

33. ALCHEMY AND CHEMISTRY

(f) LABORATORY APPARATUS AND EQUIPMENT

It will readily be allowed that the history of chemical apparatus and equipment must constitute a sector of cardinal importance in any history of alchemy and early chemistry. Was it not after all the foundation of the techniques of modern chemical science? We have already quoted the words of Francis Bacon (pt. 2, p. 32) on the husbandman and his buried gold in Aesop, and later on (in pt. 5) we shall give those of Hermann Boerhaave and Albrecht von Haller, all recognising the immeasurable debt which true chemists owe to their alchemical, iatro-chemical and artisanal ancestors. How far we shall have to accept a special indebtedness to those of them who were Chinese will appear as the following pages pass. The full appreciation of the facts will be assisted by a reference to the contents of Sect. 26g, 5 on the history of glass in China (Vol. 4, pt. 1, pp. 101ff.), and when the Sections on ceramics (35) and metallurgy (36) become available, further light will be thrown on what possibilities were open; for all these practical arts were necessarily laid under contribution by the Taoist alchemists of the Middle Ages in fitting out their laboratories.

Tshao Yuan-Yü (1) was the first to make a study (1933) of Chinese alchemical apparatus. His remarkable paper on the 'Apparatus and Methods of the Ancient Chinese Alchemists' aroused such interest that English abridgements were made by Barnes (1) and Wilson (2b, c) in the following years. Li Chhiao-Phing (1, 1) also devoted a few pages to alchemical apparatus in his book. Further short descriptions in German and Chinese were later given by Huang Tzu-Chhing (1) and Yuan Han-Chhing (1) respectively, and then in 1959 the subject of laboratory equipment was extensively reviewed by Ho Ping-Yü & Needham (3). Since then there has been little save the book of Sivin (1) which has touched illuminatingly on certain special aspects of the subject.^a In the present sub-section we have drawn materials more exhaustively both from the Taoist patrology and from ethnographical data, designing to treat the matter more thoroughly, and more comparatively, than anyone has so far done. Some of our interpretations, such as that of the East Asian types of still, were already essentially different from previous suggestions, and some techniques, like the method of *destillatio per descensum* using a bamboo tube, had not been mentioned before our first review.

Our main sources here include more than twenty different alchemical texts, all from the *Tao Tsang*, and many of them illustrated. Since they must be referred to very often it will be convenient to tabulate them in a list with the names of their writers (if possible), their approximate dates of composition, and their numbers in the standard catalogues (Table 114).

^a There are also interesting discussions in Yoshida Mitsukuni (7), pp. 223ff., 249ff., 252ff. His interpretations differ but little from ours, though we cannot quite follow him in his generalisations about the development of early chemical equipment in East and West.

Table 114. Names and details of ‘Tao Tsang’ texts useful in the study of chemical apparatus

