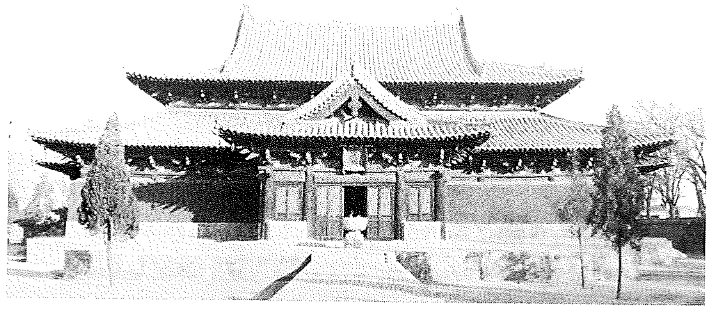
CHINESE ARCHITECTURE
A PICTORIAL HISTORY

LIANG SSU-CH'ENG

Edited by Wilma Fairbank



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Origins

The architecture of China is as old as Chinese civilization. From every source of information—literary, graphic, exemplary—there is strong evidence testifying to the fact that the Chinese have always employed an indigenous system of construction that has retained its principal characteristics from prehistoric times to the present day. Over the vast area from Chinese Turkestan to Japan, from Manchuria to the northern half of French Indochina, the same system of construction is prevalent; and this was the area of Chinese cultural influence. That this system of construction could perpetuate itself for more than four thousand years over such a vast territory and still remain a living architecture, retaining its principal characteristics in spite of repeated foreign invasions—military, intellectual, and spiritual—is a phenomenon comparable only to the continuity of the civilization of which it is an integral part.

Near Anyang, Honan Province, at the site of the palaces and necropolis of the Shang–Yin emperors (ca. 1766–ca. 1122 B.C.), excavated by the Academia Sinica, are found the earliest known remains of buildings in China (fig. 10). These are large loess platforms, upon which undressed boulders, flat sides up, are placed at regular intervals, each topped by a bronze disc (later known as a *chih*). On top of these discs are found charred logs, the lower ends of wooden posts that once supported the superstructures that were burned at the sack of the capital when the Yin dynasty fell to the Chou conquerors (ca. 1122 B.C.). The arrangement of these column bases testifies to the existence of a structural system that had by this time taken a definite form and was destined to provide shelter for a great people and their civilization from that time until today.

The basic characteristics of this system, which is still used, consist of a raised platform, forming the base for a structure with a timber post-and-lintel skeleton, which in turn supports a pitched roof with overhanging eaves (figs. 1, 2). This osseous construction permits complete freedom in walling and fenestration and, by the simple adjustment of the proportion between walls and openings, renders a house practical and comfortable in any climate from that of tropical Indochina to that of subarctic Manchuria. Due to its extreme flexibility and adaptability, this method of construction could be employed wherever Chinese civilization spread and would effectively shelter occupants from the elements, however diverse they might be. Perhaps nothing analogous is found in Western architecture, with the limited exception of the Elizabethan half-timber structure in England, until the invention of reinforced concrete and the steel framing systems of the twentieth century.

