



**INTERNATIONAL NETWORK FOR BAMBOO AND RATTAN
(INBAR)**

**TRANSFER OF TECHNOLOGY MODEL
(TOTEM)**

TRADITIONAL CHINESE BAMBOO FURNITURE PROCESSING TECHNIQUES

by

Zhu Zhaohua, Distinguished Fellow of INBAR for Life

and

Jin Wei, Publications and Training

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Acknowledgement

This TOTEM is prepared with the strong support of Mr. Chen Yunhua, a Master of bamboo weaving art and the Manager of the Bamboo Art City in Qingshen County, Sichuan Province, P. R. China. The TOTEM also introduced relative information and figures from INBAR Technical Report 26 Bamboo Industrial Utilization by Prof. Zhang Qisheng, Dr. Jiang Shenxue and Prof. Tang Yongyu in 2001 (Chapter 4, P. 163-206).

TRADITIONAL CHINESE BAMBOO FURNITURE PROCESSING TECHNIQUES

1. Synopsis

Chinese traditional furniture has not only refreshed, natural and beautiful appearances, but also cheap prices, simple techniques and light weight. Because bamboo is ideal substitute for wood, bamboo furniture development contributes to forest and environment protection. China has a long established history of using bamboo for furniture processing – the tradition has been lasted for at least more than 3000 years. The earliest bamboo furniture in China is bed. At the beginning, bamboo bed is used in many cases, such as sitting places while meeting guests, but not only for sleeping,. After the Han Dynasty, the other bamboo furniture, such as chairs, tables, stools began to be used widely, the beds are then turned into sleeping beds.

Traditional bamboo furniture is still used widely in China nowadays. Bamboo furniture is especially popular in bamboo producing areas. Large bamboo producers are concentrated in Meishan of Sichuan Province, Yiyang of Hunan Province and Guangning of Guangdong Province. Different species of bamboo are used to process furniture in these three places, so as the designs and styles. In Meishan, Sichuan Province, *Phyllostachys congesta* and *Sinocalamus affinis* are used for furniture processing, the products are chairs, tables, screens, sofas and beds that suitable for home, restaurant, tea house, office and recreational places. There are more than a hundred professional household factories producing furniture in Qingshen County. In Guangning, Guangdong Province, the specie used for furniture processing is *Pseudosasa amabilis*, a small sized bamboo which can be curved or straightened to process sofas, chairs, tea tables, etc.. that suitable for hotels and homes. Yiyang, Hunan Province is famous for its large production of daily bamboo furniture, at the same time, Yiyang produces exquisite bamboo furniture for high-grade hotels and meetings rooms. The bamboo species used in Yiyang are *Ph. congesta* and *Ph. heterocycla* var. *pubescens*.

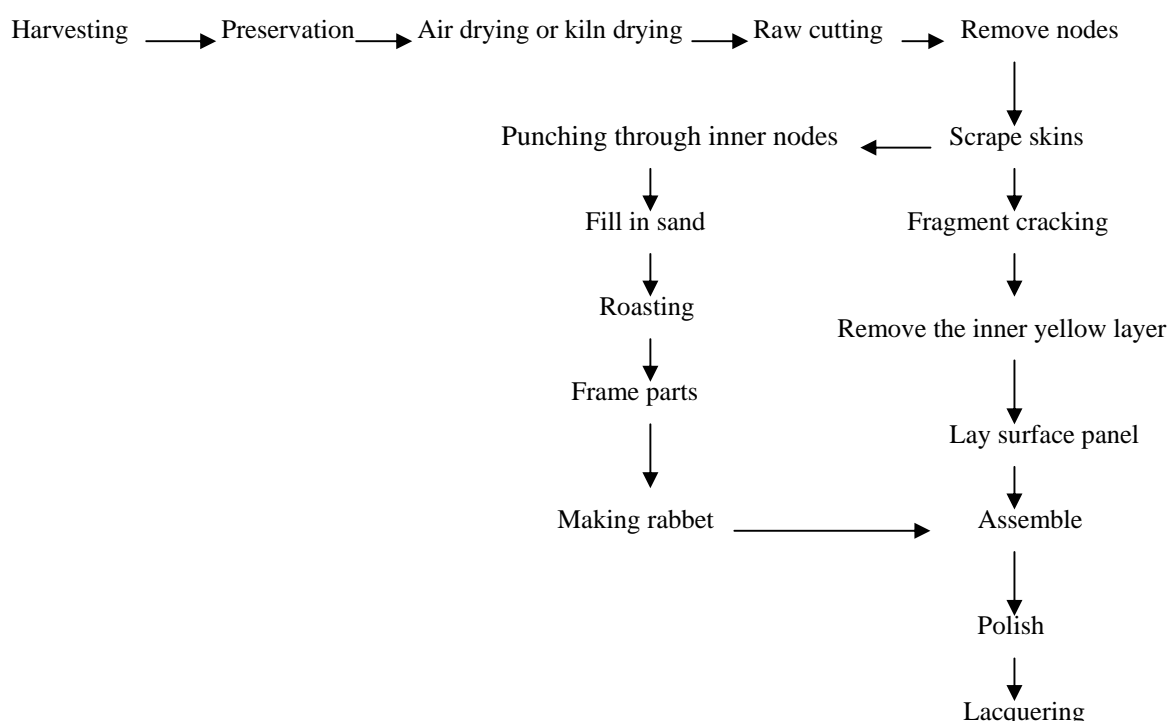
Chinese bamboo furniture, especially traditional furniture, can not be knock down, is not suitable for long distance transportation, therefore, most products are sold in local or provincial markets, only a small amount is sold to large cities or foreign countries. In North China, because the weather is comparatively dry, traditional bamboo furniture is liable to crack, so it is not as popular as in South China. However, bamboo furniture has many advantages such as light weight, natural and elegant, traditional furniture is becoming more welcomed.