Catalogue numbers			Approx. date	Author
Wieger(6) TT/	Ong Tu- Chien(x)			
229	232	<i>Huan Tan Pi Chieh Yang Chieh-Tzu Shen Fang</i> 還丹祕訣養赤子神方 (The Wondrous Art of Nourishing the (Divine) Embryo (lit. the Naked Babe) by the use of the secret Formula of the Regenerative Enchymoma) <i>Thai-Chhing Shih Pi Chi</i> 太清石壁記 (The Records in the Rock Chamber (lit. Wall); a Thai-Chhing Scripture) ^a	Sung, late + 12th	Hsü Ming-Tao 許明道
874	880		Liang, early + 6th, but including material as old as the late + 3rd (Chin)	ed. Chhu Tsé 楚澤 orig. writer: Su Yuan-Ming 蘇元明 (Chhing Hsia Tzu) 青霞子 unknown
878	884	<i>Huang Ti Chiu Ting Shen Tan Ching Chieh</i> 黃帝九鼎神丹經訣 (The Yellow Emperor's Canon of the Nine-Vessel Spiritual Elixir, with Explanations) <i>Ta-Tung Lien Chen Pao Ching, Chiu Huan Chin Tan</i> <i>Miao Chieh</i> 大洞鍊真寶經九還金丹妙訣 (Mysterious Teachings on the Ninefold Cyclically Transformed Gold Elixir, supplementary to the Manual of the Making of the Perfected Treasure; a Ta-Tung Scripture) ^b <i>Thai-Shang Wei Ling Shen Hua Chiu Chuan Huan Tan</i> <i>Sha Fa</i> 太上衛靈神化九轉還丹砂法 (Methods of the Guardian of the Mysteries for the Marvelous Thaumaturgical Transmutation of Ninefold Cyclically Transformed Cinnabar; a Thai-Shang Scripture) ^c	Thang or Sung, but incorporating some material as old as the + 2nd (H/Han)	Chhen Shao-Wei 陳少微
884	890		Thang, perhaps c. + 712	unknown
885	891		uncertain, probably Sung	unknown
886	892	<i>Chiu Chuan Ling Sha Ta Tan</i> 九轉靈砂大丹 (The Great Ninefold Cyclically Transformed Numinous Cinnabar Elixir)	unknown	unknown
889	893	<i>Yü Tung Ta Shen Tan Sha Chen Yao Chieh</i> 玉洞大神丹砂真要訣 (True and Essential Teachings about the Great Magical Cinnabar of the Jade Heaven)	Thang, early + 8th	Chang Kuo 張果
893	899	<i>Tan Fang Hsi Chih</i> 丹房須知 (Indispensable Knowledge for the Chymical Elaboratory)	Sung, + 1163	Wu Wu 吳悞
894	900	<i>Shih Yao Erh Ya</i> 石藥爾雅 (The Literary Expositor of Chemical Physic; or, Synonymic Dictionary of Minerals and Drugs)	Thang, + 806	Mei Piao 梅彪

895	901	<i>Chih-Chuan Chen- Yen Chiao Cheng Shu</i> 維川真人校證術 (Technical Methods of the Adept (Ko) Chih-Chuan (i.e. Ko Hung), with Critical Annotations)	Ascr. Chin, c. + 320, but most of it probably a good deal later	Attrib. Ko Hung 葛洪
902	908	<i>Lung Hu Huan Tan Chieh</i> 龍虎還丹訣 (Explanation of the Dragon-and-Tiger Cyclically Transformed Elixir)	probably Sung	Chin Ling Tzu 金陵子 (ps.)
904	910	<i>Kan Chhi Shih-liu Chuan Chin Tan</i> 感氣十六轉金丹 (The Sixteen-fold Cyclically Transformed Gold Elixir preapred by the 'Responding to the Chhi' Method)	Sung	unknown
905	911	<i>Hsiu Lien Ta Tan Yao Chih</i> 修煉大丹要旨 (Essential Instructions for the Preparation of the Great Elixir)	Sung	unknown
907	913	<i>Chin Hua Chung Pi Tan Ching Pi Chih</i> 金華冲碧丹經祕旨 (Confidential Instructions on the Manual of the Heaven-piercing Golden Flower Elixir)	Sung, + 1225	Phéng Ssu 彭耜 & Méng Hsü 孟煦
908	914	<i>Huan Tan Chou Hou Chieh</i> 還丹肘後訣 (Oral Instructions on Handy Formulae for Cyclically Transformed Elixirs)	Ascr. Chin, c. + 320, but actually by a Tang writer between +874 and +879	Attrib. Ko Hung 葛洪
911	917	<i>Chu Chia Shen Pin Tan Fa</i> 諸家神品丹法 (Methods of the Various Schools for Magical Elixir Preparations)	Sung	Méng Yao-Fu 孟要甫 (Hsüan Chen Tzu) <i>et al.</i> 玄眞子 Chao Nai-An 趙耐菴
912	918	<i>Chhien Hung Chia Kéng Chih Pao Chi Chhéng</i> 鉛汞甲庚至寶集成 (Complete Compendium on the Perfected Treasure of Lead, Mercury, Wood and Metal)	Thang, + 808	
935	941	<i>Thung Hsüan Pi Shu</i> 通玄秘術 (The Secret Art of Penetrating the Mystery)	Thang, + 864	Shen Chih-Yen 沈知言
939	945	<i>Thai-Chi Chen-Yen Tsa Tan Yao Fang</i> 太極真人雜丹藥方 (Tractate of the Supreme-Pole Adept on Miscellaneous Elixir Recipes)	unknown, but probably Sung on account of the philosophical pseudonym in the title	unknown
946	952	<i>Kéng Tao Chi</i> 庚道集 (Collection of Procedures on the Golden Art)	Sung or Yuan, date unknown but after + 1144	unknown
990	996	<i>Chou I Tshan Thung Chhi Chu</i> 周易參同契註 (The Kinship of the Three and the Book of Changes, with Commentary)	tradit. date of orig. text, H/Han, + 142; this comm. ascr. H/Han, c. + 160, but more probably Sung.	Attrib. ed. & comm. Yin Chhang-Shéng 陰長生
1020	1026	<i>Yün Chi Chhi Chhien</i> (itself a collection) 雲笈七籤 (The Seven Bamboo Tablets of the Cloudy Satchel)	Sung, c. + 1022	ed. Chang Chün-Fang 張君房
1054	1060	<i>Chin Tan Ta Yao Thu</i> 金丹大要圖 (Illustrations for the Main Essentials of the Metallous Enchymoma: the true Gold Elixir) ^d	Yuan, + 1333 but based on drawings and tables of the Sung, + 10th century, onwards by	Chhen Chih-Hsü 陳致虛 (Shang Yang Tzu) 上陽子 Chang Po-Tuan 張伯端 Lin Shen-Féng <i>et al.</i> 林神鳳

