GROWN FURNITURE

A move towards design for sustainability

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ABSTRACT

This thesis deals with the proposal that environmentally benign items of free standing furniture may be produced by the use of such well established techniques as training and grafting natural tree growth to shape. The project has been driven by the growing environmental concerns of which mankind has become aware in the late twentieth century, and which are starting to exert such a powerful influence in the twenty first.

A broad history of man's use and control of natural tree growth, ranging geographically from Europe to Australia, and in size from hand held agricultural picks to eighteenth century sailing ships, is followed by a brief description of the ways in which the explosive increase in world population, together with the expanding industrial activities of the Western consumer society, are feared to be threatening the stability of the natural environment. The various disasters and catastrophic accidents which have brought this situation to the attention of the general public are briefly surveyed, together with National, International and a range of Industrial responses. As one of the professions most closely concerned with the production of consumer items, the various reactions of the Design Community are similarly examined.

In conclusion, the author's proposal for an experimental item of furniture - environmentally benign in production, use and disposal - is described and illustrated. A simple free standing three legged stool, the form of both the item itself and that of the jig required to control it's growth, are described and illustrated. The growth of examples of this, carried out on three sites across southern Britain are documented, experimental results reported and discussed. A further range of designs suitable to be produced using this method of controlling and grafting natural growth is proposed, and suggestions made for further experimentation.

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ILLUSTRATIONS

Illustrations are numbered in relation to the section in which they occur - for example 2g/9 is the ninth illustration in section 2g.

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1 INTRODUCTION

The challenge of creating a sustainable world has moved from the world of idealism to that of necessity. Our survival as a human race depends upon it. The understanding of sustainability as an essential value results from a coming to consciousness in the field of design similar to that which many social groups have gone through in the past thirty years. We can note the new relations between men and women that feminists have fought for, the respect for all the world's cultures that multi-culturalists believe in, and the recognition of different gender identities that gays and lesbians have insisted upon.

Victor Margolin ' Design for a Sustainable World '
Design Issues, Summer 1998, p88

i) THE GLOBAL PROBLEM

With the evolution of Western society through the process of industrialisation, an impressive range of social advantages emerged. It was only in the last half century that their accompanying environmental problems began to be recognised.

From a global perspective, the resulting environmental debate is shared between the different courses of action to be followed by the Developed and the Developing Worlds. For the post-industrial West - sufficiently affluent to at least begin to address these ecological issues - this action must maintain the delicate balance between increasing the efficiency with which it performs it's production/consumption/disposal cycle, radically reducing it's environmental impact, and maintaining living standards at socially acceptable levels. For the Developing world, the problem lies in attempting to raise the standard of living of it's peoples to a level at least comparable with that of the West, while trying to avoid adding to the already substantial world ecological problems resulting from the West's previous industrial activities.

ii) PROJECT RATIONALE

This may be summed up as being the search for a virtuous circle of sustainable furniture production and disposal. Seen from a Western culture, and from an academic viewpoint, the current project may be viewed as a contribution to the debate on possible ways of reducing the environmental impact both of creating and of disposing of consumer durables such as furniture. While it has been shown by experiment that the proposal is indeed practical, it is not anticipated that such a system could to any appreciable extent supplant the current system of production. The intention is principally to indicate the advantages which may accrue through the use of such an approach to the creation of artefacts, by making sensible use of the natural materials and processes available to us.

In terms of the eco-debate, items of furniture occupy an uncomfortable middle ground. Unlike automobiles they do not in their daily use, require the use of energy, or pose any considerable threat to the environment. Nor, unlike automobiles, do they have an easily predictable useable life span. By it's nature, the motorcar will gradually wear out with use, requiring periodic repair and eventually disposal, while steadily depreciating in value.

Items of furniture though, depending on the quality of their construction and maintenance, may not wear out over many generations of use. Being heavily influenced by fashion trends however, they are frequently discarded long before their useful life is over, being relatively bulky and virtually worthless.

Most items of mass produced furniture are factory made, involving in the process considerable pollution and waste, and using combinations of materials, some at least of which are man made and non-biodegradable, assembled in such a way that they cannot easily be either dismantled or recycled. Even natural timber components may be assembled using glues which make them impossible to separate, and finished using acid catalyst lacquers which are difficult to remove. Current adhesive technology makes possible the permanent bonding together of widely different materials such as wood, metals, some plastics, foams and fabrics. Many of the finishing processes used on metal components such as plating, in addition to the problems of disposal of the toxic wastes produced, present problems for recyclers. The initial production of plastic components, by moulding or extruding more than one material together, present further difficulties for recyclers. As indicated by Graedel and Allenby however ;-

> Given careful attention to design and materials selection, many of the plastics in industrial use can be recycled. This is particularly true of thermoplastics, which can be ground, melted, and reformulated with relative efficiency.... The utility of recycling these materials is a function of their purity,

> which implies that the use of paint, flame retardants, and other additives should be minimized or avoided if at all possible. Having plastics of many different colours in a product limits recyclability options as well. [1]

With this knowledge available, it is evident that there is much that careful design can contribute.

iii) ECOLOGICAL ASPECTS OF FURNITURE DESIGN

Since a piece of furniture may present ecological problems both in manufacture and in disposal, it will be necessary to consider both of these points in it's life cycle.

In broad terms, several of the materials in common use may be thought suitable for this project. Before choosing any one however, some general aspects of the use of materials should be examined. In all cases, a reduction in the quantity of materials used is desireable, as less of any material will result in lighter structures, more easily and economically transported, and in turn requiring less material to support them in use. (Inflatable 'upholstery' provides a good example of this approach.) The ultimate course of action of course, is to 'dematerialise' completely, by so planning a situation that no furniture of any sort will be required. (An efficiently run 'just in time' system of appointments for visitors will obviate the need for a waiting-room, and thus the need for any waiting-room furniture.)

In terms of energy saving wood, being an organic material, has a considerable advantage over either metals or plastics. Both of these require the input of considerable amounts of energy both in their first extraction or conversion to the basic raw material, and in their reprocessing at the end of the product's useful life. (In the case of plastics, some progress is being made towards the substitution of biodegradable Bioplastics 'made from plants, usually polymers of starch or polylactic acid' [2] for the traditional oil based polymers.) As Alastair Fuad - Luke indicates ;-

> 'One measure of eco-efficiency is the degree of efficiency of use of energy within an ecosystem, that is, the energy captured, energy flows within the ecosystem and energy losses. All materials represent stored energy, captured from the sun or already held in the lithosphere of the earth. Materials also

represent or embody the energy used to produce them. One tonne of aluminium takes over a hundred times more energy to produce than one tonne of sawn timber. Materials extracted directly from nature and requiring little processing tend to be low-embodied-energy materials, while manmade materials tend to possess medium to high embodied energy.' [3]

Shown below are the indices of embodied energy for some commonly used materials, quoted from Fuad-Luke ;-

Typical embodied energies (MJ per kg)

Wood / bamboo / cork	2 - 8
Wood composites e.g. particleboard	6 - 12
Glass	20 - 25
Carbon steel *(mild steel not quoted)*	60 - 70
Polypropylene	90 - 100
Aluminium - cast	235 - 335
Carbon fibre	800 - 1,000
(and for comparison)	
Gold	5,600 - 6,000

All the common processes of manufacture involve the use of electrical energy, the generation of which generally produces pollution to varying degrees, not to mention the other undesirable factors involved. (Atomic power, while not producing 'greenhouse' gasses, has it's own well known problems of disposal.) The conversion of metals from ore to the finished component is also a very ecologically disruptive process ;-

The extraction of raw materials from the Earth's crust generally involves the movement and processing of large amounts of rock and soil. To recover 1 ton of copper, for example, requires the removal of some 350 tons of over-burden and the processing of 100 tons of ore. As a result, extraction of materials is extremely energy-intensive and tends to be destructive of local ecological habitats. [4]

and , 'A steel mill will burn about 20kg of coal to make the steel for one chair' [5]

Finally, at the end of its life, furniture faces the problems posed by changes in fashion and lifestyle which militate against the ecologically desireable aim of life extension. In practical terms however, all manufactured goods must have a finite lifespan. An appropriate strategy then must be to ensure that any materials used in manufacture can either be recycled, or at least disposed of with minimal environmental impact. In these terms natural wood has the advantage that it will, by it's nature, eventually biodegrade.

2 THE HISTORICAL CONTEXT

Man's traditional use & control of natural tree growth

At the start of the twenty first century, a proposal which involves the use of a natural process such as tree growth in the production of artefacts is unusual. Since at least the early nineteenth century, it has increasingly become the norm that artefacts are produced using combinations of raw materials which, after processing in factories, are converted into products. The current proposal will therefore be seen as a radical one.

This being so, it may be appropriate to review the very considerable number of previous (and some current) instances of man's use of natural tree growth – at times by using the forms which trees – in nature – provide, at others by controlling or modifying their growth.

Since prehistory, and broadly until the advent of the Industrial Revolution, human societies all over the world have made use of this practice. In Britain, Tabor describes the eight hundred years after the Norman Conquest as the Golden Age of woodland management, when it 'reached an intensity and efficiency never matched before or after.' [6]

While the various major types of artefact created will be dealt with later, it is proposed firstly (2a – 2d) to examine some of the general aspects of the history of this practice.

2a Dwarfing

In nature, tree growth may be stunted by factors such as high winds and poor soil conditions. Adams cites the examples of the Bristlecone pine trees growing in the White Mountains on the California/Nevada border which, although thousands of years old, ' are only feet high. At 12,000ft the ultraviolet factor is immensely potent and every tree is compact with neat foliage.' [7]

Human societies have adopted dwarfing techniques for both practical and decorative reasons. Deborah Koreshoff quotes from an article by ' a past President of India ', from which it appears that the ancient Hindu Ayurvedic physicians, in an empire which

' covered the globe ' had developed the art of Vaarmantanu vrikshaadi or 'dwarfed body trees science '[8]. In this way the small trees became portable, enabling the physicians to ensure their supply of medicinally valuable roots, flowers, bark, leaves and fruit of certain jungle trees, no matter where they were. The same author describes how the Egyptians cultivated trees in recesses cut into the rock about ' 4,000 years ago ', while trees were also grown in pots by the ancient Greeks, Romans, Babylonians and Persians. ' No Greek or Roman garden was complete without it's tub of apple trees '[9]

> Not only do apple varieties exhibit an enormous range of different blossom and fruit colour, for example, but it was interest in the ornamental possibilities of miniature Paradise trees that first pointed growers in the direction of the dwarfing rootstocks on which modern orchards are based, the improvements in the qualities of the fruit produced by decorative 'fan' trees, which first suggested the benefits of training and pruning to the fruit grower[10]

Planting in tubs thus combines both practical and aesthetic advantages. It allows trees to be moved to the most advantageous positions for the ripening of the fruit, or to more sheltered positions when there is a risk of frost, at the same time enabling the proud owner to show off his crop to his friends or dinner guests.

In China, and later Japan, the art of tree dwarfing or Bonsai is of considerable antiquity, although in this case it was a natural - albeit miniature - appearance that was prized. Joseph Addison, in an article published in ' The Spectator ' in 1712 reported that ' the inhabitants of that country (China) .... laugh at the plantations of our Europeans, because they say that anyone may place trees in equal rows and uniform figures. ' Beautiful and apparently natural miniature trees, once again grown in containers for mobility, played an important role in certain annual ceremonies such as the Flowering Apricot at the Lunar New Year. Initially, attractively shaped small trees found growing wild would be removed and potted, to stand in the garden until required for the indoor ceremony, the shape being modified and the growth restricted for aesthetic and practical reasons. Maturity - or its appearance and characteristics - has always been prized in a Bonsai - and as beautifully shaped, small mature trees were comparatively hard to find, they remained, in the early days, the prized possessions of the rich. The techniques for their successful cultivation - considered to have something of the ' half magical & unnatural art ' - were little known, being passed down from master to pupil.

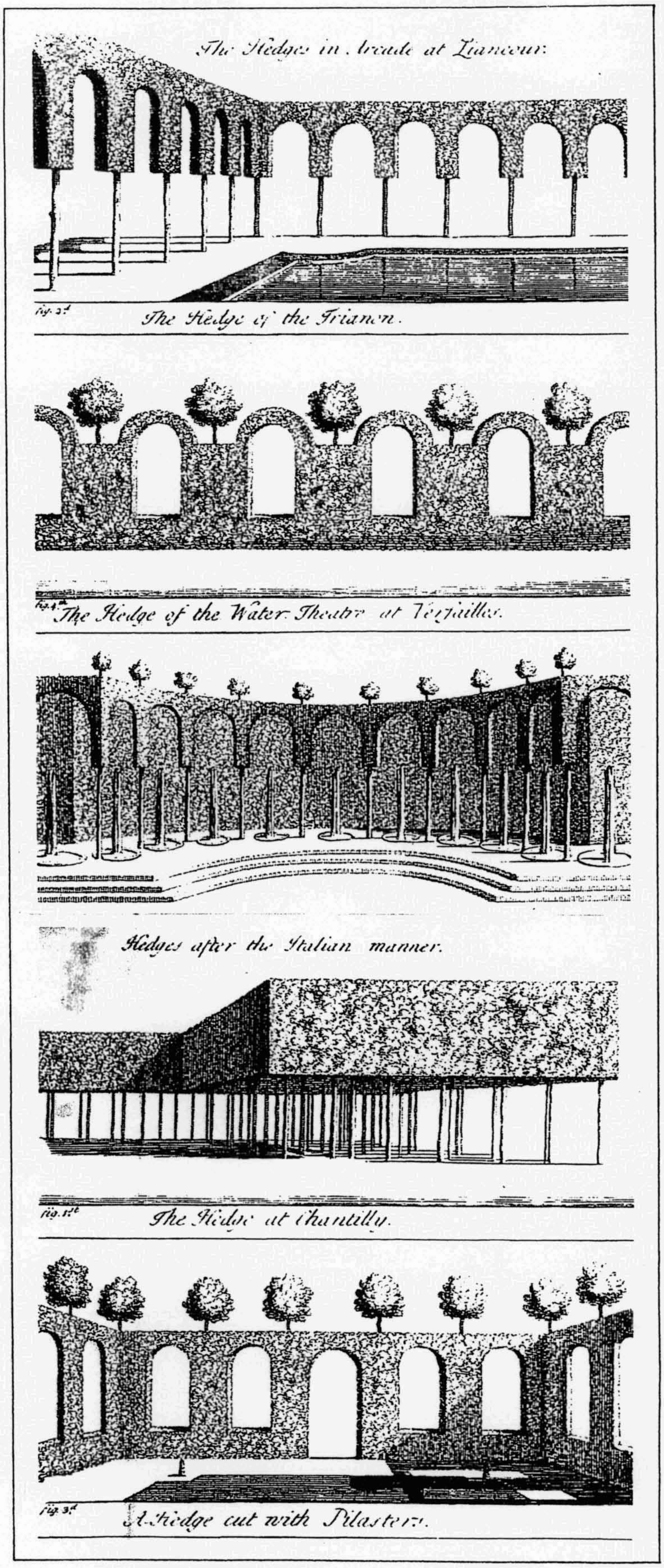
It is probable that the art of Bonsai was brought to Japan via Korea by Buddhist priests in the sixth century AD. Here it flourished until the disastrous floods in the Tokyo area in 1912, and the earthquake in 1923, which were major setbacks. Following the second world war, however, returning US servicemen helped to spread the appreciation of the art world - wide.

2b Topiary

Training and clipping growth ' into forms which are purely abstract and architectural, ..extravagant, even comic, so as to distract the eye and divert the attention '. [11] The name derives from the Latin word *Toparius* meaning landscape gardener, indicating the importance of this practice in Roman gardening. Pliny the Younger (AD62 - 110) describes extensive topiary work in his garden in Tuscany.

Bringing with them the Mediterranean Cypress and Box, the Romans introduced the practice to Britain, although only the Box proved reliably hardy here, and it is the native British Yew which is ' the tree on which British topiary exists ' [12]. Some topiary work survived in Europe after the fall of the Roman Empire - largely in monastery gardens - but it did not reappear on any scale, in Britain at least, until the Sixteenth Century. The gardens at Hampton Court under Henry VIII and later Elizabeth I were described as containing elaborate examples. Continental gardeners in Italy, France (Le Notre at Versailles, see fig 2b/1) and particularly in the Netherlands, developed this highly stylised form of gardening enthusiastically and, with first the return of Charles II from exile at the Restoration, and particularly with the accession of William and Mary, the fashion returned and spread throughout British gardens. Of the many thousands of trees drawn by Leonard Knyff in 1699 in the gardens at Chatsworth, there was ' not a single one that was not cut to shape ; the shears dominated natural growth ' [13]

The change in fashion to a more apparently natural style under the influence of William Kent and ' Capability ' Brown however, resulted in the destruction of the vast majority of the topiary work in Britain. Its reappearance - on a far less grandiose scale - occurred only with the coming of the Arts and Crafts movement at the end of the nineteenth century. The admiration of this group for the Renaissance culture resulted in a renewal of interest in this style of gardening, particularly in the Cotswold area where so



These 17th century French topiary hedges are demonstrations of man's use of and control over nature

fig 2b/1

many of them lived. Subsequent interest in - and admiration for - the work of William Morris and others of the Movement (combined with the availability of power clippers !) has ensured it's current survival.

2c Pruning, training, grafting & bundle planting

i) EUROPE

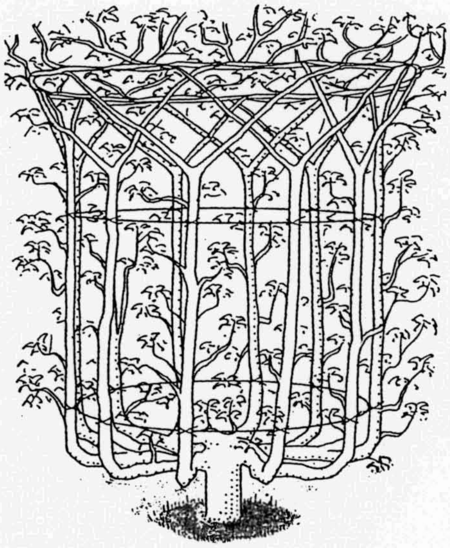
In addition to dwarfing techniques, the arts of pruning, grafting and training to shape, both with single trees and with groups, have long been practised in Europe by both fruit growers and gardeners. As with topiary, it was the Romans who - bringing the cultivated apple and it's associated skills of pruning and grafting with them - were largely responsible for the spread of these practices.

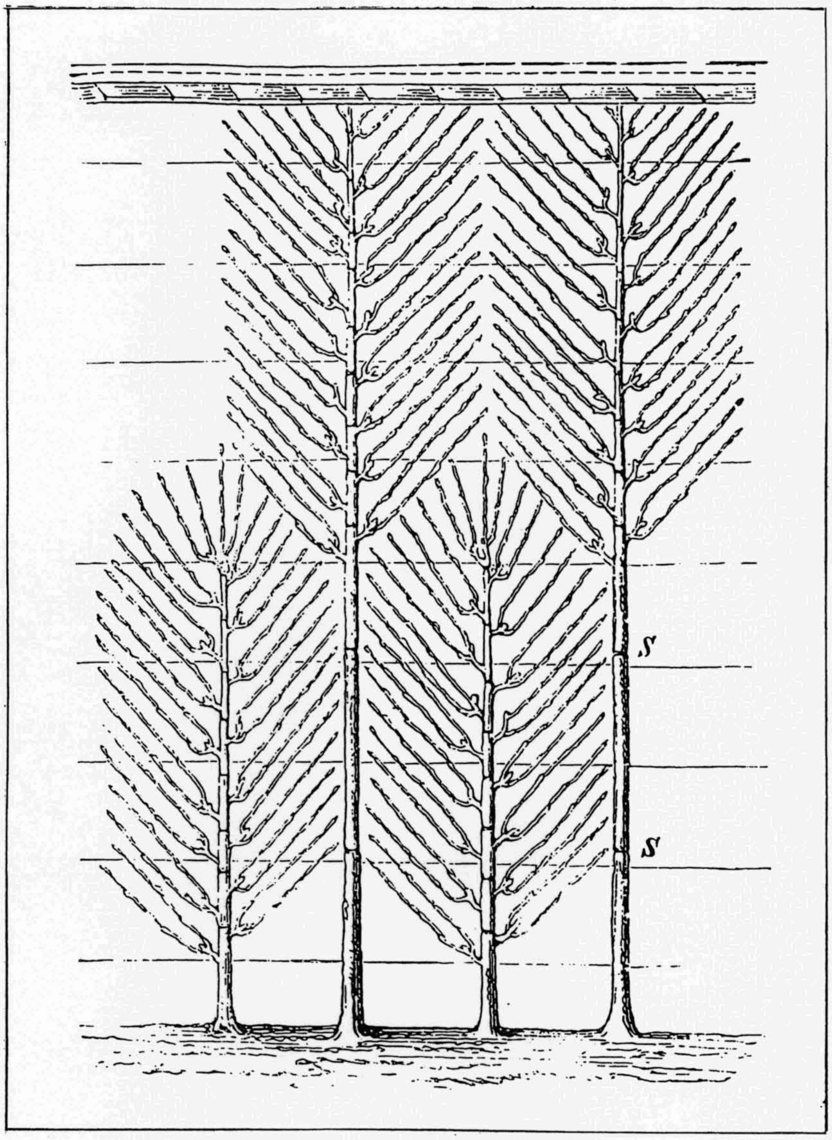
In Tudor times Britain contained many orchards. According to Thomas, Norwich was ' either a city in an orchard, or an orchard in a city, so equally were houses and fruit trees planted .' [14] This open planting system was to change however, Wilkinson and Henderson describing how ' By the early 17th century fruit walls had become important in many European gardens' [15] (fig 2c/1) necessitating a two dimensional system of training and grafting.

In the eighteenth century, following the move from the highly elaborate formal garden (with it's extensive displays of topiary) to an apparently more 'natural ' style, the training of fruit trees blossomed further, with shapes such as Cordons, Espaliers, etc becoming popular in Britain. Fruit trees ;-

> ...disappeared from the pleasure ground and were banished to the walled fruit and vegetable garden. Here teams of gardeners, relieved from the endless chores of clipping, watering and maintaining the formal garden ... exploited the advantages of espalier training .... [16]

With the coming of the Industrial Revolution and the creation of a sizeable and affluent middle class, growing one's own fruit became increasingly widespread, and the skills of grafting, training and pruning fruit trees were widely practised. The various tree forms developed enabled the growers to produce maximum quantities of fruit within





above
the 'Goblet' - a popular 19th century shape for fruit growers

below
training fruit trees against a wall to achieve maximum output. 18th century

fig 2c/1

controlled areas, to promote their ripening by close proximity to the sun - warmed brick walls, and to create elaborate and decorative sculptural trees. (fig 2c/1)

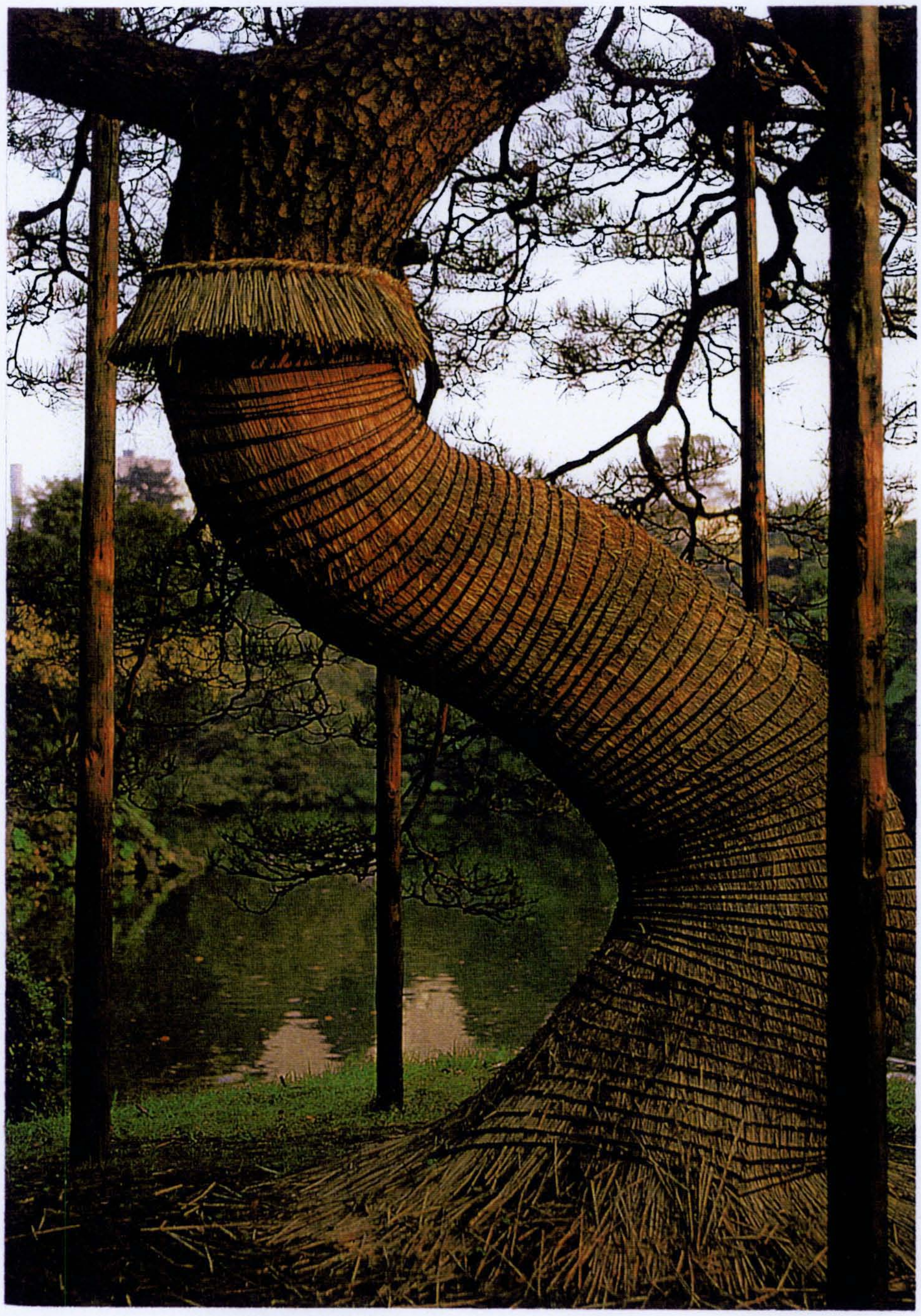
In the 20th century the Hatton (originally Bradbourne) Fruit Gardens at East Malling were created in 1938 by Dr Ronald Hatton as ' a memorial to the art of pruning & a source of information and examples for future fruit enthusiasts to admire and study.' [17] The Summer pruning techniques of Louis Lorette were studied by Dr Beryl Beakbane in the early 1940's, and introduced to the gardens in a modified form. The Gardens contain many fine examples of both two dimensional (cordons, espaliers, fan / palmettes), and three dimensional (pyramid, barrel, bateau, goblet, crown, table top, arcure) tree forms.

Particularly popular in Victorian England, ' Bundle planting ', a system of planting several trees into the same hole, has been practised traditionally in various parts of Europe and in the 1950's in North Africa. The reasons for it vary, from the practical one of providing a more robust combined trunk for the bundle, to the more decorative one of attempting to reproduce the appearance of a typical 'Gothic ' stone column. In the Spring/Summer and Autumn 1997 issues of the Journal ' Tree News ' the practice is discussed in letters from Ted Green, Dr Oliver Rackham, John White and Professor Jack Thurgood. Of particular interest to the current research is an example illustrated of a tree or bundle, brought down by a freak wind at Sezingcote in Gloucestershire. John White says ;-

> My first thought about why this tree should have five stems was that it could have been five scions of copper beech grafted onto a semi - mature green beech stump. Sezincote has several examples of Victorian tree manipulations to produce curiosities. The house is in the Indian style and a young tree on five stems would match exactly some of the ornamental embellishments of the roof. But now I'm not sure. Perhaps this is not a grafted plant at all, but another example of ' bundle planting '.

ii) THE FAR EAST

The skills involved in 'assisting nature' to produce elegant and beautiful forms have long been practised here, the training and pruning to shape of trees being an integral part of this. A single example of the elegant results achieved may be provided by the curved trunk of the venerable pine tree shown in fig 2c/2 in Koishikawa Korakuen in Tokyo, seen



Very evidently the result of prolonged training,
the bark on the trunk of this mature pine tree is protected
against winter frosts by it's straw sheath.
Koishikawa Korakuen, Tokyo

fig 2c/2

with its elegant winter covering of straw, bound carefully in place with black dyed palm ropes and finished off with a suitable collar. The straw protects the bark from frost damage.

2d Coppicing /pollarding & hedging

The first two of these describe the practice which, according to Milner [18] was well known in Neolithic times, of felling a mature tree at either just above ground level (coppicing) or at a height sufficient to be out of the reach of grazing stock (pollarding). Having a well developed root system the remaining section of the trunk , or *stool*, will not die, but will produce a ' halo ' of many small branches (fig 2d/1). If harvested at regular intervals - of between four and fifteen years depending on species and diameter required - these trees will continue to provide a regular supply of small section timber over many years.

> Not only were such cycles sustainable, it was found that the process had the effect of greatly prolonging the life of the individual trees. Ancient Hazel stools in England have been estimated by Rackham to be over 1,500 years old - more than ten times the normal span of uncoppiced Hazel. [19]

Coppiced trees were sometimes grown interspersed with standards of a different species which were allowed to grow to maturity before being felled, the rotation being typically ten times that of the coppice. In *The Forgotten Arts*, Seymour asserts that ;- ' when grown crooks (curved boughs) were needed for shipbuilding, coppice - with - standards was a very popular method, for the oaks sent forth side branches which provided the crooks. ' [20]

With the coming of the Industrial Revolution, new materials such as iron and steel rapidly took over from timber in many of the fields such as ship building where timber had previously predominated. The qualities - and the availability - of coppiced timber still found uses and exerted some constraints however, notably in the brewing and textile industries;-

> A single large cotton mill in Stockport is said to have used about 10 million bobbins at any one time, with a replacement rate of about 350,000 per week ' and ' a major constraint on the expanding acreage given over to hops in Kent was the availability of poles from the twelve - year - old

above
a newly laid hedge, showing how the stems are cut
to enable them to be laid down at an angle

below
coppiced limes - ' coppicing itself can prolong the life
of small-leaved lime almost indefinitely'

fig 2d/1

> coppices. It has been calculated that in the 1830's, 100,000 acres of coppice on this rotation were needed to supply the 25 million new poles required per annum. [21]

That such quantities of timber were used by these major industries so relatively recently should certainly give us food for thought.

The purpose of hedging - or more correctly hedge laying - is not to supply timber for other uses, but to increase the density and thereby effectiveness of a growing hedge. Traditionally used to control the movements of farm stock, well managed hedges are among the best and most cost effective barriers for this purpose, being self generating, improving with age and requiring less maintenance than most other traditional forms of walling or fencing.

Hedge laying is carried out in the winter months (see fig 2d/1), when the main stems of the hedge are slashed half through at a point just above ground level (a dramatic demonstration of the ability of a growing stem to survive what may appear to be a savage attempt to destroy it). They are then ' laid ' down at an angle of between forty five and seventy degrees to the vertical. To prevent water from entering the wound, the cut should be carried out upwards, although this is a more awkward and therefore slower process than cutting downwards. If the hedge runs up an incline the stems will lean uphill to avoid lying lower than horizontal, preferably towards the sunlight and away from the prevailing wind. In this way the new growth on each stem - tending to be vertically upwards - twines through the stems above it, eventually forming a dense barrier. Vertical stakes are then driven through the hedge into the ground at about one metre intervals, the tops of these being pleached together for strength using a twist of thin hazel rods.

Having all but died out, there has recently been a small renaissance of this craft which - with thatching - has been recognised as having a valuable place in the ecology of the countryside.

2e Hand held sticks / tools / weapons etc

i) WALKING STICKS

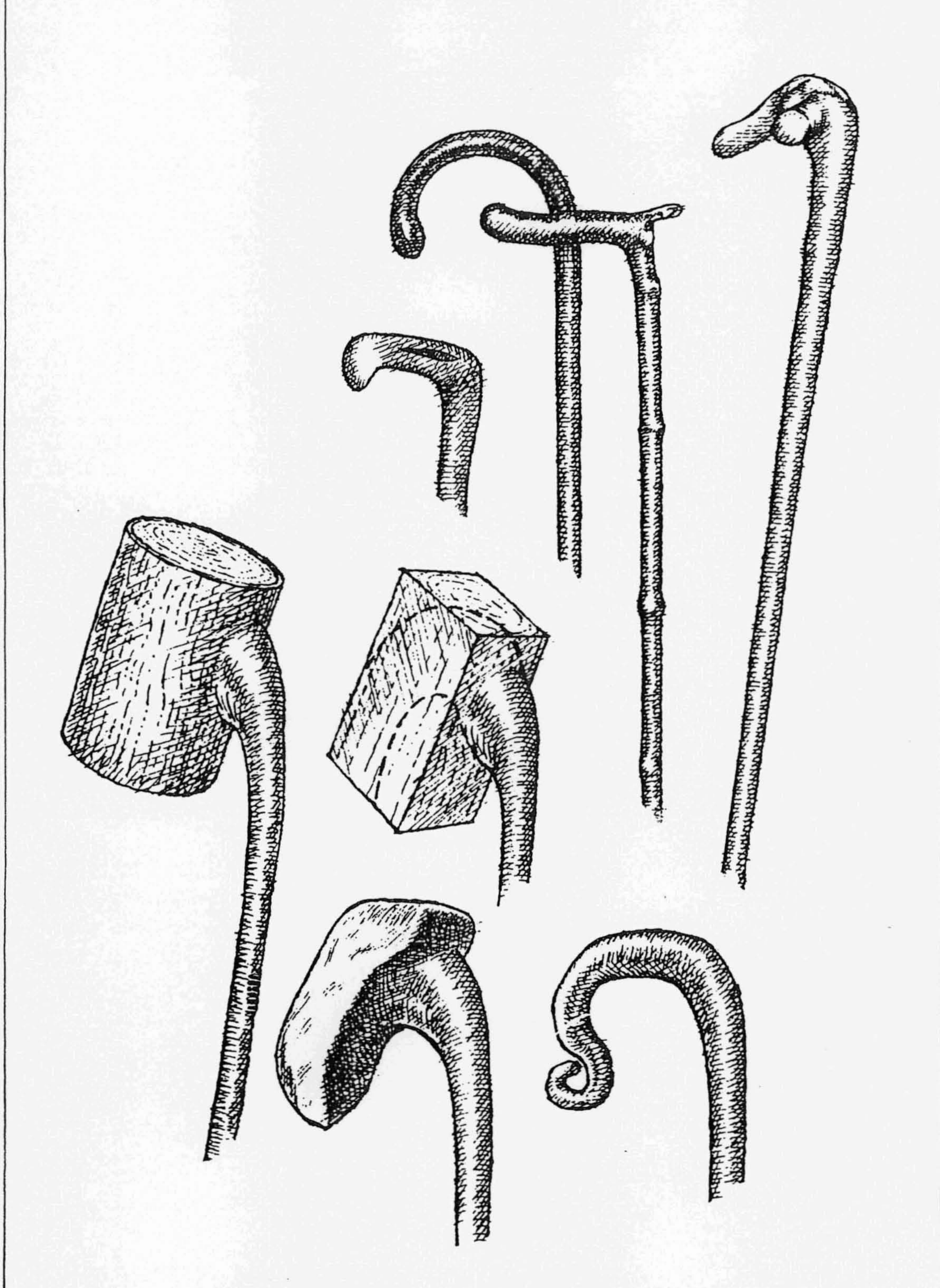
These aids are used world - wide, either over rough terrain or in infirmity, and the use of natural growth is common. Practical considerations suggest that the stick should be as light as possible consistent with its having adequate strength to support the user, and ergonomics that some form of handle is desirable. In many civilisations sticks have taken a role that is more symbolic than practical, and in most Western societies the ' walking stick ' has long degenerated into a mere fashion accessory.

In Britain in the first half of the 20th century, the process of growing walking sticks with angled handles (fig 2e/1), practised near Chiddingfold and Whitley in Surrey - was described by Herbert Edlin ;-

> Ash seed is sown in nurseries and when the seedlings are a year or two old, they are transplanted. But instead of being set upright in the normal fashion, they are placed slanting in the ground, and their terminal buds are removed to oblige them to resume growth from the side bud at the tip of the shoot. Thus the new shoot arises almost at right angles to the old stem and when it has grown stout enough it forms the main shaft of the stick whilst the old shoot becomes the handle. The grain of the wood follows the sharp bend so that these crooked sticks are far stronger than they look. [22]

ii) SHEPHERD'S CROOKS

Of the longer forms of hand held stick - generally referred to as staffs - that used by shepherds was originally contrived by intervention during growth. Young stems of Hazel or similar wood were bent over and bound into an appropriate shape, being left then to grow naturally to a suitable thickness before harvesting. More sophisticated versions of this form, frequently carved from the point where a branch emerged from the trunk of a tree (fig 2e/1) or using horn (sometimes elaborately carved) have the advantage of greater crook strength, although the horn type tend to be heavier and require a secure fixing for the crook.



Above
a variety of walking stick handles from natural growth -
the curve is achieved by heating and bending

Below
four stages in the carving of a wooden crook
from The Forgotten Arts by John seymour

fig 2e/1

Another specialised form of crook, this time having an ' S ' shaped horizontal member fixed across the tip, was used during sheep dipping. An all wooden example of such an implement, the ' S ' formed from a length of naturally occurring wood, is on show in the Museum of Welsh Life near Cardiff.

iii) HURLING & BANDO STICKS

To this day the round end of the hand made sticks used in the traditional Irish game of Hurling, are carved from a plank of timber taken from the tree at the point where a branch had emerged from the trunk. As can be seen from the illustration (fig 2e/2) the curving grain which occurs at this point gives maximum strength. Of much lighter construction, the sticks used in the broadly similar Welsh game of Bando were fashioned from suitably angled branches of Ash. An example is on display in the Museum of Welsh life (fig 2e/2)

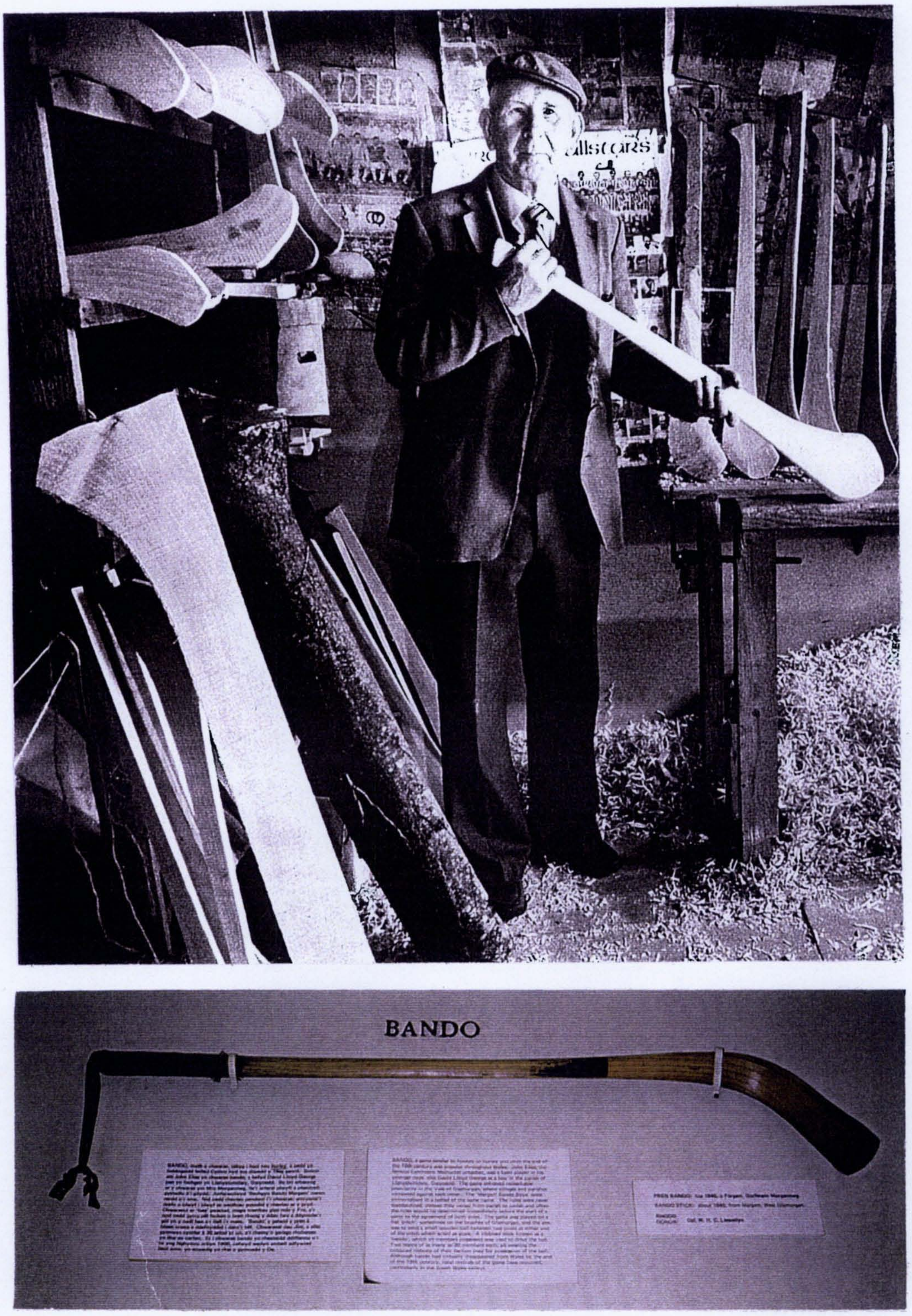
On a smaller scale, man has frequently taken advantage of the angles to be found in natural growth, using them as the shafts - and sometimes even the entire object - of both tools and weapons.

iv) TOOLS

Shown in fig 2e/3, Goodman [23] illustrates two Egyptian adzes. Dating from about 2750 BC their copper blades are secured to wooden shafts with thongs. The shape and strength of the handles, giving as they do a comfortable grip and an ergonomically correct angle of attack for the blades, can only be achieved by the choice of wood from particular parts of the tree.

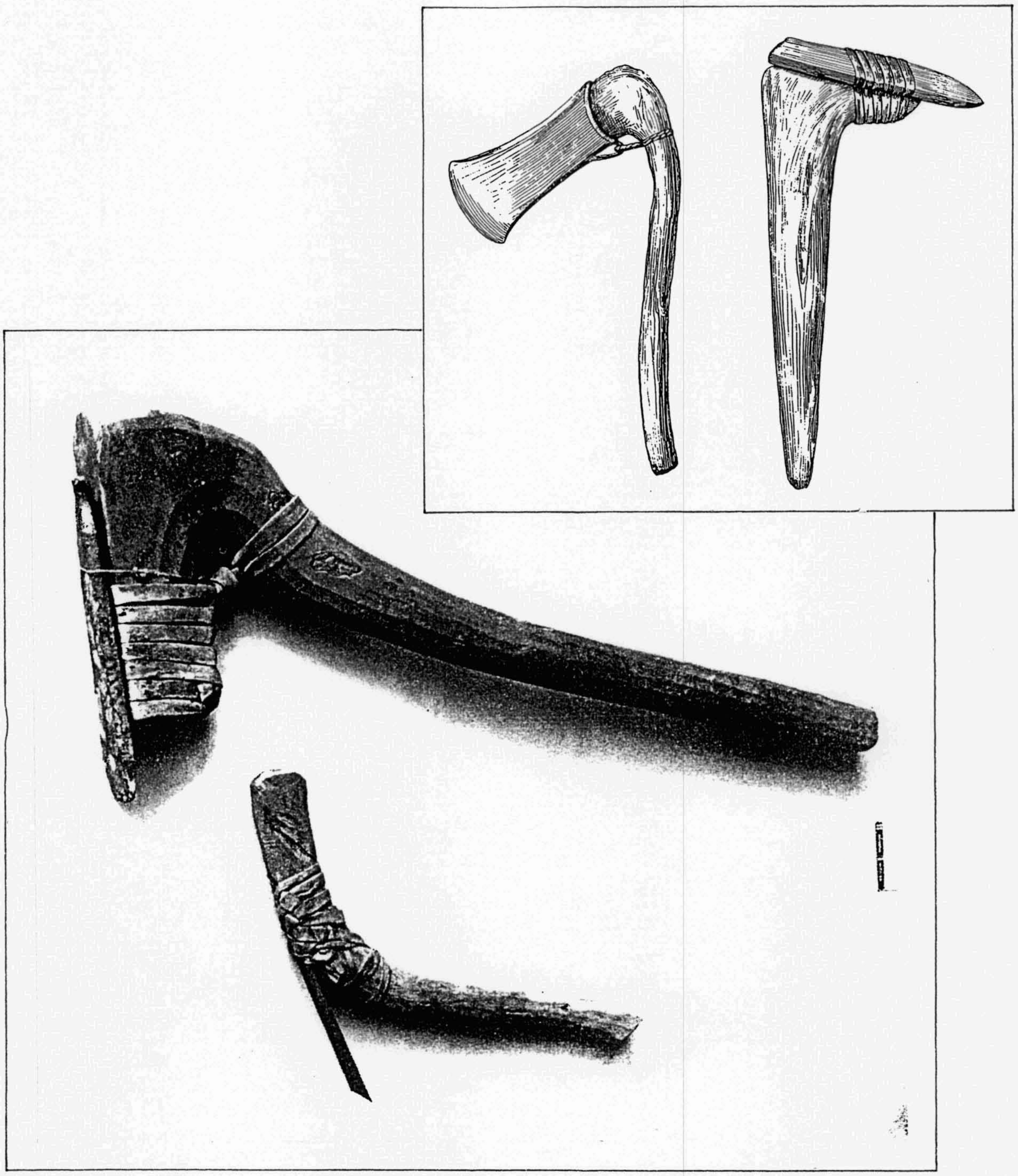
Similarly Gardi [24] includes an illustration of a selection of wooden handled tools, one of which demonstrates the use of a carefully selected natural angle to provide a strong support for the metal blade (fig 2e/4)

Fig 2e/3 also shows two European examples of the way in which naturally angled wooden handles may be used in the making of cutting tools. The material from which the cutting blade is fashioned has dictated very different forms of attachment, although the use



Above - John Joe O'Brien, Hurley maker. Note the grain direction on the selected timber (from Fitzgerald & O'Brien 1986)
Below - a Bando stick (displayed in the Museum of Welsh Life)

fig 2e/2

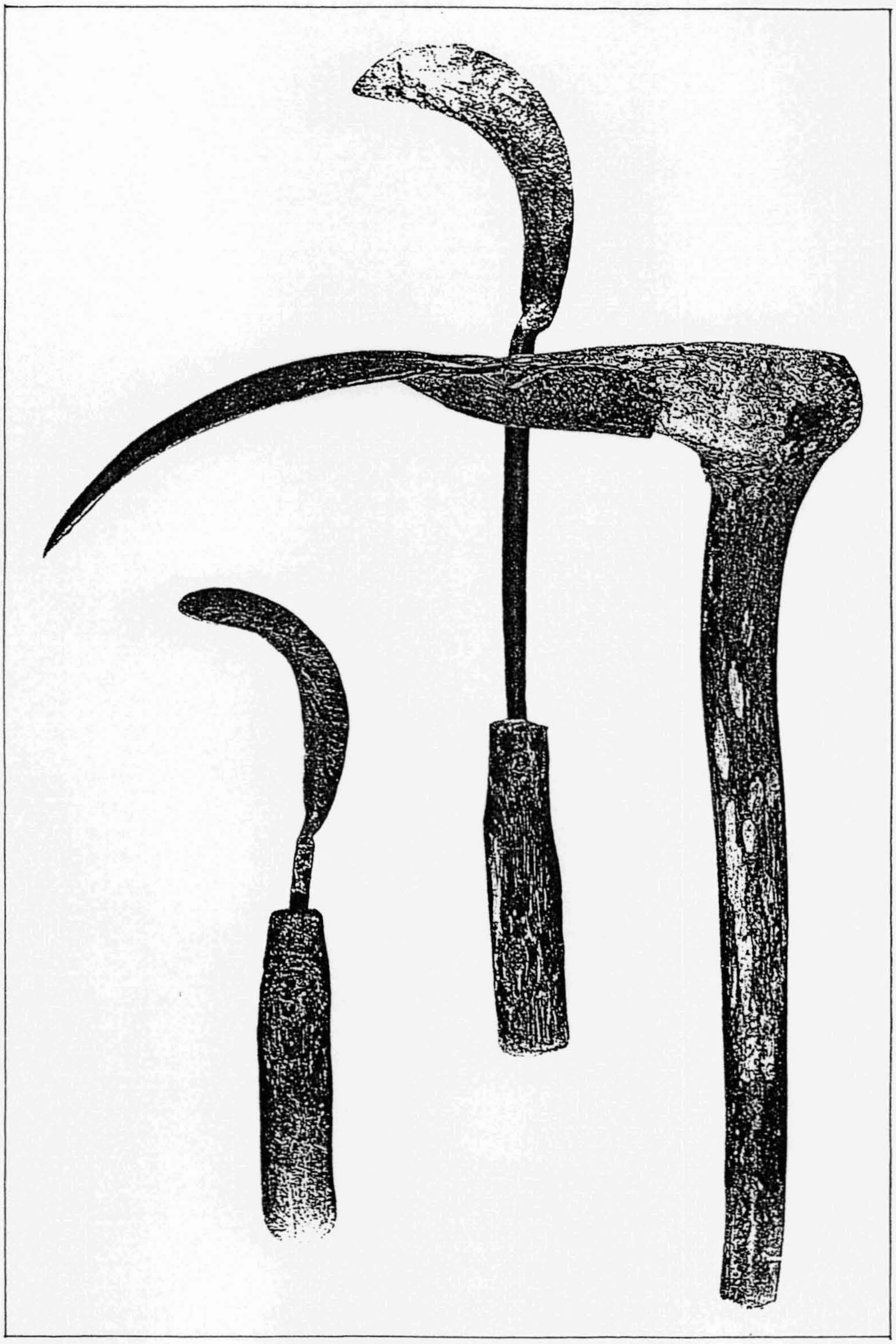


Primitive implements with naturally grown shafts

top left - bronze age axe - Austria
top right - stone age hoe - Portugal

below - two copper adzes - Egypt
17th &18th Dynasties

fig 2e/3



Some hand held cutting and shaping tools from central Africa, including one supremely elegant example of the use of natural growth forms

fig 2e/4

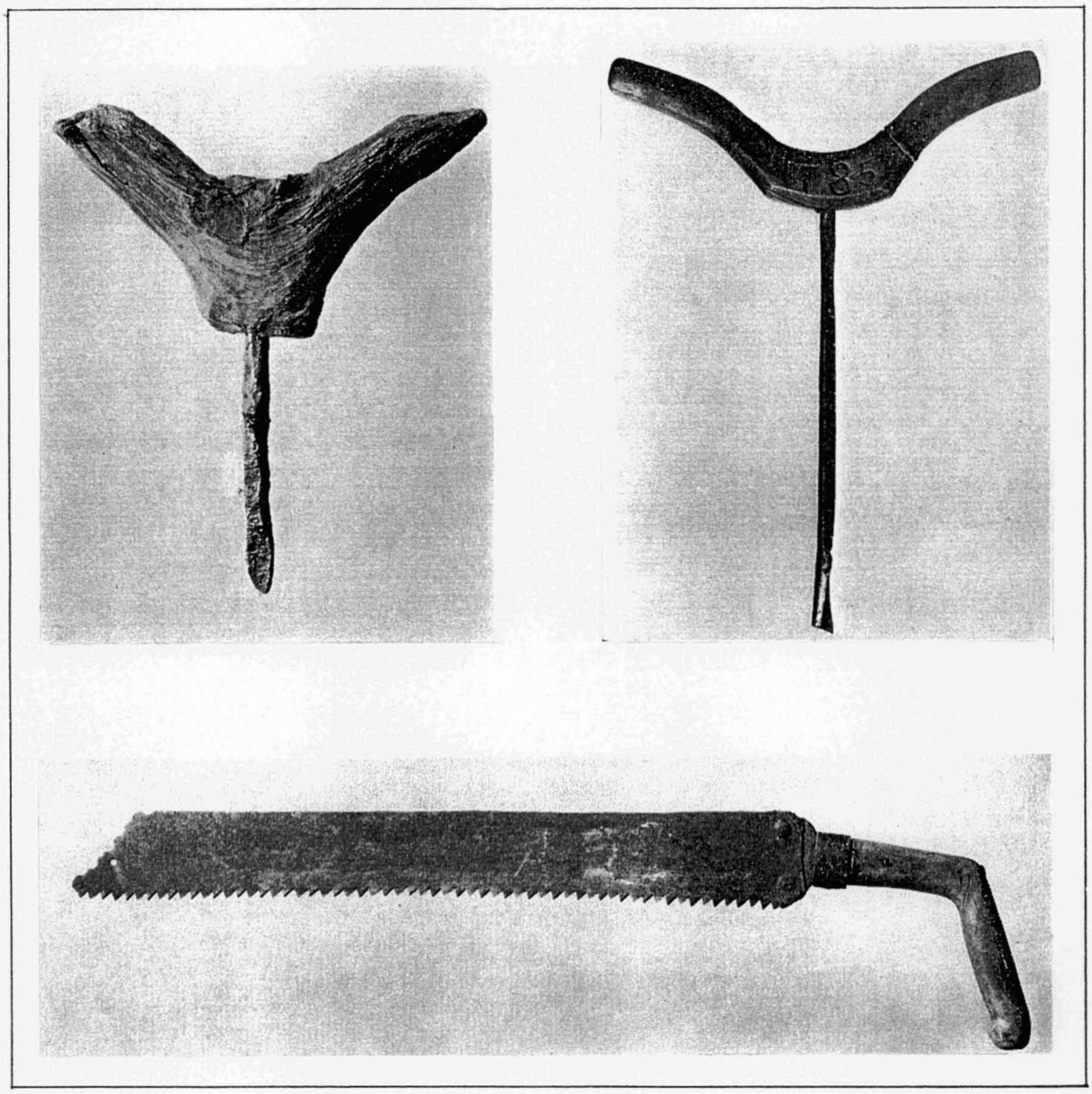
of the natural wooden angle remains constant. Three Scandinavian examples of naturally shaped wooden tool handles are shown in fig 2e/5. Ranging in age from the thirteenth to the eighteenth centuries, these two augers and a hand saw again illustrate that this use of natural strength has been both widespread and of considerable duration, although neither the reciprocating action of sawing nor the twisting action of the auger exert such severe stress as do tools intended to chop or hammer.

(fig 2e/6 top) The compact form of this adze from the island of New Caledonia makes skilful use of timber from a particular section of the tree which has been split to accept the blade and then bound up to secure it. The mass of the wood gives added force to the blow, but the weight of the head precludes the use of a long handle. Originating from a very different, and far more technologically advanced society, the adze and the axe, shown in fig 2e/7, make use not of the wooden ' knee ', but of the gentle curvature found in many tree branches. The shafts of these mast makers tools, while giving the requisite strength and resilience, also distributed the considerable weight of the cutting blade equally around the point at which it would be held, thus reducing the strain on the craftsman's wrists.

Less common but of interest nonetheless is the use of a naturally occurring bend to form the shaft of a wooden ' bitstock ' (fig 2e/8). (Sloane also shows, on p56, a hand made oak plane which uses the stub of a branch to form the handle). Thought to be similarly rare is an all wooden device described as a Rope Twister, on display in the Museum of Welsh Life. (fig 2e/8) About 180mm overall long, this has been contrived from an appropriately C shaped section of very hard timber, through one end of which a small clamping post has been inserted.

v) WEAPONS

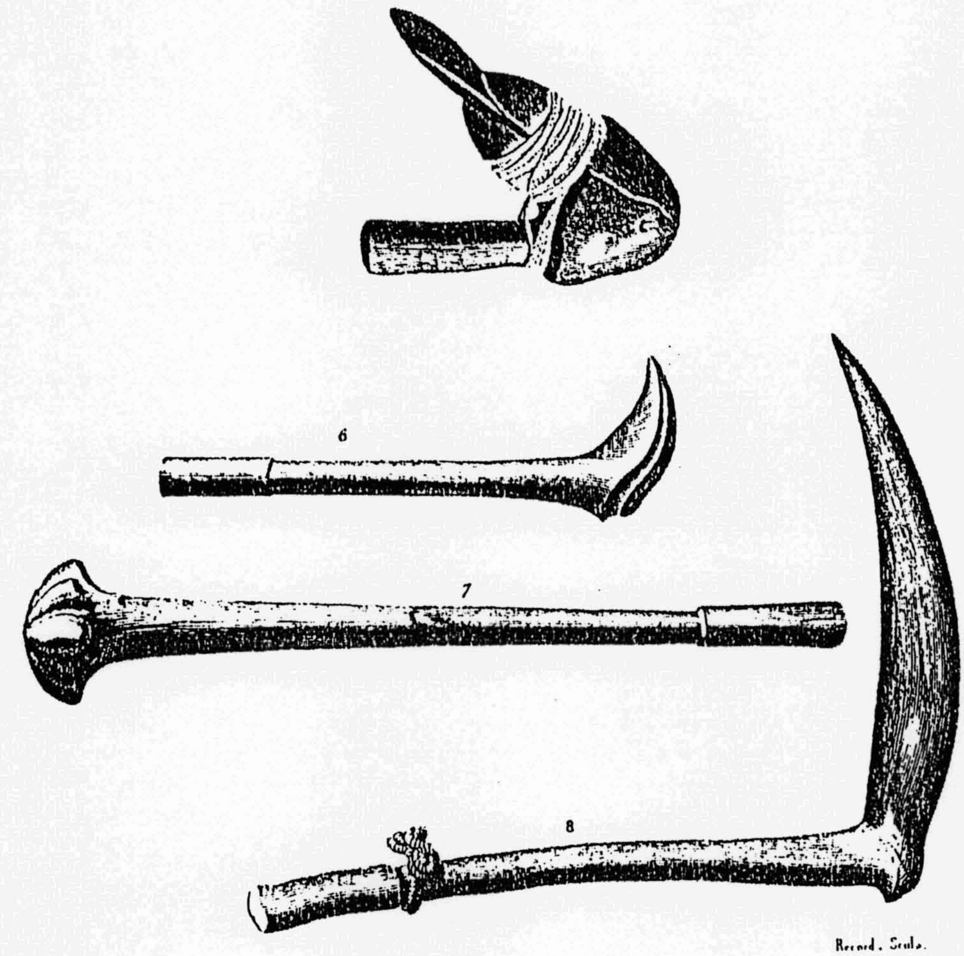
The simplest form of hand held wooden weapon is perhaps the club, depending merely upon a natural thickening in the branch or trunk to provide the heavy head required to deal an effective blow. This may be left as it has grown or, as in fig 2e/6 No 7, it may be carved in such a way as to present a smaller area of contact, the more effectively to crush skulls or bones. The head of the example shown is symmetrical, allowing it's effective use in any direction.



