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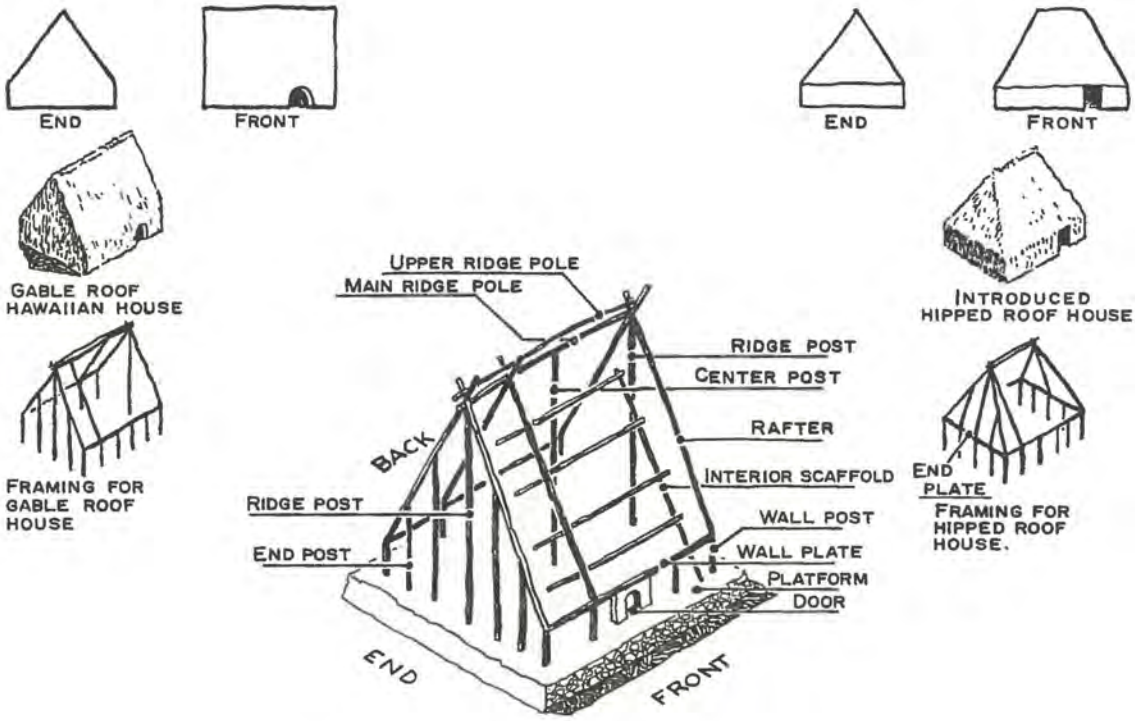
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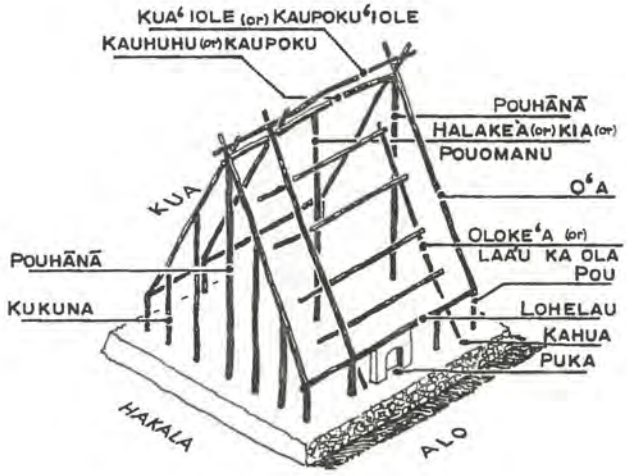
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HOUSE

ENGLISH NOMENCLATURE



HALE

HAWAIIAN NOMENCLATURE

HOUSE FRAME

This report satisfies the following Resource Study Proposals for City of Refuge National Historical Park:

H-2a, Hale-o-Keawe Temple

H-6a and H-6c, Hawaiian Chief's Housing Complexes

H-8a and H-8c, Structures and Use of Ancient Hawaiian Temples

INTRODUCTION

Projects described in this dissertation began in 1961 with the cooperation of the Bernice P. Bishop Museum, Honolulu, Hawaii. Dr. Kenneth P. Emory, who now holds the John Ledyard Chair in Anthropology at the museum, was associated with the projects from the beginning. Encouragement for the writing phases was given by the late Dr. Charles E. Hunter, Professor of History, University of Hawaii.

As research in written documents and the translations of described techniques into standing structures progressed, it became evident that the work lay in the field of Ethnohistory and was more at home in the field of Anthropology. Guidance and help in the presentation of this material came from Drs. Wilhelm G. Solheim II, Frank J. Mahony, P. Bion Griffin and Dr. Emory, of the Graduate Faculty, Department of Anthropology, and from Dr. Oswald A. Bushnell, School of Medicine, University of Hawaii. The author takes, however, sole responsibility for the material, conclusions and opinions herein.

Methodology of the techniques of describing and reproducing structures once prevalent but now absent in Hawaii is included in the appropriate sections. Documents, rather than informants, were asked the questions. Many documents were written by non-natives of the Hawaiian

Islands; others by Hawaiians a generation or so removed from the activities studied. Their biases and motives were sometimes discovered through the techniques of historical criticism. A few gaps were filled by deduction from cultures believed to be comparable, and are so labeled.

When architecture is studied from an anthropological viewpoint, the interrelations between the architecture and the culture which built and used or modified it are the major concern. Descriptions, illustrations or samples of the architecture per se have anthropological value for use in comparing cultures, in the study of cultural development or change, or in applied anthropology, as for reconstruction or restoration of structures or features.

An archaeological principle is that building remains reflect certain aspects and attributes of the culture that created them. The more complete the remains, the more value to the archaeologist. In Hawaii in 1970, the usual building remains of the prehistoric and protohistoric architectural structures found are dry masonry platforms. The bio-degradable materials of the structures the platform supported are gone. It was believed there were sufficient data in literature to build structures which would approximate those built by the protohistoric Hawaiians, if the data were properly interpreted. Part of the process was the assembly of full scale structures using materials and techniques as construed from the

literature. Research uncovered data on the late prehistoric and early protohistoric uses of the structures by the Hawaiians, as well as on the structural adaptations made in the protohistoric and historic periods caused by acculturation.

Material in this dissertation may suggest likely aspects of technology for investigation in other Polynesian subcultures and aid in the search for Polynesian interrelationships. Like fishhooks, linguistics and adzes, Polynesian structural techniques may prove useful in unraveling the migrations of founding groups and their subsequent cultural changes in isolation on dispersed Pacific islands.

The large thatched structures described herein, and used by high chiefs in their housing complexes and on major temples probably reflect those in use ca. 1812, when the last round of temple rehabilitation took place in Hawaii. This was before Western techniques had contaminated Hawaiian architecture, and before the Western cultural invasion eliminated the need for such structures.

The need to reconstruct authentic Hawaiian structures and restore selected structures for interpretation of Hawaiian prehistory and history by the United States Department of the Interior, National Park Service, was the motive for this study.

There are no surviving authentic prehistoric or protohistoric Hawaiian thatched houses. Structures built according to the formulas given can only be said to be such as could have been built by the Hawaiians, and are as close to what surviving descriptions could formulate.

Portions of this dissertation, in draft form, were used by the Department of Anthropology, Bernice P. Bishop Museum, Honolulu, in building surface structures on Kaneaki temple in Makaha Valley, Oahu Island, in 1970. Among other things, this tested the utility of the formulas presented.

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United States Department of the Interior
National Park Service
Hawaii Group
Honolulu
May 1971

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Plate artist: Paul Rockwood

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Figures by National Park Service

CHAPTER I

HAWAIIAN USES OF THATCHED STRUCTURES

In this dissertation, Hawaiian thatched houses and temples are treated as structures--in this chapter as structures evolved in Hawaii by Hawaiians for use by Hawaiians; in Chapters II and III structural details are presented; and in Chapter IV as structures which changed as Hawaiians and Hawaiian ways bowed to an invading alien culture. Chapter V presents the significance and a history of a major temple, the Hale-o-Keawe, and outlines its restoration by the National Park Service, U.S. Department of the Interior.

Prehistory

Polynesian migrations have only a background relationship to this dissertation. Problems of routes and dates are under attack by Emory (1946, 1963, 1968a); Finney (1967); Green (1966, 1967, 1968); Howard (1967); Sinoto (1967); and others. It is evident that the Hawaiian Islands were well populated by A.D. 1000 (Emory, Bonk, Sinoto, 1959:ix). By whatever route they came, and whatever the date of their arrivals, the Polynesians did not come to Hawaii without material and social culture. Modern study of the plants they brought to and found in Hawaii began with Hillebrand (1888) and more recently researched by others, including Barrau

(1958, 1961, 1963, 1965); Fosberg (1948, 1965); Yen (1963); and Yen and Wheeler (1968).

Along with the plants, the Hawaiians brought knowledge of house building, but the form and details of this house are unknown. One speculation is that such houses were thatched, rectangular, single story and without partitions. Hawaiians shared with other Polynesians the terminology for both canoes and houses (Emory, 1968b).

Hawaiian thatched buildings found in the late 1700s and early 1800s were probably products of centuries of modifications. The Hawaiian house discussed here evolved from unknown earlier Polynesian type or types, the knowledge of which was brought to Hawaii by early Hawaiians. Long before 1819, thatched Hawaiian houses and temples reflected ancient Hawaii's structural needs in terms of climate, available materials, and social-religious conditions. By whatever means they evolved, thatched Hawaiian houses and structures on temples were there to greet the invaders from the Western civilization.

The Haystacks

About 1800, Hawaiian thatched structures were labeled "stacks" by Americans and Europeans who saw them. Englishman James Cook, who discovered Hawaii for the Western World in 1778, described them as looking like "corn stacks" (Cook, 1967:283). Englishman William Ellis in 1823 called them

"hay ricks" (Ellis, 1827:315). New Englander Hiram Bingham wrote that a Hawaiian home resembled "a long hay stack without, and a cage in a hay mow within" (Bingham, 1847:116). New Englander Charles Stewart labeled Hawaiian houses as "so many sunburnt ricks of hay," and said that each house resembled a "haystack, such as is frequently seen in an American barnyard" (Stewart, 1828:149).

Hawaiians saw usefulness in thatched houses, and grace and beauty in the larger, better built houses of chiefs and their temples. Similes were used when Hawaiians wrote about thatched houses, and their prose about their houses approached poetry. Homes of chiefs and major temples held their ridges high. Such ridges arched "like a warrior's helmet." The lashings which bound the main thatch purlins to house posts reminded Hawaiians inside houses of owls in flight. Trimmed thatch suggested the bobbed hair of a beautiful woman; the flowing curve of thatch over and around a corner was compared to her knees. To other Hawaiians that same curve suggested the nose of the threadfish. Fern trimmed edges of chiefs' structures reminded Hawaiians of curly locks on virile males (Kamakau, 1870:135, 143).

Storage, Shelter, Security

Hawaiians used their houses for storage, shelter and security. The need for security of Hawaiian commoners from the taboo lapsed in 1819, but the other needs continued. Storage, shelter and security are convenient labels for the

three equally important functions of the ancient Hawaiian house. The windowless thatched structure, usually with only one door, a low one, evolved to satisfy these functions.

Storage was needed by commoner, craftsman, priest and chief. Their possessions required enclosed protection from sun, wind, rain and prying eyes. The eyes belonged to thieving peers or to legally constituted confiscators. In theory, and frequently in practice, all persons and property belonged to a ruling chief (Barrère, 1961:23).

The number and variety of items stored in a house ranged from the wooden poi board and stone pounder of a poor commoner; through the gear of a fisherman which was deposited and retrieved with prayer; through the temple drums of a priest; to the taxes, tributes and gifts-in-kind received by the chiefs.[1]

Shelter was sought from the sun and wind and was needed during inclement weather (Malo, 1951:118). Some temporary shelters were built for comfort on sunny, barren coastal areas and some doubled as windbreaks for sleepers. Temporary shelters in farmland and forest were used for protection against daytime heat, nighttime cold, and rain. While the canoe shed, which stood near the seashores, was built primarily to shelter canoes during finishing and storage periods, workmen benefited from its shade. Canoe sheds, regardless of how they were framed (and little is known about their structure), apparently were thatched only on

the roof (Vancouver, 1967:II,116; Ellis, 1827:203-204). Usually shade trees, of special benefit to commoners, grew near permanent houses (Byron, 1828:107; Stewart, 1828:134; Corney, 1896:99).

A high chief possessed at least one complex of permanent thatched houses, each house reserved for a specialized use. A ruling chief, and perhaps others of high rank, maintained several such complexes, in different locations or districts, and moved his court as desired (King, 1967:608; Vancouver, 1967:III,61; Menzies, 1920:86-87; Ii, 1959:59, 121, 143).

At least one house of each complex was of sufficient size for office and conference use during the heat of the day. Important visitors were received in it. It was also a comfortable place for the chief's mid-day naps. Such an executive house hid and shielded his sacred person from commoners, especially his spiritual radiations (mana in Hawaiian). The chief's women had separate quarters, and if they were of sufficient rank (and the chiefdom prosperous) would also have a spacious thatched house for their leisure occupancy. There would be a common house for sleeping, and one for chiefesses' seclusion during menstrual periods. Women would also have another house for their vocational and avocational work (Malo, 1951:67, 122; Thurston, 1934:35), but such might be more of a shed for shade.

A few chiefs and chiefesses were so sacred that usually they were secluded in the daytime, going abroad only between

sunset and sunrise (Manby, 1793:36-37; Kamakau, 1964:4; Kamakau, 1961:197, 259; Malo, 1951:54, 55, 57; Ii, 1959: 51-52; Kotzebue, 1821:III,247). During the day, each of these sacred ones would remain in a large thatched house.

Headroom inside a chief's executive house permitted standing, but protocol probably limited the number to those who could stand. In ceremonial audiences, a visitor might even crawl to keep his head below the level of the head of the ranking person present. Staff chiefs of lower rank might stand or squat to serve the senior chief--to hold aloft a symbol of rank, like a feathered staff; to fan; or pass a spittoon (Ii, 1959:58-59; Freycinet, 1829:6, 7, 15, 16, 17-18; Stewart, 1830:97, 117; Corney, 1896:47)--and thus be physically elevated over the ranking chief. Apparently it is a Polynesian custom even today that visitors to a house do not occupy for long periods levels above the head of a Polynesian who outranks them.

People of lesser rank could assume three known acceptable positions inside a chief's house: (1) kneeling (knees close together) (Ii, 1959:59); (2) squatting (feet touching floor, knees wide apart, back of thighs touching calves) (Walpole, 1849:297-298); and (3) seated, tailor fashion (buttocks on floor, knees wide apart, legs folded) (Conde, 1887:173; Stewart, 1828:112; Ellis, 1827:319; Bird, 1964:89). In ancient Hawaii there were no stools, chairs or other furniture for sitting (Bingham, 1847:116; Campbell, 1967:130).

Chiefs of higher rank had raised sleeping platforms covered with mats, as was the floor. Chiefs of lower orders and higher chiefs in such places as temporary shelters, where there was floor space, slept with heads toward the center, out of range of spear thrusts (Handy and Pukui, 1958:9-10; Hooili, 1919:648; Byron, 1828:119, 120; Ellis, 1827:272; Ii, 1959:111).

Commoners usually slept outdoors, on mats stored during the day in their houses for safekeeping. They crawled into their small thatched houses to sleep, day or night, during cold or wet weather (Byron, 1828:107; Stewart, 1828:134). Once inside, commoners slept on the mat-covered floor; men, women and children in a common dormitory, but in a definite order (Handy and Pukui, 1958:9-10). Commoners did most of their living and working outdoors--there were usually convenient shade trees nearby.

Shelter as a function of the Hawaiian thatched house differed between chiefs and commoners. The larger houses of the chiefs sheltered people day and night, in good weather or bad. It might be said that chiefs occupied their houses in the sense understood and practiced by Westerners. The small houses of commoners served only intermittently as shelter--as desired, or as required by weather. Commoners usually lived and worked outside, and utilized their houses for storage, occasional shelter, and for security.

Most of the descriptions of Hawaiian sleeping arrangements come from ranking Westerners who entered royal residences or from Christian missionaries who deplored common dormitories (Ellis, 1827:272; Kamakau, 1870:146; Stewart, 1828:112; Bird, 1964:89, 256; Thurston, 1934:35; Bond, 1927:137, 158; Manby, 1793:36-37; Campbell, 1967:130-131; Valentine, 1875:38; Freycinet, 1829:6, 17; Hirahara, 1931: 442).

Security was an important function of the thatched Hawaiian houses for commoners and lesser chiefs during times when they should neither see or hear, nor be seen or heard. An account of the taboo (kapu in Hawaiian) conditions, one of which sent Hawaiians inside their houses for security, is given by Christian missionary C. S. Stewart

> The tabus varied greatly both in extent and duration. Sometimes a single tree, or a single animal only, would be made tabu, and at others a whole grove or herd;--sometimes a single house, or a piece of land, or fishing ground, at others a whole district, or even island. Sometimes the tabu would be limited to a day, at others, would continue for weeks or months. Tabus of time varied in the degree of rigour with which they were to be observed; sometimes requiring only a cessation from ordinary work and amusement; at others, an entire seclusion; when to be seen abroad, was death. Every fire, too, must then be extinquished--every sound, even to the crowing of a cock or barking of a dog, prevented--and the silence and desolation of death, be made to reign throughout the whole extent of the tabu, whether of district or island. (Stewart 1830:34-35)

Note that Stewart wrote about a time after cattle had been introduced and assimilated into the Hawaiian situation.

Peter Corney was aboard a ship in Honolulu harbor in 1818 when Ka-'o-lei-o-ku, first child of Kamehameha the Great, died. Corney wrote of the preparation of that high chief's body during the day and added

> At sundown this part of the ceremony ceased, and a crier went round the village, calling out, that if any man, woman, or child, were seen out of their houses, or showed a light or fire, or even smoked a pipe, after 8 o'clock that evening, they would instantly be put to death. These restrictions extended not only to the white people in the harbour; nay, hogs, dogs, fowls, etc., were not allowed to be out, lest they should make a noise, nor were the ships suffered to strike the bells next morning.
>
> At sunrise the Taboo was taken off the ships, but still remained in force on shore . . . Six hours after the canoe [which contained the bones of the chief] sailed, the Taboo was taken off the bay, and canoes were allowed to go on the water;--in this manner they employ ceremonies towards all the people of rank. (Corney 1896:87)

John Papa Ii, a chief of lesser rank and as a youth attached to the court of Liholiho (later to reign as Kamehameha II), was brought up under the kapu system of ancient Hawaii when it was still in full flower. He wrote of his escape from death while inside a thatched house to seek security. The house stood close to a temple where an important ceremony was being held. The kapu which sent commoners and lesser chiefs inside thatched houses had been called. Ii writes of himself in the third person.

> No sooner was the kapu imposed than the boy [Ii] felt a tickling sensation in his throat that made him want to cough. He held his throat with his hands until his eyes and throat were red, but finally he could no longer bear it. He coughed two or three times, but fortunately, was not heard by those who had imposed the kapu. Those who were

> in the house with him were distressed, and one person dug a hole for him to cough into while another supplied a basin of water. When the kapu-freeing prayer was uttered, and the need for discomfort was over, he was greatly relieved. Had he been heard coughing, he would have been snatched from this world [by the security police]. Such were the many troubles that followed one about in the royal court. (Ii 1959:61)

With commoners and lesser chiefs hidden and quiet inside grass houses, high chiefs and high priests had people-free villages, trails, seacoasts and off-shore waters for religious activities of the highest importance. Such activities might include burials, burial processions, delivery of sacred logs to temple sites, and certain temple ceremonies. During such times, commoners and lesser chiefs used their houses for hiding places--where they could wait out in safety the hours or days during which they were supposed to be unseen and unheard. Law enforcement officers, the security police, would capture, kill, and present at the temples the bodies of male offenders as human sacrifices. Female offenders were just captured and killed. Women were not acceptable sacrifices to Hawaii's gods.[2]

Temporary Shelters

Worksites, or temporary shelters for such people as farmers, canoe makers, women who scraped bark, salt makers, fishermen, and those away visiting or on temporary duty, served the same purposes as permanent houses. It was only their construction complexity which differed. When they were away from their more or less permanent bases, Hawaiians also needed structures for storage, shelter and security. In

addition, there may have been vagabonds who occupied only temporary structures.

Commoners usually worked inland from their permanent home bases, but some also worked along the coast. There was much movement between coastal living areas and inland work sites. Well-defined trails linked coasts with uplands (Apple 1965:13, 14, 24, 65; Waialeale 1834:1, 6-7).

Shelters were needed on upper slopes from day heat, night cold, wind and rain, where crops were raised, birds were hunted for feathers or food, vines were gathered, bark was scraped for cordage, and timber was cut. Wind, sun and heat were problems along coasts, especially on barren lava flows. Chiefs and their retinues were more mobile than commoners. Chiefs travelled along coasts, usually by canoe (Apple 1965:1, 2), to set up temporary establishments at sites where they maintained no permanent complexes of thatched houses. Their reasons might be for business, or pleasure, usually fishing (Chamisso n.d.:29; Freycinet 1829:6; Menzies 1920:181; Kotzebue 1821: II, 191).

Temporary shelters erected for visiting chiefs and by working commoners might explain the discrepancy in estimates of the number of houses in villages at Kealakekua Bay in 1779 made by members of the Cook expedition. Surgeon David Samwell noted differences between permanent and temporary houses, and said, for instance, that Kealakekua village had sixty houses and Kaawaloa had seventy to eighty,

apparently referring to permanent structures (Samwell 1967: 1175-1176). John Ledyard at the same time listed 1,000 houses for Kealakekua and 300 for Kaawaloa, and apparently included both permanent and temporary structures (Ledyard 1963:103, 128-129).

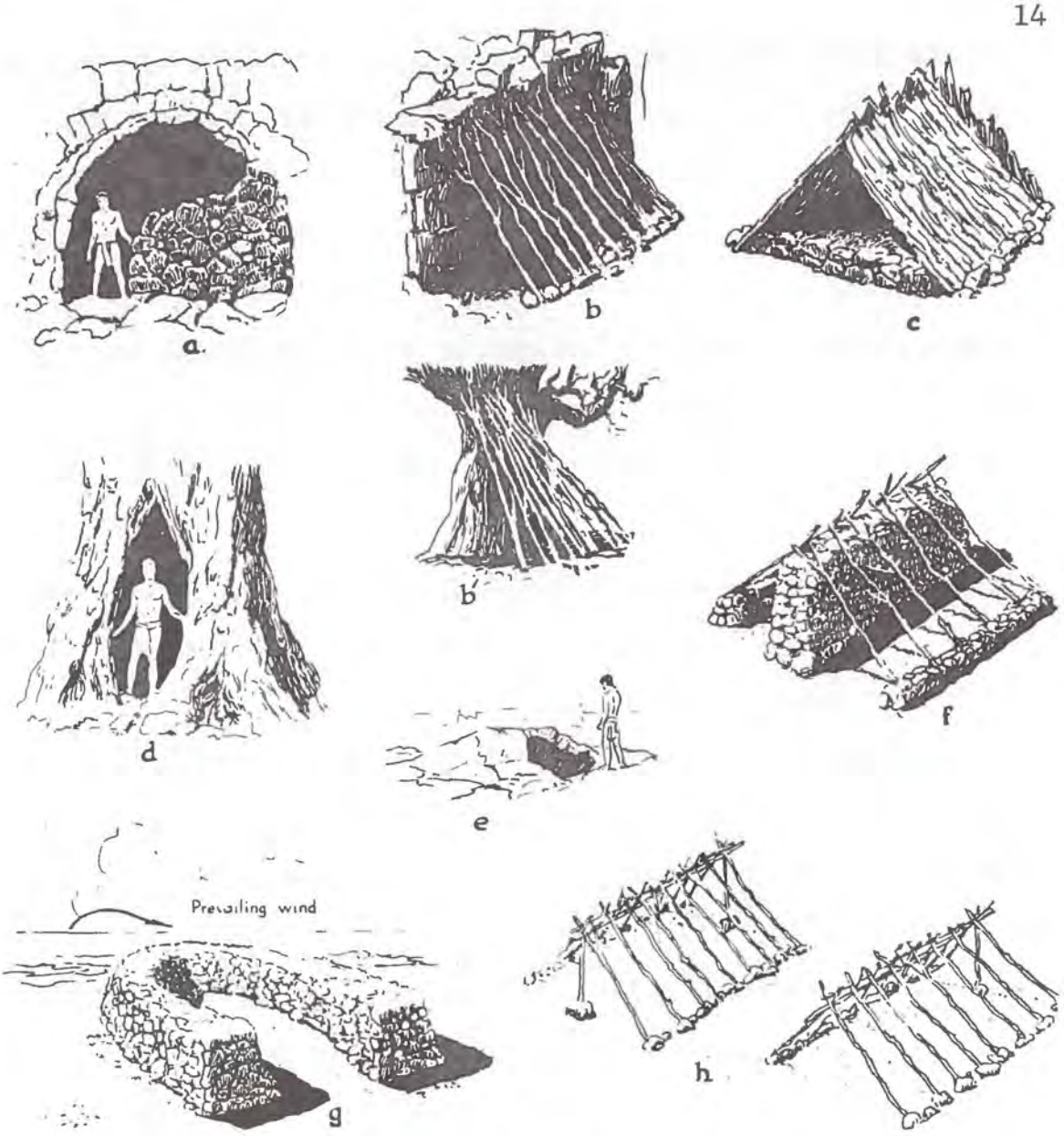
Temporary shelters at the villages which ringed Kealakekua Bay during Cook's visit in 1779 would be needed to store household utensils and tools; to offer shelter during the rare rains; to afford security during the taboo periods. They would be needed by those attracted by the foreign ships at anchor and by those called to serve the high chiefs and their foreign guests. Thus, each of the villages on Kealakekua Bay in January 1779 consisted of its usual complement of permanent structures for resident chiefs and commoners, to which had been added the temporary complexes of visiting chiefs and the temporary structures of their supporting working commoners.

Such expanded villages were described by Samwell: "These Towns, tho' the Houses are close together, are not built regular so as to form anything like streets but have paths running through them in a zig zag manner; . . ." (Samwell 1967:1176). No doubt, any Hawaiian town, even in its unexpanded state, would lack any evidences of Western town planning, such as geometric design and straight streets (Ledyard 1963:128; Manby 1793:40-41; Vancouver 1967: II, 175).

To Hawaiians, temporary structures to expand a town or create a new one could be built within a few hours, if materials were available or brought for this purpose. A "small village" of well-built huts was erected in two hours on February 14, 1794, in a remote forested area above Kapapala, Ka'u district, Island of Hawaii (Menzies 1920: 186, 190). In this instance, the Western explorers were considered to have the status of chiefs. The village contained a chief's temporary housing complex, as well as temporary shelters for the working commoners. Shelter was needed against the night cold, and there was frost on the ground the next morning.

It might be difficult to distinguish between one commoner's permanent house and a more ambitious and proud commoner's temporary shelter. The temporary shelter could be better built. Apparently, some commoners used caves, lava-tubes or lean-tos more or less permanently. Such Hawaiians, at least in post-missionary times, were not considered respectable by their peers (Malo 1951:118; Samwell 1967:1176; Waialeale 1870:1).

Plate 1 illustrates different kinds of temporary shelters. The drawings are not a complete inventory, but suggestive of how available natural materials could be utilized. For the first time in Hawaii house sites associated with worksite shelters are being systematically excavated by an archaeological team from the Bernice Pauahi



Shown here are the frameworks only.
The covering could be fern leaves, ti leaves, palm fronds or any convenient and practical material.
a. Lava tube with partially walled opening. b. Lean-to against stone face b'-against tree. c. Bark house. Koa or ohia bark over stone platform. d. Hollow trees were used as shelters. e. Lava blisters gave good shelter. f. Center wall created two areas. g. Horse-shoe design protected dwellers. h. Simple 'A' frame with and without front center post.

PLATE 1.

HAWAIIAN TEMPORARY SHELTERS

Ca. A.D. 1778 — Ca. 1950

Bishop Museum. The area is Makaha valley, Oahu Island. A typological classification of house foundations, which appears to be an elaboration of the type suggested by Plate 1,g, is underway.[3]

Temporary shelters are still being built and utilized in Hawaii. Nails have replaced lashings; frequently termite weakened 2-by-4's replace timbers. Such shelters may be found in remote coastal areas and are usually used by fishermen. Nearby dumps with accumulated piles of tins and beer containers attest to recent occupancy and may mark the sites of archaeologically significant ancient middens.

Palaces and Pup Tents

Hawaiian chiefs' houses were palaces when compared with the pup-tent size of commoners' huts. The disparity in size reflected differences in use. Chiefs occupied their structures both day and night, good weather and bad. Commoners stored things inside their low huts and crawled into them only when necessary, as for shelter from the elements or for security during taboo times.

