout many centuries. Moreover, stone was used in the West more as an artistic material than, as it was in China, for writing. Such differences in the nature, scope, and content of stone inscriptions caused them to develop in divergent directions in China and in the West.

Taking inked squizes or rubbings from stone inscriptions is similar to printing in principle and purpose, but different in process and end-product. Both result in duplication on a sheet of paper of an engraved object, but their different methods...
result in different kinds of reproduction. The technique of taking inked rubbings from stone, and eventually from all kinds of hard surfaces, can be traced back to the mid-6th century or earlier in China. Yet it does not seem to have been used in the West until perhaps the 12th century, when antiquarians and artists began to experiment with the use of a crayon-like agent in tracing designs from memorial bronzes, tombstones, brick walls, carved wood, and sewn plates. The duplications they obtained were, however, far less sophisticated than those of the inked squashes originally made by the Chinese, and it was the combination of this skill in making duplications by inking and rubbing on a sheet of paper coupled with the art of carving seals with a mirror image in relief that resulted in the methods of block printing.

Besides the necessary materials and techniques, there were also social and cultural factors which had a great effect on the application or rejection of printing. Since printing is a mechanical extension of writing, the system of writing used is one of the most important factors affecting the development of printing. Chinese writing was from the very beginning characterized by an ideographic script which is basically composed of numerous separate strokes of different shapes. Since each character has a definite and distinct form, the writing of characters tends to be elevated to an art and is thus more complicated and time-consuming than alphabetical writing, especially when a special style is sought in a formal and respectable text. On the other hand, Western writing, ever since the Phoenicians developed the rudiments of an alphabetic language, has evolved into a system of symbols representing sounds. Its written components are merely substitutes for their spoken counterparts, and have tended to evolve into simple signs composed of continuous lines. Copying in an alphabetic language is easier than in an ideographic script. It is likely, therefore, that the slower and more complicated process of copying Chinese resulted in a greater demand for mechanical aid in duplication in China than in the West. It is also natural that movable type was more acceptable to an alphabetic language, while block printing was more suitable to the Chinese writing system.

Religion is another cultural factor that has played a great part in the long history of the development of printing; religious zeal in spreading sacred writings to all believers has created a demand for a ready means of reduplication, and Buddhism, Islam, and Christianity all exerted an influence. Buddhism even teaches that mass production of its "sutra" is a way to receive blessing from the Buddha. Indeed, the Buddha is said to have remarked, "Whoever causes a copy to be made of this Dharma will gain power from the Dharma." A text is usually put at one hundred thousand, one million, and ten million copies. Carters (1), p. 55, 100 15.


5 C. K. Starr (2), p. 5. An archaeologist said in 1910 that he knew of no satisfactory method employed by Orientalists to make rubbings from inscriptions and decorations, "even the finest of lines appear most distinctly".

6 Chinese characters have been composed of one to more than thirty independent strokes or dots, straight or curvilinear, and squares since their development into the clerical and regular styles from around the advent of Christian era in the Han dynasty.

7 For a comparative study of word-syllabic and alphabetic systems, see Dringer (1), Gelt (1); for development of written forms, see Anderson (1).

8 A text is usually put at one hundred thousand, one million, and ten million copies. Carters (1), p. 55, 100 15.


10 Carter (1), p. 97.

11 Carter (1), p. 121.


scripures which could not be met by hand-copying. In the West, paper was not introduced until a rather late date, seals were not used as duplication devices, rubbing was not known until fairly recently, while printers were restricted by craft unions or guilds, and added to all this, the relative simplicity of the alphabetic script lessened the need for a mechanical duplication aid. Thus the materials and techniques necessary for the invention of printing were either not developed, or did not lead in the direction of a printing process. Furthermore, there was no such incentive or demand for huge quantities of copies as developed in connection with Buddhism: the needs that did exist could be met by hand-copying. Until all these factors were changed in the middle of the 15th century, the threshold for the invention of printing was not reached in Western society.

(g) Information on Papermaking and Inkmaking in China

Sources of information for the study of paper and papermaking include paper specimens, scientific and field reports, early records, and secondary sources. We shall take these in order.

Paper specimens are important because they can be subjected to microscopic, chemical, and physical analyses for determining their composition, technique of manufacture, and other features. Since the turn of the century, tens of thousands of early paper specimens have been found within China and outside it, including some fragments from the 2nd century which are at present the oldest known papers in the world. A few specimens bearing characters of perhaps the 1st century attest to the use of paper for writing before or at this time.4

Paper fragments and documents found in modern Sinkiang by various expeditions were primarily products of the Three Kingdoms, Chin, and Southern and Northern Dynasties from the 3rd to 6th centuries, when paper began to be used widely and to travel across Chinese borders. Paper rolls dating from the 4th to the 10th centuries discovered at Tunhuang represent the best examples of paper and paper books in a roll form before and during the Thang period.5 From this time on, specimens of different varieties of paper survive in books, documents, works of painting and calligraphy, in stationery, paper cutting, and other paper products. In addition, certain old paper documents extant outside China testify to their early diffusion worldwide.6