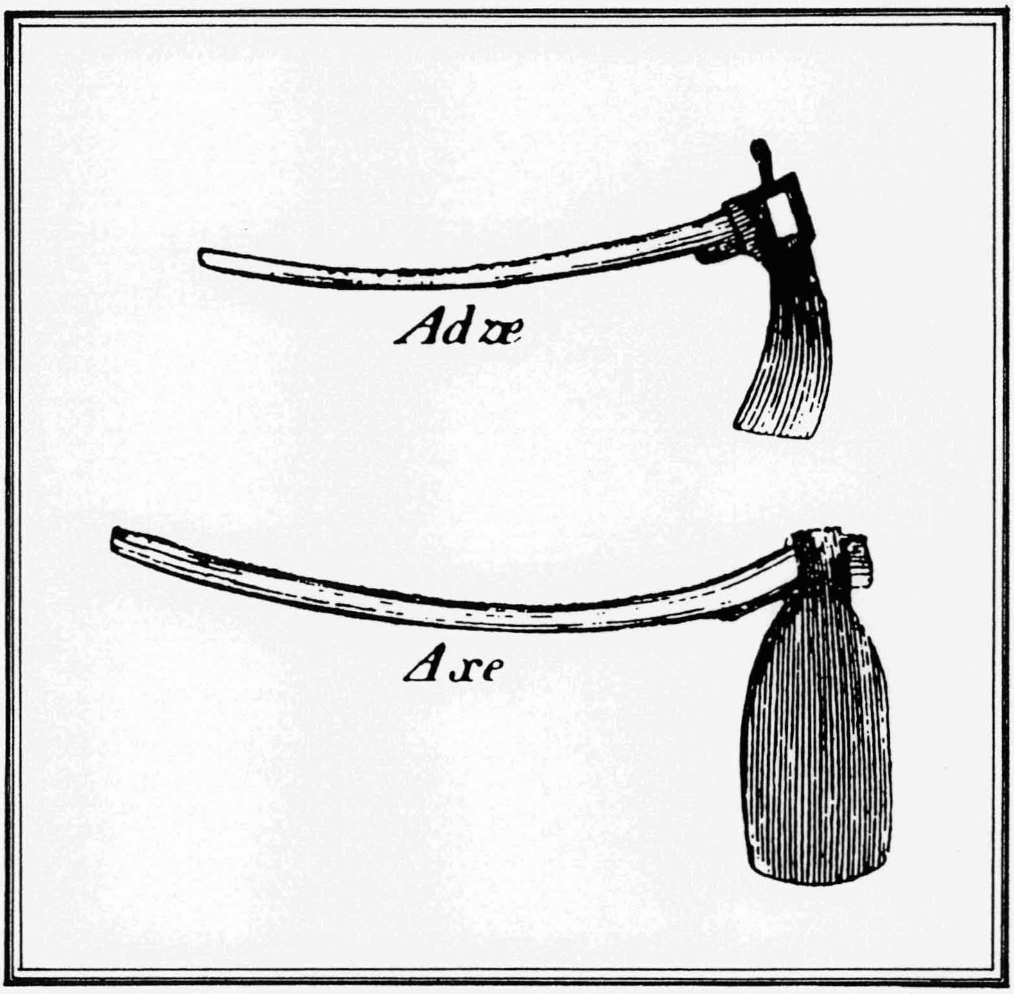
Above
Two wooden auger handles from Scandinavia, that on the left dating from the late viking period. The right hand auger is said to have been used for boring shingles

Below
The angle of the handle of this seventeenth century Swedish saw appears virtually identical to that of modern saws

fig 2e/5

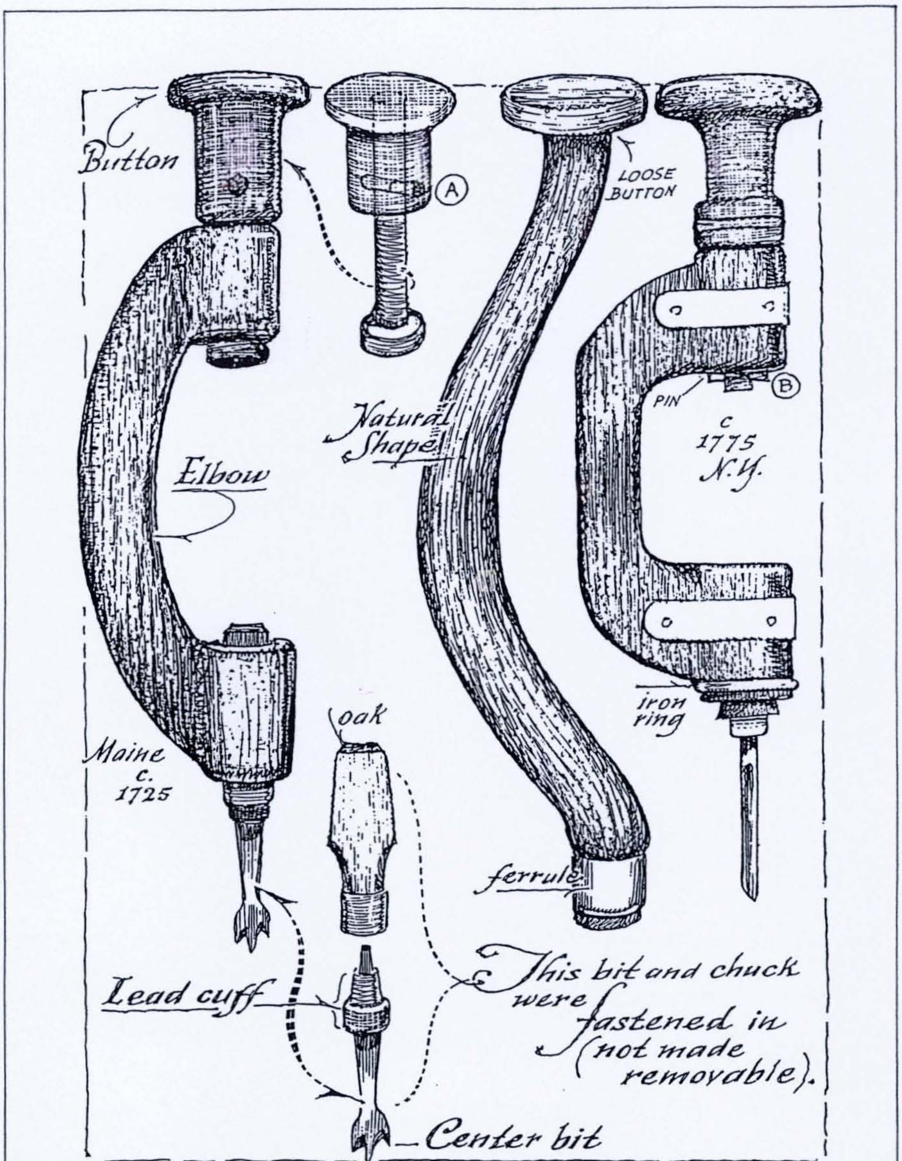


Hand held wooden weapons and an adze
from New Caledonia
making use of natural growth forms.
Atlas to Captain Cook's voyage
to the South Pacific
1772 / 75



Requiring gently curving timber for their shafts, these tools are two of those used for mast making as illustrated in Steel's ' Masting and Rigging ' published in 1790

fig 2e/7



Above - ' Some of the earliest (American bitstocks) were made of natural shaped roots or boughs. Oak and Hickory were most commonly used ' Sloan E (1964)
Below - A Welsh device used in the hand twisting of straw or horse hair ropes on display in the Museum of Welsh Life

Other forms of club, made using naturally occurring ' knees ', are intended for use in one direction only. In these cases a sharp edge or point, of metal or - if the wood used is sufficiently dense - carved from the solid may be provided. Examples of this type are shown, two from New Caledonia in the Southern Pacific (fig 2e/6 numbers 6 & 8) and one from Oklahoma in the USA, (fig 2e/9).

A further weapon type which makes use of naturally occurring wooden forms - the catapult - has been familiar to British schoolboys over many generations. (fig 2e/9).

2f Agriculture

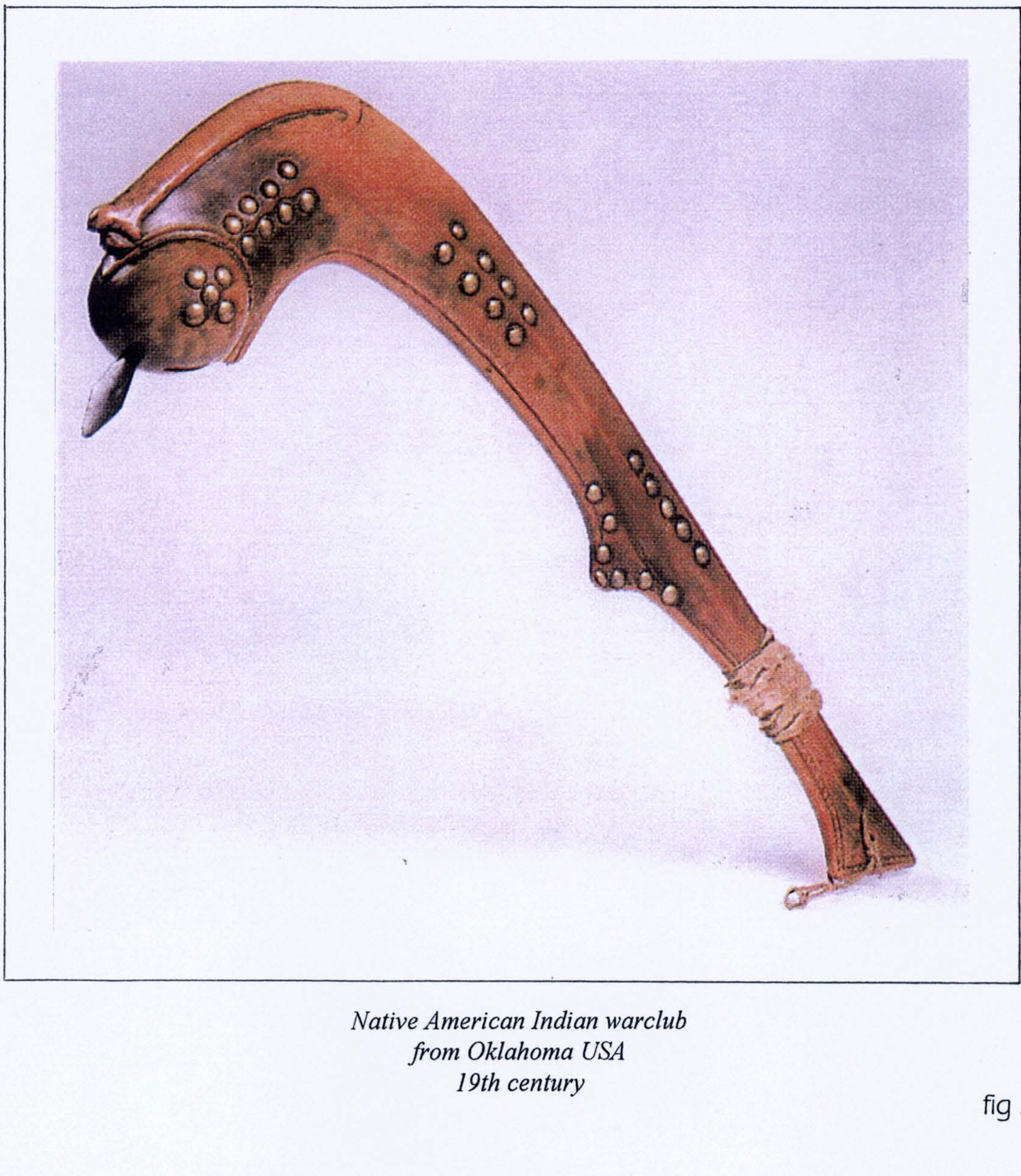
> *For most of the time since the ancestors of modern humans diverged from the ancestors of the living great apes ...... all humans on earth fed themselves exclusively by hunting wild animals and gathering wild plants .... It was only within the last 11,000 years that some peoples turned to what is termed food production; that is domesticating .... plants and eating the resulting .... crops*
>
> J Diamond, *Guns, Germs & Steel*,
> Random House, London, 1998, p86

> *Since Mesolithic times, human progress has depended upon grubbing up and demolishing the trees with which much of the land had originally been covered.*
>
> K Thomas, *Man and the Natural World*,
> Penguin Books, Harmondsworth, 1984, p192

Agriculture depends to a considerable extent on breaking into the soil, and as man was surrounded from the beginning by the remnants of the trees he had been forced to uproot to clear this, it is not surprising that he should have taken advantage of the various wooden shapes which presented themselves. Forks and angles occur at a variety of sizes, and these have found many agricultural uses throughout the world.

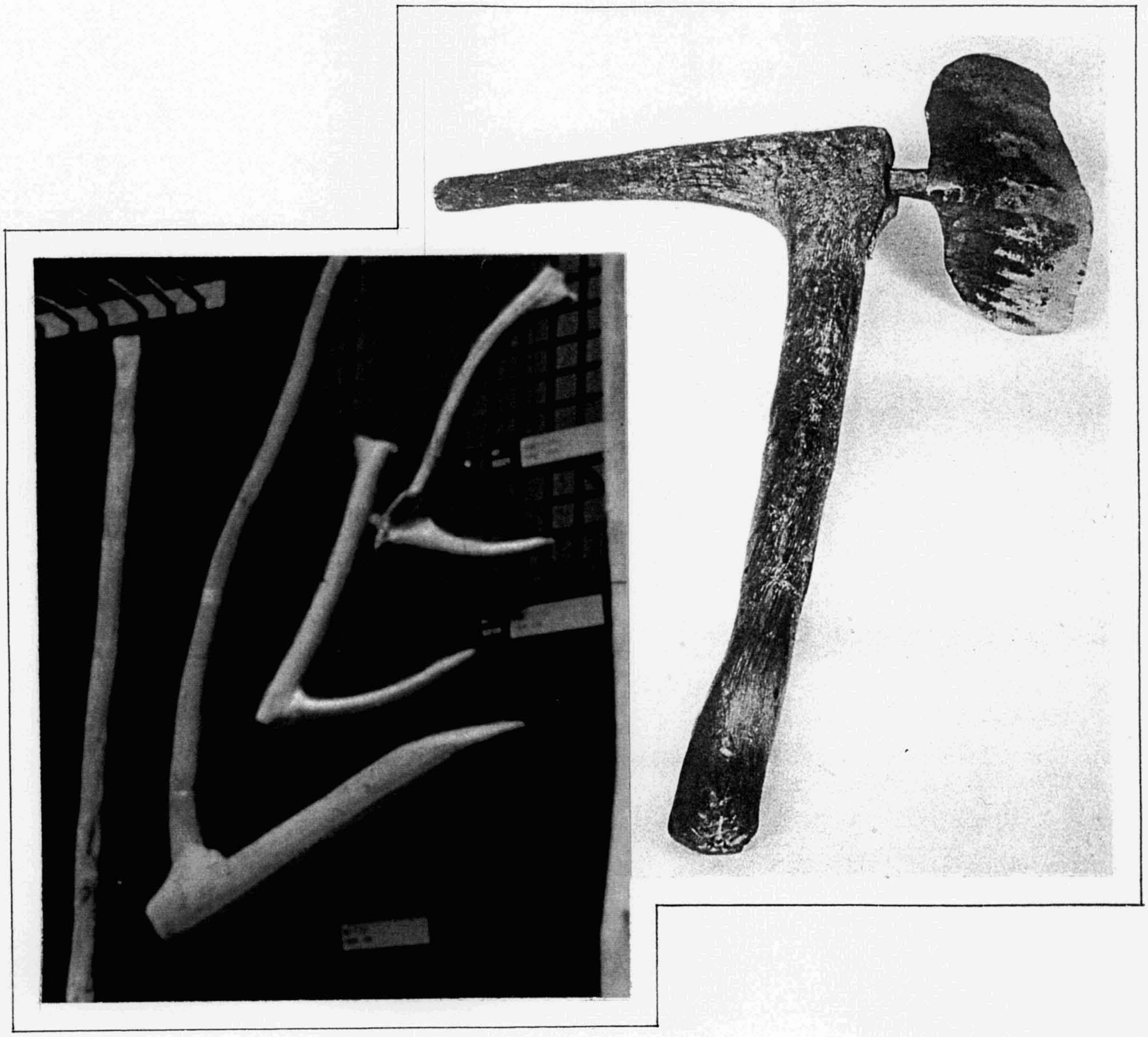
Examples of picks, the basic agricultural implement, are found in museums around the world. The National Museum of Ethnography in Osaka in Japan has a fine collection, examples of which are illustrated in fig 2f/1. Some of the most primitive of their type, these implements consist entirely of wood.

from ' Still William ' by Richmal Crompton
drawn by Thomas Henry 1925



Native American Indian warclub
from Oklahoma USA
19th century

fig 2e/9



Below left
Three wooden agricultural picks made from naturally occurring forms. From Thailand, they are exhibited in the Japanese National Museum of Ethnography

Above right
A metal bladed hoe or scraper from Angola, with naturally grown ' elbow ' shaft. It seems probable that the blade is intended to be aligned horizontally rather than vertically

fig 2f/1

Whenever possible however, a more durable material is preferred for the sharp point or cutting edge, metal or stone being obvious possibilities. The Angolan example shown in fig 2f/1, while still relatively primitive - does have a metal blade. The naturally occurring wooden angle has, however, been retained as an ingenious method of overcoming the problems of attachment to the shaft, of the angle of attack, and of two handed control.

Used for breaking into and turning the soil, the plough (used whenever sufficient power is available) has also frequently been constructed using either naturally occurring or human induced timber shapes.

In it's least sophisticated form - the breast plough (two mediaeval European examples are shown in fig 2f/2) - the blade is attached to the base of a single straight shaft, while at the top the ' breast plate ' is supported on the arms of a natural fork. (Examples of these primitive devices - dating from as late as the early nineteenth century - are to be found in the Museum of Welsh Life)

This form of plough can only really remove the top surface of the soil, whereas when draught animals are available, a different form has evolved, figs 2f/2 also showing a European wooden framed plough. Those shown in 2f/3 originate from Asia. (The practice of using natural knees and forks of timber in agricultural implements in rural Scotland and Ireland is confirmed in Kinmonth.) [25] It is unclear how many of the shapes used are of natural origin, although it seems probable that - since the forms required would have been well known to the farmers, and the timber to be used would have been growing close by - some human intervention may well have been involved. (It should be noted that the use of wood in the construction of these implements appears to have continued long after the development of suitable metal alternatives, suggesting that the advantages - perhaps cost - of this material were still recognised up until less than a century ago.)

Note that fig 2f/3 also shows an angled wooden yoke, presumably used in conjunction with these ploughs, whose form strongly suggests human intervention.

There is no doubt of man's intervention in the case of at least two of the wooden pitchforks shown in figs 2f/4 & 5. With their long handle from which the tines spring at one

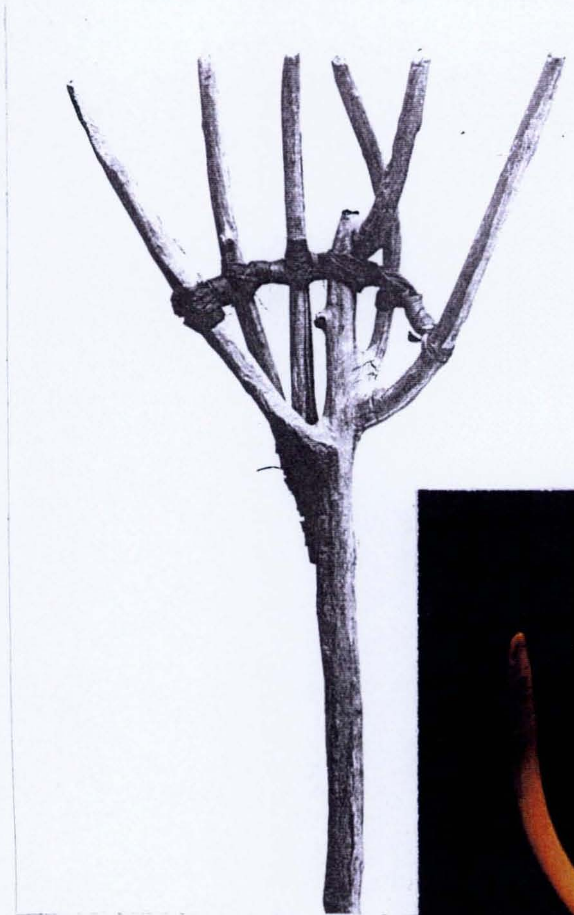
above
European wooden breast ploughs
Medieval

below
French wooden framed horse or ox drawn plough
from the Bouch du Rhone region
19th century

fig 2f/2

This right angled wooden yoke for oxen must surely have been grown to shape, as may the elegantly formed wooden ploughs in the foreground. Originating from Indonesia, these implements are in the collection of The Japanese National Museum of Ethnography, Osaka

fig 2f/3



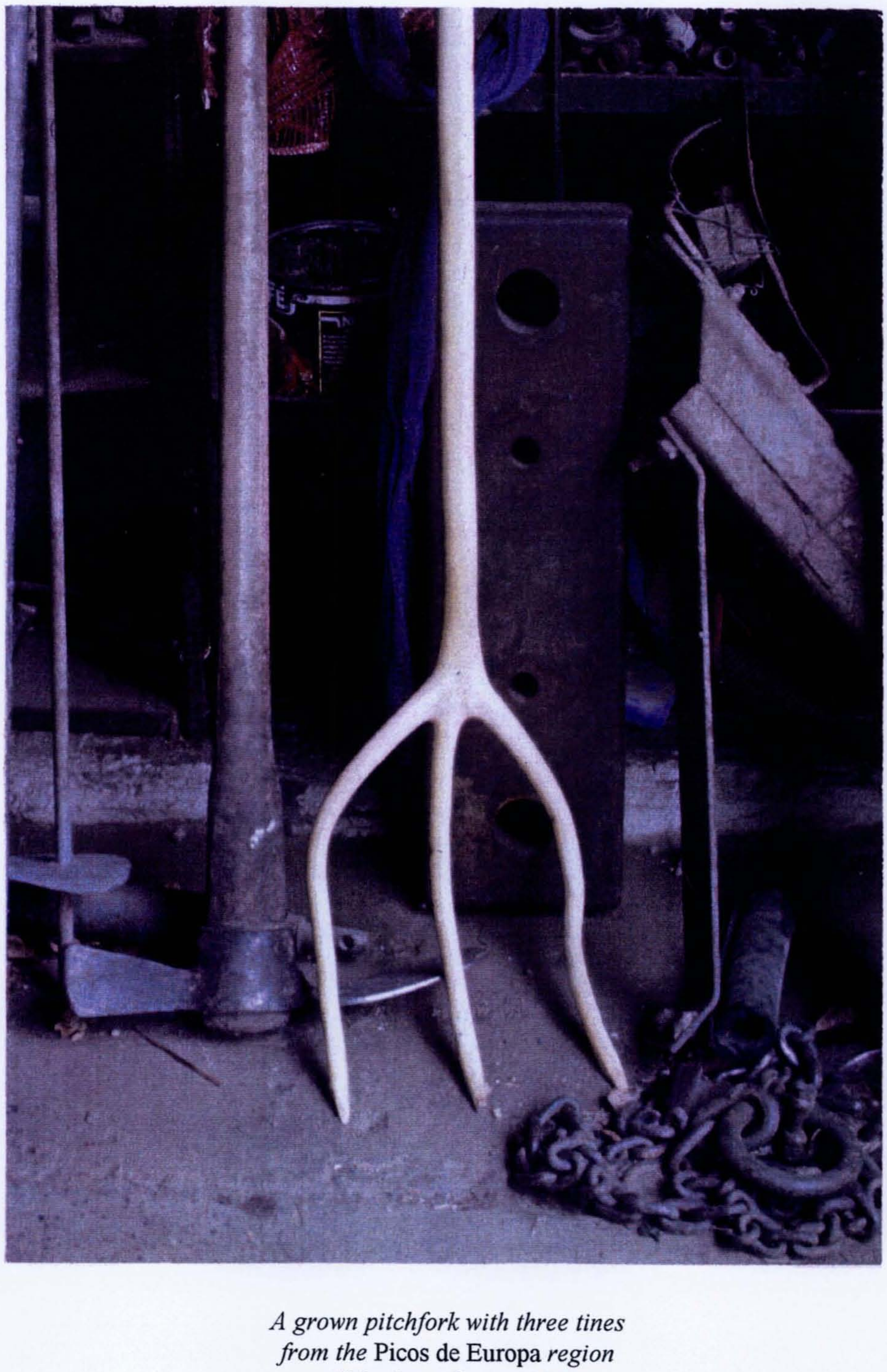
Grown pitchforks

above (from Tanazania)

Here two naturally grown elements have been skilfully bound together to form the six tined head. The shaft is a little over 1200mm overall in length

below

An elegant four tined example on show in the Japanese National Museum of Ethnography in Osaka



A grown pitchfork with three tines
from the Picos de Europa *region*
of Northern Spain, 1997

fig 2f/5

end, these must be one of the most obvious forms of implement which can be improvised from largely natural growth. While in the case of the Tanzanian fork (2f/4) the original growth has been supplemented by the binding on of two further tines, the other examples are clearly the result of a concerted effort at production. Indeed, Seymour describes how in France ;-

> Little trees are pruned to leave three or four branches, cut when they are ready and taken to a factory near St Hyppolyte du Garde. Here the handles are straightened if necessary by steaming and then sold to the local farmers. [26]

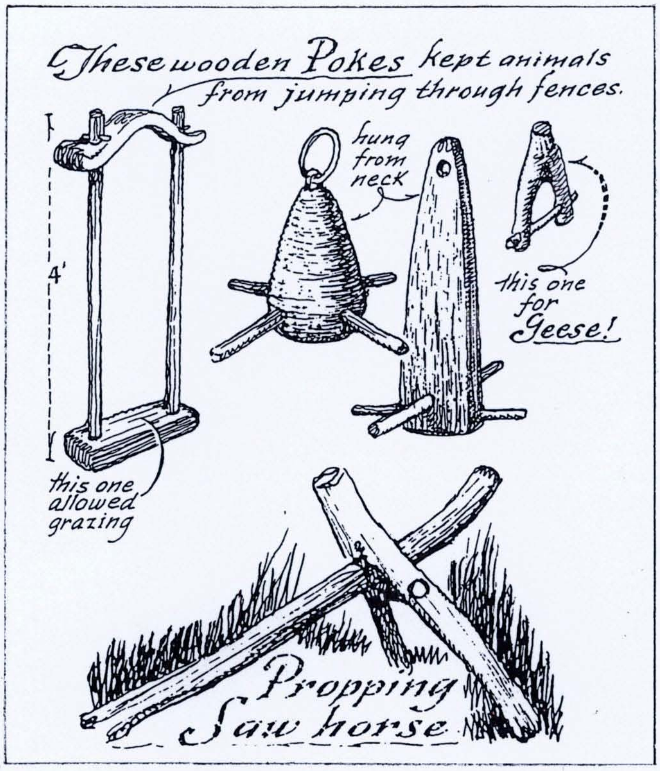
In fact the practice is clearly still in operation in Northern Spain, since fig 2f/5 shows one of the two new examples brought back from there by the author in 1997. Here the local Sweet Chestnut (*Castanea sativa*) is normally used, the growth of side shoots in opposite pairs making it eminently suitable.

In Britain, examples of grown pitchforks exist in England (in the outbuildings at the National Trust property of Erddig in Clwyd) and in Wales (in the Museum of Welsh Life at Saint Fagans, Cardiff)

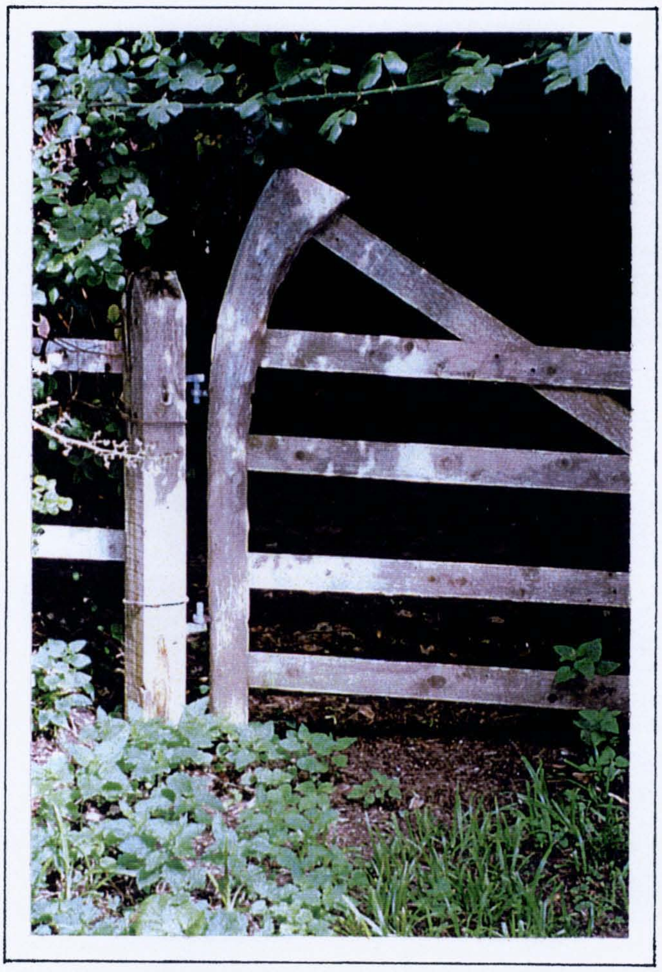
There is also evidence of the use of these forks in the USA, an example appearing in the 1991 film of Patricia MacLachlan's book *Sarah Plain and Tall*. Set on an impoverished farm in the mid - west in the 1920s, it would appear that such implements were commonplace.

This form of pitchfork, besides being low in cost, has some distinct advantages over those with metal heads, particularly when used in the presence of animals or other humans, when the blunter wooden tines are less likely to inflict accidental wounds.

All the problems of agricultural equipment faced by the early European settlers in North America must have been familiar to them, so perhaps they took the solutions with them. They were, at any rate, apparently adept at making use of the natural forks - at every scale - which surrounded them. Fig 2f/6 shows a small wooden ' poke ' devised for a goose and, at a much larger scale, a saw ' horse ' or ' tackle '. These could be used singly or in pairs, and were simple to dismantle and store when not required.



Two examples of the varied uses found for naturally occurring wooden forks
North America
18th century



A modern example of a traditional use for natural growth. Trees growing out from a hillside curve naturally to become vertical. Inverted, the trunk provides gatemakers with this useful shape.
Isle of Wight
21st century

fig 2f/6

Also shown in fig 2f/6, a modern example of a traditional use of the curved trunk developed by a tree growing on sloping ground. Although growing initially at right angles to the surface, the stem quickly changes direction to become vertical, producing the curved timber used here inverted to support the gate's diagonal brace.

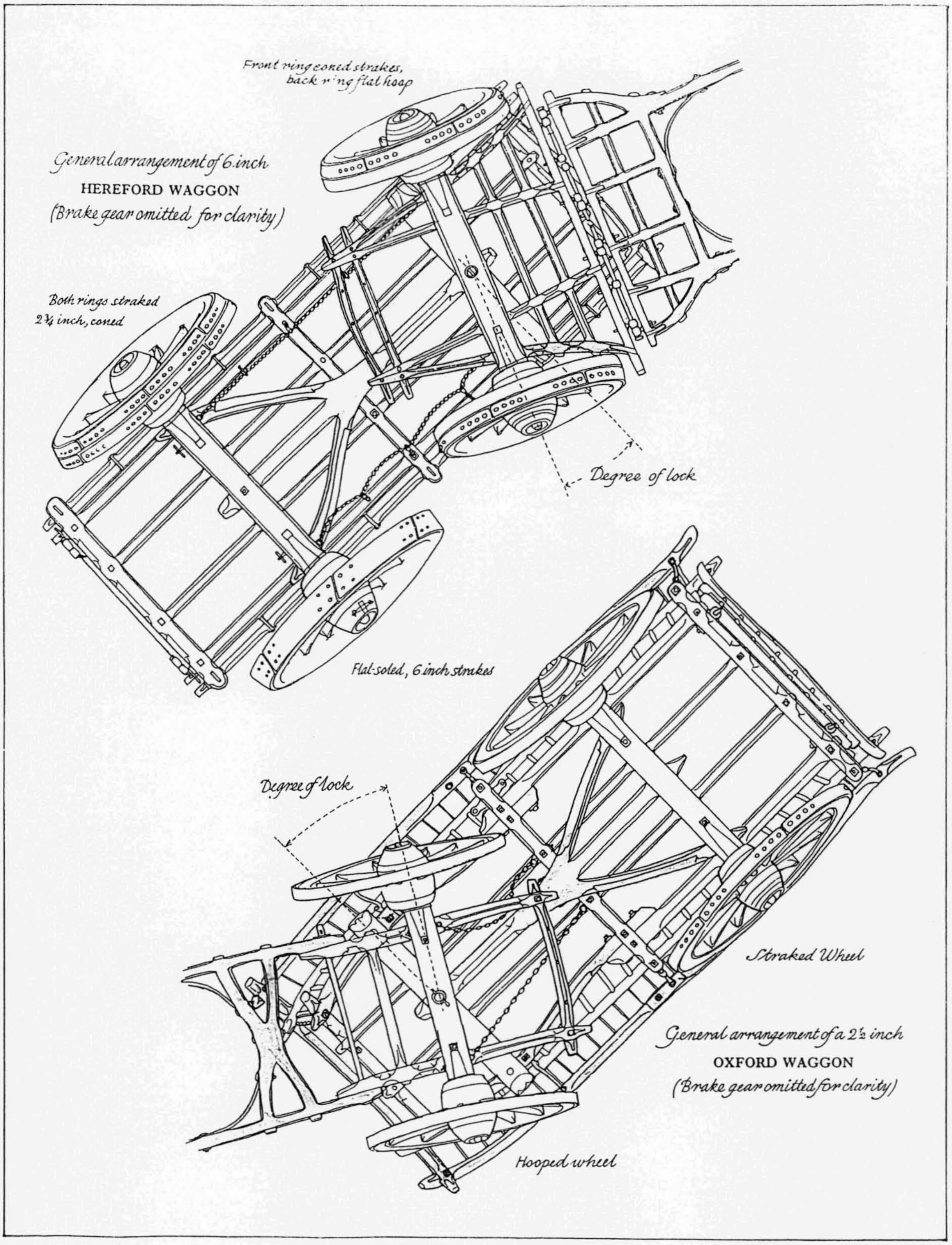
In contrast to these simple items, the horse drawn farm waggon - the commonly used form of agricultural transport up until the early years of the 20th century - evolved in Britain as in other countries into a highly sophisticated piece of wooden engineering. Of elaborate construction, these vehicles also relied for many of their components on the use of timbers the grain of which followed the form of the finished piece. Strength, reliability and durability were of the utmost importance, combined with the lightest possible weight, and the wheelwrights who built them were expert in the selection and conversion of suitable timber.

> Wheelwrights were not at all afraid of plenty of curves in their waggons and were most careful in the selection of suitable timber. This was particularly important in regard to the shafts for which the grain must 'follow through'. Timber would be noted in the forest, selected and put by for some part of the waggon. Equally was it important for the curved side frames of the body. [27]

In detail, the design of the waggons from the different English and Welsh counties varied to suit the local conditions, and in describing the construction of the waggons of East Herefordshire, Arnold writes ;-

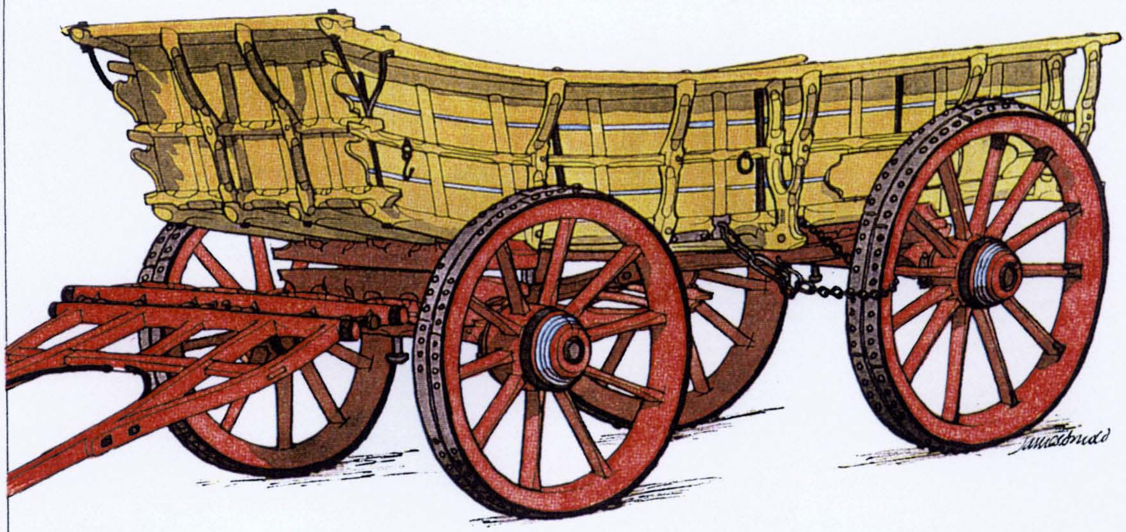
> It was in the fore - carriage that the wheelwrights really let themselves go... The curves in all these members were complicated enough that only a diligent search in the ash - woods could have produced poles with the suitable natural curves ... [28]

The pictures in figs 2f/7 & 8 show the construction of typical British farm waggons, the views from beneath in particular giving an indication of various of the members which would have required cutting from suitably curved timber. The undersides of the lightest (Oxfordshire) and the most robust (Herefordshire) types are illustrated from among the twenty four very different examples shown in Arnold (1969).

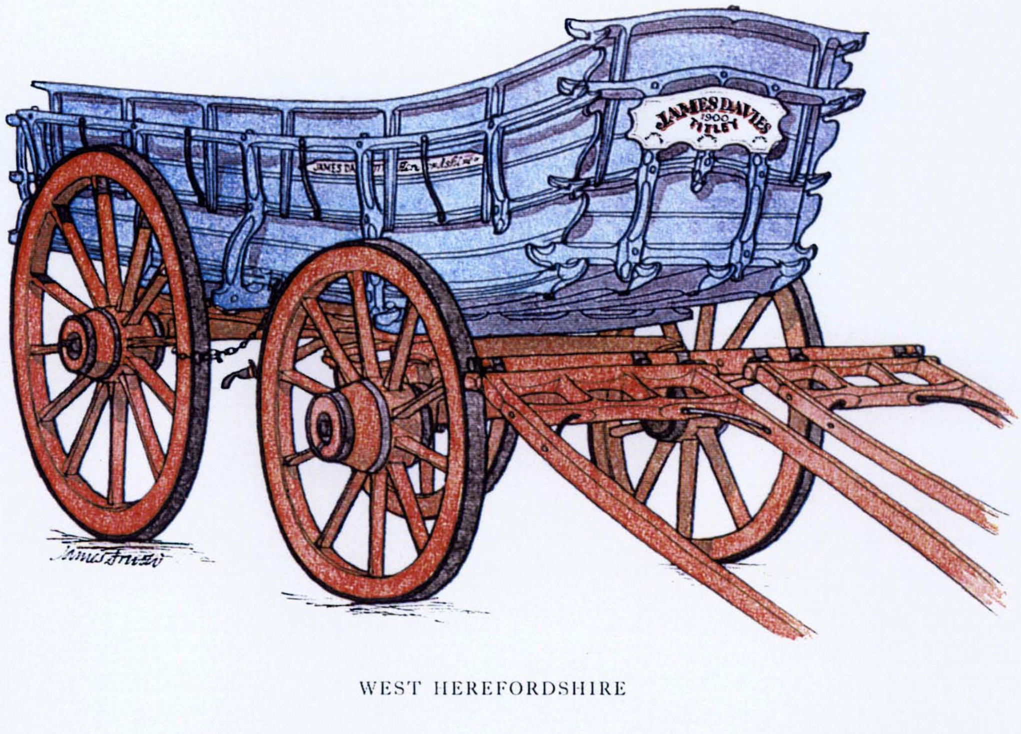


Worm's eye view of two typical 19th century British farm waggons, indicating the positions of naturally curved timbers. ' Wheelwrights were not at all afraid of plenty of curves in their waggons, and were most careful in the selection of suitable timber. '

fig 2f/7



WEST SHROPSHIRE



WEST HEREFORDSHIRE

These views of two 19th century British farm waggons illustrate both the elegant curvature typical of their bodies and the varied elbow and wishbone shapes of the wooden ' standards' used to support the body sides.

fig 2f/8

In addition to their use in the undercarriage, particular grown shapes were required from which to cut the various parts of the body. In particular these were required for the stays which supported the sides from sagging outwards when fully loaded. These normally took the form either of ' elbows ' or of ' wishbones '. Both types are shown in fig 2f/8, the waggons originating in this case from West Shropshire and West Herefordshire.

In his classic book on the subject *The Wheelwright's Shop*, George Sturt eloquently describes the skill with which the carefully selected logs were converted ;-

> Trees were rarely crooked in more ways than one; and the object was so to open them that this one curve, this one crookedness, was preserved. To save it for long foreseen uses was probably the wheelwright's object : he had arranged the cross-cutting of the tree to take advantage of this curve. Thus, if a butt of ash had the shape of a waggon shaft, it was marked off the right length for that and then split from end to end so that there were two curved pieces, one on either side of the saw, suitable for shafts. [29]

Similar to these waggons only in the fact that it was horse drawn, the simple agricultural heavy roller shown in fig 2f/9 also makes use of a naturally angled tree trunk which has been split in two to form the sides of the frame.

2g FURNITURE

(This section is divided geographically)

i) AFRICA

> *African seats may prove to be the source of new ideas that will help us revise and re-orientate the design of our own household objects in response to global economic and ecological problems.*
>
> S Bocola, *African Seats*
> Prestel Verlag, Munich, 1995, p6

In an area where trees grow profusely and quickly, it is unsurprising that man has taken advantage of the natural shapes that trees provide in fashioning not only his free standing furniture, but also the static items required for his regular meetings. *The International Book of Wood* describes how ;-

' The use of natural knees and natural forks of timber both in Scotland and Ireland, was common in rural areas in housebuilding, domestic implements and ***agricultural implements*** *such as ploughs '*

Kinmonth

> Many West African societies, for example, plant large - leafed trees (usually of the ficus family) to provide shade for their elders' meetings. The trunks and protruding roots are gradually trimmed and worn down to provide comfortable seats and back rests, and the living tree becomes the villages' main item of furniture. [30]

Alternatively natural growth may be used as a starting point, to be added to as required, as below;-

> The natural characteristic of trees to throw out branches at an angle to the main stem is utilised in many ways. Among the Acholi and other Sudanese groups, forked branches form the uprights for sleeping hut platforms; a simple bed is made by fastening cross - pieces in the forks. [31]
>
> (see also under Australia, page 44)

In the Equatorial regions - typically in Zaire - a variety of couches, stools and back - and neck-rests have traditionally been devised without the need for joints, by the use of particular portions of tree trunk or root. A relatively cumbersome and crude example is shown at the top in fig 2g/1, the major area of contact having been carved flat for some slight increase in comfort. Further, marginally more elegant examples from the Sudan, are on display in The American Museum of Natural History in New York. Two, more sophisticated - and adaptable - examples are shown in fig 2g/2, the majority of the substantial trunk here having been carved away leaving branch stumps to form the legs.

As indicated, the upper stool may be tipped forward to form a back-rest.

The back rest-formed from a naturally grown configuration of branches or roots and generally used in conjunction with a carved stool or a low hammock like bed - appears in a variety of forms in Zaire. This item of furniture, providing support with minimal contact area, ranges from the relatively simple pieces shown in use in fig 2g/1, to the elegantly decorated and sophisticated example belonging to a tribal chief, in figs 2g/3. The rich decoration, transforming a relatively simple item into an object with considerable presence, has been achieved by the use of copper wire, iron nails, or a combination of these.

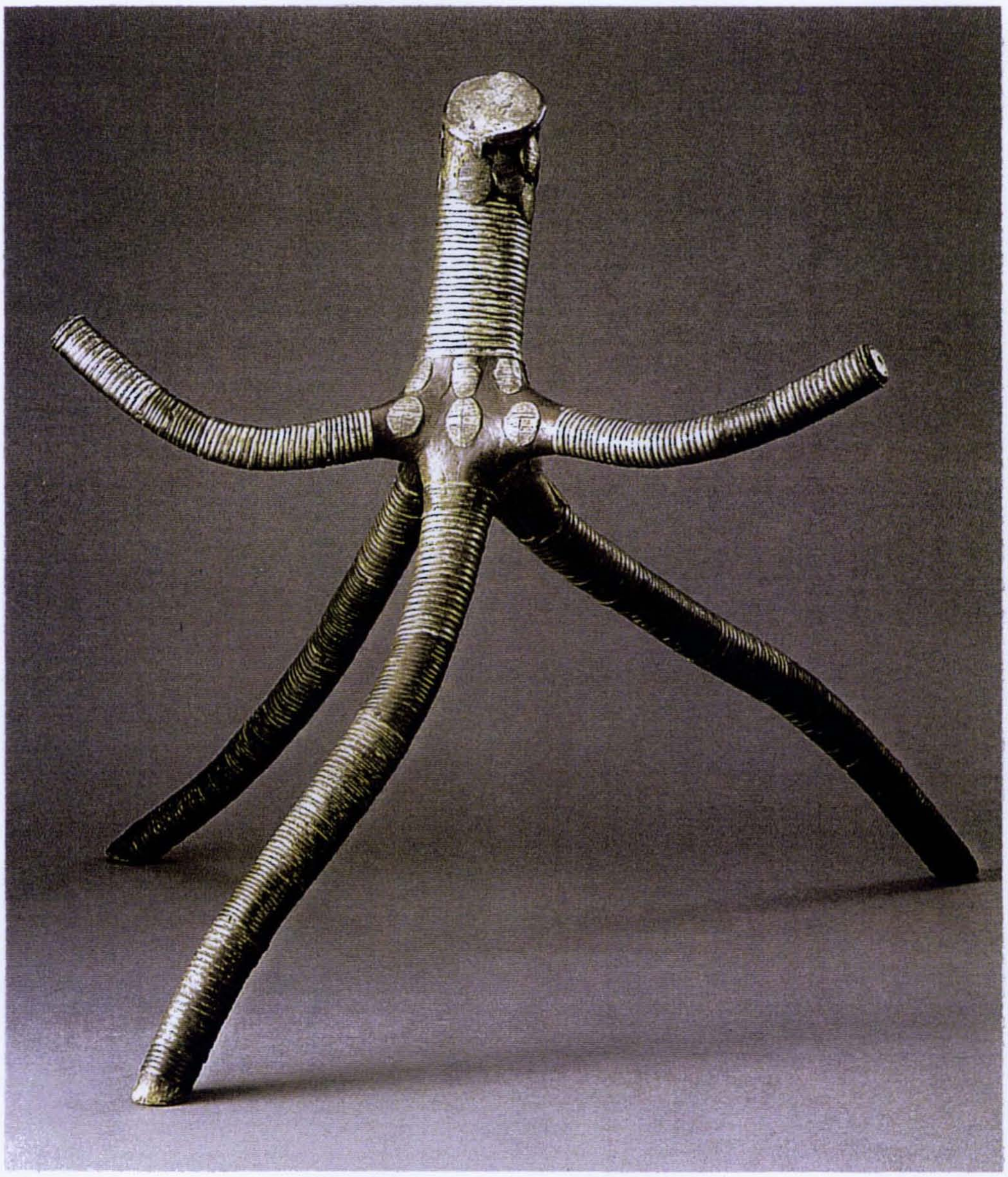
Generally the tribe's most prized possession, these items may have political, psychological and religious connotations ;-

above
'A pygmy of the Efe in Zaire, smoking as he lounges on a semi-reclining chair made from a tree root.'

below
a three legged seat (centre) and a backrest (left) devised from naturally occuring tree roots. Zaire, 1905

fig 2g/1

Two partially carved African stools, both from natural growth. Above, from Tanzania, may be tipped forward to form a backrest. Below, from Kenya, may be used as a stool or a headrest



A naturally grown, highly decorated backrest from the Wele district of Mangbetu in Zaire. Copper wire and iron nails have been used to embellish the form

fig 2g/3

> Among the Asante in Ghana, for example, a stool was not simply an object to be used by anyone at any time. It was the absolutely personal possession of its owner and regarded as the seat of his soul. For this reason the owner, when not using his stool, would always lay it on its side, so that no one - neither man nor spirit - might use it and thus pollute it. [32]

ii) THE SOUTH PACIFIC ISLANDS

On the Islands of the South Pacific such as Papua New Guinea, naturally forked branches have - as in Africa - been used as minimal seats. In the case illustrated in fig 2g/4 however, the decoration has been achieved by carving and painting.

iii) DYNASTIC EGYPT

In general, our knowledge of the wooden furniture used in Egypt during this period depends either on items found in the various tombs (mostly of the Pharaohs or other high ranking members of society) discovered relatively recently, or on the wall paintings which remain. Although a great deal of this furniture was broadly rectilinear in form, that found in the tomb of Tutankhamen (1334 - 1325 BC) in particular ' differs from earlier work in its predilection for the curve ' and many pieces have ' frames and stretchers deeply curved by some process of bending the wood, or by cutting it on a curve, or by the use of specially grown timber. ' [33] Furniture used by the less privileged has survived only rarely, and is in any case thought to have been limited in variation and quantity.

One of the most common of these items appears to have been the archetypal three legged stool, illustrated as being widely used by seated craftsmen, and an example of which (dating from the 18th dynasty of 1567 - 1320 BC) is to be found in The British Museum in London (see fig 2g/5). This example consists of a dished circular seat, about 75mm thick at the point where the legs are driven through, and three outwardly curving slightly spatulate legs. The grain of these legs follows their curvature, and it is these components which are of interest here. (This leg shape is of considerable importance, combining as it does the spreading of the base triangle to reduce tipping, reduced interference with the users legs, reduced tendency to dig into the prevailing soft floors, and perhaps a degree of flexibility for greater comfort.)

A carved and decorated three legged stool of natural growth, collected in 1900 from Goarieari in the Gulf of Papua New Guinea

fig 2g/4

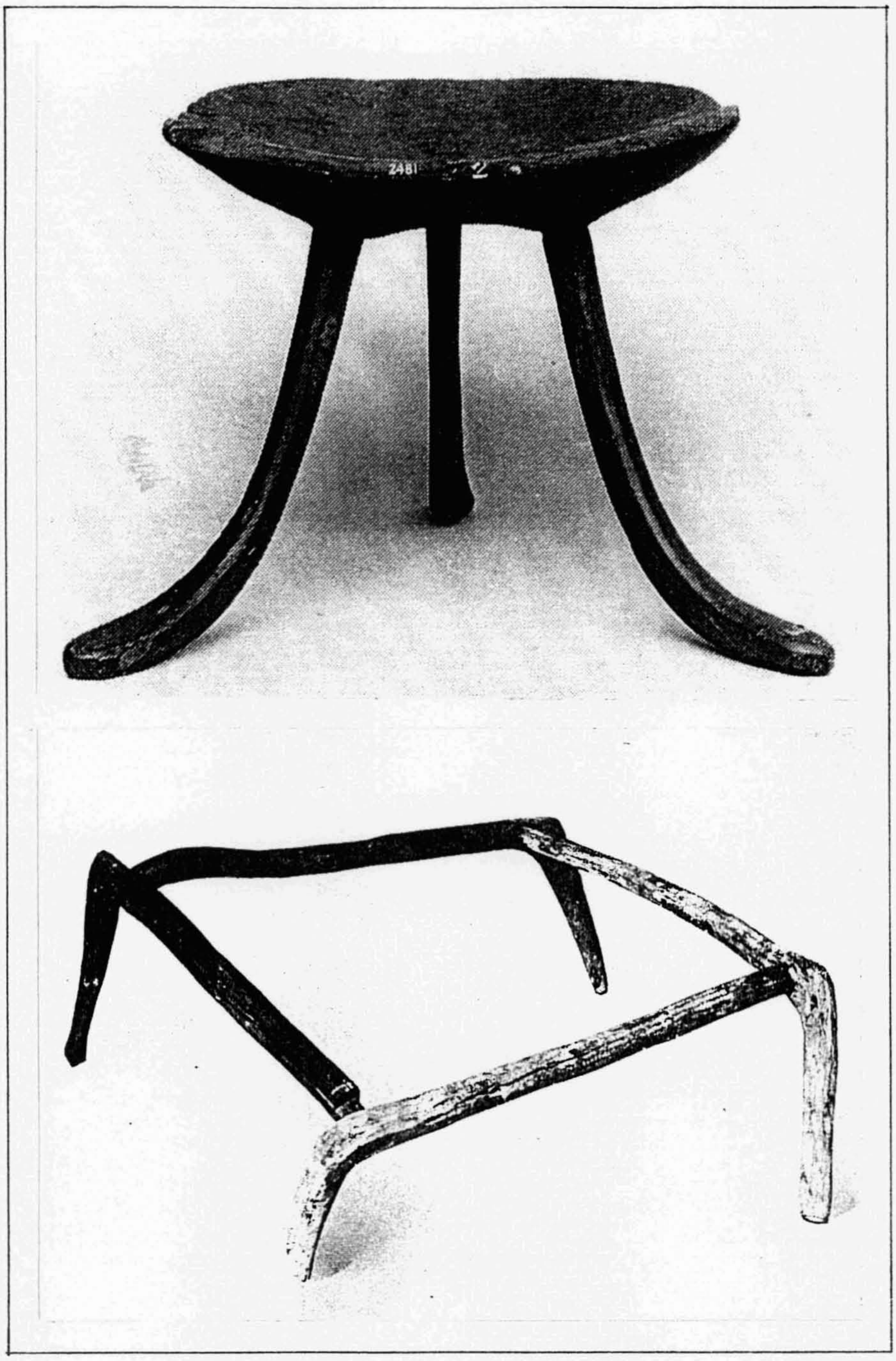
Although it is thought that the technique of steam bending was known at this time, being used in the production of archers bows, Ostergard considers it unlikely that such a sophisticated and expensive technique would have been used for such humble and crudely jointed items as these, saying that the ' ...correspondence of the grain of the wood with the form of the leg could have been achieved through the selection of timber grown into this curvature. ' [34] Expert opinion is divided on the method of production of the timber for these legs, but since it is agreed that the stool was a widely used item, and since timber for the legs would therefore have been required in some quantity, it seems not unreasonable to suggest that this may well have been preformed during growth, perhaps by the simple expedient of hanging weights onto growing branches.

Another comparatively commonly used item of furniture at this time was the four legged bed, and while the elaborate versions used be the wealthy were constructed in what to us are relatively conventional ways, at least one example of the use of natural wooden angles for these structures has survived. Known as the ' Berlin ' bed, (fig 2g/5) it makes ingenious use of four components and requires only four joints. On a smaller scale Baker, discussing the wooden angle braces widely used to strengthen the joints between legs and rails on many contemporary pieces, says ' ... since quite a good many of such pieces were used, it is possible that the naturally curved pieces available were supplemented by pieces of wood grown into shape. ' [35]

iv) ANCIENT GREECE & THE EASTERN MEDITERRANEAN

As with Egyptian furniture, our knowledge of the forms of furniture used in ancient Greece relies on written descriptions (see preface), graphical representations such as the paintings found on ceramics, or on stone carvings. Sadly, no actual examples of this furniture are known to exist.

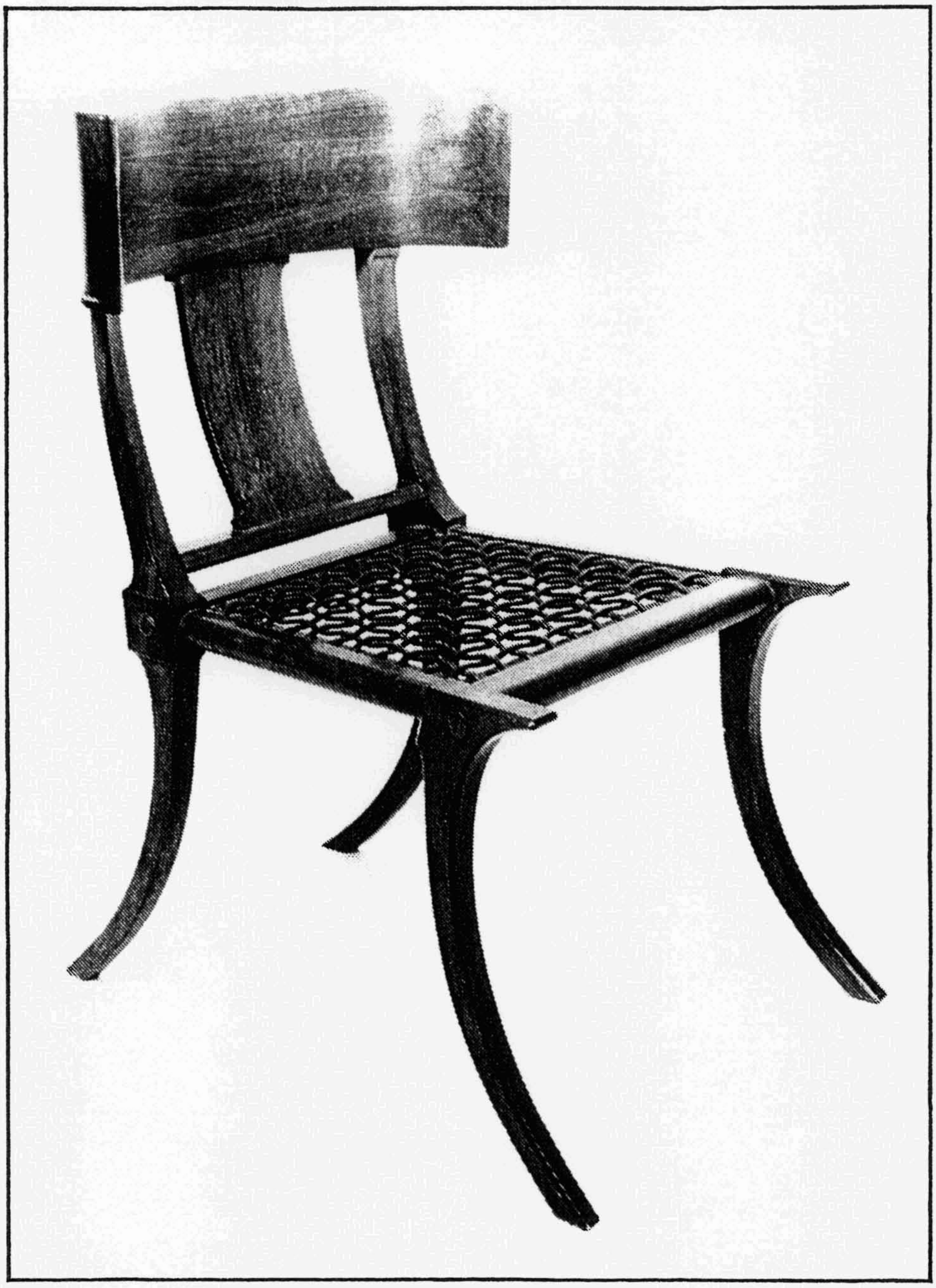
The well known ' Klismos ' chair (fig 2g/6) described by Liversidge in Hayward's *World Furniture* as ' the favourite type of chair in the home ', [36] emerged in the 5th century BC. It was comfortable, light, and easily portable, and such was the elegant curvature of the front legs that the grain of the timber must certainly have followed this form. Again opinions are divided as to how this shape may have been achieved, Ostergard speculating that 'curved legs could .... be achieved by employing wood that had either



above
Three legged Egyptian stool of the 18th dynasty,
on show in The British Museum in London

below
The dynastic Egyptian ' Berlin' bed
which, by the use of four naturally occuring angles
requires only four morticed joints

fig 2g/5



A 1970 reproduction of the Klismos chair
by Terrance Robsjohn - Gibbings

fig 2g/6

grown naturally into an approximation of the necessary curvature or were artificially trained to do so.'[37] Steam bending has been put forward as a possibility, although doubt has been expressed as to the reliability of steam bent legs over a period of time, since it is known that unless held securely in place, such components may tend to move. From the apparently accurate 1970 reconstruction of the form (based on a well known carved gravestone of Hegeso of 400 BC) it can be clearly seen that the projecting ' beak ' at the top of the front leg would have been extremely vulnerable, had not the grain followed through at this point. It can therefore be reasonably argued that, components for a popular form of chair being required to be reliably available in some quantity, there is some likelihood that a system of supply involving trained natural growth may well have been set up.