The major processing stages of traditional Chinese bamboo furniture involves a lot manual work, it takes at least a year to master the complete traditional art, besides, manual work restricted the production scale and efficiency. A traditional bamboo furniture artisan's income is between 30 to 50 RMB per day, or 900 – 1500 RMB per month, and they are mostly from poverty regions where bamboo resources are plenty. In poverty regions, bamboo furniture production is one of the important ways for local people to generate income. But in comparatively affluent regions, traditional furniture production is not favored. To solve this problem, it is necessary for large companies to involve in the business by hiring professional households or small factories for production, on the other hand, opening the entrances for domestic and international mainstream

markets.

Two new types of bamboo furniture are now developing in affluent provinces such as Zhejiang, Fujian, etc: (1) Laminated bamboo furniture: pieces of bamboo splits are glued and hot pressed into laminated boards, and then cut and curved to make parts of furniture. The final products are similar to wood furniture in outlooks. Some factories have started to produce knock-down furniture using bamboo laminated boards, the products are sold to America in large amount, and has a great potential in Chinese domestic markets. This type of furniture needs mechanized production, the production scale is usually very large. (2) Courtyard knock-down furniture: this type is furniture is quite similar to Chinese traditional furniture, but the structure is simpler and the parts are not connected by the traditional “YU” technology (collective bent mortise), but by mosaic or meets. The furniture can be knocked down for easy transportation. This type is furniture is now exported to Europe and North America in large amount.

A Flow chart of processing steps



2. Raw Material Selection, Treatment and Drying

Usually the following bamboo species are used for furniture making: *Phyllostachys pubescens*, *P. sulphurea*, *Dendrocalamopsis latiflorus* Munro, *Psudosasa amabilis*.

2.1 Raw Material Selection

The design and processing technologies of traditional Chinese bamboo furniture are very different from western style bamboo furniture (in the Philippines and in Colombia), and so is the raw material selection. Chinese traditional bamboo furniture usually requires grooves to be cut on the bamboo tube to make a collective collective bent mortise, this technology can join parts of furniture closely and form a strong framework (Fig 1-1).

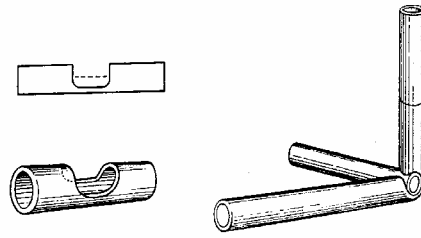


Fig 1-1 bamboo collective bent mortise

While selecting raw materials for Chinese traditional bamboo furniture, the follow principles are important:

Select middle or small sized bamboo species, with straight and upright stem, small tapering, and smooth nodes; for furniture framework processing, the bamboo culms should have comparatively thicker walls, and be tenacious enough, the age of the selected bamboo should be 3-4 years.

In China, bamboo species that are commonly used in furniture processing are: *Phyllostachys var. pubescens*, *Ph. Nigra var. henonis*, *Ph. Sulpurea*, *Ph. Heteroclada*, *Ph. Nigra*, *Fargesia spp*, *Aundinaria amabilis*, *Thyrosostachys siamensis*, *Dendrocalamus bambusoides*.

Material properties must be strictly determined by the design requirements of different products. For example, *Phyllostachys. pubscens* with short inter-nodes and thick walls is suitable for making supporting poles. On the other hand, to make laths, we had better select those culms with straight culms with long inter-nodes. Bamboo poles are cut to the desired lengths, with the lower one-third used as round structural components such as legs and frames of the furniture and the middle part for bamboo stick components such as seats and other decorative parts. The upper third of the bamboo is used mostly for handicraft. Bamboo materials for surface panels of chairs and tables are usually selected from bamboo species with long internodes, such as *Bambusa chungii*, *B. textilis*, *Neosinocalamus affinis*.

The season of bamboo harvesting is usually in winter, because there are rarely any diseases or pest found in the culms harvested in winter. Some furniture factories harvest enough materials for a whole year's use in winter, dry the materials in open air, and store in shady and cool places.

2.2 Treatments and Preservation

Bamboo is a natural material that deteriorates with time. It is prone to attack by insects and fungi and has to be treated to prevent degradation of the material. There are several methods of treating bamboo, which are grouped into the traditional or non-chemical and the chemical methods. Below some methods are briefly described. For an in-depth treatment of the subject, see the Bamboo Preservation Compendium (Liese and Kumar, 2003).

2.2.1 Traditional or Non-Chemical Methods – This includes the following:

- Soaking - freshly cut bamboo culms are submerged in running water for 2 to 3 months and then air-dried. This improves the resistance of bamboo against powder-post beetles but not against termite and fungi. In some areas, the bamboo is soaked in salt water instead of fresh water.
- Curing - this involves cutting of bamboo and leaving them standing with support on the plantation

for sometime with leaves and branches still intact.

- Smoking - culms are cut into desired lengths and placed above the stove in the kitchen until they turn dark brown. This is still a common practice in the North East of India.

2.2.2 Chemical Methods

Chemical methods are generally more effective than the traditional methods of treating bamboo. Treatment of bamboo with a chemical preservative is done by either pressure or non-pressure methods.

Non-pressure methods

- Fumigation - the bamboo culms are fumigated with chemicals such as methyl bromide, ethylene dibromide, chloropicrin or sulfurous acid gas.
- Spraying or brushing - these methods are applied for prophylactic treatments of bamboo. They only have a temporary effect due to the very low penetration of the preservatives.
- Steeping/Butt treatment - it consists of allowing freshly-cut culms with branches and crown still intact to stand to a depth of 20 to 60 cm in a container holding the preservative solution. Through leaf transpiration the solution is drawn up the culm (Fig 1-2).
- Hot and cold process - this is an open tank process intended for dry bamboo by applying alternating hot and cold solution.
- Boucherie process - the preservative is absorbed by the bamboo due to force of gravity or the application of pressure.



Fig 1-2 Steeping treatment

Pressure methods

Bamboos are thoroughly dried before treatment and placed inside a treatment cylinder. The preservatives are forced through with the application of pressure.

- Full-cell process - used when the impregnating chemicals are to be forced through the cell cavities. It involves the following operations: (1) 30-minute vacuum; (2) filling the cylinder with preservative solution; (3) building pressure; (4) maintenance of pressure for a certain period; and (5) final vacuum.