> The houses vary in size from the small hut of the kanaka [commoner], which barely hold him and his few domestic utensils, to roomy dwelling of the chief, . . . They are all, however, constructed of the same materials, i.e. poles or timbers fastened together with cord made of the twisted fibers of various plants, and covered with either the leaves of the ti . . . or a long kind of grass, and lined with various leaves, often elegantly plaited. In the chief's houses there is usually a raised platform. (Byron 1828:118)

By Hawaiian measurement methods, which utilized human body parts as units of measurement, the principal difference between the structures was that a person could stand in a chief's house, if protocol permitted. Doors to both chiefs' houses and commoners' huts were low and required a hand-and-knee posture to enter (Kotzebue 1821: II, 191). Doors are discussed in Chapter III. Once a man was inside a chief's house and standing, the more space there was between his head and the ridge pole, the higher was the rank of the chief whose house it was. High chief--high ridge.

"Ki'eki'e kaupoku o Hanalei" is a Hawaiian phrase which refers to a mountain near Hanalei on Kauai Island, and is said figuratively of a man whose ridgepole is too high; therefore a conceited or snobbish person (Pukui and Elbert 1957:128).[4] This Hawaiian saying probably evolved during Western acculturation and serves to illustrate a waning Hawaiian social custom which certain individuals chose to ignore. Standards by which a pre-contact Hawaiian was raised probably decreed the height of his ridgepole.

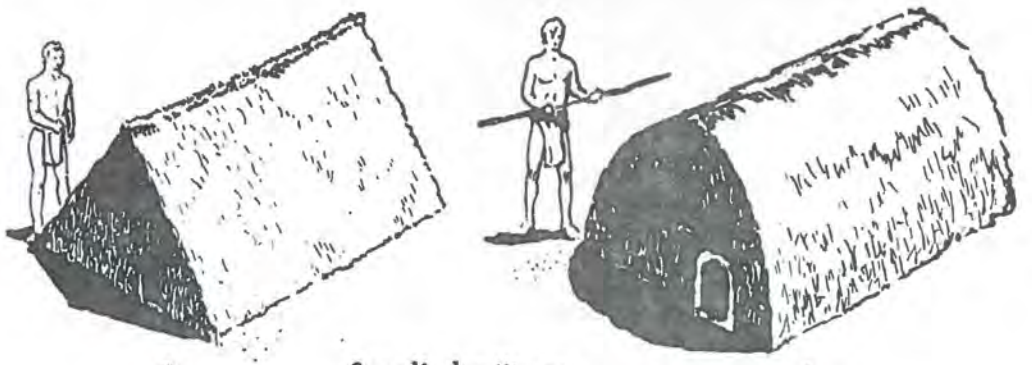
Based upon early illustrations, existing structural remains of house platforms, descriptions by contemporaries and experts translated into structures built in the field, and upon experience gained in working with native Hawaiian construction materials, Plate 2 was prepared to illustrate the types of permanent thatched structures believed to have been made in Hawaii ca. 1779. In quantity, structures with

straight rafters would outnumber those with curved rafters. In Plate 2, height estimates ignore the seven foot level. This skip was made to emphasize the difference between chiefs' structures--which would include temple structures--and those of commoners. In practice there may have been structures with ridges elevated seven feet. A leading craftsman, such as a master carver of temple images, might have had a taller house than any of his journeymen. But the master craftsman's ridge would still have been well below that of his chief.[5]

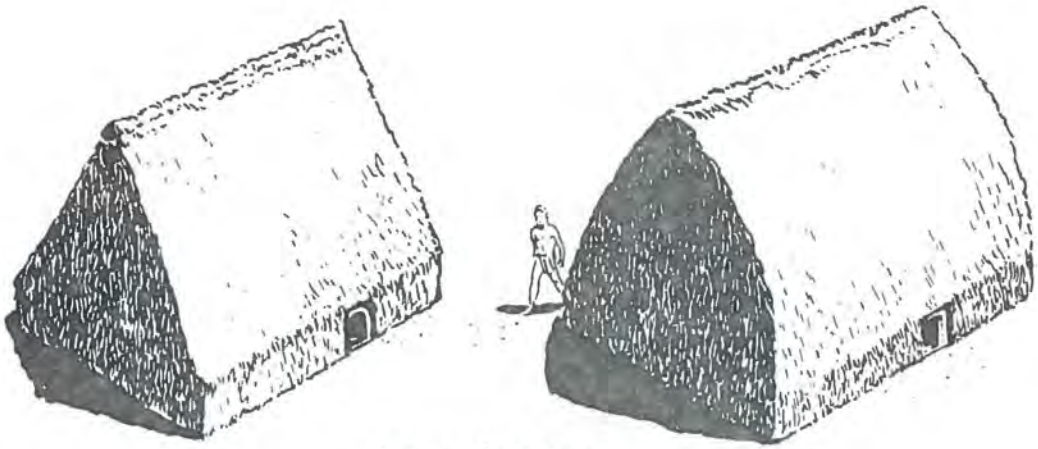
Structurally there appear to be two types of houses, those with walls and those without. Socially there appear to be two major classes, chiefs' and commoners'. It is evident that standing upright was possible inside chiefs' houses, but not in commoners'. Relate the two house types with the two social classes, and the conclusion is reached that chiefs' houses had walls while those of commoners did not.

To some observers, the "palaces" of chiefs and the "pup tents" of commoners appeared to be matched to their occupants.

> The nobles of the land are so strongly marked by their external appearance, as at all times to be easily distinguishable from the common people. They seem indeed in size and stature to be almost a distinct race. They are all large in their frame, and often excessively corpulent; while the common people are scarce of the ordinary height of Europeans, and of a thin rather than full habit. . . . Many of those whose corpulency does not amount to



a Small dwellings b



c Large dwellings Roof Elevated d

a. Roof on ground, straight rafters; ridge 4'-to 6' high.
b. Roof on ground, curved rafters; ridge 4'-to 6' high.
c. Walled house, straight rafters, ridge 8'-to 22' above ground.
d. Walled house, curved rafters, ridge 8' to 21' above ground.

PLATE 2.

HAWAIIAN THATCHED HOUSES

Ca. 1779

> deformity, are among the noblest figures imaginable. (Stewart 1830:133)

By 1823, when Stewart made that comment, the economic and physical disparity between chiefs and commoners appears to be more pronounced than at contact (King 1967:605, 611, 613-614; Samwell 1967:1160, 1180).

Real and Invisible Stockades

Stockades surrounded high chiefs' housing complexes and major temples (as well as places which contained Western items the early Western explorers wanted safeguarded). Such stockades were sacred. People within their bounds, either Hawaiian or European, were either sacrosanct chiefs by inheritance or else were considered sacred by fact of having been assigned to occupy a reserved space.

Not all of the stockades were physical. Some were invisible lines that were as effective as rock walls or picket fences. Walls and fences apparently marked lifetime or permanent taboo areas. Invisible lines marked enclosures guarded by temporary taboos. Real or invisible, they excluded commoners.

Areas temporarily taboo included the housing-headquarters establishments set up by high chiefs at locations where permanent quarters were not needed. Temporary chiefs' quarters might be set up near remote seasonal fishing grounds; or at locations where political-social-religious affairs of great

importance were occurring. A death of a ruling chief, a battle, or a visit by Captain James Cook were such affairs. Offshore, or inshore, fishing grounds were also made temporarily or seasonally taboo, as was the location of an upland tree selected for being carved into a major temple image. Such sites were marked along the shore or on perimeters and/or their corners by stakes. Stakes might be white or fly a white flag of bark cloth, or perhaps be topped with a coconut wrapped in white bark cloth. Major temples and permanent establishments of chiefs were enclosed by walls of dry-laid masonry or of wooden palings. In 1816, one temple had a stockade of coconut fronds. The enclosures were termed courts or courtyards by visiting Westerners.[6]

A ruling chief would have a number of permanent establishments, but it is not known if all would have had the same type of stockade. Availability of material might have been more of a consideration than personal preference or family tradition. The one known height estimate gives a dry-wall stockade of six feet (Manby 1793:41; see also J. Emerson 1928:58). The restored palisade of wooden pickets around the platform of the Hale-o-Keawe at Honaunau Bay is five feet high on the eastern side and seven feet on the western. (See Figs. 35, 36, 37, 38, 47, 48, 51.)

Dry-wall or picket stockades formed physical barriers to sacred ground, objects and persons, but by 1800 may have served more to mark and screen than to protect the enclosures.

Those who were not authorized admittance, especially commoner women, kept their distance, probably a minimum of 40 yards or 120 feet (Corney 1896:101; Vancouver 1967: III, 13; King 1967:519). Only female chiefs entered enclosures of male chiefs (Corney 1896:100, 101; Vancouver 1967: III, 13; Manby 1793:13, 55, 112; Lyons 1945:73), and then only as members of his household.

Each chief was surrounded and attended by numerous individuals--family, friends, and servants, most of whom were of chiefly rank. There may have been as many as 100 such individuals for a ruling chief. These individuals lived and moved with him. Most had specific duties. Some carried his spittoon and others his chamber pot in pre-contact days and until this life style was eroded. Still others, with their families, prepared, cooked and served his food (Samwell 1967:1171; Stewart 1830:137-138, 259; Malo 1951:30, 58-61, 62n, 191-192). Of the families represented in this complex organization, few were quartered within the stockade. Most lived and worked outside. All members of a chief's establishment would have need for storage and shelter, and most would have need for security during taboo periods. A stockade with thatched houses both inside and outside would mark a chief's establishment. It follows logically that the higher the rank of a chief, the larger would be his stockade and the more numerous his houses.

One aspect of the stockade system which surrounded chiefs' quarters was that only chiefesses were permitted within them. This fact put an initial restraint upon the leisure-time activities of Europeans quartered ashore within invisible stockades and who served as scientists or as guards of Western goods and equipment. In spite of extraordinary inducements, commoner Hawaiian women refused to cross the invisible barriers to join the men.

One solution was to remove the perimeter stakes. A better one, and one which did not permit commoners to have access to gear and instruments, was to provide special houses of assignation. Houses of assignation were erected outside the invisible stockades but handy to Europeans, who held the equivalent rank of chiefs. One such house was located approximately 60 yards, or 180 feet, away from the stockade (Ledyard 1963:109; Menzies 1920:27, 31, 112; Manby 1793:13, 35-36, 55; Kotzebue 1821: I, 305).

The Gods Watch

"Blessings would be the result and reward for the regarding of the rules and laws for the building of a house," as Kamakau put it (Kamakau 1870:133). He listed some of the blessings and rewards, and mentioned some of the rules and laws (Kamakau 1870, 1961, 1964; see also Becker 1969: D-7). Other nineteenth century Hawaiian writers not only listed blessings but told of the punishments visited upon transgressors for violations of the housing code of old

Hawaii (Waialeale 1870; Malo 1951; Kaawa n.d.; Haleole 1919; Hooili 1919). "Ai 'ino mai ke koko, pau pū ka hale i ka 'ino (and if the blood is bad, the house is at the same time bad)," is one of the Hawaiian sayings (Pukui and Elbert 1957:87), and implies a need for proper attitude on the part of the house builder.

Superstitions, omens, old wives' tales and rules of thumb are misleading terms, culture-bound in Western thought, for the observances and prohibitions of the Hawaiians in relation to their houses. A simplification of the matter might be to state that if a house was built with the proper observances and prohibitions, the Hawaiian gods favored the owner; but if those were neglected, the gods punished him.

But blessings, rewards, punishments, rules and laws recorded in the nineteenth century in Hawaii by Hawaiians may reflect some assimilated Western superstitions, the result of almost a century of acculturation. It is not the purpose here to separate any intermixture of cultures present in the writings of Hawaiians in the nineteenth century, but to warn of its probable existence. For instance, Waialeale tells this omen: If a dog approaches a house being thatched and howls, the house owner will perish at sea (Waialeale 1870:4; see Titcomb and Pukui 1969:2).

In the middle Atlantic United States, a howling dog outside a house where there was a serious sickness foretold death (personal knowledge). In England, hounds which bay

on moors figure in legend and fiction, such as in Sir Arthur Conan Doyle's detective stories.

Another of Waialeale's omens involves owls, which with dogs are common to both Western and Hawaiian localities. Western owls are credited with being wise; their hoots--especially at night--frequently engender fear; and owls are said to have led lost children and adults to safety, or conversely, to their doom (personal knowledge). Waialeale's Hawaiian owls alighted over a door opening during or after the thatch cutting ceremonies, and indicated that a man of the house had been selected for human sacrifice. If the family followed the owl to a hiding place, waited and returned home after troubled times were over, the man would be spared (Waialeale 1870:5). Since dogs and owls figure in both Hawaiian and Western occult lore, it is possible that Hawaiians were influenced by foreigners' tales.

Some more generalized omens are presented below, with discussion. Specific omens concerned with assembly techniques and parts of Hawaiian houses are included in appropriate places in Chapters II and III.

Some omens which relate to placement of houses contain practical wisdom, such as the need to level a hilly site and to align the length of the house parallel to the contour. Some omens also state the obvious, such as the advantages of a site near a fresh water pond and/or an irrigated taro field. Other omens recognize that easily

reached houses in favorable locations attract visitors who wish to share in the advantages, but who also bring gifts of material things not readily available in the vicinity. For instance, a family of a visiting fisherman would be sure to show up with dried fish at an inland house. To term a hillside house whose door faces uphill "unlucky" is to recognize that it is in danger from descending rocks, rain and mud. Reasons given, however, may touch upon the occult (Waialeale 1870:2-10; Haleole 1919:58-60, 76).

To recommend that a house should be built in late April or early May and that it should stand on an upland site between streams is to recognize that the dedication ceremonies would attract gifts of products of both land and sea, which would be plentiful at that time in the Hawaiian islands (Waialeale 1870:11).

Some omens would blame the house site for the drunkenness, disease, quarrels, sickness, domestic infidelity, short occupancy or death of the owners, or to indicate that certain sites benefit only the husbands if wives died first (Waialeale 1870:11-13; Haleole 1919:66).

Remedial measures for unfavorable house sites included according to the specific need of a house: straightening the house corners; placing a dog's tooth or a dog's tooth with Hawaiian salt within a bamboo tube above the door, or just a dog's tooth alone above the door; building a new and second house in certain juxtapositions to the first;

abandoning the house and moving away; planting certain shrubs in specified positions; lowering the ridge; enticing a high chief to enter the cursed house; and lowering and/or relocating the door (Waialeale 1870:2-13).

Doors and the ni'o (their interior vicinities; see Plate 13) retained occult significance long into historic times, and outlasted the occult significances that surrounded the ridge posts, which underwent a technological change as hipped roofs replaced gabled. Both framing arrangements required doors. Occult significance which related to doors persisted longer than gable lore.

Doors represented security to commoners, and were taboo to victim-seeking guards. Chiefs of superior sacredness had doors in their houses reserved for their exclusive use (Malo 1951:172-173, 260, 261, 265n; Kamakau 1870:144). The cutting of the tuft of thatch over the door of a new house symbolized the house's birth. While some commoners might occupy their new houses without ceremony, chiefs cut the symbolic umbilical cords of their houses with religious ceremony and gifts to the gods. The trimming of the thatch over the door of the principal house inside the enclosure of a state temple was an important part of temple dedication ceremonies (Malo 1951:121, 122, 124-125n; Kamakau 1870:133).

Lesser structures of lesser men than chiefs also had thatch cutting ceremonies, at least in historic times. Lore associated with the tuft of doorway thatch indicates

a critical time lapse between completion of the thatching and the cutting of the special thatch. A large and ever-increasing family would bless the owner if a woman gave birth inside the house during this period. Another omen of good fortune was seen if a gift of poi and fish were left on the threshold under the uncut tuft. A good omen in the critical period was for an old man to enter and sit inside the door with a coconut leaf fan in his right hand. A woman sitting there instead, with a roasted sweet potato in her left hand meant the house would be destroyed by lightning, but with no one hurt. If a visitor entered before the tuft was cut and wailed a greeting, sickness and death would come and another family would occupy the house. Some people cut a fish and a stalk of sugarcane simultaneously with the thatch tuft; while others put part of the cut tuft into the underground oven with the pig which was to be roasted for the "housewarming" feast (Kaawa n.d.; Waialeale 1870:3, 4, 5; Hooili 1919:646-647; Kamakau 1964:97). The specified fish was aholehole (Kuhlia sandvicensis), which had magical powers (Pukui and Elbert 1957:7).

By 1823, ruling chiefs of Hawaii held New England type housewarmings for their new houses, and instead of giving gifts to the gods, collected gifts--in cash--from their subjects. They also kept a record of each gift and set quotas beforehand (Ellis 1827:427-428; Stewart 1830:101-102, 132). Any thatch cutting ceremonies were performed away from foreign eyes, and, if performed, went unrecorded.

Death defiled doors. A corpse inside a house was removed through a hole made in the gable end. Another method to avoid "contamination" of the door, probably adopted in post-contact times, was to build a new door outside the existing one and pass the body through both doors. The new door was then broken and the parts were disposed of. The interior of the house was cleared of the contamination of death by sprinkling with sea water or with fresh water to which salt was added. Sometimes 'awa (kava) rootlets and 'ōlena cuttings were added to the sprinkling water (Kamakau 1964:35, 49, 114).

A Hawaiian god of the doorway was Kane-hohoio for some, for others it might be Kane-noio. The area between the doorposts and that both inside and outside the doorway was sacred in chiefs' houses and occupied only in passage. A priest slept between doorposts the night before a chief's son was circumcised (Malo 1951:83, 85n; Kamakau 1870:145; Kelou Kamakau 1917: VI, 6, 14; Ii 1959:119; Kamakau 1961: 160; Pukui and Elbert 1957:246). At other times the doorway may have been kept free to permit the family god to enter and leave at will.

Each gable end of a walled thatched house contained a ridge post. The two ridge posts were the tallest posts and supported the ridge pole. Their height determined the height of the house. Ridge posts stood apart from the rest of the frame and were not tied into it. All other structural members were interconnected by lashings and joints

into a mutually supporting vertical and horizontal network. A ridge post's only direct connection with the rest of the frame was its joint at the top with the ridge pole. (If the lashing which secured this joint had its knot inside or on one side, it was said that the owner would suffer a long sickness and die (Kamakau 1870:137; Malo 1951:124n; Waialeale 1870:3, 4; Hiroa 1957:86; Brigham 1908:92). There would be structural advantages to including the ridge posts in the jointed framework at other points than at their tops, but this was not done, probably because ridge posts were set apart for religious reasons.

Up to wall-plate level, the hipped frame resembles a gable frame. (See Frontispiece.) Hipped ends have corresponding posts which extend from ground level up to the end plates. Judging from the one surviving example of the hipped Hawaiian frame, some significance transferred from gable ridge posts to the corresponding middle end posts of hipped frames. The people who re-assembled the hipped house at the Bishop Museum left its middle end posts standing alone and did not tie them into the rest of the frame with lashings. Neither did they put lashings along the spans of the rafters immediately above the middle end posts.

His house affected his fortune is not an overly simplified statement of the relationship between a Hawaiian house and its principal occupant. One or both ridge posts represented the owner. In Western analogy, a crooked ridge

post meant a crooked man. In Hawaiian analogy, the taller the ridge posts, the more sacred the chief. The care and ceremony in building chiefs' houses and temples, the perfection in dedicatory ceremonies for their purposes, assured success for their sponsoring chiefs. An error in construction or ceremony augured ill. Form foretold the future. Properly propitiated gods were likely to look with favor on the occupying chief. Temple and house building activities were religious acts to chiefs (Haleole 1919:80-81; Kamakau 1870; Kamakau 1961; Malo 1951).

Once built, a chief's house apparently was inspected for signs and defects. If the two end posts adjacent to the ridge post (which symbolized the chief) bent toward the ridge post, this indicated opposition; there would be rebellion. If they bent away, their form indicated mourning; the chief would die. If, during construction, the ridge post and a corner post on the same end had to be taken up and replaced, the chief would die suddenly after the house was completed (Haleole 1919:80-81; Waialeale 1870:3).

Selection of the site; design and orientation of individual houses and features in clusters and enclosures; selection of timbers and materials, their preparation and transportation from forest to site; and probably overall supervision of construction of high chiefs' houses and temples were the duties of the royal architect (Kuhikuhipu'-uone). Much responsibility and trust rested on his

shoulders. It was believed that a kingdom could be lost if the architect misbuilt; or won if he was right (Haleole 1919:58, 59, 82; Kamakau 1870:183, 186).

Lesser chiefs, and some commoners in historic times, employed architects of less prominence. Local priests, or knowledgeable persons, gave advice to house builders before or after construction. If they helped after the house was built, they relied upon a body of lore to remedy specific defects. Some of this lore remains today. Until thatching was abandoned, these consultants were usually also experts in the difficult techniques of bonneting the ridge to make it rainproof. Prohibitions and observances marked the bonneting, if the owner revered traditions (Kamakau 1870: 133, 141-142; Hooili 1919:640; Haleole 1919:58, 60, 64-76, 80-82; Waialeale 1870:7, 17-18; Ellis 1827:317).

Under the kapu system which was designed to protect the chiefs' spiritual power from contamination, chiefs, their houses and objects were sacred. Heads and shoulders of commoners and lesser chiefs were uncovered when they were near Kamehameha the Great, or when they passed his housing complex (Campbell 1967:93-94). Other chiefs, of even more sacred rank than Kamehameha rated prostration by lesser chiefs and commoners (Malo 1951:55, 56, 57; Kamakau 1964:5, 9, 22, 27; Cook 1967:269). Once a sacred chief visited inside a house, it took on the aura of his more frequently occupied structures and could not be used by

others. A chief who was considerate of his people would refrain from entering the house of another so as not to put it out of use by its occupants. Houses once occupied, but not needed for a foreseeable time by a high chief, were burned to the ground (Campbell 1967:93; Menzies 1920:28, 86, 95). Such may have been temporary housing complexes. It is not known if the grounds they occupied remained sacred.

Construction of a modern house on the site of a former Hawaiian temple is contraindicated (Hooili 1919:640; Haleole 1919:60).

NOTES TO CHAPTER I

1. Storage in general is discussed by Byron (1828:107); Stewart (1828:134; 1830:100-101, 247); Jackson (1966: 57-58); and Ellis (1827:138, 373, 377-378).

   Hawaiian household items and trade tools are discussed by Malo (1951:46-81); Hiroa (1957:106-109); Kamakau (1870:147 and passim); and Waialeale (1870:1).

   Numerous references are found in early journals and logs to the storehouses full of Western goods. See especially Ives and Ives (1845); Ii (1959:120-121).

2. For Hawaiian views see K. Kamakau (1917: IV, 10, 14, 16, 22, 24, 26, 28, 30, 32, 34); Malo (1951: 141, 172); Ii (1959:43, 59-61); Waialeale (1870:1); Kamakau (1870:200); Kamakau (1961:154); Kamakau (1964:21).

   For Western views Vancouver (1967: II, 110, 112; III, 159, 162); Menzies (1920:53, 54); Manby (1793:30-31, 46); Freycinet (1829:21); Stewart (1830:94); Ellis (1827:4, 52, 82-83, 84, 135-136, 145, 248, 265, 327, 331, 337, 363-365, 367, 379, 391, 394-396, 422, 429); Kotzebue (1821: II, 200-201; III, 249).

3. For work and classification in progress at Makaha, see Ladd (1968). Norman Carlson (1968), Hawaii Island Forester, believes bark houses would utilize dead Koa (Acacia koa), and possibly 'ohia-lehua (Metrosideros macropus, M. collina) or naio (Myporun sandwicense) barks. See also Waolani (1919:652) for bark houses.

   Samwell (1967:1176), Waialeale (1870:507), Kamakau (1870:141) and Handy and Pukui (1958:7-14) discuss temporary shelters in general.

   Caves as shelters are mentioned by Clerke (1967:592-593), Samwell (1967:1176) and by Emory et al. (1965). Ellis (1827:138-139 discusses shelters used by warriors.

   For sheepherders' huts in the 1870s, which presumably perpetuate an earlier type on the slopes of Hualalai mountain, Island of Hawaii, see Bird (1964:256).

   Mountain huts are mentioned by King (1967:523, 524), Samwell (1967:1167), Waialeale (1870:4), Menzies

(1920:81, 82-83, 186, 188), Kamakau (1961:41), and Waolani (1919:650-657). These deal primarily with worksite huts seen on mountain trips. For more general comments on mountain shelters, see Samwell (1967:1191), King (1967:521, 522, 617), and Clerke (1967:592-593, 599).

Shoreline shelters are discussed by Menzies (1920: 40, 181).

4. For similar sentiments, from Hawaiians, see Malo (1951:74); Haleole (1919:64, 76); from a Westerner, Dibble (1909:76).

5. Reproductions of early graphics considered reliable for structural shapes are found in Brigham (1908: title page, 3, 73, 74, 89, 96, 100, 101, 105, 106 (lower), 107, 109); Hiroa (1957:77, 78, 101). See also in this dissertation Figs. 35, 36, 37 and 38 for gable ends and shapes.

For general descriptions of commoners' houses, see Ledyard (1963:128); Chamisso (n.d.:29); Vancouver (1967: II, 116); Byron (1828:107); Ellis (1827:299); Thurston (1934:126, opposite 174); Lyons (1945:54); Conde (1887:174); Stewart (1828:14, 112, 134, 192); Stewart (1830:153, 201); Bird (1964:101); Kamakau (1870:134); U. Emerson (1928:73); Clerke (1967:1321); Valentine (1875:37-38).

For descriptions of single houses in various chiefs' establishments, see Samwell (1967:1176); Menzies (1920:72, 112); Freycinet (1829:15-16); Ledyard (1963:128); Stewart (1828:101); Stewart (1830:137); Ellis (1827:125, 272, 309, 314, 376, 387); Byron (1828:113); J. Emerson (1928:46); Kamakau (1870:134); Cook (1967:283); Samwell (1967:1176).

For descriptions of chiefs' establishments, a complex of houses, see Menzies (1920:86, 87); Vancouver (1967: II, 197, III, 61); Manby (1793:36, 37); Stewart (1828: 192); Stewart (1830:137-138); Malo (1951:28, 122, 126n); Ii (1959:59, 121, 143); Kamakau (1870:133); Campbell (1967:91, 130); Bingham (1847:115-116).

For comparisons of chiefs' and commoners' houses, see Cook (1967:283); Menzies (1920:190); Campbell (1967:130); Ellis (1827:299, 317); Byron (1828:113, 119); Kamakau (1870:133, 134); Waialeale (1834:5); Kamakau (1961:238).

6. For stockades which surrounded permanent chiefs' establishments, see Samwell (1967:1163, 1170, 1175-1176); Hirahara (1931); Campbell (1967:91, 131); Manby (1793:36, 40, 41); Corney (1896:90, 98); Malo (1951:162, 261); Kamakau (1964:85, 97, 121); Kamakau (1870:184).

For stockades which surrounded temples, see Corney (1896:100, 101, 115); Arago (1823:102); Malo (1951: 162, 261); Ii (1959:56); Kamakau (1964:85, 97, 121); Kamakau 1870:184, 190, 193-196). Stockades existed around the Hale-o-Keawe, Hikiau at Kealakekua and Pu'ukohola at Kawaihae, all Island of Hawaii. Illustrations from Cook (1967) and other early voyages show temple stockades. Numerous physical remains of temple stockade walls still exist.

For descriptions of the "invisible" stockades, see King (1967:501, 508, 519, 522, 617, 622); Ledyard (1963:107, 109); Corney (1896:36, 86, 101); Menzies (1920:13, 27, 31, 156, 186); Manby (1793:12, 17, 35, 36, 55); Vancouver (1967: I, 177-178); Ii (1959:58); Malo (1951:56-57); Kamakau (1870:192); Bloxam (1925: 76-77); Cook (1967:553).

CHAPTER II

STRUCTURE OF HAWAIIAN THATCHED HOUSES

Two precepts begin this chapter. One delineates the geographic area applicable to this dissertation. The second groups together chiefs' houses and temple structures. Hawaiians made no architectural distinction between a governor's mansion and a cathedral; between the mayor's house and the church building in which he prayed.

One precept is that house structures were similar on all Hawaiian Islands--Hawaii, Maui, Kahoolawe, Lanai, Molokai, Oahu, Kauai and Niihau--at time of contact with Europeans. This was noted in 1778-1779 by the first known Westerners to reach Hawaii (Cook 1967:598; King 1967:626). Although external appearances were the same, Hiroa (1957: 82-83) later noted interisland differences in technical Hawaiian terms, which may indicate some minor variations in techniques among islands.

The second precept is that houses of major temples were structurally similar to those occupied by high chiefs. Kelou Kamakau (1917:8), Samuel Kamakau (1870:182-206) and David Malo (1957:122, 150, 162), all native Hawaiian writers on technical subjects, made no structural distinction between temple structures and chiefs' houses.

The Hale-o-Keawe, the major temple discussed in Chapter V, did "not differ from that of the grass houses

of the native chiefs" (Byron 1828:198); was "built like a large native thatched hut" (A. Bloxam 1925:73); and its "exterior was precisely similar to the habitation of one of the higher chiefs" (R. Bloxam 1923:79).