^a Tr. Ho Ping-Yü (8). ^b Tr. Sivin (4). ^c Tr. Spooner & Wang (1); Sivin (3). ^d Tr. Ho Ping-Yü & Needham (2).

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To describe their experiments the medieval Chinese alchemists and proto-chemists employed a host of technical terms.^a Unfortunately, in contrast with those used in astronomy, definitions of such terms, so far as we know, have not been found in the literature.^b A study of some of them has been made in recent times by Yuan Han-Chhing (1)^c and Ho Ping-Yü (15, 18). Their results are further elaborated in the following list:

Table 115. *Technical terms of operations*

<i>an</i> ¹ (lit. to place)	to set up, to place in position.
<i>chéng</i> ² (lit. steaming)	to steam grain, food, ferment or any other material in a steamer.
<i>chéng</i> ³ (lit. steaming)	distillation. ^d
<i>chiao</i> ⁴ (lit. to water)	to pour out a hot liquid and allow it to cool down or solidify slowly.
<i>chieh</i> ⁵ (lit. to tie up, to form an alliance)	to congeal, or solidify, generally by evaporation. Also used to refer to the formation of crystals.
<i>chien</i> ⁶ (lit. to fry)	to heat while stirring, either dry or with oil.
<i>chien lien</i> ⁷ (lit. to fry and refine)	to recrystallise.
<i>chih</i> ⁸ (lit. to control)	to prevent or delay the process of volatilisation, sublimation or distillation (i.e. fixation); to produce a change (cf. <i>fu</i> and <i>sha</i>). ^e
<i>chih</i> ⁹ (lit. to broil, stew, or toast; also to cauterise) ^f	to apply heat locally; to make an aqueous extract by heating; to dry by heating.
<i>ching</i> , ¹⁰ <i>ching hua</i> ¹¹	crystal; to crystallise or make to crystallise.
<i>chu</i> ¹² (lit. to boil)	to heat a substance in water, to simmer.
<i>chuan</i> ¹³ (lit. turn)	a cycle of changes, usually several times repeated. Cf. <i>huan</i> .
<i>chhou</i> ¹⁴ (lit. to draw out or pull up)	to distil, especially of mercury. ^g
<i>fei</i> ¹⁵ (lit. to fly)	sublimation; distillation (especially in the case of mercury); ^h vapourisation in general.

^a Hopkins gave a striking example of the incomprehensibility of technical terms to laymen, (1), p. 91. He took as his text a sample of instructions to a seamstress in 1934: 'Cross-cut bands are the medium turned in even to face and tacked at the edges; holes are used instead of eyes, made with a stiletto, and fan-stitch is used to fix the bones.' He added that not everyone, even at that time, would know the meaning of other terms such as herring-boning, fagotting, shirring, easing, piping, basting, overcasting, coarse-running and tacking out. Furthermore, he said, a foreigner would find the words hard to translate, especially if contemporary literature had disappeared, a thousand years hence. The same applies, of course, to all the arts and trades, so one cannot be surprised that there are still problems in the technical terms of alchemy and chemistry in the different cultures.