- Empty-cell process - this can be done with what is known as the Reuping process. This involves the following operations (1) building up preliminary pressure/ (2) maintenance of pressure while preservation is introduced in cylinder; (3) increase of pressure; (4) draining of the preservative; and (5) final vacuum.
- High pressure sap displacement - this is a modification of the Boucherie process. Water in freshly felled bamboo is forced out by a waterborne preservative solution introduced under pressure through cylinder caps fitted over one end of the culm.

2.3 Drying and Seasoning

This is the process of removing some of the moisture or water to improve the serviceability and suitability of bamboo. The objectives of seasoning are to obtain uniform moisture content suitable for its intended use and to minimize defects such as checking and collapse.

2.3.1 Air Drying

Air drying is the process of drying bamboo by exposing it to the natural elements either in the open air or under shed. This is the most economical method of drying bamboo since it does not require investment in equipment other than those needed to handle and transport the materials. However, it is a very slow process. Drying is dependent on the prevailing temperature, relative humidity (RH) and natural movement of the atmospheric air to which it is exposed (Fig 1-3).



Fig 1-3 Air drying

2.3.2 Kiln Drying

This is a method of drying bamboo in a closed chamber or building where the drying conditions (temperature, humidity, air circulation and ventilation) can be controlled and maintained at desired



Fig 1-4 Kiln Drying

levels.

The initial dry and wet bulb temperatures and drying time is influenced by the species, culm wall thickness, relative position within the culm length. Scraping the outer skin of the bamboo also hastens drying. (Fig 1-4)

It is easier to dry bamboo sticks than round bamboo. The butt portion of the bamboo also dries slower than the upper parts of the bamboo. There is a tendency for defects such as checks and splits occur when drying round bamboo, so great care must be exercised including segregation of the bamboo by species and different parts of the bamboo.

2.4 Removing the Outer Node

Bamboo nodes does not only affects the outlook of the final products, but also easy to hurt peoples' hands when used. Bamboo nodes at some exposed parts, for example, pressing lath, table surface, backrest lath and so on, must be smooth. So it is usually removed from the culm. The outer node of the bamboo is removed by planing with a round bottom plane. When removing the nodes, we must ensure the smoothness of the cutting section, at the same time, not to damage the culm, its surface layer, or the next node. If a bamboo node is damaged, bamboo culms are easy to crack when bent with fire.

2.5 Scraping

The outer green skin of the bamboo is scraped off. The purposes are decontamination and appearance improvement.

2.6 Splitting

Some of the round bamboos are split with the use of a large knife, hand splitter or splitting machine to make sticks.

2.7 Removing the Internal Nodes

The nodes are removed and the sticks are planed to uniform thickness.

2.8 Width Sizing

The sticks are reduced to uniform width with the use of a hand tool or with a machine.(Fig 1-5)



Sawing



Scraping



Removing the outer node

Fig 1-5

2.9 Roasting

This is a common method used in China to treat bamboo culms: bamboo culms are put on top of fire or smoke for the following three purposes: 1) soften the material (fiber); 2) beautify and smoothen the outer appearance; 3) reduce or avoid shrinkage of finished products. This method can be used to straighten the curved culms or form a curve with a straight culm. Sand is filled in the culms before heating, the sand in the culm can prevent the bamboo walls from breaking by uneven heat. (Fig 1-6)



Filling sand in the culm



Straightening



Making curves



Molding

Fig 1-6

3. FRAME PROCESSING

3.1 Material Preparation

The materials are divided into five classes according to diameters: First class: 2.6-3.3cm, second class: 2–2.6cm, third class: 1.3-2cm, substandard class: below 1.3cm. Selection of materials must be strictly according to the standard requirement of the product, the disposition of different parts of the material should be reasonable. The framework is usually composed of supporting poles, fixing collective bent mortises, and small shorings. In most cases, the supporting poles of the furniture require the use of the bottom part of the bamboo culm where the walls are thick and tough. The collective bent mortises that are used for fixing the supporting poles require the use of the middle part of the bamboo culm where the walls are thinner. For the small shorings, top part can be used. Large size furniture needs the toughest bamboo material for supporting poles, impacted or damaged culms should be avoided.

3.2 Cutting to final lengths

The various round components are sawn to final length with either a table miter or radial arm saw.

The round components include: supporting poles, fixing collective bent mortises, and small shorings (Fig 2-1).



Fig 2-1 Cutting to final length

In order to decide on the final lengths of the supporting poles and fixing collective bent mortises, technicians developed their own rulers for measuring (Fig 2-2). These will be introduced in the following paragraphs.