The Hawaiian word hale (house) is part of the nomenclature for houses in chiefs' housing complexes, on temple platforms, and those used by lesser chiefs and commoners. A modern compilation of terms which begin with hale made by Pukui and Elbert (1957:49-51) gives more than 130 entries, and includes among the many modern terms those applicable in ancient times to chiefs' houses and temple structures. Hale appears to be a generic word. Its translation as house is appropriate, and, when combined with appropriate qualifiers, includes ancient and modern dwellings, temporary and permanent structures, storehouses and temple houses; as well as modern police stations, city halls, and railroad roundhouses. "House" was selected as a better term than the anthropologists' term "habitation," because it includes more of the types of structures discussed. While they differed in use, size and complexity, thatched Hawaiian houses were structurally similar.

Experimental Archaeological Method

Written records subjected to historical criticism were the source for Chapter I, which discussed the uses of the Hawaiian thatched house. Written records became one of several sources for Chapters II and III which deal with

structure and assembly. Sources for Chapters II and III include:

(1) descriptions of late eighteenth century and early nineteenth century thatched Hawaiian structures, written by Westerners who lived in them, visited in them, and/or saw them abuilding;

(2) descriptions by Hawaiian scholars in the nineteenth century, who believed the techniques and materials they listed were those used by their ancestors to make genuine Hawaiian houses and who wrote in order to record this aspect of their traditional culture at a time when they were aware of cultural change;

(3) experimental archaeology which resulted in the building of more than a dozen houses of various sizes and design by National Park Service personnel and others;

(4) the thatched hipped-roof structure exhibited in Honolulu's Bishop Museum, the one surviving authentic Hawaiian grass house, albeit a modified one. It proved to be of value for confirming historic records. It was a guide to present-day interpretation of written records. It also supplied some missing details.

Chapter IV starts with the house types described in Chapters II and III as a standard or base, and records some of the changes in structure and in use which developed as the traditional Hawaiian and invading Western cultures meshed.

In 1963, the National Park Service, U.S. Department of the Interior, faced for the first time a need to restore a structure other than one which represented Western or Amerind culture. There were no guidelines available nor precedents to follow. No one alive had ever seen, let alone helped to assemble, an authentic Hawaiian thatched house. The number of unknown details exceeded the known. The project was to restore the Hale-o-Keawe (House of Keawe) temple at Honaunau Bay, City of Refuge National Historical Park, Kona, Island of Hawaii.

Search for structural data was made in the literature and the hipped-roof house in the Bernice P. Bishop Museum, Honolulu, was examined. Data were gathered for both the Hale-o-Keawe and for Hawaiian structures in general. Where specific details concerning the temple were lacking, they were obtained from the body of information about Hawaiian structures in general.

Framing models two feet high were made toward the end of the search through the literature. Experiments with full-size houses began in 1966, with the building of structures for Kaupo village at Sea Life Park, Oahu. The

Tongan builders distrusted the Hawaiian nail-less joints and secretly added nails to all the joints. This nailing eliminated any possibility for a fair test of the Hawaiian joints.

Later in 1966 a half-size model of the Hale-o-Keawe was built close to the site of the original at Honaunau Bay (see Fig. 27). Its ridge, eleven feet high, made even this half-size house a large structure for Hawaiian thatched houses. The restored full-sized Hale-o-Keawe was completed in June 1968 (Fig. 51). Then a small thatched house was built to experiment with curved rafters (Figs. 22, 25, 33), and the frame for a small walled house was built to demonstrate framing details (Fig. 26). In 1969 and 1970 several small structures were added at Sea Life Park, Oahu. In 1970, two temple structures were built in Makaha Valley, Island of Oahu. Drafts of Chapters II and III were used as a guide for their erection, and the draft corrected as necessary.

Some of the problems met are given in the following section on Gable Roofs. That section covers the most serious framing problem encountered and illustrates the techniques of experimental archaeology used.

Gable Roofs

External shape distinguishes gable from hipped roof thatched houses (see frontispiece). The shapes reflect the kinds of frames concealed by the thatch.

With one exception, which may be explained in terms of exaggerated perspective and artistic license, illustrations from the Cook expeditions of 1778-1779 depicted gabled-end structures.[1] Most early illustrations, as far as Hawaiian structures are concerned, contained an occasional hipped roof among the gabled. Artistic license was practiced by the expeditions' artists and subsequently by the engravers who worked from the original drawings. Artists and engravers with their Western heritages and training were familiar with both roof types. Perspective often makes ridges of houses appear shorter than their wall plates, especially when gable-ended houses are depicted in front views. Then, too, some hipped roofs may have been present in Hawaii by 1800, at a time when some Westerners were known to have been in residence.

Building descriptions detailed independently by three Hawaiian writers, Malo (1951:119-121), Kamakau (1870:134-138) and Waialeale (1870:3-4), and believed by them to be authentically Hawaiian, relate to the gable shape. They made no distinction between framing of a large chief's house and a temple house. Three Christian missionaries, Ellis (1827: 313-318), Stewart (1828:137-138), and Bingham (1847:115-117), who lived in Hawaii in the 1820s and 1830s, described building methods of the Hawaiians for large structures which resulted in gable-ended houses. None used the term gable, however. One Westerner, Valentine (1969:24), saw some

Hawaiian structures in 1786 and used the French term for gable. Clerke (1967:1321), who was with Cook in 1778-1779, also implies gable in his record.

Two directors of Honolulu's Bernice Pauahi Bishop Museum, separately published works on Hawaiian thatched houses. In 1908, Dr. William T. Brigham (1908:88, 95-96) acknowledged the gable roof as the original form, but supplied no framing details. Te Rangi Hiroa (Sir Peter H. Buck) (Hiroa 1957:81-82, 91) in his Arts and Crafts of Hawaii, published posthumously in 1957, also accepted the gable roof as authentically Hawaiian. It is concluded that the gable roof is the pre-contact style of the Hawaiian thatched house for chiefs, temples and commoners. It should be noted that there are disadvantages to a hipped-roof house, whose ridge is too low to permit standing. A hipped frame reduces the amount of usable space.

Although its date of introduction is unknown, and is presumed to be before 1800, the hipped roof appears to be a foreign introduction which became popular in later historic times, when commoners built walled houses (Scott 1968:39, 44, 82, 91, 575, 601, 616, 694, 739, 838, 840, 841; Feher 1969:177, 183, 223, 228, 232, 256, 288, 354, 378).

The hipped style of the Hawaiian thatched house, a form which represents transition to Western ways, is perpetuated by the "Hawaiian Grass House" on exhibit in the Bishop Museum. This only surviving example of a Hawaiian

thatched house has obfuscated Hawaiian structural history. The frame of the Bishop Museum's exhibit house came from a valley on the northern side of Kauai Island. It was re-assembled and rethatched in the Museum about 1900. Its reassemblers and thatchers were two Hawaiians who used many traditional techniques (Brigham 1908:88n), but their product represents an adulterated thatched house. Many of its joints and lashings conform to the descriptions in the works of the three Hawaiian writers (Malo 1951; Kamakau 1870; Waialeale 1870) and except for the modifications in the frame to make it hipped, it is believed that the exhibit house preserves the only surviving examples of many traditional Hawaiian structural techniques. Lost, however, are examples of the gable end and the door (Brigham 1908:90-94; Hiroa 1957:81, 86-87). The door is discussed in Chapter III, but an explanation of steps taken to re-create the missing gable end is appropriate here.

Most detailed descriptions of structure are by Kamakau (1870), but these, and others, lack the details of the joint between the ridge posts and pole--that is, the actual mechanical connection and the lashing. Also lacking are details as to the lashing between the gable end posts and the end rafters. These joints and lashings are not present in the frame of the hipped exhibit house at the Bishop Museum.

Neither Brigham nor Hiroa had the funds or the need to build a typical thatched Hawaiian house. They did not have practical field experience to season their publications. Hiroa, on paper, made a conjectural gable end (Hiroa 1957: 86, 87, 91).

The National Park Service two foot-high framing models indicated awkwardness with the end plate conjectured by Hiroa (1957:91). End plates interfered with the vertical rise of the end posts; and with the joint, of unknown details, right where the end plates supposedly joined with posts, wall plates, and rafters. The complexities of this four-way joint were not illustrated nor explained by Hiroa. Based on these difficulties, it was decided to eliminate end plates when it was noted that end plates are not part of Tahitian gabled structures, which presumably are also direct descendants from a prototype common to both Hawaiian and Society Island groups (Emory 1920). The absence of the conjectural end plate fostered assembly.

Still unproved in use were (1) the joint, with lashing, between the ridge posts and pole; and (2) the joint, with lashing, between end posts and end rafters. The half-size model of the Hale-o-Keawe incorporated the ridge post - ridge pole joint as reconstructed by Hiroa (1957:86-87). Slippage was immediately noted at the joint. The ridge pole, even when lashed, slid in the groove on top of the ridge posts. With this slippage, it was not possible to maintain

the arch in the ridge pole nor to secure the top rafter ends. Even with the center pole helping to maintain the arch, the ends of the ridge pole moved in and out in relation to the posts. New lashings were tried, but without firm mechanical connection between the ridge posts and pole, the joint was unsatisfactory and continued to slip as assembly of the rest of the house progressed.

The two-foot high models also incorporated the conjectural joint by Hiroa, but the models proved too small to reveal this structural weakness. On the half-size model of the temple, as the fixed thatch network was applied to the frame, the slippage reduced. When completed, the half-size model had rigidity in the joints between ridge posts and pole. This was not achieved from the joint. Rigidity was obtained only after the 'ilio (see Plate 13) pressed against the upper end of the ridge post from inside while the thatch network held it from the outside. Squeezed between two solid supports, the upper ends of the ridge posts could not move in relation to the ridge pole. Both the 'ilio and the thatch network were indirectly connected to the ridge pole through the rafters, and gave external fixation to the critical joint. When fixed in position, however, the ends of the ridge pole protruded an inch or so beyond the outsides of the two ridge posts.

With this distrust and dissatisfaction of the ridge post - ridge pole joint, the Hale-o-Keawe was reconstructed

in 1967 and 1968. With awareness of the problem and care in construction, plus a lashing which applied more strength to the joint, the joints remained in desired position through most of the reconstruction. Slippage occurred several times, but was corrected. When finally fixed in position, held between the 'ilio inside and the thatch network outside, the joints were in their desired position and rigid.

All other joints of the thatched, walled Hawaiian House were mechanically sound and of no concern as to their security. Neither did they need external fixation. It was felt there must have been a Hawaiian mechanical connection between the tops of the ridge posts and ends of the ridge pole. Funding and construction deadlines did not permit experimentation during early stages of the Hale-o-Keawe reconstruction. The ridge pole is necessarily installed early in the assembly.

Experiments with this joint were made in the last month of the fiscal year, June 1968. A solution came too late to be applied to either the half-size model or the reconstructed Hale-o-Keawe. A known Hawaiian house joint was sought which could be modified to meet performance requirements it was felt the ridge post - ridge pole joint should meet. The performance requirements were a mechanical connection which would prohibit the ends of an arched--and therefore under stress--ridge pole from thrusting out or

moving sideways in relation to the tops of the ridge posts which supported these ends. The joint selected for modification was the joint which linked wall posts to rafters (see Plate 5, i). The modification worked and was used in the Hale Pili (Figs. 22, 25, 33) and in the framing model (Fig. 26). It was felt a reasonable approximation of what skilled Hawaiian house builders might have used had been achieved. The National Park Service reconstructed joint is shown on Plate 5, h, with its lashing at the top of Plate 8.

Photographs of the joint which met the performance requirements and evolved at Honaunau are in Figures 8, 13 and 14.

Far easier of solution was the joint between gable end posts and rafters. The conjectural Hiroa reconstruction (1957:90) was based on Kamakau's description (1870:136) and his joint sound. Hiroa's lashing (1957:90), however, did not prove practical. The National Park Service solution is shown on Plate 9 and is based on lashing principles of the Hawaiians: a wrap and throttle. This solution was worked out on the half-size model of the Hale-o-Keawe.

All other joints and lashings were described in sufficient detail in the sources, or their descriptions or mentions became meaningful when compared to those which existed on the Museum House. Details of experiments to reproduce Hawaiian structural techniques are not belabored; only the National Park Service solutions are presented.

External Appearances

Classified by their external appearances, Hawaiian thatched houses took four basic forms:

Roofs with straight rafters on ground;

Roofs with curved rafters on ground;

Roofs with straight rafters elevated on walls;

Roofs with curved rafters elevated on walls.

Plate 2 illustrates these basic forms. Walls were usually wooden posts, but dry-masonry house walls also existed. Dry-masonry walls would not be thatched.

Roof frames, except for the lower ends of rafters, appear to be the same for all forms. Rafter ends secured within stone walls, braced against rocks or ground plates, or fixed into earth do not need to be worked. Rafter ends which couple with wooden wall assemblies need worked mechanical connections.

Oahu's Waikiki and Kauai's Waimea were two known places where a few houses were raised so that stream, tidal or flood waters could pass beneath their floors. Structurally, such raised houses appear to have been framed as if they were walled with posts, but with floors raised above ground level (Menzies 1920:23; Hiroa 1957:77, 99-100; Brigham 1908:77-89).

Floors may have rested on beams extended between wall plates. Usable floor space would be similar to a house whose rafters rested on the ground. Another technique could

have been to lash floor beams across pairs of wall posts below wall plates to enlarge the space above. Posts of houses raised above any ground subject to moving water would have bases fixed in soil or sand, and not within a dry-masonry platform. This does not imply that Hawaiians did not know enough marine engineering to build walls to withstand wave action, but that the locations of raised houses were in sandy or flood plain areas where rocks were not plentiful. Also, any access to or from such houses when water surrounded them, would be by canoe, wading or swimming, and obscured underwater rocks are hazardous to canoes, waders and swimmers.

Dimensions of the Hawaiian thatched house appear to have practical limits. Lower limits enclose the approximate area needed for sleeping of two adult bodies, plus some storage room, and were on the outside about eight feet long, four or five feet wide, with ridge about four or five feet high. Pup tents, indeed. Upper limits of chiefs' walled houses were set by the usable lengths of timbers to form the component frame members. If wall plates and ridges were spliced, however, there would be no limit to the number of bents (see Plate 4) which could be set in line to form the length. But graphics and descriptions of early houses, and remaining house platforms, indicate rectangles with lengths only slightly longer than widths. Practical length limits appear to have been available timbers for wall plates

and ridges (Stewart 1828:290). The Hale-o-Keawe probably approached the upper limits of practicality of native woods without joining key framing members. Its outside dimensions in reconstructed form to fit the original platform, were approximately 21 feet in length, 14 feet in width, and the top of the fern trimmed ridge is 23 feet above the platform. Bingham (1847:115) noted a relationship of wall posts to ridge posts which appears to be a generalization. He wrote that the two ridge posts were about three times as high as the wall posts of any individual walled house.

Wood Working Tools

Worked basalt tools of the Hawaiians before 1778 ranged in size from heavy adzes two or more feet in length down to tiny finger-size chisels and gouges. Supplemental wood working tools were pieces of lava, spines of sea urchins and abraders of coral. The elaborate and rare sliding door assemblies were made with a drill--pointed with an abrading shell or bone, as well as adzes and gouges.

Extensions of such basic stone tools to facilitate manual use, such as wooden hafts of adzes and wooden in-line elongations of chisels and gouges were employed, but examples of the techniques of fixing worked tool ends to hafts and handles are scanty for Hawaii. In the Bishop Museum's extensive collection there are few stone wood working tools with handles or hafts attached. References to such stone tools are found in records of the Cook expedition

(Cook 1967:285; Samwell 1967:1186) as well as in other sources (Malo 1951:51-52, 124, 127; Kamakau 1870:190, 192; Waolani 1919:656-657; Campbell 1967:143; Ellis 1827:318).

To facilitate the carving of wood, shaped adz ends need to be swung through an arc to gain momentum and to terminate in impact and shock as the tool edge strikes. Adzes fall of their own weight. The operator lifts the tool and controls the fall. Shaped chisel and gouge ends need in-line percussion: the operator aims the chisel or gouge, and controls the fall of a mass held in his other hand to strike the tool in-line. Any effective wielding of such tools requires a journeyman. Hafts and handles, and their binding to the ends of cutting tools, must withstand repeated impacts. This is true of both stone and metal tool ends.

Experiments generated by the Hale-o-Keawe restoration project at Honaunau Bay in the 1960s provided working contrasts and comparisons between stone and metal wood working tools. Knowledge of the limitations and capabilities of stone tools was desired so that cuts made by such could be duplicated by the more available and efficient metal tools. Jacob Lindberg-Hansen, professor emeritus of wood sculpture and art, University of California, Santa Barbara, handled this phase of the investigation. He is preparing a scholarly report on Hawaiian wood sculpture, especially temple images. He has reviewed this section on wood working tools, and his helpful, technical suggestions have been incorporated (Lindberg-Hansen 1970, personal communication).

A chip shaped differently and smaller in size than that of a metal-edged tool is generated by each effective impact of a stone-edged tool. Ten impacts by a stone-edged tool removes less wood than is removed by ten impacts by a metal-edged tool. To hold its cutting edge without disintegration on repeated impacts, a stone-edged tool must be broader in body and have a shorter shoulder from body to edge than does a metal tool. The working edge of a stone adz may be thought of as a wedge, while the working edge of a metal adz may be thought of as more like a knife. Penetration on each impact is far greater with a metal edge than with stone. The stone working edge, however, appears to be more durable and to require less maintenance than a metal edge. In several days of use, a stone edge may require sharpening and reshaping only once, compared with numerous sharpenings of a metal edge doing the same work in the same period. From these comparison experiments, metal wood working tools were judged to be more efficient, but this is a Western-oriented viewpoint.

Captain Cook disrupted the isolated Hawaiian civilization on January 19, 1778, when he traded a few iron nails for fish and introduced a supply source for iron (Cook 1967: 264). Later, an iron nail one and a half inches long, with a flat point, was traded for two small hogs (Cook 1967:264, 264n). Captain Clerke, who commanded Cook's companion vessel, wrote that "a moderate sized nail, will supply my

Ships Company very plentifully with excellent Pork for the day, and as to the potatoes and Tarrow, they are attained upon still easier Terms, such is these People's avidity for Iron." (Clerke 1967:269n.)

The amount of malleable iron in Hawaii before 1778 was negligible and probably came from flotsam and jetsam. Its value was high. Nails and fittings found on beaches, once freed of the encapturing wood, might be difficult to bend, but could be pointed or given a cutting edge through abrasion in the same manner as stone tools were sharpened. On one of his first visits ashore, Cook saw a metal tool, a "piece of iron hoop about three inches long fited [sic] into a wooden handle in the same manner as their stone adzes." (Cook 1967:285.) The Hawaiian word for adz is ko'i and the journals of Cook and other early visitors make frequent use of variants of the word, such as toe and toi. Ko'i are variously described as "pieces of iron formed into something like chisels" (Cook 1967:269); "iron wrought into small adzes in imitation of their own" (Burney 1967:538n); and the tool made from such "plane irons" described:--

". . . they lash a thin plate of iron, from one to four inches broad, and five or six long, to a branch which has a stem attached to it." (Campbell 1967:143.) Nails acquired by the Hawaiians from Cook's men were made into fishhooks; spikes into daggers; and iron strips into wood working tools (Samwell 1967:1186).

During his visit to Kauai and Niihau Islands in January and February of 1778, Cook traded an unknown quantity of nails, spikes and tool blanks to the Hawaiians, usually for pork, vegetables and potable water. Cook had determined, among other things, that Hawaiians valued iron and he sailed north with a diminished supply.[2]

At Nootka Sound, in Northwest America, Cook's Resolution and Discovery exhausted their official and private supplies of metal for trade (Cook 1967:302; Samwell 1967:1095-1096). In preparation for wintering in and further exploration of the Hawaiian Islands, Thomas Price, Armourer's Mate of the Resolution, and George Dixon, Armourer of the Discovery, each set up his ship's forge. The private supply of trade iron was replenished through purchase from the Russians at Unalaska; the official supply came from the large bower anchor of the Discovery, which had been damaged at the Kerguelen Islands, Indian Ocean, in December 1776.

The two forges were functioning by October 15, 1778, and the bower anchor

> . . . was cut up by order of Capt^{n} Cook & divided between him and Capt^{n} Clerke to work up into Tois or small adzes, to purchase Provisions for the refreshment of the People at Sandwich Islands. The two forges were erected & the Armourers set to work to make them, at which they continued from this Time till we left the Islands in March 1779. These Tois which were made in shape like Plane irons & of different Sizes answered our purpose very well, the Indians being very fond of them, the largest Size were about 12 or 14 inches long &

> two or three broad. We generally gave three or four of these for a Hog of 100 lb weight or more & there was nothing went so well as these Tois.[3]

The technique probably used by the armourers was to heat up a workable chunk of anchor until it could be beaten out into a thin sheet. Sheets would have been reheated and cut into strips of various widths; reheated strips would have been cut into sections, each section a tool blank for trade. There would have been blanks suitable for large tree-felling adzes and small thumb-size blanks suitable for chisels and gouges. The proper blacksmith tool used in cutting strips into sections would have left a beveled end or ends on each section. This bevel was probably left as cut by the armourers, and the cooled tool blanks sorted by sizes ready for the official ships' trade (Apple 1956). Hawaiians would perform any further working on the blanks, with the minimum being sharpening a beveled edge by abrasion on lava or sandstone, and hafting.

> Before we left Keragegooa [Kealakekua Bay, Hawaii Islands, Feb. 1779] we saw many small fishhooks which they had made with the nails they got from us, & having daily Opportunity of seeing the Armourers work at the forge they learnt the necessity of heating iron before they attempted to beat it out. We saw them trying to form a piece of iron into an adze, they heated it as well as they could in the fire, laid hold of it with wet cloth, put it upon a large Stone & beat it out with another; but between the aukwardness [sic] of their Tools & their not being able to apply a sufficient heat to the iron to make it red hot, they made but a sorry piece of Work of it, tho' with perseverance they would be able to form the iron so as to answer their purpose, as we saw proofs of it in the iron Daggers they had among them before our arrival

> which were evidently made by themselves; but where they got the iron from we could not learn, their own Adzes were made of blue Stone like those of Otaheite [Tahiti] but these soon gave way to our iron ones which came into universal use in a very short time. (Samwell 1967:1786; see also Campbell 1967:143)

Two forges worked almost daily for six months turning out iron tool blanks which were distributed--in return for ship's stores--along the coasts of Maui, Hawaii, Oahu, Kauai, and Niihau Islands during the period November 26, 1778, through March 14, 1779. On February 14, 1779, Cook was killed by the Hawaiians, possibly felled with an iron spike.[4] Hawaii's technological revolution in weaponry and wood working tools was underway. Any temple images carved, any canoes made, and any wooden structures built after 1779 could have tool marks made by metal tools.

Iron's value in Hawaii held constant with little change for many years. In 1793 a nail, or two, or three was adequate payment for a full day's arduous labor by a Hawaiian male (Menzies 1920:79, 105, 177; Manby 1793:13-14, 15, 21). Any private supply of iron among members of ship's companies went to recompense Hawaiian women for their companionship. By 1810, Kamehameha the Great had several royal native blacksmiths, and in 1817 wanted iron for use in ship building.[5]

Materiel

Names and lists of native materials used in the construction of Hawaiian thatched houses were made by nineteenth

century Hawaiian writers. General confirmation comes from Western observers who wrote in the late eighteenth and during the nineteenth centuries. Archaeological excavations of the twentieth century add data about house platforms, a subject but rarely mentioned in the sources. Few artifacts known to be associated with thatched structures have been recovered. Such as have been found confirm the Hawaiian writers. Timbers and thatch from abandoned houses rot. Timbers may have been salvaged for firewood or other uses. Thus, by the early twentieth century, little remained of the thousands of Hawaiian thatched houses except some of their dry-masonry foundations.

House Foundations

Foundations ranged from the natural soil or sand of the site to well built, dry-masonry platforms. For a house walled with posts, the soil or sand had to be of sufficient depth to embed post ends. For a house with its roof on the ground, soil had to be of sufficient depth to embed rafter ends, if the soil was to provide the major fixation. Rafter-ends laid on sand, lava, and on most soils, would need to be affixed to individual or to roof-length sills. Sills could be roof-length sleepers of log, on-ground or buried, and perhaps staked with pegs or weighted with rocks for additional fixation. Individual sills, one for each rafter end, could be made easily from rocks. A handy technique for lava, soil or sand surfaces would be to embed

the rafter ends in low, dry-masonry walls, one for each side (see Fig. 22). The mechanical interlock of the rocks in such walls makes for strong fixation. Available materials at the site and the nature of the surface would be the determining factors for the type of foundation for most houses, especially those to be built without ceremony or ritual, as for commoners. As far as is known, nothing prohibited a commoner from building a low, dry-masonry platform as a foundation for his permanent house or temporary shelter if he wished to expend the additional effort. Apparently ridge height was more important than the nature of the foundation.

Dry-masonry in Hawaii means laid-up rocks held mechanically together by careful fitting, without mortar. Dry-masonry platforms for a house foundation had social as well as structural advantages. Socially, the height of such platforms served to elevate the ridge of the structure built upon it, and thus indicate the rank of the occupant. Platforms also elevated the floor, an important consideration in situations where the horizontal plane of occupancy was important. A chief lying on the mat-covered floor of the house with the highest platform obviously occupied a plane higher than that of any other chief prone in another house. A ruling chief could nap secure in the knowledge that no other chief napped above him.

From a structural standpoint, a high platform permitted a high house. Since the amount of embedding of Hawaiian post ends was directly related to wall height, a high platform permitted deep embedment of posts. This was essential in the Hawaiian house because there were no tie beams between walls or rafters. Any pressure of the walls or roof had to be directly resisted by the post ends in the foundation. On-site soil or sand, if of sufficient depth, also permitted deep embedment of posts. The principal disadvantage of burying post ends in soil or sand is that they rotted quickly, especially in rainy areas. Hilo on the Island of Hawaii, for example, had few rocks in natural occurrence, and the practice was to embed house posts directly into the usually damp soil. The Kona district of Hawaii Island, on the other hand, abounds with loose rock, and dry-masonry platforms were plentiful.

Dry-masonry house platforms permitted rain water to drain away from post ends, and air to enter. Dry rot was kept to a minimum in this situation. Unworked basalt boulders from one-half the size of a human head up to rocks weighing many tons were interlocked in good dry-masonry practice to form the outer walls of the house platforms. Usually the platforms were rectangular in plan, with distinct corners. Outer faces of well-built dry-masonry platforms had batter, an inward slope backward and upward. The space between the walls formed a box open at the top.

This was filled with rubble of unworked basalt rocks, of one-half the size of a human head down to chips and bits. Sometimes, if the material was at hand, coral fragments were mixed with the basalt rubble for the fill. The upper surface of the platform was finished with the laying of a lumpy, but level, floor of unworked basalt rocks.[6] The one-half human head size designation is an arbitrary division between rocks suitable for wall use and those used for fill.

Foundations of houses built upon temple platforms were usually one stone higher than the overall and larger temple platforms. In this case post ends probably extended through the low house platform and into the temple platform for deep embedment.[7] Details of embedment are discussed in Chapter III under "House Posts, Planting."

To purify a site, to remove any bitterness of occult nature, to neutralize any evil which lurked in the ground, or to "sweeten" a site, to ward off all unforeseen misfortunes or accidents, as for a chief's house or temple (a process called ho'omanalo in Hawaiian), pork, awa, a red fish, a sand crab, a makaloa (unknown if sedge, shellfish or seaweed was meant) and/or other things were buried at the site, probably with ceremony and before the platform was commenced (Waialeale 1870:2).

House Floors

A floor could be the natural surface of the lava, soil, sand or the finished surface of platform on which the house

was built. A more finely-finished floor could be made within and between the house posts by filling this area with a layer of soil or small pebbles to sufficient depth to cover any lumps or unevenness. Such a layer permitted water from leaks or spills to percolate away. Small, waterworn pebbles of basalt and/or coral were preferred for the house floor.

House floors were usually covered in whole or part with hay, a cover which was disposable and easily replaced. On top of the hay, mats were spread for sleeping or sitting. Mats could be spread, of course, directly on top of the basic surface.