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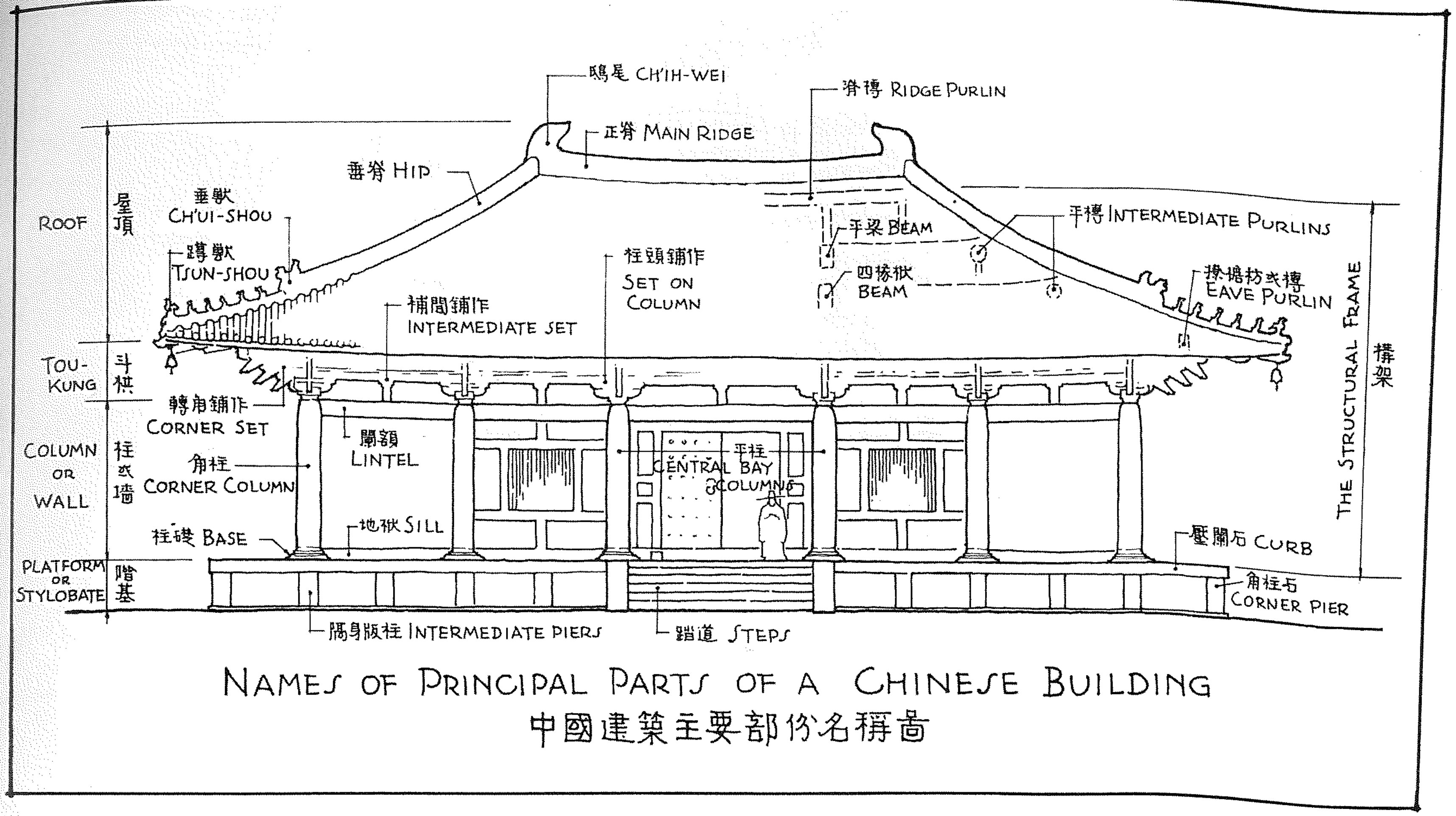
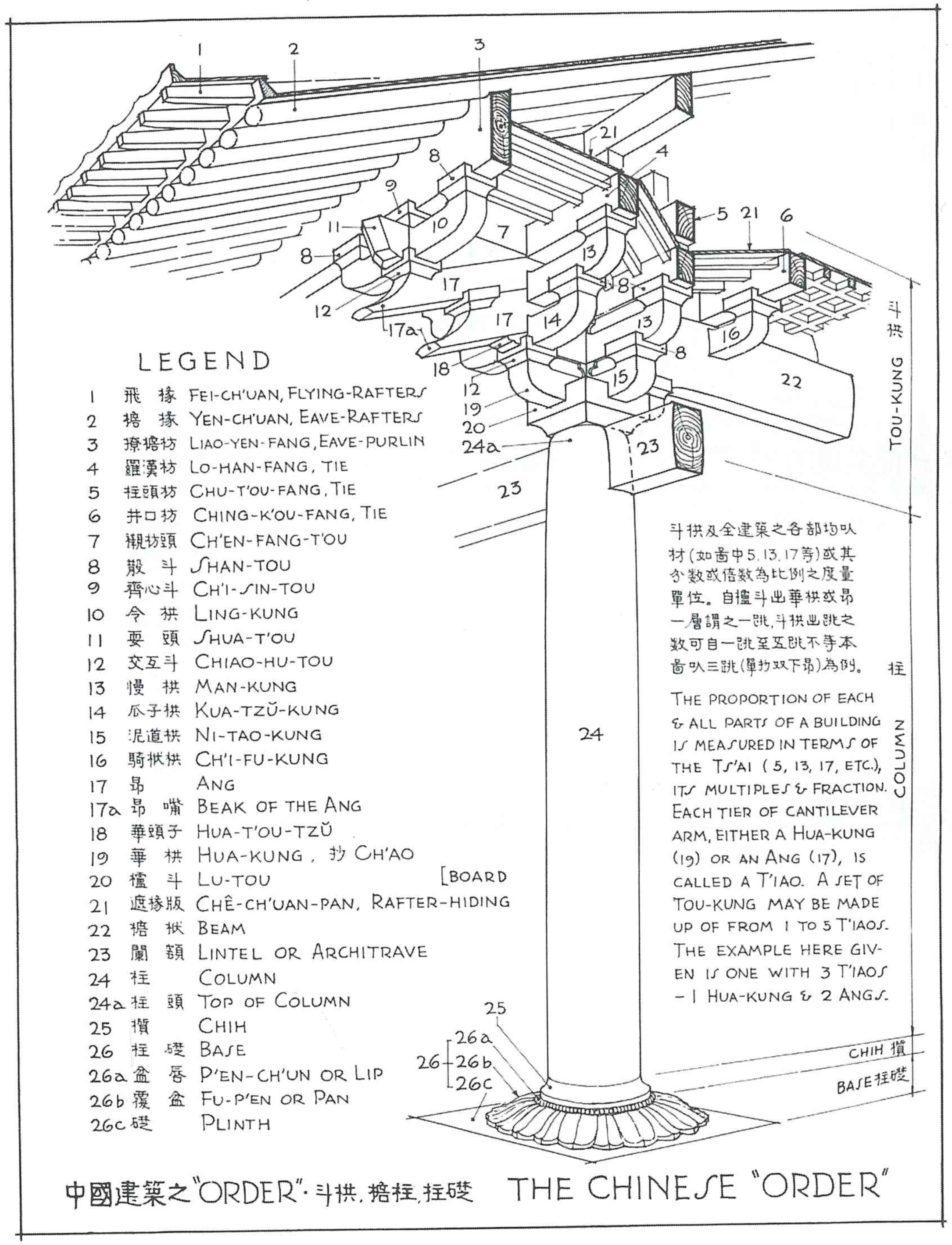
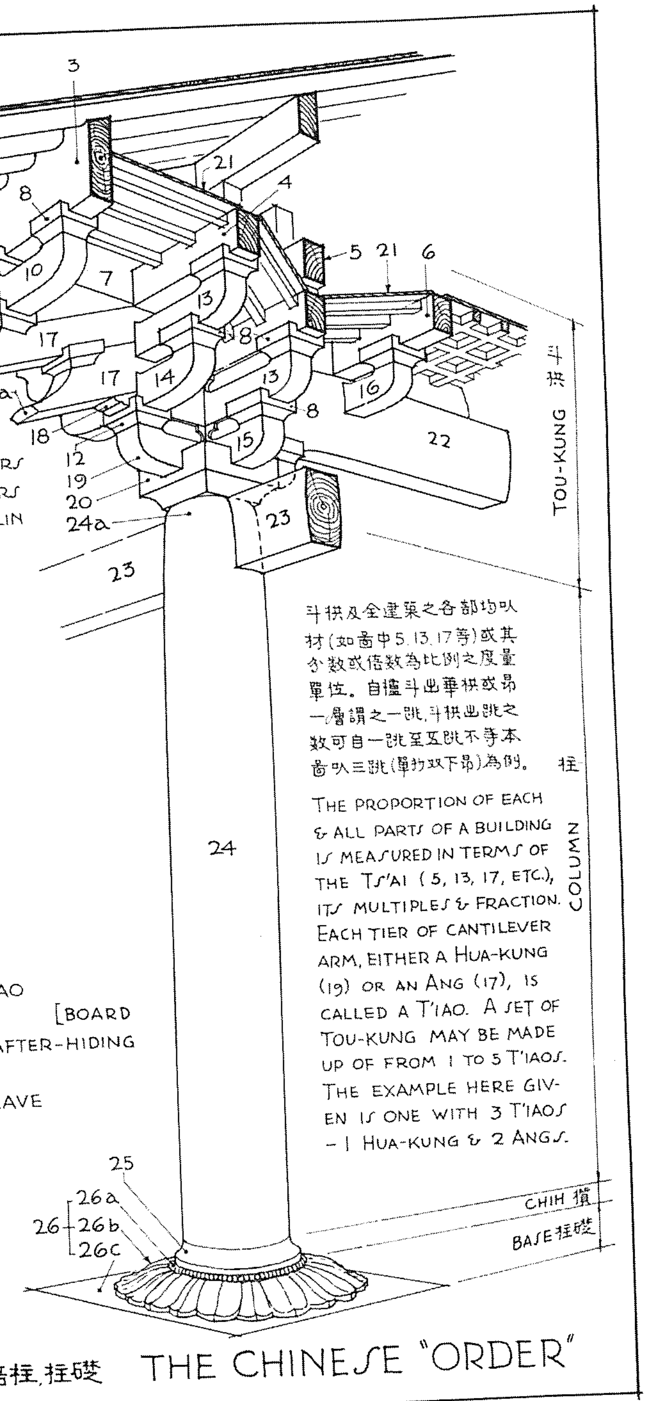