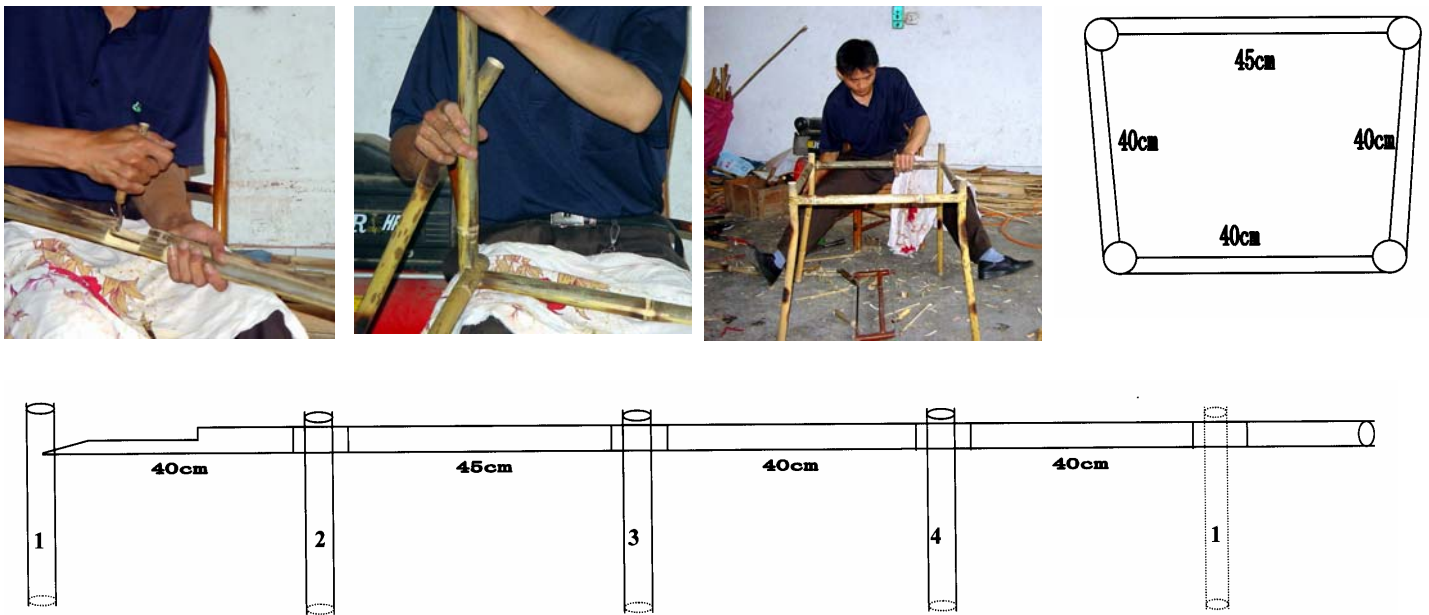


Fig 2-2 Processing of collective bent mortise

3.3 Supporting Poles

The supporting poles are used to support the whole framework. Usually, the tables and chairs have four angles, sometimes, people like hexagonal or octagonal products. The number of supporting poles should be determined according to number of angles.

For the stabilization of the furniture, the bamboo poles with the same thickness of the walls are settled on diagonal places. In order to identify the poles, technicians sometimes number the poles in sequences (1-4, 1-6 or 1-8). For examples, for quadrangular furniture: thick-walled poles are

numbered 1,3, thin-walled poles are numbered 2,4; for hexagonal furniture, thick-walled poles are numbered 1,2,4,5, thin-walled poles are numbered 3,6; for octagonal furniture, thick-walled poles are numbered 1,2,3,5,6, thin-walled poles are numbered 4,7,8. For chairs, thick-walled poles are settled at the back part, thin-walled poles at the front part.

3.4 Collective bent mortise

The collective bent mortises are used to fix the positions of supporting poles. A collective bent mortise is made of a bamboo pole, the full length of which is the perimeter of the framework plus the length of the tenon. Equidistant grooves are opened on the pole, and then bent the pole to form a collective bent mortise. Thus, the supporting poles are held by the grooves so they are fastened at their positions (Fig 2-2, Fig 2-4, Fig 2-5). In order not to break the pole when it is bent, it is

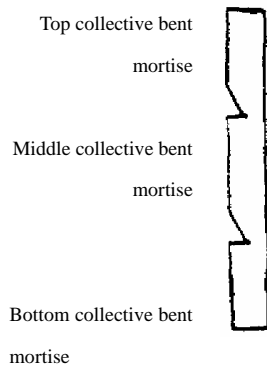


Fig. 2-3 Levels of collective bent mortises



Fig. 2-4

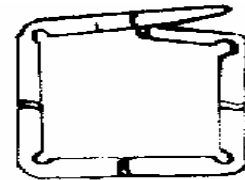


Fig. 2-5

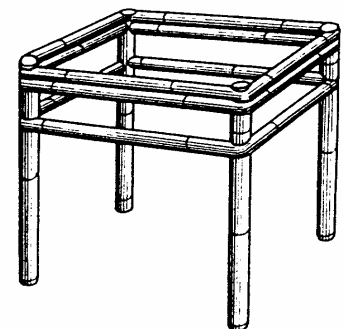


Fig 2-6 Double and three collective bent mortise

recommended to heat the pole with fire or hot water before bending.

Before processing the collective bent mortises, technicians need to determine how many collective bent mortises are needed so that the framework will be firm enough. Common products use 3-5 collective bent mortises at different height of the supporting poles sometimes two or three collective bent mortises are combined to strengthen the framework.(Fig 2-6).

In order to identify the levels of the collective bent mortises on the supporting poles, a ruler is made to mark the length of the legs (supporting poles), and the positions where the grooves hold the supporting poles (see fig 2-3).

Steps of making the collective bent mortises are as below:

STEP ONE:

Decide on how many collective bent mortises from top to bottom are needed and if combined collective bent mortises are needed. Then, select appropriate number and sized bamboo poles for collective bent mortise processing

STEP TWO:

To make sure that combined collective bent mortises are pressed with each other closely, technicians need to use a broadsword to pare off the uneven parts and nodes on the pressing surface of the collective bent mortise. The pressing surface is 90 degrees from the direction where the grooves are facing.

STEP THREE:

Mark the positions of the grooves on the pole. The distance between grooves is the same as the side length of the framework.

How to calculate the side length of the framework?

First calculate the side-length of the surface panel:

Side length of quadrangular surface panel = the Length of subtense

Side length of hexagonal surface panel = the Length of subtense $\times 0.577$

Side length of Octagonal surface panel = the Length of subtense $\times 0.414$

Second, calculate the difference between linear length (AB + BC) and the arch length (AC) at the angle of the framework, formulas are as below (Fig 2-7):

$$D = AB + BC$$

$$\text{Quadrangle product: } D - D \cdot \pi / 4$$

$$\text{Hexagonal product: } 0.58 D - 60^\circ \cdot \pi \cdot R / 180$$

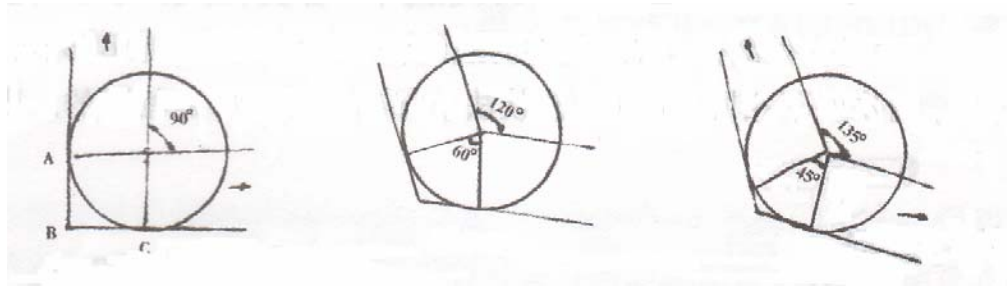
$$\text{Octagonal product: } 0.14 D - 45^\circ \cdot \pi \cdot R / 180$$

Reduce the table-board side length to framework side length, usually 0.6cm is reduced.