Interior fireplaces were built into some floors (Samwell 1967:1163; Ellis 1827:204, 207; Emory 1924:41-42; Emory, et al. 1959:12 and Fig. 12), but sufficient data have not yet been collected and studied to generalize. In early historic times, bodies were buried within the existing foundation by some families.[8]

House Timbers

In the walled houses, especially those built for chiefs and temples, there were rules to follow in the selection of material for principal timbers. All house posts were to be of the same wood. Rafters could be of a different wood. Both Kamakau (1870:137, 138) and Hooili (1919:642) specify this. Their list would include for house-posts all vertical timbers whose bases were deeply embedded in the foundation, specifically wall posts, ridge posts and

TABLE I

WOOD FOR HOUSE TIMBERS

Hawaiian Name	Scientific Name	Specified Uses	References
A'ali'i	Dodonaea		Malo 1951; Kamakau 1870:134
'ahakea	Bobea	Door frame	Kamakau 1870:144
Ha'a (Hame)	Antidesma		Kamakau 1870:134
Hāmau ('ohi'a hāmau)	Metrosideros macropus	same as ʻohi'a	Kamakau 1961:203 Kamakau 1870:134 Pukui and Elbert 1957:184
Kauila	Alphitonia ponderosa, or Columbrina oppositifolia	Temple posts and rafters	Ii 1959:138
Koai'e	Acacia koaia		Malo 1951:21 Kamakau 1870:138
Kōlea	Myrsine Suttonia		Malo 1951:21
Lama	Diospyros (Maba)	Temple posts, rafters, purlins, temple images, image stockades	Malo 1951:21 Kamakau 1870:134 Kamakau 1964:97 Kamakau 1961:203 Ii 1959:39, 41
Māmane	Sophora chrysophylla		Kamakau 1870:134

TABLE I (continued) WOOD FOR HOUSE TIMBERS

Hawaiian Name	Scientific Name	Specified Uses	References
Maua	Flacourtia xylosma	Boards (for door panels?)	Malo 1951:22
Milo	Thespesia populnea		Malo 1951:22
Naio	Myoporum sandwicense		Kamakau 1870:138 G. Judd 1830a
Nīoi	Eugenia sp.	Temple door frames, temple appurtenances	Kamakau 1961:2, 160 Neal 1965:635
'ohi'a	Metrosideros macropus	Temple timber, temple images, temple stockades	Kamakau 1870:134 Kamakau 1961:2, 14, 200, 203, 210 Malo 1951:20 Ii 1959:42, 43
Olopua (pua)	Osmanthus sandwicensis		Malo 1951:22 Kamakau 1870:134
Pā'ihi ('ohi'a-hā)	Eugenia sp.		Malo 1951:21
Uhiuhi	Mezoneuron kauaiense		Kamakau 1870:138 Kamakau 1961:203
'ulu	Artocarpus incisus	Door frame	Malo 1951:21 Kamakau 1870:144

TABLE I (continued) WOOD FOR HOUSE TIMBERS

Hawaiian Name	Scientific Name	Specified Uses	References
Wauke	Broussoneta papyrifers*	Thatch purlins (?)**	Malo 1951:22

* Scientific names and alternate Hawaiian names from Pukui and Elbert 1957.

** Wood specified for temple use could also be used for houses of high chiefs. Wood with unspecified uses available to commoners and lower chiefs. Doors which required frames and panels used only on temples, high chief's houses.

gable end posts. It is believed that the four key horizontal members--two wall plates and two ridge poles--were also included. Wall plates were integral parts of the wall assembly. The ridge poles were closely associated with the religiously significant ridge posts.

All rafters were also to be made of one kind of wood. Apparently, the entire frame could be of one kind of wood without offending the gods, but if more than one wood was used, all house posts should be of one kind, and all rafters could be of a different kind of wood. It is not clear what wood the thatch network should match, if any, or if it could be made of a different wood entirely.

Observance of these rules foretold good fortune for the occupants of the house. There may also be unsuspected practical reasons. Co-efficient of expansion may be involved. Table I lists, in Western alphabetical order, Hawaiian names suitable for house timbers. The table includes woods for house posts, wall plates, ridges, doors, rafters and thatch network.

Timbers intended for temples and high chiefs' houses were selected with perfection in mind. Absence of holes, bumps and bends was desired (Kamakau 1870:137-138; Ellis 1827:314). These imperfections could adversely affect the fortunes of the chief for whom the house was built. This search for perfection in house timbers probably was reserved only for one or a few units of a high chief's housing

complex, probably the highest one or ones. Storehouses and other utility buildings probably were built of non-sacred woods, but probably of the best quality available.

Bark was peeled from timber chosen for temples and chiefs' houses, again except for utility buildings (Kamakau 1870:134; Ellis 1827:314). Experience in the forests above Honaunau, Kona, indicates that bark is removed most easily as soon as the tree is felled, while it is still green. Immersion of timbers in fresh, brackish or ocean water, such as was done at Honaunau and at Makapuu, Oahu, will prolong the peelability of bark for months, as well as keep the wood workable. The limit appears to be nine months. A well-dried log is difficult to peel or work with hand tools; this is especially true of Hawaiian hard woods. To keep them workable, timbers may be stored for months in brackish fish ponds and tidal pools. Logs and sticks of 'ohi'a submerge and stay under water of their own weight.

Cowboys and ranchhands of the Kona area, most of Hawaiian ancestry, use a hammer or a handy rock to loosen the bark of a green tree. It can be peeled readily after such beating (Personal knowledge). A rock alone or a hafted rock may have been used by the ancient Hawaiians. A modern short cut in peeling bark uses a Japanese-style sickle. In ancient times, bark probably was removed in the forest, and if the tree were extremely sacred, its bark was probably either buried or burned as part of the ritual,

such as for a tree selected for carving as the principal image of a temple.

Delivery of the selected timbers to the site for an important structure was a "formidable undertaking," as one missionary observed (Ellis 1827:317). Timbers were carried on shoulders or dragged over rough terrain for miles (Ellis 1827:313-314; Kamakau 1870:134). Logs to be carved for principal temple images, and timbers for the building of certain temples (such as for the circumcision of a ruling chief's male heir), were delivered under strict taboo conditions which affected all commoners and lesser chiefs along the route and in the vicinity. Death was dealt to any unauthorized viewer or any noisemaker (Kelou Kamakau 1917: V, 8; Haleole 1919:80-82; Kamakau 1964:97). Obviously, such delivery processionals were occasions for commoners to seek the security of their houses.

Delivery routes, especially the direction of approach to the site, were considered auspicious only if the timber was moved from inland toward the sea (from mauka to makai) (Haleole 1919:8082).

House Thatch and Lining

In some houses there was no lining. In these, the "lining" was the backside of the thatch as seen from the inside behind the frame and thatch purlins. Slightly more sophisticated was a technique that offset and reversed (with heads aligned upwards) a thin layer of grass in the

thatch handfull which went next to the purlins (see Plate 12). This was done in the Bishop Museum's exhibit house (R. Apple 1970; Brigham 1908: Plate XXVII; Hiroa 1957: Fig. 68, p. 99). In an even more sophisticated technique the lining was sandwiched between the thatch purlins and the exterior thatch, and in some cases stitched to the purlins before the thatch was applied. In all of these techniques the thatch purlins, house posts and rafters were visible from the interior.

Other techniques hid the thatch purlins, and left the house posts and rafters visible. In one technique a lining was wrapped around the horizontal thatch purlins (Hiroa 1957:103-105), and served also as thatch (Ellis 1827:315). A thatch could also be added to this. A bundle of such leaves (see top, Plate 12) was used in one technique of ti leaf thatching. Another technique of ti leaf thatching, a bundle with tops crossed, served as both thatch and decorative lining (see Plate 11 and Fig. 20).

Table II presents, in Western alphabetical order, the modern common names, used in Hawaii, for thatching and/or lining materials.

The name pili is linked today with the specific grass Heteropogon contortus (Pukui and Elbert 1957:303). In historic and prehistoric times pili may have referred to more than one type of grass or long leafed thatch material. But pili, of whatever kind, was the preferred and usual

TABLE II

HOUSE THATCH AND LINING MATERIAL

Material	Hawaiian Names	Uses, Remarks	References
'ama'u fern fronds	lālā 'ama'u	Ridge and corner trim of temples, high chiefs' houses. See Figs. 25, 31, 32, 35, 36, 38, 50.	Kamakau 1870:135 Hooili 1919:646 Waialeale 1870:6 Ellis 1827:315 Byron 1828:120 Stewart 1830:367 Lyons 1945:125
Banana "bark" (?)	weo amaia	High Chiefs' houses.	Kamakau 1870:136
Banana leaves	lauhulu lau mai'a	Lining, thatch of lower chiefs' houses.	Waialeale 1870:6 Ellis 1827:315.
Banana trunk layers (sheaths)	pa'a'a mai'a	Lining, thatch, rain cap of temples, high chiefs' houses. See Figs. 28, 29, 30, 32.	Kamakau 1870:132, 139-140, 143 Kamakau 1961:238 Kamakau 1964:97, 135 Stewart 1828:138 G. Judd 1830a
Forest plant leaves	lau nahele	Temporary shelters of farmers, bird catchers. Ti leaves usually added to bind vines of kauna'oa (dodder) and 'uala (sweet potato) to frame. See Fig. 1.	Kamakau 1870:141 Waialeale 1870:6

TABLE II (continued) HOUSE THATCH AND LINING MATERIAL

Material	Hawaiian Names	Uses, Remarks	References
Grasses, sedges, bullrushes	pili maoli pu'upu'u pueo kawelu kiolohia 'aka'akai uki lule etc.	Bullrushes, 'aka'akai and the sedge 'uki used for lining; all used for thatch of both commoners' and chiefs' houses, perhaps some temples. See Figs. 23, 24, 25, Plate 12.	Kamakau 1870:132, 136, 139-141, 143 Kamakau 1961:138 Kamakau 1964:97 Malo 1951:23, 121, 159 Waialeale 1870:4, 6 Waiolani 1919:650 Menzies 1920:31-32, 34 Ellis 1827:315 Stewart 1828:138 Bingham 1847:116 Conde 1887:183-184 Jackson 1966:51-52
Koa bark	pa'a koa	Temporary forest shelters. See Plate 1 c.	Kamakau 1870:141
Koai'e leaves	lau koai'e	Temporary shelters	Kamakau 1870:141
Lama leaves	lau lama	Temple thatch	Kamakau 1964:97
Loulu palm leaves	lau loulu	Temple thatch	Malo 1951:159

TABLE II (continued) HOUSE THATCH AND LINING MATERIAL

Material	Hawaiian Names	Uses, Remarks	References
Pandanus leaf	lauhala ko'o i'o ko'o mu'o hala pu'awa pukani pililā'ele lā'ele pala lauhala pa'ilau'ula kī	Lining, thatch. A thatch probably added. Used by lesser chiefs and master artisans. This also applies to sugarcane leaves. See below. For illustrations of techniques see Hiroa 1957:103-104.	Kamakau 1870:141 Kamakau 1961:238 Waiolani 1919:650 Waialeale 1870:6 Bingham 1847:116 Ellis 1827:313, 315 G. Judd 1830a Stewart 1828:290 Stewart 1830:366-367
Sugarcane leaves	lau kō lau'ō lāko lā'ō	Lining, thatch. See note above	Kamakau 1870:132, 141 Kamakau 1961:238 Waialeale 1870:6 Waiolani 1919:650 Malo 1951:121 G. Judd 1830a Samwell 1967:1176 Stewart 1828:138 Bingham 1847:116 Bond 1927:128

TABLE II (continued) HOUSE THATCH AND LINING MATERIAL

Material	Hawaiian Names	Uses, Remarks	References
Ti leaves	lau ki lau'i pe'a lau'i lāki lā'i	Thatch in three known techniques covers thatch purlins to form lining. Probably used only on high chiefs' houses and temples. See Plates 11, 12; Figures 18, 19, 20; Hiroa 1957:103, 104 shows 1 technique, Plates 11, 12, other 2.	Kamakau 1870: 132, 136, 140-141 Kamakau 1961:238 Kamakau 1964:97 Ii 1959:58, 139 Malo 1951:121 Ellis 1827:153, 315 Lyons 1945:39 Bond 1927:128
Others			Kamakau 1870:132, 143 Pukui and Elbert 1957

thatch material in historic times (Kamakau 1870:134, 140; Ellis 1827:315). Among its advantages were: it could be harvested in quantity in a short time from a limited area; it took no care in handling or transportation other than to keep root ends faced in the same direction; once cut, it needed no other preparation and application was swift; it was reputed to take on a pleasing reddish color (which was not observed during National Park Service experiments with Heteropogon contortus in 1967); it gave a pleasant odor to a newly thatched house; and probably it lasted longer and shed less chaff than other grasses, sedges or bullrushes. Other grass-type materials may have been as handy to harvest, handle and apply, but apparently had disadvantages, perhaps early disintegration, rotting when wetted frequently, and/or high leakability.

Sugarcane and pandanus leaves were alike. While pandanus leaves took much preparation, their durability exceeded that of sugarcane. The nature of banana leaves permits them to be useful for only a short time and employing them perhaps was a display of conspicuous consumption by chiefs. As a lining, sandwiched between the thatch network and an exterior thatch, they might have lasted longer.

The crossed ti leaf thatch apparently was reserved for use on certain temples and high chief's houses. Preparation of the leaves for thatching was complicated, and gathering of a sufficient quantity would have been a major public works project.

Techniques of two types of ti leaf and one of pili thatching are shown in Plates 11 and 12, with discussion in the section on thatching, Chapter III.

Combinations of Material

Information on combinations of materials, such as what kind of wood went with what thatch and cordage, is scanty. A hale lau lama temple combined timbers, presumably thatch network, and thatch of lama wood and leaves, bound with 'ie cordage, but other thatch materials could be used besides lama leaves (Kamakau 1964:97). The Hale-o-Keawe temple at Honaunau Bay on the Island of Hawaii had a frame of kauila wood, the crossed ti leaf thatch, and cordage of unknown material (Ii 1959:58, 138-139). In 1830, houses were built for Christian missionaries at Waimea, Island of Hawaii, with these combinations: 'ohi'a frame with a ti leaf thatch; and naio frame, banana trunk layer lining, and pili thatch. Cordage types were not recorded (G. Judd 1830a). Some temples for the Kamehameha family, especially those dedicated to the war god Kukailimoku, had house timbers of lama wood and the crossed ti leaf thatch (Ii 1959:58).

An occasional structure, at least in historic times, had roof thatch which differed from that of the sides. In 1823, a touring Christian missionary noted that roof and sides were always thatched with the same material except sometimes when the sides were thatched with banana or ti leaves. He did not specify what was used on the

roofs (Ellis 1827:315). In 1845, a Christian church built at Kohala, Island of Hawaii, was thatched on its sides with bundles of ti leaves, and on the roof with sugarcane leaves. The type of ti leaf thatch is not clear (Bond 1927:128).

Cordage

Hawaiian cordage was a commodity desired by the early Western voyagers to Hawaii. In 1786, merchant ship captain Nathaniel Portlock noted that Hawaiian cordage was "perfectly well made . . . and much stronger than our lines of twice the size." He took aboard many balls of Hawaiian cordage, most being between a quarter and a half mile long (Portlock 1789:59). Starting with Cook in 1779, string and rope made in Hawaii enjoyed a good reputation until the art of manufacture died out (Cook 1967:489; Edgar 1967:489n; Vancouver 1967: III, 52; Kotzebue 1821: I, 294).

Vegetable fibers of coconut, bark, vine and grass (Bingham 1847:115; Stewart 1828:138, 149; Byron 1828:118) were prepared and braided into cord which were either round or rectangular in cross section. The flat, braided cordage (hilo 'o'io paki'i in Hawaiian) probably was preferred for decorative lashings on canoes and houses, while the round (milo maoli) served for other uses as well. There may have been some practical advantages to the shapes (Kamakau 1870: 137). Cordage came in different sizes, from threads to ropes (Hiroa 1957:37, 286, 290). The generic Hawaiian name for cordage was 'aha (Pukui and Elbert 1957:5).

In Western alphabetical order, the Hawaiian names for cordage materials are given in Table III.

Specimens of olonā cordage preserved in private collections in Hawaii are remarkably strong. No cordage is made today in Hawaii, although braided coconut fiber rope in both flat and round styles of various sizes may still be obtained from Polynesian islands in the South Pacific. (Personal knowledge.)

Nylon fishline of dark color for tying on thatch, and white nylon line of varying sizes for lashings, are considered practical and acceptable substitutes for olonā and other cordage by the National Park Service in the restoration of Hawaiian structures.

Personnel

Answers to the questions of how long and how many people it took to assemble a thatched Hawaiian house ready for use must take into account the size of house, its principal occupant and its purpose. Obviously a large, walled house with elaborate thatch for a chief or temple was of a more complex assembly than a roof-which-sits-on-the-ground structure for a commoner. And obviously, the number of men who worked on a house affected its assembly time.

Theoretically it would be possible for one man to assemble a large walled house, inefficient as such action would be. Most of his extra work would be eliminated if he

TABLE III

CORDAGE MATERIAL

Hawaiian Name	Scientific Name	Remarks	Reference
'ahu'awa	Cyperus javanicus	A sedge	Kamakau 1870:137
Hopue (hona) ('ōpuhi)	Urera sandwicensis	A tree, probably bark used	Malo 1951:22
Hau	Hibiscus tiliacous	A tree, bark used	Malo 1951:22 Hiroa 1957:290
'ie	Freycinetia arborea	A forest air plant, aerial roots used	Kamakau 1870:134, 137 Kamakau 1961:27, 80 Kamakau 1964:97 Ellis 1827:314, 317
Lolo niu	Cocos nucifera	Sheath of coconut tree	Kamakau 1870:143
Olonā	Touchardia latifolia	Forest shrub, bark used. Cordage stronger than hemp. Best of all Hawaiian cordage. A white product resulted	Kamakau 1961:239 Malo 1951:22 Hiroa 1957:37, 286, 290 Neal 1965:319-320
Pulu niu	Cocos nucifera	Fibers of coconut husk. Coir rope, sennit are common names	Kamakau 1870:137 Kamakau 1961:239 Ellis 1827:314, 315 Stewart 1828:138 Stewart 1830:30, 100

TABLE III (continued) CORDAGE MATERIAL

Hawaiian Name	Scientific Name	Remarks	Reference
'uki	Cladium sp.	A sedge	Hiroa 1957:102
Wauke	Broussonetia papyrifera	A tree, bark used	Hiroa 1957:290

had just one helper to fetch, to hold, to pass things aloft, or to work inside as the opposite member of a thatching pair. Likewise, there appears to be a theoretical limit to the number of men who could be efficiently employed, a limit which if it were exceeded by just one man would cause assembly time to be slowed because he would be in the way of his fellow workers.

Proper balance between numbers of workers and assembly time must have been achieved by the ancient Hawaiians, if it is to be believed that certain temple houses were erected and thatched between sunrise and sunset of one day (Kamakau 1961:97; Kelou Kamakau 1917: VI, 14). One recorded instance of fast assembly took two days. A thatched house 24 by 30 feet was built in Honolulu for shipwrecked sailors in 1806, on orders of Kamehameha the Great (Hirahara 1931). The only other known record of assembly time before 1819 was for two houses built for the storage of furs and equipment near Waimea Bay, Kauai Island. The houses were started on January 25, 1814. Sixty men were working by February 3, and by February 12, ninety men were employed. The first house was finished on February 25, and the second a few days later. Dimensions of the houses are unknown. These two houses may well be atypical of Hawaiian building in that they were built for foreigners at the command of Kauai's ruling chief, and perhaps were built to unusual specifications (Howay 1933:73). The record does give insight into

the numbers of men involved in assembly of large structures, and much of their time could have been spent in gathering material, since the command to build probably came unexpectedly.

After 1819, most records of assembly times come from Christian missionaries, and usually involved large thatched Hawaiian houses built for their use. Accuracy of their records is not questioned. But there is doubt that houses built for missionaries, or for other foreigners, in spite of the origin of the orders, would be built as efficiently, or as carefully, as the same structures built by Hawaiians for their traditional leaders. This doubt stems from the estimates that thatched houses built by Hawaiians for foreigners lasted less than half as long as houses built by Hawaiians for their chiefs. The estimate of durability was: for a chief, 7 to 10 years; for Hawaiians generally, 5 years; for foreigners, 2-1/2 years (Ellis 1827:318; Stewart 1828:176; Bond 1927:137). Low durability and high leakability of thatched houses built for foreigners may have been a factor in the desire of foreigners for more sturdy materials and different architecture and to employ Westerners in the building trades.

Missionary Ellis hinted at the administration, organization, division of labor, and proper balance of personnel to assembly time used by Hawaiians in 1823 to erect a house for a chief as a public works project. Ellis noted that the

Hawaiians arrived with the materials one morning and completed the frame that day. Thatching took the second day. On the third day the people returned to their lands. Ellis estimated that 100 men were employed on assembly of a chief's house; and wrote that different portions of the assembly had been allotted to people from different vicinities and that this assignment of jobs was based on the numbers of people available in each traditional land division (Ellis 1827: 317-318).

This assignment may also have been based on materials available, tradition, and experience of each district. Division of work and assignment of jobs to residents of various communities was also noted by others, but when used to construct Hawaiian-style houses for Christian missionaries, times spent in assembly appear to be measured in months rather than weeks or days (G. Judd 1830a; 1830b; B. Judd 1936; Stewart 1828:137, 149; Byron 1828:120).

Assembly time excludes time spent in gathering, preparing and transporting materials to the site. The time span in pre-assembly activities might involve months or years, while the assembly times might involve weeks or days. Both time spans could include periods spent in other activities such as fishing or planting, so that work in getting ready to assemble and in assembly could be intermittent.

Traditional Hawaiian culture assigned most house building activities to men. Women prepared cordage for use in construction and manufactured bark cloth for furnishings (Stewart 1828:108; Hiroa 1957:290; Stokes 1906:105-163). The less structurally sophisticated house of a commoner probably was built by just a few men of the family. Chiefs could call on specialists, especially for bonneting, to assist with their sophisticated structures (Ellis 1827:317).

Structural Measurements

The concept of measurement against a standard and the use of such terms as inches, feet and fathoms were introduced by Westerners. Ancient Hawaiians measured in relationship to parts of the human body.

An 'owā was half the width of a finger; a kīko'o was a span--the distance between thumb to end of index finger; and a poho, one half a span. A muku was the length, with arms extended to the sides, from the fingertips of one hand to the elbow of the opposite arm. An anana was the distance between tips of the longest fingers, with arms extended to the side (Pukui and Elberts 1957).

One Hawaiian's anana would obviously differ from another's. Measurements included in the structural details which follow are only approximations and usually are given in terms of the human body. Instructions given to workmen for the procurement of timber during field experiments were understood and suitable timbers were obtained when thickness

desired was expressed in terms of finger, arm and leg parts, and lengths in terms of lineal feet. Thus, a log desired for a wall plate might be specified: "as thick as your wrist at the log's butt end, and ten feet long."

Plate 5 shows comparative thickness of framing members. No two houses were the same. Each house was an individual entity. For instance, because of individually fitted joints and tailored length, a rafter could not be exchanged with another rafter of the same house, nor with a rafter of another house. There were no interchangeable parts, nor mass-production tolerance-standards.

NOTES TO CHAPTER II

1. The exception is the engraved published version of the Webber drawing widely distributed with editions of the Cook-King journals. It is entitled "An Offering before Capt. Cook, in the Sandwich Islands." It shows an apparent hipped structure with curved rafters. Such curved rafter structures may have had ends slightly inclined, but the framing need not have been anything else than pure gable. Curved rafters are discussed later. See Fig. 33.

   Most unreliable published versions are those of Louis Choris (1816), draftsman with the von Kotzebue expedition, which visited Hawaii in 1816-1817. They do not conform to other graphics or descriptions of the period. See Charlot (1958: Fig. 5). I have inspected the original water colors by Choris in the Honolulu Academy of Arts with their donor, Donald Angus.

   Figure 37 presents another example of artistic license applied to the Hawaiian scene. The hills in the background might be of Kealakekua Bay, four miles to the north. They certainly are not those of the area identified in the cut lines.

2. Cook's trade goods included adzes, axes, nails, chisels and saws when his ships sailed from England. Most of these were expended in the South Seas before the discovery of Hawaii (Beaglehole 1967:1492-1493; Cook 1967:252). See also Stokes 1931:12.

   For the Hawaiians' knowledge of and desire for iron, and the trade of the first Cook visit to Hawaii, see Cook 1967:264, 268; Samwell 1967:1083; 1084; Clerke 1967:265n, 269n; King 1967:285n; Edgar 1967:285n; Portlock 1967:285n-286n; Williamson 1967:1347; Burney 1967:538n; and Ledyard 1963:67, 82.

3. Samwell 1967:1140-1141. Other mentions of uses of the forges fall outside the Hawaiian periods (Edgar 1967:702; Clerke 1967:1319).

   For the incident of the anchor damage, see Cook 1967: 29; Edgar 1967:29n; Anderson 1967:768.

4. Beaglehole 1967:268; King 1967:557.

   For iron trade and use in Hawaii during Cook's second visit, see Samwell 1967:1151, 1152, 1154, 1161; 1162, 1170, 1182, 1186, 1225; Burney 1967:626n; Cook 1967: 474-475; Clerke 1967:475, 532n, 595, 702; King 1967: 497, 498, 501, 515, 521, 531, 557; Edgar 1967:1395.

5. Campbell 1967:144. For later value and use of iron tools in Hawaii, see Vancouver 1967: II, 52; Menzies 1920:177; Ellis 1827:318; Lyons 1945:72; Malo 1951:51; Kotzebue: II, 194.

6. Based on surface observations of house platforms in Puna, Ka'u and Kona districts of the Island of Hawaii, some of them excavated by professional archaeological teams under supervision of Apple; on surface inspection of platforms on Islands of Maui, Lanai, Molokai, Oahu and Kauai; during the period 1961 through 1968; and on the repair and restoration of platforms at the City of Refuge National Historic Park 1963-1967. Similar platforms are found, some in use, in Polynesian Islands of the South Pacific (Personal observation).

7. Based on surface observations of temple platforms associated with temples on all islands except Niihau. The nature of the basalt boulders, rubble fill, and house floors makes identification of post holes in dry-masonry platforms difficult (Personal observation).

8. Cook 1967:283, 598; Samwell 1967:1176; Ellis 1827:174, 204, 207, 314, 316, 327-328; Stewart 1828:149; Conde 1887:173; Brigham 1908:90; Emory 1924:41, 43; Emory, et al. 1959: I, 112, IV, f; Emory, et al. 1965:33, Fig. 12.

CHAPTER III

ASSEMBLY OF HAWAIIAN THATCHED HOUSES

Order of Erection

Back before front. This is the basic rule. Hawaiians believed that bad luck visited house or occupant if front walls posts were put up before those for the back, or if thatch purlins went on the front side before the back. The Hawaiian technical writers Hooili (1919:642-646), Kamakau (1870:134-138), Waialeale (1870:1-4), and Waolani (1919:648-650) prescribed the back-first, front-next order. Malo (1951:119-121) stated that posts for one wall went up before posts for the other wall. One Western observer, Ellis, also noted that posts for one wall went up first, but did not specify which wall (1827:313-318).

Accounts by other Western observers who saw Hawaiian thatched houses being built, such as Corney (1896:90-91), Stewart (1830:188) and Bingham (1847:115-116), agree with Ellis and with the Hawaiian informants as to order of erection. There are some differences as to sequence among the Hawaiian sources, but all would complete the steps with the same finished product. Western sources condense the assembly and lump together in single statements such things as the planting of wall posts. But the Hawaiian technical writers were more detailed, and some started the descriptions of post installation by noting that the two back corner

posts were planted first. None of the sources prepared a how-to-do-it guide, but described how it was done in varying degrees of detail.

Before assembly begins, site, size and orientation of the structure have been decided. All necessary materials have been prepared and stockpiled at the site (Ellis 1827: 317; Kamakau 1870:134). Detailed order of assembly, which in field experiments proved workable, follows.

This assembly sequence is for a large walled house. Steps would be omitted for assembly of a smaller walled house, such as the elimination of the diagonal bracing. Commoners' houses--about pup tent size and without walls--would start assembly with the planting of ridge posts, or with whatever substituted for them (see Fig. 22, Plate 1-h), and would omit obvious steps like gable ends posts and lining. Any dry-masonry rock platform is more efficiently built piecemeal as posts are planted, but post holes may be opened up in a previously built platform. Both methods were used in the experimental archaeology. Items marked with an asterisk (*) are not mentioned in the sources, or are only implied, and were added after full-scale field experiments proved that they were needed. (See Plates 3, 4, 5, 6.)

PLAN LAYOUT

site leveled and prepared.
posts selected and laid out.
back corner posts planted.
front corner posts planted.
alignment cords stretched.

WALL ASSEMBLY

back wall posts planted.
back wall plate inserted,
lashed to posts.
front wall posts planted.
front wall plate inserted,
lashed to posts.

INTERIOR SCAFFOLD ASSEMBLY

interior scaffold erected,
lashed, self-standing.

MAIN RIDGE ASSEMBLY

ridge posts planted.
center post placed.
main ridge pole fitted,
lashed to posts.

*waterworn pebbles or soil for floor covering most conveniently stockpiled under interior scaffold at this point.

RAFTER ASSEMBLY

by rafter pairs,
back rafter first.
back rafter up, bottom joint cut.
front rafter up, bottom joint cut.
rafter tops cut.
rafter bottoms lashed.
rafter tops lashed.
upper ridge pole laid,
lashed to main ridge.

GABLE ENDS ASSEMBLY

gable end posts up and measured,
down and cut, planted and fitted,
lashed to end rafters.

*platform, if any, accreted to completion.

DIAGONAL BRACING ASSEMBLY

timbers up, lashed to frame.