1

Principal parts of a Chinese timber-frame building



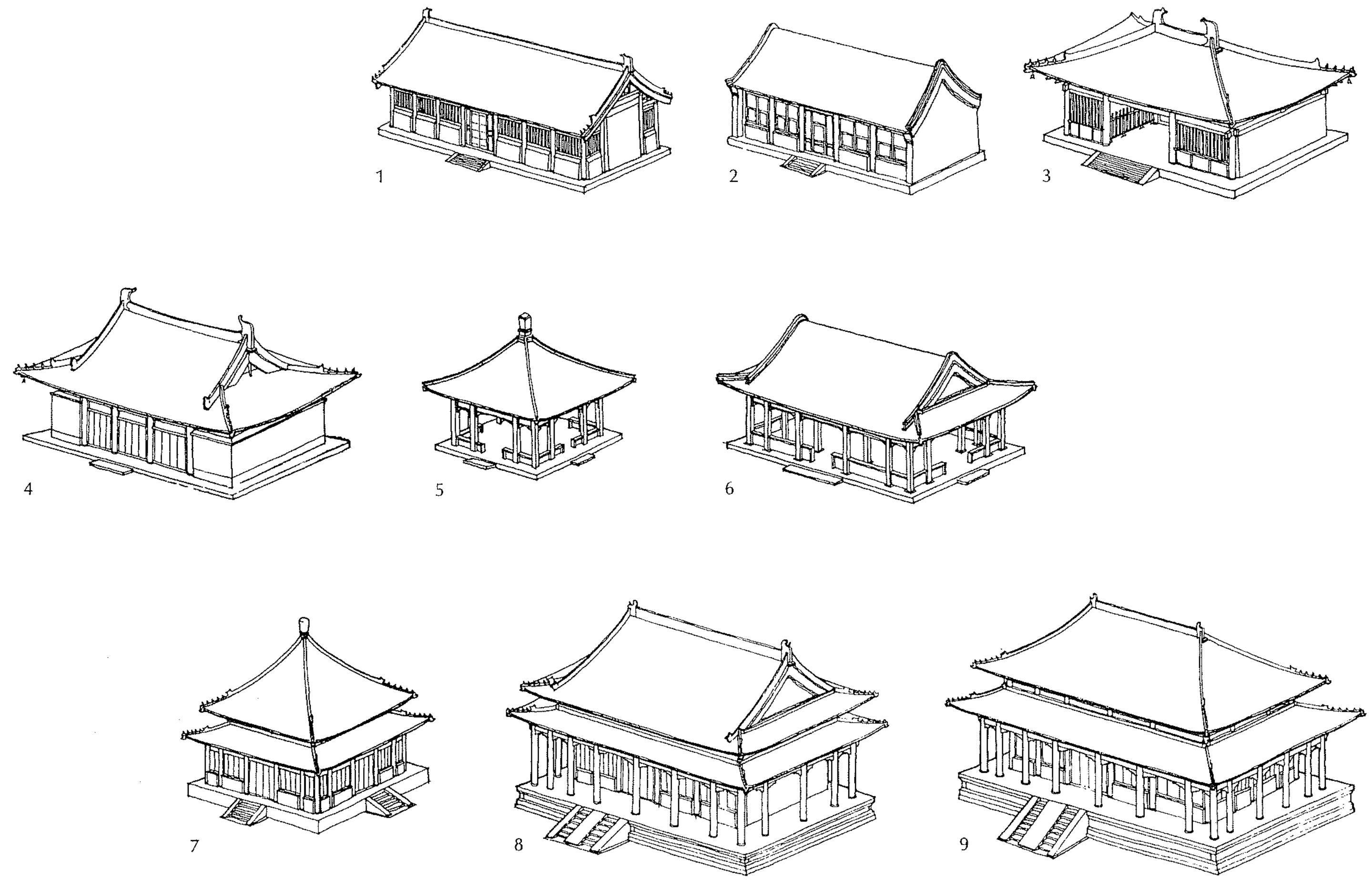
2
The Chinese "order" (the most frequently reprinted of Liang's drawings)



Editor's Note: The Curved Roof and Bracket Sets

Figures 1 and 2 present the basic characteristics of traditional Chinese architecture in a way that will be clear to a prepared mind. However, since not every reader will have had the opportunity to see in situ or to study Chinese timber-frame buildings, a few words of further explanation are offered here.

The immediately outstanding feature of Chinese monumental architecture is the curved roof with overhanging eaves, which is supported by a timber skeleton based on a raised platform. Figure 3 illustrates nine variations of the five types of roof construction listed by Liang on page 26. To understand how and why these curved roofs with their upturned eaves are constructed, we must examine the timber skeleton itself. In Liang's words, "the study of the Chinese building is primarily a study of its anatomy. For this reason the section drawings are much more important than the elevations."



3
Five types of roof
1. overhanging gable roof, 2. flush gable roof, 3. hip roof, 4 and 6. gable-and-hip roofs, 5. pyramidal roof, 7–9. double-eaved versions of 5, 6, and 3 respectively.

The section drawings show us that the roof supports in Chinese timber-frame construction differ fundamentally from the conventional Western triangular roof trusses that dictate the rigidity of our straight pitched roofs. The Chinese frame is, instead, markedly flexible (fig. 4). The timber skeleton consists of posts and cross beams rising toward the ridge in diminishing lengths. The purlins—horizontal members that support the rafters—are positioned along the stepped shoulders of the skeleton. The rafters are short, stretching down only from purlin to purlin. By manipulating the heights and widths of the skeleton, a builder can produce a roof of whatever size and curvature are required. The concave curved roof allows the semicylindrical rooftiles to fit together snugly for watertightness.

The extent of eave projection is also remarkable. For example, the eaves of the T'ang temple Fo-kuang Ssu (857 A.D.), which Liang discovered, project about fourteen feet out from their supporting columns (fig. 24). Their importance in sheltering the wooden structure from weather damage for over 1100 years is obvious—for instance, they throw away from the building the rainwater that courses down the tile troughs of the concave roof.

But the immediate function of raising the roof edges is to permit light to penetrate to the interior of the building despite the wide overhang. This necessitates both extending support far outside the interior skeleton to carry the overhanging eave and also building up this support vertically to handle the upturn. How is this achieved?