STEP FOUR:

A tenon is made to fasten the joint of the collective bent mortise. Cut a slit at 30 cm from the end of the pole, the depth of slit is half of the diameter of the mortise pole, cut out a groove, the length of

groove is $\frac{7}{8}$ of the perimeter of the pole-tenon (Fig. 2-8).

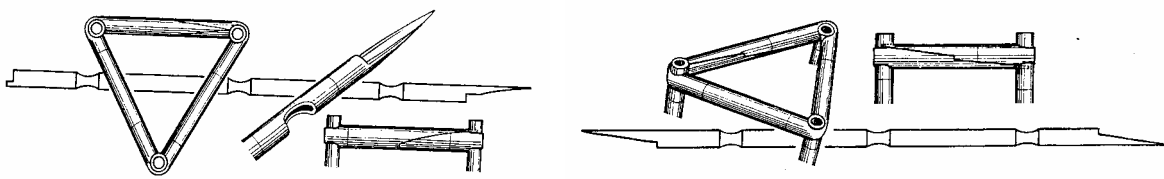


Quadrangle product

Hexagonal product

Octagonal product

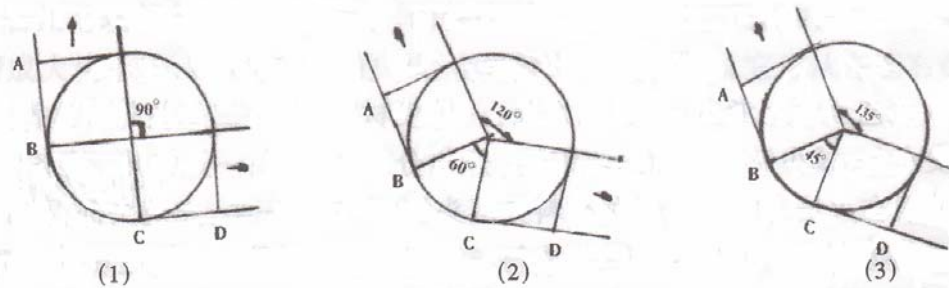
Fig 2-7



Single connection

Double connection

Fig 2-8 Tenon Processing



(1)

(2)

(3)

Fig 2-9

(1) Quadrangle product; (2) Hexagonal product; (3) Octagonal product

Remove half of wall from the groove at the end, cut the retained wall to form a thin piece for wrapping the tenon and drive two nails to fix the joint. The joint will be more firm if it is twined with rattan material.

STEP FIVE:

Cut the grooves at the marked positions, carve the openings into semi-circle shape.

How to calculate the diameter of the open mouth of the grooves? If "t" is the length of the notch open, "m" is the circle length of the supporting pole, "d" is the diameter of the supporting pole, "R" is the semi-diameter of the supporting pole, "a" is the central angle of BC, the formula is as below (please see fig 2-9)

$$t = AD = AB + BC + CD$$

$$\because AB = CD = R$$

$$\therefore AB=CD=d=m/\pi$$

$$\therefore BC=a \cdot \pi \cdot R/180$$

$$\therefore t=m/\pi + a \cdot \pi \cdot R/180$$

STEP SIX:

Roast the notch parts to make them soft, bend and try them on the supporting poles.

STEP SEVEN

Connect the two ends of the collective bent mortise. Cut off half of the ends in arrisways like showed in Figure 2-9, the distance from the tip where the cutting started is about 30cm. Note that (1) the direction of cutting must be perpendicular to the direction of grooves, the retained tube wall on both ends should be in opposite directions; (2) the connective part of the tube forms a side of the geometric figure; (3) the connection should be fixed with oblique bamboo nails.

4. Processing of Other Parts

There are many parts, for example, bamboo nails, pressing lath, slotted lath, bearing, surface panels, backrest lath and so on, which are made of *P. pubescens*. They should be processed into proper sizes and shapes according to the requirement of the product.

4.1 Facial panels

Facial panels are one of the important components of bamboo furniture, people sit, lie or put articles on them. The main producing method is as the following:

4.1.1 Fragment facial panel

A. Fragment cracking

Such panels can be made in the form of knot panel or non-knot panel.

Non-knot panels are made of bamboo material between joint knots. Usually they are for the production of small-sized furniture. First of all split a bamboo tube into two half fragments, make slits on the green surface of fragment, the length of slits should be $3/5$, and the space between slits be $0.3 \sim 0.4$ cm. Then make slits on the surface of other side, the slits on this side should be positioned in the middle of space between slits on green surface (Fig. 3-1).

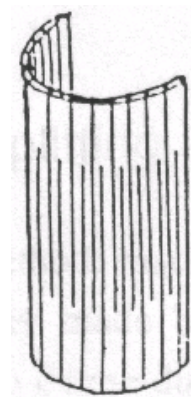


Fig. 3-1 Craking fragments

B. Montage

Collect the slit fragments into a panel material according to the design of furniture. The fragments of same size should be arranged together. The thickness of fragments should be even. They must be mended with a knife where the connection does meet the requirements.

C. Sewing up

Lay the slit fragment on an operation stool with the yellow surface upwardly. Put two sleepers under the fragment. The space between sleepers is adjusted according to the length of fragment. Fix one end of pressing rod on the stool, press the fragment pushing the other end of rod slowly. Bind the pushing end of rod to the stool with a rope when the fragment is pressed into a plane panel. Prepare a thin strip,

which is 0.5 cm in width and 0.2 cm in thickness, and its length is somehow larger than the width of fragment. Make slits for sewing with a slit saw perpendicular to the slits for cracking, the depth of these slit should be $\frac{2}{3}$ of the thickness of fragment. Insert the thin strip into the sewing slit. There should be two sewing slits on small-sized panel and four slits for larger panel (Fig 3-2).