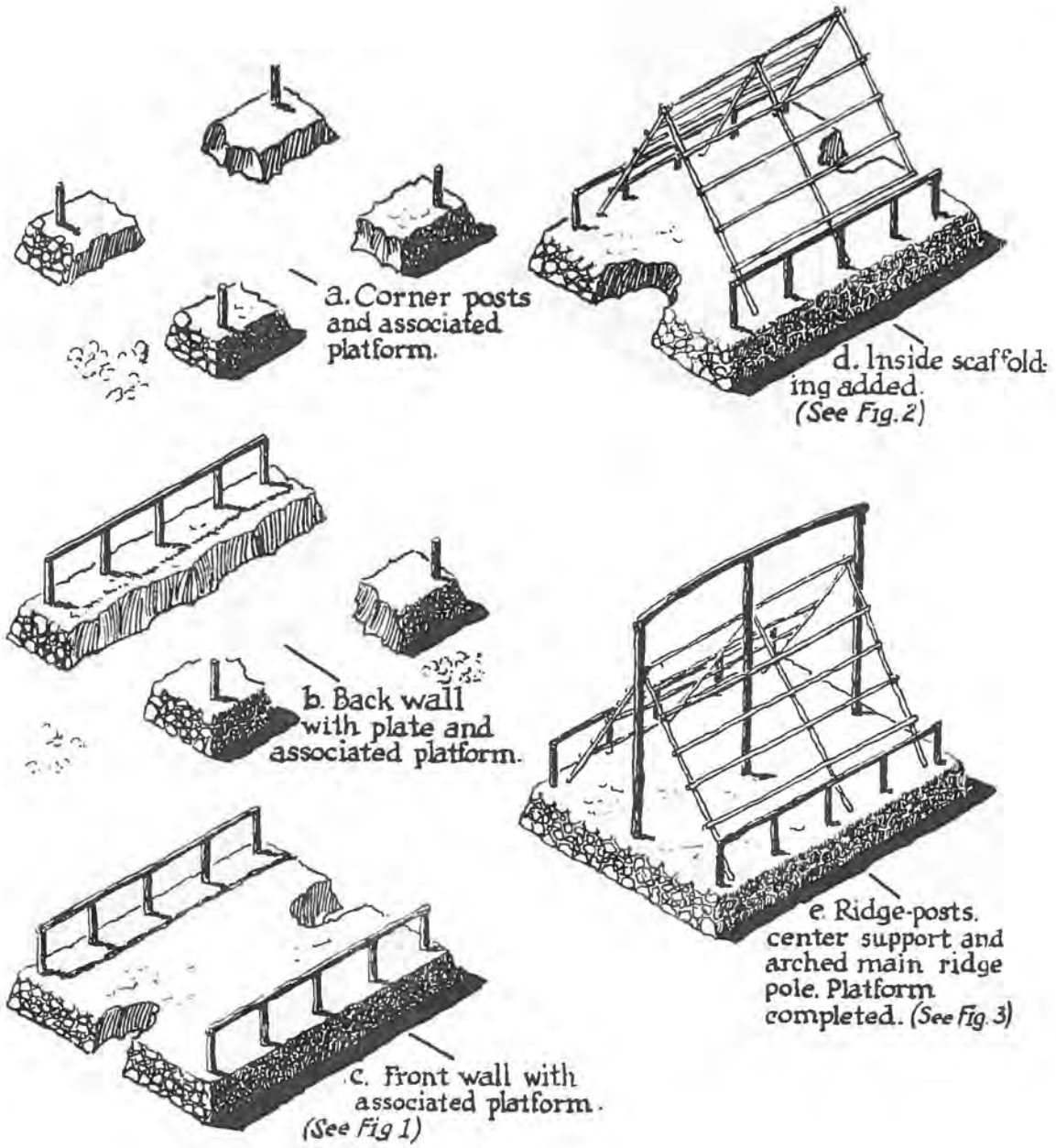
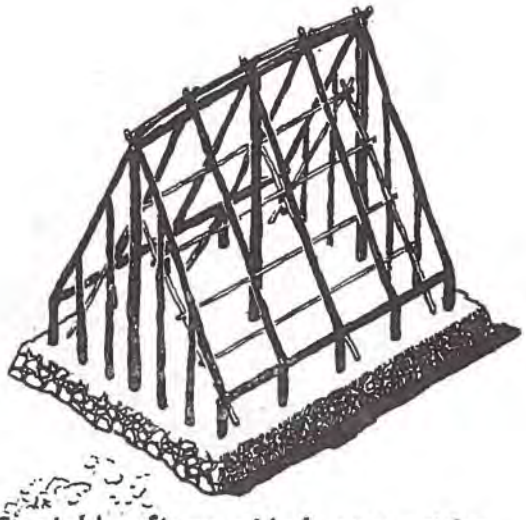
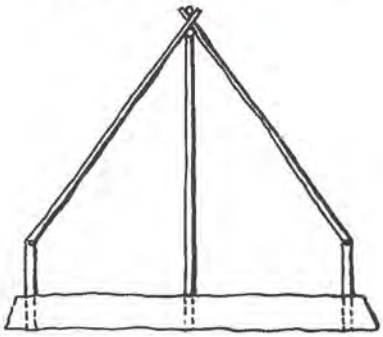


PLATE 3.

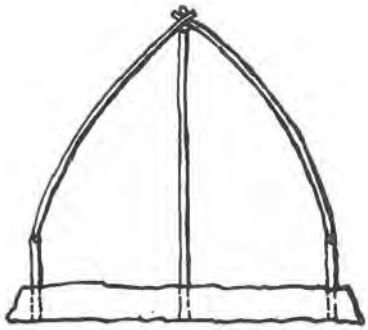
HAWAIIAN WALLED THATCHED HOUSE
ORDER OF ERECTION, PART 1.



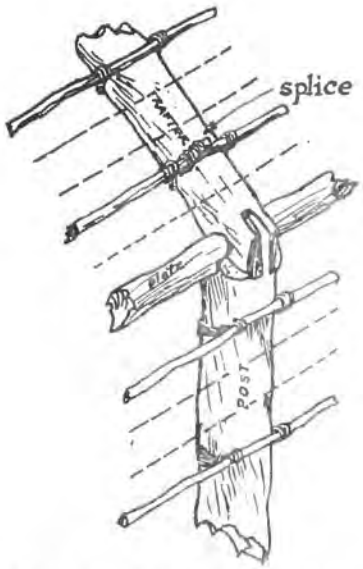
f. Straight rafters added - one set for each pair of opposite wall posts. End posts added.



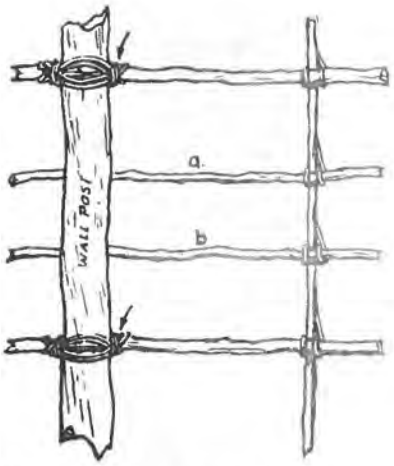
g. Section through bent - straight rafters.



h. Section through bent - curved rafters.



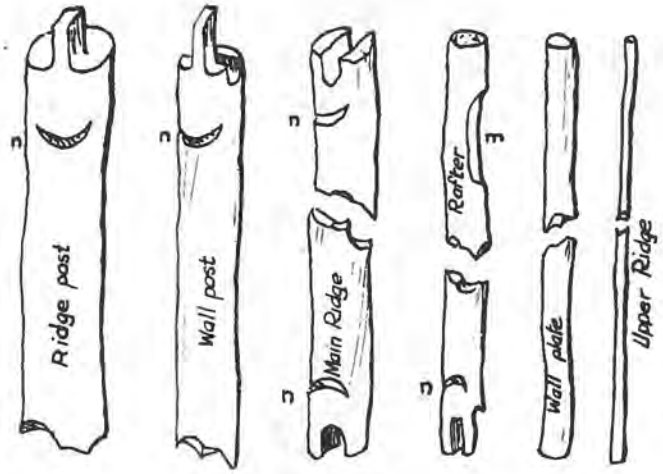
i. Addition of fixed thatch network. (See Figs 4 and 5) Dotted lines indicate position of floating network.



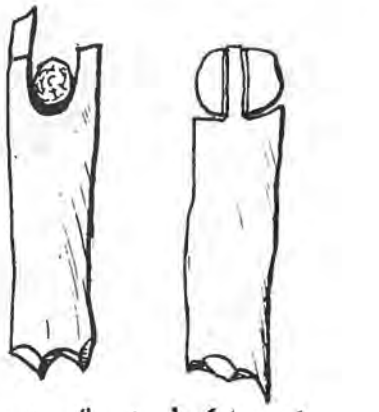
j. Addition of floating network, inside view - arrows mark fixed purlins, a and b mark floating purlins. (See Fig 6)

PLATE 4.

HAWAIIAN WALLED THATCHED HOUSE
ORDER OF ERECTION, PART 2.

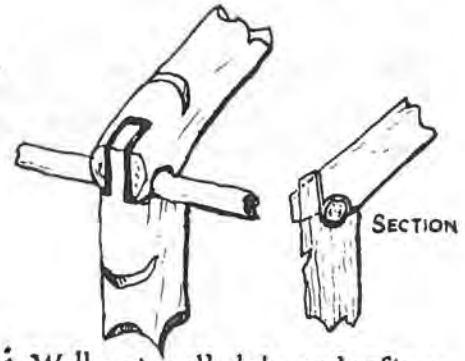


Comparative Thickness of framing members.
n - lashing notch - m - mesh notch.

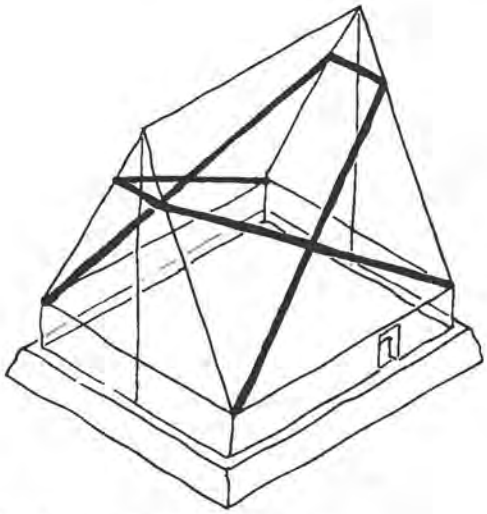


g. Joint, wall post and wall plate (See Fig. 7)

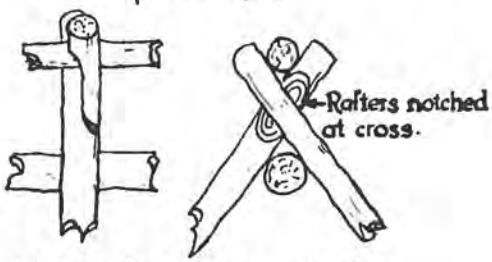
h. Joint, ridge post and ridge pole (See Figs. 8 & 14)



i. Wall post, wall plate and rafter. (See Fig. 7)

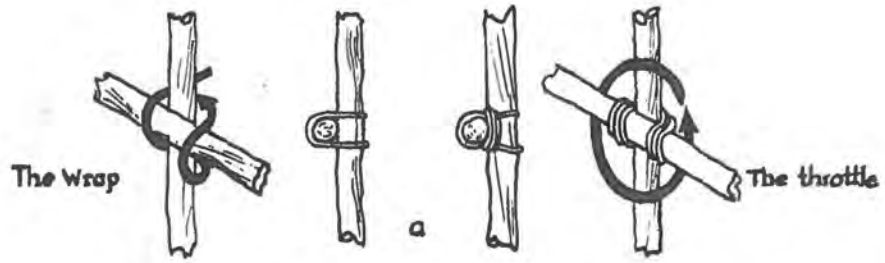


k. Large walled house - diagonal bracing of roof. (heavy lines, See Figs. 10-18)



J. Joint, rafter pairs and ridges (See Fig. 9)

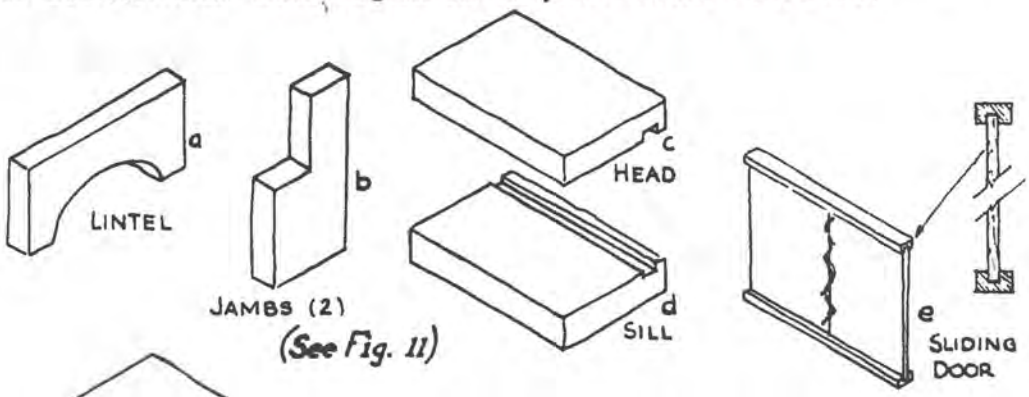
PLATE 5.
HAWAIIAN WALLED THATCHED HOUSE
FRAME DETAILS

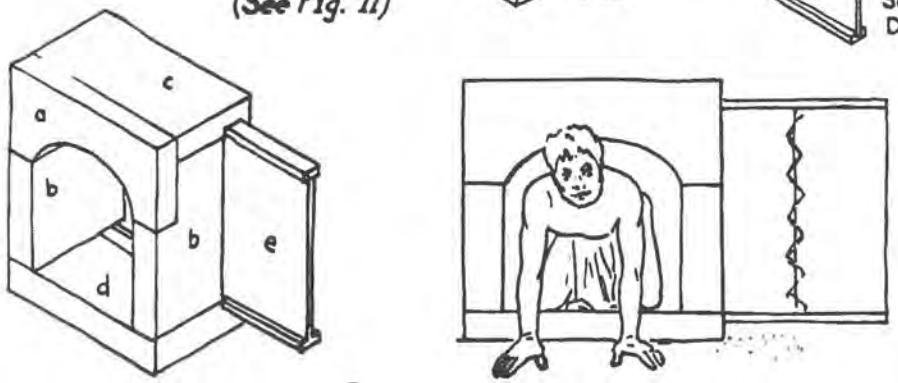


a. (best, safest) and b. (simpler) lashings for scaffolding and temporary poles.



Note: Lashings start with encirclement of one pole; the cord is tied to itself to form a tight loop around the pole. Three complete turns for the wrap and three for the throttle are adequate. Lashings end with a tie-up to the wrap. Tightness and neatness are essential. Turns adjoin and lie parallel with each other.





DOOR ASSEMBLED

DETAILS OF DOOR

PLATE 6.

HAWAIIAN WALLED THATCHED HOUSE DETAILS OF DOOR, DETAILS OF SCAFFOLD LASHINGS.

THATCH NETWORKS ASSEMBLY

*any elaborate door assembly installed.
fixed network lashed to frame, bottom to top,
back first, then front, ends.
floating network sewed to fixed, top to bottom,
back first, then front, ends.
*exterior scaffold erected,
lashed to frame.

THATCH ASSEMBLY

lining, if any, sewed to purlins,
back first, then front, ends.
thatch applied to purlins, bottom to top,
back first, then front, ends.

FINISHING OPERATIONS

ridge area bonneted and braided OR rain cap
sewed to ridge area and fern trim sewed
over rain cap and down corners.
*interior scaffold removed.
*exterior scaffold removed.
*floor covering spread.
any unelaborate door assembly installed.
side thatch of doorway braided.
corners, if not fern-trimmed, braided.
furnishings installed.
birth-of-house ceremony held.

It is not known exactly how the walled thatched Hawaiian house was assembled, but it is known the steps listed below will result in a functional product.

Layout

Layout as a process or beginning step in the assembly of a large walled house ended with the four corner posts planted. The four corner posts marked the corners of an inexact rectangle, and determined the width, length and height of the walls. Wall height had a relationship to the height of the ridge.

Between the time a high chief ordered a house built and the time the four corner posts stood, someone--perhaps the

chief himself or his kuhikuhipu'uone (architect)--made numerous decisions. They involved material, personnel and the dimensions of the house.

It was known, for instance, how many posts would form each side, how high the wall plates would be above the platform, how deep the posts would be buried, and how high would be the main ridge. Probably the architect planned to lay out the length of each side and the width of the ends by use of his own iwilei, which was the distance from his collar bone to tip of his middle finger (Pukui and Elbert 1957:98). This distance is in agreement with estimates for the spacing of house posts in Ellis (1827:314) and Stewart (1828:137) and indicates about one yard from center to center of posts. Emory (personal communication) believes that house dimensions were approximations of multiples of three feet.

Wall heights always appeared to be much less than half of ridge height. Early illustrations indicate that many walls were between one quarter to one third of total building height. Different wall heights would change the pitch of the roof, if the ridge height remained constant. Steep roofs, i.e., low walls, appeared to be in the majority (Samwell 1967:1176).

Layout and Order of Erection, as with other parts of Chapter III, discuss the most complicated house, that of a large walled thatched house, so as to include the greatest number of steps. Application to smaller structures may be inferred, but where a specific change or application is known, or an alternate technique is supplied, it is so labeled.

Before layout begins the site, size and orientation of the structure have been decided. All necessary materials have been gathered and stockpiled at the site. Timber has been selected for its perfection, the bark peeled and obvious projections--such as knots or stubs of branches--adzed off to smoothness. The site has been leveled, and perhaps blessed.

Kaawa (1865) says that before any posts are planted a fish is placed under where the "house post" will be. For fish, he specified either an āholehole or kole (Pukui and Elbert 1957:7, 149). Since there are a number of posts, it was not known which post was meant. However a synthesis of sources (Elbert 1959:205; Pukui and Elbert 1957:316, 317) which utilize the Hawaiian word pouamanu identifies this word as the one for the post designating place of human sacrifice and places it in the center of the house, the center prop. A recurring tradition, which has not yet been traced to its source, indicates that a human sacrifice was buried in the platforms of important structures. Under the center post may be the location, and Kaawa's statement may time its placement at the very beginning of assembly. A fish is a substitute for a human body (Pukui, personal communication).

Kamakau (1870:134) begins his description of the assembly with the sorting of posts by size, and adds that the holes are dug next and the two back corner posts set up. His words compress a complex process.

Post Selection

Posts for the walls were selected and laid near the spots where holes for them would be. Plate 5 shows the comparative thickness of framing members. Sources are silent as to special criteria, if any, for the corner posts. It seemed logical in field experiments to choose posts stouter than those selected for the medial wall positions. Corner posts also should be as straight as possible in order to establish the two vertical planes (or lines on the posts) where the sides and ends of the house will be. Wall, ridge and gable end posts need only one vertical line to fit into the plane which will be the side or end.

Even logs peeled of bark and with obvious projections adzed off are not giant machine-made dowels with perfect roundness and constant diameters throughout their entire lengths. There are tapers, twists, hollows, knots, and bulges in natural logs. Corner posts were selected for two relatively straight sides which occurred where they would establish the ends and sides of the house. Two small notches were made along the selected vertical sides with a chisel. Lashings of the fixed thatch network are tighter and better if the side is a narrow ridge which runs the length of the post. These lines were established only for that portion of the corner posts which would be above the platform. If the nature of the line turned bumpy or crooked

along the part to be buried this was ignored. Ancient Hawaiians may have used notches to mark the course of a line, a chalk-like sea urchin spine, or charcoal. The purpose of the approximately straight vertical lines was to facilitate the installation of the fixed thatch network. Experience showed that posts or rafters with much disproportion along the lines which the horizontal purlins spanned made the purlins weave in or out of the plane. When thatch was applied it bulged or sank in accordingly. In several cases the purlins could not be made to bend sufficiently to meet the posts, and lashings were imperfect. It became evident that early steps in construction affected the final product.

Total length of each post must include that portion above the platform and that portion to be buried. Since posts provide the principal support of the house and during assembly support men working aloft, their deep embedment into dry-masonry platform or in the ground itself is essential for even a house with a low wall plate of perhaps three or four feet height. Embedment of wall posts on the restored Hale-o-Keawe, which has a seven foot high wall plate averaged about four feet. In this case, each wall post was more than eleven feet in length before fitting. Diameters of the restored temple's posts were about as thick as a big man's calf. Some, such as corner posts and ridge posts, tended toward the thickness of a thigh. These

were thick posts for a large house. Posts for smaller houses would be in proportion.

In early experiments, posts were planted, their tops were cut to a uniform height and the joints at their tops adzed for wall plates while the posts were standing. The job was accomplished but involved much work and effort. Scaffolding had to be built to permit the men to swing adzes at the tops from above. Repeated adz impacts loosened posts in holes. The only way to adjust the relationship of man to post top was to move the scaffolding. This method proved to be both awkward and unnecessary.

The National Park Service solution was to accomplish the preliminary fitting and joint making of posts while the members of an entire wall assembly (corner posts, intermediate posts and wall plate) were laid out on the platform in a horizontal plane. Base ends of each post were adjacent to the corresponding hole location. Marks were made on each post to indicate the place where the post would emerge from the platform when the post was installed. This permitted measurements to rough-match post with hole-depth and to rough-fit the top of a post to the wall plate.

It might appear possible to assemble the entire wall in horizontal position, then raise the pre-fabricated and lashed unit and insert it in the holes. Such a procedure not only ignores the "corner posts first" practice of the Hawaiians but overlooks the nature of the materials and

tools. Even fine metal adzes do not cut a log in two with the precision of a saw, and rocks do not come in standard sizes. Prefabrication could only be rough; final fitting and joining was best done in place.

Back Corner Posts, Preliminaries

Posts selected to be the back corner posts were laid parallel and with their thicker bases pointing to the spots selected for their holes. Posts were laid with their top ends toward what would become the interior of the house. This placed the marked line that would form the plane of the back wall in horizontal position on top of the horizontal post; and the marked line which would form the plane of the end wall in a horizontal position along the post to the outside. A post so placed lay flat and had only to be raised upright to be in final position. Posts were laid with their tops toward the inside of the house because many platforms did not have sufficient room for layout outside the house area. Material, especially rocks, was generally stockpiled just outside the wall lines. The interior was used for the working area. The wall plate was laid on the ground or platform just above the tops of the poles.

Approximate hole depth having been decided, a stick to be used for measuring was marked with this distance. Holes for the corner posts were opened up in an existing platform, or base rocks were set up in proper position if

the platform was to be built concurrently with post-installation. Base rocks and holes are discussed in more detail in "post planting," below.

In an existing platform, the holes for corner posts were excavated to the approximate depth desired. The excavator looked for a firm foundation at a level which would put the top of the base rock at approximately the depth required.

In a platform to be accreted, the elevation of the finished platform was known and included sufficient height to embed the posts. Base rocks were set up and fixed at corner locations, at an elevation which would insure the proper amount of embedment below the finished platform's surface. On sloping ground the reference point for the placement of base rocks would be the planned elevation of the finished surface. The base rocks would be set up at approximately the same distance below the planned surface.

When a base rock for a corner post was firmly fixed, the distance from the base rock to the top of the platform or ground was measured with a stick and this measurement was transferred to the corresponding corner post.

But before this distance was marked on the corner post, its butt end was examined to insure that it was properly shaped. A properly adz-finished butt resembled a broken pencil point. There was no sharp point to collapse or to slide about on the base rock. Additional adzing may be

performed to truncate the post end so that it can rest on the rock. A chain saw is useful for this cut in modern restorations.

The actual hole-depth measurement is transferred to the corner post from the post's butt end along its length to establish the ground line. The ground line is the approximate line around the circumference of the post where the post emerges from the platform (or earth). The ground line became the reference for measurement to indicate where the top of the wall plate would be. If the plate's top was to be four feet above the ground, then a mark was made four feet along the post toward its top from the ground line.

Wall Plates

A wall plate log, as most logs are, is thicker at the butt, tapers toward the top end, and along its length has twists, hollows, knots and bulges. These were trimmed with an adz to minimize them. The wall plate was at least a foot or more longer than the distance from corner post to corner post. Visual inspection of the plate sought the straightest side to be its top. When found, the line was marked for the top. The marks were essential to insure that the top would always be in the same position as each post is fitted around the appropriate place on the wall plate. The marks were best made on the ends of the wall plate, where the men who handle it during numerous trial fittings

could see them and insure that the plate was turned so that the marks were always in top position.

Fitting the wall plate to the corner posts was necessary to insure that the top of the tapered plate was level. Hawaiians did not have spirit levels, but probably used the horizon as their reference in fitting the plate (see Fig. 43). The taper of the wall plate meant that its butt end required a deeper seating within the top of one corner post than did its top end in the other.

Joint: Wall Post to Wall Plate

This joint, for all corner and intermediate wall posts, is given a rough fitting while the post is in its horizontal position. To facilitate working, posts were elevated on sawhorses (see Fig. 41), but still kept horizontal. Four horses were needed, two for each corner post. The joint is illustrated on Plate 5, g. Inner and outer lips were cut when the wall post was shaped and then were left alone and not worked further. Their working awaited the rafters later in the assembly. Figures 12, 41 and 44 show the joint with the lips unworked and the wall plate inserted.

At this preliminary fitting of the back corner posts, the hollowing with adz and chisel was concerned with obtaining a slot of sufficient width to admit the plate; and of sufficient depth to bring the top of the plate almost down to the pre-marked line on the corner post. It should be noted that the sides of the slot extended beyond and

above the top of the plate, leaving lips for future use.

National Park Service adzmen cut the slot when they began to make the joints: wall post to wall plate, but cut it only down to the level where the top of the plate was about two inches above the mark. They cut away this last two inches during final fitting while the posts were fixed in their holes. This removal of wood was done while the workers stood with arms upraised and was arduous. Two slots were made in this manner. For the rest of the slots, the cuts made while the posts were in horizontal positions were continued down to within about a quarter of an inch of the desired depth.

Adz and chisel are effective tools with which to make the slots. One adzman asked to use a chain saw. He was experienced in its use. After several attempts, he voluntarily returned to adz and chisel to complete the slots.

Post Planting

At the bottom of each post hole was placed a base rock, firmly fixed in position, to support the butt end of the post. An ideal base rock had a flat central area on which the truncated butt sat, with a downward slope on the rock's upper surface away from the higher flat area. This convexity permitted rainwater to drain away from the butt. Few ideal base rocks were found.

There were no such things as standard rocks or standard holes. Matching posts to holes involved options. One

option was to trim the bottom of the post; another was to adjust the elevation of the base rock.

In accreted platforms, adjustments to the base rock usually can be made. Another base rock may be substituted, or smaller rock shims may be inserted or removed to raise or lower the base rock.

In existing platforms, or in earth, adjustments to the base rock inside a hole may force a man to work upside down in confined space and dim light. Good masonry practice dictates that in existing dry-masonry platforms holes should be only as large as necessary. Experience indicates that excessive disturbance of the interior of typical platforms--especially if composed of rubble fill--may cause cave-ins. The less disturbance of a hole opened up in an existing platform the better. The preferred option in this situation is to trim away the base of the pole, if that is the adjustment indicated.

It is obvious that post butts can be trimmed, but cannot be added to. If adjustment is needed to raise a post's top, the bottom of a hole must be raised by at least the desired distance. If raised more than the desired amount, then the post's butt can be trimmed.

Fitting and matching of posts and holes is a process of trial and error, of much measuring, of putting posts in and taking them out, and perhaps vexation.

Practical limits for the positioning of base rocks were up to six inches above or below the desired point, a range of 12 inches. With the desired point known, even a man with his head hanging down inside a dim hole can use his hand to check if a newly established base rock is within proper range of the desired position. In Hawaiian terms, allowance above or below the desired elevation should be less than a kīko'o (span), the distance between the thumb and the end of the index finger.

When the base rock was established and firm, and preliminary fitting of the post has been completed, the time has come to fix the deeply embedded post fast within the hole. Fixing posts in holes is described by Waolani (1919:648). Hooili (1919:642) added the suggestion that excavated materials from a hole be thrown into the house to be used eventually as part of the floor. Waolani recommended that small stones and dirt be tamped in around the pole. This logical and widely-known method was used with all posts planted. Each post was hand-held in position while rocks were dropped in to secure its butt and hold it on top of the base rock. Rocks were then struck with the lower end of an iron bar to wedge them around the butt of the post. Smaller rocks, and/or sand or dirt were dropped in to fill interstices among the larger rocks and secure them further. This filling material also was tamped in place. Filling the hole in this manner continued toward

the surface, each layer being packed tight. Close to the surface special care was taken to insure firmness of fixation so that the top of the post could not move in any sidewise direction. The platform surface was finished immediately in order to provide good footing for workmen. Holes in earth or sand were filled with tamped rocks and fill material up to ground level. Each post was tightly hand-held in the desired position while the hole was filled and tamped.

An <u>'ō'ō</u> (digging stick) probably was used as a tamper by the ancient Hawaiians, who lacked iron bars. Such a wooden tool did not leave scars and marks on tamped rocks. A metal bar did.

To build up an accreted platform around a post which rested on a base rock, ordinary rocks were laid in good dry-masonry fashion around the post almost up to surface height. The post was built into the platform. Sufficient platform must be built in order to support the post. The surface area around the post was finished with flat rocks, if that was to be the style of the platform surface. A complete platform portion was built around the post.