32. PAPER AND PRINTING

Samples of these old papers have been scientifically analysed, and reports are available concerning fibre composition, surrogates used for sizing and coating, and such physical qualities as thickness, strength, opacity, absorbency, and watermark, if any. In 1885–7, Joseph Karabacek (2) and Jules Wiener (1, 2) made the first analysis of Arabic paper documents from the +4th to the 14th centuries, which had been found in Egypt. Then, in 1902–11, Wiener (3, 4, 5) studied the papers found by Aurel Stein in the course of his first two expeditions to Chinese Turkestan and Tunhuang. It had formerly been discovered in the West that cotton papers were first made by the Arabs in the 8th century and that the making of rag papers was discovered by the Europeans in the 13th century, but the findings of these studies confirmed that paper was invented in China at least in the early Christian era, as recorded in Chinese histories. Moreover, using the scientific data obtained from these analyses and with the support of documentary sources, the history and routes of the migration of paper step by step from China westwards over a period of more than a thousand years have been reconstructed.

The Tunhuang papers at the British Museum were further studied by Robert Clapperton (1) in 1934, M. Hardens-Steinhausner (1) in 1963, and Jean-Pierre Dorig (1) in 1968, and those in the Peking collection by Phan Chi-Hung (1) in 1966. Samples of other discoveries have also been examined by Chinese scientists. A piece with characters of the Later Han period found at Chu-yen in 1942 was analysed by Wu Yin-Chhan,7 a botanist, and reported by Lao Kao (4). Specimens of the +4th to +8th centuries found in Sinkiang by Chinese archaeological teams in recent years and now at the Sinkiang Museum, as well as samples of papers used for calligraphy and paintings dating from the +3rd to the +12th centuries now kept at the Palace Museum in Peking, have also been studied and reported on by Phan (p. 5, 7). The data collected on their physical appearance, the fibres used in manufacture, and the techniques for treating them, in addition to descriptions in ancient literature, have been used in reconstructing the methods of old papermaking in China (Fig. 1093).8

Literary sources on paper in Chinese can be divided into two major categories. One consists of general works, the other of chapters or books specifically on historical documents, local gazetteers, literary and miscellaneous writings, and classified encyclopedias. For instance, the beginnings of paper are recorded in such historical works as the Tsung Kuan Han Chih,9 a contemporary official record compiled about +120, and the Han Han Shu,10 a standard history of the Later Han dynasty based on earlier sources. The subsequent development of paper and its manufacture in different periods are described in dynastic and other histories, and also in works on administrative codes of successive dynasties, such as the Tsung Lien.

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4 Up to the present time (1988), at least seven discoveries of old paper fragments of the Han period have been reported, but only one or two said to have been dated to the Later Han (Yin, writing, see discussion on pp. 326–8, below).

5 Cf. Paris (1), pp. 143–48; see also discussion on pp. 43 f., below.

6 A glotto library of some 30,000 paper books and documents in Tunhuang was first visited by Aurel Stein in 1927, and later by many others, see Stein (1), Giles (1), Pallas (60), Ch'en Yüan (5), and a summary of the documents by Fujieda (2).

7 Some 1550 paper documents discovered in Egypt, dating from +380 to +1380, are now preserved in the Erhard Rainer Collection at Vienna, and many Chinese papers of the Su and Thang periods survive in Japan and Korea.

8 Experiments of papermaking with hemp fibres according to analyses of old specimens and descriptions of the Han period were conducted in 1956 by the Institute of the History of Natural Sciences, Academia Sinica, and the results were reported to be successful; see Phan Chi-Hung (6).

9 吴印钵

10 杨权明
T'ang (*OE* 570–906) of the early Tang period, in which official positions of those in charge of the manufacture, acquisition, processing, and use of paper in various branches of government are listed. Local materials, products, or tributes are recorded in local gazetteers or regional descriptions, including the Yuan-Ho Chien Hsin T'ao Chih¹¹ (OE+850), a Thang geography; Chia-Chi T'ou Chi Chih¹² (OE+1201), a local history of Kuai-ch'i, Chekiang; Chiang-Hsi Sheng Ta Chih¹³ (OE+1356), a provincial history of Chianghsi; and many of other periods. Occasional references to paper are found in literary collections by noted writers of the Thang and Sung periods, whose poems acknowledging gifts made of paper are included. Descriptions of paper and paper products or the use of paper at festivals or ceremonies are found in such memoirs as the Yang-Ching Meng Hua Lao¹⁴ (OE+1148), about the Northern Sung capital of Kaifeng, and such collections of miscellaneous notes as Kui T'ai T'ang Kuan¹⁵ (OE+760). Finally, special chapters or sections devoted to paper are found in classified encyclopedias, including the Tai P'ing Tung Lao¹⁶ (OE+985) and the Thu Shih Chi Ching¹⁷ (OE+726), in which quotations from histories, anecdotes, poems, prose, and miscellaneous items on paper are systematically arranged, even though they may not always agree with the original texts.