D. Mending

Lay the sewn panel on a table with yellow surface upwardly. Press it with a pressing rod. Mend both edges of panel as shown (Fig. 3-3). The width of slope parts is 4 ~ 5 cm, the thickness of edge is 0.02 cm.

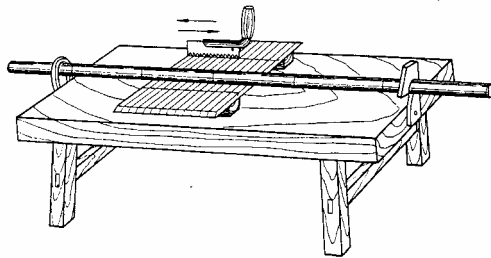


Fig. 3-2 Slitting bamboo fragment

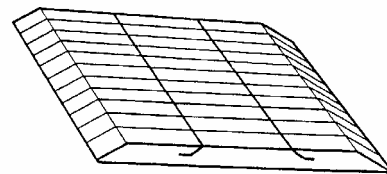


Fig. 3-3 Slit bamboo fragment

4.1.2. Facial panel of bamboo strips

Facial panels of bamboo strips are made of parallel bamboo strips. They must be of same width, same thickness and similar color. If they are not arranged closely, the space between every two strips must be also the same. The width of strips is 0.7 ~ 2 cm in accordance with the style the furniture. Strips for furniture of free and easy style may be wider and those for exquisite furniture be narrower.

There are three kinds of such panels: holes-fixed panel, slit-fixed panel and pressing-fixed panel.

A. Holes-fixed panel

Holes-fixed panels are made by inserting the ends of strips into the hole-mortises of frame tubes. Before inserting both the ends of strips must be cut into dowels. Make slits 2 cm in depth on the ends to shape dowels. The thickness of dowels must fit the mortise-holes. The strips can be arranged closely or sparsely (Fig. 3-4, Fig. 3-5).

B. Slit-fixed panel

Slit-fixed panels are made by inserting the end of strips into the slit-mortise of frame tubes. The strips must be arranged closely.

The width of slits must fit the thickness of strips (Fig. 3-6).

C. Pressing-fixed panel

For making pressing-fixed panels, the ends of strips are arranged between two frame tubes. The frame tubes must be stable, without mortise holes or slit. There should be certain space between tubes for arranging strips. Under the arranged strips it is necessary to lay a lining tube perpendicular to strips for sustaining the panel. In addition put one tube thinner than and parallel with the frame tube on the panel, and another one under the panel to fix the panel with bamboo nails. Such panels are selected in manufacturing furniture of high grade (Fig. 3-7).

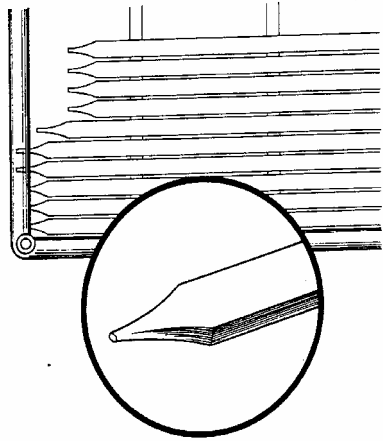


Fig. 3-4 Holes-fixed panel

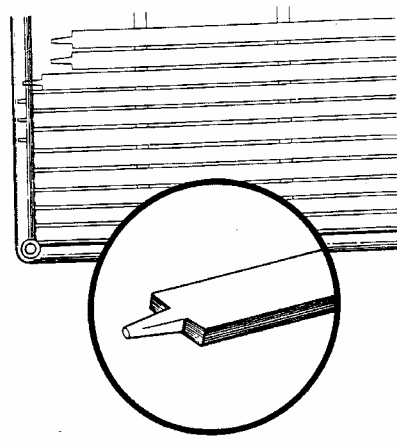


Fig. 3-5 Holes-fixed panel

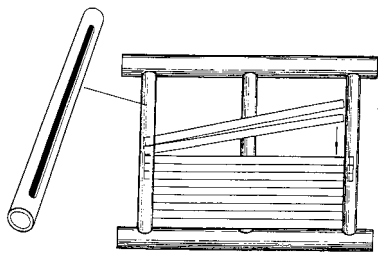


Fig. 3-6 Slit-fixed plate

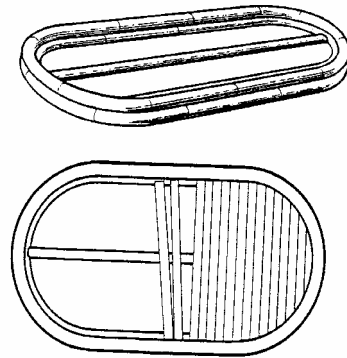


Fig. 3-7 Pressing-fixed plate

D. Panel of strung and doweled strips

Such panels are fixed with a string in the middle part and dowels on both edges. The strips are strung through drilled holes on strips together with lining tube (3-8). For panels of large furniture, there should be two or three lining tubes and strings.

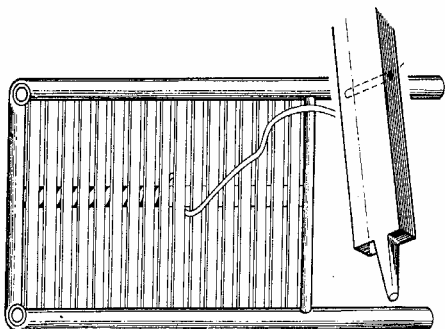


Fig. 3-8 Panel of strung and doweled strips

4.2 Bamboo nails

Bamboo nails are the indispensable fasteners (Fig. 3-9). They are usually carved into taper shape.

4.3 Pressing lath

Pressing lath is long bamboo lath that used to press the surface panels closely on the frameworks (Fig. 3-10). The downside should be pared smooth, one side of the lath is thick, the other is thin, see Fig 3-10, the tips should be sawed into bevels.