Back Corner Posts, Final Preliminary

The two back corner posts had been rough-fitted to the back wall plate. The corner posts had been rough-fitted to their base rocks. The wall plate had been in and out of its slots; posts had been in and out of their holes. Finally

the architect felt that the top of the plate would be approximately level with the horizon if the posts were fixed in place.

About the last time the corner posts were taken out of their holes and laid in horizontal position, each corner post received a lashing notch which eventually served the joint: wall post to plate.

Lashing Notches

All joints were lashed when the component parts of the house were in position. To facilitate the lashing and its holding power, lashing notches were cut in most house timbers. Lashing notches were slightly undercut toward the joint they served. Minor undercutting was within the capabilities of stone adzes.

In the corner posts, lines which were to form the vertical plane of the back wall were on top of the posts while they rested on the sawhorses. The plate was again inserted. The notch's position was found on one corner post by making the first turn of the lashing: wall post to plate (see Plate 7). The notch would be cut where the cord lay across the outside of the post. The curved line of the cord was marked with sea urchin spine "chalk," or perhaps with charcoal. The cord was removed and the notch was cut with an adz or chisel. The other corner post received a notch in the same manner. Because of the taper of the wall plate, both notches were not exactly the same distance

below the top of the plate. The two notches in the corner posts later served to mark the location of lashing notches in the medial wall posts.

As workmen became experienced with lashing-notches, they no longer needed to make a wrap of the cord to mark a notch's location. Experience had trained their judgment. But for the notches for the lashings of wall posts to plates, it was necessary to follow the steps outlined to insure regular and decorative lashings on the inside of the wall posts. It was on the other timbers that lashing notches were cut without controls other than the adzman's judgment.

Wall post lashing notches are shown in Figures 12 and 26. Other figures and plates also show notches.

Back Corner Posts, Installation

In summary, the two back corner posts are selected for their vertical lines to form side and end planes; each has been rough-fit to its hole and a joint is cut to hold the wall plate approximately level with the horizon at a predetermined approximate distance above the ground or house platform; and each post receives a lashing notch. The wall plate has been selected and is longer than the span between the corner posts. It is unworked other than for the debarking and something of major surface irregularities. The straightest line from end to end of the wall plate is selected and marked for its top. A base rock has been firmly set to hold the butt end of each corner post at a depth

below the ground or house platform which would insure sufficient embedment of the post.

For installation, first one and then the other corner post was raised for the final time to vertical position, each butt rested on its base rock, and the post so turned that its marked vertical lines were in alignment with the side and end planes they would establish. The wall plate was inserted in the slots at the tops of the corner posts. The corner post holes were filled with tamped rock and smaller solid matter to fix the corner posts. While this was done the wall plate was in its inserted position in order to help the men hold the posts in proper position. As the hole filling reach the top, vertical alignment of the corner posts was again checked; minor adjustments could still be made by force and the help of good tamping technique. (See the section on "Post Planting," above.)

With back corner posts fixed in the platform or the ground, the level of the back wall plate was again checked with the horizon (see Fig. 43). If all the preliminary fitting had been done well, no fine-fitting was necessary. (Such expertise was never experienced during experimental archaeology.) The higher end of the wall plate was lowered through adz or chisel work on its supporting joint: wall post to wall plate, and the sides of the joint were enlarged if necessary to facilitate insertion and removal of the plate during the fittings of the intermediate back wall

posts. The wall plate was not lashed to the corner posts at this time. The protruding ends of the wall plate beyond the outsides of the back corner wall posts were not cut off at this time.

Front Corner Posts, Installation

The two front corner posts and their associated front wall plate were installed in the same manner as the back corner posts and plate. The front wall plate, however, was reversed so that its butt end was opposite the smaller top end of the back wall plate. One additional control was needed. This was to insure that the front wall plate was approximately the same height and parallel to the level back wall plate. If eye, front wall plate, back wall plate, and horizon were in general agreement, the plates were in proper position. Plate 3a shows the four corner posts installed together with appropriate portions of an accreting dry-masonry platform.

Alignment Cords

With the four corners of the walls established by the more or less vertical straight lines of the four corner posts, an alignment cord was stretched between the bases above ground line; and another just above the notches of the two corner back posts. These cords served as guides for the installation of the intermediate wall posts. Similar cords were stretched between the two front corner posts when the

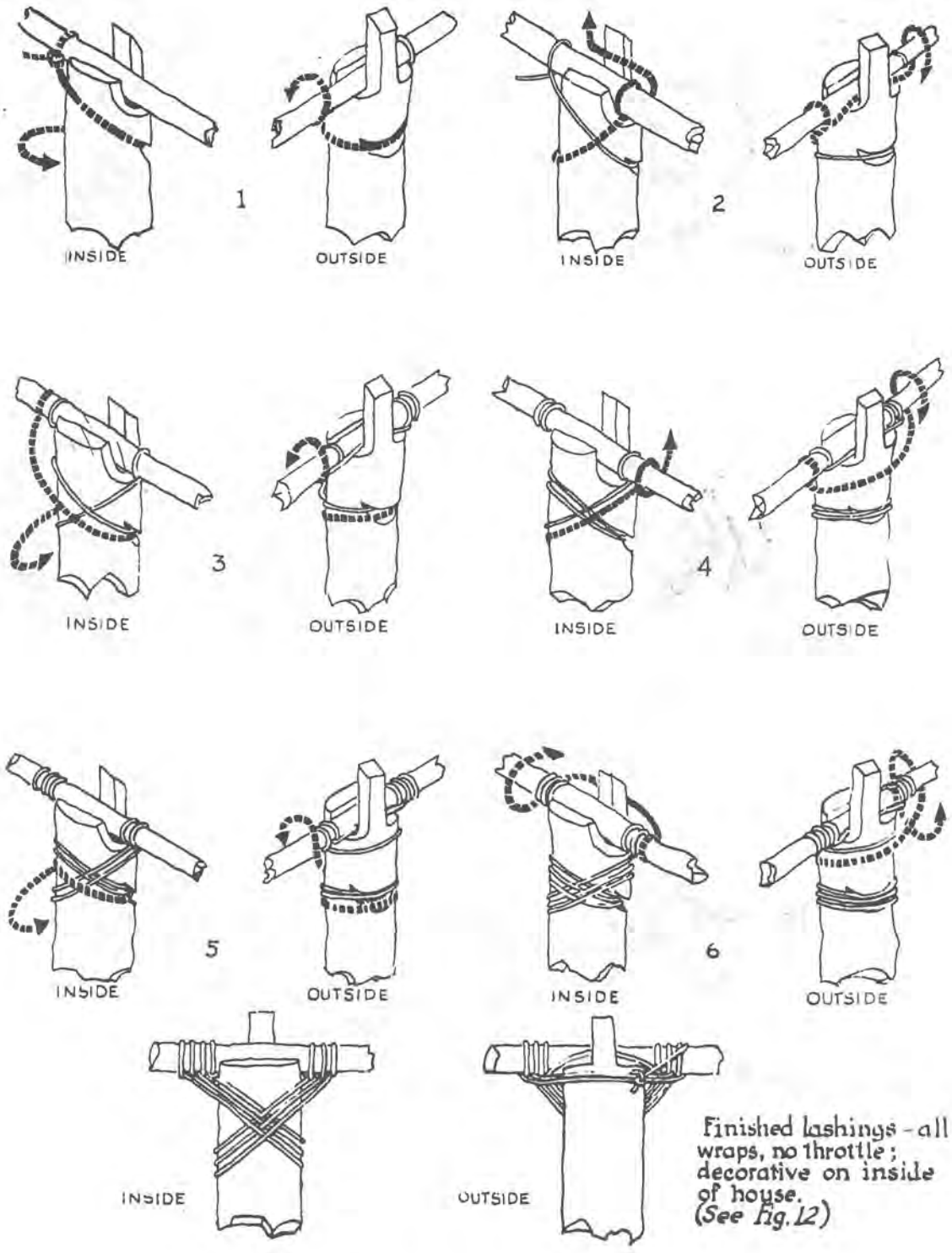


PLATE 7.

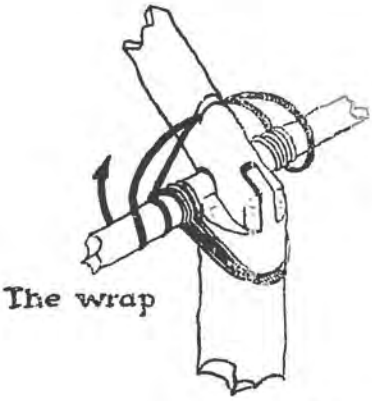
HAWAIIAN WALLED THATCHED HOUSE LASHING, WALL POST TO PLATE.

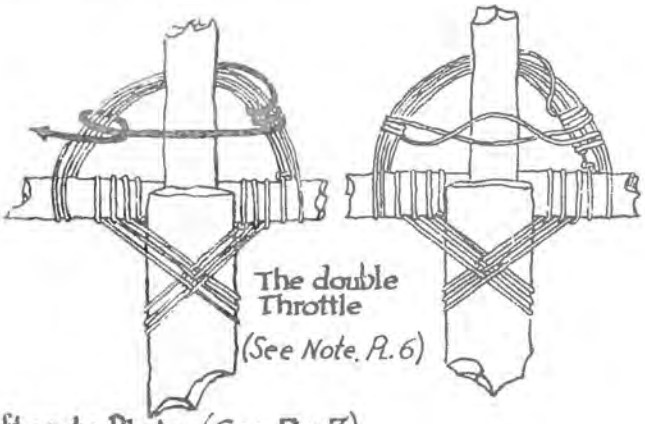




(See note. Plate 6)

Lashing - Ridge post to Main Ridge
(See Fig. 13)





Lashing - Rafter to Plate (See Fig 7.)



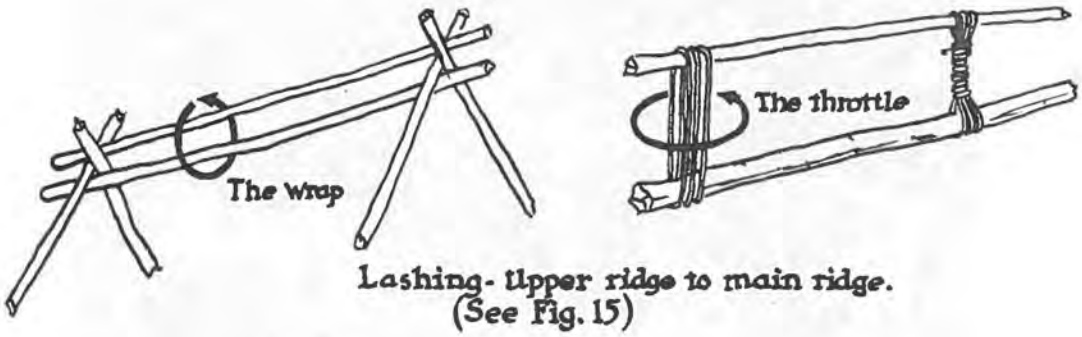


Lashing - Rafter top to Rafter top
(See Fig. 13)

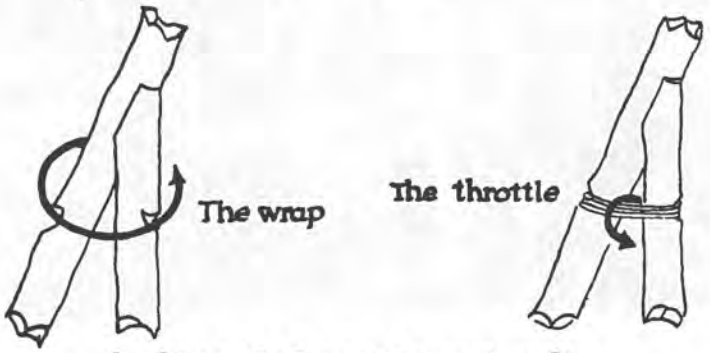
(See Note. Plate 6)

PLATE 8.

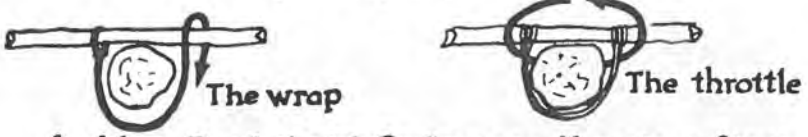
HAWAIIAN WALLED THATCHED HOUSE LASHINGS



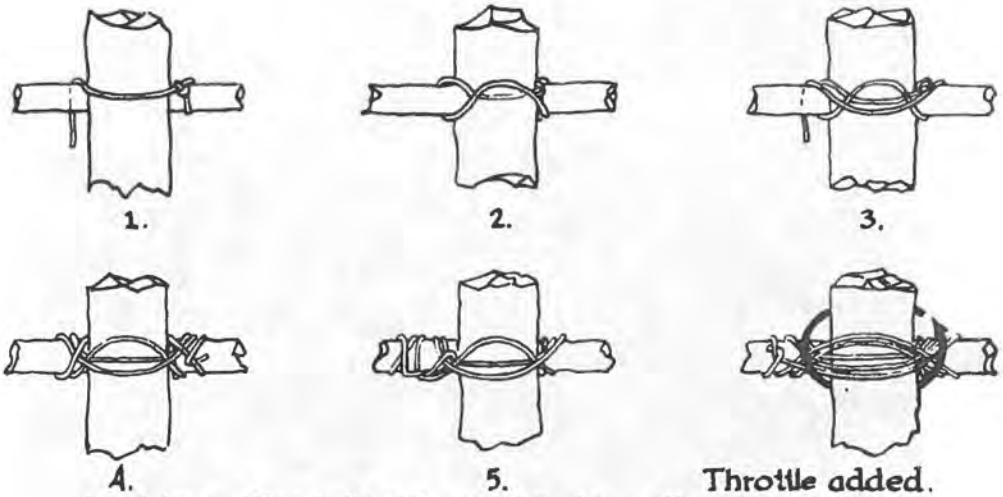
Lashing- Upper ridge to main ridge.
(See Fig. 15)



Lashing- End post to end rafter.
(See Fig. 18)



Lashing- Fixed thatch Purlin to wall posts, rafters.
(See Fig. 16 and below)



Lashing- Fixed thatch purlin to wall posts, rafters.

PLATE 9.

HAWAIIAN WALLED THATCHED HOUSE LASHINGS



Fig. 1 - Platform, with front and back walls assembled.

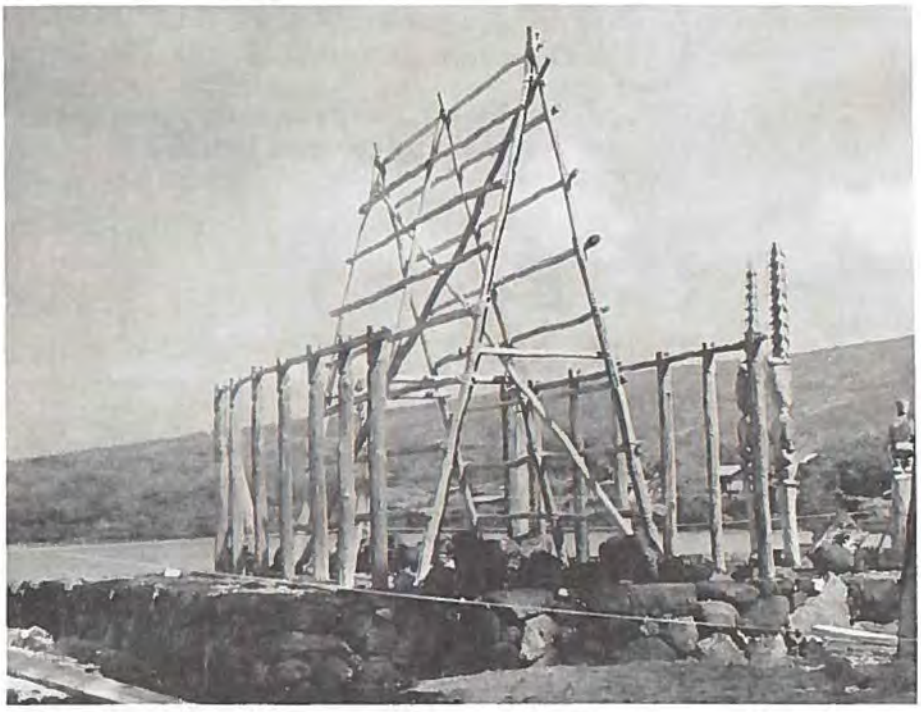


Fig. 2 - Inside scaffolding erected.

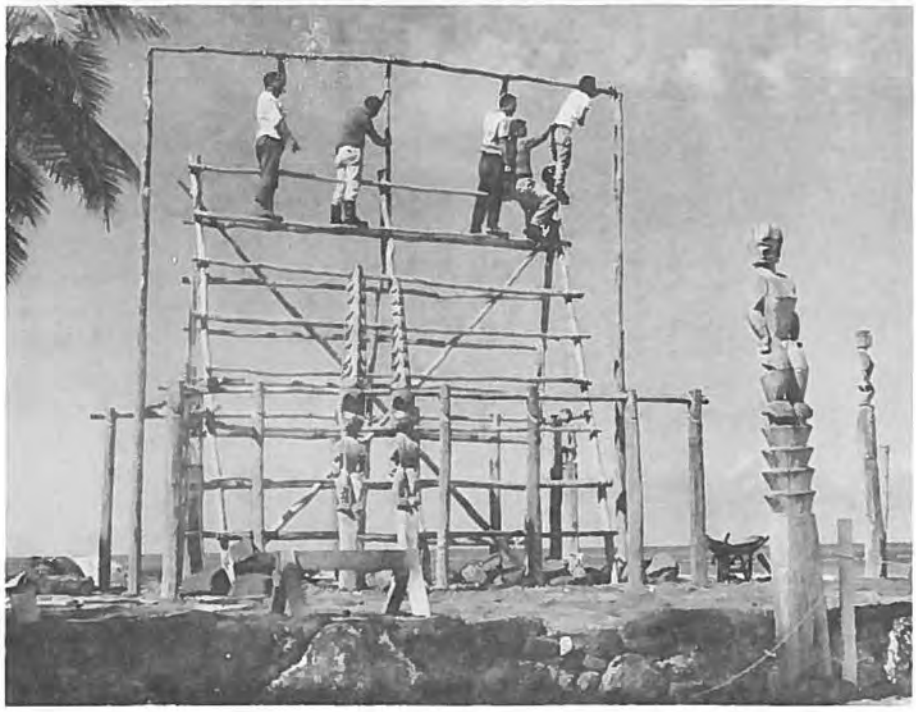


Fig. 3 - Arched main ridge installed.



Fig. 4 - Fixed thatch network under assembly.

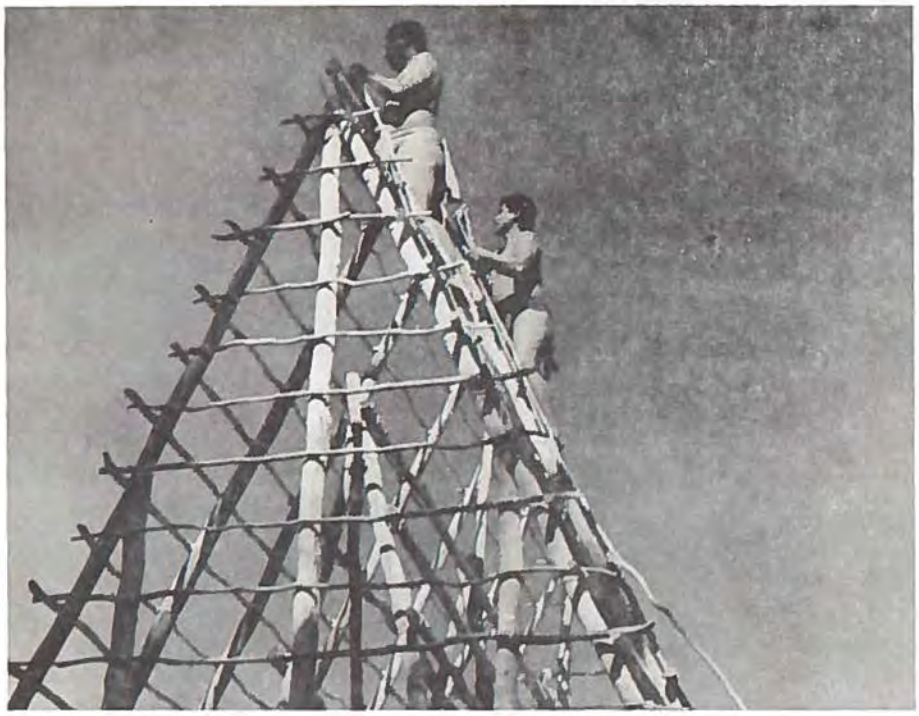


Fig. 5 - Exterior end detail, fixed thatch network.

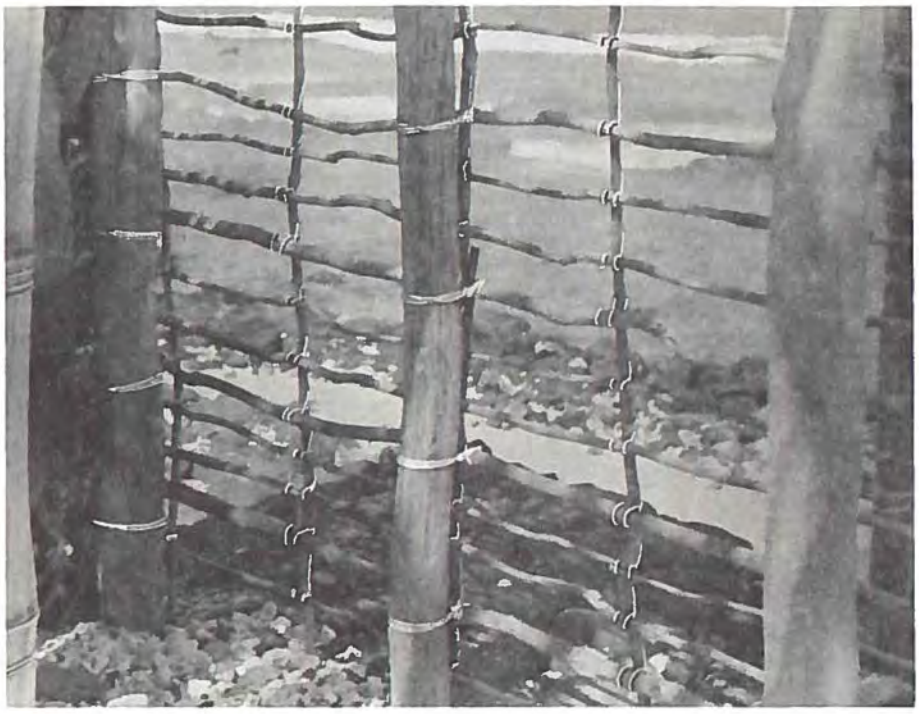


Fig. 6 - Completed thatch network, interior view.



Fig. 7 - Joint, wall post, plate, rafter; with lashings.



Fig. 8 - Joint, ridge post, ridge pole, before assembly. See Fig. 14.

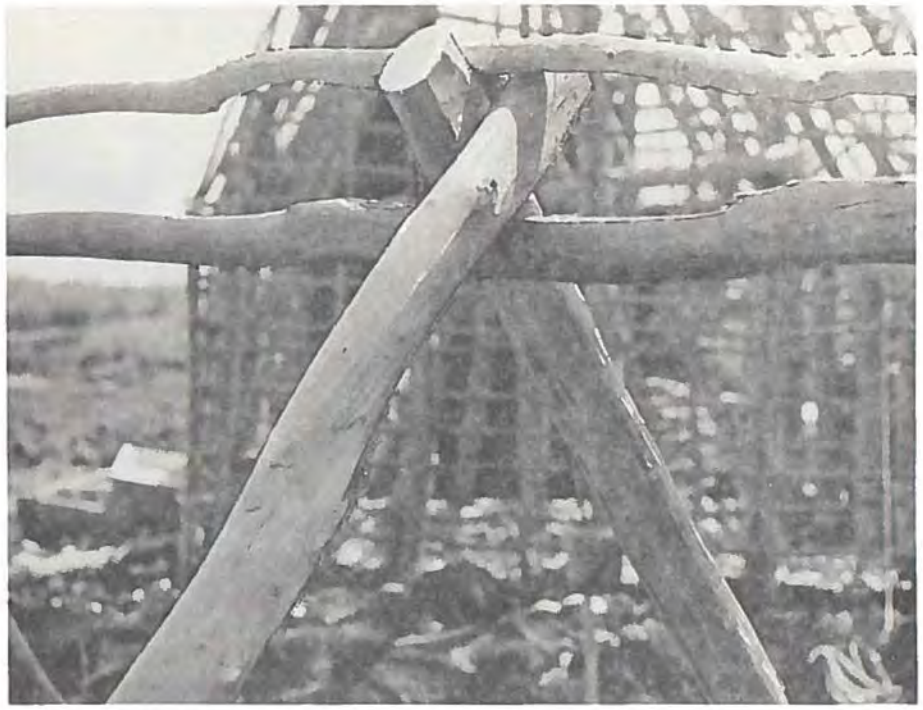


Fig. 9 - Joint, rafter tops, upper ridge pole.

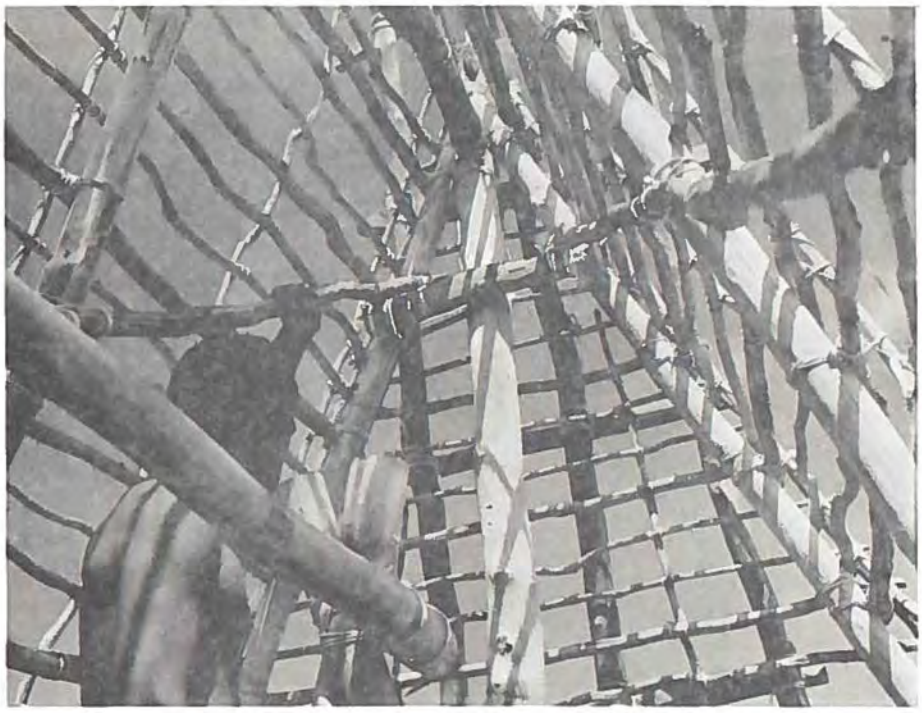


Fig. 10 - Interior diagonal bracing, upper end. See Fig. 18.

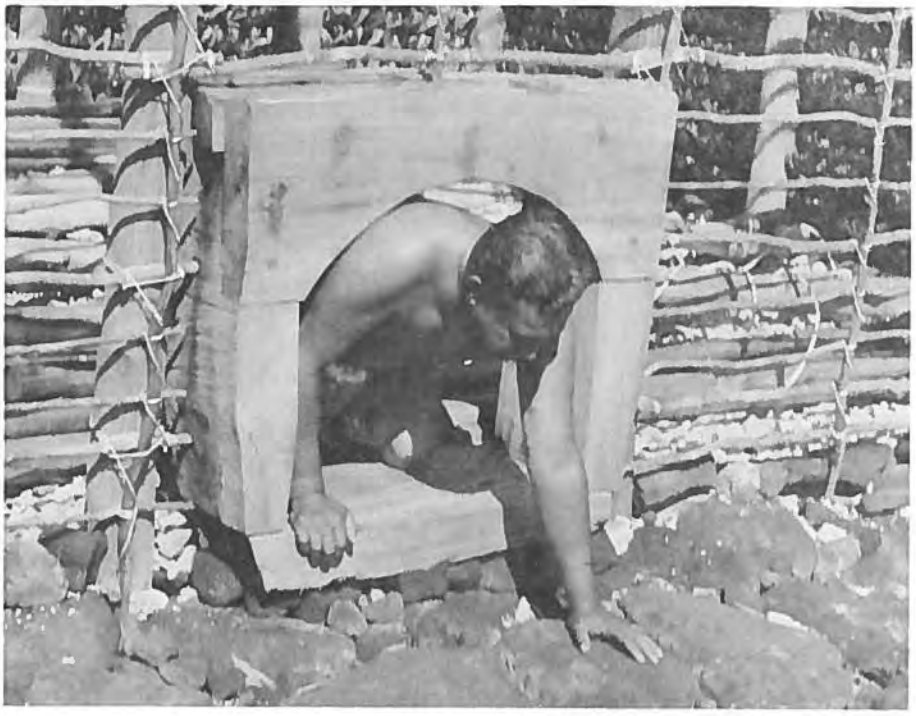


Fig. 11 - Door assembled and in use.