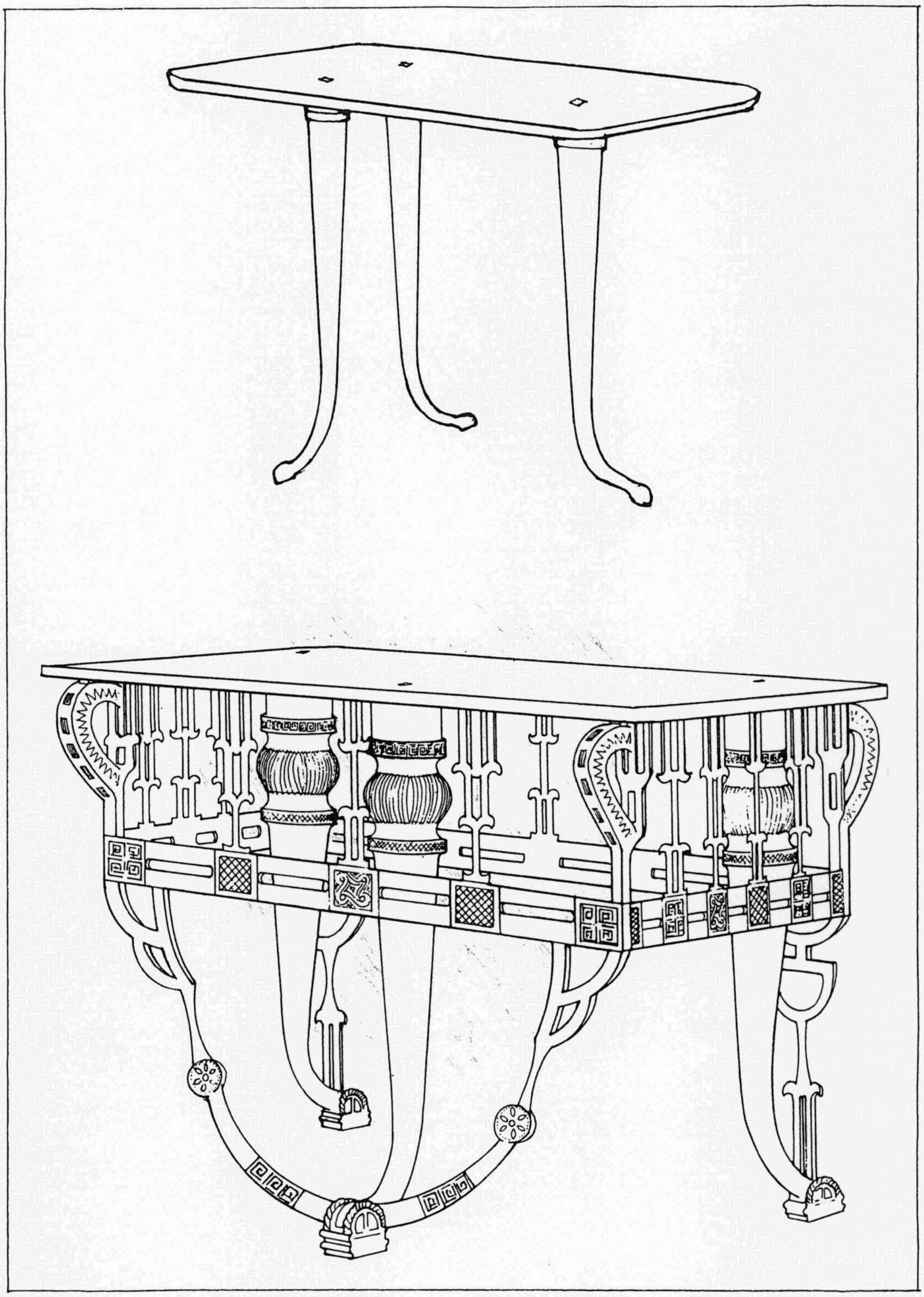
There is historic evidence that the adoption of three legged furniture as a solution to the problem of uneven floors was not confined to Egypt but was, in fact widespread. Nor, it seems, was the problem confined to the less affluent areas of society. Discoveries in 1956 and 1957 at Gordion the capital of ancient Phrygia (now Turkey) revealed the contents of several important tombs. The largest of these, believed at one stage to be that of King Midas of the 'Golden Touch' contained - among other things - the remains of several fine three legged tables. Fig 2g/7 shows reconstructions of both the more simple and the very elaborate ' Pagoda ' tables, and as can be seen in both cases, the bottom ends of the legs curve dramatically outwards, presumably as an aid to stability.

> The grain of the wood follows the curve of the legs, suggesting that they were bent before shaping, although it is possible that naturally curved pieces of timber had been made use of.[38]

As in the case of the Klismos chairs, it seems questionable whether steam bent legs would have proved sufficiently reliable, particularly for use in such prestigious items for use in what appears to have been a Royal Palace. Again naturally or artificially grown curved timber would seem to provide a more likely solution.

v) THE BRITISH ISLES / ENGLAND

The fashion for ' Rustic ' furniture and decor which swept through the affluent sections of British society in the mid 18th century had, not too surprisingly, relatively little to



Drawings of two examples of the three legged tables found in the 'Royal' tomb at Gordion in what is now Turkey. In all cases the legs curve dramatically outwards towards the foot, the wood grain following the curve. 721 - 705 BC. From Baker (1966)

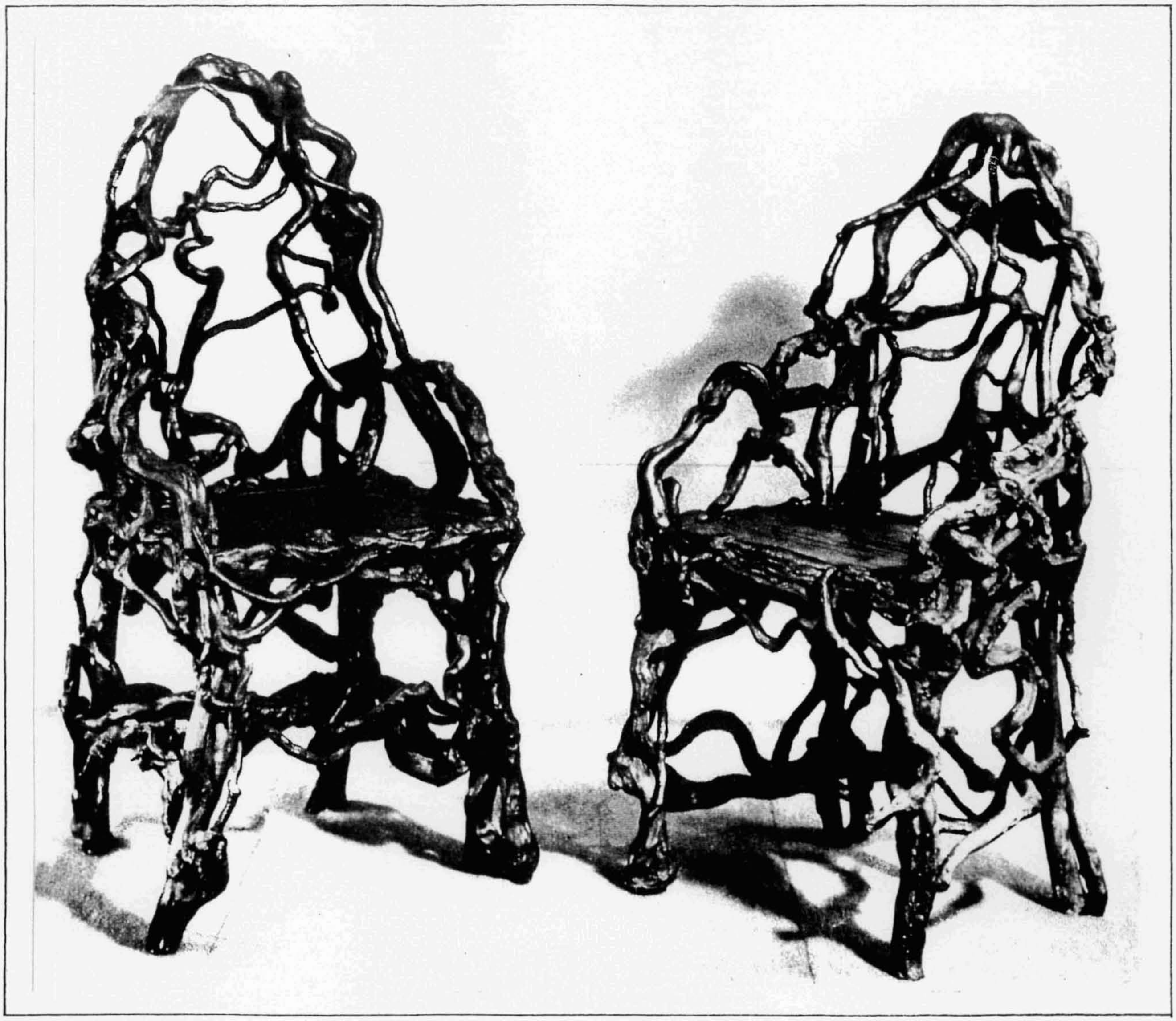
fig 2g/7

do with the actual use of naturally grown forms. It was, in fact largely fired by a growing European taste for the flamboyant combined with a fascination for ' The East '.

The laborious Chinese practice of excavating contorted sections of tree root, which were then elaborately combined in the form of furniture (fig 2g/8), was perhaps introduced to the British public by an enterprising sea captain returning with a cargo of spices. In any event, the concept of ' Rustic ' appearance caught on to such an extent that, over the next two decades, all the foremost British and European designers included interpretations of this style in their Directories - typically Thomas Chippendale in 1759 - 62, Robert Manwaring in 1765 and later Matthew Darley (figs 2g/9 -11). Indeed, so durable was the fashion that Johann Gottfried Grohmann featured examples of the style in his directory of 1805 (fig 2g/12) and at least one elaborately carved Rustic chair was exhibited at the Great Exhibition of 1851. By this time of course, the coming of the Industrial Revolution had made possible the mass production of elaborate ' Rustic ' style pieces in other materials such as cast iron and even ceramic ! (fig 2g/13)

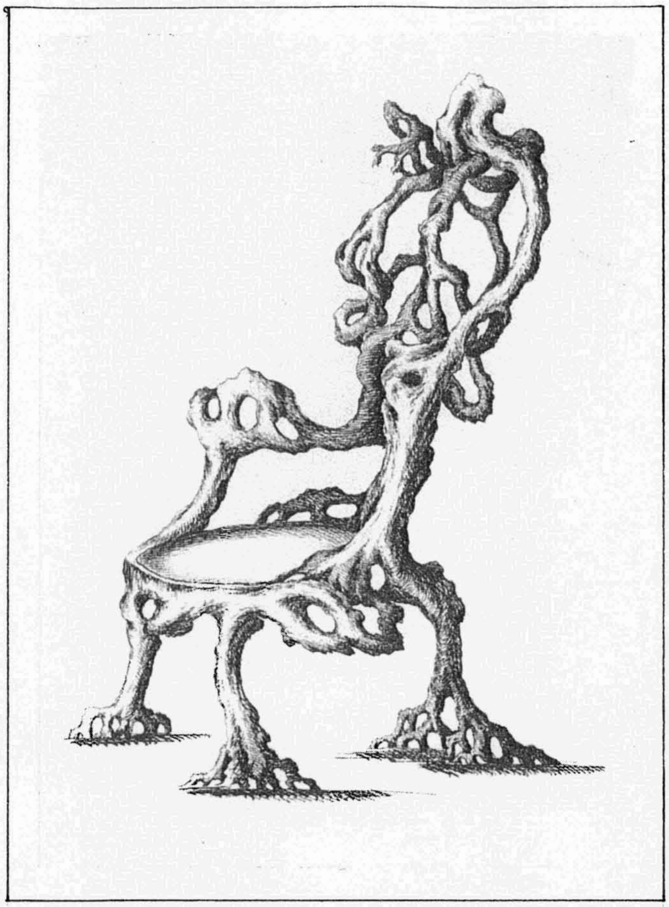
How many of the pieces shown in the directories did, or were intended to, incorporate actual natural components, and how many could only have been achieved by the use of elaborately carved simulations, in many cases remains open to question. (The simulation shown in fig 2g/14 shows the lengths to which it was possible to go.) In some instances however, the intention is clear. In fig 2g/9 the root chair and the table below it are clearly intended to have been totally fabricated from natural growth, whereas the canopied chair and the table in fig 2g/10 combine man made elements with the natural. In the case of Robert Manwaring's chairs illustrated in fig 2g/11, the interpretation was left open to the craftsman, although items such as rocks, grass and flowers can hardly have been other than carved.

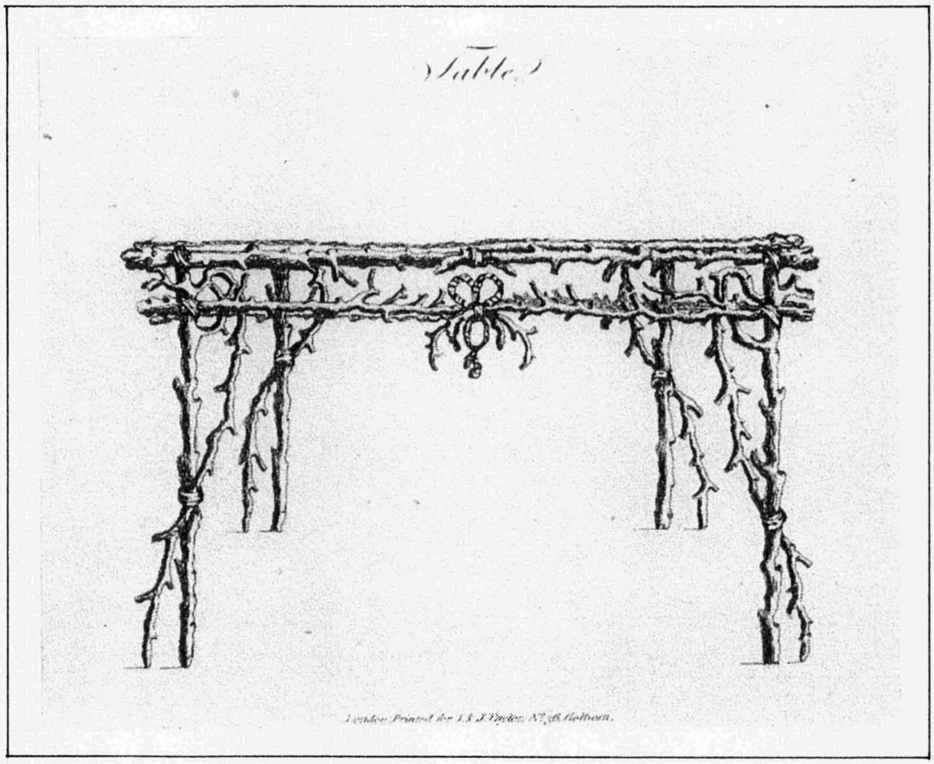
Owing nothing to this world of high fashion, one of the commonest types of English country chair (having a solid wooden seat and turned legs,) has frequently made use of naturally occurring wooden curves in the making of the arm bow. In general these bows are composed of a single growth which has been halved and subsequently jointed at the centre, a degree of symmetry being thus ensured.



Undoubtedly constructed of tree roots, these
18th century chairs serve to demonstrate the possibility
of constructing useable furniture in this way.
Of Chinese origin

fig 2g/8

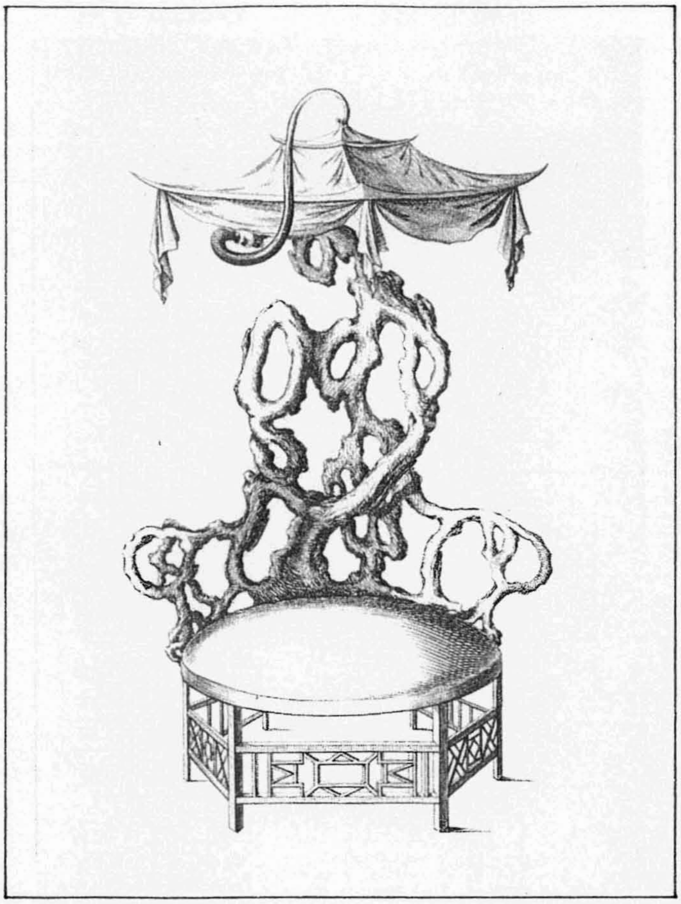


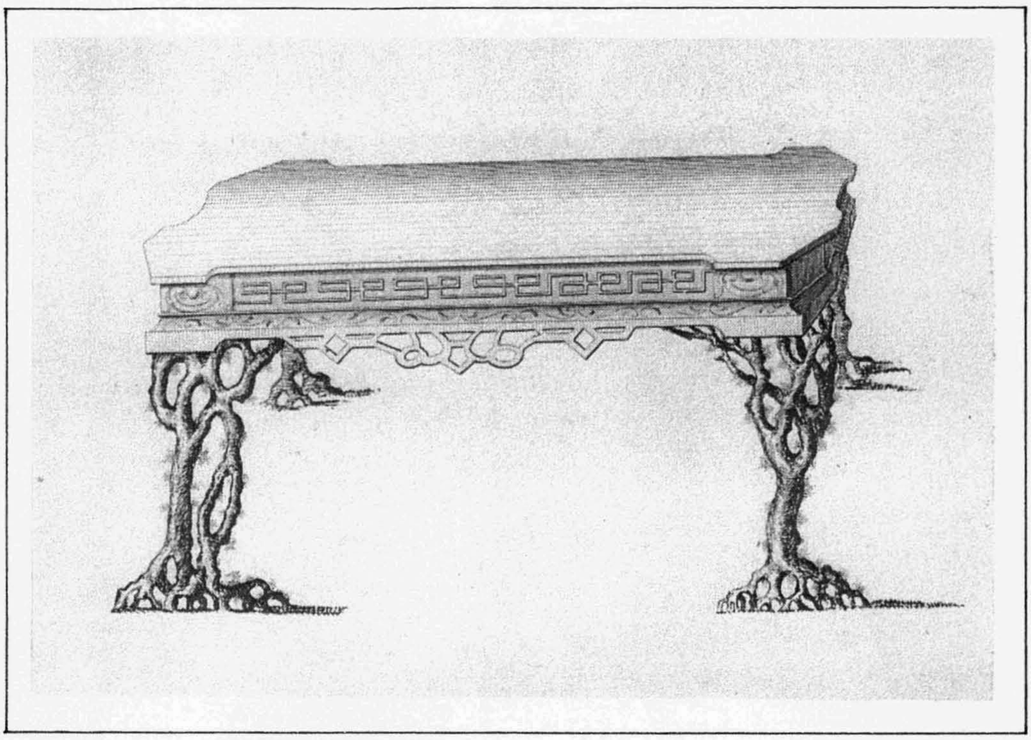


above; a chair of apparently natural growth from Edwards & Darly's 1754 ' A New Book of Chinese Designs '

below; an anonymous 18th century design for a rustic table, to be carefully constructed using naturally grown branches

fig 2g/9

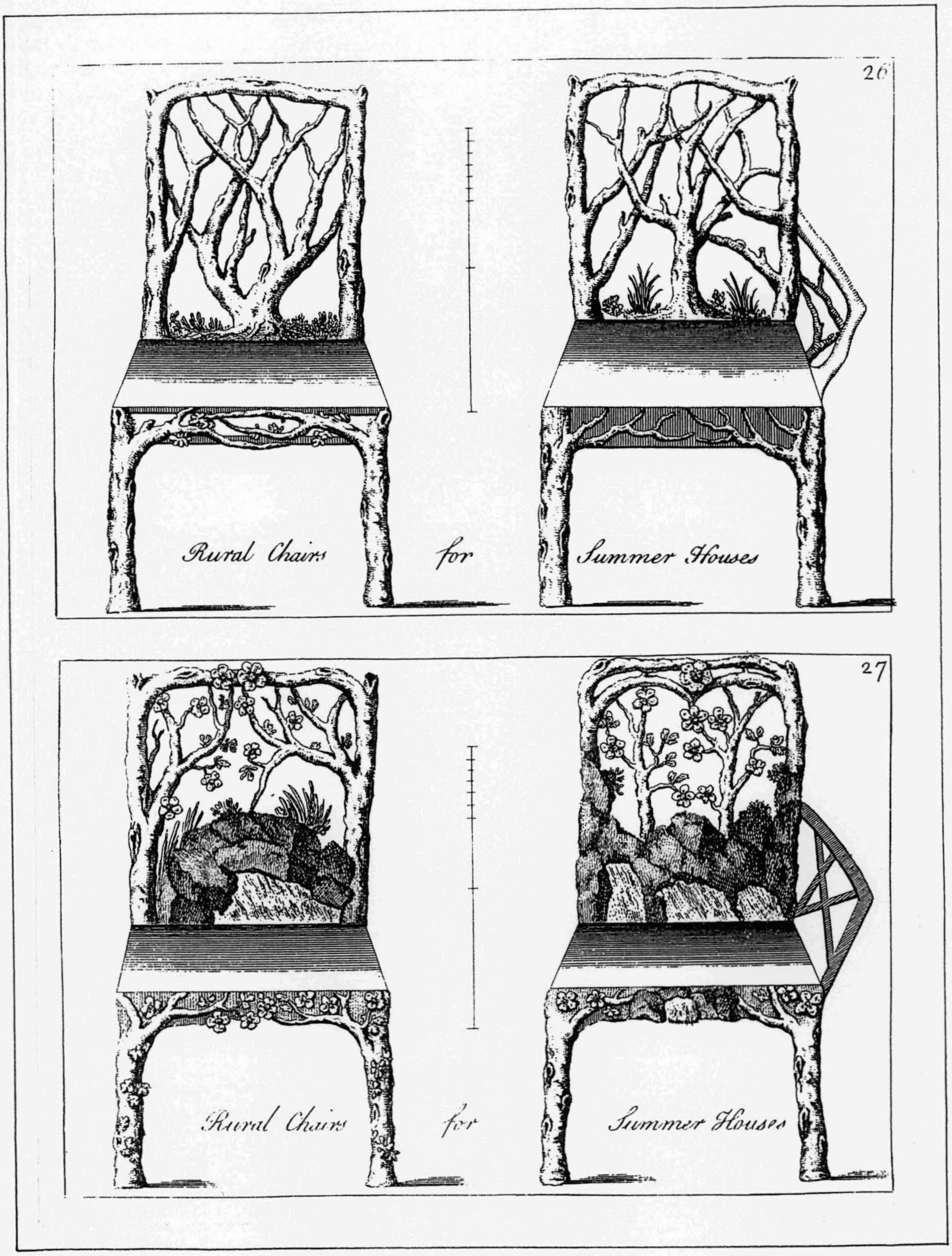




A rustic chair and table from
'A New Book of Chinese Designs'
by Edwards & Darly 1754.

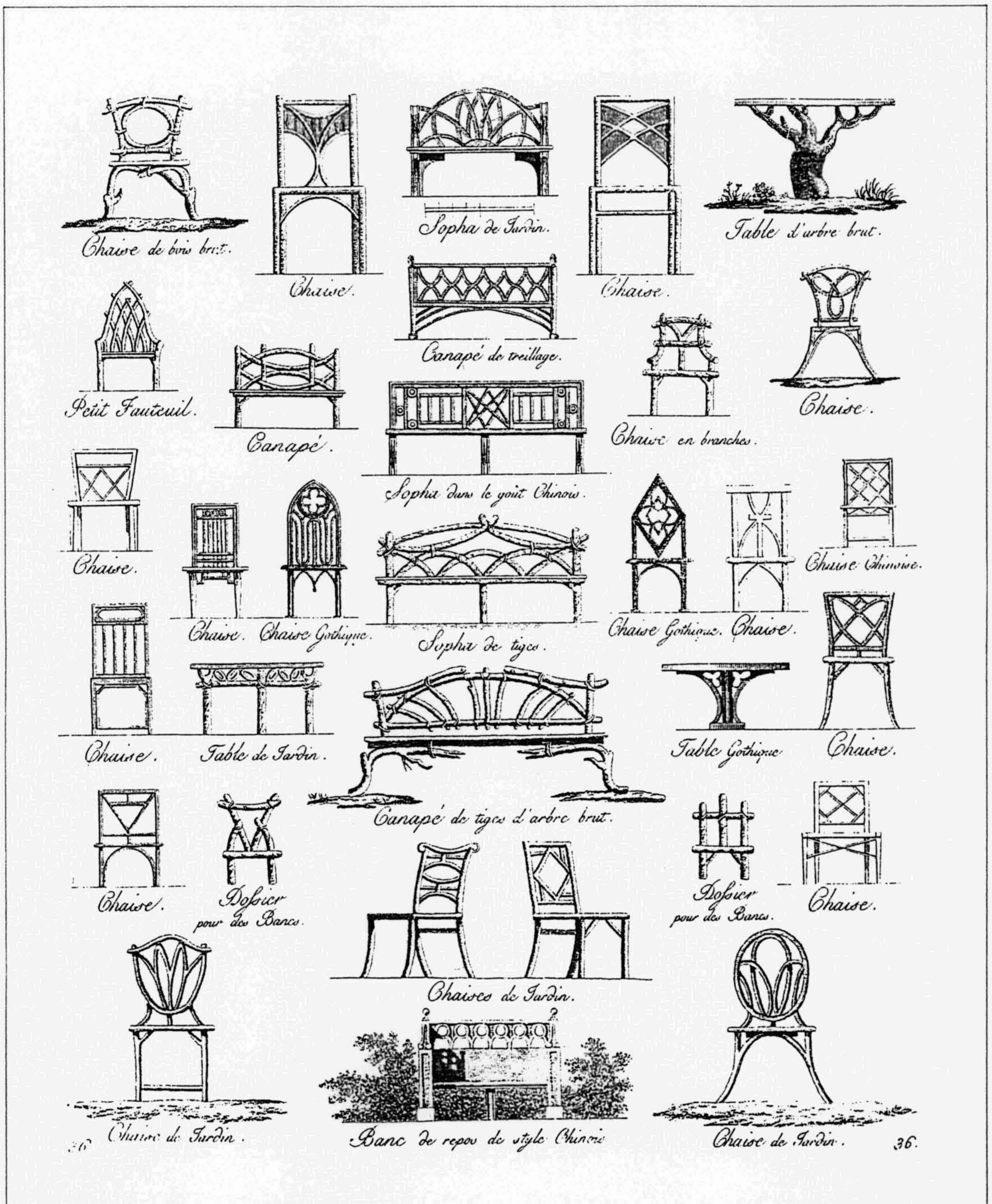
In these examples, carefully constructed frames and upholstery are combined with apparently natural growth

fig 2g/10



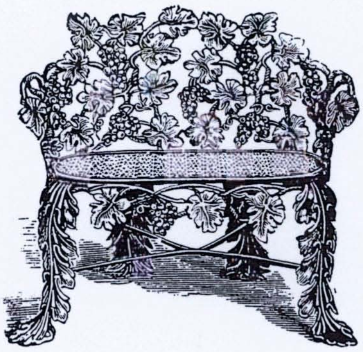
Four of Robert Manwaring's designs for Rural chairs from ' The Cabinet & Chair Makers Real Friend and Companion ' of 1765. It was suggested that these could be made either by carving, or by a combination of carving and the incorporation of suitable natural growth

fig 2g/11



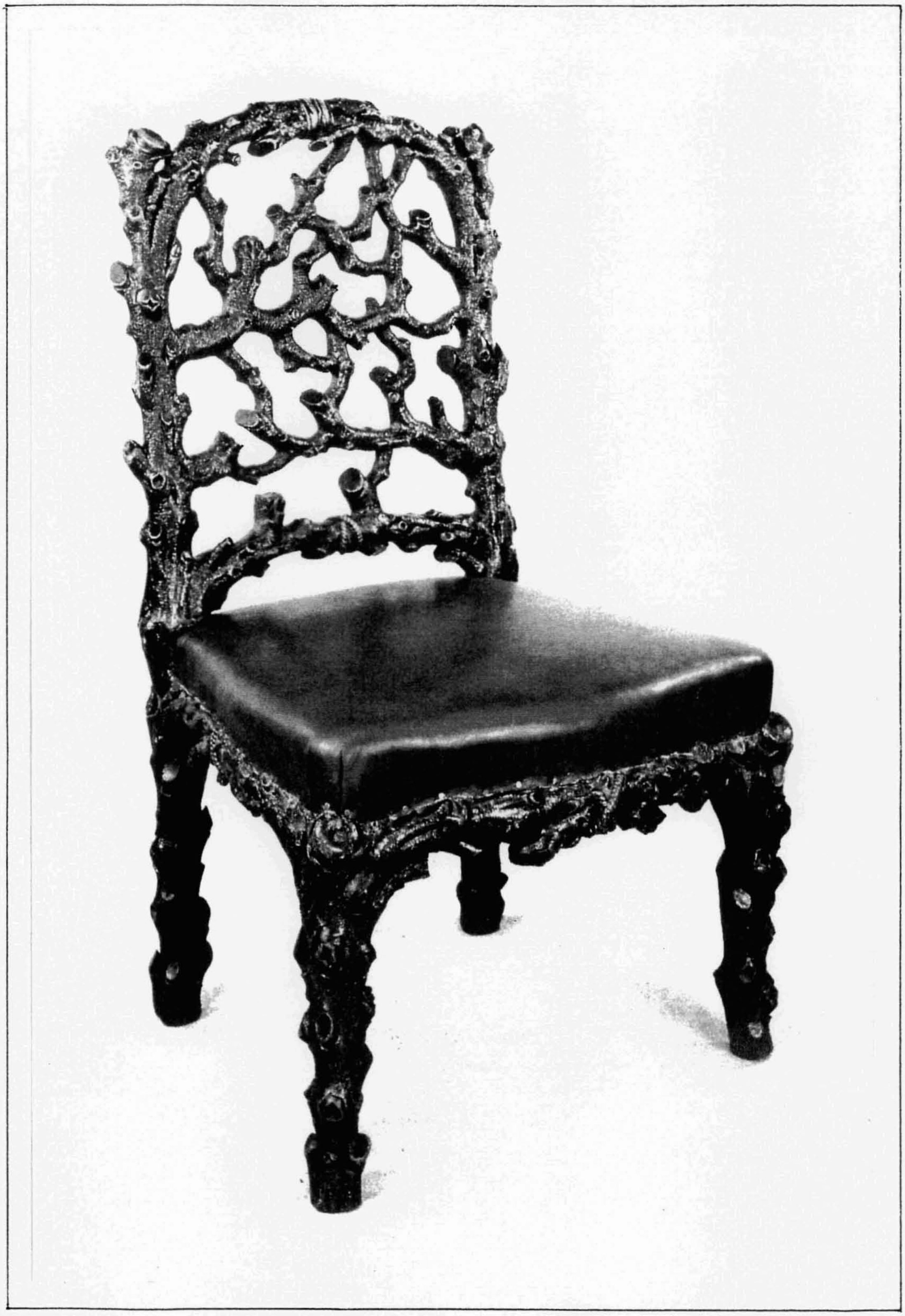
In 1805, many ' Rustic ' designs featured in
' Recueil de Dessins d'une Execution peu Dispendieuse'
by Johann Gottfried Grohmann

fig 2g/12



Two nineteenth century pieces of ' Rustic ' furniture. Developments in the technique of iron casting enabled the large scale production of pieces such as that shown above. The ceramic seat below is by Royal Doulton.

fig 2g/13



A rustic dining chair of about 1770, elaborately carved
to appear to have been made from naturally grown branches.

Victoria & Albert Museum

fig 2g/14

Similarly the humble wall mounted hook has, in rural situations at least, frequently been devised from a naturally occurring wooden fork. The handsome example illustrated here (fig 2g/15) is to be found in Smallhythe Place in Kent.

Yet another category in which examples of the use of natural forms may be found is that of the product of the eccentric maker who, while on occasion producing relatively conventional pieces (fig 2g/16 on right), at other times invents a piece inspired simply by the materials to hand and his own imagination. A delightful example of this genre is shown in fig 2g/16 on left. Little is known of its origins, the age having been deduced from the style of the shoes depicted, and its location of origin from some of the seeds found in its upholstery.

vi) THE BRITISH ISLES / SCOTLAND

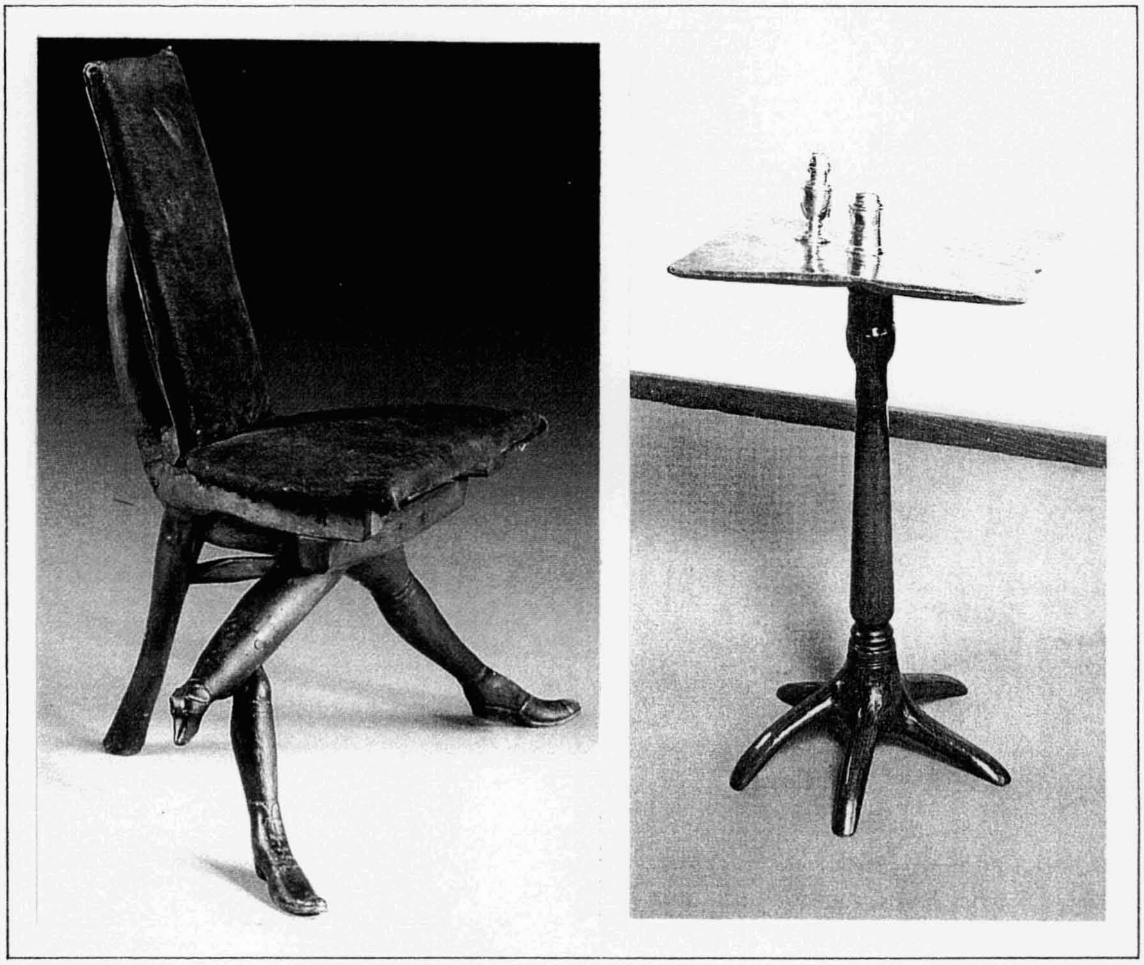
Originating from one of the remoter and more impoverished areas of Scotland, the ' Sutherland ' or ' Caithness ' chair provides an excellent example of the use of a naturally occurring wooden form to overcome one of the practical problems of chair construction, that of how to provide and support a sufficiently durable back rest. Ross Noble ;-

> Their main structure is composed of a pair of acutely bent, naturally grown ' knees ' of timber, which in some examples have been cleaved from a single piece, or are otherwise closely matched. These paired knees are united by a series of through wedged horizontal rails, and upheld by four similarly jointed legs. [39]

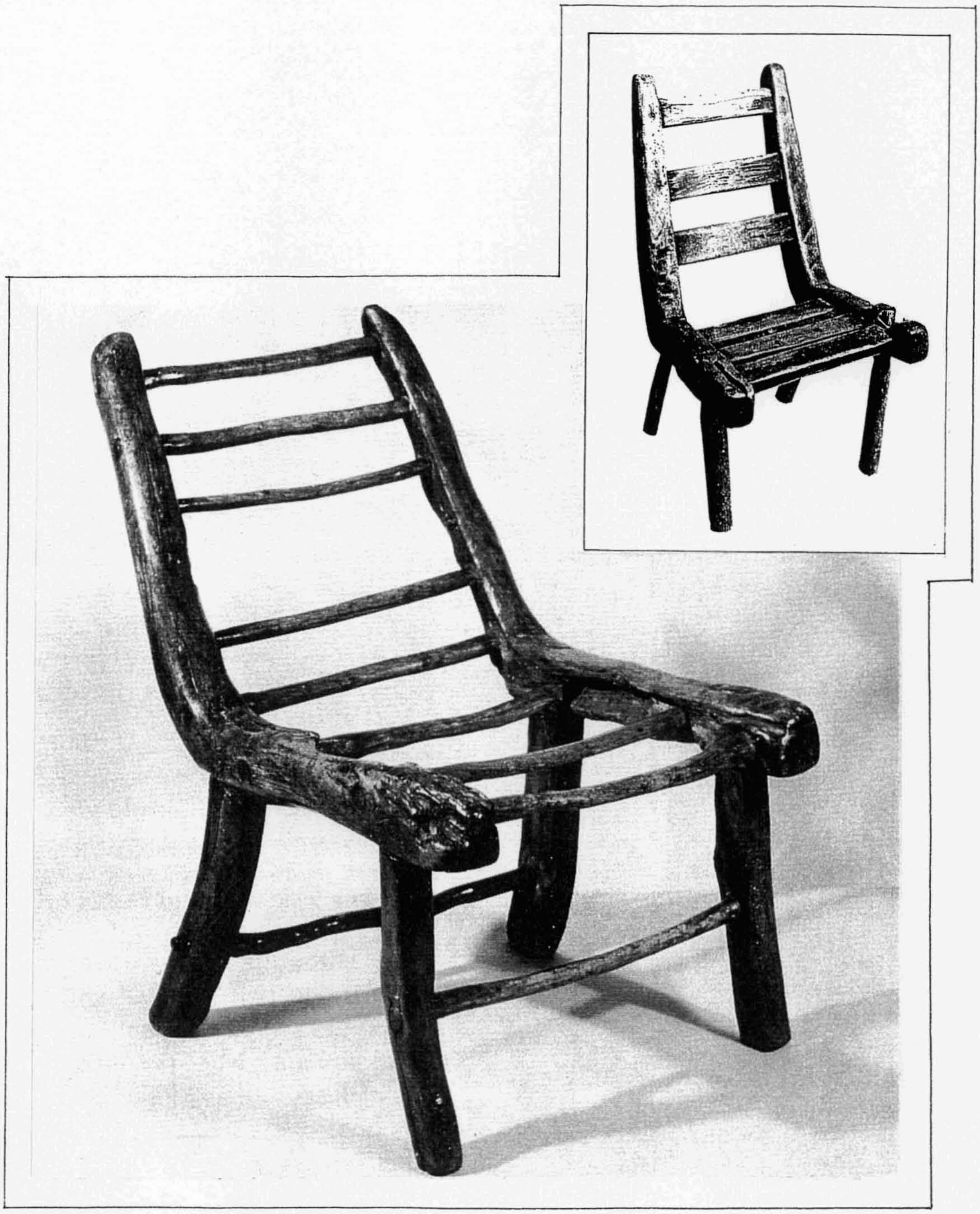
In these rural situations furniture is seldom produced by a specialist maker, and it is therefore not surprising that the wooden knee, a component commonly used in boat building, should have been used. As can be seen from fig 2g/17, the cross rails used on these chairs vary in form dependant on availability, while the example in fig 2g/18 was evidently built for a child. On adult's chairs at least, it appears that the front seat rail could provide a useful place to hang wet socks to dry in front of the fire.

This form of construction exists also in Northern Ireland in County Derry, and at least one chair of this type is recorded in Australia, the technique presumably having been taken there by Scottish or Irish emigrants.

*A natural timber fork used as a robust hook,
seen in 1998 at Smallhythe Place, in Kent. Bought by the
actress Ellen Terry in 1899, the cottage is now
owned by The National Trust*



Two examples of the use of naturally occurring wooden shapes to produce relatively sophisticated items of furniture. Left is a late nineteenth century eccentric three legged chair in Hawthorn which combines two natural angles to provide the front legs and tall back support. Right a late eighteenth / early nineteenth century pedestal table or candlestand. In Elm, the base of the central column is formed from the roots of a young tree



Two Scottish ' Sutherland ' chairs, their main structures formed from naturally grown timber' knees' which have been cleaved to form the side frames. The form of the cross rails making up the seat and back supports varies, as does the presence or absence of cross rails between the legs.

A stick backed chair from the Museum of Welsh Life, the arms formed from a naturally occuring bow. Dated before 1750.

A childs ' Caithness' chair, 25 inches high and probably of birch, believed to be 19th century.

fig 2g/18

As mentioned previously, wall mounted hooks are frequently devised by the use of natural growth, the examples illustrated in fig 2g/19, to be found on the Isle of Lewis, demonstrating that multiple storage can equally be attained with a little ingenuity.

vii) THE BRITISH ISLES / WALES

As in England, the most common use of naturally occurring wooden shapes appears to have been the arm bow to be found in Welsh stick backed chairs. Again these are either in the form of a single piece (in which case the arms are generally rather shallow and widely spread as in fig 2g/18 top) or of two pieces jointed in the centre (usually the two halves of a simple 'knee'). Research having failed to bring to light any uniquely Welsh uses of natural growth, a curiosity has however emerged in the form of the three legged open seat shown in fig 2g/20. Originally thought to have been a primitive toilet, it is now believed to be a birthing stool. As is the case in many similar instances, the exact origins and age of such country items is virtually impossible to ascertain.

viii) THE BRITISH ISLES / IRELAND

As is the case in Scotland, the historically harsh and rugged living conditions, combined with widespread poverty, ensured that the local craftsmen made good use of whatever natural growth could be found, Kinmonth describing how ;-

> The use of natural knees and natural forks of timber both in Scotland and Ireland, was common in rural areas in house-building, domestic implements and agricultural tools such as ploughs. [40]

Limited demand has meant that - certainly until about the start of the 20th century - few specialised furniture makers were able to exist. A characteristically Irish craftsman did however exist - the hedge carpenter. As his title implied, he ;-

> ....could choose part of a tree for the job to be done,' or ' go to a tree and carry home a plough. This skill of finding timber which saved him labour explains his choice of naturally bent ' knees ' of timber for chair parts, which achieved a desired shape with a minimum cutting. [41]

The interior of a Scottish ' Black House ' on the Isle of Lewis, Outer Hebrides. Note the branched tree tips hanging to the right of the doorway

fig 2g/19

above
Late eighteenth century Irish ' Hedge ' chair
whose backrest is partially formed from
a naturally grown ash ' knee '

below
Of unknown age, this three legged Welsh seat
is believed to be a birthing stool

fig 2g/20

Fig 2g/20 top illustrates a chair made in just this way, both the angles in the continuous arm bow being of natural growth scarf jointed together.

As previously mentioned, the ' Derry ' chair, to be found in that area of the north of Ireland, is closely related to the Scottish ' Sutherland ' type.

It is interesting to note that despite the use of simple earth (or 'clabber ') floors, the Irish version of the universal three legged stool - known as the ' Creepie ', existed without the benefit of the outwardly curving legs found in ancient Egypt. It must be presumed that the earth of these floors was sufficiently compacted as to present no such problem.

ix) THE BRITISH ISLES / THE ISLE OF MAN

As might be expected from it's geographical location, traditional country furniture found here shares at least some aspects with pieces from Scotland, Ireland, and according to Cotton (1993) even Newfoundland. The use of gorse as a timber for stool legs though, is believed to be uniquely Manx. A Mrs Annie Clague of Dalby, Isle of Man, giving evidence to the Folk Life Survey in 1949, is quoted as saying '.... there were three legged stools galore - they were made of sections of tree trunk and gorse legs. ' [42]

As shown in fig 2g/21, many of these made use of natural timber crotches for their seats, sometimes with the addition of a strip of timber nailed across the fork. While giving a greater seat area, this may also have provided a convenient means of carrying the stool single handed, or perhaps a rail over which to hang wet clothing to dry in front of the fire. The shapes of the pieces chosen for the legs - while sometimes unworked - seems to be the result of at least a certain aesthetic / practical consideration, some of them echoing those of far more sophisticated pieces.

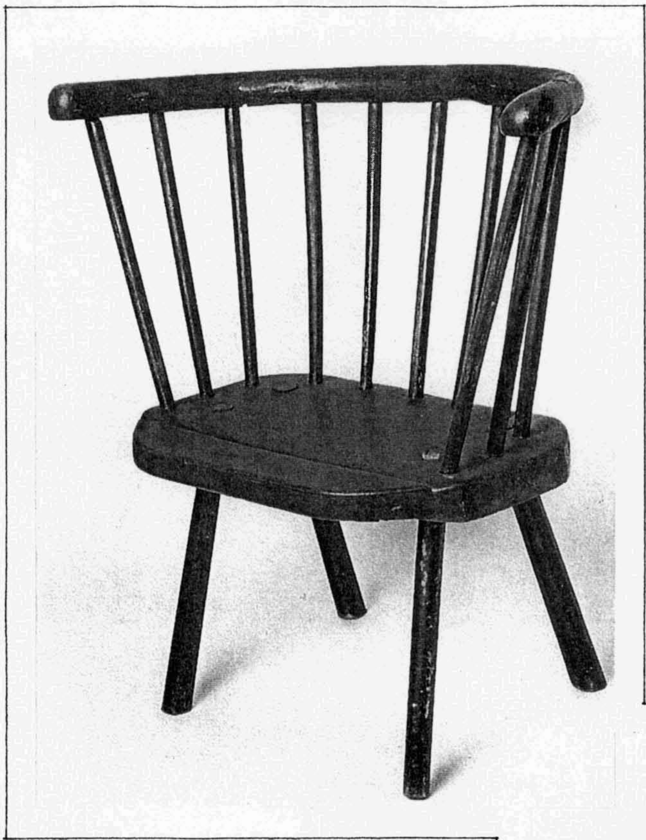
As in England, the Manx use of naturally occurring curved timber to form the arm bow of the Windsor type chair is illustrated in fig 2g/22 above, while a less common form of chair - perhaps with overtones of a traditional Chinese or *Bergere* style - is also shown in fig 2g/22 below. The arm bow on this chair is similarly formed from two halves of a natural bend.

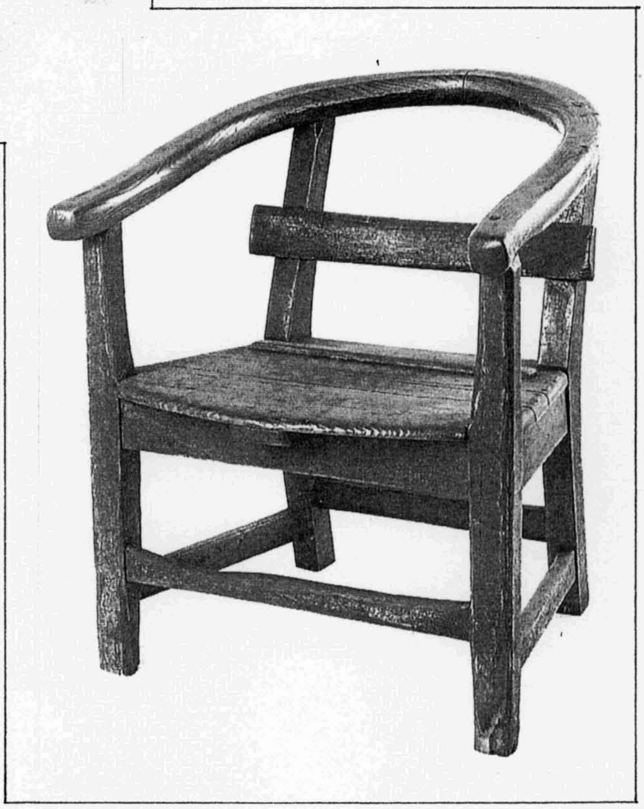
Two variations on the traditional Manx three legged stool, using a naturally occurring wooden crotch with a separate wooden rail nailed across the front of the seat.

Above - Scots pine seat with oak rail, two legs pine, one gorse. Late 19th/early 20th century

Below - Ash seat with oak rail and gorse legs Late 19th century

fig 2g/21





Two very different 19th century chairs from The Isle of Man.
The wooden bows of their continuous arms are both formed from
matching pairs of naturally occurring bends which are jointed at the centre.
While the chair on the left is a relatively conventional Windsor
type however, that on the right - whose form is perhaps
reminiscent of some traditional Chinese
or Bergere designs, is very unusual

fig 2g/22

x) ITALY

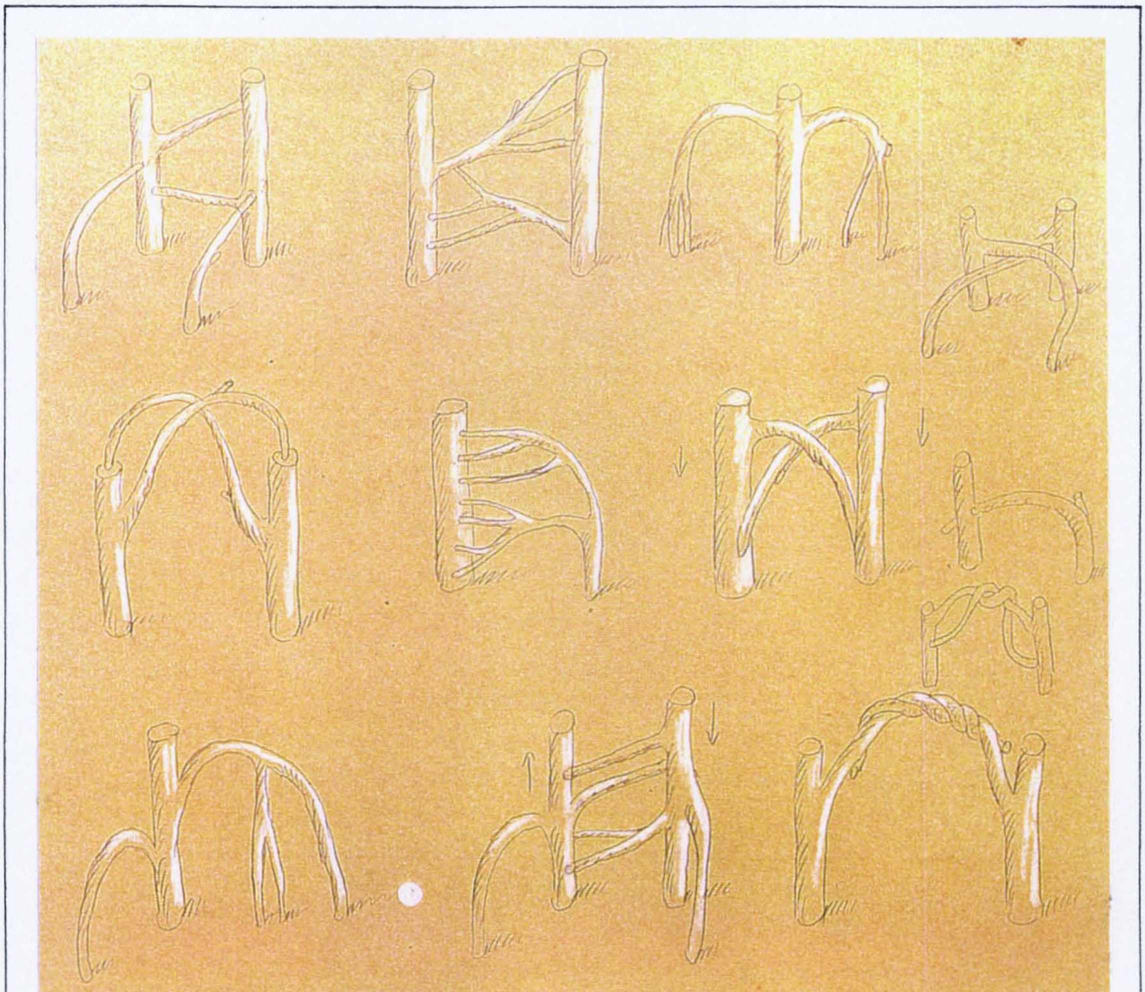
In his 1985 work *Domestic Animals - The Neoprimitive Style*, Andrea Branzi [43] argues that the mass market has disappeared, being replaced by ' the intelligent consumer, a citizen able to make independent choices.' Tracing their antecedents from a Maori dwelling, through some early 20th century ' Rustic ' designs from the USA and the Maggia valley in Italy, he presents his own designs. Some of these consist of a range of furniture - chairs, settee and lamps, incorporating sections of raw timber (apparently silver birch) having their bark still in place. Entitled ' Preliminary studies for Domestic Animals ', he also illustrates a variety of possible configurations of naturally grown timber components (fig 2g/23). While most of these appear to be possible uses of ' found ' elements, a few are of such a form as to demand human intervention in the growth of a living tree. Of these possibilities however, none are illustrated among the examples of actual furniture pieces.

xi) NORTH AMERICA

Although Thomas Jefferson apparently intended to build a Gothic Pavilion for himself at Monticello as early as 1771, the Gothic and Chinese ' Rustic ' tastes prevailing in Europe in the 18th century (see under The British Isles / England) had little effect in America at that time, the natural scenery being ' if anything, far too raw for comfort. ' [44]

It was not until increasing industrialisation brought the inevitable overcrowding to American cities that the need was felt - as in Europe - to 'get away from it all ' in the newly built resorts on the East and South coasts, and here the Rustic style was much in favour. In 1847 it even found its way into an abbey at Valle Crucis near Boone, North Carolina. [45]
(Here several chairs still exist, including a massive rhododendron 'Bishops Chair'.)
Among city dwellers the taste for ' Rusticity ' owed much to the publication (1842/1850) of books by Andrew Jackson Downey - the original planner of New York's Central Park, which included several spacious ' Rustic arbors '. The roofs of these shelters were supported on tree - like columns, below which ' Adirondack ' style benches allowed visitors to relax.

In the 1870's and 80's ' a curious rebellion against feminine social tyranny resulted in a large scale movement that might be called ' Man - and - boy - in - the - Wilderness.' [46]



From Andrea Branzi's Domestic Animals
Preliminary sketches & chair 1985, flower stand 1986

fig 2g/23

To cater for this movement, many rural hunting and fishing camps were built, the style being overwhelmingly ' Rustic '. (Although built much later, the staircase in fig 2g/24 gives a good flavour of the style.)

Furniture of this type was already being made by various rural communities, typically the Southern Appalatian mountain settlers, for whom it appears to have originated more as a practical solution to a real problem than as a stylistic flight of fancy. According to Stevenson, four distinct styles are discernible during the period 1820 to 1930, and while each makes use of naturally occurring timber in more or less recognisable form, these vary from rustic interpretations of mainstream fashions to the flowing forms attainable only by the use of the thin flexible stems of hickory or willow.

Gilborn [47] also tells how, beginning in the 1870's, the Adirondack region became an increasingly popular holiday area. Hotels, camps and private holiday cottages were built in large numbers, the style of their buildings and furnishing being that which was currently popular, and which became known as 'Adirondack'. Using the trunks and branches of local trees 'as found', frequently with the bark still attached, the buildings and their furniture created an undeniably rural impression. The style took many forms, from the relatively delicate use of twigs and peeled bark for mirror frames, to the robust use of whole tree trunks - their trimmed roots still attached - to form table bases. (fig 2g/25 although late examples, are typical.)

As in Britain, so in America, the coming of the technology enabling elaborate forms to be cast in iron, produced an enduringly popular series of items of ' Rustic ' outdoor furniture (see fig 2g/13, top). In the late 20th century, American (and other) enthusiasts continue to enjoy the creative possibilities offered by ' making - it - themselves ', with Daniel Mack [48] showing ways in which the use of such raw materials, sometimes in combination with even less conventional components, can produce a pleasing variety of pieces. (fig 2g/26).