As Liang points out, "the *tou-kung* [bracket set] plays the leading role, a role so important that no study of Chinese architecture is feasible without a thorough understanding of this element, the governing feature of the Chinese 'order.'" Figure 5 is an isometric view of a bracket set, and figure 6 shows such a *tou-kung* (pronounced doe-goong) in place atop a supporting column. Again we are encountering an exotic element. We in the West are accustomed to simple capitals that receive a direct weight and transfer it to the column. The *tou-kung* is a very complex member. Though its base is simply a large square block on the top of the column, there are set into that block crossed arms (*kung*) spreading in four directions. These in turn bear smaller blocks (*tou*) that carry still longer arms spreading in the four directions to support upper members in balance. The jutting arms (*hua-kung*) rise in tiers or "jumps" and extend outward in steps from the large-block fulcrum to support the weight of the overhanging eaves. This external pressure is countered by internal downthrusts at the other ends of the bracket arms. Intersecting the *hua-kung* in the bracket set are transverse *kung* that parallel the wall plane. Long cantilever arms called *ang* descend from the inner superstructure, balance on the fulcrum, and extend through the bracket sets to support the outermost purlins (fig. 6). This outer burden is countered by the downthrust of upper interior purlins or beams on the "tails" of the *ang*. The extruding "beaks" of the *ang* easily identify them in the bracket sets. Liang explains more fully these and other complexities in the evolution of this construction.—Ed.

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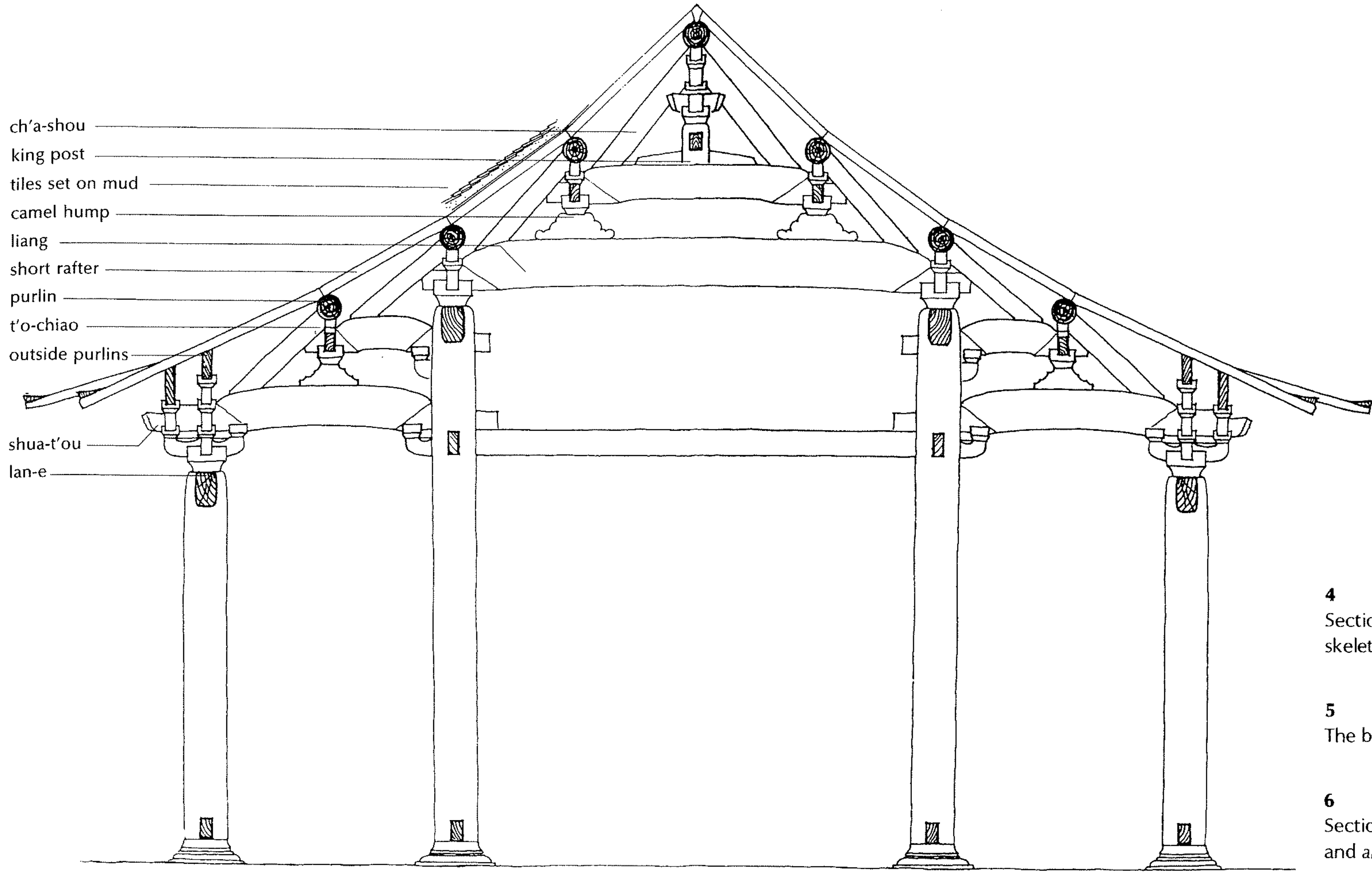
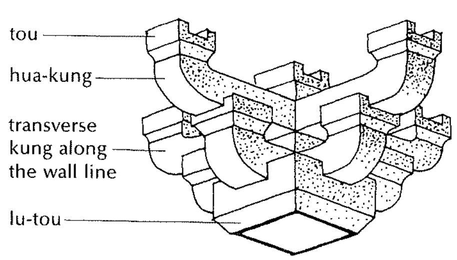
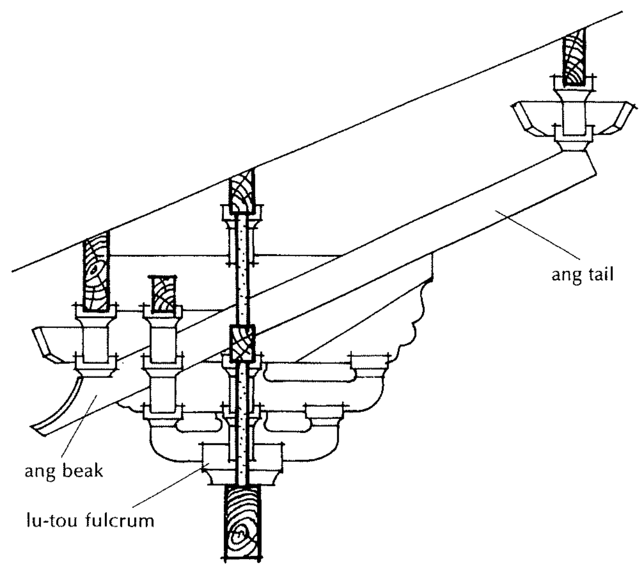


4
Section, showing flexible beam skeleton supporting curved roof



5
The basic bracket set



6
Section, showing bracket set and *ang*

Two Grammar Books

As this system matured through the ages, a well-regulated set of rules governing design and execution emerged. To study the history of Chinese architecture without a knowledge of these rules is like studying the history of English literature before learning English grammar. Therefore, a brief examination of them is necessary.