^b There is similar need for a glossary of technical terms in pharmacology and this we propose to provide in Sect. 45 (Vol. 6).

^c Pp. 207ff.

^d Mod. *chéng liu*.¹⁶

^e For example, heating sal ammoniac with tin so as to produce stannous chloride.

^f By confusion with *chiu*,¹⁷ the correct medical term for moxibustion and other forms of cautery.

^g Cf. e.g. TT893, p. 7a, b.

^h Cf. again TT893, p. 7a, b.

¹ 安	² 蒸	³ 蒸	⁴ 澆	⁵ 結	⁶ 煎	⁷ 煎鍊
⁸ 制	⁹ 炙	¹⁰ 晶	¹¹ 晶化	¹² 煮	¹³ 轉	¹⁴ 抽
¹⁵ 飛	¹⁶ 蒸餾	¹⁷ 灸				

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Table 115 (continued)

<i>fu</i> ¹ (lit. rotten, corrupt)	putrefaction; but also certain special fermentations.
<i>fu</i> ² (lit. to subdue, to make to lie prostrate)	to extract; to separate out from; to purify; esp. to prevent or delay the process of volatilisation, sublimation or distillation (i.e. fixation); to inhibit the potency of some other substance; cf. <i>chih</i> and <i>sha</i> .
<i>fu chi</i> ³ (lit. cover and bed)	a layer of mineral substance placed below and above the reactants in the vessel.
<i>fu huo</i> ⁴ (lit. to subdue in the fire)	to heat until the substance is subdued (i.e. fixed).
<i>hua</i> ⁵ (lit. to change)	to undergo, or make to undergo, chemical change; to melt or to solidify.
<i>hua chhih</i> ⁶ (lit. radiant or flowery pool)	a bath of strong acetic acid (vinegar, with additions), in which is immersed a substance or substances, sometimes contained within a pared and sealed bamboo tube. ^a
<i>hua khai</i> ⁷ (lit. to change so as to separate)	fusion; melting; thawing; digestion.
<i>huan</i> ⁸ (lit. return)	a cyclical operation several times repeated. Cf. <i>chuan</i> .
<i>hui chhih</i> ⁹	ash-bath (sand-bath)
<i>hsia</i> ¹⁰ (lit. down)	to put an ingredient in a vessel; to drive down; precipitation; descensory distillation.
<i>hsiao</i> , ¹¹ <i>hsiao hua</i> ¹² (lit. to disperse, dissipate)	to dissolve; to digest.
<i>jou</i> ¹³ (lit. weak, to weaken)	to soften; to macerate; ceration.
<i>jung</i> ^{14, 15, 16} (lit. to melt)	to smelt; to melt; to fuse; to blend; to dissolve.
<i>kang</i> ¹⁷ (lit. hard)	to harden.
<i>Khan kua</i> ¹⁸ (<i>Khan</i> trigram) ^b	to boil in water; to heat over a water-bath.
<i>kou</i> ¹⁹ (lit. to hook)	to extract (e.g. a metallic <i>chhi</i> from its ore).
<i>ku chi</i> ²⁰ (lit. firmly enclosed)	sealing the parts of a vessel together, with the aid of a lute, to make it as gas-tight (or water-tight) as possible, so that processes of change, especially those involving ascent and descent (as in sublimation and distillation), can go on in the interior, isolated thus as far as possible from its surroundings. ^c

^a One must be on the watch for very different meanings of this term, partly in pharmacy and medicine where various drugs might be combined with salts and vinegar, but especially in physiological alchemy, where (as with other *wai tan* terms) the significance is entirely different (cf. pt. 5 below).

^b Cf. Vol. 5, pt. 5 below, in our discussion of physiological alchemy.