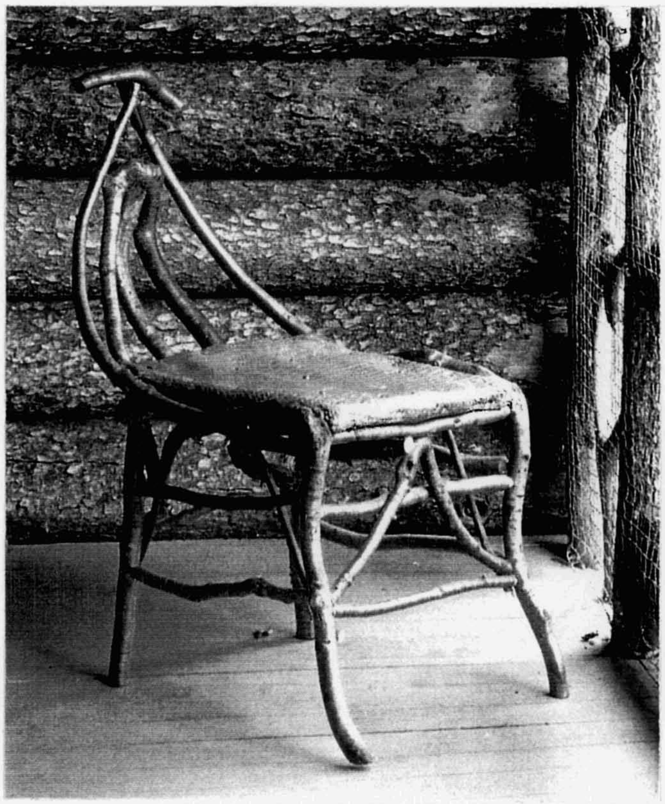
In the 20th century, the USA has the distinction of having produced at least three eccentrics who, for varied reasons have decided actually to grow themselves furniture.

> ... perhaps the ultimate rustic statement was made by John Krubsack of Embarrass, Wisconsin, who - over a period of 11 years - literally ' grew ' a chair from living trees. Krubsack was a banker and farmer who had studied

' Adirondack ' staircase of peeled Spruce
built in 1937 - 1938

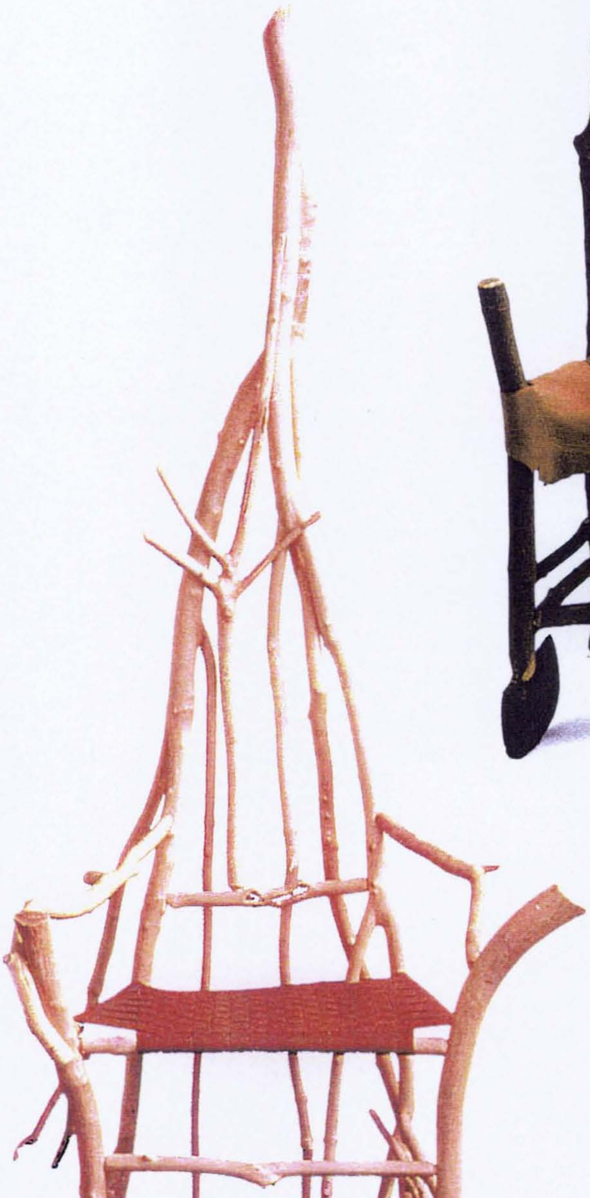
The Adirondack style

right
Chair in yellow birch
by Ole Lynn Snyder
1890 - 1914



below
Table with applied white
Birch bark panels and
base of Yellow Birch
by Joseph Bryere
1905

fig 2g/25



Two rustic chairs designed and made by Daniel Mack.

Above is an example of the style Mack calls his ' Chairmakers chairs', incorporating tools in the wooden structure

The seat of the ' Wishbone' chair below is made from woven webbing in traditional Shaker style the art of plant grafting and who, in 1908, decided to test his skill with an unusual project.

Krubsack planted 28 box elder seeds in a carefully - designed pattern. After a few years, he began to train the direction of the saplings' growth along a trellis, and eventually grafted the trees together at critical points to form the arms, seat, and back of a chair. At the end of ten years, Krubsack cut all the trees except the legs, which he allowed to strengthen for an additional year. Dubbed ' The Chair That Grew, ' Krubsack's creation became a popular curiosity in the 1920s. It toured the country with several exhibitions and was featured in *Ripley's Believe It Or Not.* [49]

(see fig 2g/27)

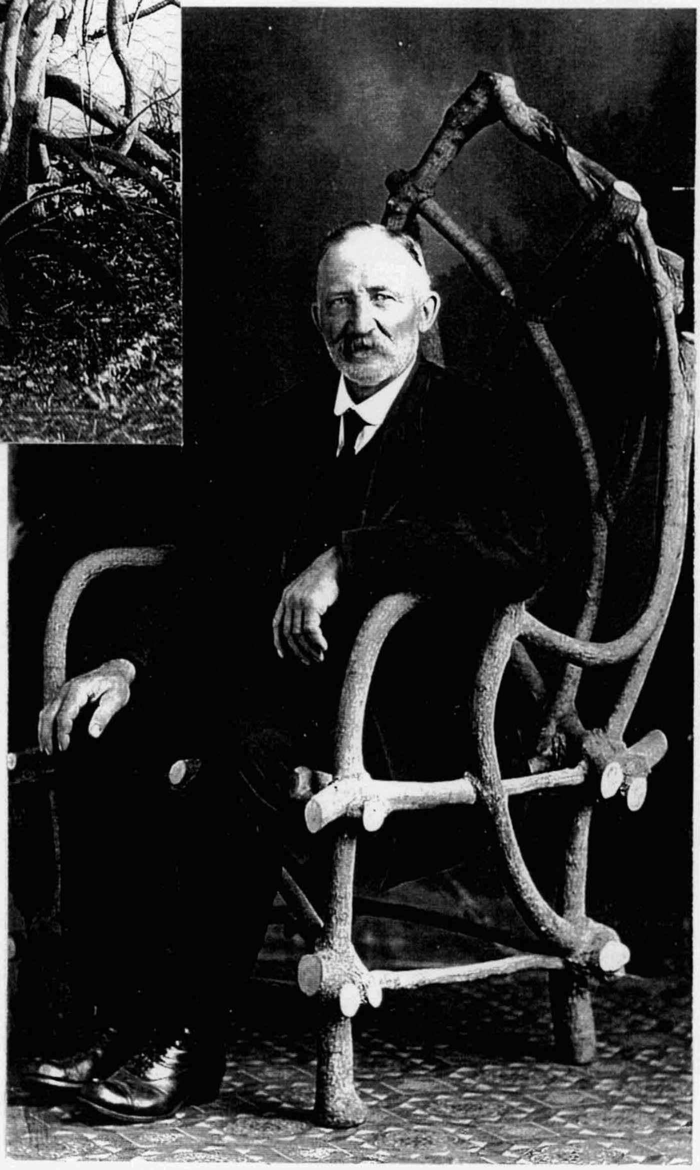
From west of the Great Lakes to the West Coast, Axel Erlandson of Santa Cruz in California was perhaps the most prolific and successful grower / grafter of living structures. He worked from about 1925 until his death in 1964, but since most of the structures in his ' Tree Circus ' were sculptural, these will be described under that heading. One of the chairs that he grew is shown here in fig 2g/28.

Working currently on the idea of producing living furniture by growing it (and another admirer of Erlandson), Richard Reames of Williams in Oregon (fig 2g/29) offers for sale growing chairs and tables which he plants in large diameter pots and trains to shape. These he suggests may be planted in your own garden, or left in their pot if you prefer. Richard is also growing experimental sculptural shapes, and has - with Barbara Delbol - written a booklet entitled *How to Grow a Chair*, in which he describes both the work of Erlandson and the various techniques of training and grafting used in such work.

xii) THE FAR EAST

Known locally as ' the father of living furniture ' Nirandr Boonnark of Chiang Mai in Northern Thailand has been planting living furniture since 1980. Explaining his reasoning, he is quoted as saying ;-

> Thailand is gaining an increasingly bad reputation abroad for destroying our own forests as well as plundering those of Laos, Burma and Cambodia for timber for the furniture industry.....
> But many conservation groups are calling for a ban on the import of furniture from our country because of the uncontrolled destruction of the rain forests. [50]



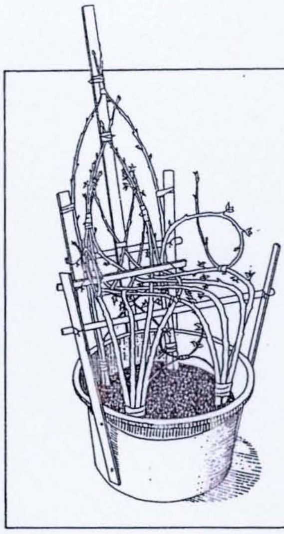
John Krubsack's chair took 11 years to grow.

The 28 box elders, planted in 1908, were trained and grafted together to form the chair in which he is pictured sitting. Wisconsin USA.

from Mack 1992

fig 2g/27

Axel Erlandson seen sitting in his grown sycamore chair at the Scott's Valley ' Tree Circus ' California, December 1954



Richard Reames with his growing chairs at the San Francisco Garden Show, The Cow Palace, March 1998. The pictures on the wall show (above left) his own work, and that (below right) of Axel Erlandson, John Krubsack and Nirandr Boonnetr. Reames' book ' How to Grow a Chair' lies on the wooden pedestal

fig 2g/29

Worried also about maximising profits from fruit tree yields, he goes on to say ;-

> Many people in Thailand have a lot of spare time. After the harvest, during the rainy season, they've got nothing to do. So by growing living furniture they benefit in a two fold manner. They can have the satisfaction of filling un - productive hours with a creative project as well as literally harvesting the fruits of their labour. In other words they can grow fruit on the tree as well as shaping that tree into a piece of furniture at the same time. Then when the tree reaches the end of its productive life, it can remain in the garden as a piece of outdoor furniture or it can be pulled up and sold for 100,000 baht. *(about £1,500 at 2002 exchange rate)*

One of Nirandr's Guava chairs was ' harvested ' and exhibited at the Tantapan Airport department store in Chiang Mai for three years (fig 2g/30).

Keen to enable others to follow his example, Nirandr has published a booklet with instructions and helpful hints. Rather than using jigs as a method of training the structure to shape, he recommends that strips of lead should be bound in place and then bent to shape, (which might be viewed as dubious on ecological grounds !) As suitable species he recommends Teak, Guava, Tamarind or Jack Fruit in that order. Although admitting that Eucalyptus is suitable, he prefers to have nothing to do with it in Thailand, as its thirst for water disturbs the natural water table.

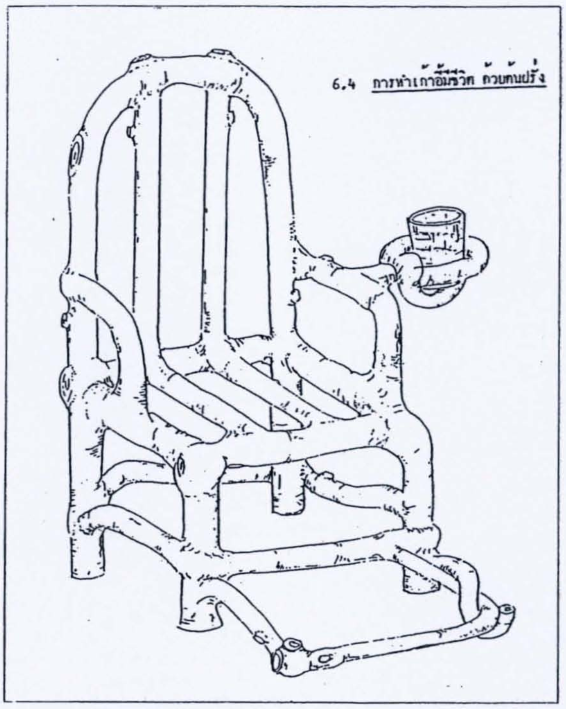
xiii) AUSTRALIA

The history Australian furniture as we know it can be said to date from the establishment - in 1788 - of a British penal colony in Botany Bay. With the first settlers originating from Britain, it is unsurprising that the use of naturally grown forms there falls broadly into categories similar to those found in Europe, i.e. simple utilitarian structures existing purely to fulfil a need, components used in the making of relatively sophisticated but simple items such as chairs, self - consciously 'rustic ' items intended for use in the garden or on the veranda, or 'designer craftsman ' pieces, frequently sculptural in nature.

<u>Simple utilitarian structures</u>

In the early days conditions in Australia were considerably more arduous than most experienced in Europe, besides which many of the deportees had little knowledge of the

In Thailand, Nirandr Boonnark has been growing furniture since 1980. Known locally as ' The Father of Living Furniture', he feels that the pieces should remain where they grow. To encourage others to do the same he has produced a small booklet showing how he suggests the pieces may be planted and trained.



He is seen below with one of his grown Guava chairs

practical skills needed in such circumstances. The pressure to devise usable structures from any available material must therefore have been considerable. Typically ;-

> Simple forks, the Vs supporting cross members and the trunks driven into the earthen floor, formed the fixed structure of those ' permanent ' beds so often described in the simple huts of early pioneers. Complex forks of three or more branches made free - standing construction possible and, squared off, were incorporated as bases for tables, stools and, more rarely, chairs. [51]

This practice of using suitably formed tree forks, or trunks with roots attached to create the bases of tables ' was a traditional country technique in Britain and Wales ' [52]

This overwhelmingly sensible technique for the production of strong and simply contrived furniture bases may have been used in the early days from necessity, but it continued to be popular well into the next century, Cornall further indicating that ' The use of three - branch tree forks for stools was common bush practice and recommended in numerous journals and manuals of the period. ' [53] A few of these pieces which have survived are illustrated in fig 2g/31, from which it may be seen that the use of naturally occurring shapes was not confined only to forks !

Components

As time went on and conditions gradually improved, there appeared the slightly more sophisticated forms of furniture typified by the chairs illustrated in fig 2g/32. In these, the naturally occurring components are used, either singly or as a matching pair, in making the side frames.

Natural knees were another source of material which - the idea having almost certainly been brought from Scotland or Ireland - could be pressed into use (see also under Britain). Dated to about 1840, one of these ' Sutherland ' style chairs is recorded as having been found at Truro, South Australia, while Cornall also mentions ' Shearer's fork ' chairs as examples of this general type.

In the ' Cootamundra Jack ' chair, named after the creator of this form of seat, a reversed ' Y ' shaped fork - halved to create left and right hand members - is used to create

Australian bush furniture & equipment. Clockwise from top left;-
Stool - Queensland, 1900   Commode - Victoria, 1860
Table - Western Australia, 1890   Bootlast - Western Australia, 1890

(all dates approximate)

fig 2g/31

the side frames (fig 2g/32). This example, from Southern New South Wales and thought to date from the 1880's, appears to be an attempt at a ' Bush ' version of ' Regency ' style, the curved section of the fork having been used to good effect to form the arms and front legs while the back rails are carved as crude replicas of the then fashionable ' rope twists '.

Rustic furniture

As mentioned with reference to the newly independent America, in a country where nature has so recently been ' tamed ', a fashion for so called ' rustic ' furniture may find some difficulty of acceptance. This European fashion did however appear in the 19th century in Australia, although ;-

> ' In largely avoiding the more extreme Romantic styles, Australian branch garden furniture reflected the relative closeness of colonial urban society to its rural roots rather than accentuated its distance. ' [54]

The method of construction can of course, be easily mastered by the enthusiastic amateur, (fig 2g/33) indeed ;-

> This vogue was so widespread that contemporary journals regularly printed articles illustrating types of furniture that could be easily made by the home craftsman. Construction methods were extremely simple: joints were most commonly only nailed, although crude mortise and tenon joints using drilled sockets were also used. In a society with strong rural affiliations these techniques, which had been traditionally employed in the bush ..... would have often been familiar even to urban woodworkers. [55]

Ease of making notwithstanding, at least some sophisticated versions of the style were produced, and ;-

> ... it is probable that the better pieces in this free-form style were the products not of suburban amateurs or mass production by furniture retailers but of the many small craft workshops in country areas that specialised in garden furniture. [56]

Finally, it is evident that at least some Australian craftsmen - notably in Melbourne - did produce pieces of a quality which could be exported to Britain, Sanders Trotman being listed in the *Victorian Directory* of 1851 as a ' Rustic chair and Summerhouse maker ', while

above
An Australian ' Cootamundra Jack' chair, the single piece side frames formed from the two halves of a forked branch.

below
The side frames of this rocking chair in Eucalyptus are similarly created from the halves of a naturally occurring fork.

Both chairs from New South Wales, about 1870 - 80

This Australian rustic garden chair with vestigial arms makes good use of the apparently plentiful supply of contorted Eucalyptus branches available to the makers of such pieces.

Adelaide, about 1900

a rustic seat by another craftsman was exhibited at the London International Exhibition of 1852. ' Ten years later, ' Rustic chairs and tables made of various colonial woods ' were shown by John Foy, also of Melbourne [57]

There must have been an abundance of suitable branches literally ' lying about ', as the local saying ' Never sit under a gum tree on a hot day ' [58] would indicate.

<u>20th century designer - craftsman pieces</u>

In the twentieth century, Australian society in common with most others, encompasses a group of designer - craftsmen who, among many other forms, produce pieces made using naturally grown wooden forms. Generally designed to evoke a strong visual impact, the pieces produced by these designers are both stylish and varied. (see fig 2g/34)

Pip Giovanelli's work consists almost entirely of naturally grown components. ' Part of my satisfaction comes from being able to draw a very direct connection between what the environment has to offer in the way of materials, then working with them in their natural state to produce a functional item.' [59] He is reported to have a disdain of art for art's sake, and to take pride in the fact that many ordinary people can identify with his rugged forms. Gay Hawkes uses largely found timbers, both naturally grown and driftwood. By contrast the majority of John Smith's work illustrated in Bogle & Landman uses brightly coloured man made materials. In combining these with the naturally grown base used in his ' Tri - stool ' (fig 2g/34), Smith makes a dramatic statement about the contrast between the man made and the natural.

2h Sculpture

For topiary - which may also be regarded as sculpture - see also sections 2b & 2k.

Brought up in Weybridge, David Nash trained as a painter at Kingston. As a child however ;-

> Wood was always around to build huts and carts and forts. We nailed and screwed bits together to make big things - a three storey tower fort for instance. [60]

Tri - stool by John Smith
Australia 1985

fig 2g/34

It is hardly surprising then that when, at the age of 19 he became dissatisfied with painting, he changed to sculpture and, at the age of 21, moved to Blaenau Ffestiniog in a part of North Wales where he had spent his childhood holidays. Having worked there for several years ;-

> In the apocalyptic mid - Seventies .... David Nash's work took a new and positive turn. On a four and a half acre plot of wooded hillside .... he planted an ash dome as a pledge to the 21st century. ' My inspiration was the Royal navy in the Napoleonic War planting a lot of oak forests so they would have the wood to build the fleet at the end of the 20th century. I love that long term thinking. ' The circle of carefully trained trees was also an answer to the problem of a wooden sculpture outdoors that does not rot, and to the question of making it genuinely of it's place..... Nash says ' In 1977 when I planted it they were three - foot whips which were grafted and fletched, [61]then stepped over with pruning and bending . Another 35 years and the shape will be consolidated.' He will be 85. [62]

See fig 2h/1. The dome is not his only growing sculpture however ;-

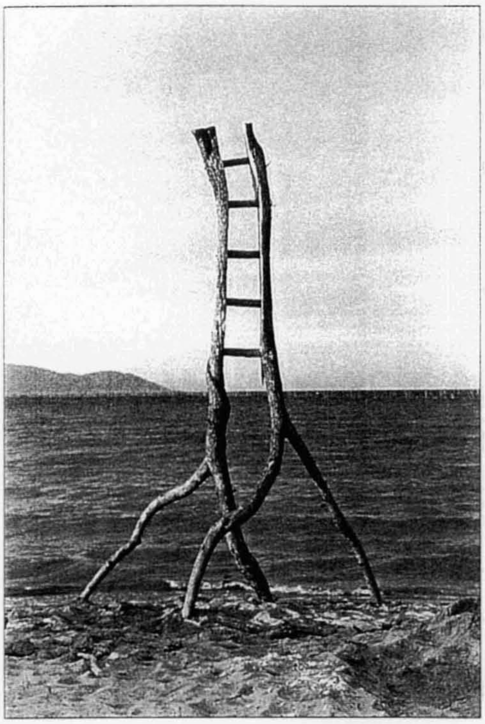
> Since the Ash Dome, Nash has planted many more living sculptures, including a thicket-like Celtic hedge of sycamore and common maple, planted in thirty-three groups of three trees, twisting this way and that, in a restless rhythm. With a lovely clump of larches planted in 1983, the rhythm and musicality of the artist's design are intensified: they have been trained to swing out and up like dancers turning rather than shooting straight up as is their way. Further off, complementing the closed form of the dome, Nash is growing an open bowl of spread - eagled oak, on a slope so that it tilts towards the sky like a receiving radio or satellite dish. Living ladders of sycamore, and irregular squares of birches, ... are also thriving in this earth work, this artist's experiment with forms over time. [63]

Working generally in wood and frequently on a heroic scale, many of Nash's other sculptures make use of partially carved and juxtaposed natural timbers. See fig 2h/2

Among the British sculptors currently working with natural materials Andy Goldsworthy must be both the best known Internationally and perhaps the most prolific. While famous for his ephemeral pieces, Goldsworthy appears equally happy to work with a wide range of natural materials, timber among them. Keen to take his inspiration from whatever can be found locally, he has created at least two relatively large scale works by juxtaposing the curved timbers produced when trees grow bent over by snow, wind, etc.

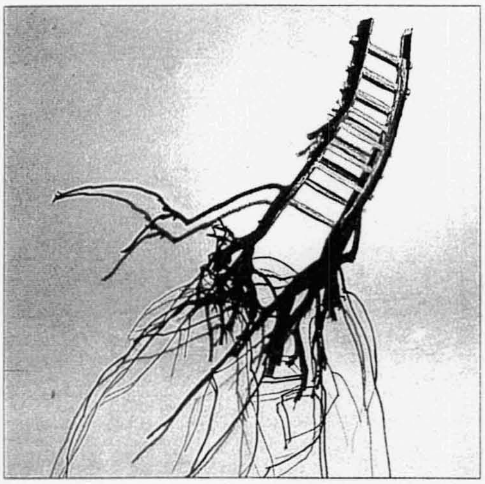
David Nash's Ash Dome in Blaenau Ffestiniog, North Wales
Planted as 3ft whips in 1977, pictured in 1995.

fig 2h/1

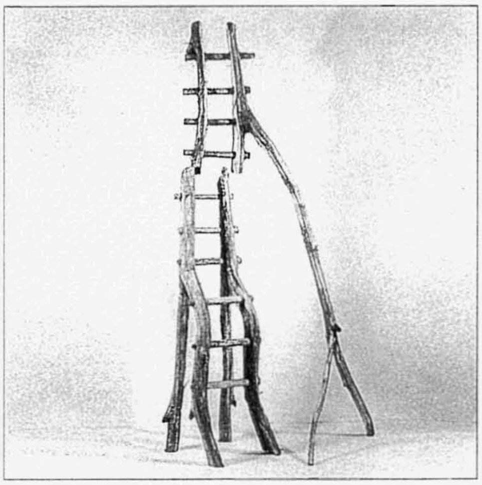


Ladder, 1984, unknown wood, Lake Biwa, Japan

Big Gum Ladder, 1991, eucalyptus, La Jolla, USA



Flying Ladder, 1993, Lime, Bracknell, England



Double Ladder, 1983, oak, Ffestiniog, North Wales

some of David Nash's many
'ladder' sculptures built from inverted combinations
of naturally occuring tree forks.
1983 - 1993

fig 2h/2

One of these - created in Spring 1985 - constitutes a gently undulating form, snaking it's way among the living pines in Grizedale Forest. The other - a pair of large hoops - provides a very appropriate entrance to John Makepeace's research establishment at Hooke Park in Dorset (fig 2h/3).

On a more modest scale, the British sculptor Richard Wincer's ' Armchair ' (fig 2h/3) refers quite directly to a conventional item of furniture.

> The idea for the ' Armchair ' came from seeing one that had been dumped in a wood. Initially I was angry at seeing the evidence of someone using the wood as a tip. Later, I began to imagine how, over a period of time, the growth of new trees would take over. I envisaged saplings growing through and around the chair until it was almost obscured from view. An object that at fist had looked out of context now seemed to be more acceptable in its new form and environment and somewhat comic. It seemed a natural progression from this to make a chair from small branches and twigs and place it in an outdoor setting. [64]

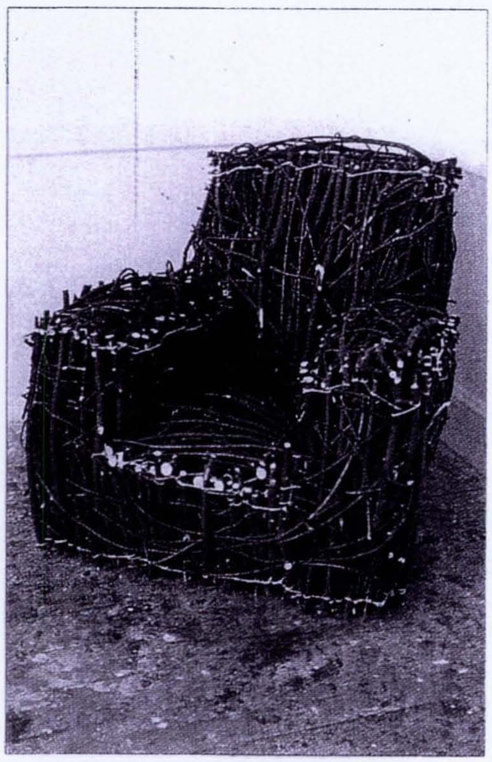
Of all the 20th century sculptors who have chosen to work with living trees however, Axel Erlandson of Santa Cruz in California - with over seventy examples to his credit - must surely be rated as the most ambitious, apart from being extremely technically successful.

Working as a farmer in Turlock, about 80 miles south east of San Francisco, his interest in the possibility of training and grafting trees into structures was first aroused when he noticed a natural graft between two sycamores.

> ' Not having been formally trained in horticulture, Axel had the gift of ignorance - he explored and innovated techniques without the constraints of orthodoxy.' [65]

His first experiment - later christened the four legged giant - consisted of four sycamore trees, planted in a six foot square. These were trained together and grafted into a single stem. (fig 2h/4) Presumably encouraged by the success of this piece he quickly set out to produce a range of unusual shapes, some starting from a single stem to which additions were grafted, others the result of grafting several stems together.

These two Andy Goldsworthy sculptures flank the entrance to Hooke Park in Dorset



Armchair sculpture by Richard Wincer

' The idea for the armchair came from seeing one that had been dumped in a wood'

The ' Four Legged Giant ', an early tree sculpture
by Axel Erlandson. A feature of the ' Tree Circus', it was moved
to Scott's Valley, California in 1946

fig 2h/4

> Erlandson would first draw his tree designs to scale on paper, plant the required number of trees, then create the scaffolding structures to help train the young trees to shape. Although bending and grafting were his basic techniques, Erlandson carefully guarded all that he learned about tree shaping. According to his daughter Wilma, when a visitor asked how he shaped the trees, he would simply reply; ' I talk to them. ' [66]

No records, nor any of these drawings were kept, so that in some cases it is only possible to guess at how the shapes were achieved. This work is not helped by the fact that successive layers of new growth tend to engulf the evidence of grafting.

In his article in Fine Woodworking, Sandor Nagyszalanczy tells how he ;-

> ....created a wonderland of fantastic trees in the shapes of ladders, spiral stairways, hub-and-spoke back chairs, a small cathedral, single and double hearts, a gothic archway, and innumerable ree form loop-the-loops, curlicues, and geometric patterns. [67]

Most of the sculptures were created using sycamore or box elder, although alder, apple, ash, birch, cork oak, eucalyptus, loquat, mulberry, poplar, redwood and willow were all used on occasion. Erlandson himself was apparently surprised by how consistent the shapes he created were.

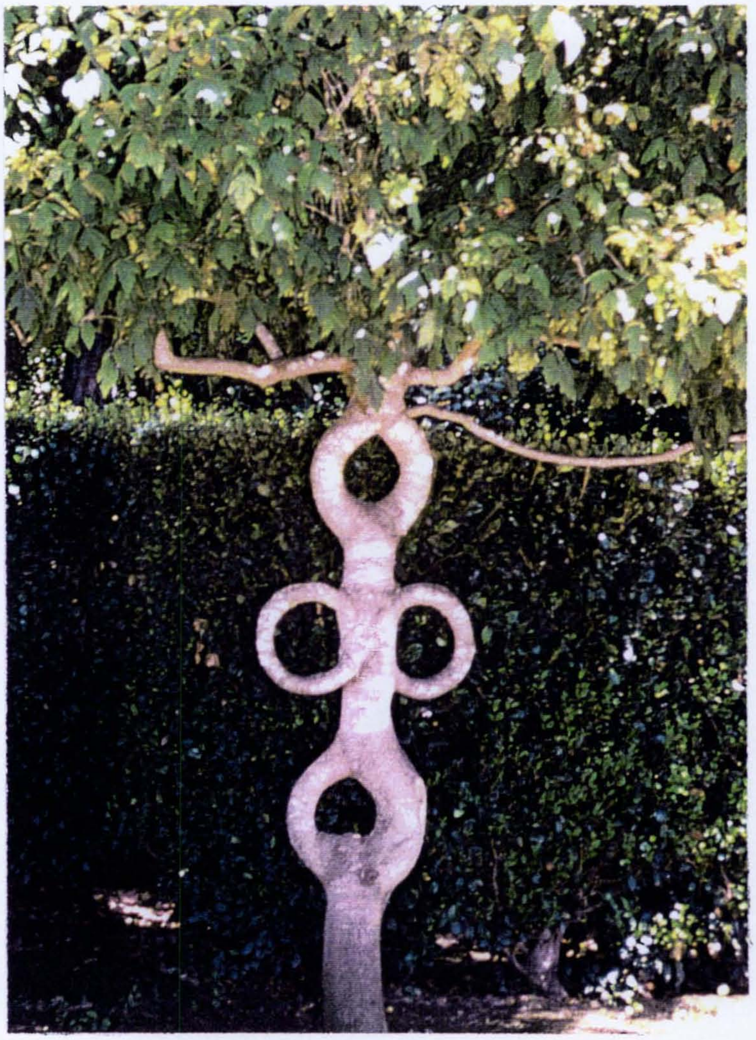
> You would think that as the trees grow, the formation would change. But they don't. Branches get larger in circumference, but the shape will remain about the same. [68]

Having started his experiments simply for his own amusement, in 1945 his wife and daughter finally persuaded Axel - at the age of 60 - to attempt to take commercial advantage of his skill, and a 3/4 acre plot in Scott's Valley, a popular holiday route to the sea, was acquired. Having created about twenty eight sculptures on his farm, as many as possible of these were transplanted to the new site, and a further forty or so sculptures were gradually added. (see figs 2h/4 to 2h/9)

Although untrained, Erlsandson must have followed - or discovered for himself - the basic principles of grafting which are well known and understood. In addition to these however, it is likely that the success of his more elaborate shapes depended on his ability to judge the correct time - both of the season and in the growth of the various

Tree sculptures by Axel Erlandson
from his ' Tree Circus' in Scott's Valley
California. 1925 - 1964

fig 2h/5

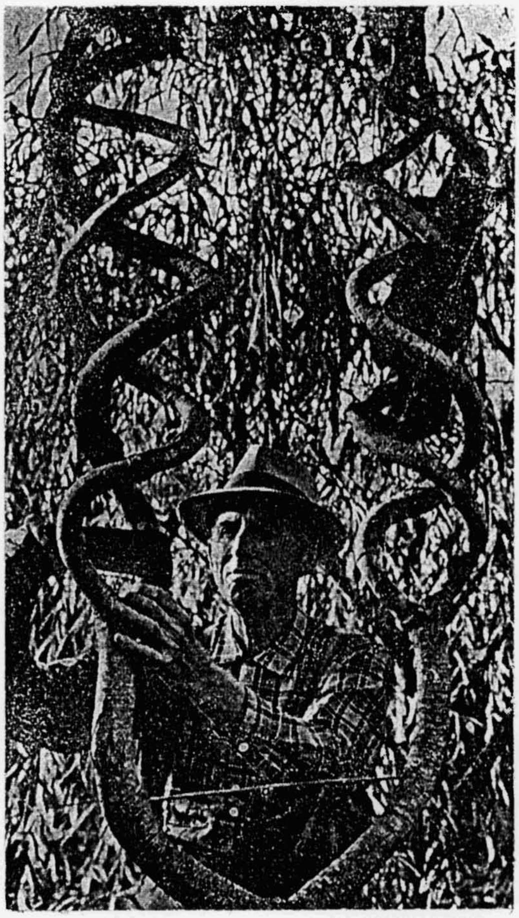


A four ringed tree sculpture - possibly a species of oak - grown and grafted by Axel Erlandson as a part of his ' Tree Circus ' in California.

fig 2h/6

This tree sculpture was skilfully grown and grafted by Axel Erlandson as a part of his ' Tree Circus ' in Scott's Valley, California.

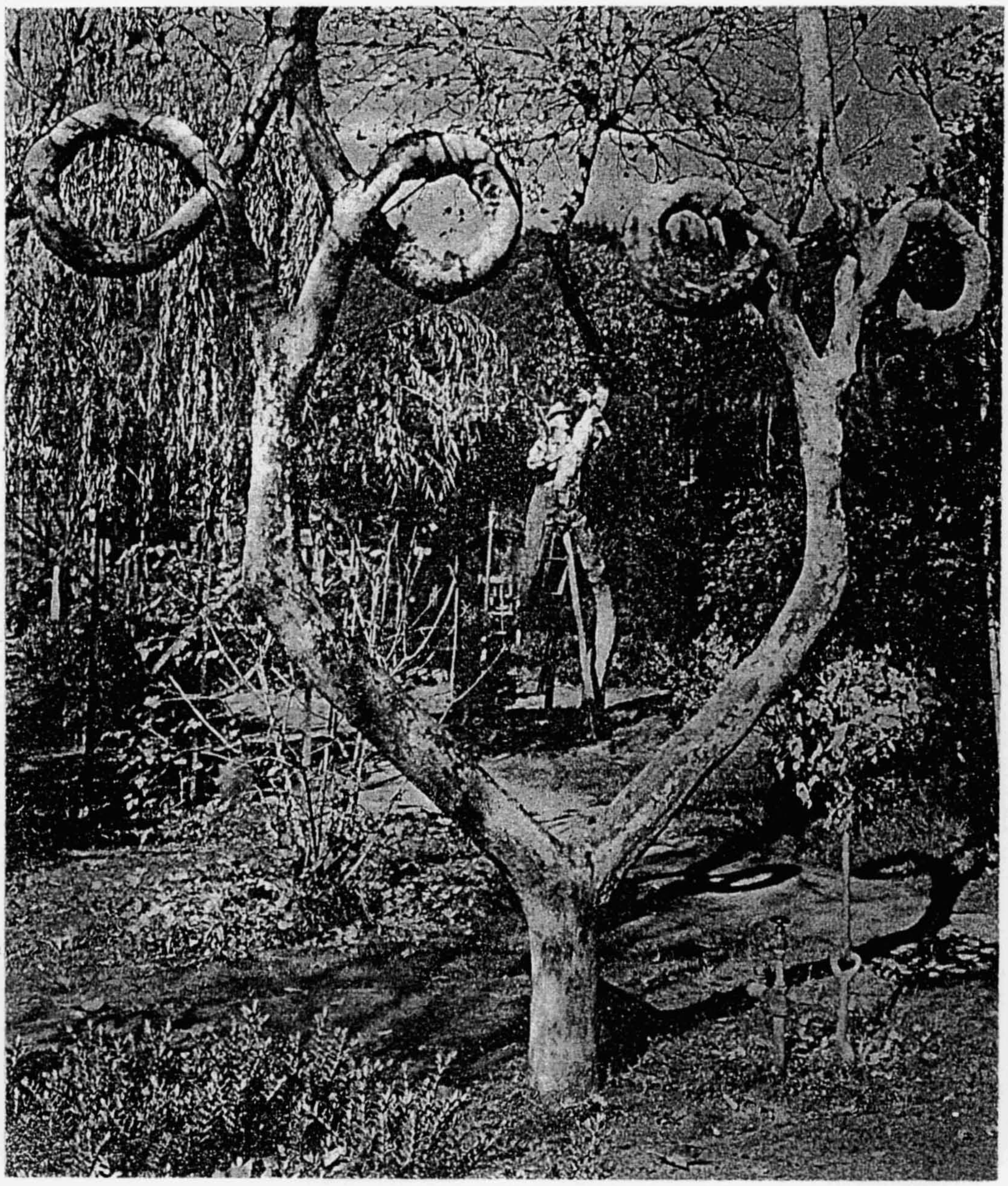
fig 2h/7



Axel Erlandson with exhibits from his tree circus in Santa Cruz California USA

1925 - 1964

fig 2h/8



A 28 year old Sycamore in the tree circus created by Axel Erlandson
Santa Cruz California 1925 - 1964

components - at which particular grafts should be made. The various pictures available show at least some of the techniques he used ;-

- The scale of the pieces he created required relatively substantial temporary support structures, which were frequently external to the form.

- The passage of sap from roots to leaves and vice versa will tend to prefer the most direct vertical route, and the members along this route will therefore grow more strongly than any others. Two of the pieces shown here, the rectangular panel (bottom right of fig 2h/5) and the four ring tree (fig 2h/6) both have relatively weak growth on their outer and less favoured sections. If there is no alternative however, the sap will ' loop the loop ' on its way up and down. (fig 2h/9)

- As growth accumulates at crossing points, the form may be seen to ' round out ' to provide a pleasantly smooth junction in the most successful cases. Erlandson must have grown at least two ' lattice ' towers (bottom left fig 2h/5) and while the original form was contrived by weaving alternate strands in and out, the eventual form is smooth. (Indeed given time, it appears that the form may ' fill out ' to give a solid tubular structure, similar to those envisaged by Arthur Wiechula (see section 2k)

- To ensure that it unites well, the two halves of a joint to be grafted must be held together under some pressure, otherwise new sections of bark will form. It can be seen that Erlandson used some form of broad tape (fig 2h/8) presumably for this purpose, and perhaps also to seal up the necessary ' wounds ' made where joins are in progress of healing.

Having finally sold his ' Tree circus ' in 1963, Erlandson died the following year, but a considerable number of his creations were saved, many being preserved in a museum in Santa Cruz, and in the Bonfante Gardens Theme Park in the western Gilroy hills.

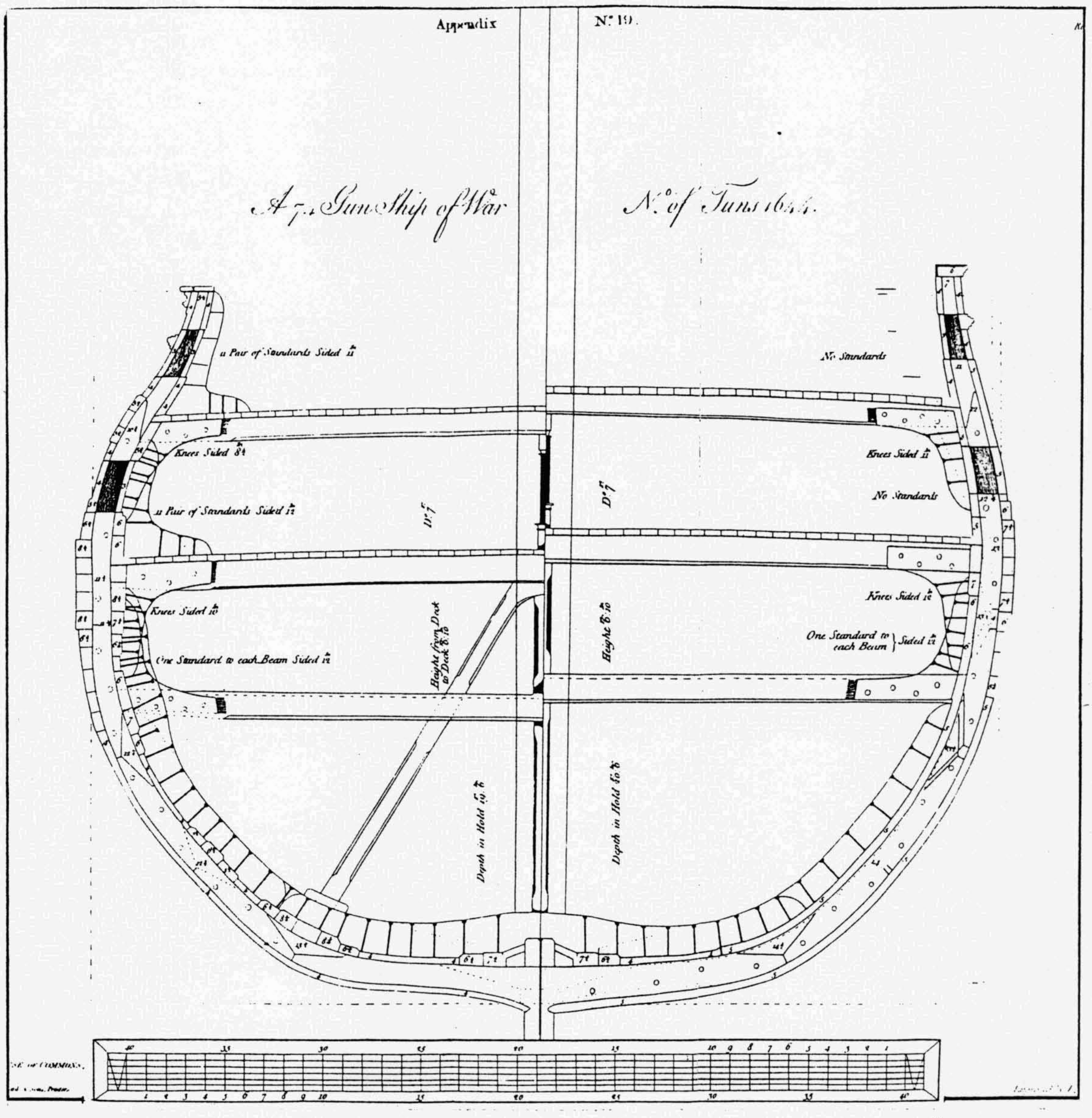
2j Shipbuilding

Of all the timber structures traditionally built using curved, angled or forked growth, the large wooden sailing ship, built largely of Oak (or Chestnut, see Thorne 1997) is probably the most thoroughly resolved and developed example. All the maritime nations, but particularly Britain, relied heavily upon their fleets of these ships, and efforts to improve them were considerable. All the more surprising then, that their design and dimensions varied so little between 1650 and 1850.

At about 200ft from stem to stern and more than 50ft across at the broadest point, the hull of a British Naval ' seventy four ' of this period was a larger, more curvaceous, and far more complex, wooden structure than the typical contemporary country house. Being built to withstand the worst Atlantic storms and the considerable stresses involved in the firing and receiving of repeated ' broadsides ', these hulls had to be most carefully designed to make the best possible use of the available timber shapes. The problem raised by the necessity of providing rows of ports through which the guns could fire was only one of many.

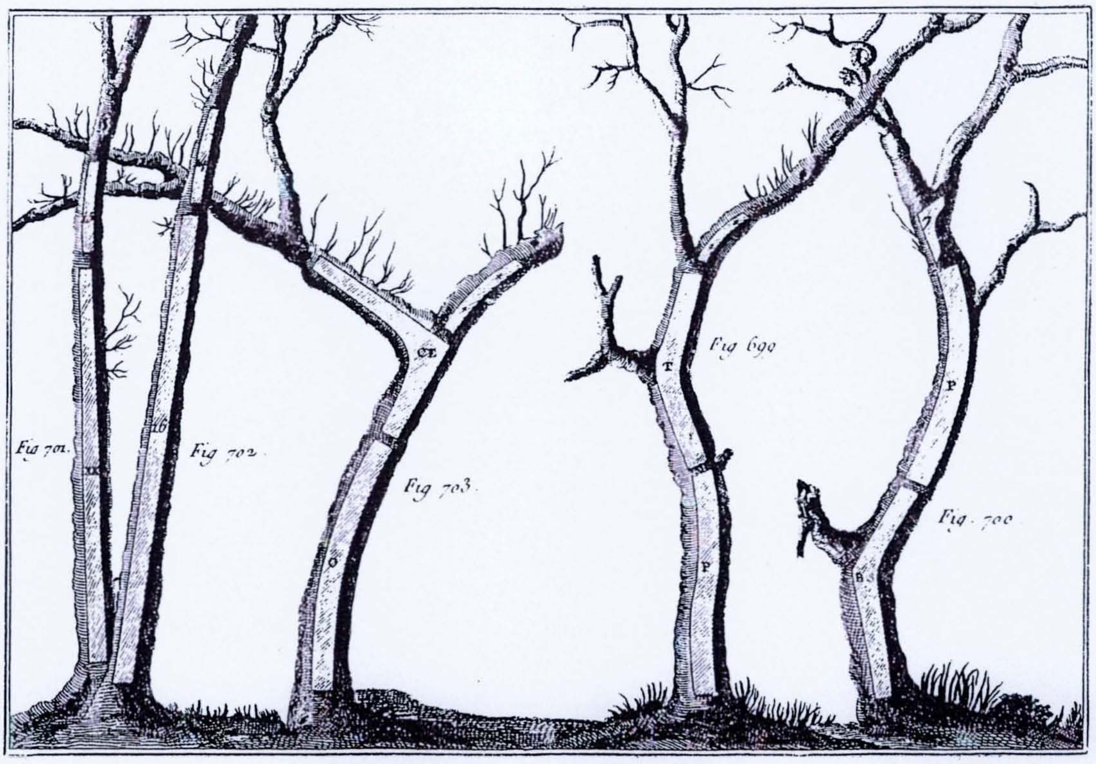
The ' skeleton ' consisted of the keel which was crossed by perhaps sixty or seventy curved ' ribs ', and was clad by a double skin of planking. Running the length of the boat and rising to the stem at one end and the stern post at the other, the keel consisted of about a dozen pieces - several of which were curved - each being over twenty inches (500mm) thick. The ribs, whose form varied along the length of the hull, consisted of an assembly of variously curved and angled components. Within these ran the decks whose supporting beams were attached to the ribs by angled ' knees ' (see fig 2j/1). In total, a very large number of naturally shaped components - some of considerable size - were required. The diagram shown in fig 2j/2 taken from the French *Encyclopedie Methodique Marine* of 1783, shows how some of these would have been cut.

It is in fact the shipbuilders' heavy reliance on the supply of these naturally shaped components which explains not only the relatively static nature of ship design, but also the fact that it was soon evident that there was a maximum size to which a seaworthy hull could be built.



From a British Parliamentary report of 1771.
The right hand side of the diagramme shows projected improvements

fig 2j/1



Showing how various of the wooden components required to build an 18th century Man of War could be cut from trees of suitable growth. From the ' Encyclopedie Methodique. Marine.' 1783

The elegantly curved prow of a Saxon dug-out boat, found in the Thames at Walton in Surrey. Created from an oak log,it has been carbon dated to between 405 and 530 AD

> There was some increase in tonnage, but the second Royal George of 1788 was only twelve feet longer and two feet wider than the Royal Sovereign of 1719. [69]

Larger ships, capable of carrying even more guns would have been a considerable advantage, but the curved and angled compass timbers which would have been required were simply not available in the necessary sizes.

Even at the sizes at which it was possible to build the ships however, finding a sufficient supply of correctly shaped timbers became more and more difficult as time went on, a situation exacerbated by Naval requirements in time of war. ;-

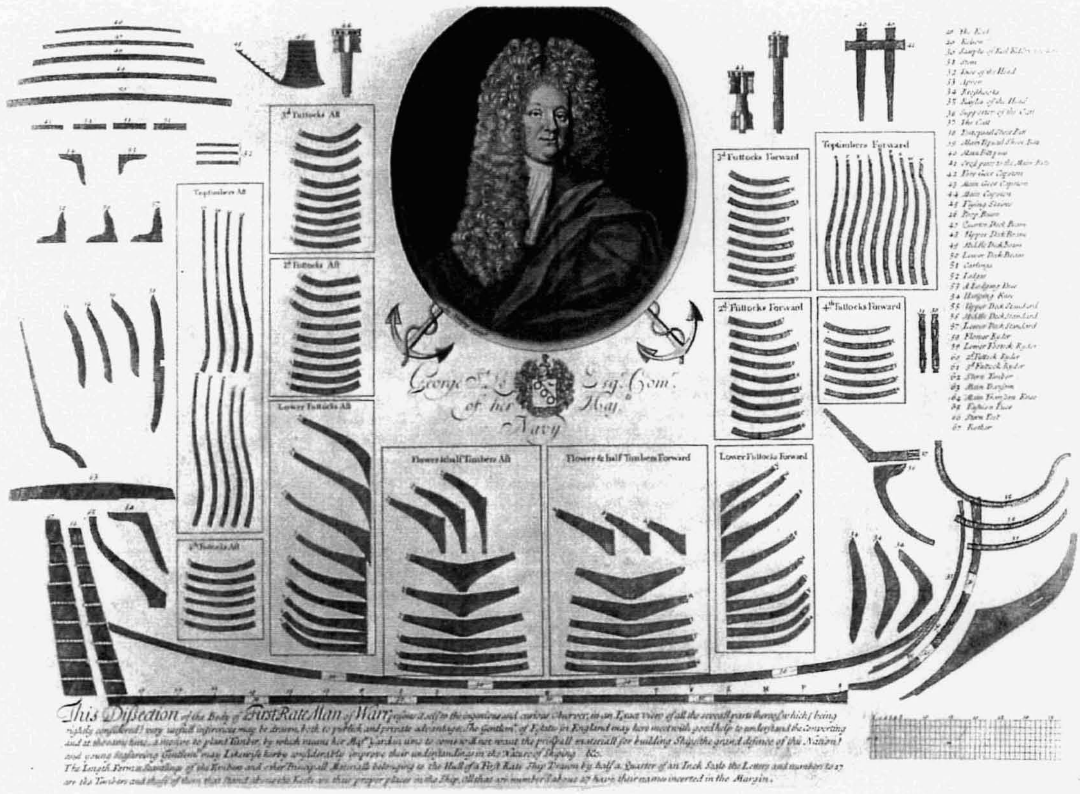
> There was considerable difficulty in procuring the large curved pieces for the stem, as well as for the cathead, the heavy crooked timber which supported the anchor. The knees, which were cut from the intersection of large branches with the trunk, also presented a problem, for only the trees raised in isolation tended to have large branches. One of the hardest pieces in the whole ship to procure was the wing transom knee, which had two thick arms twelve or fourteen feet long, whereas most knees had arms not over three or four feet in length. [70]

Attempts to cope with this problem fell broadly into three categories ;-

- encouragement of landowners to husband their suitable timber
- ship design modifications
- suggestions for the possible training of trees into suitable shapes

By about 1700, landowners - whose trees might provide suitable timbers - were already being encouraged to plant, and to recognise the shapes as they grew, to which end broadsheets illustrating the various components needed were produced (fig 2j/3)

The trend towards land enclosure, involving the removal of many established hedges (even though new hedges were subsequently installed) had made matters worse, since the large, angular and curving shapes required for Compass timbers were typically sourced from the mature Oaks to be found growing in these hedges. While querying many widespread assumptions on these matters, Rackham confirms that ' Much shipbuilding timber, especially in large sizes and special shapes came from hedges and parks, not woodland.' [71] also;-



' This dissection of the Body of a First Rate Man of War presents itself to the ingenious and curious observer, in an Exact view of all the severall parts thereof, which (being rightly considered) very usefull inferences may be drawn, both to publick and private advantage. The Gentlemen of Estates in England may here meet with good help to understand the converting and at the same time, a motive to plant timber, by which means Her Majesty's yards in time to come will not want the principall materiall for building ships (the grand defence of this Nation) ... '

published about 1700.

fig 2j/3

> From about 1750 there appears to have been a steady decline hedgerow timber in the ancient countryside, which - rightly or wrongly - alarmed the Navy by 1792. Timber trees were planted in many of the enclosure-act hedges, but we do not know whether this was an adequate compensation.[72]

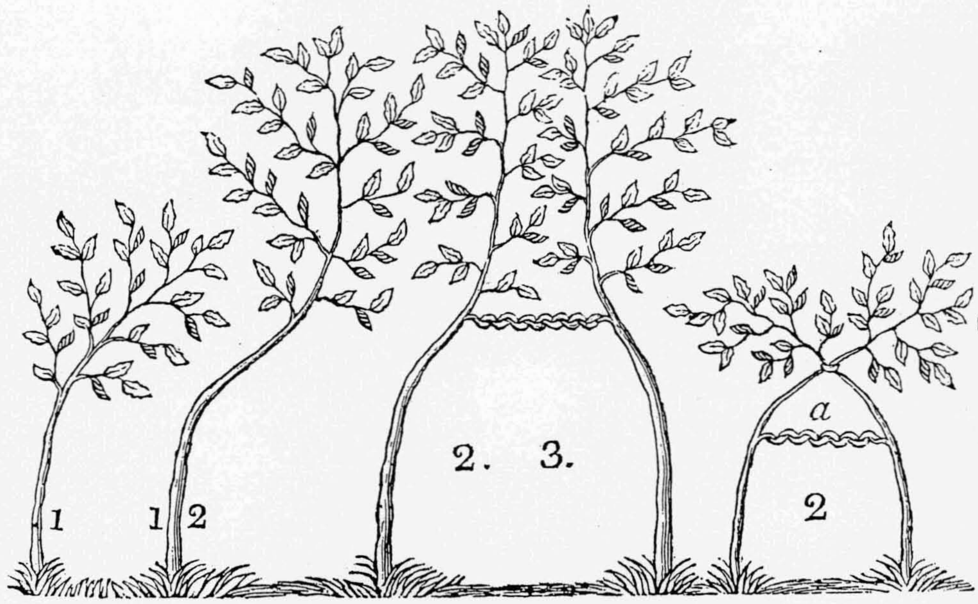
As the situation became increasingly difficult, in an attempt to reduce both the quantity and size of the compass and other timbers required in the building of a ' 74 gunship of war ', as early as 1771, British parliamentary report proposed certain design modifications. (These are shown in the right hand half of fig 2j/1, the existing design being shown on the left.)

The possibility of training trees to grow into the required shapes was also proposed, although the major problem in this case was of course, the slow rate of growth of the necessarily tough and water resistant timbers such as the Oak (*Quercus robur*) or Elm (*Ulmus procera*). The problem did not however deter a certain William Randall of Maidstone from carrying out some experiments into ways in which young oaks might be persuaded into ' compass ' shapes. Having done so, he submitted his ideas to The Royal Society of Arts, which accepted and published his letter and the illustrations of his proposed techniques in ' The Transactions of The Society ' volume 13, dated 1795 (fig 2j/4). These involved the unbalancing of the tree's growth by the removal of side shoots ;-

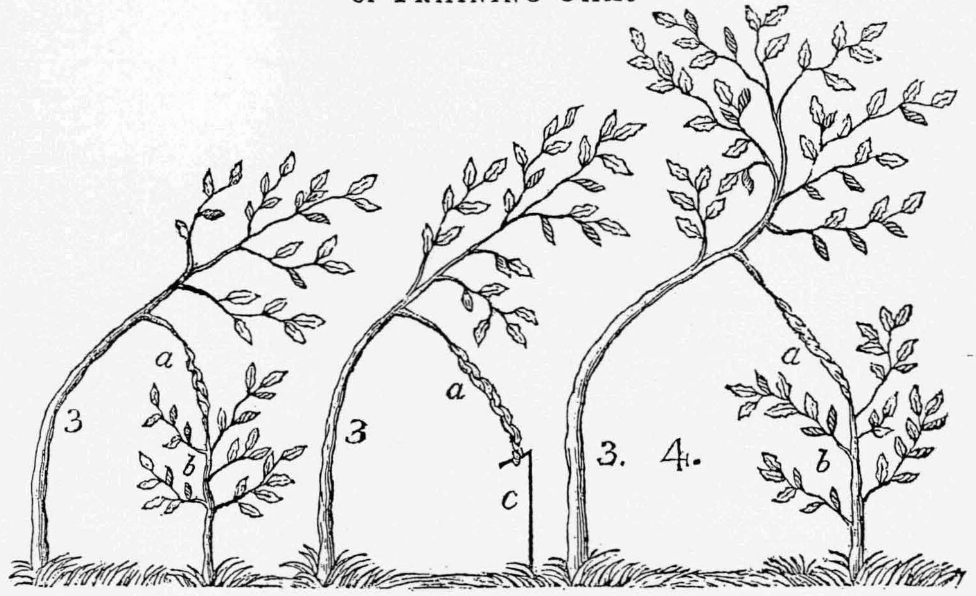
> clofe to the ftem; beginning when about eight feet high, and continue till twenty or more feet. This will caufe the Oak-trees on which it is practifed to nearly refemble the form No.1 (fee the cut) ; after which time, if left to nature, the ftem will in its regular courfe affume, in an advanced age, a form fomewhat like that marked No1,2. This part of the plan might be well adapted to parks, hedge-rows, and open plantations.

The remaining illustrations show how, in situations where the trees are growing in groups, they may be pulled down and attached either to each other or to a stake driven into the ground. Their natural tendency to resume vertical growth will then produce the desired shape. He concludes ;-' None of thefe proceffes are expenfive; the two laft plans, I find, can be done in ten minutes each tree; it can only be a trifling obftruction to the growth. '

Cut, No. 1, of Mr. Randall's Method of Training Oaks.