For this purpose we are fortunate to have two important books left to us from two epochs of great building activities: the *Ying-tsao fa-shih (Building Standards)* of the Sung dynasty (960–1279) and the *Kung-ch'eng tso-fa tse-li (Structural Regulations)* of the Ch'ing dynasty (1644–1912)—two "grammar books" on Chinese architecture, as we may call them. Both government manuals, they are of the greatest importance for the study of the technological aspects of Chinese architecture. We owe to them all the technical terms that we know and all the criteria that we employ today for the comparative study of the architecture of different periods.

The *Ying-tsao fa-shih*

The *Ying-tsao fa-shih (Building Standards)* was compiled by Li Chieh, superintendent of construction at the court of Emperor Hui-tsung (ruled 1101–1125) of the Sung dynasty. Of the thirty-four chapters thirteen are devoted to rules governing the design of foundations, fortifications, stone masonry and ornamental carving, "major carpentry" (structural framing, columns, beams, lintels, ties, brackets, purlins, rafters, etc.), "minor carpentry" (doors, windows, partitions, screens, ceilings, shrines, etc.), brick and tile masonry (official rank and use of tiles and ornaments), painted decoration (official rank and design of ornamental painting). The rest of the text contains definitions of terms and data for estimation of materials and labor. The last four chapters contain drawings illustrating various kinds of designs in carpentry, stonework, and ornamental painting.

The book was published in 1103. During the eight and a half centuries that have since elapsed, both technical terms and forms have changed, and in an atmosphere in which scholars and literary men looked upon technical and manual work with contempt, the book receded into obscurity and was treasured only by connoisseurs as a rare oddity. It is extremely difficult for the layman today to understand, and many of its passages and terms are almost meaningless. Due to the conscientious efforts of the Institute for Research in Chinese Architecture, first by mastery of the regulations of the Ch'ing dynasty (the *Kung-ch'eng tso-fa tse-li*), and later with the discovery of a considerable number of wooden structures dating from the tenth to the twelfth centuries, many mysteries of the book have been clarified, rendering it now quite "readable."

Because timber is the principal material used in Chinese architecture, the chapters on "major carpentry" are the most important part of the book for understanding the structural system. The essentials of these rules are explained visually in figures 2 and 7 and may be summed up as follows.

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1. Modules (*ts'ai* and *ch'i*)

The term *ts'ai* has a twofold meaning:

(a) A standard-sized timber used for the *kung*, or "arms" of a set of brackets (*tou-kung*); and all timbers of the same depth and width. There are eight sizes, or grades, of *ts'ai*, which are determined by the type and official rank of the building to be erected.

(b) A module for measurement, described as follows:

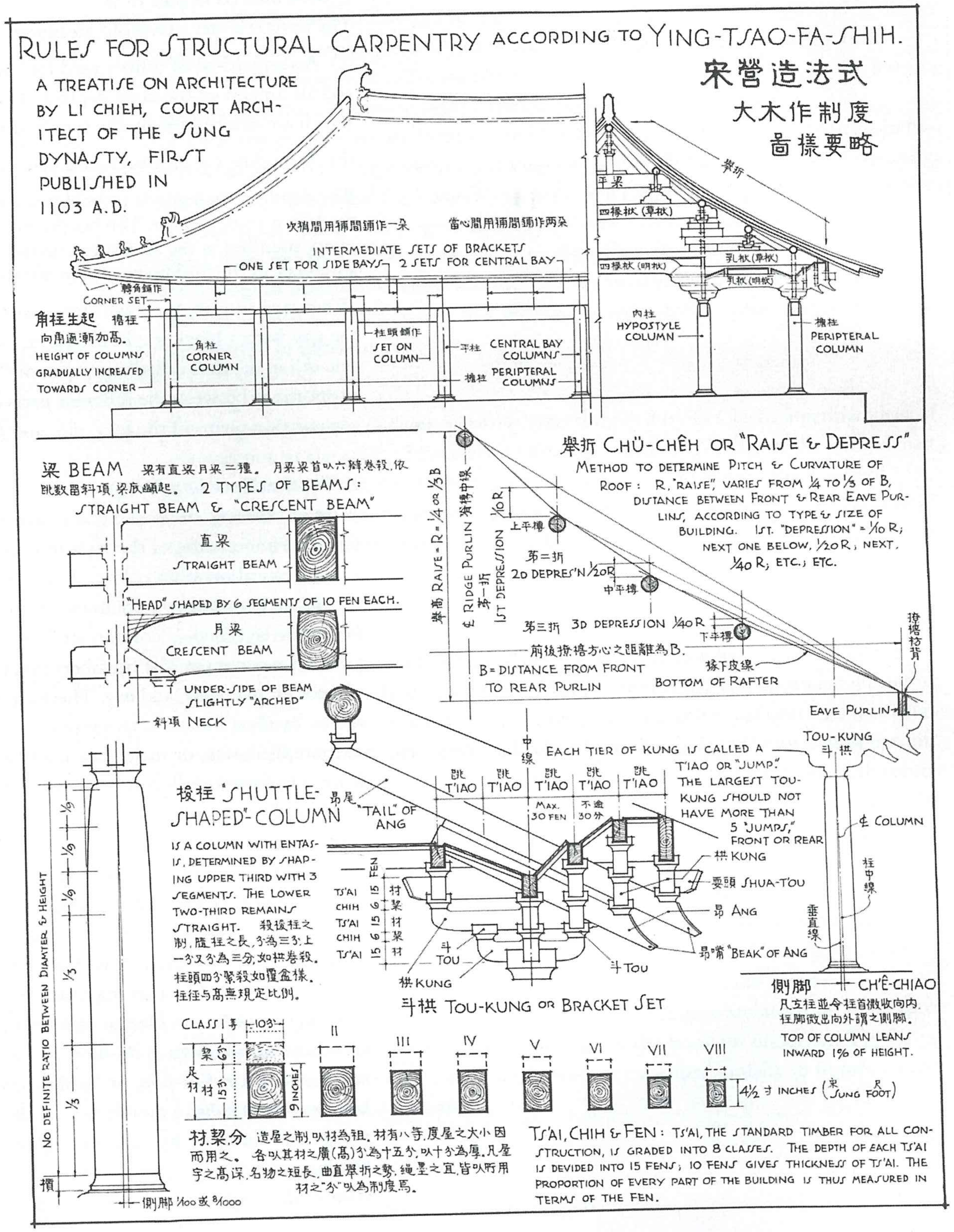
The depth of each *ts'ai* is to be divided into 15 equal parts, called *fen*, and the width of the *ts'ai* is to be ten *fen*. The height and breadth of every building, the dimensions of every member in the structure, the rise and curve of the roofline, in short, every measurement in the building, is to be measured in terms of *fen* of the grade of *ts'ai* used.