^c This expression is an obscure one, and has given rise to some misunderstandings. Its second character evokes the hexagrams *Chi Chi* and *Wei Chi* (cf. pp. 68, 70-1); and here implies a perfecting of Yin-Yang relationships in compensation and equilibrium. That this could be done by moving things up and down was mirrored in the origin of these two *kua* themselves from the trigrams *Khan* and *Li* by

¹ 腐	² 伏	³ 覆籍	⁴ 伏火	⁵ 化	⁶ 華池	⁷ 化開
⁸ 還	⁹ 灰池	¹⁰ 下	¹¹ 消	¹² 消化	¹³ 揉	¹⁴ 熔
¹⁵ 鎔	¹⁶ 融	¹⁷ 剛	¹⁸ 坎卦	¹⁹ 勾	²⁰ 固濟	

Table 115 (continued)

<i>kuan</i> ¹ (lit. portal)	to bury in a container under the ground and allow slow chemical change to proceed without heating.
<i>Li kua</i> ² (<i>Li</i> trigram) ^a	to heat directly in the fire of a stove.
<i>lien</i> ³ (lit. to refine)	to heat a substance (especially a metal) without water; more broadly, to effect any chemical transformation.
<i>lin</i> ⁴ (lit. to soak)	to dissolve part of a substance (e.g. a mixture of salts) in water; to separate a solution from a precipitate or residue by filtration or decantation.
<i>liu</i> ⁵ (lit. steamed food)	some preparation submitted to the action of steam.
<i>lo</i> ⁶ (lit. gauze)	to sift through a sieve of cloth.
<i>lu</i> ^{7, 8} or <i>lü</i> ⁷ (to strain)	filtration; to filter.
<i>mu yü</i> ⁹ (lit. to bathe)	to grind in the presence of water or some other liquid.
<i>niang</i> ¹⁰ (ferment)	to ferment; fermentation.
<i>ning</i> ¹¹ (lit. to congeal)	to solidify; to harden; coagulation.
<i>o</i> ¹²	see <i>wu</i> .
<i>phu</i> ¹³ (to spread)	to spread out a bed of mineral material.
<i>san</i> ¹⁴ (lit. to scatter)	to separate; to disperse; to comminute; a medicinal powder.
<i>sha</i> ¹⁵ (lit. to kill)	to change a substance so that it is no longer volatile (cf. <i>chih</i> and <i>fu</i>).
<i>shai</i> ¹⁶ (lit. to sift)	to sift through a sieve of hair or rattan.
<i>shang</i> ¹⁷ (lit. up, above)	to drive up; sublimation; distillation.
<i>shêng</i> ^{18, 19} (lit. to rise or raise)	to sublime; to distil; to evaporate and vaporise in general.
<i>shêng hua</i> ²⁰ (lit. rising flower, ascending floreate essence)	sublimate; distillate; condensate.
<i>shih</i> ²¹	see <i>wei chhi shih</i> .

changes in the position of their central lines (cf. p. 271). In the simplest *wai tan* usage, therefore, *ku chi* gave the instruction ‘seal and sublime’ (cf. pp. 47, 79); though in some contexts the first half might perhaps predominate over the second (cf. Tshao Yuan-Yü (1), pp. 43, 52 (78, 85); Yuan Han-Chhing (1), p. 209; Sivin (1), p. 185).

But the phrase was also adopted in *nei tan* terminology, referring then to the sealing in of secretions normally lost from the body (cf. pt. 5), and to the ascent and descent of *chhi* and secretions within it; hence further to the ultimate retention of the enchyroma when formed. As we read in *Chin Tan Ta Chheng* (HCSS, ch. 10, p. 9b): ‘Thai-I Chen Jen says: “Seal the container (lit. womb, *thai*²²) firmly; then the chemical transformations (of the various materials inside) will take place with celerity”. He is speaking of “water” and “fire” combining to form the *kua Chi Chi*. Close the doors of the mysterious chamber and let nothing escape.’ Later on, the ‘hermetic’ sealing idea was applied to the sealing out of sense impressions and wandering thoughts (cf. pt. 5). ‘Forgetting forms and abandoning desires and memories, that is called *ku chi*’ (HCSS, ch. 1, p. 3b).

Finally, *ku chi* was also used in medical language, again with the nuance of ascent and descent within. Fang I-Chih explains the method that went by that name (*Wu Li Hsiao Shih*, ch. 4, p. 17b) as applying drugs which would drive up or down the malign *Yang chhi* according to the illness concerned.

^a Cf. Vol. 5, pt. 5 below, in our discussion of physiological alchemy.