Cut, No. 2, of Mr. Randall's Method of Training Oaks



' Rules for training OAK TREES to Compass Shapes, for Naval Purposes', submitted to the Royal Society of Arts by William Randall of Maidstone on 21st January 1795, and reproduced that year in volume 13 of the ' Transactions of The Society'

fig 2j/4

In the 20th century, the development of reliable waterproof glues which may be used for the lamination of complex wooden shapes, has freed the boat builder in most developed countries from this total dependence on natural growth.

By the use of a large portion of a suitable tree's trunk - carefully shaped and hollowed out - many early societies avoided the necessity for jointing of any sort. In Britain at any rate, this practice can be traced to at least the first century AD, as shown by the remarkably well preserved Saxon log boat currently on display in The River and Rowing Museum at Henley-on-Thames (fig 2j/2). That the trunk of the oak selected provided a suitably curved profile at the bow and stern of the vessel is clearly evident, enabling the makers to produce the desireable form, tapered at both ends, without resulting in the sections of short grain which would have been inevitable had a totally straight trunk been used. This was a sturdy and relatively sizeable hull, capable of carrying nine men.

Today, there are some who prefer to continue to use aspects of these traditional systems when they can, and yet others in less developed countries who continue it from necessity. Ralph Clayton of Hibbs Point, Newfoundland, is one boat-builder who seeks out suitable natural growth from preference. As Dr Bernard Cotton reports, [73] he not only uses such timber for prows, (fig 2j/5) but hopes to find suitably radiussed timbers which, when split in two, will form a pair of strong central ribs. In Egypt, the building and repair of the hulls of the traditional wooden hulled craft such as the lateen sailed Felucca, continues to rely on the use of timber which has grown into a suitably curved shape (fig 2j/6)

2k Architecture / pseudo architecture

In terms of the provision of human shelter, perhaps man's most primitive use of natural tree growth is that of living within the hollow trunk of a tree. Since large old trees may become hollow with age, the idea probably originated in just these situations. It is however, perfectly possible in certain circumstances to hollow out the trunks of living trees without harming them.

In some areas of Africa - such as Botswana's Kalahari desert - where rain is infrequent, the Baobab tree (*Adamsonia Digitata*), leafless for most of the year (the explorer Dr Livingstone described it as resembling ' a carrot planted upside -down ') has

Ralph Clayton of Hibbs Point, Newfoundland,
with an example of one of the naturally grown timber shapes
he uses in building his boats. This knee will form a prow

fig 2j/5

As in many countries, Egyptian boatbuilders take advantage of the naturally curving shapes to be found in timber evolved a hugely enlarged trunk for the storage of water, and Rudofsky relates how, with trunks reaching up to 30ft in diameter ' it's wood being soft, live trees are often hollowed out and used as dwellings '. [74] Further south, in Ombalatu in Namibia, the tree shown at top right in fig 2k/1 was once used as a prison by the South African Army, and now houses a small unused chapel.

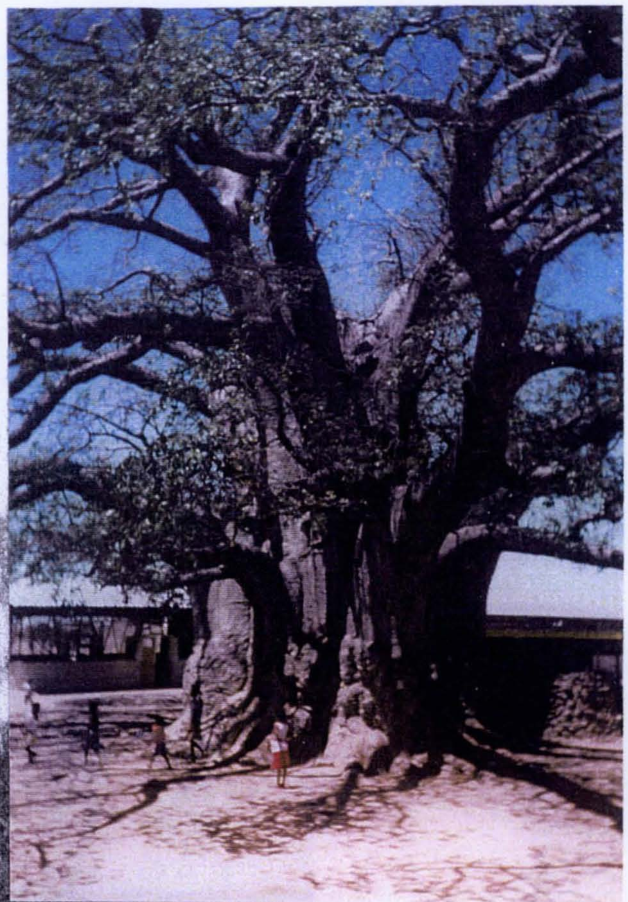
Nor is it only such ' primitive ' peoples who have been glad of this form of shelter. The first European settlers in Australia, in extreme circumstances were glad to come across very different trees whose massive trunks could likewise offer some form of ready made shelter, ' Trees sometimes served new settlers as homes for years during the first settlement period (see fig 2k/1 lower left) and one large tree in Gipps land was used as a church for almost three decades. ' [75]

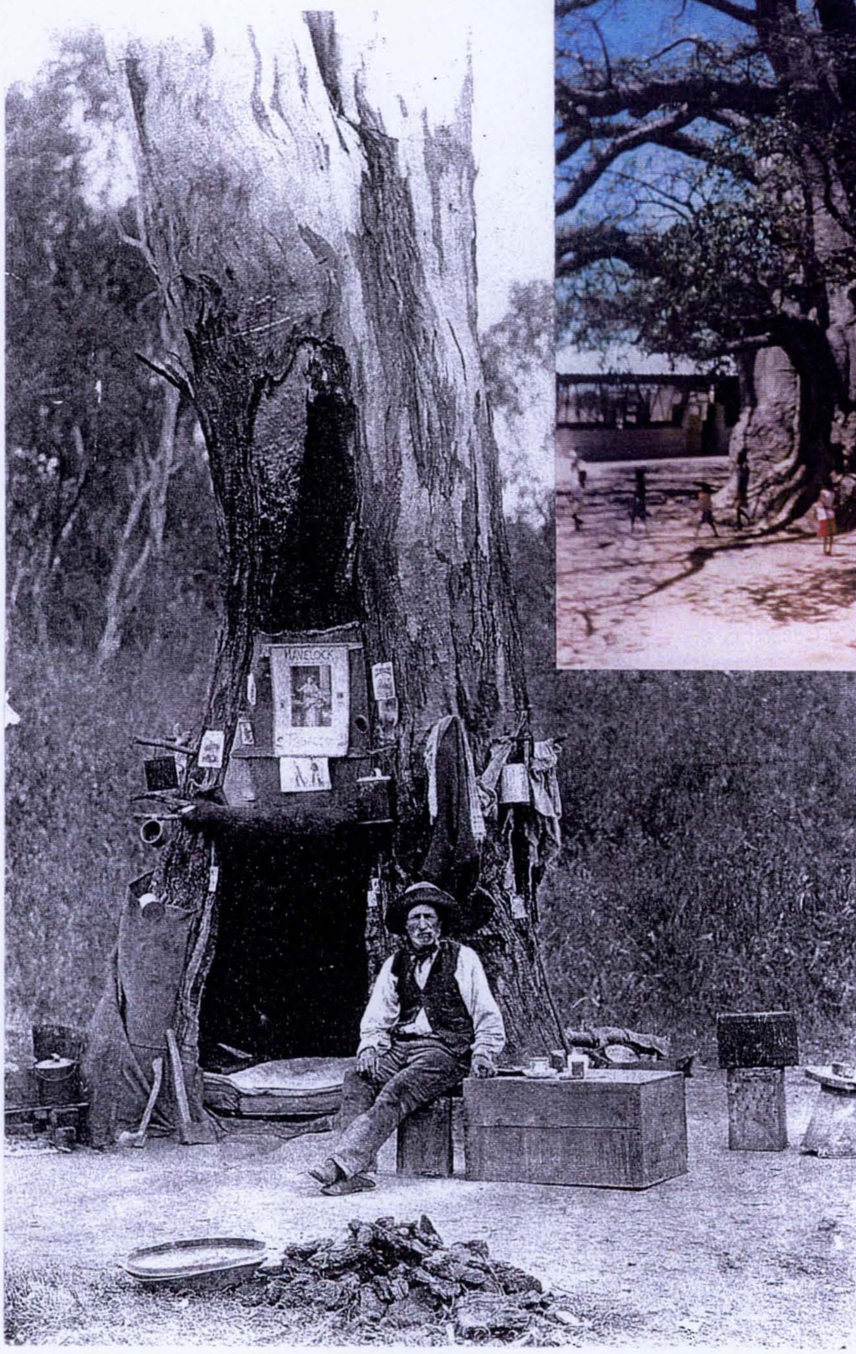
Related to this practice only in that the tree was used *in situ*, the construction of houses - or at least habitable spaces - in the branches of living trees was practised in both Britain and Europe over several centuries. The tree houses which were popular in some of the more affluent European gardens in the 16th and 17th centuries were however, intended more for relaxation and pleasure than for habitation. Thought to have originated in the Middle East, they were certainly popular in Persia in the 16th century (fig 2k/2 top right) while Michel de Montaigne (writing in 1580/81) describes ;-

> a little chamber made amongst the boughs of an evergreen tree of . . . luxuriant growth ' at Castello. ' It is entirely clipped out of the green boughs of the tree, so dense that the windows had to be made by clearing away branches. In the midst of the chamber, from pipes which are concealed, rises a fountain which is set in the middle of a marble table. By a certain device the water made music. [76]

In the engraving of a Dutch garden of the 17th century one 'bower' has columns supporting the outer edges of the floor, forming a second room beneath. Montaigne saw such tree houses in Germany and Switzerland and commented that ' the tree brought into this form is a very beautiful object.' [77]

Parkinson was awed by 'an arbour at Cobham in Kent, ... the goodliest spectacle that ever he had seen. It was made in three stories ... and was large enough for fifty people. ' [78] (similar to fig 2k/2 main picture)

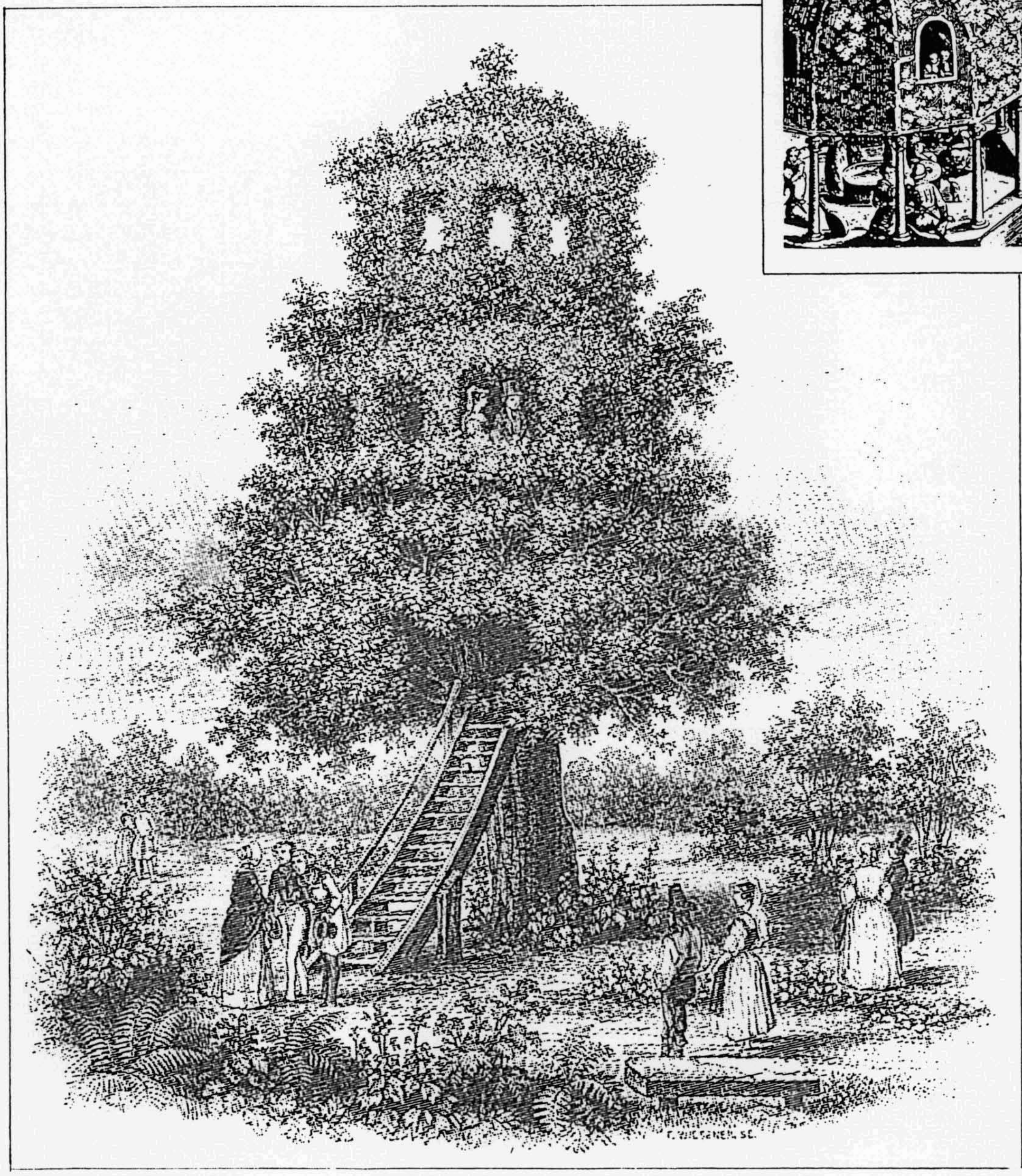




top right
the massive hollow trunk of this Baobab tree has been used as a prison and subsequently a chapel

lower left
early European settlers in Australia were sometimes driven to use hollow tree trunks for shelter

fig 2k/1



top right

tree houses such as these were popular in Persia and across central Europe in the 16th and 17th centuries

main picture

said to be ' The Maple of Ratibor' which drew crowds of admirers in Italy. Early 19th century

fig 2k/2

Such houses, essentially making use of the fact that the tree continued to live and retain its leaves, perhaps represent the art of topiary at its largest, if not its most elaborate. Other examples of topiary on an architectural scale included a ' Temple of living trees ', which was constructed for Catherine de Medici in the Tuilleries in the 16th century, [79] and ;-

> Bernard Pallissey, in Recepte Veritable, advises that young elms should be planted to form the outline of a small temple. The branches are to be lopped off at the proper height to form columns, and at the top and bottom the bark is slashed. As the tree heals, the protruding scar tissue forms capitals and bases. The branches that shoot out from above the capitals are then woven into a decorative frieze to complete the temple. [80]

Although not quite as strictly imitative of architectural forms as this, a similar structure is described and illustrated (fig 2k/3) in *Terence Conran on Design* ;-

> the enchanting eighteenth - century garden of Beloeil, near Brussels, consists of a series of interconnecting rooms created by lines of beech trees and hedging, once the setting for balls, fetes and outdoor entertainments. [81]

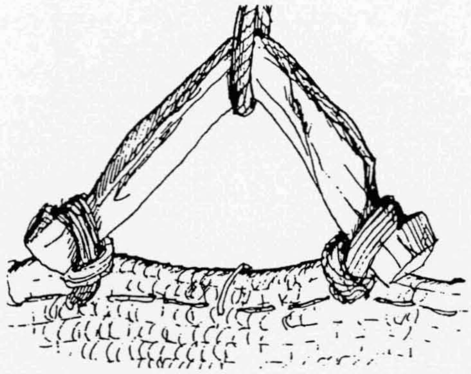
The more mobile forms of shelter used by nomadic and semi - nomadic peoples, while very different in structure, also make use of naturally occurring forms. Tents supported by a structure of simple forked sticks which can be driven into the ground, between which span horizontal lintels, are used in a variety of forms by the Saharan Tuareg. Naturally angled wooden knees are also used as a means of attaching their guy ropes to the woven or hide coverings (fig 2k/4).

In the Southern Hemisphere the Aboriginal Australian ' mosquito houses ' built in Arnhemland are also formed by driving forked sticks into the ground to support lintels. (fig 2k/5 above)

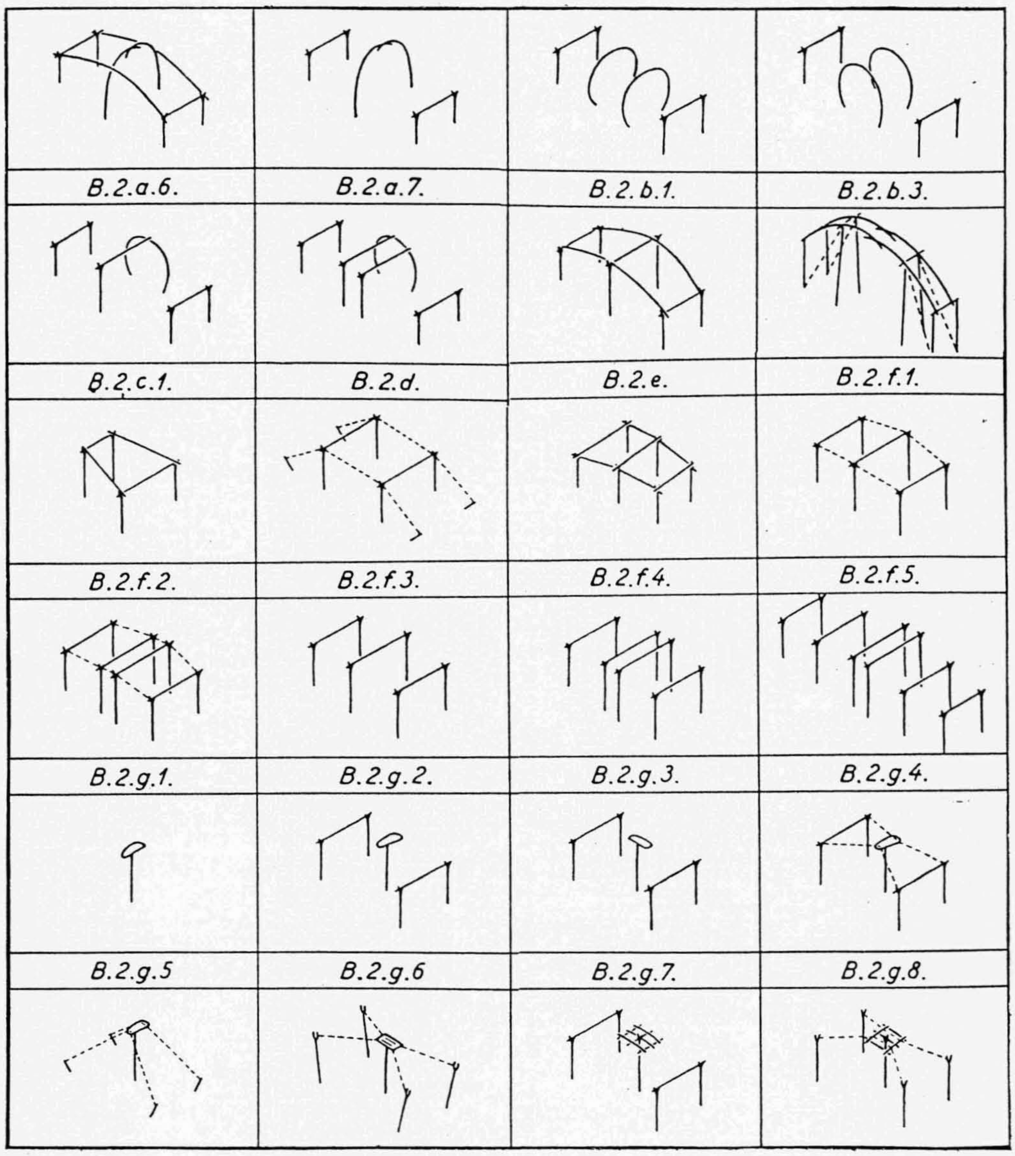
> The construction (of bark and poles) is entirely made from the local native tree, Stringybark (Eucalyptus tetradonta) . It is important that the materials can be quickly gathered, since... time is a critical factor in bush life, and since aboriginal tribes are traditionally mobile, the structure is not intended to last, in fact ... the house is meant to be degradable and to be renewed in whole or in part every few months.[82]

Nature strictly under control - the Gardens at Beloiel in Belgium. ' A series of interconnecting rooms created by lines of beech trees and hedging . . ' Eighteenth century

fig 2k/3

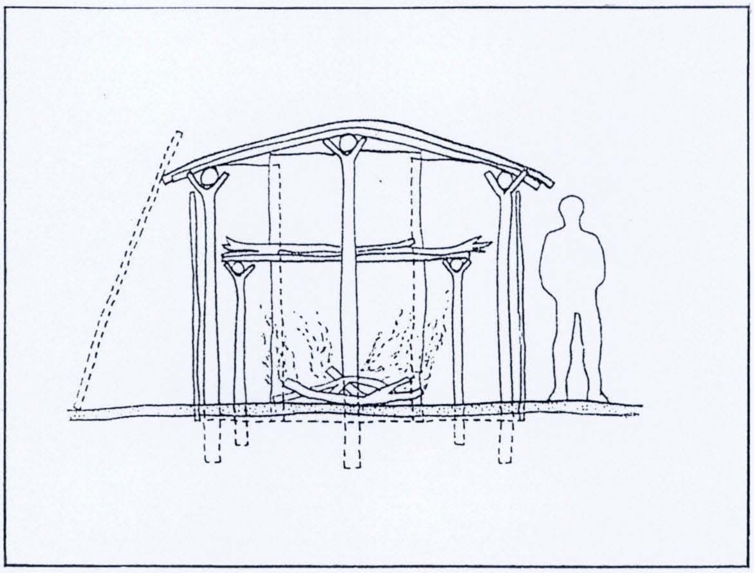


drawing of a typical wooden guy rope clevis, carved from naturally angled timber, and used to spread the load where a guy rope is attached to woven tent fabric.
Nomadic tent or ' Khyyma'



The many varieties of Tuareg tent were covered with either skins or mats. The wooden supporting frames for those covered with mats made extensive use of naturally forked uprights

Naturally forked tree trunks, driven into the ground, are used the world over to support roof beams or other horizontal members. This diagramme shows an aboriginal Australian 'Mosquito House'.It's frame is built from the trunks of the indigenous 'stringybark' eucalyptus while the walls and roof are skinned with inter-locking panels of the bark.



In Northwest New Guinea the trunks of the local trees (genus Pometia) are inverted to perform the same support function, the buttress like roots allowing their heads to be elaborately pierced and carved.

fig 2k/5

In these cases even the 'skin ' of the dwelling is naturally occurring, being made from flexible interlocking panels of springy bark, enabling these structures to deform rather than be destroyed by the violent winds which occur in this area of northern Australia.

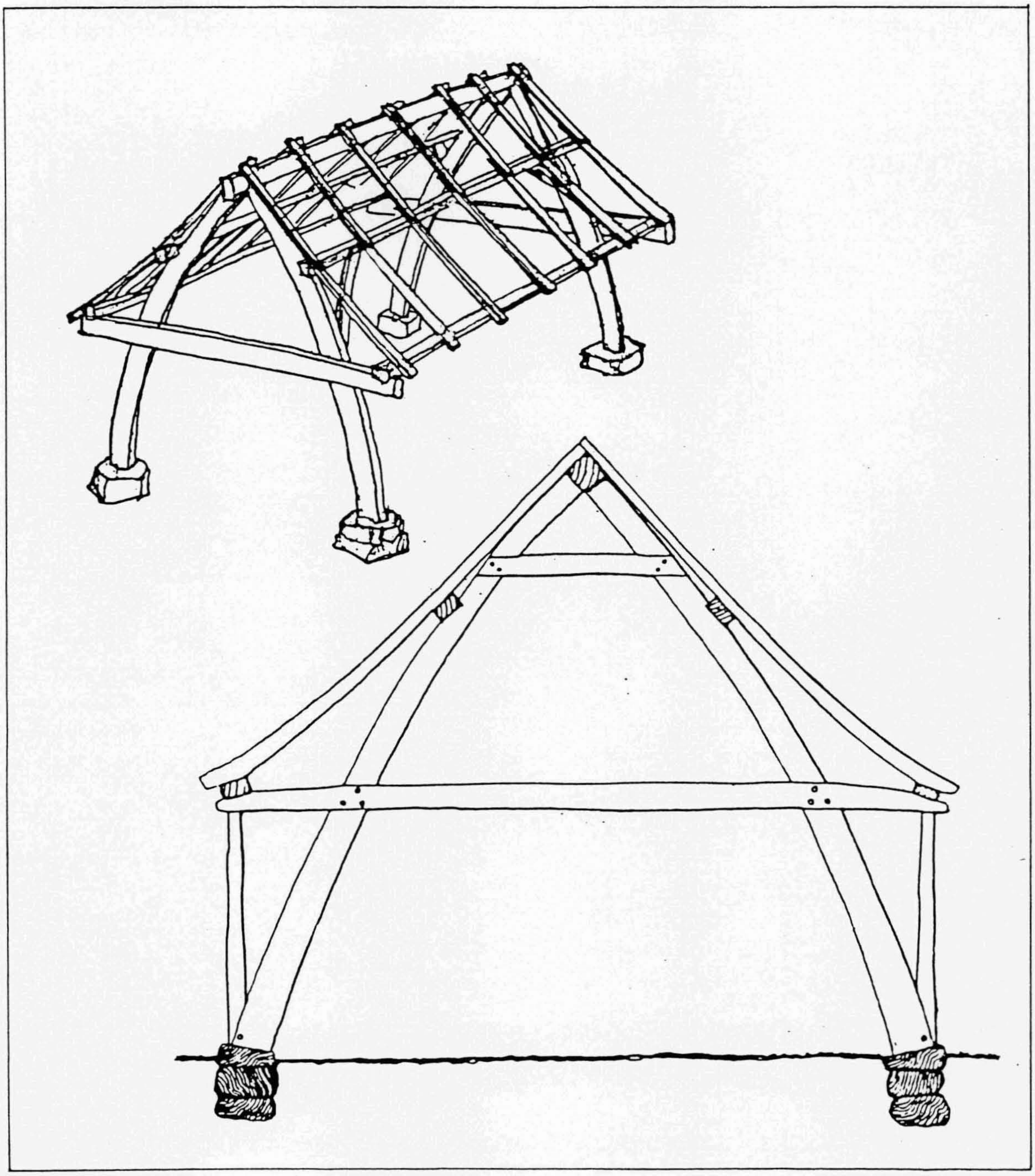
Also in the southern hemisphere, in Northwest New Guinea, the unusually pronounced buttress roots of local trees (*genus Pometia*), are used to perform a similar support function. These tree trunks are used inverted, frequently being elaborately carved (fig 2k/5 below)

In Britain in the middle ages, when wood was the predominant house building material, (and oak was so plentiful as to be known as ' the Sussex weed ') ;-

> The most primitive type of framed structure was with crucks. The idea was to find a tree with a natural curve and if possible to slice it along its length into two halves, which would ensure a symmetrical arch. If two or three more similar trees could be found, they would be used to make further arches, placed at intervals one behind the other, and linked horizontally at the top by a lighter piece known as the ridge pole. Fill in the interstices with branches, cover these with straw thatch or perhaps only with heather or brushwood, and you had your house. [83]

This primitive form, being used both for houses and for barns, was gradually refined, subsidiary timbers being added to create vertical walls and support the conventional roof timbers, but the fact that so comparatively many examples have survived for hundreds of years is a tribute to the basic soundness of this form of construction. (figs 2k/6 & 2k/7)

At the beginning of the 20th century, the German horticulturist, philosopher and designer of gardens Arthur Wiechula became interested in the possibility of growing useful structures. Aware of the natural inter-growth that appeared common among red Beeches in the north of Germany, he also remarked that a mature pine, blown over in a storm and having become wedged in the fork of a neighbouring tree, had evidently been kept alive via this contact, new shoots and annual growth being apparent at the lower end of the severed trunk, not normally the case in mature pines.

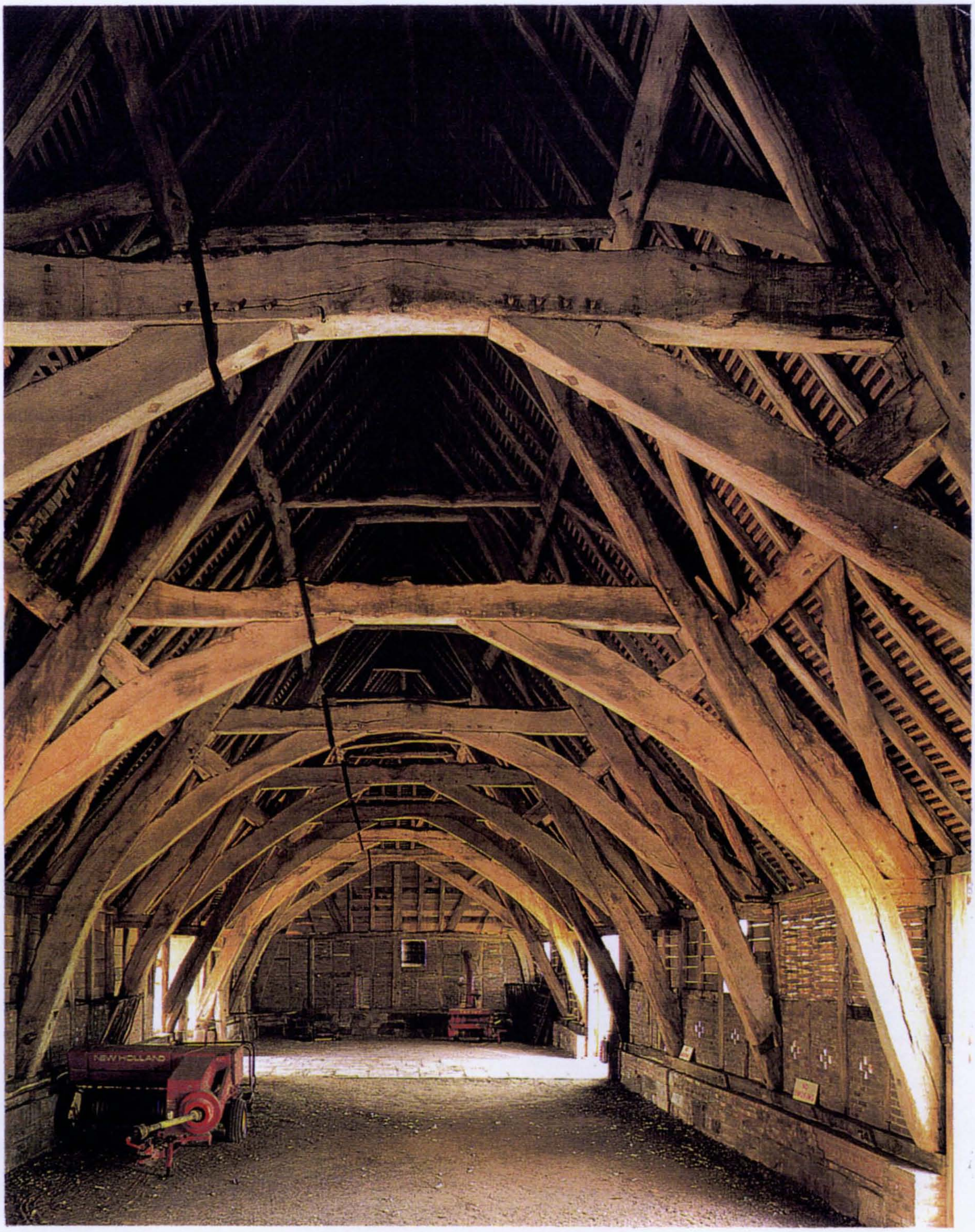


The CRUCK frame

' Pairs of naturally curved trees, split in half, (were) used as opposing rafters. Each pair of crucks was usually braced by a cross beam. As cruck construction developed, and houses became larger, these cross beams were extended to a point vertically above the base of the crucks, and connected to the base by posts.'

Shelter

fig 2k/6



Early 14th century barn at Leigh Court, Worcestershire.
'Medieval builders sough out trees with an elongated curve,
or cruck, from which timbers were cut, often halved,
and then hewn into paired blades.'

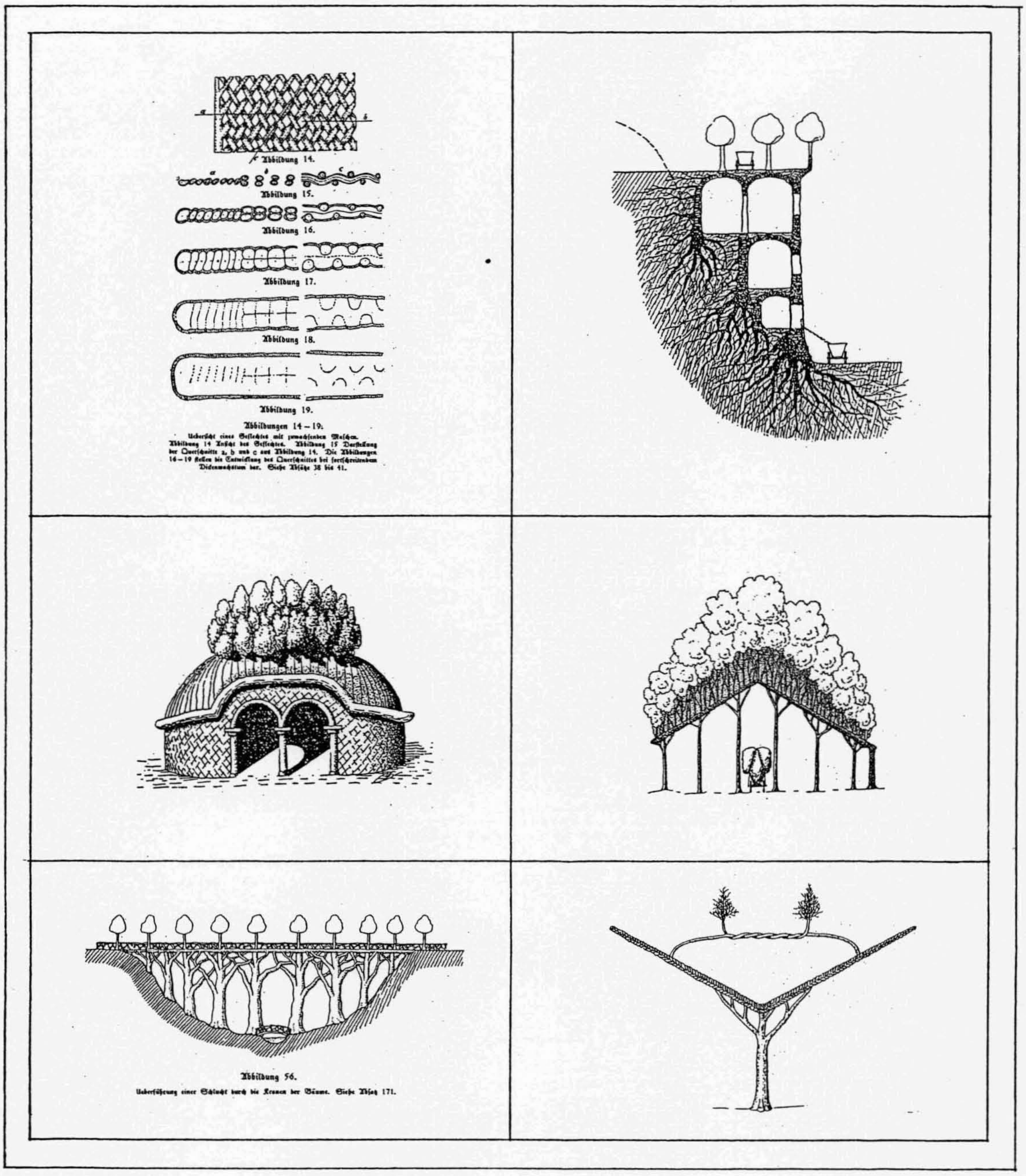
fig 2k/7

Experienced in the grafting and training carried out by gardeners, and the routine practice of hedge planting, Wiechula set out to explore the various possible planting and interweaving systems from which - he surmised - a variety of hedges, grown fences and even walls for buildings might be formed. (see Appendix C, and note that the possible success of this theory appears to be at least partially born out in the ' lattice 'columns of Axel Erlandson illustrated under ' Sculpture '). His ideas are described and illustrated in his book *Wachsende Hauser aus Lebenden Baumen Entstehend,* (*Growing Houses out of Living Trees*) which was eventually published in 1929. [84] In this he deals with all aspects of the design of grown structures such as single or double storey buildings suitable for farm, industrial or similar use. Double or even treble skinned walls are suggested as a means of frost proofing these buildings, the cavities either left as air pockets or filled with turf or pine needles (to heat such buildings, while not impossible, would present problems of damage to the living walls). Outdoor shelters, architectural components and engineering structures such as bridges are also proposed (see fig 2k/8). Irregularities and gaps in walls would, he predicted, even themselves out as growth continued, and the structures should be as waterproof as a good barrel (!) since the trees were capable of transporting water over considerable heights from roots to leaves.

Durability should be comparable with conventional buildings it was claimed, as trees have considerable lifespans, and even when dead, the timber could be weather - proofed as was already the practice with conventional timber buildings. A further advantage claimed for all living wooden structures was that they are ' producers ' rather than ' consumers ' of materials, as the roofs of such buildings should produce new growth which could be harvested and sold every six to eight years.

When originally put forward before the First World War in 1914, this radical idea found little favour. With the widespread poverty found in Germany after the war however, the relatively low cost of the initiation of such projects gave the idea greater impetus, and the ' Nature Construction Company ' of Berlin - Friedenau was formed. Over the next fifteen years at least eight patents were taken out by the company (see Appendix C), and a periodical magazine on the topic was published.

It appears however, that Wiechula's ' missionary zeal ' (and perhaps impatience) led the company into difficulty, taking on more (and more elaborate) projects than it could



Arthur Wiechula

These illustrations from Wiechula's ' Wachsende Hauser aus Lebenden Baumen Entstehend ' show (from top left) his proposal that closely planted woven stems would grow to form solid walls, a typical grown building, two living bridges, how tree roots could help to reinforce an embankment, an open sided farm building, and a shelter for a railway platform

fig 2k/8

successfully cope with. Many projects were consequently less than totally successful, the particularly severe winter of 1928 - 29 making matters worse. The company's contract for snow protection walls for the German Railways appears to have survived however, fig 2k/9 showing a small section of a surviving one of these. Finally however, the Company went into liquidation in 1929.

The idea was too good to die however and the Company, taken over by a new managing director Friedrich Herr, was re - named Neulohe Ltd. Under his leadership a more cautious and reliable approach was adopted, and one of the patented tools for quickly making joints where woven stems cross (now known as the ' Neulohe ' system) was developed. With the advent of World War II however, this Company also was forced to close. (The patented Neulohe tool is still in production by the Herran Tree Nursery in Austria, see fig 2k/9 top)

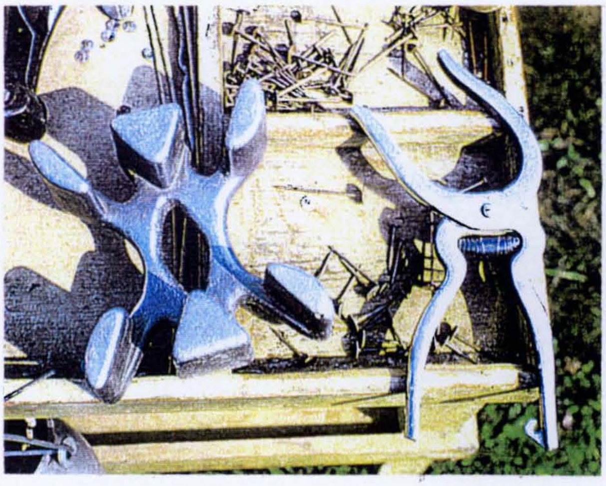
The most recent chapter in the story is that of Konstantin Kirsch, yet another enthusiast for this process of grown structures. His book *Naturbauten aus Lebenden Geholzen* [85] (*Natural buildings from Living Wood*) gives a description of his own experiments in growing trellis structures as well as in tracing the work of Wiechula, Herr and many of the others who have experimented in the production of more or less exotic grown structures.

On a smaller but equally eccentric basis, the continuing use of grown building components in America should not be overlooked. First started on any scale in the 19th century with the rise to popularity of the ' Adirondack ' rustic fashion, it appears to continue to this day in suitable situations. (fig 2k/10)

2L Review of Historical Context

The fact that an artificially lengthened arm may be used to increase the power of a blow has been put to good use by arable farmers world wide, wielding variously wooden, stone, or metal bladed picks. By utilising the strong 'V' forms found at various points on a growing tree, the problems inherent in attaching a blade at 90 degrees (sometimes in both planes) to the shaft of a tool was eased. As agricultural techniques improved, other parts of

The cast aluminium positioning jig, originally patented by Wiechula's company, was later developed - together with the pins, washers and the insertion pliers - as ' The Neulohe System'
It remains in production today



A surviving section of the snow protection lattice fence grown in the 1920's by Weichula's ' Nature Construction Company' for the German Railways

fig 2k/9

The 'Adirondack' tradition of the use of rustic timber in buildings, as in furniture, continues today. Note the use of such timbers for the veranda handrail supports and in the construction of the staircase of this forest cabin, built by a retired engineer in California, USA

fig 2k/10

the tree were used in the construction of the primitive breast plough, and eventually the more sophisticated horse drawn implement (fig 2f/2)

Shepherds have traditionally achieved their crooks by carving the heads from the section of the trees trunk from which the branch originally extended (fig 2e/1) while herdsmen, needing to control rather than rescue their animals, developed the art of hedge laying as a durable and effective means of enclosing space (fig 2d/1)

The traditional means used to create living structures have varied widely with need, from the creation of useful; barriers by 'hedging' to the largely decorative and symbolic systems of pleaching, topiary etc.

According to Thomas, in the 16th, 17th, and 18th centuries, the treatment of trees in Britain (like horses and children !) ;-

> fluctuated according to changing educational fashion...timber trees were to be pollarded... trees preserved for ornament were brought severely under control by gardeners who clipped, pruned and manicured them...' The luxuriancy and vigour of most healthful trees ' declared John Lawrence in 1726 ' is like the extravagant sallies of youth, who are apt to live too fast, if not kept within due bounds, and restrained by seasonable corrections'. [86]

By 1776 though, under a more relaxed regime, Alexander Hunter was to write ;- ' Everyone who has the least pretentions to taste must always prefer a tree in it's natural growth. [87]

Coppicing (and it's close relative pollarding) differ from both hedging and topiary in that the resulting young growth is to be harvested, proving a continuing supply of raw material. Both hedge laying and coppicing however, take account of the ability of the living tree to survive a severe attack on it's growth above ground, provided that the root system is well established and is undamaged by the process. Topiary is another example of this ability. Having largely gone out of fashion by the late 18th century, it made something of a comeback in Britain in the late 19th and early 20th centuries.

As the study of botany in Europe grew in sophistication in the 18th and 19th centuries, the cultivation of fruit trees, itself an ancient art in the Middle East, became widely popular. The trees were trained two dimensionally against sun (or artificially) warmed brick walls or in free standing three dimensional forms, as decorative as they were useful, displaying their fruit for the pleasure of their owners, and for the admiration of his guests (fig 2c/1).

Prior to all these developments, hunter gathering societies had used similar techniques for the attachment of blades to shafts as those used by early farmers. The weapons thus created had been used for hunting, in warfare, or sometimes simply as symbols of authority for ceremonial use. Later (figs 2e/5 & 2e/8) even societies with well developed technologies in metalworking continued to select particular natural wooden shapes to use as the handles of their woodworking tools. As late as the twentieth century, when an angled handle or a curved head was required on a wooden stick for walking or playing games (Bando in Wales, Hurley in Ireland, fig2e/2), appropriately shaped growth – either naturally occurring or especially trained – has been chosen for it's combination of strength and shock absorption.

On a larger scale, the builders of both wooden vehicles and vessels have made extensive use of the inherent strength of naturally grown wooden components to achieve the curved forms they sought. To make efficient passage through water, the hull of any vessel requires a degree of three dimensional curvature, as the builders of even the apparently crude dugout canoe preserved in Henley-on-Thames appreciated (fig2j/2). As can be seen, a trunk having gentle curves was selected for the construction of this vessel, enabling the shipwrights to produce a rounded and uplifted prow, avoiding the less desireable and less durable section of short grain which would have otherwise have been inevitable. (The size and form of such a trunk may well have been similar to those which would have been selected for the building of a 'Cruck' dwelling.

As the size of vessels increased, the size of the grown forms used became smaller relative to the whole. These 'compass timbers' were normally of carefully selected natural growth, although there appears to have been some attempt at artificial generation (fig2j/4). More recently with advancing technology, it has become possible to achieve these curved forms either by steam bending or by laminating.

The need for shaped timbers in farm waggons is less evident, springing as it does merely from the requirement to combine strength with minimum weight and a visually elegant appearance. (As with any hose drawn vehicle, the elimination of unnecessary weight is of prime importance, allowing a greater useful load to be drawn.) These factors, combined with the need for durability and manoeuvrability, dictated the shapes of the timbers used. And finally, the farm waggon, besides transporting a variety of loads under frequently adverse conditions, was an object of pride both to the owner and to the builder, having to reflect their respective skills and their status in the community.

In the construction of tents and other mobile or temporary forms of shelter, the natural wooden crutch has been commonly used as a means of supporting horizontal timbers (figs 2k/4 & 2k/5) while the 'Cruck', formed from halved pairs of curving tree trunks, is used in one of the most primitive forms of timber framed permanent buildings (figs 2k/6 and 2k/7). In 'The English House Through Seven Centuries' Olive Cook suggests that the upturned boat shape created by the use of these timbers ;-

> ... points to the conclusion that the timber - framed structure represents the survival of an ancient tradition preserved in it's stone form in the treeless expanse of the Dingle Peninsular. Professor E Estyn Evans does indeed suggest that the primitive wattled dwellings of Ireland, which were contemporary with the (stone built) Gallerus Oratory, were supported by crucks, or pairs of curving timbers joined together at the top. [88]

In the early 20th century, Arthur Wiechula's proposal that buildings – as well as other engineering structures – might be achieved through the planting and training of growing trees, may perhaps be seen as an unlikely but ingenious reversion to a combination of earlier practices.

As for furniture, in Britain the use of natural forms as a means of solving practical problems has been evident in many of the more economically deprive areas (figs 2g/17 – 22). This was also the case in Australia, from the setting up of the first penal settlement in 1788 onwards. Conditions here were if anything even harsher than in rural Britain, and the creation of viable settlements was not eased by the fact that the enforced immigrants were in general drawn from urban rather than rural situations, with few relevant practical skills (fig 2g/31). Not for perhaps a hundred years would this new society feel sufficiently well established and confident in itself to look upon the quaint 'Rustic' style as desireable (see fig 2g/32).

In the very different affluent world of British society however, the fashion for 'Rustic' furniture appeared from about 1730 onwards, being one of several styles which became popular at this time ;-

> All conjured up remote or exotic places and times, and are best understood when viewed as kindred variations on the picturesque, an aspect of romanticism that had more to do with scenery and picture making at this early stage than with profound emotion. [89]

In many areas of life, there emerged a growing interest in the 'exotic', particularly in this case things Chinese. ' The earliest use of twiggy rustic furniture in sophisticated settings occurred in China, where the tradition goes back hundreds of years. ' [90]

Popularised by the appearance of design suggestions in many of the published directories, the style was however only considered 'proper fro Garden Seats, Summer Houses, Hermitages, Cottages, etc ' [91] In these situations the use of tree branches as they had actually grown was thought appropriate, since these fashionable gazebos or hermit's huts would in any case have been built using such materials. It was also felt – perhaps optimistically – that the construction of such furniture should not be difficult, Robert Manwaring reassuring his readers ' I have made it my particular study to invent such Design as may be easily executed by the hands of a tolerable skillful (sic) workman.' [92]

Only occasionally though, did the popularity of the style – and the availability of sufficiently able craftsmen – lead to it's use in more sophisticated circumstances (fig2g/14, equally a demonstration of the skill of the carver.)

Significantly, however, this period coincided with the birth of the Industrial Revolution, and with it the appearance in the nineteenth century of the newly affluent middle-class – the first consumer society. Able to move out of town to the leafier suburbs and the country, these consumers continued to demand furniture in this 'twiggy' style, technology having by now advanced sufficiently to enable this demand to be met with rather more durable products. With the newly developed coke process, elaborate pseudo-natural forms could be reliably mass produced in cast iron.

In the nineteenth century fashion in the USA tended to follow that in Britain, and so, 'By the second quarter of the nineteenth century, rustic work began to appear in places of public assembly, highly social environments where Americans left the workaday world behind them. '[93]

Previously, appropriately furnished 'rustic' cabins had existed in mountainous regions for many years, but now their popularity flourished as city workers sought an escape from the overcrowded towns and cities. Particularly was this so in the Adirondack region, to the extent that the style became widely known under this name. Unlike the situation in Britain, the continuing wide availability of suitably 'rustic' materials has allowed enthusiasm for this style of furniture to continue on a limited scale to the present day.

Examples of furniture which has actually resulted from a pre-planned intention to grow it are few. Current research has located three only in the USA and one in Thailand, none of which are on a significant scale. Krubsack's chair may be regarded as a publicity stunt, while Erlandson's is one of a range of sculptures he developed initially for his own amusement. Only Reames, currently offering his products for sale, can be said to have approached the growth of furniture with anything like serious intention, although his motivation appears to be a combination of perhaps mystical/ecological concern and commercial opportunity. Boonnark's approach has more to do with a wish to provide growers and carvers with an occupation during slack periods than with commerce, although his motivation is certainly ecologically benign.

As with any other method of producing furniture, growing it will have an influence on it's appearance. It is only necessary however, to examine the few examples cited above to see that this influence need in no way be regarded as a 'straight jacket'. While each of these examples was grown from several saplings, the chairs of Krubsack (2g/27) and Erlandson (2g/28) demonstrate very different approaches to the problem – one voluptuously curved, the other angular and cross braced. And while the illustration of Reames' design takes a similar route to Krubsack, Boonnark's Guava chair (2g/30) is considerably more 'rustic' in appearance and approach than any of the others.

Further, the many historic and modern examples shown of chairs made using grown components only (e.g. fig 2g/34), demonstrate the visual versatility of the system.

3 THE CONTEMPORARY CONTEXT

The environment & **consumerism** in the **20th/21st centuries**

> *'Only through a re-evaluation of industrial and agricultural practices, and exploring the synergies between the two, will there be a chance of satisfying our aspirations without consequent terminal damage to the environment and ultimately ourselves.*
>
> T Smit, *Eden,*
> Bantam Press, London, 2001 p174

3a Introduction

In the early twenty first century, the motivation for the current research is concern for the environment. Ever increasing levels of technological expertise appear to offer solutions to more and more of the problems we face. Yet as our expertise (and our populations) increase, so too do our global problems, caused to some extent at least by our own activities.

The internet has increased our ability to communicate across the globe as never before, and with minimal pollution. Yet in spite of - or perhaps because of - this, we increasingly transport both ourselves and our goods over previously impractical distances, at ever greater speeds, and with ever increasing pollution.

We recognise the obscene imbalance between the living standards of the developed and the developing world, [94] yet seem unable, or perhaps selfishly unwilling to redress it.

These and similar factors have prompted the current research, suggesting as it does an example of a method of responding to society's apparently insatiable demand for products to consume - while attempting to avoid any threat to the 'ability of future generations to satisfy their needs'.

3b Environmental concerns

We are now only too aware of the hugely complex nature of the earth's ecosystem, in which it is evident that each component influences, and is influenced by, the others. Indeed, the ' Gaia ' hypothesis, put forward by the British scientist James Lovelock, [95] in 1979, proposes that the entire biosphere behaves as one giant living organism. This organism, Gaia suggests, has thus far proved able to adjust itself to maintain its natural balance, despite the various environmental changes which have occurred over time.

i) THE POPULATION EXPLOSION

The accuracy of the Gaia hypothesis, and whether or not the system will in the future be able to sustain itself in balance, despite the rapid increase in world population, is currently uncertain. The population explosion is a fact - ' Since 1970, human population has grown 8-fold; it is now approximately 5.3 billion and is anticipated to peak at between 10 and 15 billion late in the twenty-first century. ' [96]

ii) ENVIRONMENTAL IMPACT OF THE TECHNOLOGY EXPLOSION

With this increasing - and increasingly technologically advanced - population, have come increased industrial activity, and with it's advantages, it's ecological problems ;-

> It is undeniable that modern technology has provided enormous benefits to the world's peoples: a longer lifespan, increased mobility, decreased manual labour, and widespread literacy, to name a few. Nonetheless there is growing concern about the relationships between industrial activity and Earth's environment. These concerns gather credence as we place some of the impacts in perspective. Since 1700, the volume of goods traded internationally has increased some 800 times..... In the early 1900's, production of synthetic organic chemicals was minimal; today, it is over 225 billion pounds per year in the United States alone. Since 1900, the rate of global consumption of fossil fuel has increased by a factor of 50. Together with these obvious forcing functions, several underlying trends deserve attention. The first is the diminution of regional and global capacities to deal with anthropogenic emissions. For example carbon dioxide production associated with human economic activity has grown dramatically, largely because of extremely rapid growth in energy consumption. This pattern is in keeping with the evolution of the human economy to a more complex state, increasing growth

> in materials use and consumption, and an increased use of capital. The societal evolution has been accompanied by a shift in the form of energy consumed, which is increasingly electrical (secondary) as opposed to biomass or direct fossil fuel use (primary), the result being the now familiar exponential increase in atmospheric carbon dioxide since the beginning of the Industrial Revolution. Thus human activities appear to be rapidly consuming the ability of the atmosphere to act as a sink for the by-products of our economic practices. [97]

The change from primary to secondary sources of energy is crucial ;-

> If wood.... hydro power, wind or solar energy itself is used, the energy has either been converted from sunlight almost immediately, or has been stored for at most a few years. These latter sources of energy are renewable ... [98]

iii) POPULAR AWARENESS

Worldwide awareness of these problems - particularly industrial pollution, global warming, and the gap between developed and developing nations - has been heightened over the last half century by a series of events, eg ;-

1952 the London ' Smog ' (which claimed 4,000 lives)

1962 the publication of Rachel Carson's ' Silent Spring ' (in which the dangers to the ecosystem posed by the then widely used insecticide DDT were graphically reported) [99]

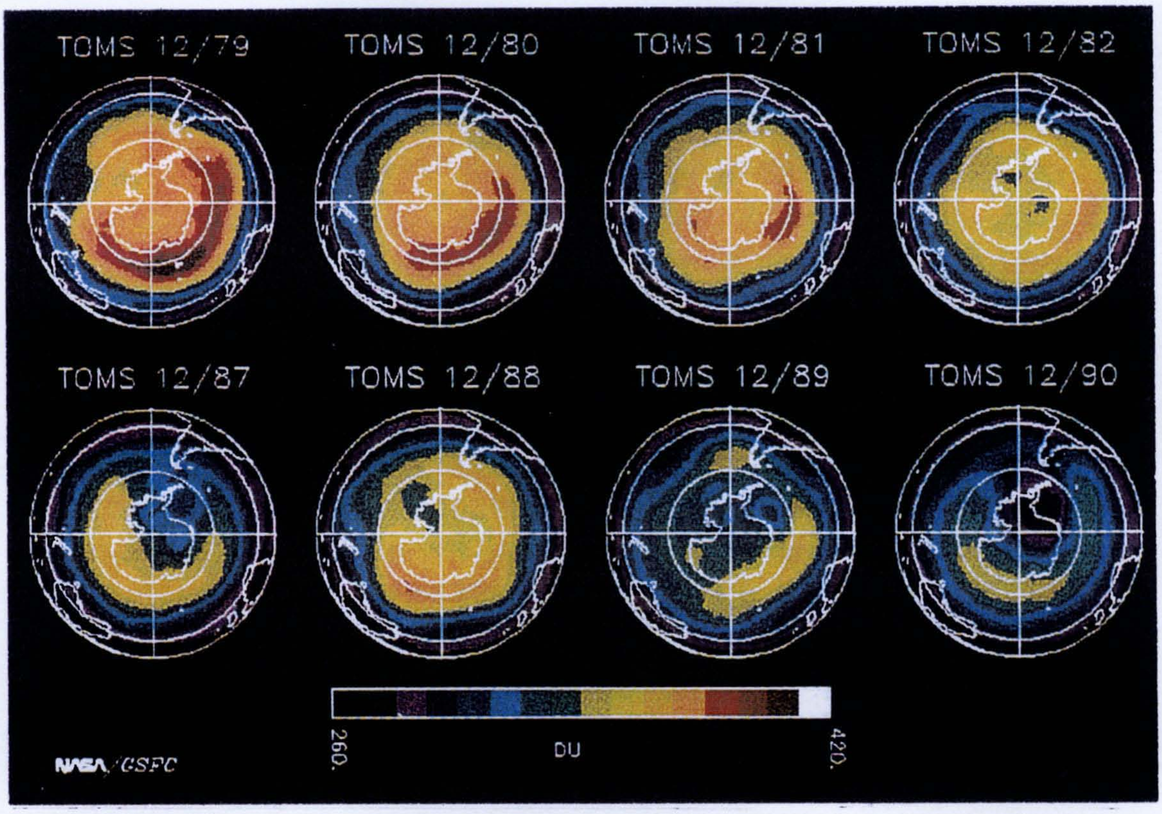
1984 the accidental release of deadly gas from the Union Carbide plant at Bhopal (2,500 dead) [100]

1985 the confirmation of the decrease in the Ozone layer, (fig 3b/1) emphasised by the rapid increase in the size of the hole over the Antarctic, (posing a variety of threats to animal and plant life).

1986 the nuclear reactor disaster at Chernobyl (estimates suggest that 34,000 could die over the next 40 years) [101]

iv) INTERNATIONAL RESPONSES

The combined result of these and other similar disasters has been a sequence of international efforts to understand the problems, and to work out strategies to tackle them.



above
decreasing levels of ozone (shown in these satellite images in red and yellow) over Antarctica, 1979 - 90

left
recycling at it's most basic. This is the Smokey Mountain rubbish tip at Manilla in the Philippines

Prompted by the Norwegian Government, in 1983 the United Nations set up the ' World Commission for Environment and Development ', to be chaired by (and it's report named after) Dr Gro Harlem Brundtland.

> After three years of intensive work and countless hearings in practically every corner of the globe, the commission published it's report, Our Common Future, which must rank as one of the most important documents of the decade.... A new term was used to help bridge the gap between environmental and developmental aspirations: sustainable development. [102]

Sustainable development was defined as *'Development that meets the needs of the present without compromising the ability of future generations to meet their own needs'.*

In 1987, prompted by the discovery of ozone depletion, (caused largely by the use of CFC's which persist in the upper atmosphere) the ' Montreal Protocol on Substances which Deplete the Ozone Layer ' was signed.