When two *ts'ai* are used one above another, it is customary to cushion them by filling the gap with a block six *fen* in height, called a *ch'i*. A member measuring one *ts'ai* and one *ch'i* in depth is called a *tsu-ts'ai*, or "full *ts'ai*." The measurements of, and the proportions between the different parts of a building of the Sung dynasty are always expressed in terms of the *ts'ai*, *ch'i*, and *fen* of the grade of *ts'ai* used.

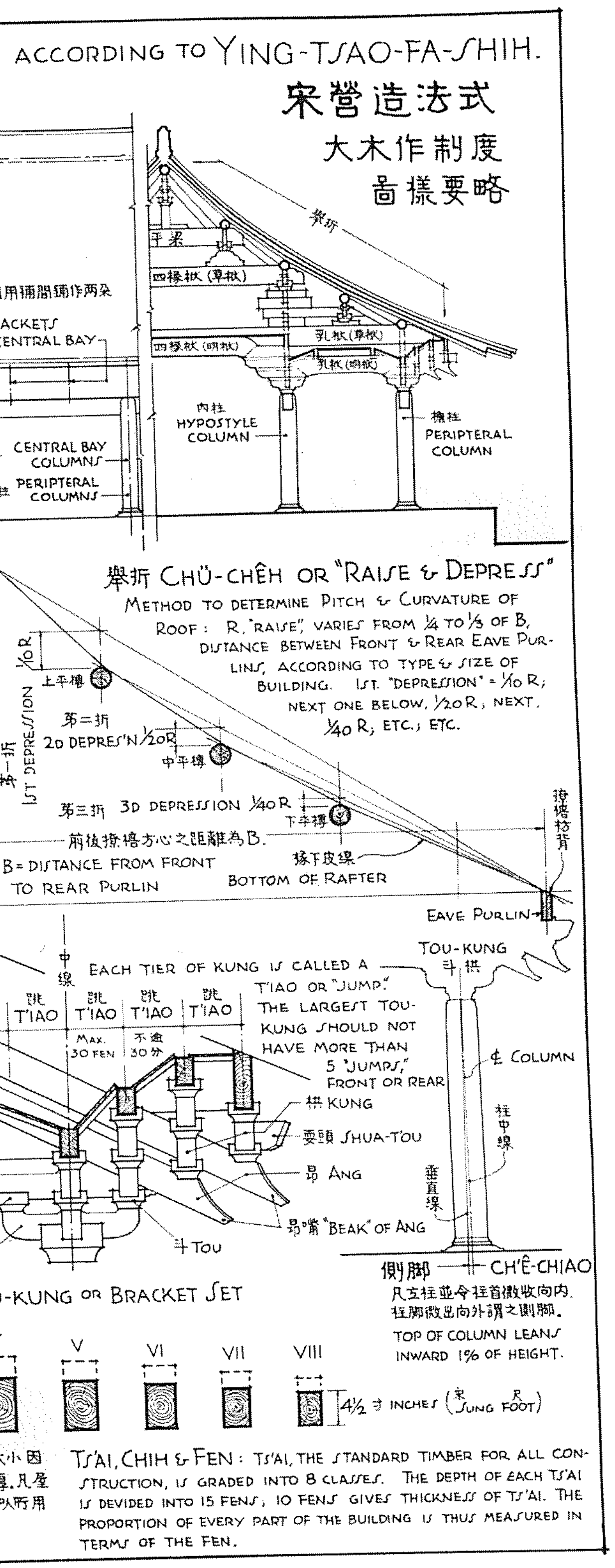
2. Bracket Sets (*tou-kung*)

A set of *tou-kung*, or brackets, is an assemblage of a number of *tou* (blocks) and *kung* (arms). The function of the set is to transfer the load from the horizontal member above to the vertical member below. A set may be placed either on the column, or on the architrave between two columns, or on the corner column. Accordingly, a set of *tou-kung* may be called a "column set," "intermediate set," or "corner set" depending on the position it occupies. The members that make up a set may be divided into three main categories: *tou*, *kung*, and *ang*. There are four kinds of *tou* and five kinds of *kung*, determined by their functions and positions. But structurally the most important members of a set are the *lu-tou*, or major bearing block, and the *hua-kung*, or arms extending out from it to form cantilevers to both front and rear, at right angles to the facade of the building. Sometimes a slanting member, at approximately a 30-degree angle to the ground, is placed above the *hua-kung*; it is called the *ang*. The "tail" or upper end of the *ang* is often held down by the weight of the beam or the purlin, making it a lever arm for the support of the large overhang of the eave.

The *hua-kung* may be used in successive tiers, each extending front and rear a certain distance beyond the tier below. Such a tier and extension is called a *t'iao*, or "jump," and the number of *t'iao* in a set may vary from one to five. Transverse *kung* intersect the *hua-kung* in the *lu-tou*. One or two tiers of transverse *kung* may be used in a *t'iao*. Such an arrangement is known as *chi-hsin*, or "accounted heart," while a *t'iao* without transverse *kung* is known as *t'ou-hsin*, or "stolen heart." One tier of transverse *kung* is called *tan-kung*, or single *kung*; a double tier is called *ch'ung-kung*, or double *kung*. By varying the number of "jumps," by "accounting" or "stealing" the "hearts," by cantilevering with *hua-kung* or with *ang*, and by using single or double transverse *kung*, different combinations of the *tou-kung* can be assembled.



7
Sung dynasty rules for structural carpentry



3. Beams

The size and shape of a beam varies according to its function and position. The beams below a ceiling are called *ming-fu*, or "exposed beams." They are either straight or slightly arched; the latter is called *yüeh-liang*, or "crescent-moon beam." Above the ceiling *ts'ao-fu*, or "rough beams," are used to receive the load of the roof. The circumference of a beam may vary according to its length, but the cross section always retains, as a norm, a ratio of 3 : 2 between its depth and width.

4. Columns

Rules governing the length and the diameter of a column are rather loose. The diameter may vary from one *ts'ai*-plus-one *ch'i* to three *ts'ai*. The column may be either straight or shuttle-shaped. The latter is given an entasis on the upper third of the shaft. The most important rules in columniation are: (1) a gradual increase in the height of the columns from the central bay toward the corners of the building, and (2) a slight inward incline of the columns, about 1 : 100. These refinements help give an illusion of stability.