¹ 關	² 離卦	³ 煉	⁴ 淋	⁵ 餾	⁶ 羅	⁷ 濾
⁸ 漚	⁹ 沐浴	¹⁰ 釀	¹¹ 凝	¹² 惡	¹³ 鋪	¹⁴ 散
¹⁵ 殺	¹⁶ 篩	¹⁷ 上	¹⁸ 升	¹⁹ 昇	²⁰ 昇華	²¹ 使
						²² 胎

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Table 115 (continued)

<i>shui fa</i> ¹ (lit. water method)	solubilisation; bringing substances into aqueous solution.
<i>shui fei</i> ² (lit. flying on water)	purification of a powdered mineral by flotation on water (cf. <i>fei</i>).
<i>shui hai</i> ³ (lit. water sea)	a cooling-water reservoir or condenser vessel. ^a
<i>shui kuan</i> ⁴ (water pipe)	a cooling-water tube or coil. ^a
<i>ssu</i> ⁵ (lit. death, to die)	change of a substance so that it loses its original form or properties; to detoxicate; to decompose.
<i>tao</i> ⁶ (to beat)	to pound (as in a mortar).
<i>tê</i> ⁷ (lit. to obtain)	'going well with', the synergistic action of substances chemically or pharmacologically; one thing enhancing the action of another (an expression which could have covered cases of what we should now call catalysis). Cf. <i>wei chhi shih</i> .
<i>thi ching</i> ⁸ (to cleanse)	to purify; to separate a metal from an alloy.
<i>thi lien</i> ⁹	to refine.
<i>tien</i> ^{10, 11} (lit. a spot)	a pinch, a speck, a knife-point, 'a spot of'; and to put such a small amount into a larger body of something else; projection.
<i>tien hua</i> ¹²	projection; a small quantity of one substance producing change in a much larger quantity of another substance.
<i>tuan</i> ¹³ (lit. to forge)	to heat at a high temperature.
<i>wei</i> ¹⁴	'to have a fear of', i.e. to be capable of dissolving in, some solvent. ^b
<i>wei chhi shih</i> ¹⁵	'acting as its envoy (or adjutant)', ^c said when one substance enhances or activates the effect of another, chemically or pharmacologically. Cf. <i>tê</i> .
<i>wu</i> ¹⁶ (lit. to hate)	to inhibit the potency of some other substance.
<i>yang</i> ¹⁷ (lit. to nourish)	to apply heat gently over a long period, as by dung fire, charcoal embers, the water-bath, bed of ashes, or sand-bath (athanor).
<i>yen</i> ¹⁸ (lit. to grind)	to comminute, to powder.
<i>yü yen</i> ¹⁹ (lit. fish eyes)	bubbles appearing on the surface of a heated liquid, like fish eyes.
<i>yü yen fei</i> ²⁰ (fish-eye boiling)	a particular stage in the boiling process (cf. Vol. 4, pt. 1, p. 69).
<i>yung</i> ^{21, 22, 23}	see <i>jung</i> .

^a On these two expressions see particularly *TT907*, discussed on pp. 35 ff.
^b Said, for example, of gold with respect to mercury, because of the formation of amalgams.
^c Cf. our account of the most ancient Chinese pharmacological classification system in Sect. 38 (Volume 6).

¹ 水法	² 水飛	³ 水海	⁴ 水管 (筥)	⁵ 死	⁶ 壽	⁷ 得
⁸ 提淨	⁹ 提煉	¹⁰ 點	¹¹ 点	¹² 點化	¹³ 煨	¹⁴ 畏
¹⁵ 爲其使	¹⁶ 惡	¹⁷ 養	¹⁸ 研	¹⁹ 魚眼	²⁰ 魚眼沸	²¹ 熔
²² 鎔	²³ 融					