Fig. 12 - Lashing, wall post to plate.

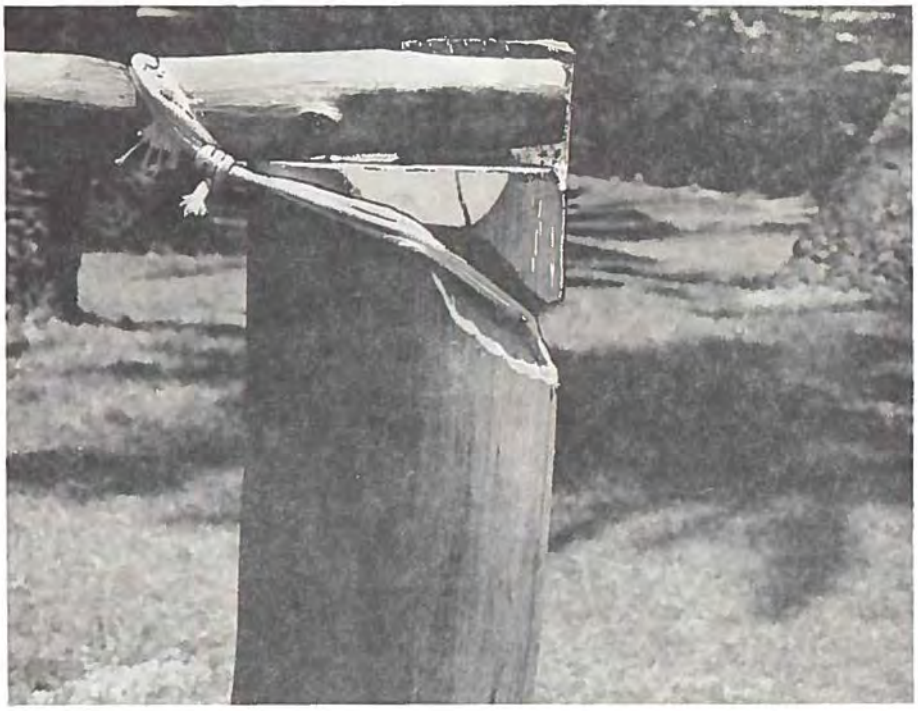


Fig. 13 - Lashing, ridge post to ridge pole.

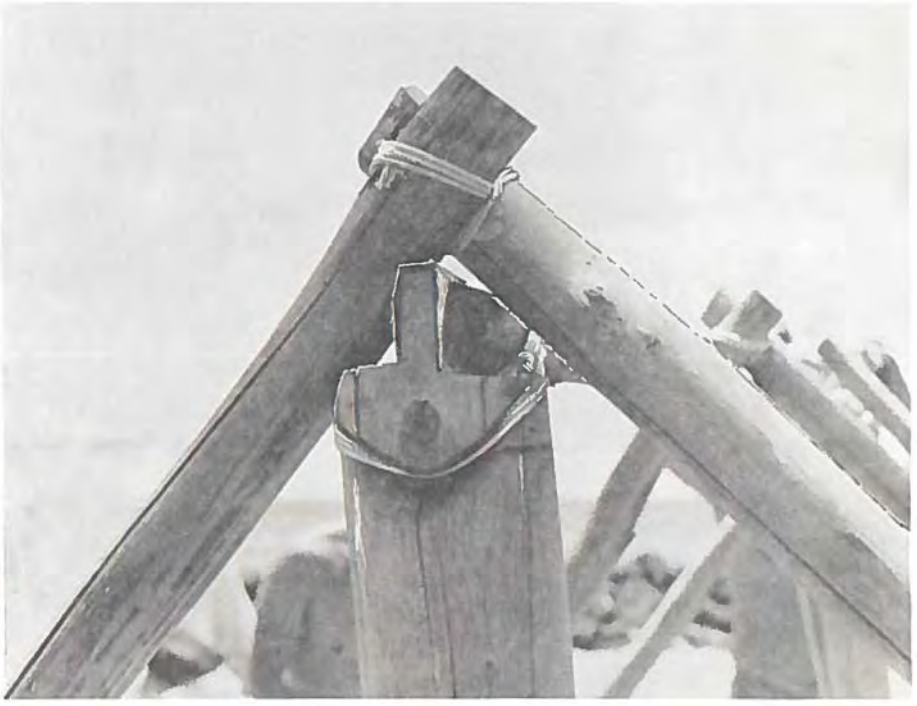


Fig. 14 - Lashing, rafter top to rafter top.

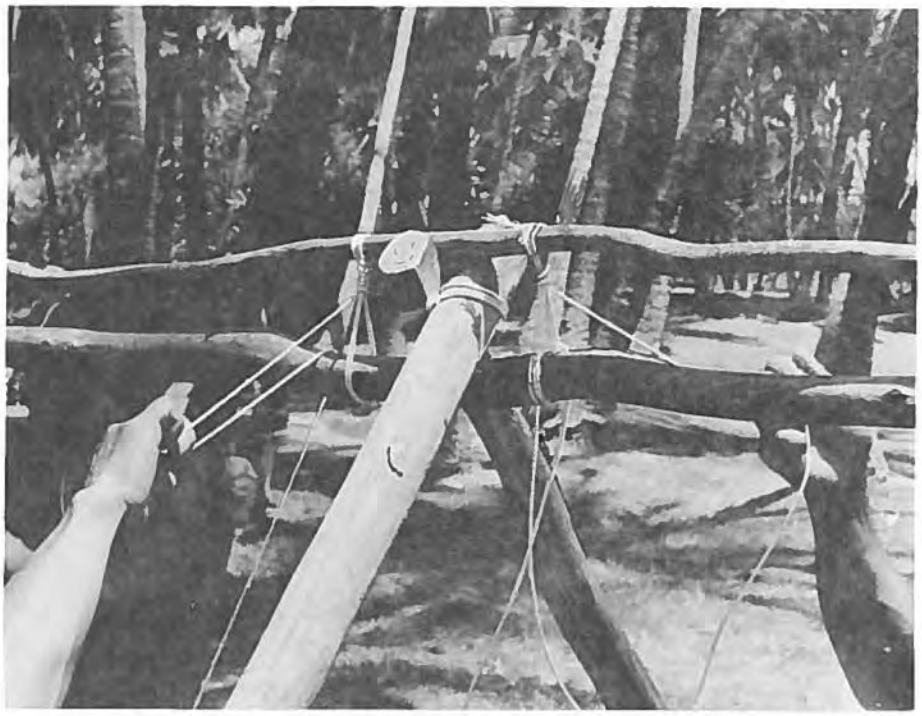


Fig. 15 - Lashing, upper ridge role to main ridge pole.

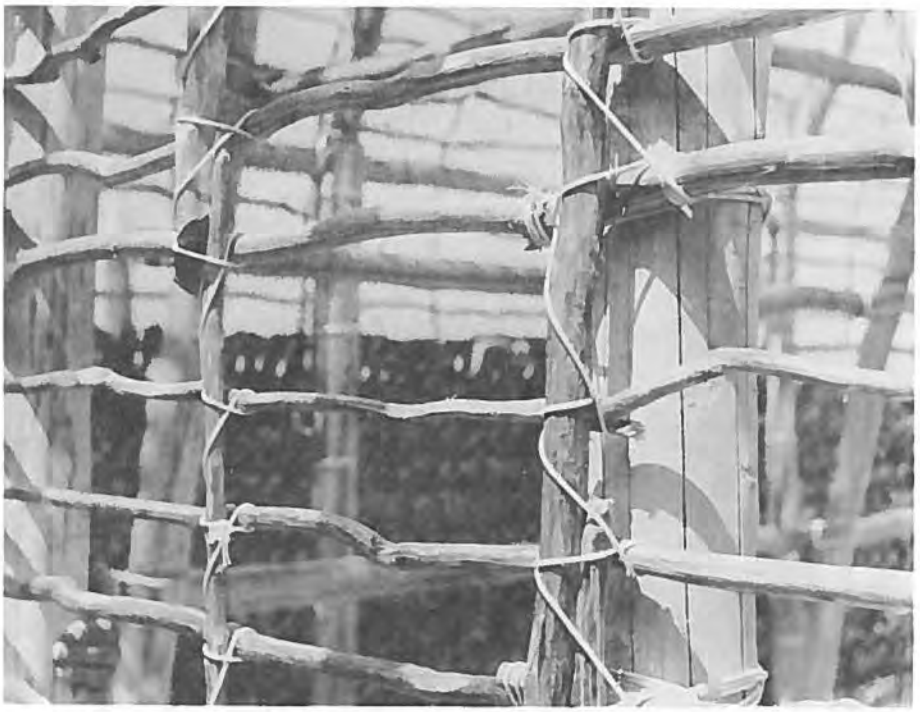


Fig. 16 - Clove hitches, floating to fixed thatch network.

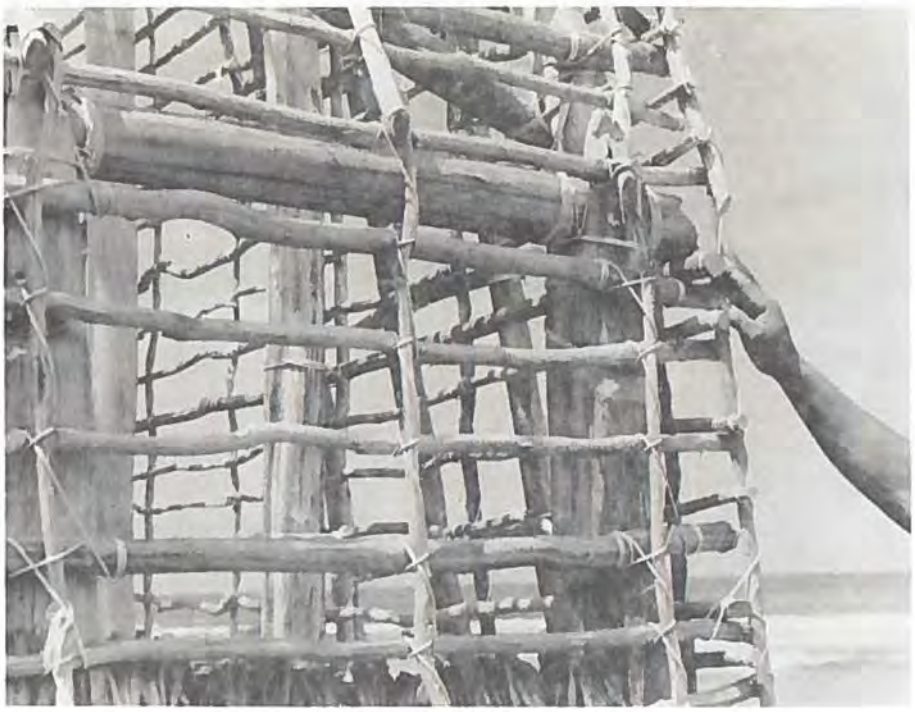


Fig. 17 - Completed thatch network, corner detail.

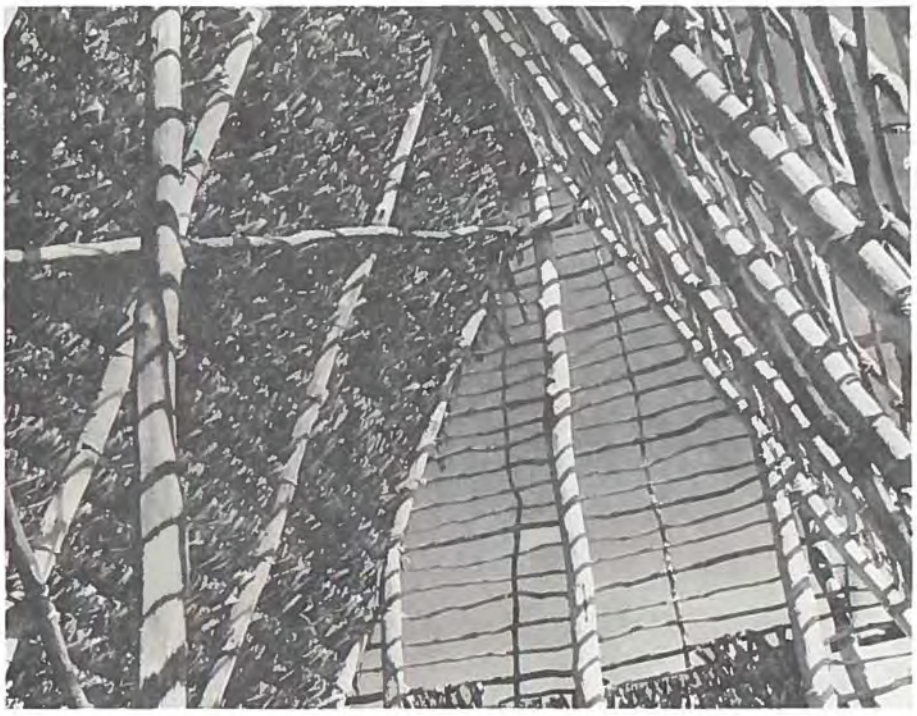


Fig. 18 - Crossed ti-leaf thatching in progress, interior view.



Fig. 19 - Crossed ti-leaf thatching in progress, exterior view. See plate 11.

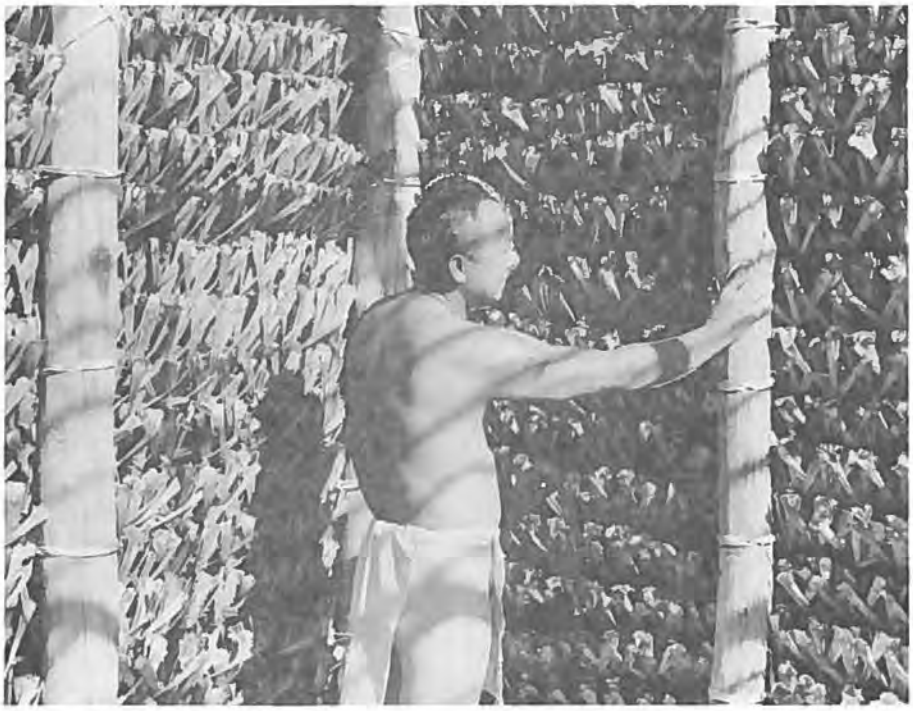


Fig. 20 - Crossed ti-leaf thatching, interior pattern. See Plate 11.

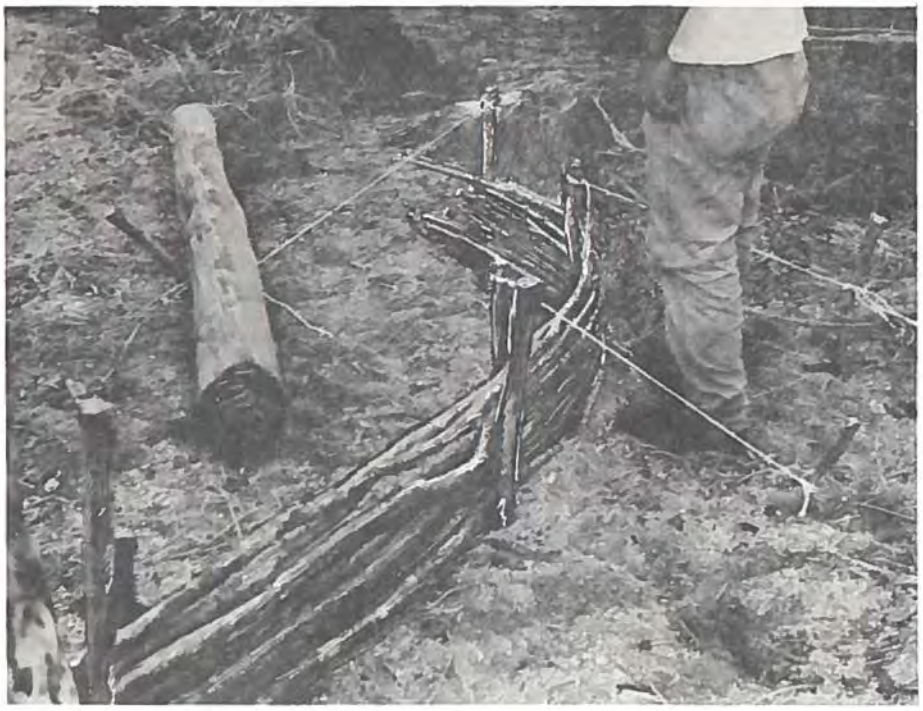


Fig. 21 - Green 'ohia rafters drying to curved shape.

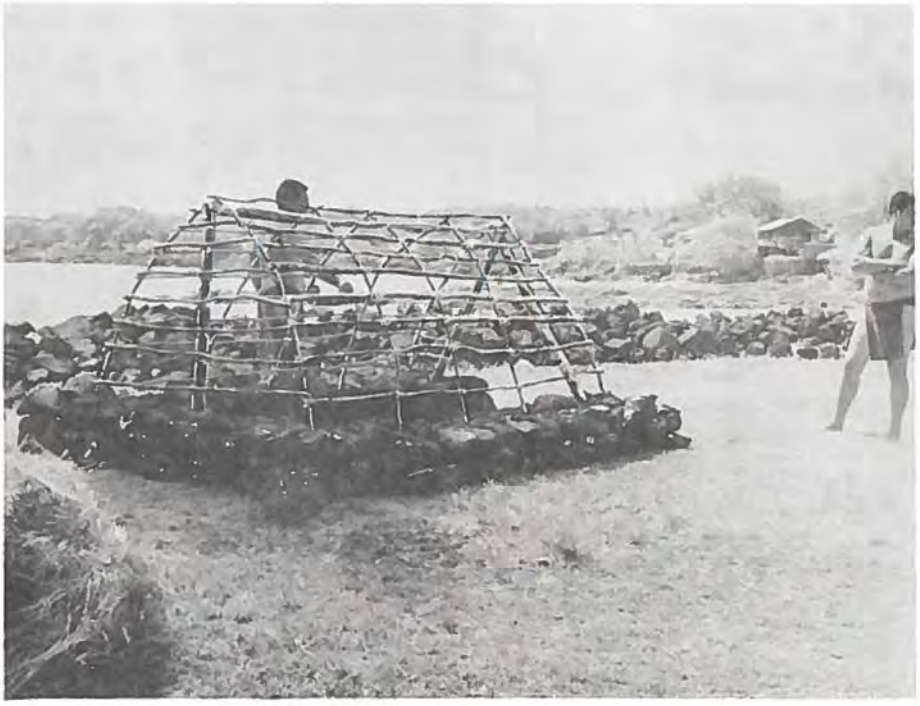


Fig. 22 - Framework for small curved-rafter house. See Plate 2.

front wall's intermediate posts were placed. A bottom alignment cord can be seen in Figures 40 and 42. Cords were on the outside of the posts to mark the vertical plane of the wall.

The function of the alignment cords was to keep the outside vertical lines of all wall posts in a plane, so that the horizontal thatch network, when applied to the outside of the posts, would also be in a plane. The result was a neat wall of thatch.

With placement of alignment cords, the layout stage ends. The four corner posts determine the width, length and height of the walls, and have a relationship to the eventual ridge height.

Sources, Layout and Wall Assembly

For portions of the layout and wall assembly sequences, the National Park Service navigated dark and unknown seas with few check points. Sources were silent on many details, details which were perhaps so obvious to the writers that they did not see the need to mention them. Their rediscovery was made by trial and error.

Wall Posts: Ellis (1827:314) noted that wall posts were six to eight inches in diameter and set three to four feet apart. Ellis wrote that in small houses the wall posts were three to four feet high (above ground?) and had the bark left on. Larger houses had wall posts 12 to 14 feet high (above ground?) which were round, straight and smooth.

Stewart (1828:137) reported that wall posts for two houses being built for missionaries at Lahaina, Maui, in 1823, on orders of the Queen, were as thick as the arms of a man and stood five feet above ground. Kamakau (1870:134), in describing houses for important chiefs and major temples, wrote that wall posts were frequently nine feet long, with a limit of 12 to 15 feet. He did not state if these lengths were before or after insertion in holes. G. Judd (1830a) and Malo (1951:119) mentioned house posts but no details about dimensions.

Slots on top of wall posts to accommodate wall plates (the beginning of the three-way joint of post, plate and rafter) were described by Kamakau (1870:135) and mentioned by Ellis (1827:314) and Stewart (1828:138). The three-way joint exists on the Bishop Museum's exhibit house, and the slots may also be found on single artifacts in museum and private collections. The lashing notch may also be found on the museum house and other artifacts. It was described and named (see Plate 13) by Kamakau (1870:134).

Wall plates were mentioned by Stewart (1828:137-138); Ellis (1827:314), Kamakau (1870:135), and Malo (1951:121). Post-holes were mentioned by Kamakau (1870:134), Kaawa (1865), Hooili (1919:642) and Waolani (1919:648). Alignment cords and their function were discussed by Kamakau (1870: 134), Waolani (1919:648), and Malo (1951:120).

Lashing: Wall Post to Plate is mentioned by Ellis (1827:135), Stewart (1929:138), Bingham (1847:115), and Malo (1951:121), frequently in connection with the total joint and lashing: wall post, wall plate and rafter, of which it is a part. Kamakau (1870:135) mentioned it specifically. Bingham described the lashing: post, plate and rafter as cordage "put on manifold, so as to act as four braces--two from the post, and two from the rafter, extending to the plate, all being attached six to twelve inches from the joint." Plates 7 and 8 detail this lashing, which is installed in two parts with two cords, and it is illustrated in Figures 7, 12, 44 and 45. This method of lashing was used on the Bishop Museum exhibit house.

Hawaiian names for house parts are given in the frontispiece and on Plate 13. Nomenclature is adapted after the original Hawaiian used by Kamakau (1870), Malo (1951), and others with help from Pukui and Elbert (1957) and Andrews (1865). Pukui and Elbert supplied the glottal stops and macrons.

Wall Assembly

Intermediate wall posts were installed during this stage, to result in the progress shown in Figure 1. Back and front wall plates were lashed to wall posts; the platform was partially accreted (if this was the method used); and the only unfinished wall details were the cutting of

the protruding ends of the plates and the shaping of the lips at the top of each post. These procedures awaited later steps. Figure 1 shows a platform which is being built, but the edge of the platform as shown proved to be too close to the wall posts to support them adequately. The platform was enlarged, and the broader platform, which adequately supported the posts, is shown in Figure 27.

Back Wall

The medial wall posts were spaced along the back wall plate by visual judgment. Cords, one for each medial post, were looped freely, so they could slide and be adjusted, around the back wall plate. The lower end of each cord was weighted with a small rock. On an existing platform the rocks hung just above the completed platform. On an accreting platform, the rocks hung just above the level of base rocks. Eventually the cords used on an existing platform were extended to hang to a level just above the base rocks.

When the architect was satisfied that the spacing of the cords was correct, selected posts were laid out on the platform, with their butts adjacent to the hole sites, and their tops toward the interior of the house, that is, toward the opposite wall location. The best vertical face or line on each post was selected and marked. If a narrow ridge could be found which ran the length of the post, this made

an easy and firm line for attaching the thatch purlins later.

A trench instead of a hole was opened under the wall plate in an existing platform. Figure 40 shows the beginnings of a trench for intermediate wall posts. Figure 42 shows the trench partially backfilled.

Upon opening up the trench in an existing dry-masonry platform, a firm support under each hanging weight was sought at about the correct depth. Once a base rock was fixed for an intermediate wall post, there was seldom need to adjust it up or down. Adjustments were made more conveniently to the post, especially for an existing platform.

When a base rock was fixed, its corresponding post could be raised, set upon it, and held against the wall plate. The post's preselected vertical line touched the plate and was held against the loop of the hanging cord. A mark was made on the wall post opposite the bottom of the wall plate. This mark indicated the bottom of the slot needed to insert the plate. The eye of the adzman, usually aided by his finger, determined the width, which approximated the thickness of the plate at that point. The post was returned to its horizontal position, elevated on sawhorses and the slot cut with an adz.

When the adzman thought this slot would fit around the wall plate, the post was again raised. This time the wall plate was lifted from one end at the nearest corner post and

tried for fit. Trial fittings for each intermediate post were numerous during experimental archaeology. After each trial fitting the post was returned to horizontal for further working.

When the adzman thought the post was rough-fitted to the plate--that is, when only a small amount of wood had to be removed to permit the plate to rest at its proper level--the post was laid on the platform. The adzman then worked on another post to rough-fit it. Intermediate wall posts could be worked on simultaneously if enough skilled adzmen were available.

Once all the posts for the back wall were rough-fitted, they were hand-held in place. This took at least one man for each post, plus two men to insert the wall plate into all the slots. This was a trial fitting of the wall as a unit, and it detected any post with a gross misalignment of its slot. Attention was given to the misfit slot, and trial fittings were held as many times as necessary to insure that the wall plate was evenly supported by all posts, and that one or more posts did not bear most of the weight of the plate.

Now the horizontal alignment cords were brought into full use. They stretched between the two back corner posts, above ground line and above the lashing notches, and helped align the intermediate wall posts into the plane of the back wall. Theoretically, the vertical line of each post

touched the plane. In practice this was an ideal never quite met. Sometimes the small deviations of the plate from end to end displaced the top of a post; sometimes the slot at the top of a post had been centered too far out or too far in; sometimes the line was not perfect; and sometimes the base stone was not properly positioned or had been knocked askew during post fittings. Adjustments were made in an attempt to form a vertical plane of the back wall posts (see Fig. 42).

Toward the end of the mass fitting, when all posts were upright and the plate was in place, a line was stretched from the lashing-notch of one back corner post to the lashing-notch of the other back corner post. Where the line crossed the outer faces of the intermediate posts a mark was made. Posts were taken down and lashing notches were adzed. This marking insured that the lashings: wall-post to plate, would match and be in a straight line when seen from inside the house. Then the posts were put up again, the plate inserted, and the trench backfilled and tamped.

When an excess amount of wood was left purposely in each slot of the intermediate wall-posts, the posts held the wall plate slightly--perhaps a quarter inch--above the bottom of the slots in the two corner posts.

When all back wall-posts were fixed in holes, the final fitting was performed to seat the plate properly in the intermediate posts. On one occasion during experimental

archaeology, final fitting removed too much wood from the bottom of one slot. To compensate for this, a hole was opened up around the post down to the base rock, which then was raised about an inch.

During final fitting, very little thinning of the wall plate was done if the fit was too tight. Because the wall plate was a thinner structural member than the upright post, wood was removed from the sides of the slot in preference to thinning the plate. Men who raised and lowered the plate were careful to keep the top of the plate in upright position. Each slot was made to fit the plate at one point and position.

According to Haleole (1919:60, 62, 78), it was unlucky during construction to draw posts out of holes, and unlucky to redo any part. Haleole qualified this when he said posts may be drawn out of holes for houses being built for chiefs. He also stated that bark should be removed from wall plate sections over doorways. Apparently for both posts and bark he was referring to commoners' houses.

Lashing: Wall Post to Wall Plate

When all back wall posts were deeply embedded in ground or platform, lashing-notches were cut in their outer faces, and the wall plate was inserted for the last time, then each wall post was lashed to the plate. This was the most decorative lashing in the entire Hawaiian house and clearly visible from the inside. Its Hawaiian name is unknown. Figure 12 shows the lashing being applied; and Plate 7

diagrams the manner of its tying. If the lashing notches were in line, the decorative lashings were in an even line when seen from inside.

Note: For the Hale-o-Keawe each lashing took 19 feet of 1/8 inch cordage or about three and one half "stretches" of arms extended. The lengths of cordage needed depended upon post thickness. Most lashings took about three "stretches."

Front Wall

The procedure described for the back wall was followed for the front wall. Front wall-posts were placed opposite the corresponding posts of the back wall, to form pairs. This was necessary in order to insure that rafters met above the main ridge. See Plate 4, g and h. The completed wall assembly is shown in Figure 1. (See also the first paragraph of this section.)

