Chemical Traditions in China

Science and Civilisation in China. Vol. 5, Chemistry and Chemical Technology. Part 2, Spagyrical Discovery and Invention: Magisteries of Gold and Immortality. JOSEPH NEEDHAM. With the collaboration of Lu Gwei-Djen. Cambridge University Press, New York, 1974. xxxii, 510 pp., illus. + plates. $35.

The book under review is one of five parts into which volume 5 of Joseph Needham's continuing great treatise is to be divided. Like its predecessors it throws as much light on the development of Western as of Oriental history and it is concerned with technology as much as with science. This volume begins with an outline of the literature, concepts, and definitions of alchemy and proceeds to an examination of the biochemical and metallurgical actualities underlying the theoretical superstructure. The detailed history will appear later.

The alchemical tradition began to take form in China before the end of the first century B.C. and was systematized by Ko Hung early in the fourth century A.D. Needham makes it clear that three different observational-practical bodies of knowledge had to develop and be joined before true alchemy could be said to exist, two of them being parts of laboratory protochemistry (*wai tan*) and the third being physiological alchemy (*nei tan*). The theoretical aspects took root in the metallurgical-chemical operations of gold making and gold faking and in the pharmaceutical search for botanical and inorganic materials for use in therapy, which suggested the preparation of the drug of deathlessness.

Macrobiotics, which developed earlier in the Far East than in the West, exploited the changes in well-being produced by the taking of elixirs. Needham points out that these may have been beneficial in times of nutritional inadequacy, and that the aphrodisiac effects of initial small doses of arsenic, for example, may have served as bait to urge the adept on to more cosmic experience with larger amounts. Even the aim of bodily incorruptibility (suggested by the permanence of gold) may have had a real basis in Taoist practice—witness the recently excavated body of the Lady of Tai, preserved without decay for two thousand years by methods that did not involve mummification, tanning, or embalming.

Wai tan had two metallurgical roots, for which Needham invents the delightfully appropriate terms "aurifiction" and "aurifaction." The first of these was the treatment of a base metal to confer on it the superficial qualities of gold by one of several methods; the second was the high but until recently impossible aim of making real gold, with all the philosophical implications of transmutation, perfection, and immortality carried thereby.

Aurifiction played an important role in developing metallurgical knowledge. In all times before the present, new materials and the techniques for handling them usually originated in the making of decorative objects. This began in the dyes, ceramics, jewelry, and sculpture of the Middle East. Complex art castings of bronze, copper treated with arsenic to make it look like silver, and superb inlaid colored metal work all appear in Sumeria or Anatolia long before they do in China. The Chinese quickly made up for their slow start by showing superior understanding, however. A visitor to the current exhibition at the National Gallery of Art of recently excavated objects from China will note the particularly ingenious methods of casting, inlay, patination, and local etching that appear in the Warring States period, a century or two before the time to which Needham traces the beginning of alchemical thought. Most Far Eastern ceramic, lacquer, and metal work (except that in too-pliant gold) is superior to its Western counterparts until the last century, and it reveals a desire to cooperate with the material rather than to force it. But it may be that this very sympathy of the Chinese for sensually perceivable qualities of materials delayed an intellectual approach to them. The road from Chinese alchemy to today's medicine seems to have been more direct than the road to modern chemistry, the immediate roots of which reside in the temperature-dependent phase separations of the practical smelter and the quantitative operations of the assayer far more than they do in anything alchemical excepting only the desire to understand constancy and change.

Needham examines in some detail all known realistic methods of changing the color of metals. (Like his alchemists he pays too little attention to the equally advanced parallel processes for coloring or otherwise decorating textiles and ceramics.) He discusses the faking of silver by adding arsenic to copper and of gold with zinc. Other methods involved the application of a superficial layer of gold by mechanical means or by amalgamation, the formation of a golden yellow sulfide on silver, the purple patina on that superb Japanese alloy *shakudo*, and, most significant of all, the chemical removal of all metals except gold from a thick surface layer of a solid alloy containing only a minor fraction, perhaps as little as a tenth, of the precious metal. These processes—the basis of the alchemist's multiplication—became the cementation and parting processes of the refiner, but they began in esthetic delusion. Cementation, done with the materials hot and packed in dry powder, involves the diffusion of base metals to the surface for removal as chlorides; parting, done with cold materials, is selective corrosion (analogous to the dezincification of brass) which leaves in situ a layer of gold with continuously connected porosity maintained at the time of corrosion but easily consolidated by subsequent heating or burnishing. Refiners or assayers today use nitric or sulfuric acids; in ancient times it was ferric sulfate. An important paper by H. Lechtman (*Application of Science in the Examination of Works of Art*, No. 2, W. J. Young, Ed., Museum of Fine Arts, Boston, 1973, pp. 38–52) describing the use of the parting process in Peru was published too late for reference in this volume: the best demonstration of the validity of alchemy is provided by pre-Columbian "gold" objects, most of which are alloys containing a third or less gold with an intact layer of pure gold on the surface produced by pickling.

Needham distinguishes carefully between the two kinds of adepts in the heyday of alchemy. One was the artisan, in intimate contact with the real properties of alloys as revealed in crucible, cupel, and chemical bath and familiar with methods for producing the appearance of gold in cheaper materials for legitimate delight or illegitimate profit. His knowledge of the glittery fraudulence of alchemical gold and its incapability to withstand cupellation belonged to a different world from that of the philosopher seeking signs of immortality and incorruptibility and impatient with the realities of assay. These adepts being from different social classes, their contacts would be few and superficial. Moreover, even today there are times when theoretical inconsistency sustains disbelief in experimental evidence.

The author's extensive discussion of alloy compositions and coloring techniques is of necessity based mainly upon European literature of a rather unreliable kind—the formularies or compilations of workshop recipes that stretch back to the catchpenny Books of Secrets of the early 16th century and the much earlier manuscript compilations that reflect the activities of archivists more than those of artisans. This reviewer had always regarded Hiorn's copious listing of alloys and coloring methods in 1902 as the work of an uninspired hack. Needham's dependence on this listing gives unfortunate permanence to the names of some proprietary and transitory alloys best forgotten, but the very fact that such phenomena have been beneath the notice of the professional metallurgist serves effectively to emphasize Needham's point about the dangers of separation between different classes of people dealing with similar phenomena.

There is rich ammunition here for both sides in the debate over diffusion versus independent invention, as well as for studying the roles of internal and external factors in the development of science and technology. This volume, though shorter than most of its predecessors, is important on many levels. The perspective of the whole work is leading to a true world view without loss of detail, and it is sure to be regarded as one of the great intellectual achievements of the 20th century.

The book is pleasant to handle and easy to read. There are two sets of footnotes, one giving the Chinese characters for the names of key persons and writings, the other technical or bibliographic information; these are where they belong but so rarely appear nowadays, at the foot of the page. Both the copious bibliography (which lists titles without annoying abbreviations) and the detailed index are unusually useful, fully meriting the cost of the 200 pages that they occupy alongside the 300 pages of text.

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