> The thirty six signatories, who accounted for over 80 per cent of total consumption, agreed to reduce their consumption of the five major chlorofluorocarbons and three important halons with effect from January 1989. [103]

The Brundtland report led - in 1992 - to the convening in Rio de Janeiro of the ' UN Conference on Environment and Development ', mandated to prepare a Programme of Action on Environment and Development. Referring to the 21st century, the programme was entitiled ' Agenda 21 '.

> Agenda 21, a huge document of more than 800 pages ..... covers all conceivable topics from overcoming poverty, biotechnology, technology transfer, urban renewal and financial means to implement all this .. but in no way does it address the paramount global problem, the unsustainable lifestyles prevailing in the North. [104]

And from the same author, but quoted elsewhere, an illuminating statistic ;-

> Actually we are more than ten times better at wasting resources than at using them. A study for the US National Academy of Engineering found that about 93 per cent of the materials we buy and ' consume ' never end up in saleable products at all. Moreover, 80 per cent of

> products are discarded after a single use, and many of the rest are not as durable as they should be. Business reformer Paul Hawken estimates that 99 per cent of the original materials used in the production of, or contained within, the goods made in the US become waste within 6 weeks of sale . [105]

In physical quantities ' It has been estimated that the average family in the technologically developed countries throws away some 16 to 20 tons of garbage and waste a year.' [106]

In his introduction to the discussion paper ' Less is more ' Andrew Summers reminds his readers - now accustomed to such lifestyles - of von Weizsacker's thesis ;-

> Environmental commentators argue that if we are to continue to demand the same quality of life as we currently enjoy then we need to be four times more efficient in our use of resources. In fact, some leaders in the field estimate that a factor 10 improvement in efficiency is required. Even if the more conservative estimate is taken, it is clear that we need to seriously examine the environmental resource and disposal implications of our products and services. [107]

v) NATIONAL & COMMERCIAL RESPONSES

In addition to these multinational efforts, individual nations have all approached the problems of sustainable design and development from their own particular standpoints, as have government agencies, academics, industrialists, and industrial designers.

A Design Council discussion paper, aimed at British Industry and published in1997 states ;-

> No longer is the environment simply a resource to be squandered or a sink for waste. Companies are now seeing it as an opportunity and as a valuable asset. In short, the view of the environment as a business constraint has undergone a paradigm shift and it can now be demonstrated to provide opportunities for innovation and competitive advantage. The shift is one of the most significant changes in business philosophy of the last 50 years. [108]

Predictably, large organisations in the manufacturing or supply industries, have tended to move slowly - if at all - and for commercial reasons, or in response to legislation.

It is also noticeable that in general it is those companies most likely to be criticised in the debate - that is to say those most concerned with the production and consumption of (currently non - renewable) sources of energy such as oil - that have been the first to engage.

The American electronics giant AT&T, having seen commercial advantage in ' being green, and being seen to be green ' have produced a comprehensive textbook entitled ' Industrial Ecology '. [109] Also in the USA, the wireless and fibre optics group of companies Lucent Technologies, stated in their 1996 ' Second Nature ' environmental report that ' As a goal, Lucent aims to develop and apply Design for the Environment Criteria for all its operating units by the year 2000.' [110]

In the Netherlands, where public environmental awareness is perhaps at it's highest level in Europe, the Dutch company Philips Electronics NV have responded to increasing public concern by playing a constructive part in the environmental debate, publishing their EcoDesign guidelines under the title ' Point of no return '. [111] In Italy Kartell SpA, a major consumer of oil based polymers in the production of domestic furnishings, have similarly sought to improve their public image by - for example - co-sponsoring ' The Solid Side ' project (see under The Blue Sky eco-debate, p77).

Problems such as those resulting from increasing demand for energy, may of course be tackled in a more environmentally benign way by reducing demand. Under the heading of ' Buying and Selling Efficiency ' von Weizsacker describes how, as long ago as 1980, Public Utility Commissions in the United States instituted a ' Negawatt Revolution '. In response to a change in policy which allowed both producer and consumer to benefit financially, The Pacific Gas and Electric Company of Northern California ' ...started investing strongly in end-user efficiency in order to cut customers bills by saving electricity more cheaply than it could be produced. ' [112]

As for the furniture industry, the behaviour of two companies, one on either side of the Atlantic, may be taken as typical of the responses of the environmentally responsible furniture manufacturer. Both work in the contract field, and are highly regarded for their design standards. The American manufacturer Herman Miller has taken the long term view. Introducing his Company's environmental report for 1999-2001, Micheal A Volkema has said ;-

> Sustainability may be a new word to many of us, but it is our future, not just as a business, but as a planet as well. We must stop the cycle of " take-make-waste. " For Herman Miller that means a long-term commitment to becoming a sustainable business. We have a long way to go. The journey is, in many ways, just beginning. [113]

In statistical terms, the Company has ' been very aware of environmental issues for some time and has reduced the quantity of waste sent to landfill from 60% in 1994 to 18% in 1995. The company is also aiming to use Life Cycle Analysis in all new product development activities, reduce material waste by 30%, and halve the volume of packaging materials for finished goods.' [114] This reduction in packaging has now been attained by the adoption of returnable pallets for goods 'in', while products 'out' are predominantly delivered protected by re-useable blankets and shrink wrapping. In terms of individual products, Miller's environmental report quotes the recycled content of four of their work chair models as ranging from almost 42 to 77% by weight. Fourteen ' Honours earned ' are quoted in their report, among them two from ' Fortune ' magazine - who ranked them number three in 1999 for social responsibility among America's most admired companies, having cited them as one of the nation's 10 most environmentally responsible corporations in 1993.

In Germany, Wilkhahn Gmbh, also the makers of a range of high quality contract furniture, has for many years pursued an environmentally responsible policy. In a booklet entitled Wilkhahn Green published in 1995 [115] the company describes its total commitment to ecological attitudes which cover its factory buildings, staff, working practices, products, packaging etc. In a new twist to it's 'company car ' policy, staff are financially encouraged to prefer public transport wherever possible. Products are made using as few different materials as possible, and components which are joined using dry connections for ease of replacement or recycling (see fig 3b/2). All materials used are either recyclable or - as a last resort - may be disposed of with minimal environmental impact. (Wilkhahn insists however, that its sales depend on the quality of it's products rather than on its environmental policy)

Both companies are proud of the environmental aspects of their factory buildings.

The PICTO swivel chair from Wilkhahn, an environmentally aware manufacturer. ' Economical on the quantity and types of materials, using only pure materials, which are recyclable and with easily demountable joints.'

fig 3b/2

vi) THE RESPONSE OF THE DESIGN COMMUNITY

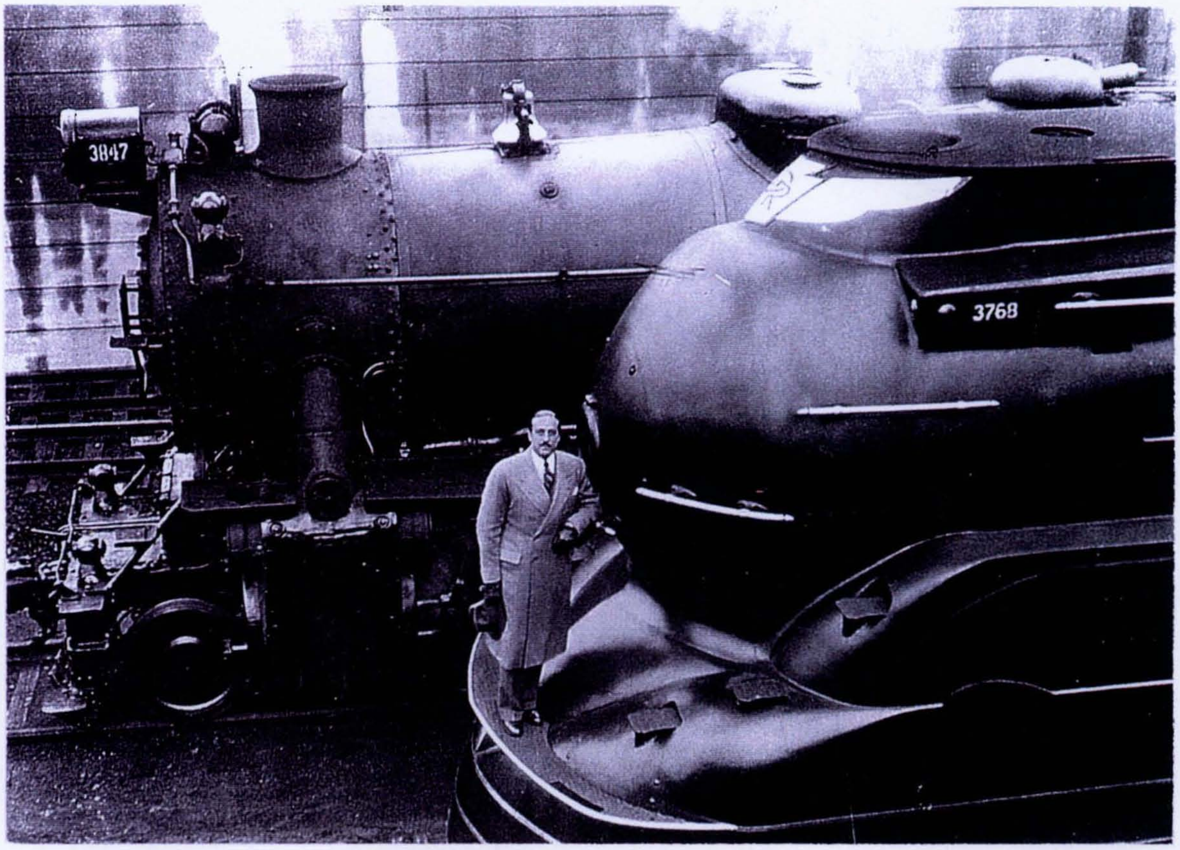
Despite the foregoing examples, the active response of the design community as a whole has been slow, perhaps because the job of the industrial designer has traditionally been assumed to be to increase sales in a competitive market. Starting in 1934, Raymond Loewy's office, ' produced icons of consumption ' [116] aided by Loewy's ' unerring vulgar taste '. [117] Since then, successful designers have prospered in the rapidly developing consumer society, where ' built in obsolescence ' and regular changes in fashion have helped to guarantee their continuing employment (fig 3b/3).

As environmental concerns grow however, this situation is gradually changing. The materials and processes used in production, previously assessed simply on the basis of financial cost, will increasingly be measured also in terms of sustainability. Government, commercial and public pressure are beginning to have an increasingly powerful influence, and designers are slowly beginning to accept the need to respond.

To date however, the design profession has tended to confine it's activities to theoretical debate, typically at conferences such as that convened by ICSID (The International Congress of Societies of Industrial Design) in Toronto in 1997 under the title of ' The Humane Village '. In Britain the debate continues within the academic world. Organisations such as The Centre for Sustainable Design, set up with a government subsidy in association with Surrey University, has convened a series of international seminars under the general heading ' Towards Sustainable Product Design '. (The commercially run Centre for Alternative Technology at Machynlleth has also been active in bringing ecological problems to the attention of the general public, as has the O_2 organisation in the Netherlands.)

The fact remains however, that all these activities have had minimal impact on events in the 'real ' world outside ;-

> In the final chapter of Agenda 21, which addresses the question of implementation, various groups whose participation is deemed crucial for achieving sustainable development are named. These include women, youth, indigenous people, farmers, and labor unions. Nowhere are designers mentioned. Once again design remains invisible because the design professions have not done



above Raymond Loewy with his 1936 redesign of the Pennsylvania Railroad locomotive. (note footsteps and handrails !)

below Built in obsolescence - John Salts ' 58 Ford without a Hood '

fig 3b/3

> an adequate job of explaining to themselves and others the powerful contribution they could make to the process of creating a sustainable world. [118]

In the article from which the above quotation is taken, Margolin further argues that ' with the exception of Papanek, (Buckminster) Fuller and a few other critics and visionaries, designers have not been able to envision a professional practice outside of the consumer culture.' [119]

Few practicing designers have tried. Far from attempting to engage with the practical problems faced by society, the majority of the best known ' Names' in the profession have continued to produce designs which vary in appearance only. While most of the furniture sold to the general public continues with little fundamental change to either its form, function, or manufacturing methods, ' High style ' furniture continues to be little more than a form of sculpture.

Following the fall of the Berlin Wall in 1989, with the accompanying sense - in Europe at any rate - of liberation from oppression, an exhibition was organised in Paris in 1991, to celebrate ' The New Design ' from around the Continent. As shown by the items of furniture illustrated in Clare Downey's ' Neo Furniture ', the exhibits formed an agglomeration of eccentric structures. Amongst this sizeable collection of internationally recognised practitioners, not one shown appears to have tackled what might be identified as a real problem - ecological or other. Indeed as Downey states ;-

> There is no compulsion in designers of the postwar, post-industrial post modern Europe to work in natural materials in order to simulate nature. In stead the materials (they use) are often the signs of a society that destroys and wastes. [120]

There does however exist a small body of ecologically aware design thought and action. Victor Papanek - who might be termed the ' Founding father ' of the ' Down to Earth ' school of design, was certainly an early voice raised in the debate (although as Margolin points out ' he may have taken some of his points from an earlier diatribe on a similar theme by journalist Vance Packard '. [121] In 1972 Papanek's ' Design for the Real

World ' had a considerable impact on design student's thinking - though little effect in the developed world - at the time. Encouraging designers to work on practical problems, his attack on their current work was scathing ;-

> ... by creating whole new species of permanent garbage to clutter up the landscape, and by choosing materials and processes that pollute the air we breathe, designers have become a dangerous breed. [122]

Papanek has continued to argue his case over the years, teaching, designing and publishing his thought provoking books. His 1995 ' The Green Imperative ' examines a broad range of design issues, but his concern for the environment remains central. Providing numerous examples, he discusses the ways in which the buildings and artefacts with which we surround ourselves can and must satisfy, nurture and stimulate us and our children, while respecting nature's laws and preserving the balance of our ecosystem. There is much to be done ;-

> It is vital that we all - professionals and end-users - recognise our ecological responsibilities. Our survival depends on an urgent attention to environmental issues, but even now there still seems to be a lack of motivation, a paralysis of will, to make the necessary radical changes. [123]

There have been a few contributions from other established and eminent practitioners,. One example of the type of practical solution put forward by such designers is the ' Closed circle ' concept, proposed by Dieter Rams - well known for his design work with the German company Braun Gmbh - in a lecture delivered on the occasion of the RSA Student Design Awards in 1999 ;-

> The 'purchase - attraction ' aesthetic upon which design today is almost exclusively based, and which only fuels the destructive product extravagance, will give way to an aesthetic which supports long term use and the conservation of resources. ....One example could be the development of a 'closed circle ' for consumer goods: products would not be bought, but would remain the property of the manufacturer. The user would not pay for the ownership, but for the use of the product and it's maintenance. After use the products would be returned to the manufacturer, serviced, repaired, recycled and put back into

> circulation. This structure would change the way products are perceived, and would thus change the emphasis of design away from creating a higher ' purchase - attraction ' to the optimisation of longevity and usefulness. [124]

Implicit in this scenario, is that the manufacturer would - under this system - give a higher priority than is currently the case to such aspects of design as reliability and the ease, speed and cost of repair. And since the disposal of any components which were incapable of repair or recycling would be the responsibility of the maker, this aspect also would receive careful attention.

Other concepts such as that of shared ownership of occasionally used machines such as lawn mowers or perhaps even cars have also been proposed, with one such scheme involving the latter being currently in operation in the Netherlands.

As a garden designer and entrepreneur, Tim Smit has made considerable efforts to educate the public about the problems of sustainability. Having successfully restored ' The Lost Gardens of Heligan ' in Cornwall, he has now created the ' Eden Project' near St Austell in Cornwall (see fig 3b/4). Consisting mainly of a series of huge, plant filled geodesic 'Biomes', the project's prime objective is nevertheless to bring home to the visitor the ways in which our consumer society relies implicitly on the natural world, which must therefore be preserved. He insists however, on a 'distinctive and innovative' approach, as indicated by this quotation ;-

> ...if young guys come here and think they are going to be bored witless, and the only thing that interests them is music, if I can show them Eric Clapton's guitar and explain that the sound of that guitar comes from the quality of the wood, and that's because of this .... Or you've got rubber. Here's the actual rubber tree. You've got latex and the rest of it. But if that bores you here's a Jean Paul Gaultier outfit, or a giant Durex turned into a bit of art - I don't care what does it, provided I can engage you and get you started on understanding the fact it's about you, it's about things you didn't think were in your world but they're actually all around you. [125]

Tim Smit's Eden project, set in an exhausted china - clay pit near St Austell in Cornwall, sets out - by entertaining - to convince visitors of man's dependence on nature, and thus our need to protect it

fig 3b/4

vii) THE BLUE SKY ECO-DEBATE

In recent years the debate on sustainable systems of production and consumption, while centring in the USA mainly on economic and business strategies (see under The Contemporary Context, National & commercial responses, p70), has in Europe broadened to encompass more philosophical approaches to the problem.

Among the 'other critics and visionaries ' mentioned by Margolin [126] stand the Italian architects, critics and designers Ezio Manzini, Professor of Environmental design at Milan Polytechnic, and the co-founder of The Domus Academy in Milan, Andrea Branzi .

In 1985 with his range of furniture entitled ' Domestic Animals ' Branzi ;-

> *Took a divergent stance from the world of rational or supposedly post-industrial design. A collection of furniture half made by machine, half of tree branches, comes as if from no where. Branzi says of his collection ' They make use of primitive archetypal symbols and materials, in conformity with a canon of myth, to produce emotional effects. ' In each piece in the collection the strength lies in the striking contrast between brute gesture and emotions.* [127] *(see fig 2g/23)*

At first glance, one may look in vain for any sign of such ecologically desireable qualities as longevity, recyclability, or economy in the use of materials. It is in the symbolism of the pieces however, that the message lies. It presents itself in the unlikely juxtapositioning of the materials chosen, and in the use of such inherently improbable components as the flamboyantly 'man-made ' bamboo legs on some of the pieces. The argument proposed, that mankind is an integral - and potentially devastatingly destructive - part of the biosphere, is one that he forgets at his peril.

In similar vein, the subject of the 18th Milan Triennale, held in1992, was taken as ' Life between artefact and nature: design and the environmental challenge.' Among it's thematic exhibitions was one brought together by Manzini entitled ' The Garden of Objects.'

Under the title 'A new ecology of the artificial ' Manzini introduces this as ;-

> ... a metaphor for a world in which we cultivate technology, just as in a garden of plants we might cultivate nature. A world in which the objects are as attractive and varied as plants in nature. And where objects, much like plants, have a life of their own - objects that last for a century, like an oak tree, or that wilt after a day, like a blossom .... a world in which objects are not merely tools, but partners in a dialogue with our own sensibilities and our own memories. [128]

Once again, man's place within - and reliance upon - the natural world is emphasised. The concept that the objects with which we surround ourselves should be such as to require our care, engaging our senses and our sympathies in this way should it is argued, lead to a greater awareness of the natural world, a more discerning pattern of acquisition, to higher quality objects, and to greater care for our environment. Thus the production of fewer artefacts of higher quality would be encouraged, some at any rate of which would enjoy longer useful lifespans, and the materials used would vary, to be appropriate to the intended lifespan of the object.

Yet a further example of this debate is recorded in an account of a project which was initiated by The Domus Academy under the overall title of ' The Solid Side '. Involving twenty eight designers, the work spanned 18 months, with results being published in 1995. In it, aspects of the potential role of the designer in an era of increasing environmental concern were considered in some depth.

In a contribution entitled ' Freed space ', Andrea Branzi proposes what is described as an ' Imperfect Neoclassicism ' [129]. A variety of solutions are described, including at an individual level, a small prosthesis which is to be temporarily attached to the skin. This ;-

> .... guarantees the wearer a certain period of operating efficiency while under strain, compensating his or her energy needs within a particular period of time. Every thirty seconds the blood composition of the wearer is checked and, in accordance with fixed guidelines, the optimal amount of the active ingredients is then released. [130]

On a variety of larger scales, ranging from the individual product or building up to complete landscapes, solutions are proposed which refuse to differentiate between ;-

- the functions of a particular hand held artefact - is it an electronic

newspaper or a reprogrammable book, or both ? *(this proposal was similar in many aspects to one such which had also been explored during a 'brainstorming' session 'La Bottega dell'Arte' previously co-ordinated by Stefano Marzano of Philips Corporate Design);*
the uses of conventional houses or rooms - are they private home or business workplace ?

- buildings and countryside - are we indoors or outdoors, in a city or in the countryside ? (se fig 3b/5)

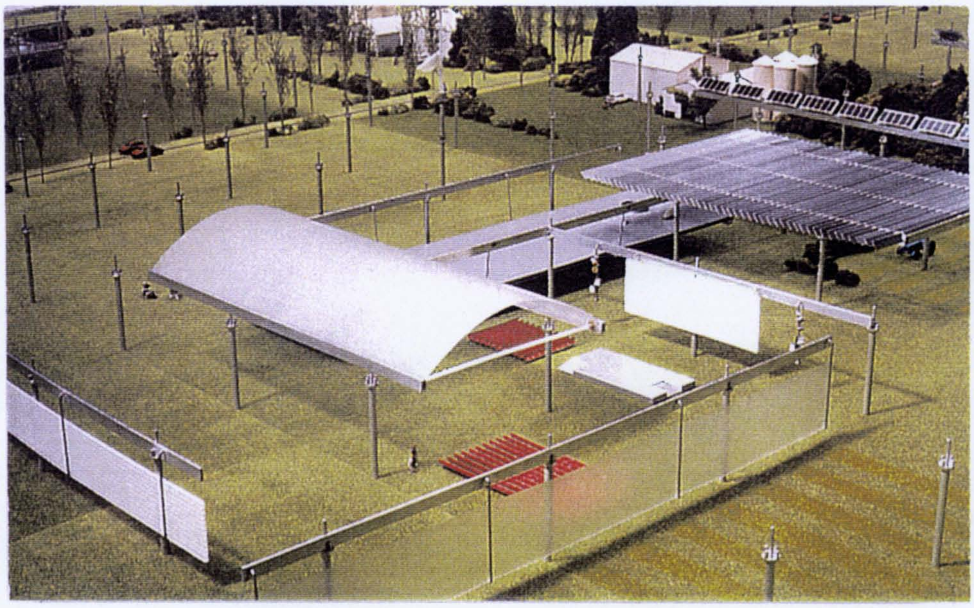
Branzi's solutions rely on computer software or sets of multifunctional physical components which are to be temporarily installed as the need arises, being quickly and easily reconfigured as required. In this way the best use is made of the flexibility offered by modern technology, and the production of artefacts - to be manufactured, maintained, and eventually recycled - is eased, their quantity reduced, and the best possible use is made of the available space.

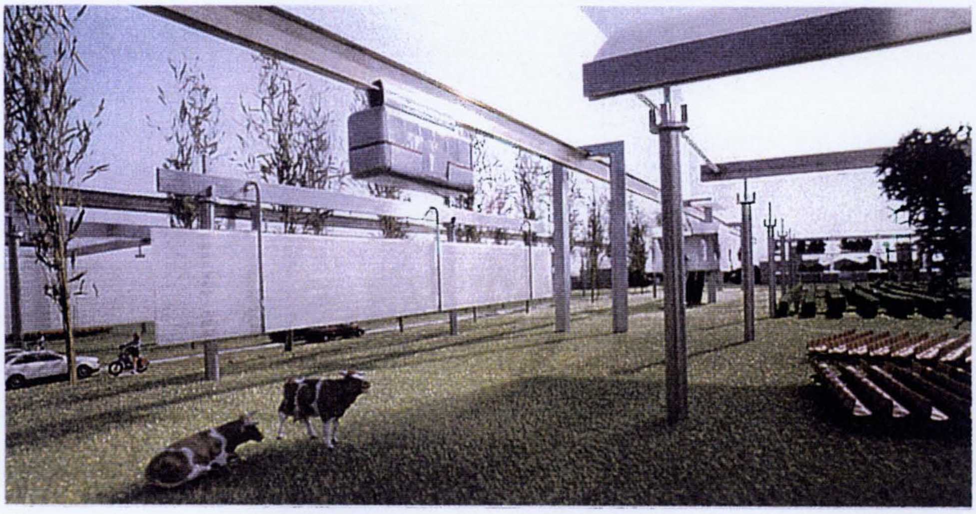
3c Consumerism

With ever improving communication , culminating in the internet, the unacceptably high disparity between living standards in the developed and the developing worlds has become ever more apparent. This difference is bound up with the system of production, consumption and disposal which - exploding in scale - has become the mainstay of the economy of the (largely Western) developed world.

> In the last 100 years, the world's industrial production has increased more than 100-fold. What is important is not just the numbers themselves, but their magnitude and the relatively short historical time they represent. [131]

The system however - with its inherent use of resources, demand for energy, and problems of disposal - cannot remain static, but must continue to expand if it is to survive. In this sense, the efforts of the developing world economies to catch up with the west might be welcomed, as the demand created by their considerable populations could ensure such an expansion. (There will be much catching up to do.[132])





In ' Freed Space' Branzi et al propose a flexible landscape set with a grid of columns. By the temporary addition of components from a standardised range, any area may be converted for a variety of uses

To enjoy equality however, it follows that - without an unacceptably large reduction in the Western standard of living - the new consumers in these countries must be enabled to experience an equally congested man-made environment. Donald Norman, in *The Design of Everyday Things*, suggests that ' ...there are perhaps twenty thousand everyday things that we (the consumers) might encounter in our lives ' [133]

These man-made things may range in size from the buildings which make up a city, to the microchips which invisibly control so many of it's electronic devices, but in each case they have been created ' by disassembling and reassembling parts of nature. ' [134] It is this process of converting material, consuming the products thus created, and all too quickly discarding them, which is increasingly aggravating the environmental problems addressed here, and which is eventually unsustainable.

Modern Western building techniques provide a good example of the wasteful use of energy and materials. The factors which influence the form and location of our buildings have always been subject to change. Historically however, building methods have ignored this, and to carry out the constant changes required has tended to be a laborious and undesirable process. It is also ecologically damaging. According to Stewart Brand ;-

> Almost no buildings adapt well. They're designed not to adapt; also budgeted and financed not to, constructed not to, administered not to, maintained not to, regulated and taxed not to, even remodelled not to. But all buildings (except monuments) adapt anyway, however poorly, because the usages in and around them are changing constantly. [135]

The reasons are that ;-

> Buildings keep being pushed around by three irresistible forces - technology, money, fashion .... The march of technology is inexorable, and accelerating .... If people have money to spare they will mess with their buildings .... As for fashion, it is change for its own sake - a constant unbalancing of the status quo, cruellest perhaps to buildings, which would prefer to remain just as they are, heavy and obdurate, a holdout against the times. [136]

So the procedures use quite unnecessarily large amounts of energy and materials. They are also very expensive, and are required on a huge scale. Only in the USA in 1989 for example, the cost of renovation and rehabilitation of commercial buildings alone is quoted as ' some $200 billion, (5 per cent of the gross national product) ' [137]

Or consider the production of artefacts (which include furniture);-

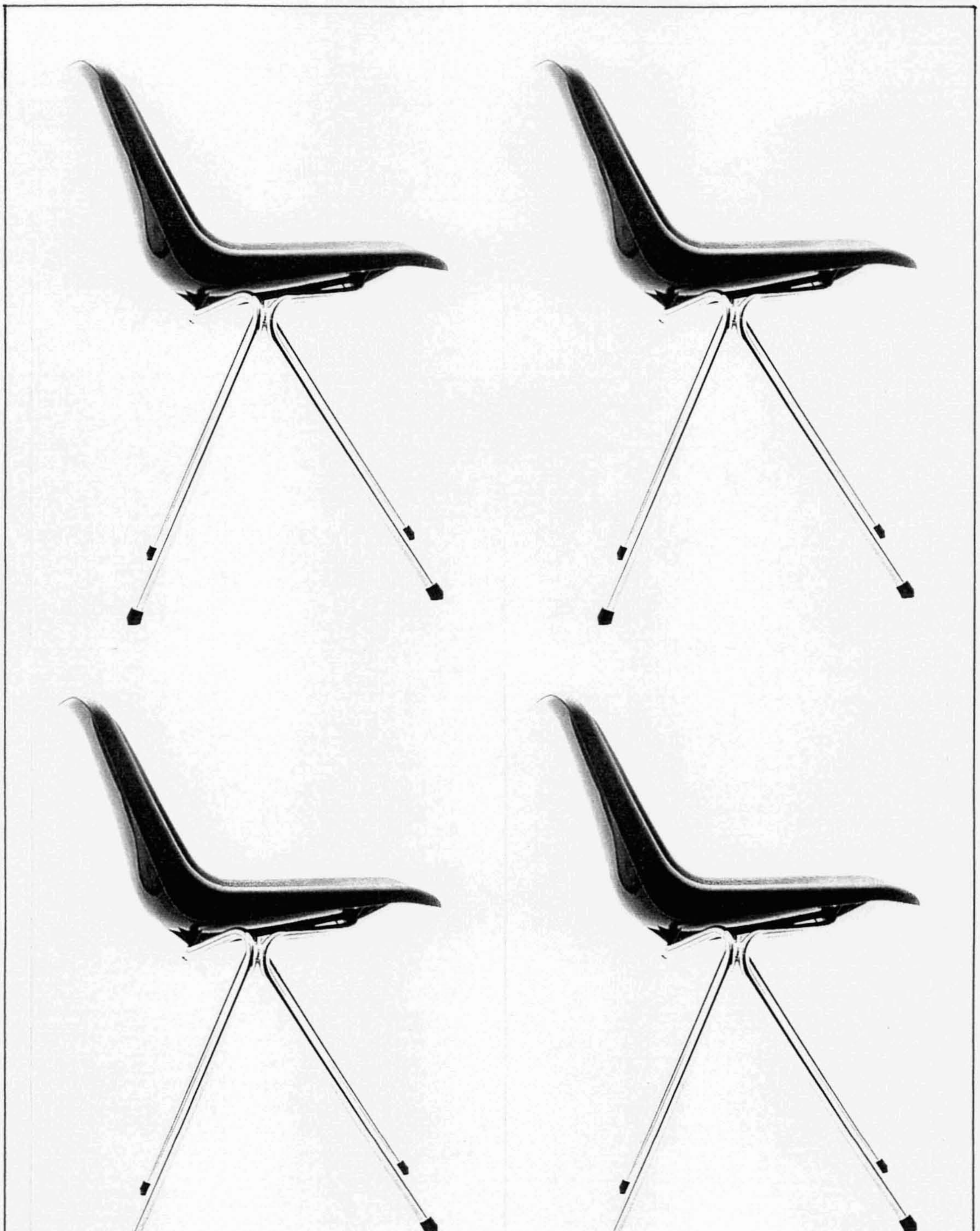
> Our urban civilization is witness to an ever-accelerating procession of generations of products, appliances and gadgets by comparison with which mankind appears to be a remarkably stable species. [138]

One theory regarding this apparently constant need to produce, has two supporters. Both Giedion in ' Mechanisation Takes Command '[139], and Forty in ' Objects of Desire ' [140] agree that having developed the technology required to produce a new product, manufacturers will seek new products whose manufacture will enable them to make further use of this technology.

A twentieth century example of such a situation is the case of Hille's polypropylene shell chair (fig 3c/1). In 1963, the plastics division of the Shell Oil Company, having developed the polymer as an excellent substitute for the previously universal enamelled steel washing-up bowl, sought and found a totally new use for both the polymer and the moulding process in the furniture industry. The chair's then unfamiliar form was accepted largely on the basis of it's sales to institutions whose overriding consideration was low first cost. The disadvantages of this use for the material, namely the fire hazard (discovered following a tragic accident), poor comfort and difficulty of cleaning, became apparent only later. To these must now be added, an environmentally sound means of disposal.

Another theory suggests that the impossibility of 'perfecting ' any man made object, since all are - by definition - a series of compromises, encourages successive attempts at improvement.

> *' The thought that things could be better is woven indelibly into our hearts and our brains '*
>
> *Paul Simon* [141]



The original plastic shell chair. Designed by Robin Day for Hille in 1963, it's form resulted from the Shell Oil Company's search for new outlets for it's polypropylene moulding process, used previously in the manufacture of washing up bowls

fig 3c/1

The initially attractive design philosophy, that since 'form follows function' the ultimately functional solution to a problem will produce the definitive object, is fairly easily demolished. David Pye, in demonstrating the specious nature of this (Louis Sullivan's defence of his building ' that the life is recognizable in it's expressions, that form ever follows function.'), [142] points out that ;-

> The concept of function in design ... might be worth a little attention if things ever worked. It is, however, obvious that they do not... Our dinner table ought to be variable in size and height, removable altogether, impervious to scratches, self cleaning, and having no legs... Every thing we design and make is an improvisation, a lash-up, something inept and provisional. [143]

Yet another theory is that the patent system (disliked by the great engineer L J K Brunel, on the basis that as ' most good things are being thought of by many persons at the same time ' [144] it obstructed progress) ensures that there will be as many versions of an object as there are manufacturers wishing to compete in the market.

A further theory, undoubtedly true in a minority of cases, is that politicians, financiers, architects, designers and others, will create objects in the hope of ensuring for posterity a record of their power, skill, or even just their existence.

Theories regarding the necessity of manufacture, and those regarding the necessity of ownership of objects, while approaching the problem from different directions, are interdependent, since each requires the other to survive. According to Baudrillard ;-

> There are no limits to consumption....consumption must henceforward either keep surpassing itself or keep repeating itself merely in order to remain what it is - namely, a reason for living. The very will to live ... is condemned to repeat itself and repeatedly abolish itself in a succession of objects.... Consumption is irrepressible, in the last reckoning, because it is founded on a lack. [145]

Baudrillard also explains man's need to surrounding himself with objects rather than people or even neutered animals, with the bleak theory that ;-

> The object is in fact the finest of domestic animals - the only

> 'being' whose qualities exalt rather than limit my person. In the plural, objects are the only entities in existence that can genuinely coexist, because the differences between them do not set them against one another, as happens in the case of living beings: instead they all converge submissively upon me and accumulate with the greatest of ease in my consciousness.' [146]

From all these arguments it can be seen that man, having once adopted the system of consumerism, will find it difficult if not impossible to reject, and that the ecological problems of continuous production and disposal must therefore be faced. If the system will not to change, then it's methods surely must.

4 THE GROWN FURNITURE PROJECT

Consider how fast this is done, in Spring ..... In winter you walk by your currant bush, or your vine. They are shrivelled sticks - like bits of black tea in the canister. You pass again in May, and the currant - bush looks like a young sycamore tree; and the vine is a bower: and meanwhile the forests, all over this side of the round world, have grown their foot or two in height ...... Where has all this come from ?

John Ruskin 'Proserpina', quoted by J Batchelor in
No Wealth but Life, Chatto & Windus, London, 2000

4a The Brief

To propose designs for one or more items of free standing furniture, the manufacture and lifecycle of which are to be as environmentally benign as possible, and to demonstrate by experiment, the practical feasibility of the proposal.

i) BACKGROUND

<u>Materials</u>

The materials used should be chosen on the basis of their environmental impact - in extraction, production, possible recycling, and eventual disposal. Waste of material should be minimised.

<u>Production / energy saving</u>

Taking into account the problems associated with the generation of energy, it is desireable to use a production process which reduces energy requirement to a minimum. It should be borne in mind that the consumption of energy is involved not only in the production unit itself, but also in the transport of both raw materials to the factory, and of the finished product to the end user (in the case of domestic items, frequently via the retailer). Furniture may also be moved from place to place during it's lifetime, and weight should therefore be kept to a reasonable minimum.

End of useful life

All furniture will eventually reach the end of it's useful life. At this point it is important that pieces can be disposed of with minimal environmental impact. With this in mind, it is important that any components made from different materials can be readily dismantled for recycling or disposal.

4b The Proposal

The brief was to be answered by proposing a system of growing items of furniture by planting young saplings in suitable configurations, training them to shape by the use of jigs as they grew, and making use of the traditional technique of grafting to form any joints required. The rationale behind this proposal was;-

i) RAW MATERIALS

In environmental terms, wood appeared preferable to either plastics or metals. Occurring by a natural growth process, it requires no man made energy for it's production. It is self generating, and being a natural material it is completely biodegradable. The only energy involved is a combination of that provided by the sun - via the process of photosynthesis (defined in Webster as 'The production of organic substances, chiefly sugars, from carbon dioxide & water occurring in green plant cells supplied with enough light to allow chlorophyll to aid in the transformation of the radiant energy into a chemical form.') [147] and human manual intervention.

It's ready availability, strength for weight, durability, ease of working with simple tools and pleasant appearance have ensured it's widespread use throughout history by any culture to which it has been available. It is thus both physically suitable and widely familiar.

Further if wood is chosen, it is possible to use a particular quality of the growing tree which has hitherto - in the field of furniture at least - been largely ignored. Since growth is gradual, and since the young growth is in general quite flexible, it is possible to train this new growth by hand, as it appears, into the forms required, holding it to shape by the use of jigs.

In addition, to create the joints between the individual saplings which may be required, it is possible to use any one of the well established grafting techniques, utilising the natural growing together which takes place in a graft. (see APPENDIX B)

Having been planted in an appropriate configuration, the saplings can be gradually manipulated into shape, being secured in place on their jigs until sufficient subsequent growth has occurred to ensure the permanency of the form. Unwanted growth can be removed by hand as the season progresses, with joints grafted into place as appropriate. The only other attention required will be general maintenance such as weed and pest control, and watering if required.

ii) PRODUCTION

The experimental method being independent of the need for any heavily serviced or specialised buildings, or of large quantities of labour, the basic requirement is for a suitable area of sufficiently fertile ground. The timing of planting, installation of grafts and eventual harvesting, will be controlled by the growing season, weather, and the progress of individual plants.

The time span between planting and harvesting will depend on the size and complexity of the pieces. A period of five to eight years is estimated from planting to completion and harvesting, although it is anticipated that a further period will be required to allow the structures to be air dried.

iii) ADVANTAGES OF SUCH A SYSTEM

- by forming the structure as it grows - using solar energy - the demand for artificially generated energy is much reduced, or even eliminated
- operating organically, without artificial fertilisers or pesticides, and producing only biodegradable waste, it is fully sustainable
- it produces its own raw material on site, eliminating the cost and pollution usually involved in its delivery An additional advantage of this system would be a reduction in the necessity for the long distance transportation of either raw materials or finished products.

- the production of waste material is much reduced, and any that is produced is ecologically benign and thus easily disposed of
- jointing can be achieved using the naturally occurring process of grafting, obviating the need for the production or use of mechanical fixings or adhesives
- the system is equally suitable for production in large or small quantities, with the quality and design of the product being unaffected by the size of the ' batch ' from which it came
- much of the knowledge and the skills required already exist in the field of horticulture
- elaborate, decorative and non rectilinear forms are relatively simple and inexpensive to achieve if required
- the process is an example of intermediate technology, The system named and characterised by Schumacher which, ' Making use of the best of modern knowledge and experience, is conducive to decentralisation, compatible with the laws of ecology, gentle in it's use of scarce resources, and designed to serve the human person instead of making him the servant of machines.' [148]

iv) DISADVANTAGES

- such a system will be unsuitable for the production of identical items
- the speed of growth being relatively slow, last minute changes of form will be impossible
- very accurate predictions of the strength of structures or of joints will be difficult, if not impossible
- finishing will require hand work

v) PRECEDENTS

The history of man's varied and widely distributed uses of the forms in which trees grow, or can be trained to grow, is dealt with in detail in the various parts of section 2. From this it may be seen that the current research project consists not in experimenting with unknown or untried processes, but simply in directing their use in a hitherto little explored direction.

Where man has set out specifically to control growth in such a way as to create an item of furniture, research has identified four only well documented examples of successful experiment ;-

John Krubsack (USA) a single chair	page 41
Axel Erlandson (USA) a single chair	page 42
Richard Reames (USA) a range of chairs & tables	page 42
Nirandr Boonnark (Thailand) several items	page 42

Historically, two further possible examples or the controlled growth of furniture components are ;-

The legs of Dynastic Egyptian stools	page 33
The legs of the Classical Greek ' Klismos ' chair	page 34

In other areas such as buildings, one experimenter, with an unknown record of success (see section 2k) ;-

Arthur Wiechula (Germany)	page 57

4c The Experiment

The research project being centred on the technical feasibility of growing furniture structures, practical experimentation was considered essential. It was therefore proposed that an experimental structure should be designed, and that a number of these should be planted and grown. In this way it was hoped ;-

- to demonstrate whether or not the proposed system might be technically viable.
- to examine the technical possibilities and problems inherent in such a system.
- to enable the strength and rigidity of a grown structure to be tested under laboratory conditions, in the knowledge that the joints of such a structure would have been grafted, and that it would contain a proportion of the sapwood which is discarded in conventional manufacturing.
- if possible, to carry out some experiments into the various techniques of binding, scarring or engulfing which could be used for decorative effect.

i) THE EXPERIMENTAL DESIGN

It was considered important that the design should be clearly recognisable as a usable item of furniture, that it should be free standing, and that it's appearance should be acceptable to a reasonably large section of the furniture buying public. It was also thought desireable that the appearance should be such that it would not easily be dismissed as suitable only for outdoor use, or that it was too 'arty' for general use. For these reasons, , a simple three legged frame was identified as the most suitable (a conventional top was to be added to the finished frame to form either a stool or small table).

As initially designed (seat 1, fig 4c/1), this was to consist of three straight legs, angled to grow and be grafted together at the top, before turning outwards to provide support and fixing points for the seat. These were to be braced in each case by a single side shoot which would be trained diagonally towards its neighbouring leg, passing through and being grafted to it to provide a triangulated frame. (It was hoped to identify a suitable shoot on each leg, or failing natural growth, to graft one on.) In discussion with Dr John Barnett of the School of Plant Sciences at The University of Reading however, the naiveté and complexity of this proposal became apparent, and a considerably simpler and more appropriate design was evolved (seat 2, fig 4c/2). In this form each leg consists of a single stem which is trained across more or less horizontally at mid height, to be approach grafted to its neighbour before continuing upwards to meet its companions at the apex, eventually turning outwards as before. (Some concern as to the strength of the structure being adequate at the apex - the point at which all three legs join - led to a further vertical central stem being added in one of the Sycamores planted at Shinfield.)

ii) THE EXPERIMENTAL JIG

Having settled on the design for the stool, it was necessary to devise a method of ensuring that this design could not only be grown, but that - for experimental purposes - it could be repeated in as near identical a form as possible. (Such a system would also begin to explore the possibility of producing a single design in quantity)

Initially a version of the cane growing frames commonly devised by gardeners to support - for example - their runner beans was considered, and would certainly have been

GROWNup

seat 1

plan and elevation of proposed experimental
design with approximate dimensions
scale 1 : 5

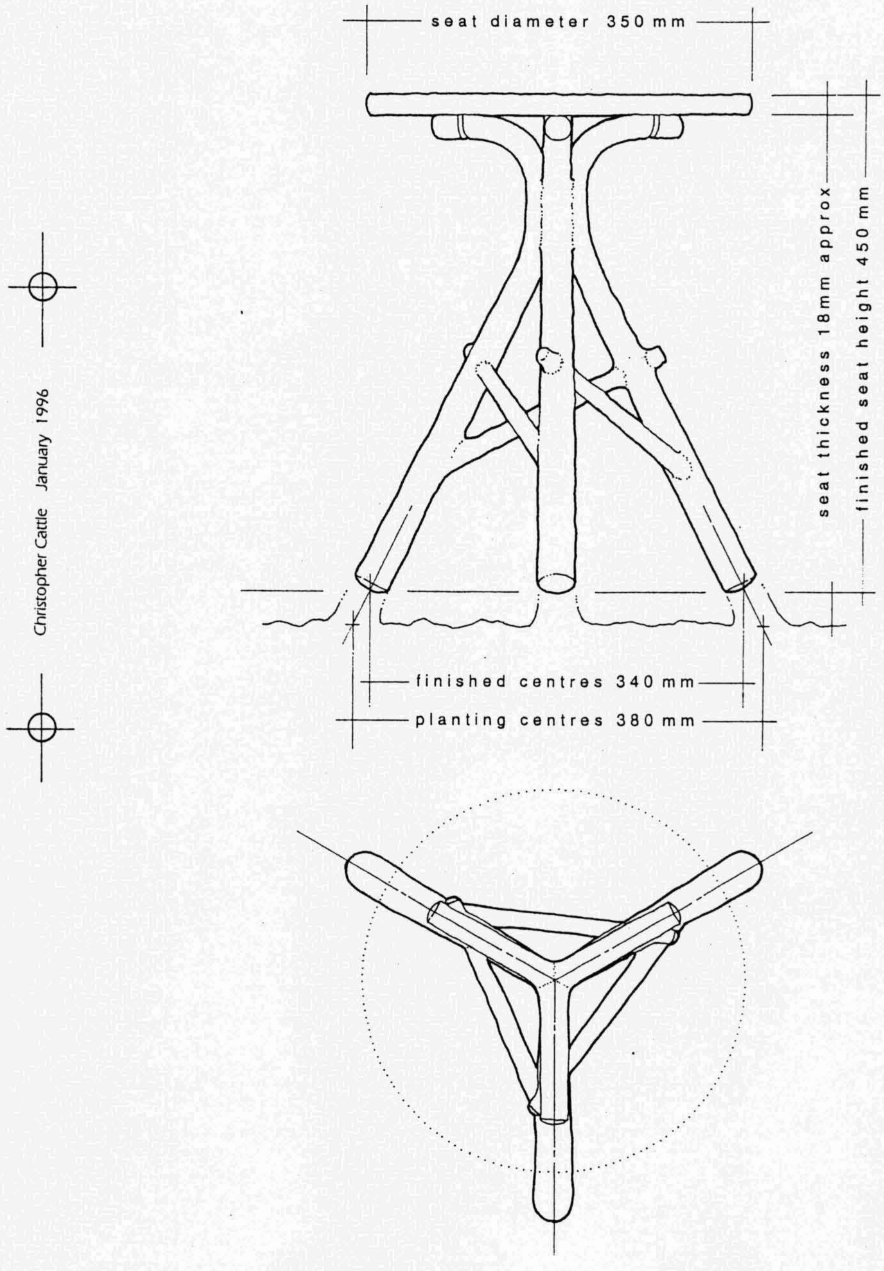
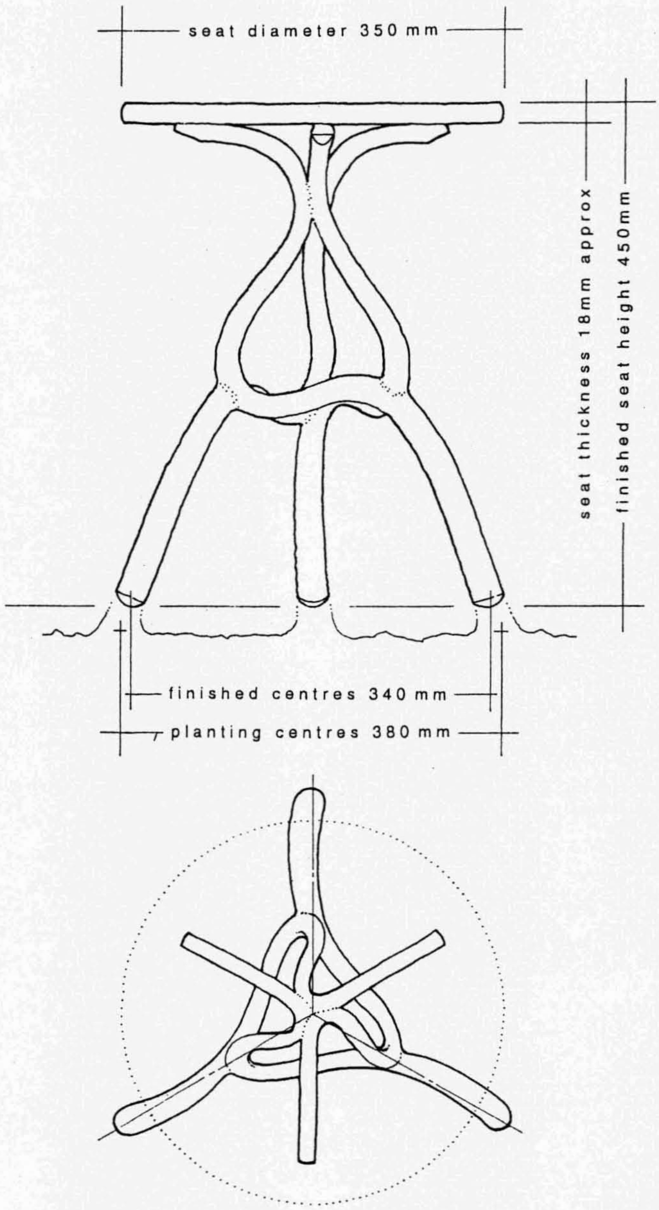


fig 4c/1

GROWNup

seat 2

plan and elevation of proposed experimental
design with approximate dimensions
scale 1 : 5



Christopher Cattle April 1996

fig 4c/2

ecologically benign (although the canes would almost certainly have been imported). Experimentation showed however that the difficulty of constructing identical durable versions of such a frame, particularly in view of the unevenness of the ground at a typical growing site, would be considerable. It was therefore decided to revert to a type of jig whose structure, while requiring the use of less desirable materials and processes, would provide the required integral strength and repeatability, and would stand reliably on uneven ground. (Eventually of course, the jig itself could be grown.)

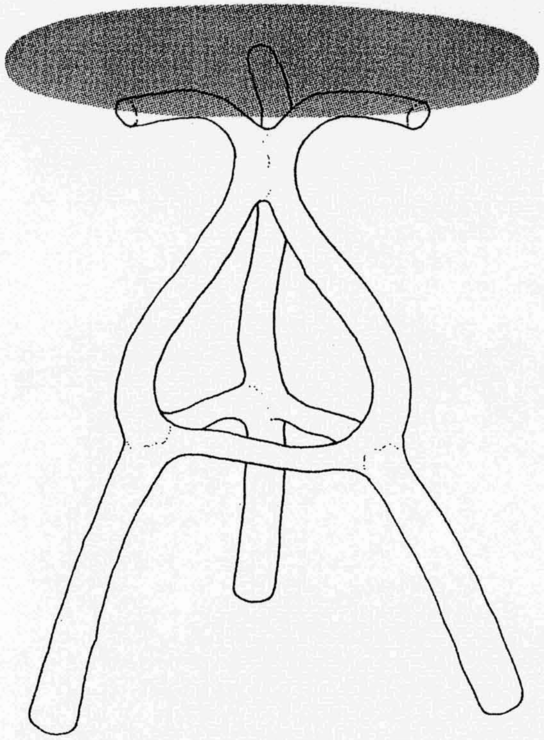
To be cut from 4mm WBP plywood, the final design (drawings Nos S2J/01,02,03) consists of a three sided pyramid with projecting ' ears ' at its apex, to which is attached a horizontal member to ensure that the seat supporting arms are horizontal and regularly spaced. The serpentine path to be followed by each growing sapling is traced out in pairs of holes, bored to accept the required ties, with the points at which grafts are to be made cut away to allow access. The faces are joined by a slotted tab at the foot (the V thus formed accurately locating the position of each sapling) and by wire ties at the mid and upper points. The horizontal top member is similarly located by tabs through slots which are secured by wooden dowels. Since it was realised that this structure would become imprisoned within the frame when fully grown, and it was hoped that these jigs might be re-used, each of the faces consists of two overlapping halves, held together by a single weatherproof nut and bolt. An initial batch of twenty such jigs were produced.

In view of the difficulty of planting the young saplings accurately, a further ' planting jig ' was devised (drwg No S2J/04). Having dug out the holes required to plant the saplings, this jig can be placed on the undisturbed ground in the centre of the site and the slots in its extremities used as guides to position the young plant stems before ' firming up '.

4d The Experimental Sites

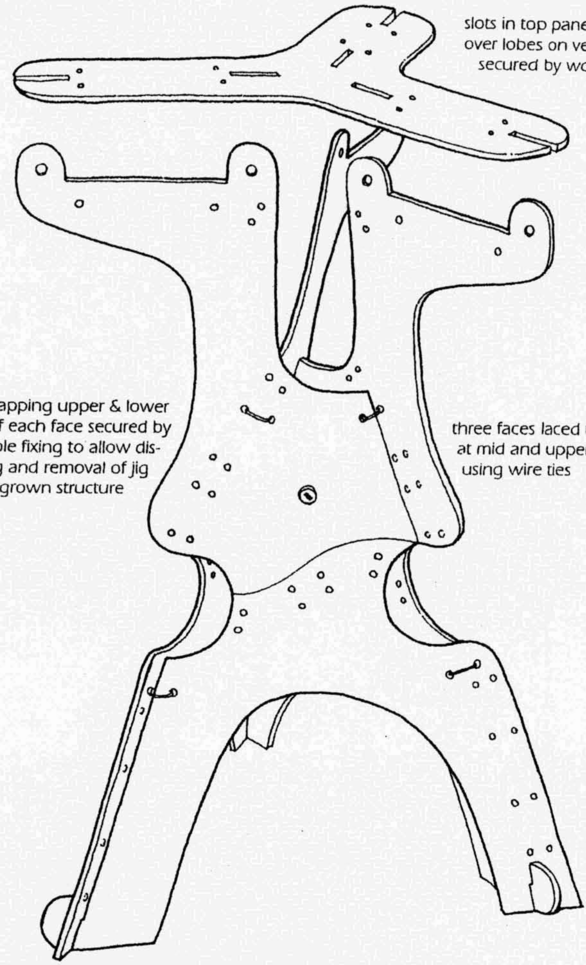
i) SHINFIELD (site 1)

Having established the experimental structure, it was necessary to obtain the use of a convenient site on which to experiment, and for this purpose the School of Plant Sciences at Reading University was approached in late 1995. Having had the proposal outlined to them, it was agreed that a suitable area could be made available on one of the University's



finished SEAT 2 structure

NB the faces of the jig may be assembled overlapping clockwise
(as was the case for the structure above) or anticlockwise
(as shown right)



4mm thick material from which components are cut is left to the growers discretion. As shown the jig is designed to allow it to be dismantled from within the grown structure, (after approximately five years), and if in good condition to be reused.

Early experiments have used 4mm marine ply, treated with two coats of Cuprinol preservative

GROWNup furniture

Seat 2 growing jig

general arrangement
S2J / 01

scale : full size (A2 drwg)

date : 27.11.97

drawn by : [signature]

one of a set of four drawings giving full size details of components necessary to construct the jig

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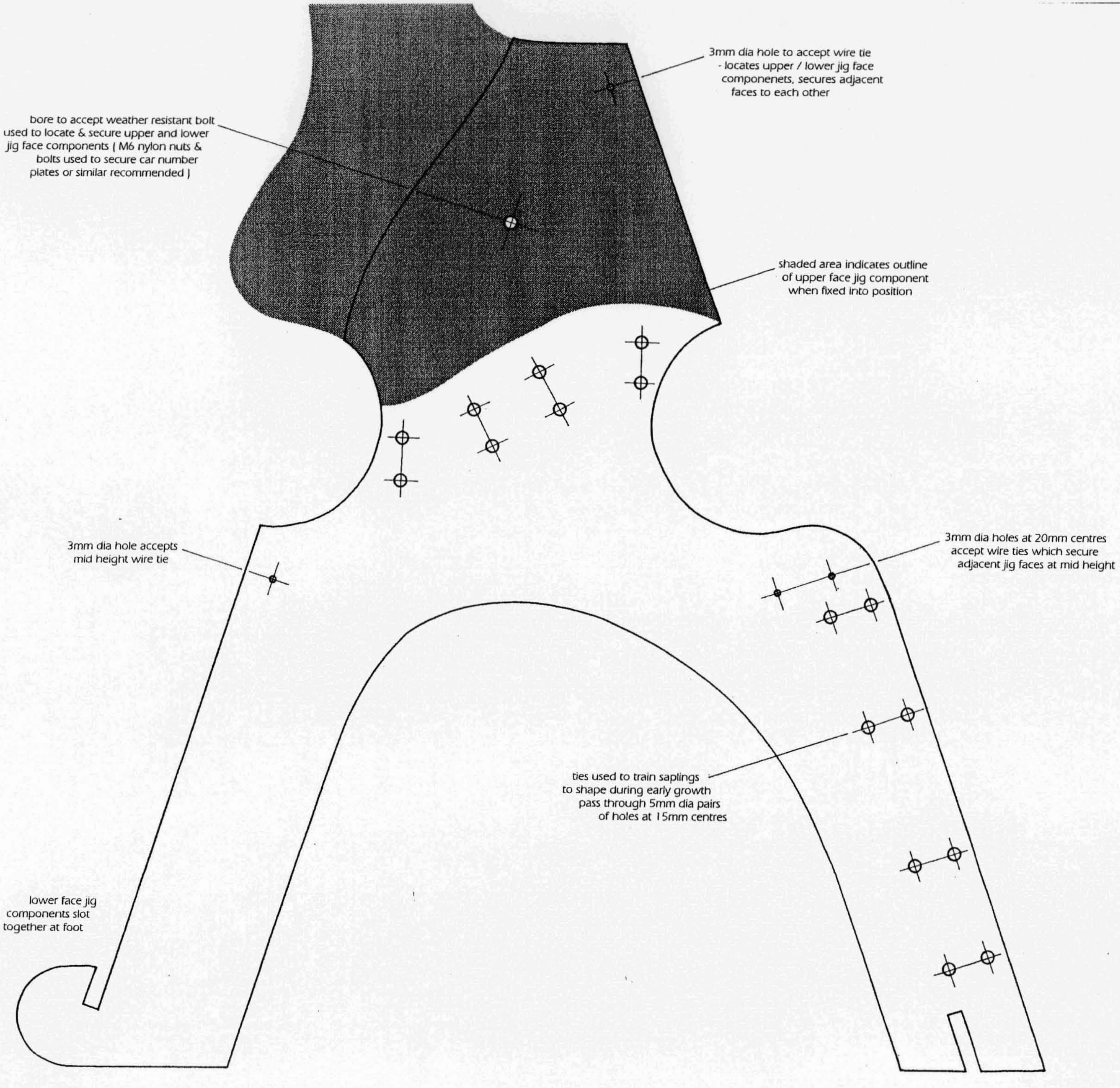
01235 - 524 307



4mm thick material from which components are cut is left to the growers discretion. As shown the jig is designed to allow it to be dismantled from within the grown structure, (after approximately five years), and if in good condition to be reused.