5. The Curved Roof (*chü-che*)

The profile of the roof plane is determined by means of a *chü*, or "raising" of the ridge purlin, and a *che*, or "depression" of the rafter line. The pitch is determined by the "raise" of the ridge, which may make a slope varying from 1 : 2 for a small house to 2 : 3 for a large hall, with gradations in between. The height of the raise is called the *chü-kao*. The curve of the rafter line is obtained by "depressing" or lowering the position of the first purlin below the ridge, by one-tenth of the height of the *chü-kao*, off a straight line from the ridge to the eave purlin. Another straight line is then drawn from this newly plotted point to the eave purlin, and the next purlin below is "depressed" by one-twentieth of the *chü-kao*. The process is repeated, and each time the "depression" is reduced by half. The points thus obtained are joined by a series of straight lines and the roof line is plotted. This process is called *che-wu*, or "bending the roof."

Besides these basic rules, Sung methods for the use and shaping of architraves, ties, hip rafters, purlins, common rafters, and other elements are carefully specified in the *Ying-tsao fa-shih*. A careful study of the evolution of the major carpentry of different periods introduced in later chapters gives a fairly clear idea of the development of the Chinese structural system through the ages.

The chapters on minor carpentry give rules for the designing of doors, windows, partitions, screens, and other nonstructural elements. The tradition is generally carried on in later ages without drastic modification. Ceiling coffers are either square or rectangular, and the large principal coffer is often decorated with miniature *tou-kung*. Even Buddhist and Taoist shrines are highly architectural in character and are decorated with *tou-kung*.

The chapter on tile and tile ornaments specifies the sizes and numbers of the ornamental dragon heads and "sitting beasts" that decorate the ridges, according to the official rank and size of the building. The making of a ridge by piling up ordinary roof tiles, though still practiced today in southern China, is a method no longer used in monumental architecture.

The chapters on decorative painting specify the kinds of painting for different ranks of buildings. Rules also govern the distribution of colors, mainly on the principle of contrasting warm and cool colors. We also learn that the shading of colors is obtained by the juxtaposition of colors related in the chromatic scale rather than by deepening a single color. The principal colors used are blue, red, and green, accented with black and white. Yellow is occasionally used. This tradition has been followed from the T'ang dynasty (618–907) to the present.

A great deal of attention is also paid to the details of parts and members, such as the shaping and curving of the *tou*, *kung*, and *ang*, the arching of the beam and the pulvination of its sides, the carving of ornaments on pedestals and balustrades, and the color schemes of various types and grades of decorative painting. In many respects the *Ying-tsao fa-shih* is a textbook in the modern sense of the word.

The *Kung-ch'eng tso-fa tse-li*

The *Kung-ch'eng tso-fa tse-li (Structural Regulations)* was published in 1734 by the Ministry of Construction of the Ch'ing dynasty. The first twenty-seven chapters are rules for constructing twenty-seven kinds of buildings, such as halls, city gates, residences, barns, and pavilions. The size of each structural member in each building type is carefully specified, differentiating this book from the *Ying-tsao fa-shih*, which gives general rules and ratios for designing and computation. The next thirteen chapters specify the dimensions of each kind of *tou-kung* and the sequence of assembling them. Seven chapters treat doors, windows, partitions, screens, and stone, brick, and earth masonry. The last twenty-four chapters are rules for the estimation of materials and labor.

The only drawings are twenty-seven cross sections of the twenty-seven building types described. There are no instructions for details, such as the shaping of the *kung* and *ang*, decorative paintings, and the like, which would have been permeated with the characteristics of the time. This drawback, however, is fortunately overcome by the existence of numerous examples of Ch'ing dynasty architecture that can be conveniently studied.

From the first forty-seven chapters of the *Kung-ch'eng tso-fa tse-li* a number of principles can be derived, of which the following, explained visually in figure 8, are the most important ones concerning major carpentry or structural design.

1. Reduction in the Depth of the *Ts'ai*

As noted above, the depth of the *ts'ai* of the Sung style is 15 *fen* (with a width of ten *fen*) and the *ch'i* measures six *fen*, resulting in a *tsu-ts'ai*, or "full *ts'ai*," of 21 *fen* in depth. However, the concept of *ts'ai*, *ch'i*, and *fen* does not seem to have existed in the minds of the builders of the Ch'ing dynasty. The *tou-k'ou*, or "mortise of the *tou*" [literally "block mouth"], for receiving the *kung* is specified as the Ch'ing module. It is equivalent to the uthern China, is a method no longer used in

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8
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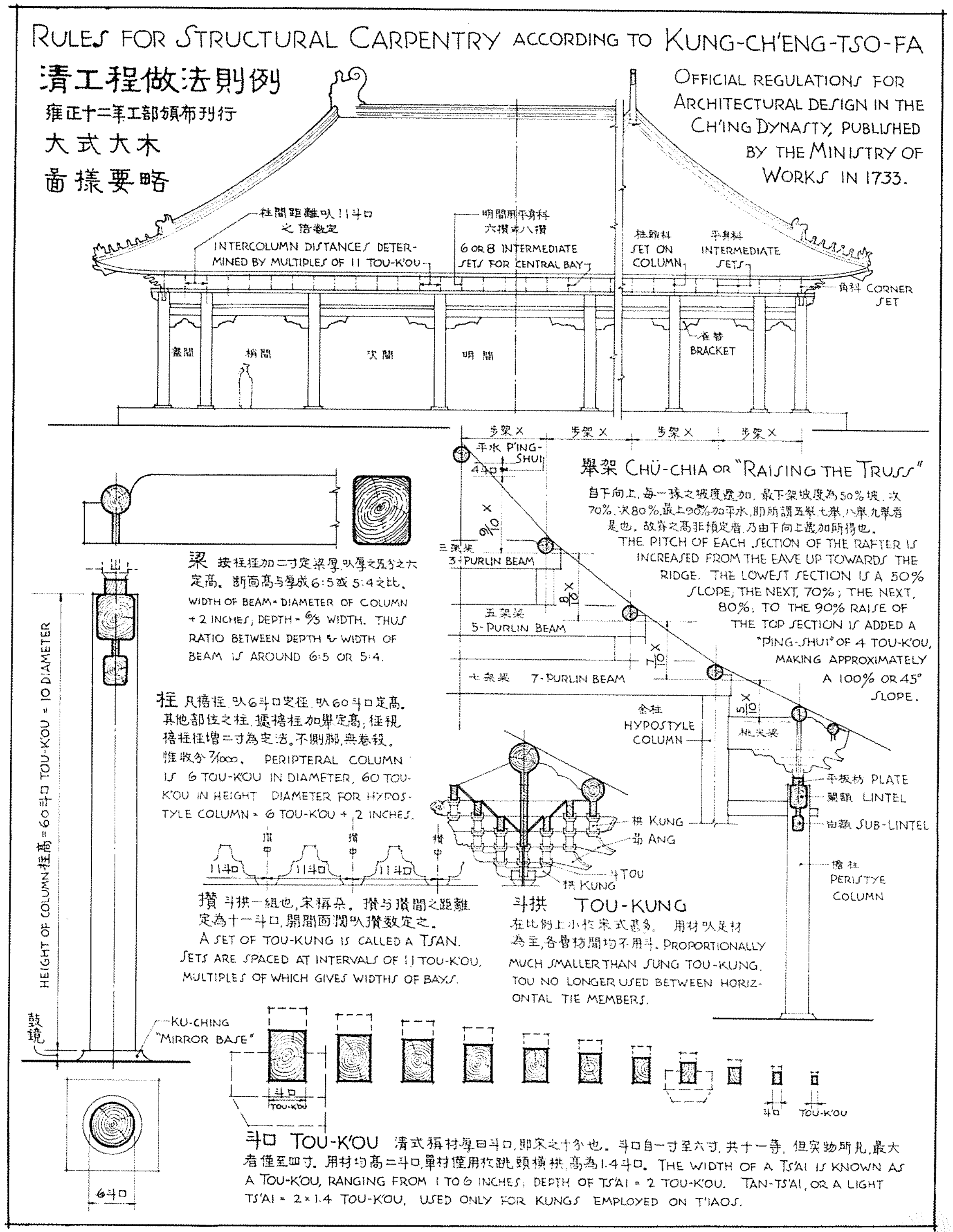