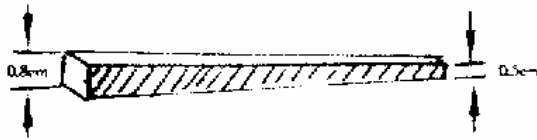


Fig. 3-9 Nail

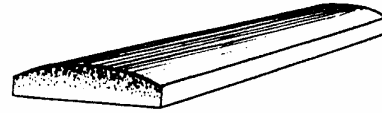


Fig. 3-10 Pressing lath

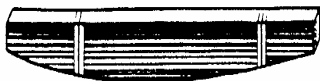


Fig 3-11 Bearings

4.4 Bearings

They are underlay lath works installed between frameworks and surface panels to prevent the surface panel from bending and shedding when its middle part is under pressure. The size and number of laths needed for bamboo furniture depend on the type and uses of the object. The top one third of a bamboo culm is appropriate material for the bearings. Select a bamboo culm, cut off its top one third, cut the pole into laths of desired width and length, pare the lath into arc form, embed the ends of the bearings in the first collective bent mortise (the collective bent mortise on the top of the framework). (Fig 3-11)

5. Assembly

5.1 Framework assembling

Check if the connection between parts is suitable (Fig. 4-1).

Make each groove occlude to its corresponding supporting poles and fix the tenon part with bamboo nails (Fig 2-2, Fig 2-6).

5.2 Connecting the surface panel with the framework

The process includes four steps: inserting pegs, installing bearings, nailing the press laths, finishing.

A. Inserting pegs

A wood peg with proper size is inserted into the cavity of a supporting pole to make its top expand, to ensure tight connection between the supporting pole and the notch (Fig. 4-2).

B. Installing bearings

Installed the bearings to support bamboo panels (Fig. 4-3).

C. Nailing press laths

Put the panel on top of the framework, and then fix it with bamboo nails (Fig. 4-4).

D. Finishing

Smooth and polish the surface of furniture with a knife (Fig. 4-5).

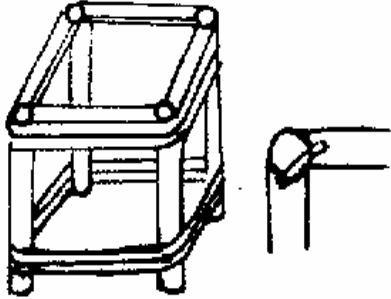


Fig. 4-1 Frame assembling



Fig. 4-2 Peg inserting

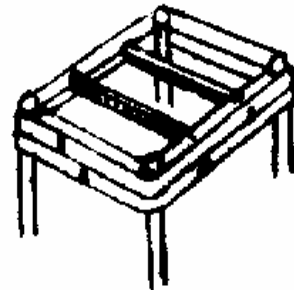


Fig. 4-3 bearing installing

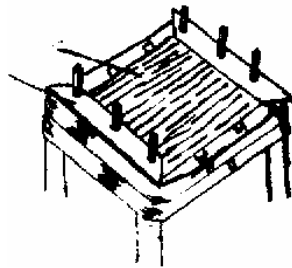


Fig. 4-4



Fig. 4-5

6. Tools for making traditional bamboo furniture

Traditional bamboo furniture is made with special tools. In order to make such furniture, knowledge of the tools is necessary.

Although there are some special machines developed in this field, such furniture is made mainly manually. As the area of bamboo furniture making is widespread, the tools are also highly varied.

A. Knife for cutting thin strips

This is an important tool for bamboo furniture making. Culm cutting and slicing are carried out by means of such knives. The knife blade is 26 cm in length and the handle is 12 cm. The end of blade is hook-shaped, which is applied to remove bamboo nodes. The back of the blade is quite thick, about 1.5 cm, which improves the efficiency of operation (Fig. 5-1).

B. Pointed knife

Pointed knife is a tool frequently used for making holes, peeling, sharpening, frame making, assembling and clearing. Pointed knives are small and easy to use. The blade must be sharp (Fig. 5-2).

C. Scraper

The scraper is a specialized tool for removing the wax cover of bamboo. The blade is arc shaped, with two wooden handles for operation (Fig 5-3).

D. Gouging tool

The gouging tool is specially applied to scoop out mortises for assembling (Fig. 5-4).

E. Plane for removing bamboo joints

This is a specialized tool for removing the flange of bamboo nodes (Fig 5-5).

F. Line plane

This is a tool similar to planes used in woodworking, but it is comparatively light and handy (Fig 5-6)

G. Splitter and chisel

Splitter and chisel are used for splitting bamboo culm into strips of required width. The splitter is 12 cm in length and 3 cm in width. The width of the splitter blade is about 0.5cm. The blade with an iron handle does not need to be very sharp. The chisel is similar to that used in woodworking, but light and handy (Fig 5-7).

H. Round chisel and square chisel

Both the chisels are used for making round and square holes on bamboo material for assembling bamboo furniture. The size of square holes can be 3, 6, 10 mm and more (Fig. 5-8).

I. Hand saw

The hand saw is applied to cut bamboo culm and bamboo pieces, or to split bamboo material according to the requirements of furniture design. The saw blade must be thin and saw-teeth be fine (Fig. 5-9)

J. Surface saw

Surface saw is applied to slit the surface of furniture parts for connection (Fig. 5-10)

K. Hand drill

The hand drill is applied to drill holes into bamboo material. Before pushing bamboo nails into bamboo strips or tubes it is necessary to make holes for them. Therefore the hand drill is the tool most frequently used. As bamboo culm wall is thin and can be broken easily, the bit must be very sharp and of different sizes (Fig. 5-11).

L. Hammer

The hammer is applied to drive nails into furniture parts, it must be light and handy in comparison with that used in woodworking.