Early experiments have used 4mm marine ply, treated with two coats of Cuprinol preservative

GROWNup furniture

Seat 2 growing jig

lower face component S2J / 02

scale : full size (A2 drwg)

date : 15.11.97

drawn by :

one of a set of four drawings giving full size details of components necessary to construct the jig

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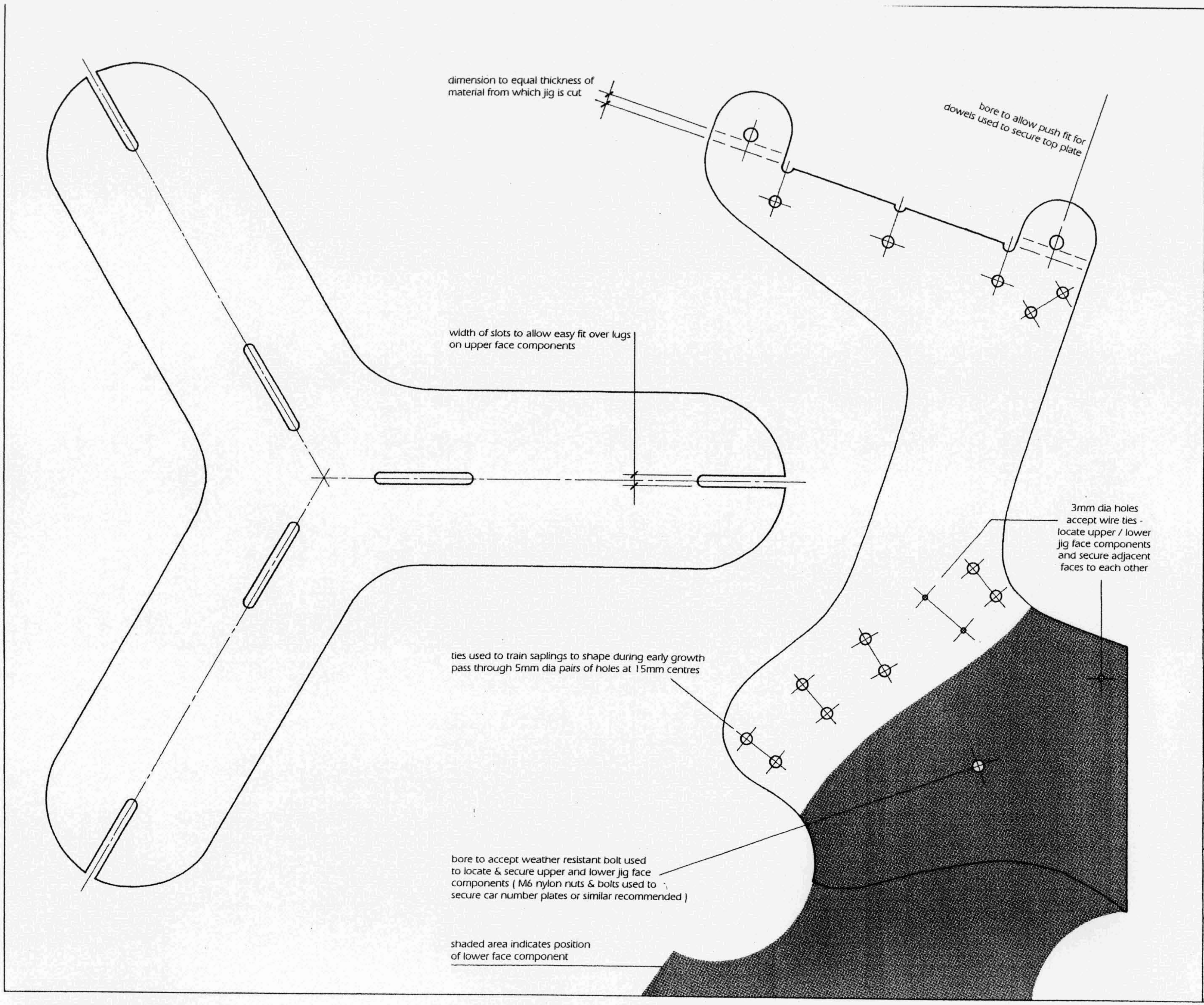

4mm thick material from which components are cut is left to the growers discretion. As shown the jig is designed to allow it to be dismantled from within the grown structure, (after approximately five years), and if in good condition to be reused.

Early experiments have used 4mm marine ply, treated with two coats of Cuprinol preservative

GROWNup furniture

Seat 2 growing jig

upper face component & top plate

S2J / 03

scale : full size (A2 drwg)

date : 26.11.97

drawn by :

one of a set of four drawings giving full size details of components necessary to construct the jig

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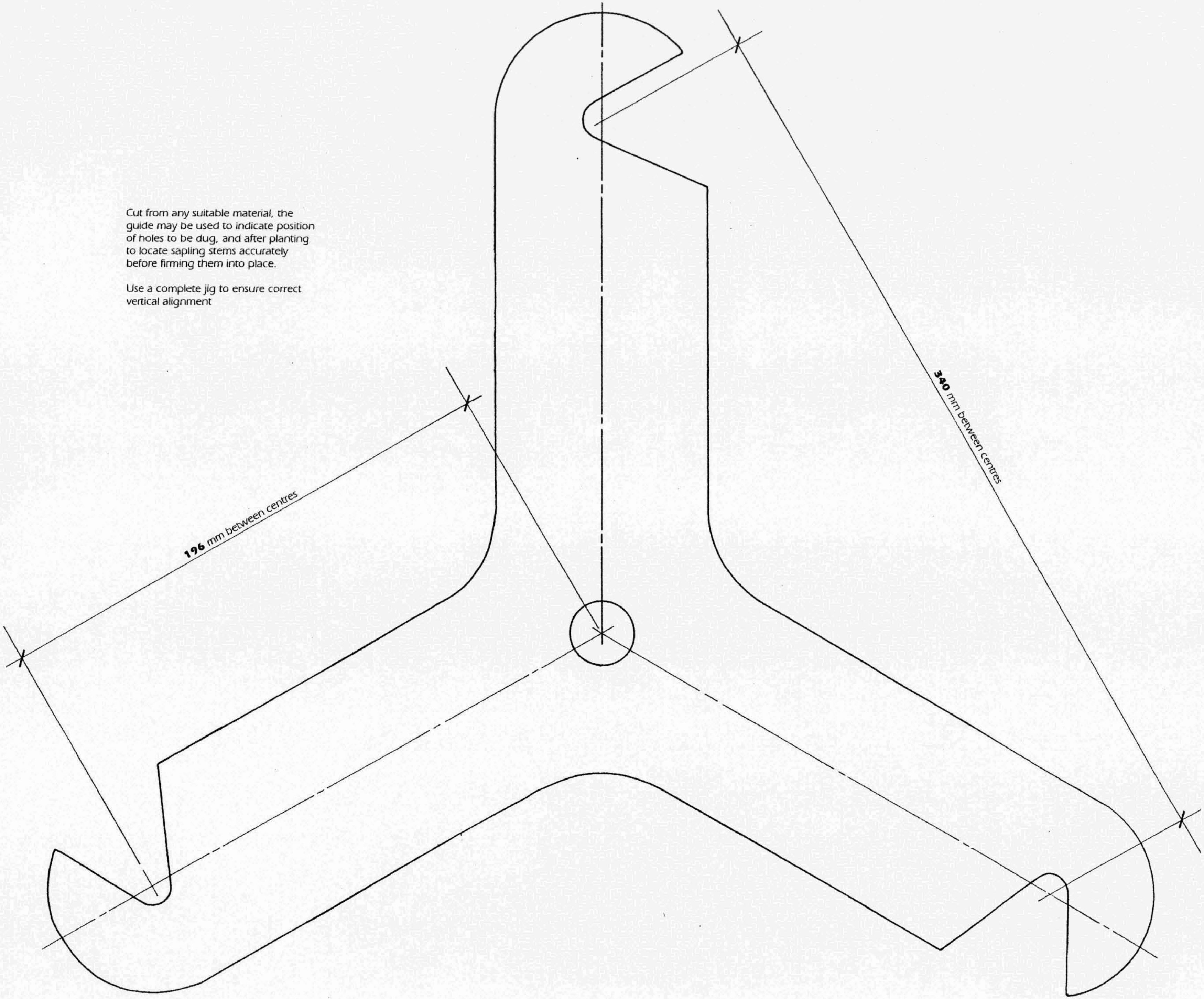
Cut from any suitable material, the guide may be used to indicate position of holes to be dug, and after planting to locate sapling stems accurately before firming them into place.

Use a complete jig to ensure correct vertical alignment



GROWNup furniture

Seat 2 growing jig

planting positioning guide

S2J / 04

scale : full size (A2 drwg)

date : 25.11.97

drawn by :

one of a set of four drawings giving full size details of components necessary to construct the jig

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experimental sites at Shinfield, just south of Reading. A total of eight structures were planted in early 1996, together with some further saplings 'for use as spares'.

ii) LLWYDCOED (site 2)

The experiment at Reading having received some favourable publicity on national press and radio (see APPENDIX D Project publicity) an approach was received late in 1996 from a section of the 'Groundworks' organisation [149] situated at Llwydcoed, just north of Aberdare in South Wales. Despite the distance, this was felt to be too good an opportunity to miss, and a considerably larger area than that at Shinfield was identified, allowing a total of 29 structures to be planted early in 1997.

iii) PRIESTFIELD (site 3)

Late in 1998 it was suggested that a third site could be made available in the Priestfield Arboretum, a small privately owned and run arboretum in the village of Little Kingshill, just north of High Wycombe, with the result that a further small experimental planting of four structures was installed early in 1999.

4e The Experimental Species

With regard to the choice of species with which to experiment, expert advice was sought, but with so many variables to consider - speed of growth, suitability to the location of experiment, ease of grafting, malleability of young growth, durability and finished appearance etc, apart from lack of experience in this precise field - it is hardly surprising that the choice was not obvious.

The first sources of recommendations were the accounts of the species used by the two American furniture growers, Erlandson and Krubsack. (Reames' work not having been discovered at that point) Erlandson did not however, appear to have had a strong bias towards any one species, using Alder, Apple, Ash, Birch, Box Elder, Eucalyptus, Loquat, Mulberry, Cork Oak, Poplar, Redwood, Sycamore and Willow at various times (see under Sculpture). Krubsack also used Box elder, a member of the *Acer* family, *Acer negundo*

(also known as Ash leaved Maple and a native of the Eastern USA) which appears to have been familiar in Britain until at least the 1960s, but which the author found difficulty in tracing. In either case both the soil and the climatic conditions would have been different to those currently pertaining. Several other sources were consulted, including Garner (1947) with regard to ease of grafting, and Stevenson (1979) regarding species previously used - yielding Apple, Beech, Birch, Cedar, Chestnut, Cypress, Hickory, Laurel, Maple, Red & White Oaks, Pear, Poplar and Rhododendron. It was noted that Apple, Birch and Poplar appeared in both lists. Staff at both Buckinghamshire College and Reading University were also consulted with similarly inconclusive results.

Many different species were mentioned and recommended, but from all the information gathered it appeared that the *Acer* family - including the Sycamore *Acer pseudoplatanus* (the species first noticed by Erlandson to be grafting in the wild) and the Maples - *Acer platanoidese, campestre*, or *saccharinum* appeared to offer good possibilities.

For the first planting at SHINFIELD however, the options were limited to those available from the Forestry Commission's establishment at Alice Holt Lodge, who had kindly agreed to supply these at no cost. Luckily these included two *Acers*, and from those offered, the final selection was Sycamore *Acer pseudoplatanus*, Silver maple *Acer saccharinum*, Common alder *Alnus glutinosa*, Wild cherry *Prunus avium*, & European beech *Fagus sylvatica*.

The saplings later planted at LLWYDCOED were a mixture of young trees being grown on the site and some obtained from a local supplier. These consisted of European Ash *Fraxinus excelsior*, Wild cherry *Prunus avium*, Sycamore *Acer pseudoplatanus*, and Field maple *Acer campestre*.

By the time of the most recent planting at PRIESTFIELD, a certain amount of experience had been gained, and the choice of four Sycamores *Acer pseudoplatanus* was based on experience.

With regard to the qualities identified as being desirable, the following comments are based on the experience gained to date (which include growing, grafting and training, but exclude harvesting etc) ;-

SYCAMORE *Acer pseudoplatanus*

In general a vigorous and fast grower, although the rate of growth of individual plants is difficult to predict in practice, as apparently similarly healthy and vigorous saplings having been planted together they frequently vary. In fact it appears common - although by no means universal - that one of the three saplings forming a structure may tend to dominate the others. Whether this is a result of their having been planted closely together is unclear. It does not appear to depend on the position of the plant relative to the sun, wind, drainage etc. This having been said, the species appears at this stage to be very suitable for this use, being easy to train - provided that this is done about two months after the appearance of the growth of the new length of stem. It should not be attempted too early as the new growth is tender and will be marked easily by the tie, or too late when the stem may snap when bent. As predicted, this has also been one of the easiest species to graft. Sycamore leaves do seem to be susceptible to a ' tar spot ' disease, (caused by the fungus *Rhytisma acerinum*), but this has not so far proved a serious problem.

SILVER MAPLE *Acer saccharinum*

Many of the above comments apply to this species, although problems with equal growth are less common in this case. It appears equally easy to train and graft, and grows equally vigorously. Both species tend to throw out occasional side shoots along their length, particularly at a point where a bend away from the vertical has been introduced, but provided that these are removed early they present no problem.

FIELD MAPLE *Acer campestre*

The nature of growth in this case is rather less suitable for training, tending to be long and thin with frequent leaf shoots. Being thin the stem may be easily trained but it then appears to take very much longer to reach a thickness at which grafting may be attempted, and the frequent small growths of leaves are undesirable. The experimental structures attempted have also shown a greater tendency to fork into two stems of relatively equal size, and to throw out undesirable side shoots. The young growth is less fleshy than *Acer saccharinum* though, and therefore less easily marked by the ties.

WILD CHERRY *Prunus avium*

Although not quite as vigorous or fast growing as the Sycamore, this species has also proved promising in terms of trainability and vigorous growth. The problems of uneven rates of growth between the different saplings are also less pronounced. The young shoots are slightly hardier than the sycamore, and tend to harden up rather faster, requiring quicker training for this reason. The grafts attempted on these structures have not taken as readily as the sycamores or maples, but this may well be the result of the lack of skill of the grafter.

EUROPEAN ASH *Fraxinus excelsior*

Producing tough and springy saplings which take up the most elegant bends of all the species tried. Although later than the other species to bud, the growth rate is then quite acceptably fast, although the points on the stem at which the pairs of buds are produced tend to be flattish and slightly stiffer, sometimes requiring the use of the Bonsai wiring technique described elsewhere to overcome this problem. At the time of writing no grafts have been attempted, so no comments can be made in this respect.

COMMON ALDER *Alnus glutinosa*

The least successful of all the species tried, these saplings were irregular in growth, and when young were so limp that they were difficult to train elegantly into the required shapes. Since this species is one recommended as suitable in Reames (1995), it may be that it responds better to his technique of using saplings of considerably greater age and length - up to six feet - when the bends installed would of necessity be of a larger diameter.

EUROPEAN BEECH *Fagus sylvatica*

Although beech is a well known and deservedly popular timber in the manufacture of conventional furniture, the young saplings - being of a distinctly ' zig - zag ' configuration caused by the growth of the leaves on alternate sides of the stem - did not appear to present themselves as being a suitable basis for these experiments. This characteristic did however suggest that beech might be eminently suitable for weaving together to form a lattice growth if required, and a small length of such a lattice was constructed on experimental site 1. (Initial growth being extremely poor, this structure was neglected during its second year. By the end of 1998 however it had shown signs of becoming established, and by October 1999 several of the crossing points were tending to form natural grafts.)

4f Diary

At December 1999, a total of approximately 38 experimental stool bases had been planted on the three sites.

i) SHINFIELD (site 1, see fig 4f/1)

In mid March 1996, in an area which had been especially fenced off for protection against deer and rabbits, a total of seven experimental structures, 3 Sycamore, 1 Silver Maple, 2 Wild Cherry, I Common Alder were planted. All but one of these consisted of the standard three saplings. Experimentally, one of the Sycamore structures Ru5 (see fig 4f/1) was installed with an additional vertical central stem, on the basis that this would provide added girth at the weakest point of the structure, where all three stems converge at the top.

All of these saplings were supplied free by The Forestry Commission, the author having selected them personally. They were thus as nearly ideal for the purpose as possible, being generally vigorous single stems, straight, of the required length and girth, and in matching sets of three. No special treatment, fertiliser etc, was applied, the ground having been regularly used for experimental planting by research students from the University, and being considered suitably fertile. On advice, the saplings were initially left untrained so as to give them the best chance to establish themselves. Some further saplings of the same species which appeared less suitably matched were nevertheless planted in a row as 'spares'. When the need for spares made itself apparent the following season however, their rate of growth had made these unsuitable to act as substitutes. Being untrained and unpruned however, they have formed a valuable comparison with the trained saplings which form the structures, there being no doubt that the pruning has reduced the rate of growth by perhaps 40%.

At approximately two or three weekly intervals further site visits were made and the various bends were installed into the saplings as they grew. The Sycamores and the Maple developed well from the start, and by mid July they were considered ready for the initial - that is lower - approach grafts to be installed on two of the structures. Following a demonstration from an experienced student from Reading University, these were

grown furniture

Experimental site 1

location Field unit / University of Reading School of Plant Sciences / Cutbush Lane / Shinfield / Berkshire

description a moderately level site, exposed to the south and west only, fenced for protection against deer and rabbits.

first planted March 1996

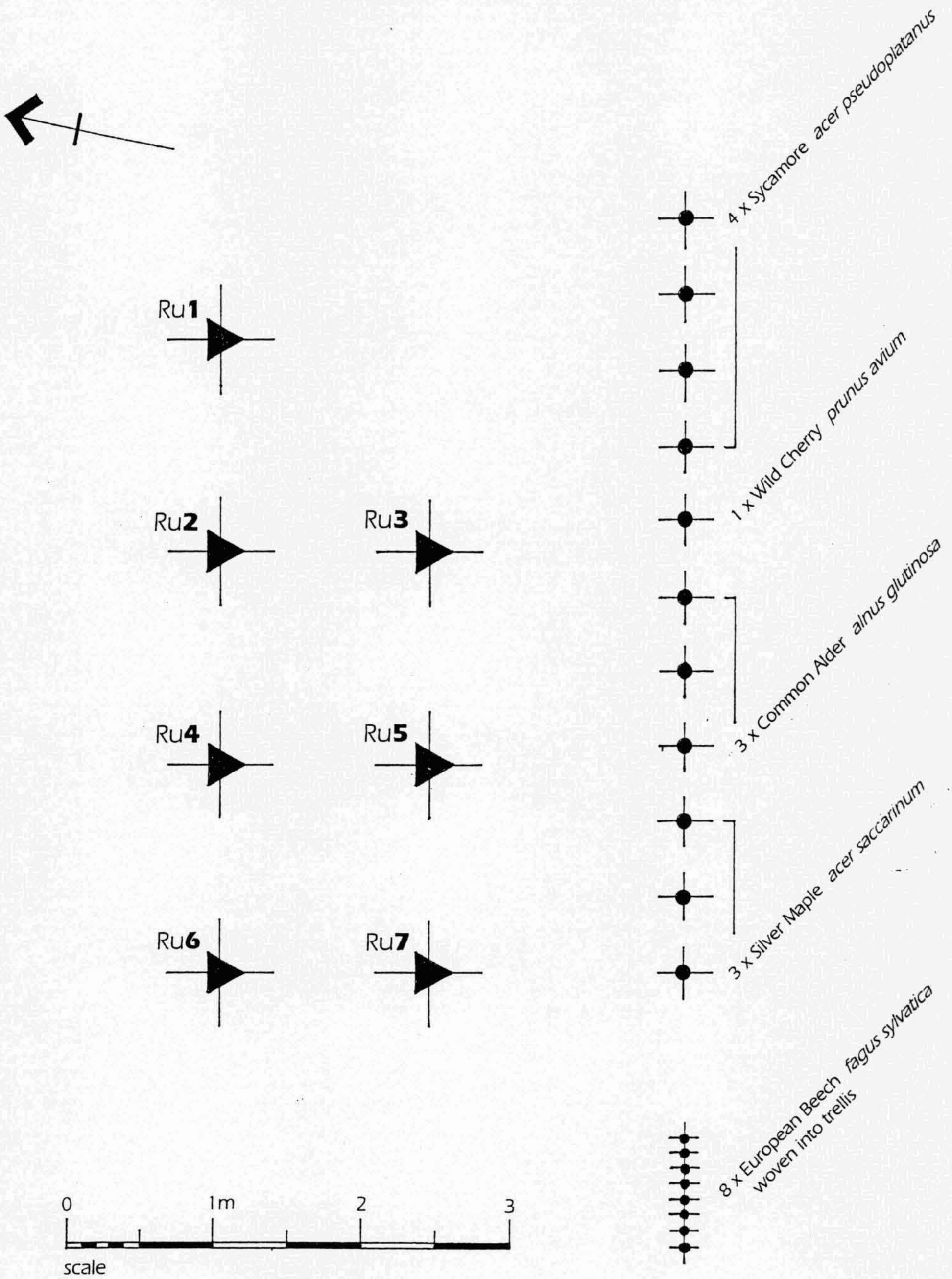


fig 4f/1

attempted on one of the Sycamores (Ru5) and the Maple (Ru4), using grafting tape to hold the joints under pressure. The grafting of the remaining two Sycamores (Ru6 & 7) was carried out approximately three weeks later. In late August the tapes were removed from the first grafts, and in late September from the second. Overall an approximately 60% success rate was established. Undesirable side shoots were removed as they appeared.

The Cherries (Ru1 & 3) established themselves to a limited extent but were slower to develop, no grafting being attempted on them during that growing season. The Alder (Ru2) emerged as to be so inappropriately limp and irregular in it's early growth that, despite an attempt to train it to shape, it was aborted at the start of the next season.

Between mid - March and early November 11 visits were made to the site. By late October all the Sycamores and the Maple had grown to well beyond the tips of the jigs, being held in place with the wire ties which had to be inspected (and several loosened) on each visit. Of the six stems making up the two Cherry structures, four were growing well although three had not yet reached the tips of the jigs. The Alder saplings had barely reached mid height and looked very frail.

Weeding the site was efficiently carried out as required by the resident staff, while watering proved unnecessary that year.

Site visits resumed in early March 1997, 11 being carried out between then and late October. During the year the Sycamores and the Maple continued to grow strongly, the topmost horizontal element of their jigs being installed to ensure that the lateral top growth remained horizontal and accurately spaced. By mid summer the leafy canopies of all these structures had grown to a considerable size, extending approximately 900mm above the tops of the jigs. At this height there was considerable movement in the wind, and it was felt prudent to prune this growth back quite extensively to avoid the possibility of damage. As noted this pruning seems to have had a detrimental effect on speed of growth.

The problem of how to repair the grafts which had failed to ' take ' was addressed in late May. The use of tape to hold the joints together while the graft was established, while doubtless suitable in smaller and less stressed situations (and while it had succeeded in several instances), did present problems. The several weeks taken for the graft to become *sufficiently mechanically strong, meant that considerable growth would have taken place, and the bulges above and below the constriction which resulted, while not apparently harming the tree's growth, were nonetheless aesthetically undesirable. At this stage the work of Arthur Wiechula had been identified (see under section 2k) and it was decided to adopt one of the techniques used by him, that of holding the joints together by a single fixing passing through the centre of the joint. In this instance, the diameter of the sections to be held being small - perhaps 9 to 11mm of living wood - a variety of methods were attempted. Stainless steel wire ties and small gauge brass woodscrews were tried without success.*

At this point it was realised that some of the problems being encountered were caused by the necessity of pulling the sections to be grafted more closely together than they had grown. To overcome this problem in future it was determined that once the major form of each sapling was approximately established, the ties attaching it to the jig were to be removed and replaced by fabric bandages binding the saplings together at the points where the grafts would eventually be made.

When in July two of the Cherry saplings were discovered to have been broken off low down (cause unknown) it was decided to remove both of these, together with the Alder (Ru2) as being unlikely to produce viable results. Their places were to be taken by new structures in the next year.

By the end of this second year of growth the form of the successful structures had become well established, with many of the ties being removed as no longer necessary. There were signs that the topmost horizontal sections of the jigs were being distorted by the strength of the growth beneath them.

As planned, two of the three vacant positions on the site were filled early in 1998 by the planting of new structures using Sycamore saplings (once again donated by The Forestry Commission, but on this occasion not personally selected). Site visits were continued during the year, although personal circumstances meant that these were fewer than had been planned, a total of 6 being made between mid February and mid September. From late June until late August no visits could be made, resulting in a lot of untrained early growth by the newly planted saplings. (A useful demonstration of the necessity of regular attention to growing structures.)

The four mature structures (Ru4,5, 6 & 7) continued to develop, and a third method of securing the joints to be grafted was used. This involved the cleaning out of the joint and the drilling of a small preparatory hole. A length of threaded stainless steel rod was then inserted, nuts and washers screwed onto each end and the joint pulled up tight. During this season it became evident that the strength of the topmost jig section was by now unable to resist the upward pressure of the growing stems which pushed it aside, resulting in seat supports which now angled gently upwards.

The first site visit of 1999 was made in mid March. The mature Sycamores and the Maple had all progressed well and further threaded rod fixings were installed. It was decided not to prune the canopies of these structures until the end of the growing season in order to improve their rate of growth. Also at this stage it became apparent that the structures were well able to stand unaided, and the ply jigs were removed by stages.

At the end of 1999, (see figs 4f/2 & 3) the status of the structures was as follows ;-

position	species	comments
Ru1	sycamore	was cherry but replaced 1998 due to uneven growth
Ru2	was alder	not currently replaced
Ru3	sycamore	was cherry, replaced 1998 due to accidental breakage
Ru4	maple	mature growth, seat supports somewhat angled
Ru5	sycamore	fair growth, balance fair, grafts good
Ru6	sycamore	excellent growth, one stem somewhat over large, grafts fair/good
Ru7	sycamore	mature growth, grafts excellent

ii) LLWYD COED (site 2, see fig 4f/4)

The initial 1996 planting at Shinfield having received some considerable publicity in the National Press & Radio, an approach was received that Summer with an offer to install further stool structures on this site in South Wales. This offer was accepted, and in late March 1997, 27 stools were planted. These consisted of 11 Sycamore structures, 8 Maples (in this case Field Maples supplied by a local nursery and therefore not selected

Experimental site 1
Shinfield Berkshire

Two views of structure Ru6 pictured at November 1999.

The growing jigs have been removed, and the balance of the growth is fair, although as can be seen in the (slightly distorted) picture above, the leg nearest the camera is the largest. As far as can be judged, the lower grafts are partially successful, those at the apex less so. Ineffectively controlled, the outward branching seat supports have started to grow upwards

fig 4f/2

Experimental site 1
Shinfield Berkshire

*Seen left is structure Ru**5** with central reinforcing member (on harvesing this will be trimmed close above and below junction) Balance of growth of two of the legs is fair, one will require additional growing time to reach equity. Lower grafts appear to have taken well, resulting in slim 'cross rails'. Will these prove adequately strong since they will normally be in tension ?*

Seen right is structure Ru7 pictured at November 1999. As with Ru5 above, the lower grafts appear to have taken completely, resulting in sturdy legs (which are moderately well balanced for growth) with relatively slim ' cross rails'. Again, the upward growth of the seat supports has proved too powerful for the growing jig (which has been removed) to restrain

grown furniture

Experimental site 2

location Groundwork Merthyr & Cynon / Llwyddcoed / Aberdare / Mid Glamorgan

description a gently sloping, moderately exposed south facing site

first planted March 1997

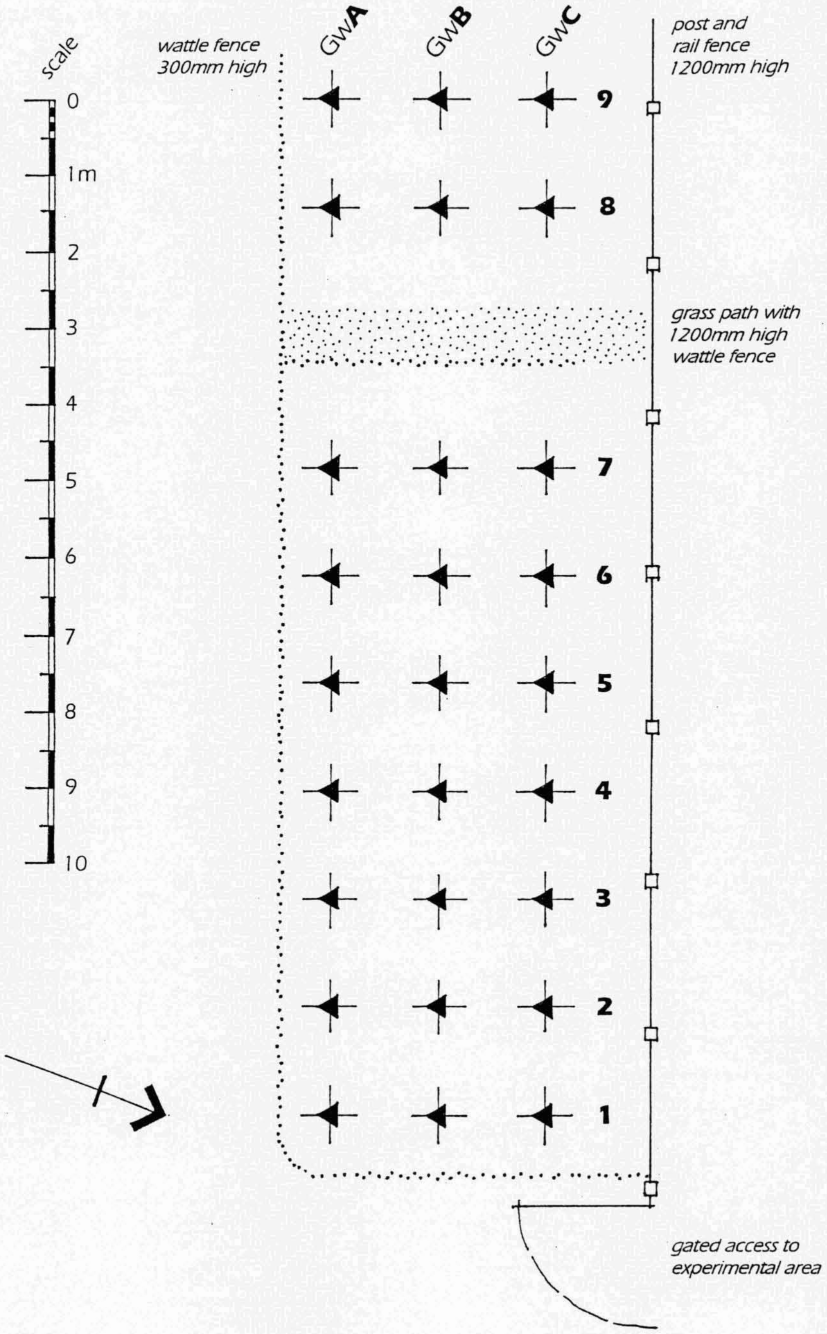


fig 4f/4

for the purpose) 5 Ash, and 3 Wild cherry, also locally supplied.

On this site the ground had been especially cleared of it's previous rough growth, and three long troughs of mushroom compost installed. These troughs were then covered with a layer of black plastic sheet and finally a covering of wood chippings to reduce the incidence of weeds.

During the year a total of nine visits were made from late March to late October. As was the case at Shinfield it was the Sycamores which developed the fastest, the Field Maples turning out to be a less obviously suitable tree, growing rather long and thin stems with regular and frequent leaf groupings. They were also more prone to throwing out side shoots which were likely to be of equal strength to the main stem, and had to be quickly removed. The Ash appeared to be of suitable habit, although developing more slowly. This relatively slow growth was a feature of all the structures planted here during the first season, the reasons being unclear. Some training and pruning was carried out as before, with the majority of the Sycamores reaching the tips of their jigs by the end of the growing season. The equality of growth within each structure was less marked than at Shinfield however, indicating the important of selection and the matching of the saplings to be used together.

With regard to maintenance, local volunteer staff were on hand on an irregular basis, to observe progress, and were very helpful in loosening any ties which threatened to become restrictive and with occasional weeding.

During 1998 the rate of growth increased, with approximately 90% of the specimens growing to the tips of their jigs, and initial grafting was carried out on approximately 20% of the lower junctions of the Sycamores. None of the other stems appeared ready to be grafted at this stage though. This improvement proved a ' mixed blessing ' however, since a total of only four trips could be made, the inability to make visits from late June to late August allowing some of the growth to occur in inappropriate forms.

In seeking subsequently to train growth at a stage which would not ideally have been attempted however, the bonsai technique of spiralling a soft wire around the stem before gently bending it to shape proved successful. It is important not to leave these training wires in place for too long - perhaps four or five weeks at most - to avoid scarring the stem.

The relatively slow growth and thin stems of the Field Maples, and the flexibility of the Ash, meant that some of these species could be pruned and trained back into shape.

Site visits in 1999 began in late April, when It was decided that 2 of the Sycamore structures, (B3 & C6) should be abandoned due to irrecoverably inaccurate growth. A very inaccurately grown example (A5) was retained for its curiosity value. One of the Ash structures (C9) was replaced with young saplings which was being grown elsewhere on site. The ability of Ash saplings to graft together is at this point untried, although this species was successfully used by Erlandson, and is recommended as suitable by Reames & Delbol [150] in their book.

Grafting was completed on a majority of the lower joints on four of the eight remaining Sycamore structures using the threaded rod technique as used at Shinfield. Depending on the successful formation of these grafts, the rods may be removed later or left in place to be engulfed by later growth.

As of October 1999, the status of the structures was as follows ;-

(refer to site plan at fig 4f/4)

position		species	comments
GwA	1	sycamore	
	2	sycamore	
	3	sycamore	
	4	sycamore	
	5	sycamore	inaccurately formed but retained
	6	ash	
	7	was ash	not currently replaced
	8	wild cherry	
	9	ash	
GwB	1	sycamore	
	2	sycamore	
	3	was sycamore	not currently replaced
	4	sycamore	
	5	field maple	
	6	sycamore	
	7	field maple	

8	wild cherry	
9	ash	
GwC 1	sycamore	was field maple
2	field maple	
3	was field maple	not currently replaced
4	was field maple	not currently replaced
5	was field maple	not currently replaced
6	sycamore	replaced 1999
7	field maple	
8	wild cherry	
9	ash	replaced 1999 due to unequal growth

iii) PRIESTFIELD (site 3, see fig 4f/5)

In early April 1999, four Sycamore structures were installed in a free grouping under a mixture of mature trees in the Arboretum. Up to the end of July seven site visits had been made.

These saplings, again donated by The Forestry Commission, established themselves well within a few weeks and were successfully trained to shape. The comparative rate of growth of each set was well within acceptable limits to begin with. By early June though, several of the saplings were suffering from what appeared to be mildew, their leaves covered with a greyish powdery layer, curling up and becoming brittle. The growing tips, while still alive, ceased to develop. In view of the lack of rain and their proximity to several mature trees, the Sycamores were watered in late June and again in mid July. In late July all diseased leaves were removed. By October, all the plants were still alive, although their growth had been retarded.

As of October 1999 the status of the structures was as follows ;-
(refer to site plan at fig 4f/5)

position	species	comments
Pa1	sycamore	balance fair
Pa2	sycamore	balance good
Pa3	sycamore	balance poor
Pa4	sycamore	balance good
		(growth retarded in all cases)

grown furniture

Experimental site 3

location Priestfield Arboretum / Stony Lane / Little Chalfont / Buckinghamshire

description a small site sloping gently down SW to NE, the experiments being well sheltered by existing mature trees, positions indicated

first planted March 1998

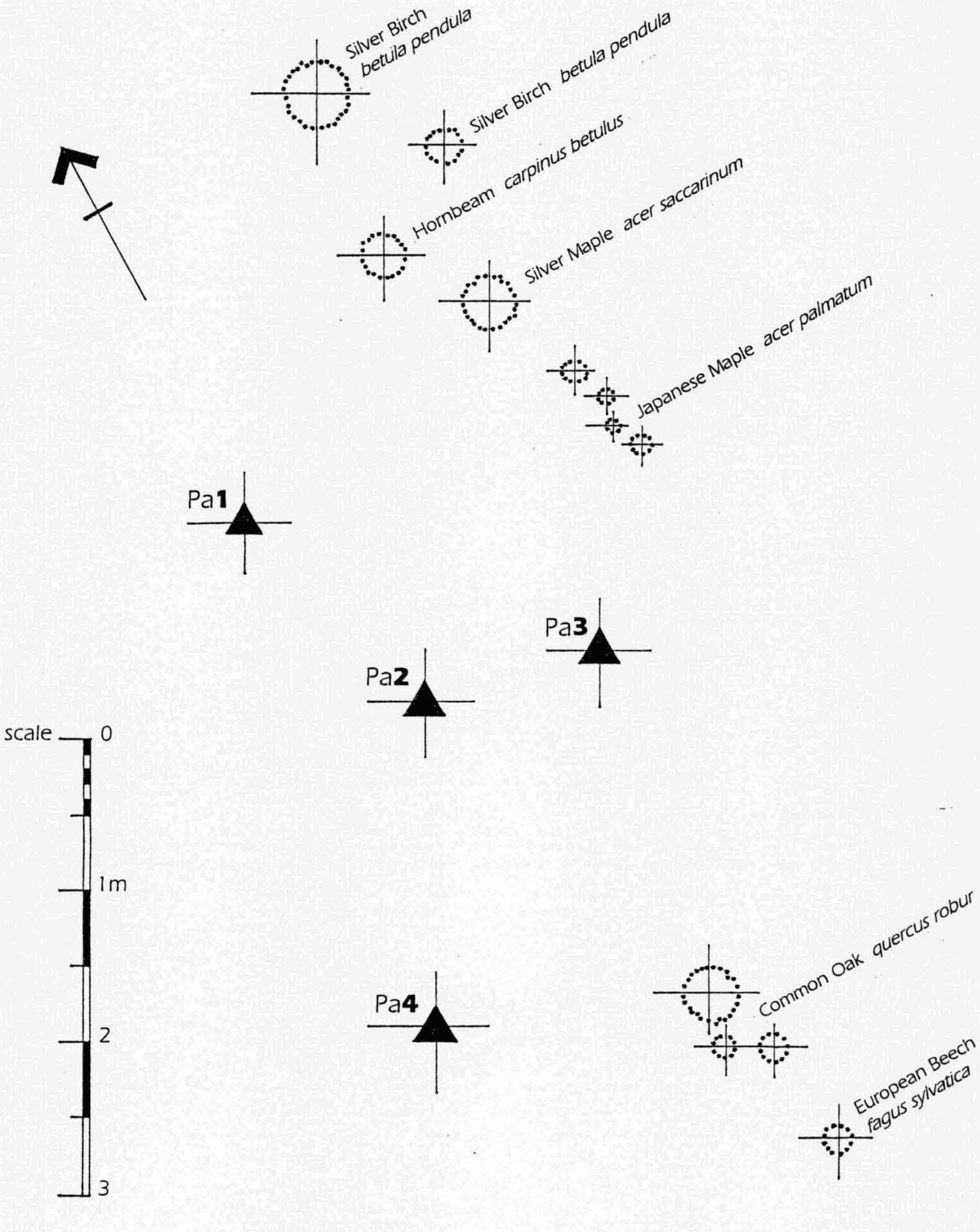


fig 4f/5

5 EXPERIMENTAL RESULTS

i) GENERAL

Since this production method is considered unsuitable for furniture intended for use where total consistency or ultimate reliability is essential, to attempt to lay down standards to which such pieces must conform may be seen as inappropriate. The following comments should therefore be taken in the context of the production of a variety of pieces on a limited scale by the 'Grower-craftsman'

ii) SELECTION

The most successful outcomes overall have been obtained using saplings from the *Acer* family, either Maple or Sycamore, these species having been found to graft more readily than the others tried. In terms of the ability of their young shoots to accept being trained to shape however, all of the other species used - with the exception of the Alder - proved suitable, with Ash in particular tending to produce elegantly curved shapes when trained early enough (although some less flexible sections of stem could give problems).

All the current experimental structures were grown from saplings rather than from seed, and this system is to be recommended as it enables healthy plants to be selected, to be grouped in matching sets.

iii) THE JIG

In performing it's intended function, the jig designed to support and control the growing structures has proved successful. These are simple to cut, to transport and to assemble accurately on site. Later, they are robust enough to support the sets of saplings while the basic form of the stool is being established. The quantity of pairs of holes provided for the ties proved more than sufficient in number, allowing alternative fixings to be positioned avoiding sensitive areas, buds or damaged sections of stem. The only element on the existing design requiring modification has proved to be the horizontal capping panel which has in some cases, been found to be inadequate to resist the upward thrust of the growing stems. A more robust solution to this problem is required, and one which will better locate the final upward growth. The durability of the WBP plywood from which these jigs have been cut, having been twice coated with preservative, has proved sufficient to last while the form of the structure was established. On current evidence however, they would not last for a second four or five year period. (see comments below)

In terms of energy conservation however, the manufacture of a new jig for each grown structure is undesirable, negating at least some of the advantages of the system. Possible alternatives are ;-

- The use of sufficiently durable, recycled and recyclable board materials from which the jigs might be cut, such as Centriforce 'Stokbord', Tetrapak 'Tectan' or perhaps a suitable non rusting metal sheet such as recycled aluminium.
- The 'dematerialisation' of the jigs by the use of suitably durable stakes driven into the ground, to which are attached tension cables of organic fibre such as hemp.

The exact type of jig required will vary with each design, (perhaps comprising a combination of the above) as will the length of time for which they are required. The nature of the growing process is such that once the form of a particular part has been established, it's controlling jig may be removed and if required, reused elsewhere. Similarly, the jigs controlling the later stages of growth become necessary only later in the process.

iv) PLANTING

While the planting of individual saplings is simple enough, in these cases the accuracy of their positioning relative to each other is essential. For this purpose the planting positioning guide (S2J/ 04) has been found to work well.

v) TRAINING

When installed during the appropriate stage of growth, the redirection of the newly grown shoots has proved simple to carry out by hand, the ties being easily threaded through the holes in the jig and gently twisted together around the sapling stem. When carried out at a later stage of growth, more care and patience was required in bending the stems to shape. In these cases the technique of coiling soft wire around the more rigid stem to support it proved useful.

The nature of the paper covered wire ties used to hold the stems in place allowed for accurate control, while meaning that they required attention at regular intervals to avoid marking the growing stem. Once the shape was established however, these were removed and replaced by strips of cotton fabric at the points where grafted joints were to be installed.

vi) GROWTH

The sets of saplings used for each structure having, as far as possible, been chosen and matched for size and apparent vigour at the time of planting, the only subsequent failures of individual plants were due to accidental damage by others.

The speed of growth of individual stems has - as might be expected - varied, and was retarded in some of the earlier experiments by what proved to be unnecessarily vigorous pruning. Experience has now shown that such pruning need only be used as a means of retarding the growth of the more vigorous stems, to allow a better balance of growth to be achieved. This simple technique of selective pruning appears to be all that is required.

vii) JOINTING

The preferred method of jointing is by grafting. Experiments have shown however, that the degree of success achieved by grafting may vary between an apparently total union of the stems, and a result in which the two passing stems, while evidently united at the point of contact, nevertheless appear to remain individual in terms of their further growth. The relative strength of these grafts can only be properly assessed by from experience, and by experimental testing.

The quantity of frames grown and harvested has not yet been sufficient to allow for any structural testing, and it is not therefore yet possible to make any strength comparisons with more conventional construction methods. When the quantity of available frames is sufficient, such testing will be instituted. The nature of the product is such however, that no very consistent results are to be expected, or are deemed desireable. Similarly, it is recognised that the strength of individual joints is relevant only to their contribution to the structure as a whole. The technique of holding the joints together by the use of threaded rods while the graft develops (as described at Site 1 during 1998) may well be expected to affect the strength of these joints in some cases.

viii) GRAFTING TECHNIQUE (see also APPENDIX B)

The technique of approach grafting requires careful matching of the area on each stem to be mated. In this regard, it was discovered in the course of the experiment that if the two sections of growth to be joined were bound closely together for a period of only three weeks during the growing season, a slightly flattened area would be produced on each stem, giving a good guide to the correct positioning of the section of bark and cambium to be removed.

As described elsewhere, as an alternative to binding the stems together while the graft 'took', a system of bolting through the two stems to be joined was used in order to avoid the problem of bulging which tended to occur on either side of the bound area. This in itself produced some more localised bulging around the point of entry and exit, which is expected to disappear as the new growth covers the bolt heads.

ix) TIMING OF GRAFTS

Experimental results have shown that grafting is best carried out during - and preferably at the beginning of - a period of vigorous growth. In Britain this may be assumed to be generally in March / April.

Where grafted joints have been successfully made, the flow of sap between roots and leaves has taken the shortest route, and along this path growth has continued as in a normally growing stem. The section of the stem now bypassed has tended to remain at or about the girth it had reached when the graft was installed.

In the case of several of the experimental stools, this phenomenon has produced a structure having 'legs' which are considerably stouter than the 'rails' which join them. It can thus be seen that grafts should not be installed until the sections of growth which will become bypassed by them have attained the girth required in the finished piece.

x) MAINTENANCE DURING GROWTH

Generally maintenance of the growing structures has proved to be remarkably trouble free, the removal of small unwanted buds and side shoots being a quick and simple hand operation, occasionally requiring the use of a scalpel or sharp knife. Some weeding in the immediate vicinity of the structures was required during the growing season on one of the sites which had not been protected by the use of plastic sheeting.

The potential problems of attack by pests or hungry animals has not been encountered, and on only one of the sites was any form of disease noted.

Among the technical considerations which arise from the use of these techniques however - bearing in mind the desirability of maintaining an ecologically sound approach - are ;-

- Harvesting /drying / shrinkage / warping. As with any grown timber product, the normal practice of harvesting when growth is dormant will yield timber with the lowest possible moisture content. This is then air dried for a period of approximately one year for each 25mm (1inch) of timber thickness. In the case of the stool frames under consideration, whose round section members vary in diameter from 20mm to 45mm, a period of 18 months has been found suitable. At the end of this time, a small amount of splitting is evident at the upper tips of the harvested frames. In anticipation of this eventuality all the members were cut at least 100mm (4inches) over finished length. With regard to warping, it is impossible to anticipate any difficulties which may occur, since the frame of each piece will normally form an integral three dimensional structure.
- Sapwood. All grown structures will - as harvested - consist to a considerable extent of sapwood. This timber is less dense than the more generally used heartwood, and is liable to the problem of infestation. To prevent this, it will be necessary to treat these pieces, probably by soaking in a suitable liquid.
- Debarking. This process may or may not be carried out, dependent on the appearance required. Various mechanical techniques may be used such as sand or shot blasting, or removal by hand using abrasive techniques involving files,

sandpaper etc. The first is - in terms of the use of energy - undesirable, the second very labour intensive. The possibility of removal by soaking is under examination.

- Decoration - the process of growth invites many forms of decoration peculiar to this process such as scarring, the incorporation of suitable ceramic or glass beads, etc.

5a Conclusion

' with the exception of Papanek, Fuller and a few other critics and visionaries, designers have not been able to envision a professional practice outside of the consumer culture. '

V Margolin, *'Design for a Sustainable World'*
Design issues, Vol 14 No2 MIT press,
Cambridge MA, Summer 1998

i) CONTRIBUTION TO KNOWLEDGE

As stated in the introduction, the aim of this thesis has been to contribute to the current environmental debate, and to demonstrate the practicality of the proposal that furniture structures may successfully be grown.

Experimental results have varied. Nevertheless the possibility of success has been demonstrated, and with it the need for a new specialisation within the Design profession.

Forming as they do an essential link between production and consumption, designers - in this case particularly designer craftsmen - are surely ideally positioned to lead the move away from the currently accepted consumer attitudes ? Yet as noted by Margolin and others, they have so far been markedly reluctant to accept this, surely their natural role.

Over the period of these experiments, an increasing number of books have been published on the so called Eco - topics. Many of these are aimed specifically at students of design, perhaps providing evidence of a long overdue increase in student interest in environmental problems. The interest shown in the current research by the media - Press, TV and Radio, may be taken to support this view. (see APPENDIX D)

If this particular new and exciting area of design is to flourish however, there will be a need for a group of craftsmen - 'Designer Growers' - with a different combination of skills.

These specialists must of course be aware of - and skilled in - the arts of both training and grafting young trees. Beyond these practical skills however, such craftsmen must possess a degree of both creativity and aesthetic judgement. They must also show and enjoy the patient application needed to work with nature in the gradual process of creating beautiful and useful items of furniture over a period of several years.

ii) RECOMMENDATIONS FOR FURTHER RESEARCH

The experiments carried out so far, having answered the fundamental question as to the practicality of producing furniture by the use of controlled growth, have indicated the following promising areas for further research ;-

- Control of rates of growth. In order to achieve the required relative balance of growth of the individual stems which make up a piece of furniture, the various means of both retarding and encouraging growth should be explored.
- Control of grafting union. As may be seen in fig 5a/1, the relative degrees of union formed by a graft may vary. As these variations will have a noticeable effect both on the appearance and presumably on the strength of the piece, it is highly desireable to be able to control and predict the outcome.
- To achieve a finish other than that which may be termed 'Rustic', it will be necessary to remove the bark, and perhaps some of the irregularities which are inevitable with this type of structure. Finding appropriately environmentally benign ways of performing this task, which are nonetheless not overly laborious, will provide another fruitful area for exploration.

Graft variations
The degree to which grafted stems unite has a marked effect on the relative thickness of growth of the various members of a structure, and consequently on their appearance and strength.

top left
the grafts on this structure have united to a minimal extent, the thickness of individual stems being little affected by the graft.

top right
this graft has substantially but not totally united the stems, a considerable amount of the post grafting growth now following a near vertical path.

lower left
following the installation of these grafts, each ' leg ' of the structure has almost totally united, this growth pattern taking over completely from the original serpentine route.

6 POSTSCRIPT
Design proposals for grown furniture

So far, practical experimentation has been limited to the growth of examples of the three legged stool/table frame illustrated in fig 4b/2. At this point however, it is possible - using the knowledge gained over the research period - to propose designs for some of the other larger and more elaborate furniture structures which are considered appropriate to be produced by means of this technique.

Since the ' production method ' is so different from the conventional system, it would seem logical that substantially different forms of furniture should emerge, and indeed in purely logical and in ' design ' terms this is so. In commercial or ' marketing ' terms however, where public acceptance of a product is of prime importance to it's commercial success, a radical departure from the norms currently obtaining would appear unwise. Since the writer's aim, having established the technical viability of the system, is to secure it's public acceptance, it has been thought better to lead the consumer gently down the 'green' path than to risk rejection simply on the grounds of unfamiliar appearance. For this reason the proposals shown and discussed here, aim - while being appropriate to their method of production - to avoid antagonising the reasonably 'enlightened ' potential furniture buyer. (Since none of the initially grown pieces have been fully finished at the time of writing, it has not yet been possible to test customer responses.)

For this reason, the various panel components of these designs such as table tops or chair seats and backs, are proposed to be constructed and fixed to the grown frames using appropriately benign forms of the available conventional systems and materials.

(A range of upholstery fabrics currently in production by the Swiss Company Rohner Textil is claimed to be totally environmentally benign in its production, use, and final disposal, while the manufacturers of man made boards are - not before time - making considerable efforts to reduce the environmental impact of their products.)

6a General considerations

i) SPECIES SELECTION

Further practical research is required to further establish the particular suitability of the many possible tree species. Characteristics such as rate of growth, ease of training and grafting, resistance to disease and attack by pests, squirrels, deer etc, as well as strength, durability and the appearance of the finished timber must be considered.

ii) SELECTION OF SAPLINGS

It is anticipated that all free standing grown furniture structures will consist of a number of individual saplings, and that the selection and matching of these will most easily be made once the seedlings have attained a height of at least 300 - 400mm or more. This will ease the choice of healthy young plants which are of approximately equal size and vigour.

iii) TRAINING TO SHAPE

To ensure that the maximum amount of growth will occur once the stem has been directed to the required shape, it is desirable to train new growth as soon after it's appearance as practicable. In many species this new growth is however, too vulnerable to be manipulated for from two to three weeks after it's first appearance. It may also lack the desirable springy resilience to ensure the type of graceful curve required. Once this phase has passed however, it is preferable to impart the required form as soon as possible, before the new growth becomes intractably rigid later in the year.

Once trained and held in place for the remainder of the growing season, the form will in general tend to be maintained. It has however been noted that some - particularly horizontal - sections have tended to revert to a more vertical stance during subsequent growth if not securely restrained.

iv) FIXING

The experimental method adopted by the author, of securing the stems by tying with either wire plant ties or with strips of cloth, has proved generally successful with one proviso. This is that these ties must be monitored during the growing season and adjusted as necessary. Failure to do this at two to three week intervals, can result in constriction of the growing stem, leading to unsightly scarring and damage.

An alternative method - using pins driven through the stem and into the supporting jig - might offer advantages, there being minimal interference with the cambial region. To date however this system has not been attempted.

v) PRUNING

In order to achieve as smooth a final result as possible, it is desirable that unwanted side shoots be removed before they can achieve any substantial girth. By reducing the quantity of leaves available to the tree however, this practice may retard it's rate of growth, and it is consequently necessary to attempt a balance between these two conflicting requirements.

Once the growing tip has passed the topmost point of the finished item this problem no longer exists, and bushy top growth can be encouraged to provide rapid development of the lower stems. A further consideration now becomes apparent however as, depending on location, this mass of branches and leaves may be liable to considerable buffeting by strong wind, perhaps resulting in damage to the as yet incompletely grown structure.

vi) GRAFTING

Successful grafts are important to the physical strength of the finished piece, and since they involve the infliction of 'wounds', they should be carried out during the period of the year when growth is vigorous - before May is best, after July worst. Following the installation of a successful graft, the sap will establish new connections between roots and leaves, these occurring on the most direct vertical routes. Once these have formed, the growth of any members lying outside these routes will tend to diminish, developing slowly if at all.

Having been understood however, this process may be used to the furniture growers advantage. By the judicious positioning and timing of grafts, and by removing or restricting the relative size of either roots or tree crowns, it should be possible to redirect the flow of sap, thereby strengthening grafted unions.

vii) HARVESTING

To ensure that minimum shrinkage - and consequent damage by splitting and warping - occurs, the finished structures should generally be harvested when the trees are dormant, that is to say during the early winter months.

6b **The grown tripod** used as a leg structure (see fig 6b/1)

Grown individually but intended for use in multiples, this is the simplest and most versatile of the grown structure proposals. Each unit consists of either three or four saplings, trained to shape and is used inverted. As can be seen from the illustration, these structures can be grown either symmetrically to provide a leg central to its crown (its base as grown) or - as shown under the cabinet - biased to give a leg under any one of its component stems. These units will normally be used under a self supporting top or the relatively rigid base of a cabinet, being fixed in place by inserting the three or four doweled stubs of the structure into prepared sockets on the underside of the top.

i) THE GROWING JIG

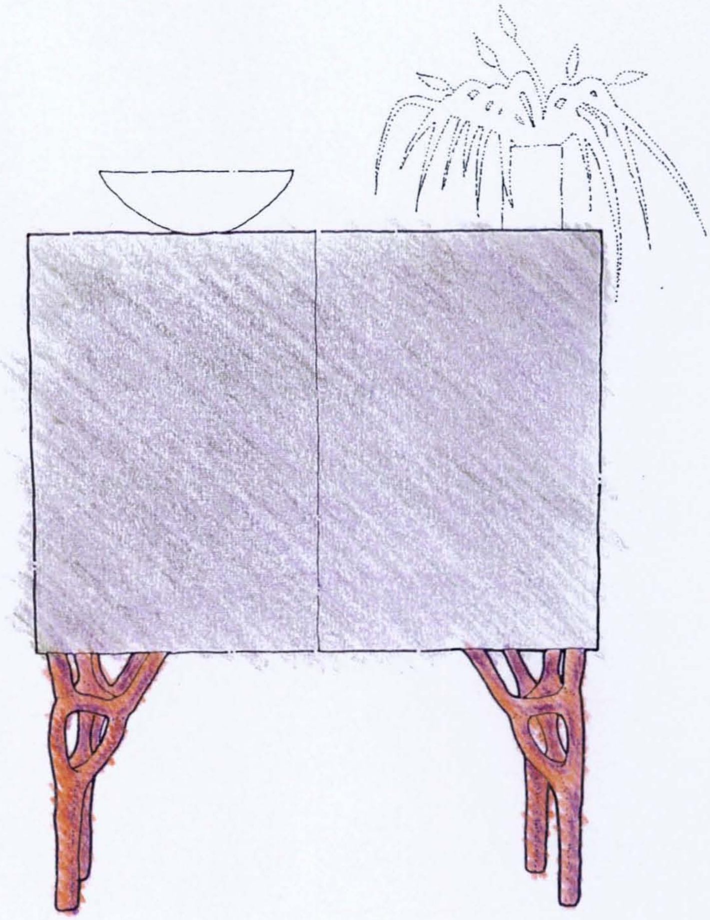
Simple three or four sided internal pyramid structures, similar to that described and illustrated in Drwg No S2J/01 (Practical experimentation, the experimental jig) will be used to control the form of the bases of these structures, the united growth which eventually forms the leg being braced if necessary by the use of guy ropes.

The grown tripod used as a leg structure

The simple tripod structure used as the base for the experimental grown stool / table, may also be used in multiples to form individual legs for larger furniture pieces. When grown for use in this way, the individual saplings - rather than being spread in order to support a top - are grafted together to form a single sturdy leg.

As examples, both the cabinet and table proposals shown here make use of these tripod structures, reversed head to foot.

The table top and the bottom of the cabinet are rigid enough to be self - supporting, and in both cases the legs may either be permanently attached or removable.