width of the *kung*, and therefore, of the *ts'ai* (ten *fen* in terms of Sung construction). The dimensions and proportions of the parts of a *tou-kung* bracket are now expressed in multiples or fractions of the *tou-k'ou*. While retaining the six *fen* (now 0.6 *tou-k'ou*) for the gap between the upper and lower *kung*, the depth of the *kung*, or *ts'ai*, itself is reduced from 15 to 14 *fen* (now 1.4 *tou-k'ou*). The *tsu-ts'ai* is then reduced to only 20 *fen*, or two *tou-k'ou* in depth.

There is another major difference between Sung and Ch'ing bracket sets. In the Sung period the major block (*lu-tou*), in which the cross arms rest on the center line of columns parallel to the facade, supports several tiers of *ts'ai* with open or plaster-filled gaps between. These tiers are cushioned by *tou* blocks. In the Ch'ing set the tiers of *tsu-ts'ai*, measuring one × two *tou-k'ou*, are laid one directly on top of another. Thus the *ch'i*, or gaps allowing space for the *tou*, are eliminated. These seemingly trifling modifications affect the general aspect of the *tou-kung* so much that the difference is immediately apparent by even a casual glance.

2. A Specific Ratio between the Diameter and the Height of the Column

The Ch'ing regulations specify the diameter of a column as six *tou-k'ou* (four *ts'ai* in Sung terms), and its height as 60 *tou-k'ou* or ten diameters. The diameter of a column of the Sung dynasty, according to the *Ying-tsao fa-shih*, never exceeded three *ts'ai*, and the height was left to the discretion of the designer. Thus proportionally the Ch'ing column is much enlarged and the *tou-kung* drastically reduced in size, dwindling into insignificant pettiness. An unprecedented increase in the number of intermediate bracket sets results. In some cases seven or eight intermediate sets are perched on the architrave between two columns; in the Sung dynasty the number never exceeded two, both according to the *Ying-tsao fa-shih* and as evidenced in existing buildings.

3. The Length and Width of a Building Determined by the Number of *Tou-kung*

As the number of intermediate sets is increased, the distance between them is strictly specified as 11 *tou-k'ou* center to center. Consequently the distances between columns, and therefore the length and width of a building, must necessarily be determined by multiples of 11 *tou-k'ou*.

4. All Facade Columns of Equal Height

The Sung practice of increasing the height of the columns toward the corners of the building was discontinued. The columns, though slightly tapered, are straight with no entasis. Thus a Ch'ing building as a whole presents a more rigid appearance than a Sung structure. The slight inward incline, however, is still the rule.

5. Increase in the Width of the Beams

Beams of the Sung dynasty generally have a ratio of 3 : 2 between their depth and width. In the Ch'ing rules the ratio is changed to 5 : 4 or 6 : 5, betraying an obvious ignorance of mechanics and of the strength of materials. Moreover, the overall rule of making the f the *ts'ai* (ten *fen* in terms of Sung construction). The parts of a *tou-kung* bracket are now expressed in *u*. While retaining the six *fen* (now 0.6 *tou-k'ou*) for ver *kung*, the depth of the *kung*, or *ts'ai*, itself is 4 *tou-k'ou*). The *tsu-ts'ai* is then reduced to only 20 *fen*,

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beam "two inches [*fen*] wider than the diameter of the column" seems most arbitrary and irrational. All beams are straight; the "crescent-moon beam" has no place in official Ch'ing architecture.

6. Steeper Pitch of the Curved Roof

What is called in the Sung dynasty *chü-che* ("raise–depress") is known in the Ch'ing dynasty as *chü-chia*, or "raising the frame." The two methods, though bringing about more or less similar results, are entirely different in their basic conceptions. The height of the ridge purlin of the Sung structure is predetermined, and the curvature of the roofline is achieved by "depressing" the successive purlins below. The Ch'ing builder starts from the bottom, giving the first *pu* or "step" (that is, the distance between the two lowest purlins) a "five *chü*," or a pitch of 5 : 10; the second step a "six *chü*," or 6 : 10; the third, $6\frac{1}{2}$: 10; the fourth, $7\frac{1}{2}$: 10; and up to "nine *chü*," or 9 : 10. The position of the ridge purlin becomes the incidental outcome of the successive steps. The pitch of the Ch'ing roof thus obtained is generally steeper than that of the Sung roof, giving a convenient clue for identifying and dating.

As we shall see below, a Ch'ing building is generally characterized by harshness and rigidity in the lines of the posts and lintels, in the excessively steep pitch of the roof, and in the smallness of the *tou-kung* under the eave. Perhaps it was the uncompromising strictness of the dimensions given in the *Kung-ch'eng tso-fa tse-li* that succeeded in effacing all the suavity and elegance that we find so charming in a building from the period of the *Ying-tsao fa-shih*.

Neither book mentions ground plans. The *Ying-tsao fa-shih* contains a few plans, but they show columniation, not the internal division of spaces. Unlike European buildings, the Chinese building, whether house or temple, is rarely planned by subdividing the individual unit. Since it may be subdivided so easily by means of wooden partitions or screens between any two columns, the problem of internal planning hardly exists. Planning, instead, concerns the external grouping of individual units. The general principle is the arrangement of buildings around a courtyard, or rather an arrangement that forms a courtyard or patio. The buildings are sometimes connected by colonnades, but these are eliminated in smaller houses. A large house is composed of a series of courtyards along a common axis, and deviation from this principle is rare. The same principle is applied to both religious and secular architecture. In plan there is no basic difference between a temple and a residence. Thus it was not an uncommon practice in ancient times for a high official, or even a rich merchant, to donate his residence to the service of Buddha and have it consecrated as a temple.