From this it can be seen that the armamentarium of technical terms available to the ancient and medieval Chinese alchemists, proto-chemists and pharmacists was quite parallel with those used by the Greeks^a and Latins^b in the West. Lists of standard operations are often found in the occidental texts,^c and it may be worth looking at them for a moment by way of comparison. One can tabulate them as follows, in accordance with the changes of state which they implied:^d

solid→solid	
Calcination	G/4
Fixation	G/7
Ceration	G/8
solid→liquid	
Fusion	G/5
Solution	G/2
Descension	
liquid→solid	
(Crystallisation)	
Coagulation	G/6
(Precipitation)	
(Filtration)	
solid→gas	
Fermentation or Putrefaction	
solid→gas→solid	
Sublimation	G/1
liquid→gas	
(Evaporation)	
gas→liquid	
(Condensation)	
liquid→gas→liquid	
Distillation	G/3

In the old lists of definitions the terms occur in a variety of different orders, sometimes with omissions, sometimes with additions, and they do not include all of the modern operational ideas which one would expect. A few words of further explanation will suffice to assist comparisons with the Chinese terms.

By Calcination^e was meant the reduction of any solid to a powder by chemical means (e.g. a metal to its oxide)—‘the pulverisation of a thing by fire’.^f Fixation,^g reminiscent of *chih*,¹ was ‘the convenient disposing of a fugitive thing to abide and

^a See Berthelot (2), i.e. Berthelot & Ruelle (1), pp. 263–4.
^b See e.g. Holmyard (1), pp. 43 ff.
^c As also in Syriac and Arabic MSS. For such lists of operations see Berthelot & Duval (1), pp. 165 ff.; Stapleton, Azo & Husain (1), pp. 326 ff., 356 ff., 366 ff., 385 ff.
^d Terms primarily modern, though occasionally used in medieval times, are placed in brackets. The numbers marked G show the order of description in the Geberian *Summa Perfectionis*, c. +1290.
^e *Summ. Perf.*, ch. 51 (like all the other chapters here quoted, in bk. 4).
^f *Ibid.*, Russell tr., p. 101.
^g *Summ. Perf.*, ch. 54.
¹ 制

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sustain the fire'.^a Ceration,^b softening or 'waxifying', was 'the mollification of a hard thing, not fusible unto liquefaction',^c e.g. the formation of amalgams and sulphides. Fusion applied generally to all smelting and melting; it might have been regarded by the Geberian writer as a form of Solution,^d 'the reduction of a dry thing into water',^e as happens when a salt is dissolved. Descension^f was simply what we shall shortly discuss as *destillatio per descensum*,^g the liquefying of mercury or an oil by heat and its descent into a receiver below. Coagulation^h was defined in Geber as 'the reduction of a thing liquid to a solid substance by privation of the humidity',ⁱ as when mercury is combined with sulphur to form vermilion.^j Crystallisation, Precipitation and Filtration were processes known, of course, to all the proto-chemists from Hellenistic times onwards, and China also; though not often listed in the Western medieval categories of operations. These do generally include, however, Fermentation or Putrefaction, names referring to the natural changes occurring in dead organic materials under the action of bacteria, yeasts and moulds, often with the evolution of gases; as also the formation of gases from inorganic substances in certain reactions—but the terms were commonly applied as well to any chemical change brought about by long subjection to mild heat. Sublimation,^k on the other hand, was a term always used in much the same way as we ourselves use it, vaporisation with condensation above in solid form; and this 'elevation of a dry thing by fire, with adherency to its vessel'^l was the process which occasioned the lengthiest descriptions in the *Summa Perfectionis*. Evaporation and Condensation are terms rather more modern, but Distillation^m necessarily gave rise also to a long discussion. 'The cause why distillation was invented' said the Geberian writer, 'and the general cause of the invention of every distillation, is the purification of liquid matter from its turbulent faeces and the conservation of it from putrefaction'.ⁿ The term included also a medieval process which has few remains in modern technique, *destillatio per filtrum*, where a siphon is made of a piece of cloth hanging across the edge of a pan to take the solvent over by capillary attraction into a separate receiver.^o Finally, besides all these we must remember the characteristically alchemical processes of Projection, clearly recognisable in *tien hua*¹ (pt. 3, pp. 38, 88, etc.); as also Separation, Mortification, Ablution, *Nigredo*, *Albedo*, *Citrinitas* and *Rubedo* (pt. 2, p. 23), about which no more need be said here. Thus, all in all, an inspection of the two lists of technical terms will show considerable parallelism in the development of chemical technique in the Far East and the Far West.