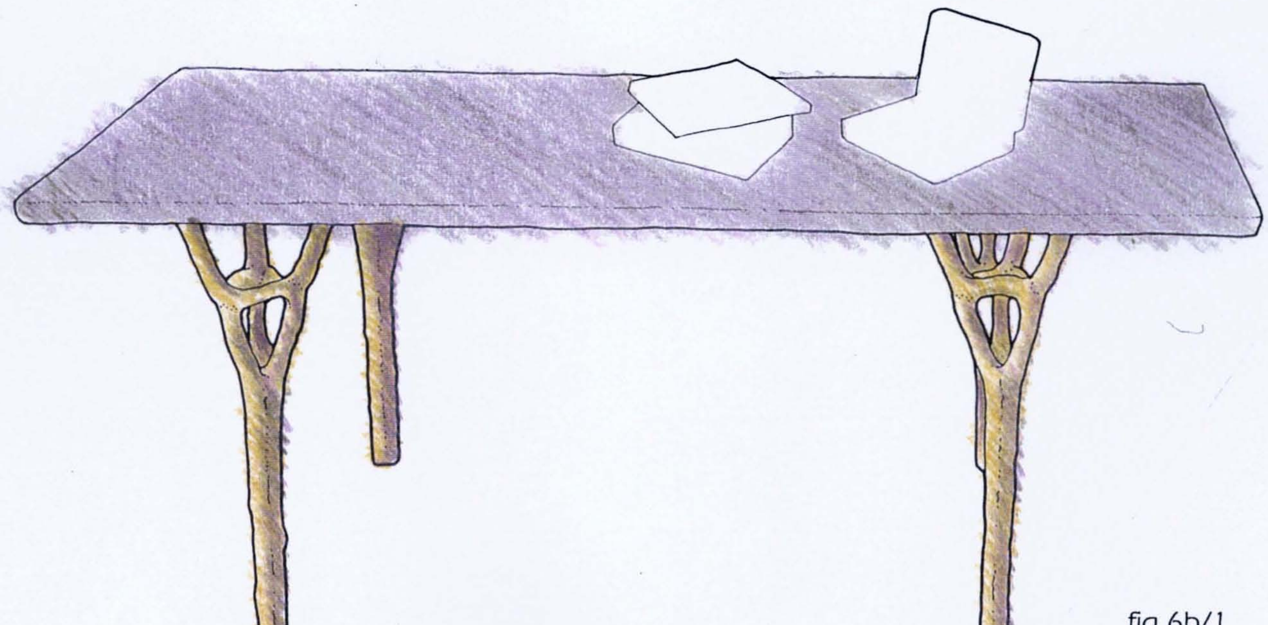


fig 6b/1

ii) THE GROWING METHOD

Having been selected on the basis of approximately equal vigour and size of growth, the sets of three or four saplings - having grown to a height of 300 to 400mm - are planted simultaneously at the corners of the jig. Successful transplanting having been established, these are then carefully trained to shape and secured in place on the jig. The timing of the installation of the grafts will depend on the rate of growth of the various members, but should be carried out at a time of vigorous growth, allowing a good union to be formed and the wounds inflicted on the stems to heal as soon as possible. Unwanted side shoots should be removed as they appear. On reaching the tip of the jig the three stems are grafted together to form a single column, being allowed to continue to grow vertically, while side shoots should continue to be removed until a total height exceeding the required finished height is exceeded by approximately 400mm. Beyond this point the development of leaves should be encouraged, to allow growth to be as rapid as possible. If thought advisable, the leafy crown may be supported by the use of guy ropes until a suitably robust growth is achieved, and harvesting carried out.

6c **Pyramids** storage structure (see fig 6c/1)

Using a minimum of two of the basic grown tripod structures, a wide variety of free standing storage or display units may be devised. While shown in combination with simple shelving elements, these grown supports are suitable for use with a range of display panels, shelves, cabinets etc, which may be of rigid panel or flexible skin construction. Standing approximately two metres high, the vertical posts must be grown to a sufficient girth to provide support adequate for their intended use, and these structures will be of substantially greater dimension - and consequently age - than the otherwise similar inverted tripod leg structures described above in section 6b.

i) THE GROWING JIG

As above, simple three or four sided internal pyramid structures, similar to those described and illustrated in Drw No S2J/1 (Practical experimentation, the experimental jig) will be used to control the form of the bases of these structures, the united growth which

Pyramids grown domestic storage unit proposal

A tentative first step towards the less conventional design possibilities opened up by the new production technique.

As shown this open shelving unit consists of a pair of grown columns, each of which is self - supporting on a four legged pyramid base, but since each column stands independently, the assembly may conveniently be extended by the addition of further columns and shelves.

The adjustable shelves are dropped over the columns and supported by pegs inserted through holes in the columns.

If required, lateral bracing may be provided by diagonal tension wires.

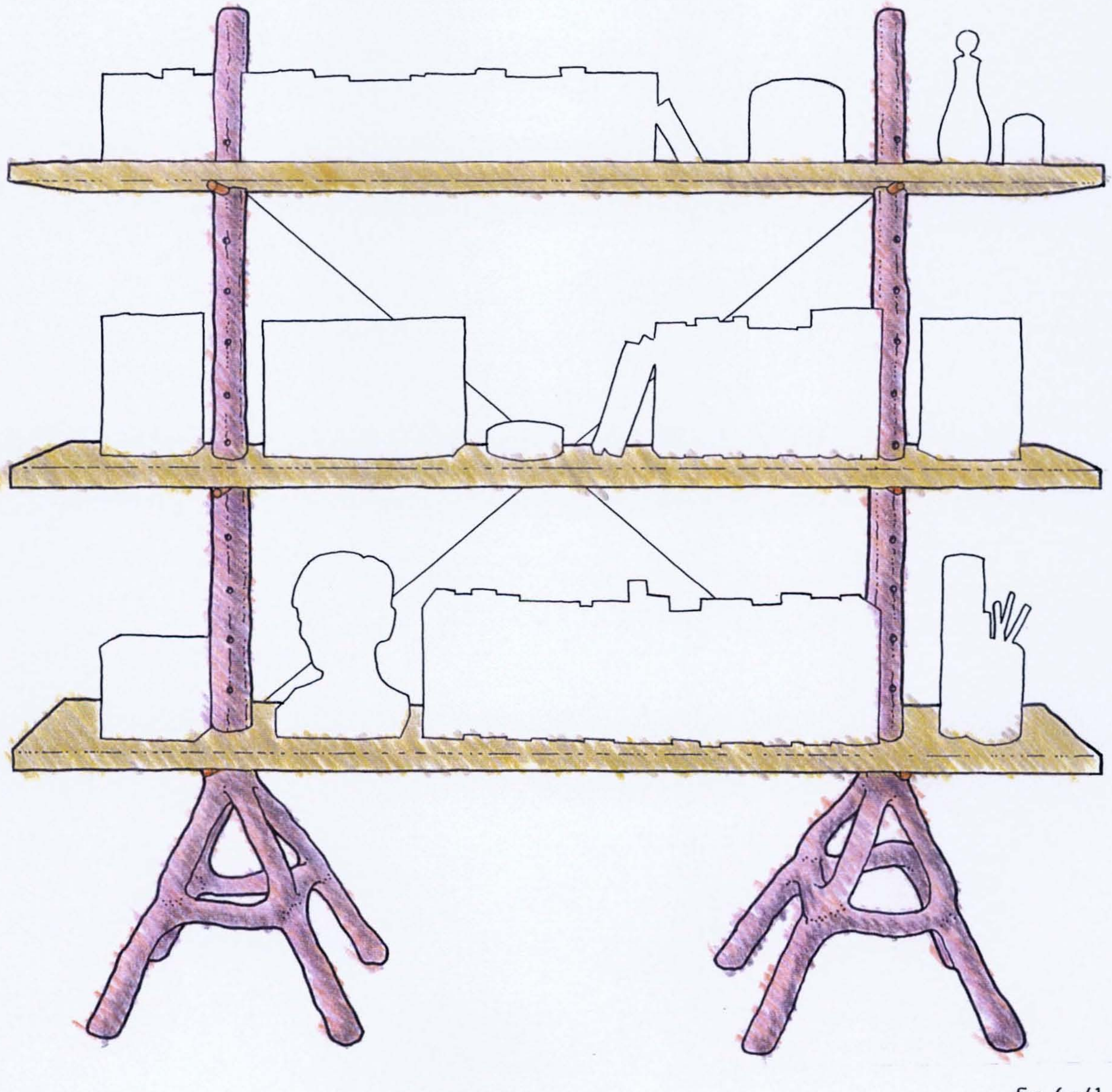


fig 6c/1

eventually forms the leg being braced as necessary by the use of guy ropes. In these cases however, the overall dimensions will be substantially larger.

6d **Threesome** grown table (see fig 6d/1)

A simple three legged table proposal with cross braced underframe. The basic design is suitable for growing in a range of sizes and heights, and while illustrated with a glass top, this leg frame could support tops in a range of shapes and sizes. The angle of inclination of the legs and the point at which the cross bracing occurs could equally be modified to suit.

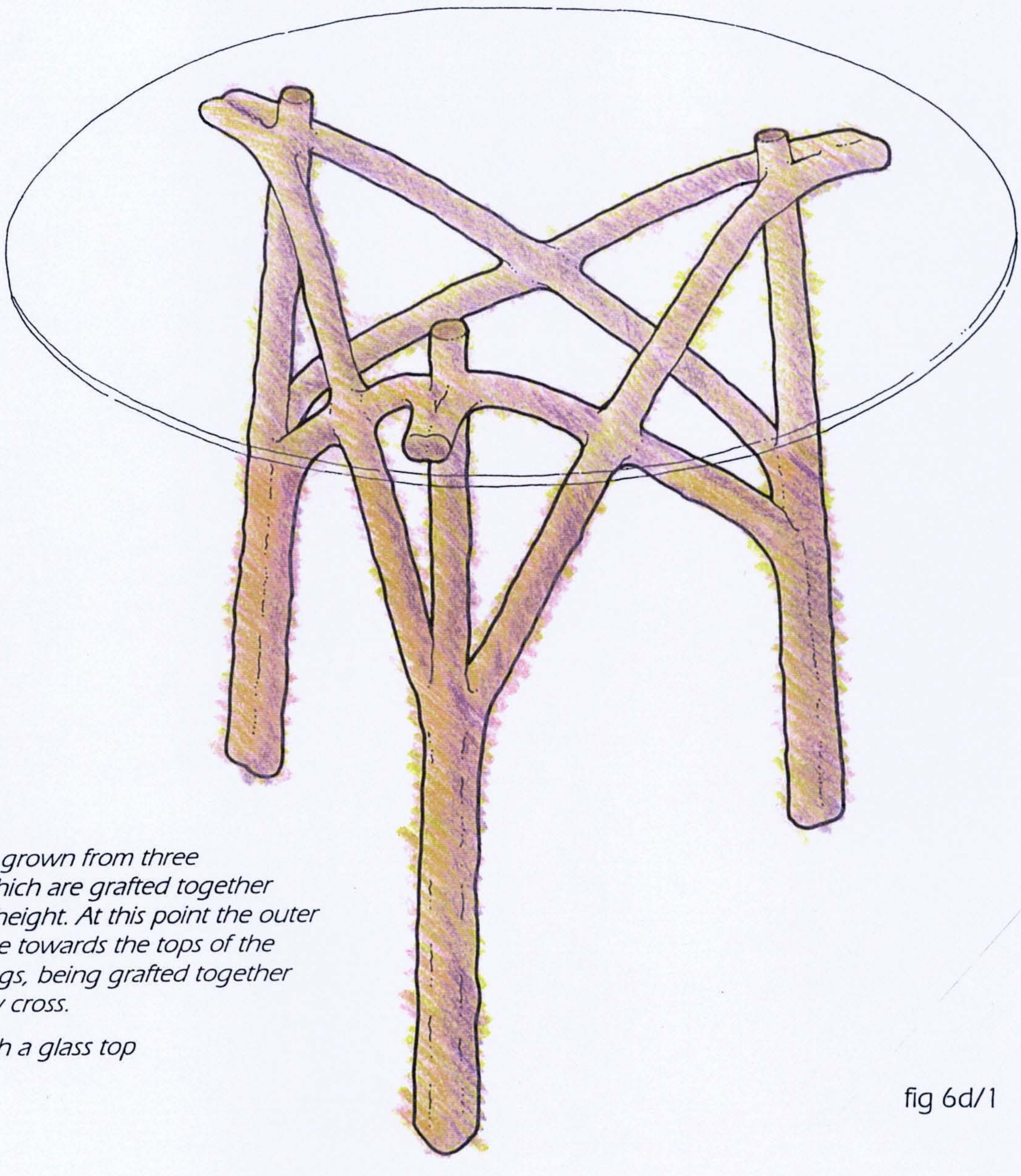
i) THE GROWING JIG

The internal growing jig will consist of a demountable frame resembling - and set closely within - the finished table. The three vertically inclined leg supports are accurately positioned relative to each other at the top by diagonal bracing on each face, and at the bottom by the use of a removable planting jig. (see fig S2J/04 for an example of such a jig) An additional horizontal element will eventually be required to ensure the horizontal termination of the upper ends of the diagonal members.

ii) THE GROWING METHOD

Since in this design the legs are straight and of greater girth than the diagonal subsidiary members, these leg saplings should be pre-grown to a height of approximately 850 - 900mm (if for use as a dining table) , their stems being clear of side shoots to a height of 750mm. Having selected three well matched saplings, these should be transplanted to the corners of the growing jig, suitably secured to it, and allowed to become established. The six subsidiaries - also suitably matched for size and vigour - are then installed as pairs, as close as practical to the legs. These subsidiaries should be of sufficient height to allow them to be immediately trained up the legs and diagonally across the faces of the jig, crossing at the central point, while their girth should be such as to allow this. This phase being installed at an early part of the growing season, all the constituent stems are then grafted together as indicated in the illustration, being allowed to grow until the completed framework is achieved.

Threesome grown table proposal



Each leg is grown from three saplings which are grafted together up to mid height. At this point the outer two diverge towards the tops of the adjacent legs, being grafted together where they cross.

Shown with a glass top

fig 6d/1

At this point the crowns of the leg members should be removed at a suitable point above table top height (or at least drastically reduced in size). In this way their well established root structures will be encouraged to form better and stronger connections with the crowns of the diagonal braces.

6e **Wishbone** grown table (see figs 6e/1 & 2)

A four legged centre pedestal table. The top, supported on the central pedestal, is fixed and braced by the ' wishbone ' pairs of subsidiary stems which spring from the legs and radiate outwards beneath it.

i) THE GROWING JIG

The jig is installed in two stages, as required by the progress of the growth. The initial lower stage consists of four curved formers set at 90 degrees to each other, over which the legs are trained to meet. The upper second stage is in the form of a horizontal cruciform frame which surrounds the grown central column at slightly more than the height of the future table top. This is supported and accurately located by the lower section, providing attachment points for the subsidiary stems as they grow.

ii) THE GROWING METHOD

Being of by far the greater girth, the saplings which form the four legged base, having been carefully matched, are planted individually at the foot of each of the four formers of the lower jig. They are then trained to curve up them and to meet to form the central column, where they are grafted together. Unwanted side shoots are removed until the column has grown to a point well above finished table height, or approximately 1 metre from the ground. Thereafter bushy growth is allowed to develop, to encourage rapid thickening of the existing stems. This part of the structure is allowed to develop for at least two or three years before the remaining saplings, which form the subsidiary top braces, are planted in pairs on either side of each of the four legs. At planting these should be of approximately 800mm length but of flexibility such as to enable them to be trained to shape to follow the curve of the legs. They then meet and are grafted canting outwards in

Wishbone grown table proposal

The legs are grown to shape on a jig and grafted together to form a central column. The bracing ' wishbones ' are formed by four pairs of saplings subsequently planted between the legs and grafted firstly to them and then together, before splaying out to support the top.

If required to be removeable, the wishbones could alternatively be grown separately for dry attachment

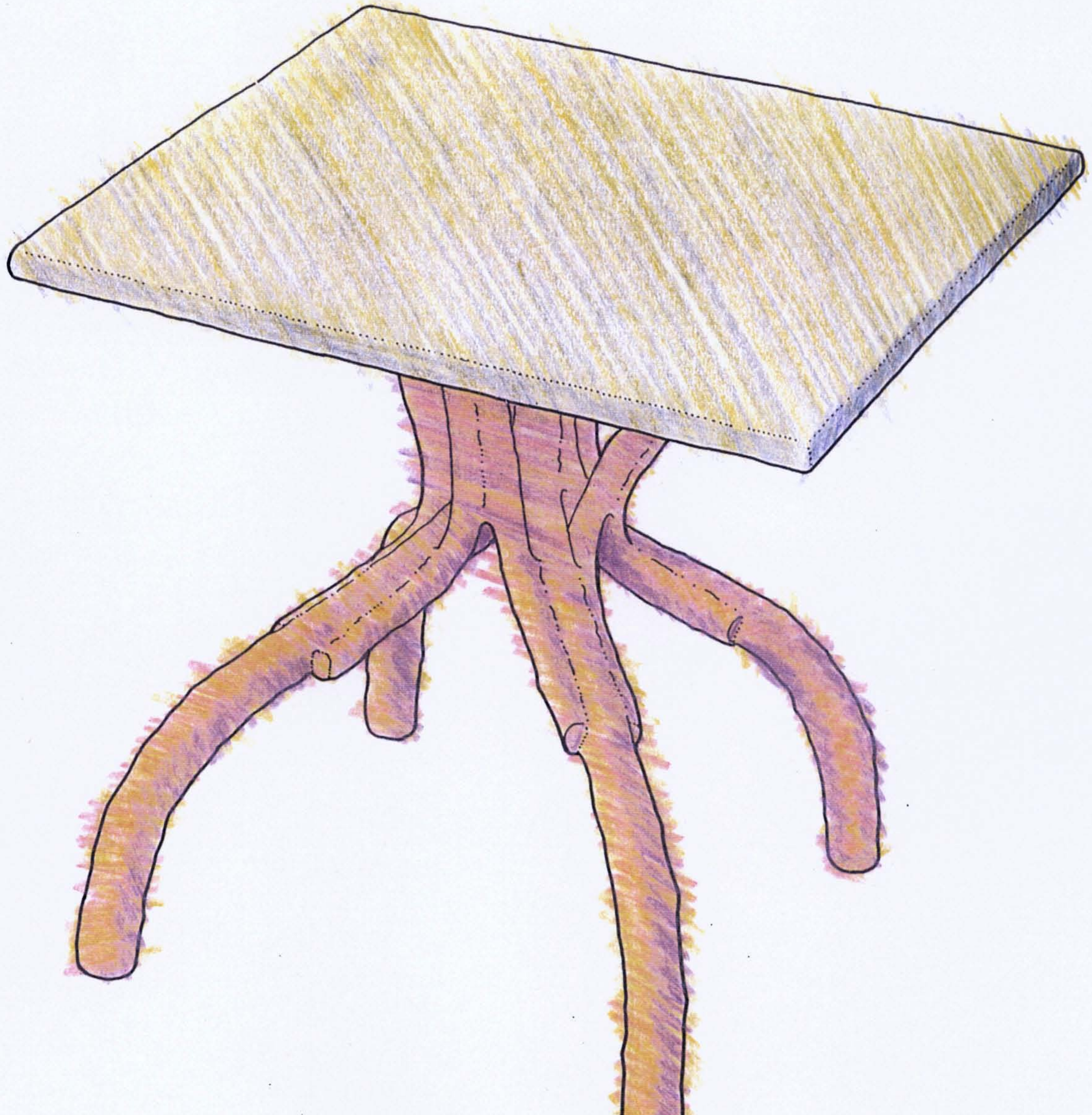
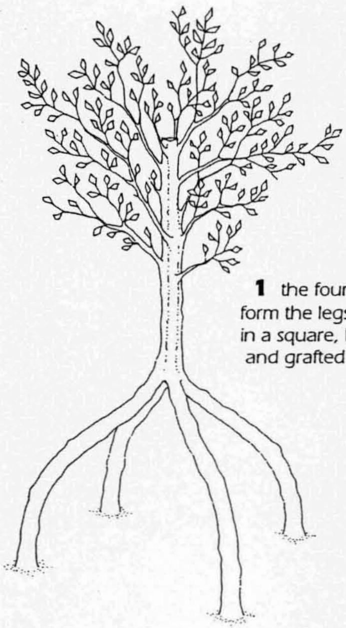
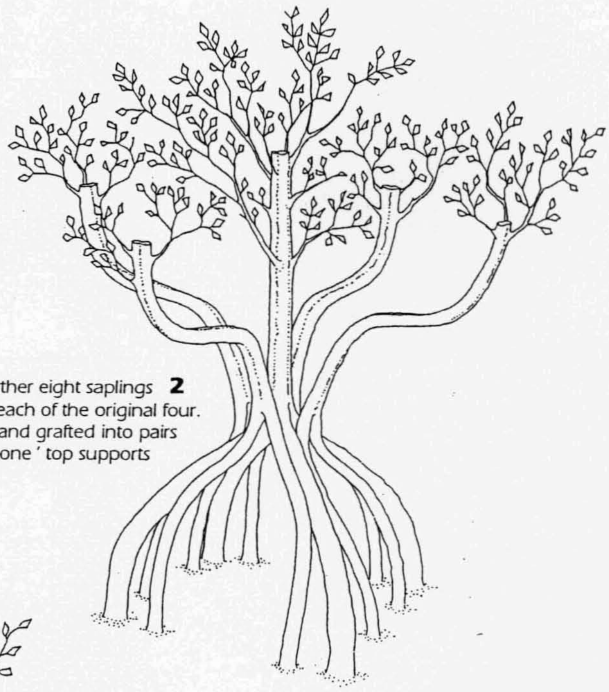


fig 6e/1

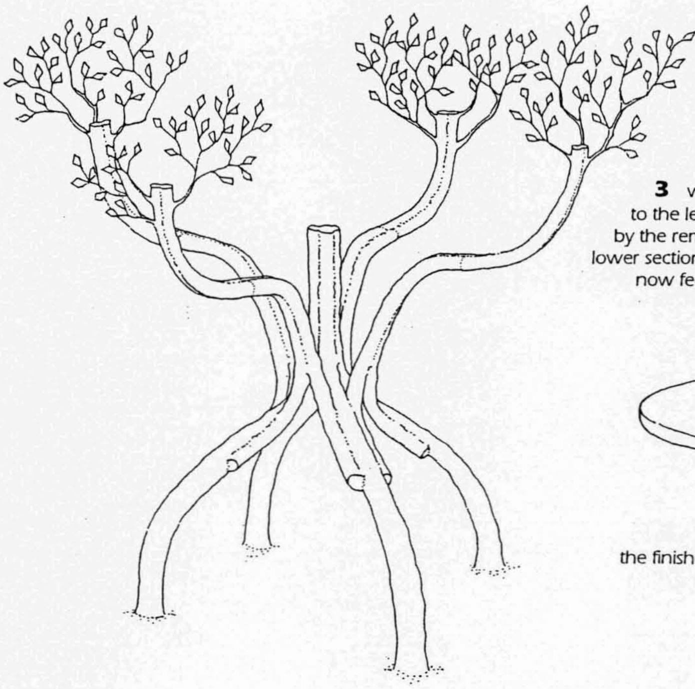
Wishbone grown table proposal



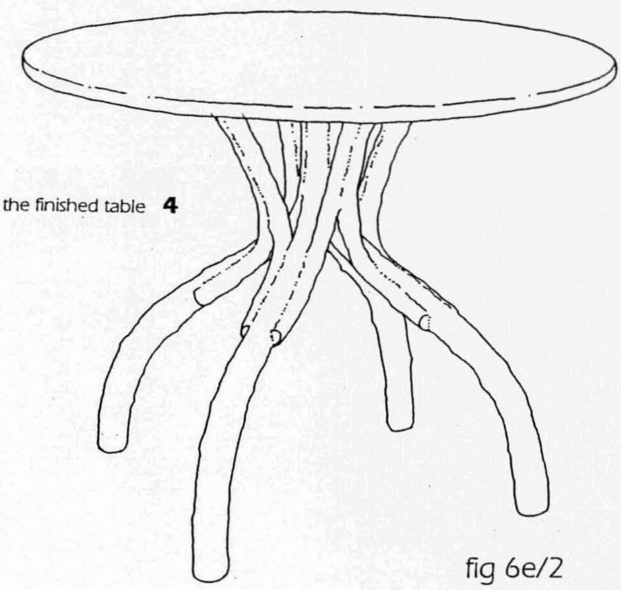
1 the four saplings selected to form the legs of the table are planted in a square, being trained to shape and grafted together



after a suitable period a further eight saplings **2** are planted on either side of each of the original four. These are trained to shape and grafted into pairs to form the 'wishbone' top supports



3 when appropriate, further grafts joining the wishbones to the legs are instigated. The bonding of these may be promoted by the removal of the upper section of the leg structure and the lower sections of the wishbone structures, the roots of the one now feeding the crown of the other



the finished table **4**

NB if required the growth of the structure might also be undertaken partly in component form, the wishbone structures being grown independently and suitably dry fixed in place to allow dismantling

fig 6e/2

pairs, as can be seen in fig 9e/2. This form having been established, the upper component of the jig is installed, providing guidance for the remaining growth of these saplings.

The finished form of all components having been set, the grafts connecting the major and the subsidiary components are installed. To encourage these unions to develop strongly, the crown of the central column is removed or severely pruned, while at the same time the bases of the subsidiary saplings are removed. In this way the well established roots of the leg structure are encouraged to develop strong inter - connections with the leafy crowns of the subsidiary or ' wishbone ' saplings. Only when all the unions are sufficiently grown and the girth of the various members is judged to be adequate should the completed frame be harvested.

6f Dyna grown chair (see fig 6f/1)

A four legged upright or dining chair, the frame consisting of eight individual stems which are variously approach grafted together to form the whole. The design allows for a variety of different patterns to be grown within the chair back.

i) THE GROWING JIG

The diagonally braced four legged jig sits within the growing chair frame, offering sufficient horizontal attachment points in the seat area to allow close control of growth at this crucial point. In the area of the chair back a subtly curving but rigidly supported panel is also required. The eight saplings used will produce a considerable crown of leaves which must be well braced to eliminate the danger of wind damage.

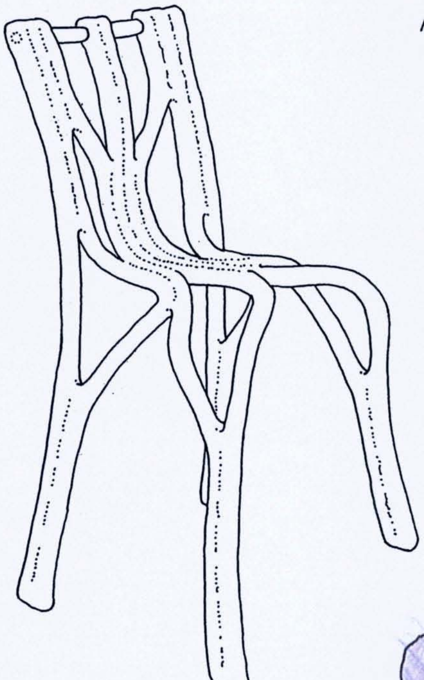
ii) THE GROWING METHOD

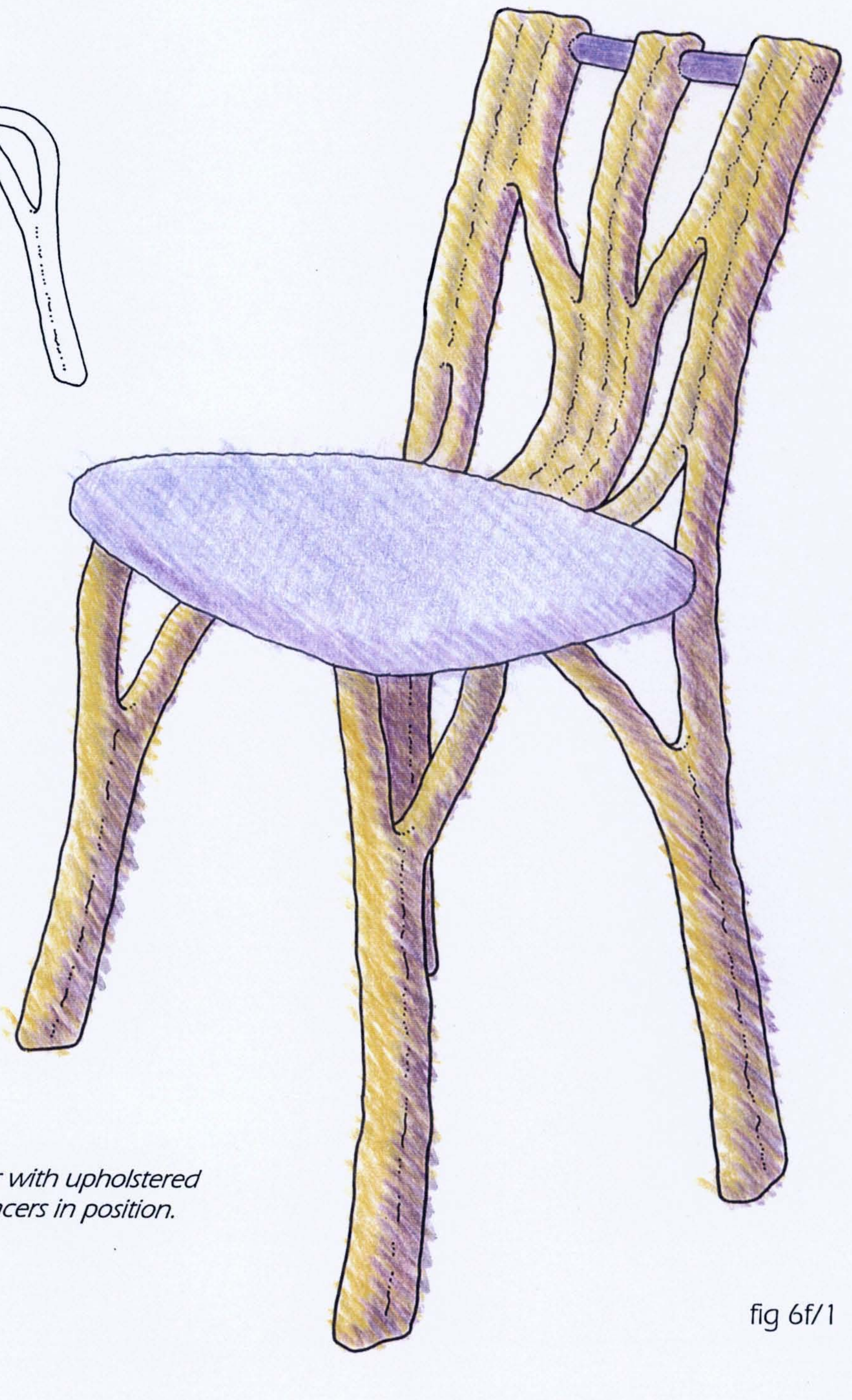
In a structure composed of so many saplings, the choice of well matched sets is of more than usual importance. In this case the sets of eight saplings should be approximately 800mm in height, enabling them to be installed and trained to reach the back of the seat area immediately. In this way the growing tips of all the saplings are able to continue to develop vertically up the back, and the problem of avoiding unwanted side shoots from developing in the seat area is reduced, although doubtless not totally eliminated. The grafts

Dyna grown dining chair proposal

The jig with which the form of the chair is controlled sits centrally between the two sides, extending upwards at the rear to allow for the attachment of the chair back. Omitted for clarity, this jig should be sufficiently rigid to withstand the stresses of wind etc, which must be resisted by the leafy heads of the growing saplings

Each leg is formed from two saplings, planted together and initially grafted together. At a point 150mm below the seat these separate, converging to form the central seat support structure before finally rising as indicated to provide the chair back





The finished chair with upholstered seat and back spacers in position.

fig 6f/1

between the pairs of saplings forming the legs should be installed as soon as possible, the final strength of these unions being of crucial importance. The chosen pattern to be formed within the chair back having been trained and grafted into shape, the grafts between the various saplings in the seat area may finally be installed. (It may be found necessary to retard the growth of any of the component saplings which tend to grow at a greater rate than the majority of the others.)

6g **Woodsman** dry assembly chair (see fig 6g/1)

A four legged upright armchair utilising two grown side frames, each composed of three saplings. These frames are linked by dry fixed structural seat and back panels and by two underframe rails.

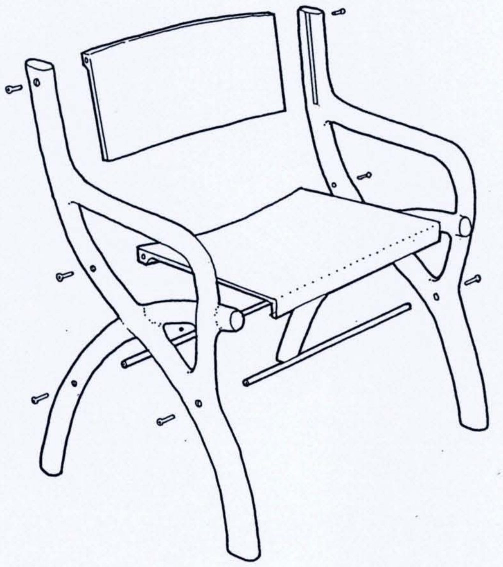
i) THE GROWING JIG

The flat jig replicates the required grown form, being double sided to allow matching pairs of frames to be grown on each side. Although an exact match between left and right hand frames for each chair will be difficult if not impossible to achieve, the design is such that limited variations may be accommodated. (An alternative would be to grow a single larger frame, which could then be halved to ensure an exact match as seen in fig 2g/32.) Jigs will require lateral bracing in order to stand upright, although if more than one jig is used, these may be positioned at 90 degrees to each other for mutual support.

i) THE GROWING METHOD

The angles and curvature of all the members in this design being relatively gentle, it should be possible to achieve these by the installation of full height (approximately 1200mm) saplings from the start, provided that the species used is of sufficient flexibility - for example European Ash *fraxinus excelsior*. The grafts between the pair of saplings forming the front leg / arm / back support should be installed first, and once these are established those joining the back leg to it should follow.

Woodsman part grown *dry assembly* chair proposal



As shown, the grown and grafted side frames of the chair are each formed from three suitably trained saplings. These support - and are linked by - the rigid seat and back panels. A tubular metal underframe completes the structure

The assembled chair. The rigid seat and back panels might equally well be upholstered, the dry assembly enabling simple replacement in case of damage

fig 6g/1

iii) THE OTHER COMPONENTS

The materials used for the other component parts of this design will not be dealt with in detail here, except to say that as far as possible ecologically benign materials and methods of production, finishing and fixing should be preferred wherever possible.

APPENDIX A Natural tree growth

i) EVOLUTION

Plants having evolved originally in water, their need to expose their leaves to sunlight was initially satisfied by the leave's buoyancy, while their stems provided an anchorage.

As they progressed onto land however, the function of the stems (or trunks as the stems of trees became) changed to one of support, resisting the earth's gravitational pull, while that of branches and twigs became that of holding the leaves in such a way as to expose them to maximum sunlight. *(Of all the circumstances affecting the development of trees - climate, soil quality etc - gravity is the one factor that has remained constant over the millennia, and which trees have consequently evolved best to resist.)*

In these circumstances the ability to avoid being shaded - by growing to greater heights than their competitors - gave trees a considerable advantage. It also required that they evolve the ' woody ' trunks they now possess, providing the combination of strength, flexibility, and the complex semi - tubular structure needed to transport nutrients over the sometimes considerable heights between roots, leaves, flowers and fruit.

ii) THE NATURE OF GROWTH

Trees increase in size according to an annual cycle, this growth being influenced by such factors as temperature, available hours of daylight, availability of moisture, nutrients etc. (Tree roots, most of which develop in the dark within the top 500mm of the soil, are naturally affected more by temperature than by daylight.)

Each year the tip of the trunk will grow in height, new branches will appear, and the girth of all of these will increase through the addition of new layers of cells produced - just below the bark - by a layer called the *cambium*. The new cells are of two types, those growing outwards forming the *phloem*, and those growing inwards a new ring of *xylem*. In this way the ever more extreme loads imposed on the enlarging 'crown ' of the tree are supported by an increasingly robust structure.

As with all other successful living things, trees have evolved - in terms of shape and size - by developing structures which give them the best possible chances of survival. Having a single trunk, this has involved the development of a root system which will provide a secure anchorage in the earth, together with a 'crown ' of leaves and branches which is deployed in such a way as to ensure that the tree is in balance. To achieve this, any tendency it may have to develop asymmetrically will be automatically corrected by subsequent growth. Since the direction of the existing growth cannot however be modified, the process is a gradual one, with new growth occurring so as to make the correction. It is this process of either gradual or dramatic changes in the direction of growth that produce the characteristic forms of trunks and branches which we admire so much, which help us to identify the various species of tree, and which men have put to such good use over the centuries.

It should be noted that this process of growing so as to be in balance is not confined to the tree's major elements. Not only branches but also twigs and even leaves, have been identified as growing at such angles, and in such configurations, as to ensure that this balance is maintained. Even such aspects as the length of the stems of individual leaves may be used by the tree for this purpose.

To enable it to withstand the very considerable wind loads imposed on a large tree in full leaf, the pattern of growth of the cells in a tree's trunk combine considerable strength with a degree of flexibility. For this reason the layers of cells have been found to grow in more or less of a spiral, the speed of rotation increasing as it ascends the tree. In some cases the direction of rotation will change gradually from clockwise to anti-clockwise as each growth ring occurs, producing a form of ' lattice ' pattern.

iii) THE INCLINATION OF BRANCHES

In trees which mature to develop a rounded crown (termed deliquescent growth) in which the branches grow as fast as or even faster than the trunk - in general the hardwoods - the inclination of each branch must change gradually as the tree grows. The relatively vertical angle of the uppermost branches must become more horizontal as new growth appears above them, producing some of the gently curving shapes so much sought after by ship and waggon builders in the 16th - 19th centuries. The direction of growth will also be affected by other external circumstances such as the appearance or removal - and the proximity - of neighbouring trees or other obstacles. If such changes occur, buds which may have failed to develop into branches and been engulfed by layers of new growth (termed *suppressed*), may be stimulated to erupt through the stem, being then termed *adventitious*.

APPENDIX B The nature, art & science of grafting

Since the proposed method involves the system of joining living stems known as grafting, some examination of this process, and the research into its nature, may be appropriate.

The growing together of previously quite independent living stems, roots or branches, occurs under certain circumstances in nature. The tendency varies among the different species ;-

> Some species are particularly prone to natural grafting and, among the commoner trees beech, whether growing naturally or in hedge form, provides numerous examples. The elm, ash, common maple, ... have all been reported as forming unions between their own branches by natural grafting. [151]

As described in appendix 8a, the layer of cells from which new growth is formed is known as the *cambium.* And since the formation of a graft will depend on the union of the two *cambial* layers, normally separated from each other by their protective bark, it is necessary to expose these to each other. Once having marked the point at which the two stems - in the case of the approach graft - cross, they are brought into close, firm and tolerably accurate contact for a sufficient period to allow the *callus* (defined by Garner as ' healing tissue arising from the cambium at wounds' [152]) to form. While this process is taking place, it is necessary to protect the open wound from the entry of water, and to some extent to limit air circulation.

This protection may be provided in many ways using a variety of materials. The basic requirements are that water and air are excluded, and that the materials used do not damage the tree or hinder the slight changes of shape and position which will occur during the healing process. The potentially suitable materials range from either hot or cold waxes or flexible sealants through clay (modelling clay or 'Plasticene' is thought to be suitable although rather expensive), rubber latex, petroleum jelly, etc. It is suggested that waxed cloth or tape which has been impregnated with one of the above solutions may be suitable, although care must be taken that this, when wound around the stems to be held, will not restrict their growth as they swell.

The main use of grafting has traditionally been mainly in the field of fruit growing or timber production, where the two sections of growth to be united are generally one which includes the roots of the plant - the *stock* - and the other with a growing tip or leaves, referred to as the *scion*. In this field, the aesthetics of the new union are in general of secondary importance, Garner implying this when he says;-

> Seeing that almost any carpentry which achieves cambial contact between scion and stock may lead to a successful graft, it follows that the forms of grafting may be very numerous. [153]

Of some significance to the current experiments however, he comments that ' Approach grafting is necessarily somewhat cumbersome ...' [154] (The distinguishing feature of 'approach' grafting is that the stems to be united remain intact both above and below the graft.)

Garner - the accepted British authority on grafting - has confirmed that the anatomical changes that occur during the formation of a graft union are basically the same for all woody perennial species, including the death of some layers of cells at the interface, the cohesion of scion and rootstock, generation of callus cells and establishment of vascular continuity and a new stem centre.

Although the origins of man's use of this technique are lost in antiquity, the scientific study of the process is known to have been in progress as early as 1758, and continues to this day, 'Early anatomical studies of the graft union revealed the presence of callus tissue at the graft interface (Duhamel du Monceau 1758; Goppert 1874) ' [155]

Exactly when, how quickly, and from which parts of the wound the callus develops has been extensively studied, as the range of experimental data quoted by Miller and Barnett indicates ;-

> The time elapsing between grafting and the onset of cell division for callus production apparently varies according to

> species, grafting technique and post graft environmental conditions. Mergen (1954) described the occurrence of cell divisions 2 to 3 days after grafting in *Pinus elliottii* Engelm. Copes (1969) observed cell enlargement at 4 days and callus arising from parenchymatous cells of medullary rays, phloem rays and cortex 5 to 7 days after grafting in *Pseudotsuga menziesii* (Mirb.) Franco. Dormling (1963)reported pronounced callus formation in localised regions of *Picea abes* (L.) Karst. Homografts, for example where needle traces, resin canals, and ray cells were severed. [156]

Following their own experiments on Sitka spruce, Miller and Barnett observed ;-

> The first cells to respond in this way, within two days of grafting, were the epithelial cells of severed resin canals and ray parenchyma exposed where the phloem and xylem of the scion and root stock were cut through. Fusiform cambium cells near to the graft interface dedifferentiated into callus much later (12 - 15 days after grafting)... Most callus was produced by cells external to the cambium by dedifferentiation and proliferation of ray cells, and of parenchyma associated with severed needle traces. [157]

In summary, it can be deduced that the growth of the callus can be expected to start in a period of from two to fifteen days after the installation of the graft.

Some of the research carried out into one of the post grafting conditions which may affect the success rate of grafts has examined the effects of different temperatures.

The grafting of scions onto Sitka spruce is normally carried out in polythene covered tunnels during late winter of early spring. This practice, necessitating both the heating of the tunnels and the maintenance of a humid atmosphere to reduce transpiration and water stress in the scions, is both expensive and environmentally undesirable.

> In order to avoid this type of problem in grafting *Corylus avellana*, Lagerstedt (1981a,b,c,) applied heat locally to the graft unions made between dormant scions and rootstocks. The method, referred to as hot-callusing, involved surrounding the graft unions with warm air while maintaining the root system and scion buds at ambient winter temperature. Heating the graft interface encouraged callus growth when the apical bud was dormant and no water stress was present in the scion. This in turn led to high graft success rates. [158]

A similar experiment, carried out by Dr J R Barnett and Helen Miller at the University of Reading, this time using Sitka spruce *Picea sitchensis* was described in the Journal of Experimental Botany in January 1994. The experiment was however carried out during relatively mild winter conditions with the ambient temperature in the experimental tunnel never falling below 0 degrees C, reducing the difference in the temperatures experienced by the experimental specimens and the controls, and probably affecting results in favour of the controls.

No final difference was detected in the rates of success achieved between the heated and the unheated grafts, although ;-

> On the other hand, scions of grafts which had been heated for three weeks, and then returned to ambient conditions showed considerably greater growth than unheated controls during the following spring and summer. The amount of extension depended on how late in the winter the graft had been prepared and heated, with least growth by grafts made in October, and most by grafts made in March. Microscopical examination showed that callus formation was more rapid in heated grafts than in controls, although callus formation occurred in all control grafts examined. [159]

Also discussed in the paper is the range of experiments which have been carried out over the years, looking into the effects both of a) varying temperatures and b) on the timing of graft installation, on the formation of callus. The findings of these researches may be summarised thus ;-

Oliver (1901) *Walnuts and Hickories*

Use of an incubator gave 75% success rate in grafting

Ravaz (1921) *Vitis*

Graft unions developed more quickly with increasing temperature

Shippy (1930) *Apple*

Callusing very slow between 3 - 5 degrees C

Between 5 -32 degrees C callus formation increased with rise in temperature

Above 32 degrees C tissues damaged, at 40 degrees death occurred [160]

On the timing of grafting, the grafting of scions onto rootstock has not been proposed in the designs shown here, although this might in future be considered. In such cases, the length of time for which the scion is stored before grafting may be crucial to the success of the union. This factor has been the subject of research on Sitka Spruce (*Picea* *sitchensis*) carried out in 1988 by Barnett and Weatherhead. [161] Having been stored in the dark, in sealed polythene bags, at a temperature of 1- 2 degrees C, the leaf water potential (a crucial measure of the ability to retain water) of the experimental scions was measured ;-

> After 1d storage the four clones examined had water potentials in the range - 1.4 to -1.6 MPa. This fell slightly during the next 3d after which there was a more dramatic reduction in water potential, until by 14d the range was -2.1 to -2.6 MPa... [162]

Having carried out the grafts after seven days of cold storage, it was found that the scions having the lowest water potential (and whose potential had dropped noticeably relative to the others, when measured after four days) were the least successful.

The leaf water potential of the scions whose grafting was successful, having dropped during the two days after grafting from -1.95 to -2.63 MPa, recovered gradually over the following 16 days, finally stabilizing at about -1.7 MPa.

The conclusions and explanations to be drawn from this and a previous study are summarised thus ;-

> In a recent study (Barnett and Weatherhead, 1988) it washown that the first observable stage in the formation of a successful graft union in *Picea sitchensis*, as in other gymno-sperms (Mergen, 1954; Dormling, 1963; Copes, 1969), is the formation of a callus bridge between the scion and rootstock. This bridge is essential in that it provides a pathway for the transport of water, by-passing the damaged tracheids at the prepared surfaces of rootstock and scion. The callus must function in this way until cambial union is established between the graft components 6-8 weeks after grafting. Grafts which fail at an early stage do not produce a callus bridge. Interestingly, callus formation in successful grafts is established By the 3rd d following grafting (Barnett and Weatherhead,1988). This coincides with the onset of recovery of water potential in scions as demonstrated by this study.
>
> Callus formation involves dedifferentiation of ray parenchyma and cambial cells, followed by repeated cycles of cell enlargement. Water is required as the driving force for cell enlargement and must, in the first instance, in the newly Grafted scion, be drawn from the scion itself. If the scion is stressed beyond a certain point (possibly -2.2 MPa in this Case) at the time of grafting, there is presumably insufficient water available for the development of callus. Rootstocks, however, are not under stress at the time of grafting, yet in a failed graft are found to have produced no callus at the inter-face between the components. This suggests that the formation of callus by the scion is under the control of the scion. Thus the formation of callus at the cut surface of the scion may depend firstly on the existence of sufficient water in the scion, in turn permitting the formation of callus under stimulation of growth substances released as a wounding response. Baspetal

flow of such substances across the interface of the cut surface of the rootstock would then stimulate callus formation there. Failure of the scion to develop in this way, resulting from it's stressed condition, would mean that no stimulation to callus formation would occur at the surface of the rootstock. The latter, decapitated and stripped of leaves in the graft region during preparation, lacks the normal sources of growth substances associated with cell proliferation and will therefore not produce callus.

This work has demonstrated the importance of carrying out grafting as soon after collection of scion material as possible in order to ensure success rates in excess of 90% in *Picea sitchensis*.[163]

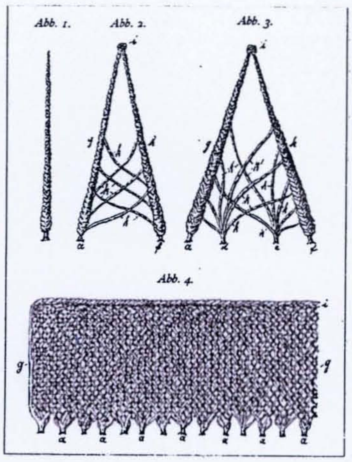
APPENDIX C The patents of Arthur Wiechula

These German patents are illustrated and described by Kirsch [164] *(see fig 8c/1)*

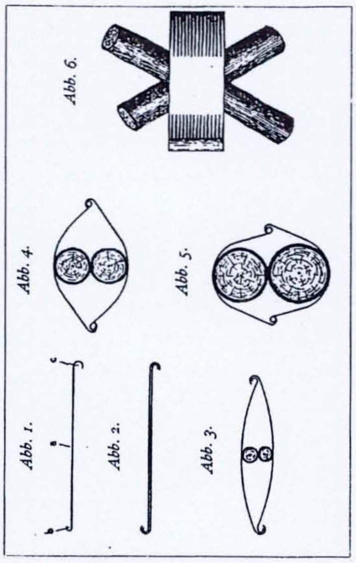
The first two patents, No 287847 dated 24th November 1914, (at the outbreak of the First World War) and No 386940 dated 1st April 1922 concern techniques for growing and interweaving living fences. *The practice of ' laying ' hedges and interweaving their stems and branches, known in Britain as Hedging, is of great antiquity, and could hardly have been patentable.* Wiechula's idea however, is to develop a rather more orderly system. Two parallel rows of trees of a uniform height are to be planted perhaps 1 - 1.5m apart, angled towards each other so that their tips meet to form an inverted V section. As with traditional hedge laying the top of this structure is to be united with a continuous plait, while the hollow section at the base of the fence gradually becomes consolidated by the interweaving of the lower branches growing from either side. In a further development, intended to provide a denser and even more robust barrier, Weichula shows the two basic rows of trees planted somewhat further apart, still angled together but with additional rows of saplings planted in the spaces between, whose shoots would help to provide an even denser infill.

In the years between the two World Wars, Wiechula was granted a further six patents, all of which dealt in some way with the problems of linking individual trees together to form a structural wall. (*NB Wiechula worked on the then conventional assumption that grown walls, fences etc, would be required to run in straight lines, a premise which Kirsch finds risible, considering that curved shapes are far more suitable for grown structures.)*

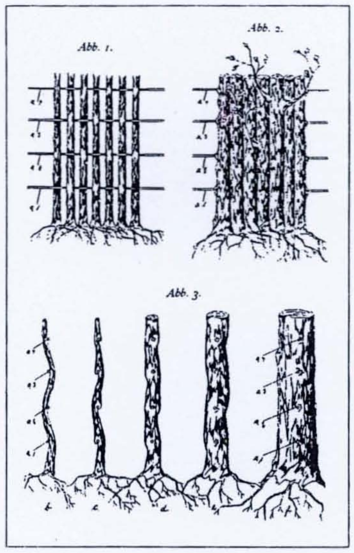
Patent No 433298, running from 3rd February 1925, is for a clamping device, designed to hold two saplings firmly together as they cross, in order that the natural process of grafting may take place. The device consists of two identical sprung steel plates, the ends of which are rolled over in such a way that they can be clipped together at each end. The flexible nature of the plates enables them to deform to encompass saplings (or indeed other objects) of a variety of sizes. Kirsch explains that this system was finally rejected on grounds of cost, although it would appear to the writer to have had the added disadvantage that, if left in place too long, it would have become embedded in the trees growth.



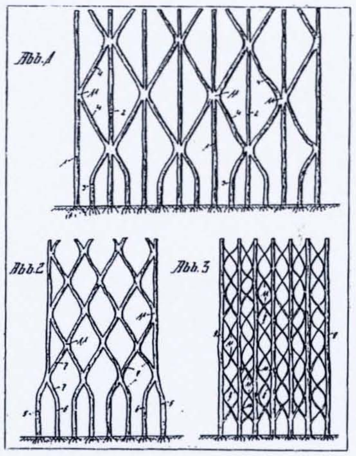
Pat No 386940 1 April 1922



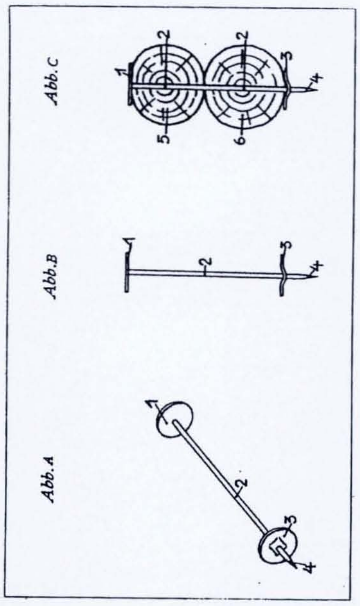
Pat No 433298 3 Feb 1925



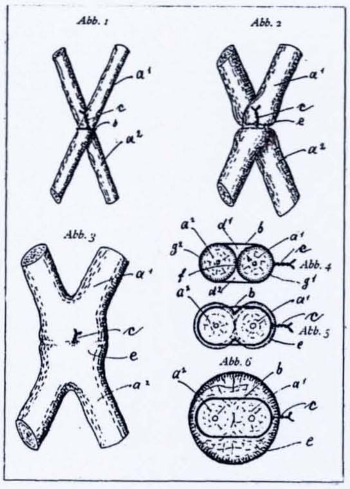
Pat No 459870 4 Oct 1925



Pat No 459996 18 Sept 1930

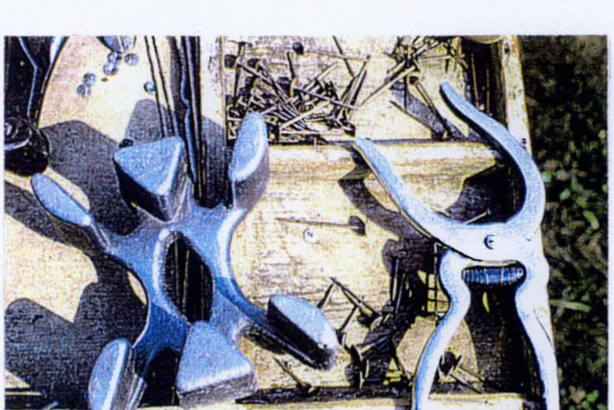


Pat No 554735 23 June 1932



Pat No 621944 31 Oct 1935

shown right are the patented positioning jig & hand tool, devised for the quick and easy insertion of the pins & their holding washers covered by the patent number 554735 illustrated above. These items are understood to remain in current production



The Patents held by ARTHUR WIECHULA

fig 8c/1

On 26th April 1928 two patents were granted, Nos 459870 and 459996. In these a number of horizontal wires, spaced above one another, are to form the 'weft' of a woven fence or wall, the 'warp' being provided by a row of closely planted young saplings woven into these. As the trees grow they will engulf the wires, eventually producing a wooden wall of trees inextricably linked together by the wires passing through them. There appears to be no reason why this system should not work as intended, although the durability of the wires would be crucial, and the method of stretching the wires and of maintaining them in place is not dealt with.

On 23rd June 1932 patent No 554735 was granted to Wiechula's Company Neulohe GmbH. Apparently an attempt to overcome the problems of the excessive cost of the previous clamping device, this method involves the use of a simple pin having a large flat head, to be driven through the two stems to be linked at the point where they cross. The pin is secured in place by a pressed metal washer designed to resist its withdrawal. This method, later to be known as ' The Neulohe joint ' has proved to be the most successful of all, remaining in current production, together with a specially designed hand tool with which the pin and washer can be inserted in a single operation.

Patent No 621944 granted 31st October 1935, was another attempt to tackle the problems of excessive cost encountered with patent No 433298, while making use of the process of engulfment incorporated in Nos 459870/996. Here the saplings are to be held together using a simple wire tie, to be twisted around them at the point where they cross, or at the point where a support wire or rod crosses a growing stem. The tie is to remain in place as the tree grows, eventually engulfing and concealing it completely. Again, there appears to be no reason why this system should not work as illustrated, although as related to the current research project there exist two drawbacks. The first is aesthetic, in that such a practice will inevitably produce a swelling and a scar where the tie has been applied. The second is more serious, in that it has been found that despite the trees ability to engulf an encircling wire, there remains a local weakness at this point, which while unimportant in a woven structure such as a fence, could seriously weaken an item of furniture.

Patent No 508516 dated 18th September 1939 *(at the outbreak of the Second World War, and in the name of Neulohe Gemeinnutzige Gesellschaft)* illustrates three alternative lattice patterns to be used to form grown panels or walls.

APPENDIX D Project publicity 1996 - 2002

i) THE PRESS

Publication / page number	*date*	*title of article*	*author*
The Independent *Weekend section* p8	1/6/96	Plant your own furniture - watch it grow	David Davies
The Sunday Telegraph p6	3/8/97	How does your garden grow? Into furniture...	Catherine Elsworth
The Times p6	31/12/97	Long wait for a seat as garden grows furniture	Simon de Bruxelles
Evening Standard p61	9/11/98	A trunk call to the future	Chris Partridge
The Garden *RHS News* p222	April '97	Grown to measure	Jean Stowe
Eco Design p31	Vol 5 No1	Furniture that grows on you	Chris Sherwin
Timber Trades Journal p2	16/8/97	Mr Cattle farms furniture	un-credited
Readers Digest *Environment matters* p119	April '98	Household Harvest	refers to The Times 31/12/97
Frame p10	May/June 1998	Grow your own furniture	un-credited
Made in Britain *British Consulate General - Milan* p10	Maggio 1998	Coltivare Mobili nel Proprio Giardino	un-credited
Journal of Sustainable Product Design p37	October 1998	Sustainable Grown Furniture	un-credited
World's Best Ideas p170	1998	Chairs grown out of shaped saplings	Summarised from The Times 31/12/97

The Futurist p60	February 1999	Grow it yourself Furniture	Dan Johnson
Furniture Today p200	April 27 1998	Grow your own furniture !	Lianne Finger
P.M. magazin p74	April 1999	Baume wachsen zu Mobelstucken heran	W Goede
Ville Giardini p100	Febbraio 1999	Mobili da coltivazione	Andrea Ratti
Das Beste *Readers Digest* p151	Juli 1999	Aus alle Welt Grossbritannien	quoted from P.M. magazin 4/99
The Independent *Monday review* p4	Sept 7 1999	English Eccentric	'Pandora'
Woodland Heritage Journal p4	Spring 2001	Grown up furniture ?	Christopher Cattle
The Daily Telegraph *Gardening section* p10	May 19 2001	Where furniture grows on trees	Yvonne Thomas
Woodland Heritage Journal P9	Issue 7 2002	Grown up furniture One year on	Christopher Cattle

ii) TV / RADIO INTERVIEWS

station	*date*	*programme*	*Interviewer*
BBC radio 5 Live	10/3/96	The Magazine *Environment news*	David Davies
BBC radio Wales	10/9/97	Good Morning Wales	Rebecca John
HTV (Cardiff)	23/3/98	Local news	Jonathan Hill
Radio Deutshe Welle (Koln) *English language service*	16/11/98	Science & technology	Paul Chapman
CBC radio 1 (Canada)	2/11/99	Basic Black	Arthur Black

iii) CONFERENCES / SEMINARS

Conference / seminar / organiser	*date*	*venue*	*title of paper*
ICSID '97 The Humane Village Congress *20th Congress of ICSID*	23 - 27th Aug 1997	Toronto Canada	Grownup furniture - a case history
Forest to Product *The Parnham Trust*	8th March 2000	Hooke Park Beaminster	An alternative approach

APPENDIX E Site visits

year	site 1	site 2	site 3
	University of Reading *School of Plant Sciences* *Field research station* *Shinfield Berkshire*	Groundworks *Fedw Hyr* *Llwyd Coed* *Mid Glamorgan*	Priestfield Arboretum *Little Kingshill* *Buckinghamshire*
1996	March 13/28		
	May 23		
	June 6/19/26		
	July 4/18		
	Aug 30		
	Sept 13/20		
	Oct 11		
	Nov 8		
1997	March 12 / 17	March 24	
	April 3 / 16		
	May 30	May 16	
	June 6	June 13 / 26	
	July 1 / 2	July 15 / 31	
	Aug 4		
		Sept 9 / 24	
	Oct 7 / 24	Oct 21	
1998		Mar 23	
	May 5	May 11	
	June 26		
		July 31	
	Sept 17		
		Nov 9	
	visits severely curtailed this year due to ill health		
1999	March 19		
		April 23	April 8
	May 5/25		May 5/25
	June 15	June 8/29	June 6/15
	July 6/27	July 22	July 6/27
	Aug 24	Aug 4	Aug 24
	Sept 14	Sept 2/22	Sept 14
	Oct 15	Oct 29	Oct 15

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