The other category of literary sources consists of chapters or works exclusively on paper and papermaking. The earliest one, Wen Fang Su P'ei¹⁸ (OE+953–960), contains a section on paper which is divided into four parts: history, manufacture, anecdotes, and literature selected from earlier sources, chiefly of the Thang period, many of which have since been lost. Another work limited to local descriptions, the Shu Chia Pe¹¹ on Szechuan papers written by Fei Chu¹² of the 14th century, includes information on local products, papermakers, and designers in that particular province. Many similar works by noted men of letters, such as the P'ing Chih T'ae¹³ by the Sung artist Mi Fu,¹⁴ describe the qualities and appreciation of paper. The most important and only early work on the technology of papermaking is included in the Ch'ing Kang Kuan Wu¹⁵ by Sung Ying-Hsiing¹⁶ (OE+1582–1660), in which an illustrated chapter is devoted to methods of papermaking with bamboo and paper mulberry.¹⁷ Later works of a similar nature include an eyewitness account of papermaking by Huang Hsing-Sun¹⁶ of the 18th century,¹⁷ a systematic treatise on paper by Hu Yün-Yü¹⁷ (OE), whose description of the manufacture of the famous Hsüan chih¹⁸ in Anhui is especially useful; a technical work on papermaking with bamboo by Lo Chi¹⁹ (OE) published in 1935; and a recent illustrated work on various plant fibres used in papermaking in China by Yu Ch'eng-Hung²⁰ & Li Yüan²¹ (OE).

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¹ Cf. tr. Sun & Sun (1), pp. 235–235
² Cited in Yang Chung-Hui (2), ch. 5, pp. 395–396
The contributions of modern scholarship to Chinese papermaking include the scientific studies of old papers already mentioned, and historical research into the origin, development, and migration of paper, and field surveys of traditional papermaking in modern societies. The historical studies were initiated primarily by sinologists like Stanislas Julien (1931), Friedrich Herth (1939), Edouard Chavannes (1928), Berthold Laufer (1968), and especially Thomas Carter (1917), whose chapter on paper in his book on printing is still an authority on its dissemination westwards. Since then, works by paper historians and experts, including André Blum (1970), Armin Renker (1977), Henri Alibaux (1979), R. H. Clapperton (1981), and especially Dard Hunter (1975), have given the Chinese invention a proper place in the history of papermaking. Hunter was not an expert on China, but his field investigations of handmade paper mills in China, Korea, Japan, India, and his personal experience with handmade paper, have added a new dimension to the comparative study of traditional papermaking in Asian civilization.

The few articles on papermaking published by Chinese scholars during the first half of the 20th century largely consisted of translations of Western sources on the subject or explications of traditional opinions. An early study by Yao Tseh-Wu (1931) on the introduction of paper to Europe, published in 1928, was primarily based on Western scholarship supplemented with documentation from Chinese sources. Lao Kan (1936), writing on the origin of paper in 1942, reaffirmed and further elucidated a theory advanced by the Chingh scholar Yuan Yu-Tshai (1735–1805), that paper originated from the use of silk fibers and from washing rags in water, and this has since been followed by many Chinese and Western scholars.

During the second part of the 20th century, little has been added to our knowledge of Chinese papermaking in Western languages, but more contributions have been made in Chinese and Japanese. Works in three major areas may be mentioned. On the origin of paper, reports and studies of new discoveries of what are now the oldest known paper specimens, identified with the Former Han period, have not only pushed back the date of invention at least two or three hundred years before Tshui Luan, but also confirmed that early papers were made of hemp and not silk fibers. Also, a theory was advanced by Ling Shun-Sheng (1951) that the origin of paper might have been influenced by the 4th century culture widespread in southern China, the Pacific, and other tropical regions in ancient times. Although this theory is not new and some of his conclusions are doubtful, his thesis, supported by

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8 Hunter published some twenty monographs on paper, most of which were printed by himself on his own handmade paper; see partial list in Bibliography: the specimens collected during his trips are exhibited at the David Hunter Society, Appleton, Wisconsin.
9 The article was first published under the name Yeo Shih-An in 1930 and was reprinted under the pseudonym Shun-Ying in 1930–76; see bibliography in Yeo Tshui-Woo.
10 See the discussion of the definition of paper in the Sun Yat-Sen Chiao Tuo on pp. 31 ff., below.
11 Ling’s theory that paper money, paper armor, and Chou-Shu paper were all made of bark cloth and not bark paper has been proved to be wrong; literary records or recent tests of the products confirm that they were made of real paper.
12 科学者 12 電磁 2 科技 3 橡皮擦 13 教授 14 流士
15 四明