M. Bending column

The bending column is a kind of auxiliary tool for bending bamboo tubes. A wooden column is made in T shape, the width of column is about 13 cm and the length is about 250 cm. Several holes are made at a height of 120 ~ 140 cm. The diameter of the holes is 3 ~ 5 cm. Bamboo tubes to be bent are inserted into the holes and heated over fire for bending (Fig. 5-12). Now a blowtorch is used for bending (Fig 5-13)

N. Electronic planer (Fig 5-14)

O. Electronic drill (Fig 5-12)

P. Electronic drill (Fig 5-15)

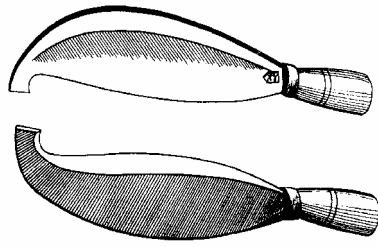


Fig. 5-1 Knife for cutting and making slivers

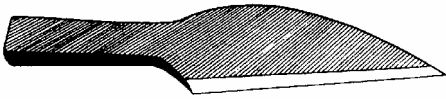


Fig. 5-2 Pointed knife



Fig. 5-3 Scraper

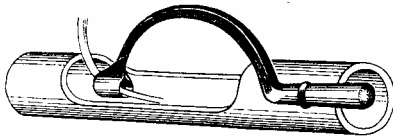


Fig. 5-4 Gouging tool for scooping out mortise

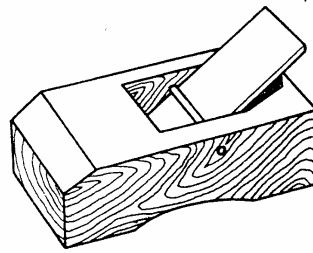


Fig. 5-5 Plane for removing bamboo nodes



Fig. 5-6 Line plane

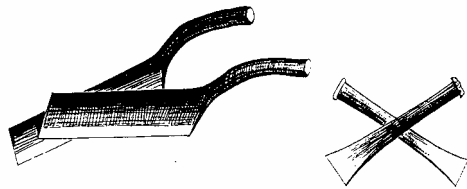


FIG. 5-7 SPLITTER AND BAMBOO

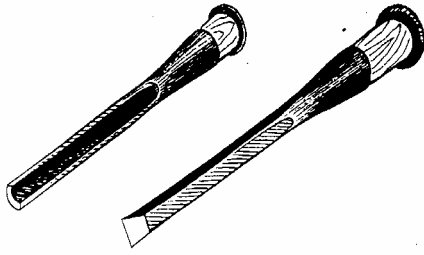


Fig. 5-8 Gouge and square chisel

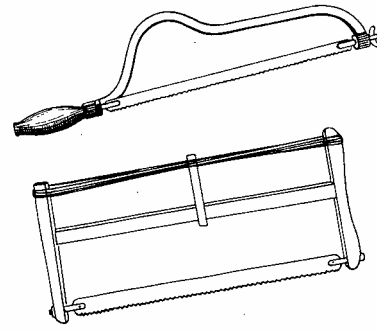


Fig. 5-9 Hand saw

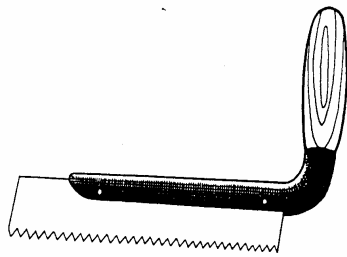


Fig. 5-10 Surface saw

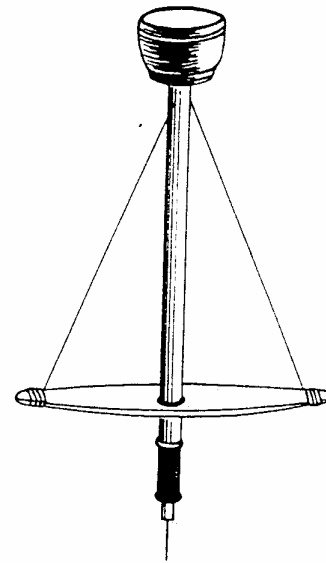


Fig. 5-11 Hand drill

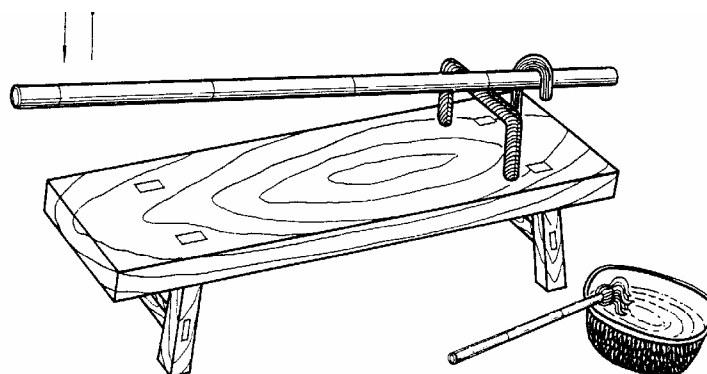


Fig. 5-12 Bamboo-straightening stand with fire

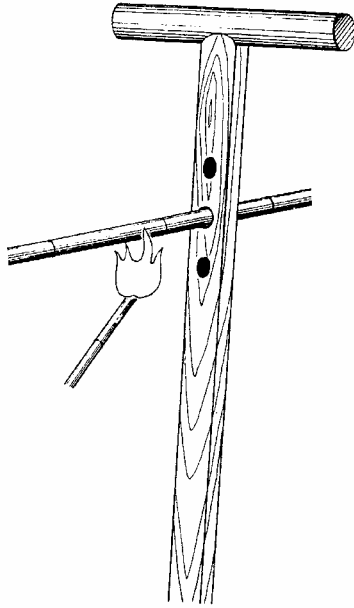


Fig. 5-13 Bending column



Fig 5-14 Electronic planer



Fig 5-15 Electronic Drill

7. Financial aspects of a village traditional bamboo furniture unit

Staff: 15, annual production value: 1 million RMB

Bamboo treatment:

1 steel boiling tank and 1 bleaching tank: $5000 \text{ RMB} \times 2 = 10000 \text{ RMB}$

Start-up costs:

1 300m^2 workshop and 1 200m^2 air drying place

Tools: $1000 \text{ RMB/set} \times 15 \text{ sets} = 15000 \text{ RMB}$

Running costs:

Bamboo material: 500 RMB/ton

Treatment

Power

Appendix 1 Sample Designs



Chairs



Sofas



Sofas



Tables