We are now in a position to make a tour of the Chinese medieval alchemical and

^a *Ibid.*, Russell tr., p. 116.

^c *Ibid.*, Russell tr., p. 119.

^e *Ibid.*, Russell tr., p. 107.

^g Pp. 55 ff. below.

ⁱ *Ibid.*, Russell tr., p. 110.

^k *Summ. Perf.*, chs. 39 to 48 incl.

^l *Ibid.*, Russell tr., p. 74.

ⁿ *Ibid.*, Russell tr., p. 96.

^o Whether or not this practice was also current in medieval Chinese alchemy we are at present unable to say.

^b *Summ. Perf.*, ch. 55.

^d *Summ. Perf.*, ch. 52.

^f *Summ. Perf.*, ch. 49.

^h *Summ. Perf.*, ch. 53.

^j Cf. pp. 262–3 below, and pt. 3, pp. 126, 198.

^m *Summ. Perf.*, ch. 50.

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iatro-chemical laboratory,^a and to examine systematically the pieces of apparatus that were used there.^b

(I) THE LABORATORY BENCH

The Chinese alchemist's version of the modern laboratory bench was the *than*¹ (lit. platform or altar). No specific rules were laid down with regard to its dimensions and constructions. *TT904*, a Sung book, gives an illustration of it (Fig. 1374)^c together with the following explanatory notes:

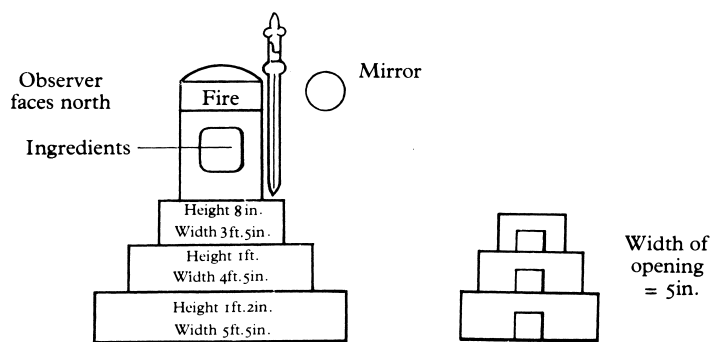


Fig. 1374. Stove platform from *Kan Chhi Shih-liu Chuan Chin Tan* (a Sung text).

The *tsao*² (furnace) is the *yao lu*³ (chemical stove). The *ting*⁴ (vessel) is called the *sha ho*⁵ (cinnabar enclosure). The *shen shih*⁶ (magical reaction-chamber) is the *hun tun*⁷ (world of chaos).

The same text describes the diagram, saying:^d

Build a *than* (platform) of three stages, with a (total) height of 3 ft. 6 in. The platform is square with a perimeter of 10 ft.

One notes that this description does not coincide with the dimensions given in the diagram itself.

^a Here we are concerned primarily with the 'hardware', but later more will be said about the liturgical and magical aspects of the matter (cf. pp. 289ff. below, and Fig. 1521). The sword, the mirror, the jars of pure water, the peach-wood talismans, all have to be borne in mind along with the aludels, mattresses and stills; cf. Yoshida Mitsukuni (7), pp. 250, 257.

^b We may be excused from offering any complete guide to the lists of apparatus and instruments used in other culture-areas. For the Hellenistic apparatus Berthelot (1, 2) and Sherwood Taylor (2, 5) are of course indispensable. Arabic apparatus (*tadābir*) is listed and described, *inter alia*, in Berthelot & Duval (1), pp. 150ff. (Syriac MSS); and in Stapleton, Azo & Husain (1), pp. 324ff., 353ff., 362ff., 378ff.; Stapleton & Azo (1), pp. 60ff. Wiedemann (22) consecrated a special paper to the apparatus of the Arabic chemists such as al-Rāzi (c. +900); and names of the parts of apparatus can be found in the dictionary of Siggel (2). Holmyard (18) covers clearly and succinctly the whole range from the Hellenistic proto-chemists through the Arabic writers and the Latin West to the 17th century in Europe.

^c P. 8a.

^d P. 7b.

¹ 壇 ² 竈 ³ 藥爐 ⁴ 鼎 ⁵ 砂合 ⁶ 神室 ⁷ 混沌