Interior Scaffold Assembly

Modern straight ladders and step ladders were used to build the first few structures in the experimental archaeology because of lack of details as to the scaffolding arrangements of the pre-contact and early historic Hawaiians. Scaffolding was mentioned and named (la'au ka 'ola) by Waialeale (1870:3). The Hawaiian word 'oloke'a (Pukui and Elbert 1957:263) also can mean scaffold. It soon became

evident that Western ladders were unhandy and inefficient in working on a Hawaiian house, especially inside it. An exterior scaffold is needed only for thatching or ridge trimming, but an interior scaffold is needed on a large structure to install the ridge and is used through to the completion of the assembly. Neither interior or exterior scaffolding is needed for a commoner's "pup tent" size house. The ridge can be reached from the ground. A scaffold for use inside a small walled house can be a small portable "A" frame, resembling a modern step ladder in design.

A handy and efficient solution to the interior scaffold design was provided from the Polynesian islands of the South Pacific through Dr. Kenneth P. Emory, who had watched gable end structures being built there (personal communication, February 23, 1967). He mentioned that the design was a simple "A" frame. With this as a clue, the scaffold was built and is illustrated in Figure 2 and shown in use in Figures 3 and 10. Lashings used are diagramed at the top of Plate 6. Plate 3 d shows the interior scaffold built as part of the order of erection.

Performance requirements for an interior scaffold were an easily erected and dismantled framework on which men could climb and work, which permitted access to the interior surfaces of the structure which were higher than those which could be reached from the ground. A side view of a proposed house drawn to scale on paper, enabled designing of a scaffold which left between two to three feet of work space

between rafters and scaffold and permitted men to work on the ridge but still have space above the scaffold to change sides without descending. A steeply pitched roof, such as that for the Hale-o-Keawe, was very narrow in its upper interior. How the ancient Hawaiians solved this relationship between scaffold and ridge height is not known. Perhaps the scaffold itself played a part in determining final ridge height.

The scaffold shown in Figure 3 worked well as far as access to rafters and ridge was concerned, but proved to be too short in relationship to the ends. Men found it difficult to reach the joint: ridge post to ridge pole. The scaffold should have been built to within two feet of the inside line between the two end corner posts. Spacing of the rungs was wide enough to permit men to cross at ground level from side to side and have access to floor area under the scaffold. The scaffold was held rigid by the use of diagonal bracing. Logs used for scaffolds within large houses were so long that they had to be cut apart after dismantling so they could be removed through the door.

Main Ridge Assembly

Ridge posts were placed in the middle of the house ends, midway between and in line with the corner posts of the front and back walls. A vertical center post was placed midway between the two ridge posts. The tops of the ridge posts and the center post supported the arched main ridge

pole, against which the tops of the rafters were leaned. Thus, the main ridge assembly shared with the walls the support of the roof. Deep embedment of the ridge posts was necessary.

Ridge Posts, Installations

Placement of the hole for a ridge post was determined by stretching a cord between the two corner posts of the same end, and by doubling the cord to find the half way mark. A twig could be thrust through the cord at the half way mark, or a smaller cord tied on. A small rock was also placed on the platform or ground to mark the half way point between the two corner posts. The same cord was then tied between the corner posts at ground or platform level, with loops around the corner post so adjusted that the line extended from center to center, with the half way mark of the cord over the small marker rock. Then the hole was opened in the platform, with the ground level cord helping to establish the location and depth of the base rock. Base rocks for ridge posts were deeper than the base rocks for corner posts. The taller posts required deeper embedment. In accreting platforms also, the platform level cord was used to establish the location and placement of base rocks.

Ridge posts were laid out with their bases close to the holes, and with the posts lying close to but outside the line of the corner posts. When raised, ridge posts had to pass the protruding ends of the wall plates. A straight

vertical line was selected along the length of each ridge post in order to determine the end plane, and the line was marked. The butt ends were checked for a good truncated cone to rest upon base rocks, and any necessary changes were made with an adz. The distance of the depth from the cord at platform level to the top of the base rock was carefully marked along the line of one ridge post to establish the ground line, and the mark was made. This was done to the other ridge post also to match each ridge post to its hole and to insure that the ground lines of the posts would be level with the platform-surface when the posts were raised. Ground level cords were then removed so they would not interfere with raising the posts.

Ground lines were used as bases for measuring along each post to establish the tops at the same distance above the platform. No allowance was made for the taper of the ridge pole, since such tapering would be minor in the arched position and not noticeable. Tops of ridge posts stood about three times as high as wall plates above the platform, preferably slightly more.

The male side of the joint: ridge post to ridge pole (see Plate 5 h; and Plate 8, top; Figs. 8, 13, 14) was cut with adz or chisel so that the top of the cut came at the mark for the top of the ridge post, with prong or tenon extending above. A lashing-notch was also made in each post to serve the joint.

Thus prepared, one ridge post was elevated into position, an all-hands job. Men at the top of the scaffold pulled the top to them with lines attached to the lashing notch, while men on the platform raised the post and eased it into the hole to rest on the base rock. With the pole in vertical position and held by men atop the scaffold, two alignment cords were stretched between the corner posts at each end. One cord went at ground level, the other just below the wall plate. Cords marked the end plane into which the preselected and marked vertical line of the ridge post would fit. The post was turned about its vertical axis as needed in order to place its line against the alignment cords, and was moved as necessary to insure that it was vertical. In this position, securely held, the post was fixed by tamping the rock filling the hole. The other ridge post was raised in the same manner.

Hooili (1919:642), Bingham (1847:116) and a note by Emerson in Malo (1951:124n), suggest that some ridge posts were not vertical but were inclined slightly inward. That is, just before the hole was closed, the tops of the ridge posts were drawn slightly toward each other by the men on the scaffold. A slight structural advantage might be gained in maintaining the arch of the ridge pole, and to Hawaiians such an inclination may have improved the aesthetics of tall houses. Field experiments in 1970 included this technique. Whether they were vertical or inclined, care in planting the

ridge posts insured that the ends of the main ridge pole would be approximately the same height above the platform.

Center Post

A shallow embedment of the base of the center prop could be used as extra insurance that the post's bottom could not be knocked askew, but experience showed that the prop was held firmly against the platform by the bow of the ridge and the weight of the rafter tops. The resting of the butt directly against a flat rock on the platform's surface eliminated the need to replace the platform around any inserted butt. Also, if an offering or sacrifice had been buried under the site of the center post, it was not disturbed if the butt rested on the surface directly above it.

The length of the center prop was the distance from the platform to the tops of the ridge posts, plus up to a kīko'o (span), or perhaps just a little less than the distance between a thumb to end of index finger. A kīko'o-sized bow at the center of the main ridge beam gave a noticeable arch, and when the bowed ridge pole had been installed in the restored Hale-o-Keawe, the amount of the arc of the bow at the center was the subject of much discussion among the crew. The bottom of the arch shown in Figure 3 is five and one half inches above a taut cord stretched between the tops of the ridge posts, although wagers ranged from six to nine inches before the measurement was taken. One

practical limiting factor to the amount of bowing is the bendability of the ridge pole, a timber almost as thick as a wall post of the same house (see Plate 5 for comparative thickness of framing members).

A concave groove was cut into the top of the center post. This concavity prevented the ridge pole from moving to either side.

Two lashing notches were cut below the groove on opposite sides of the prop. The center prop was lifted in a more or less horizontal position to the top of the scaffold and then its butt end was lowered within the scaffold until the post was upright. It was turned about its vertical axis to make the concave groove line up with the ridge posts.

If there were an odd number of wall posts, this placed a pair of wall posts in the center of each side. In this instance, a center prop which stood dead center between the ridge posts would interfere with the rafter tops. With wall posts centered on the sides of the house, the base of the center prop was offset to one side or the other of a line between the pair of wall posts so that its top and its associated lashings would be clear of the rafter tops where they crossed above the main ridge pole. In practice this placed the center prop a foot or so off-center. This is not a consideration when there was an even number of wall posts to a side, and the center prop was then directly

behind the door. Sources indicate that there may have been more than one central post in some large structures in order to support the span of the ridge and contribute to the arch.

The top of the center post was either hand held for the fittings of the main ridge, or lashed in vertical position to the scaffold for this short period.

Main Ridge Pole

In horizontal position, the long timber selected for the main ridge pole was lifted up one side of the scaffold and its center was placed in the groove at the top of the center post. Then the ends of the main ridge pole were forced down to meet the tops of the ridge posts, and the underside of the main ridge was marked with "chalk" where it touched the tenons. At this time places for four lashing notches were marked. They were (1 and 2) on top of the pole at either side of the center prop and (3 and 4) on top of the pole for each joint: ridge post to ridge pole. The ridge pole was then lowered to the ground, the female sockets of the joint: ridge post to ridge pole was cut with an adz, and the lashing notches were cut. Then the pole was then relifted to the top of the scaffold and replaced in the groove stop the center prop. This was lashed first, from the notch on one side of the prop to the notch on the other side of the pole; then between the other pair of opposing notches, forming two crossing lashings which

held the center prop firmly in the groove and prevented movement of the main ridge pole.

One end of the ridge pole was forced down upon its supporting ridge post in order to finish fitting the joint: ridge post to ridge pole. When the fit was complete, the lashing: ridge post to ridge pole was applied (see Plate 8, top; Figs. 13 and 14). The other end of the ridge pole was then forced down, finished and lashed. Progress to this point is shown on Plate 3 e and Figure 3.

". . . the ridge pole would arch as proudly as the crest of a helmet, dipping down at the ridge posts and curving upward in the center of the House." (Kamakau 1870: 135). Waialeale (1870:2, 3) said that houses with center props did not fall down easily in a windstorm, and that houses without center props were likely to have their rafters dislodged to fall and hit people beneath, sometimes killing them.

Main Ridge Assembly: Wall-less House

One function of the main ridge is to support rafter tops. Even in a small wall-less house, that is, in a house whose roof sits on the ground, ridge poles must still be supported. If conventional ridge posts were used in both ends of the small house, there could be difficulty of access to the inside. One solution, an "A" frame support on the entrance end, is shown in Figure 22. The assembly of a wall-less house began by erecting ridge posts (or their

substitutes), and then installing the main ridge. No attempt was made to arch the ridge. The joint: ridge post to ridge pole was used on the house shown in Figure 22, but the front end of the ridge pole rested in the cross of the "A" frame. Both ends were lashed in place.

Sources

Ridge pole data came from Hooili (1919:642); Kamakau (1870:135); and Stewart (1828:138). Waialeale (1870:3-4) cautioned that if the knot of the lashing which fastens the joint: ridge post to ridge pole is on the inside where it can be seen, that the owner would sicken and die. Hawaiian names for the ridge pole came from Malo (1951:119, 121), Kamakau (1870) and were confirmed by Pukui and Elbert (1957).

Ridge post data came from Kamakau (1870:135, 137); Hooili (1919:642); Malo (1951:119, 120, 124n); Ellis (1827: 314); Stewart (1928:138) and Bingham (1847:115). Pouhānā is the Hawaiian name for the ridge posts (Pukui and Elbert 1957:316); the macrons have been added by Elbert (personal communication, February 1970).

Center prop details came from Haleole (1919:115); Hooili (1919:646); Kamakau (1870:135); Malo (1951:121); Waialeale (1870:2, 3); Stewart (1830:100) and Bingham (1847:115).

Multiple posts were mentioned or inferred by Haleole, Kamakau, Malo and Stewart. Ellis (1827) is strangely silent on a center prop or props. Hawaiian names were Halake'a,

Kia, Pouamanu or Pouomanu (Pukui and Elbert 1957:48, 134, 316, 317). All were used by the Hawaiian writers.

Rafter Assembly

A rafter extended from the top of each wall post up to the top of the main ridge pole. Opposite pairs of wall posts supported rafter-pairs which met and crossed at the ridge. Because of the arched ridge pole, rafters were longer at the center of the house than at the ends.

Lashed joints connected a rafter-bottom to a wall-post and plate, and a rafter top to the top of its mate. At the bottom of each rafter a circular groove was cut to fit around the top of the wall plate, and the weight and thrust of each rafter was placed upon the wall plate. The forked end of the rafter straddled the tenon cut from the outer lip of the slot on top of the wall post; its function was to stop any sideways motion of the rafter bottom along the plate. The joint: wall post, plate and rafter is diagrammed on Plate 5 g; the joint at the rafter tops is diagrammed on Plate 5 j. Illustrations of the joints are found in Figures 7, 9, 14 and 15.

Installation of a rafter pair began with the fitting of the back rafter's bottom joint. The outer lip of the joint: wall post to plate, purposely left unworked during wall assembly, was now cut with chisel into a tenon. The rafter bottom was worked with adz and chisel to fit snugly around the plate, but the fit was made adjacent to the wall

post, with the rafter top resting against the ridge. This was because the rafter must be primarily supported by the plate, and the lips on top of the post interfere with fitting the rafter in place. The inner lip of the wall post may also require modification to permit the rafter to rest properly on the plate (see Fig. 45). However, it was left as high as possible, so that it hid the joint from inside the house (see Fig. 7). When the fit was snug, with the rafter set adjacent to the post top, then the fork was cut and the rafter fitted in place. In field archaeology, workmen found a Japanese-style folding pruning saw was an aid in making the fork. Fitting was made by means of chisel cuts, as needed, to the tenon, fork, and/or inner lip, and to the groove if necessary, but the plate was not worked. The aim was to cut equally from both of any touching surfaces so as not to get any part of the joint too thin or weak. Rafters were taken down for working on the bottom ends.

When both bottom ends of a rafter pair had been fitted to their respective joints: wall post, plate and rafter; the rafters were placed again with their tops crossed above the main ridge pole. The upper joints were marked where each rafter touched the other; rafters were taken down and the touching-point was adzed to make a flat surface. This surface was larger than just the touched area, to permit the rafters to fit snugly against the main ridge pole. The ends of each rafter were cut off sufficiently above the touching area to permit the thin upper ridge pole to nestle above the

with lashings to a fixed frame. Some broke in the process and had to be replaced with more supple ones (Malia Solomon, June 11, 1969, personal communication). Canoe outriggers were bent into shape after steaming in an underground oven (Imu hau hana: Pukui and Elbert 1957:94). Rafters may have been curved by similar means.

Waialeale (1870:4) warned that, if the first rafter pair fitted from a back corner post to over the ridge post finds that the back rafter does not mesh properly with the front rafter, and that the back rafter has to be discraded for a substitute, this portends the nature of the owner's wife. She will constantly fight with relatives, and the husband will remain silent. If the lashing: rafter top to rafter top does not fit snugly over the lashing: ridge post to ridge pole where end rafters meet over a ridge post, this is a sign of poverty and cruel deaths for the occupants. However, Waialeale said such fate can be prevented with this remedy (ho'omanalo) to sweeten the trouble, by burying under the door several mountain shrimps and a pāo'o fish.

Rafter Assembly, Wall-less House

Rafters whose bottom ends do not couple with wooden wall assemblies do not need to be worked at their bottom ends. Rafter ends secured within stone walls, braced against rocks or ground plates, or fixed into earth, require no other bottom end than a cut as neat as the workman cares

to make it. A fuller discussion of techniques may be found in Chapter II, under "House Foundations" in the section on Material. Rafters of "thumb size" sticks were not worked at upper ends. Where they crossed above the main ridge they were lashed.

Upper Ridge Pole

Kamakau (1870:136) wrote, "Above where the rafters crossed each other was laid another long pole, extending from one ridge post to the other, and this second ridge pole, the kua'iole, was lashed down (pueo iho) to the main ridgepole with a cord winding around (hawele ana) [itself], and the 'mouth' of the lashing (waha o ka pueo) [the cord spread] turning towards (haliu ana) the front of the ridge-pole below. The row of the lashings (pae pueo) was like the wings of birds spreading over the ridgepoles (e uhi ana i kaupaku)."

Malo (1951:121); Ellis (1827:315); and Bingham (1847: 115) also mentioned the upper ridge pole and its unique lashing to the main ridge pole. Its Hawaiian names, kua'iole and kaupoku'iole (literally rat ridge pole) are found in Pukui and Elbert (1957:128, 156).

The joint and/or lashing is illustrated on Plate 5 j, Plate 9, top; Figures 9, 15, 26, and 27. The lashing: upper ridge to main ridge, best illustrates the Hawaiian lashing techniques of a wrap and throttle. In this case the throttle took on major importance. As the throttle

turns were added, the two ridge poles were increasingly forced towards each other, squeezing rafter tops in a vise which bound the front and back roof sections into a unified whole. The lashings: upper ridge to main ridge are spaced about a foot apart along the ridges: one goes on either side of each rafter pair.

A critical time came for some Hawaiians during the laying, and presumably the lashing, of the upper ridge pole. They believed that if a man's wife, child, or other relative called him during the operation, it was essential that he cease his work and get someone else to complete the job. If he went ahead and completed the job himself, his fate was insanity which would last until his death (Waialeale 1870:4).

Gable Ends Assembly

Gable end posts, about the thickness of wall posts, close up the ends between the ridge posts and corner posts, and extend from the rafters into the ground. They diminish in height as they go toward the walls. Their principal functions appear to be as support for the thatch network on the ends, to enhance the internal appearance by spacing of posts completely around the perimeter, and to inhibit sidewise motion of the frame after they are tied into the thatch network.

Holes (or a trench) were opened in an existing platform, and base rocks put in place. Each gable and post

was set upright upon its base rock and leaned in a vertical position against the end rafter. Its straightest vertical face was turned toward the outside of the house, as with other vertical posts. It was marked by "chalk" in line with the underside of the rafter, taken down to horizontal position and a slanting groove was cut to fit under the rafter. Several rough fittings were necessary for each gable post. The joint and lashing are shown on Plate 9 and Figure 18. The lashing is completed, and the posts are aligned with the plane of the end wall before the holes are closed by filling and tamping.

Bends and imperfections in gable end posts had meanings to some Hawaiians. (See the section titled "The Gods Watch" in Chapter I.) Gable end posts were mentioned by Haleole (1919:80, 81); Kamakau (1870:136); Malo (1951:119); Stewart (1828:138) and Bingham (1847:115-116). Hiroa suggested that the slanting groove to fit under the end rafter was a necessary feature (1957). The lashing illustrated on Plate 9 evolved during experimental archaeology.

Gable posts were the last to be planted in a large walled house. Gable end posts were necessary only in large walled houses. When they had been placed, an accreting platform could be completed. Progress to this point completes the basic frame (Plate 4 f).

Diagonal Bracing Assembly

Diagonal bracing was needed in a large walled house, but was omitted in others. Its function was to stiffen the entire house and eliminate sway from end to end. The assembly is diagrammed in Plate 5 and its parts are labeled in Plate 13. Figures 10 and 18 show portions of the bracing installed on the restored Hale-o-Keawe.

No joints were needed. Component parts were lashed to each other at meeting points. The lashings included the cross of the two long timbers on the front side and those on the back side. The long timbers were lashed to each rafter they crossed. The small end pieces ('ilio, literally dog) were lashed across end rafter pairs near their tops, but not to the ridge posts. Lashings used at Honaunau are shown in Plate 6, top.

Elimination or minimization of side sway, that is movement from end-to-end along the ridge poles, in all but the larger houses was achieved by the thatch network. Before the thatch network or diagonal braces were installed on the restored Hale-o-Keawe, a man could climb to the top of the interior scaffold and sway the ridge pole back and forth in a total movement of about five inches. With thatch network added, the motion was reduced to less than two inches, and considerable more force was needed to achieve this movement. The diagonal bracing was added to the restored temple's framework by removing a portion of the

thatch network to permit the bracing timbers to pass inside. With the diagonal bracing installed, no sway could be detected even if several men tried to induce it. Obviously, in the order of erection the diagonal bracing should follow the rafters and upper ridge pole, and should precede the thatch network.

Diagonal braces were added to the half-size model of the Hale-o-Keawe more than a year after it was built. This was done to make its structure conform to that of the restored temple. The half-size model had no side sway after the thatch network was installed, and structurally the diagonal braces were superfluous.

Kamakau (1870:138, 140) was the only writer who mentioned diagonal bracing, and he limited its use to large houses. His description permitted the component timbers to be installed, but it was not possible to follow his lashing without a model. Attempts to work out the lashing he described were fruitless, and standard scaffolding lashings were substituted.

Elaborate Door Assembly

Elaborate door assemblies, like that of the restored Hale-o-Keawe, interlocked with the thatch network. Horizontal purlins of the fixed thatch network extended into square holes chiseled into the outside of the jambs (see Fig. 11). For this reason, an elaborate door assembly must be installed before the thatch network. Other and less elaborate

doors and doorways were installed as part of the finishing operations, and did not directly join with the network. Whether they were elaborate or simple, the doors were low.

Crawl-in Doors

Samwell, a member of the Cook expedition of 1778-1779 which discovered Hawaii, said of Hawaiian houses,

> . . . the entrance to them is just like the mouth of an oven & very little bigger, so that every one is obliged to creep into them; this entrance is made out of a board cut in the proper form and placed in the wall, & they have a slider on the inside to draw across it occasionally. As they have no light but what comes in at the door their Houses are very dark. (Samwell 1967:1176)

Cook himself wrote that Hawaiian doors were "so low that a man can hardly get in without going upon his hands and knees, and they have no other light except what may come through the crevices in the wall; some of our gentlemen observed that when they wanted light they made a hole in the wall and closed it again when they had done with it." (Cook 1967:283). One of Cook's marines wrote, "They have but one passage which is used both as door and window." (Ledyard 1963:128).

Doors, which had religious significance (see "The Gods Watch" in Chapter I) were no different in the 1790s, or Vancouver (1967), who had been with Cook in 1778 and 1779, would have mentioned the change. It was a pioneer Christian missionary of 1820 who next described the single low door and the absence of windows by noting that the former "royal

palace" assigned to her husband in March 1820 at Kailua-Kona, Island of Hawaii, was distinguished from all the rest of the houses by having two doors. One was about two and a half feet high on the front side; adjacent to it was the entrance formerly used exclusively by the king and which was three and a half feet high and had hinges and a hasp (Thurston 1934:44, 47-48; Bingham 1847:91). Other early missionaries and visitors confirm the traditional low door (Manby 1793: 37; Campbell 1967:131; Ellis 1827:207, 316; Stewart 1828: 101, 149; Byron 1828:107; Bingham 1847:116; Lyons 1945:59, 76; Conde 1887:172, 174, 175; Bond 1927:137).

An exclusive entrance for the ruling chief, a door no other person dared use, was mentioned by Malo (1951:260, 261, 265n), Ii (1959:119) and by Kamakau 1870:144). Houses occupied by chiefs who rated exclusive doors must have had at least two entrances. Some may have had more (Ii 1959: 119; Kamakau 1961:238), but this may have been only in historic times.

A commoner's house, thatched with pili grass, needed no more than a plaited lauhala mat for a door closure (Lyons 1945:59; Hooili 1919:646), but there may have been a roll-up variation (Hooili 1919:646). Door frames for commoners' houses probably were used only after commoners adopted walled houses and higher doors, but traditional techniques of joining frames may have been retained. Artifacts B4043, D1566, D1567, a lintel and jambs collected

in 1920 from Lanai Island by Emory and held at the Bishop Museum, Honolulu, contain features which fit in part the only known described details of the elaborate Hawaiian door. The three artifacts are the only extant door parts. They probably date from the late 1800s.

Hale-o-Keawe Door

Those three artifacts, together with specific details for the elaborate door described by Malo (1951:121) and Kamakau (1870:144-145), enabled the National Park Service to reconstruct the door to the Hale-o-Keawe. Missionary Ellis pushed aside the sliding door of the Hale-o-Keawe in 1823 to peep inside (1827:154). His description of his action to open the door sufficiently to see the interior; combined with descriptions of the Hale-o-Keawe door by others who saw it or passed through it (Ii 1959:138; A. Bloxam 1925:73-74; R. Bloxam 1923:79-80) provided sufficient data to determine that the temple door was similar to the one described by Malo and Kamakau. Andrew Bloxam noted that the door was arched and was about two and a half feet high.

Ellis not only described the temple in 1823, he sketched it. Andrew Bloxam both described and sketched the temple in 1825 (see Figs. 35, 36, 38). Note that the Hale-o-Keawe door as sketched by Ellis and Bloxam differs from the descriptions. To show the door at all behind the stockade, its height had to be exaggerated. Doors in many early drawings of Hawaiian houses are taller than their descriptions warrant.

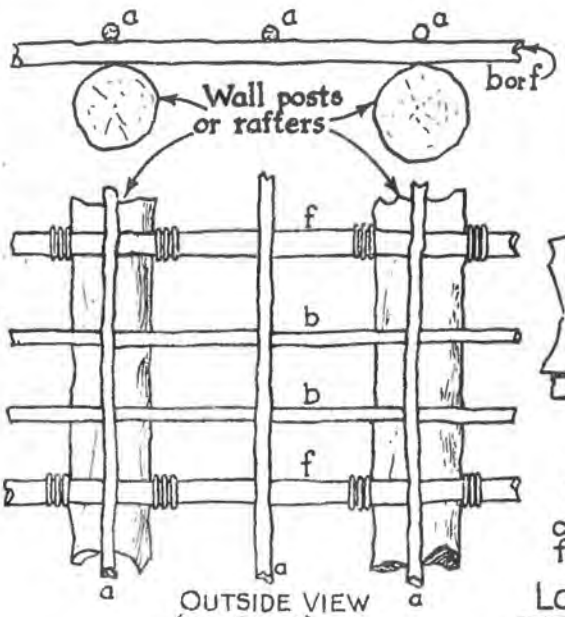
The basis for the elaborate door shown in Figure 11, and the views shown on Plates 6 and 13 were the descriptions by Malo and Kamakau and the three known artifacts. The restored door for the Hale-o-Keawe was built from unseasoned breadfruit wood, rough-shaped by chain saws, rough-planed by machinery, and finished with adzes. The complicated tenon and mortice joints indicated by the three artifacts were not included because of lack of skill and of time to experiment with the massive and limited number of breadfruit wood sections. Instead, holes were drilled after final assembly and wooden dowels were inserted to join the parts. Square holes for the insertion of the purlins into the jambs were made with a chisel. Insects attacked the breadfruit wood shortly after installation. Infestation stopped after repeated paintings with pentachlorophenol.

The March 1820 assignment of a "royal palace" structure to the Rev. and Mrs. Asa Thurston at Kailua-Kona for their use as a dwelling preserves the information that even its royal door was on the front side and that the wall plate was three and a half feet high. This was the limiting factor for the height of this door according to another missionary who visited them frequently (Bingham 1847:91). This "royal palace" was probably a permanent structure made surplus about 1812 when Kamehameha the Great built a whole new complex of houses at Kailua-Kona (Ii 1959:119-122). Some of the new houses had doors and windows in their gable

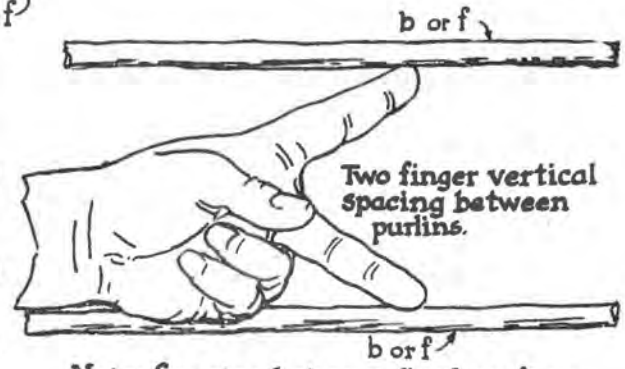
ends. Doors in gable ends are not limited in height by end plates and, although this is not stated, Kamehameha the Great's doors made in 1812 may have been higher than crawl-in size. Other architectural innovations were included in the new complex, such as a house with mortared stone walls, and with an arched doorway of masonry, obviously a use of the Western keystone principle by its French or Portuguese builder. Kamehameha the Great was utilizing some Western ways and fusing them with the traditional. The house for Kekauluohi, one of the chiefesses so sacred she went abroad only at night, had only one door, probably a low one. It faced a high stone stockade for privacy, and the house itself probably was of traditional structure for its sacred occupant and her retinue.

It is believed that the house assigned to the Thurstons in 1820 represents an unadulterated Hawaiian royal structure (except for the hasp and hinged door), a large walled house, and that doors of such houses were low and located on the sides and not the ends. Admittedly, this one house is a small sample, and this had a modified royal door.

Even a royal door three and a half feet high caused a stooped posture to use and was perhaps an aid to an aging monarch. The normal door, two and a half feet high, forced a person to drop to his hands and knees. Such low doors on authentically restored contact-era Hawaiian structures pose problems of access to the modern public. The 24-1/2 inch

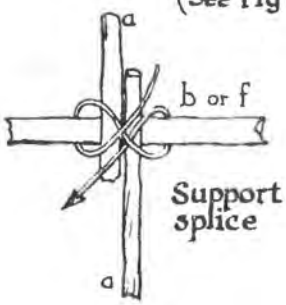


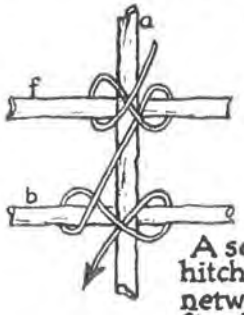
OUTSIDE VIEW
(See Fig 6)



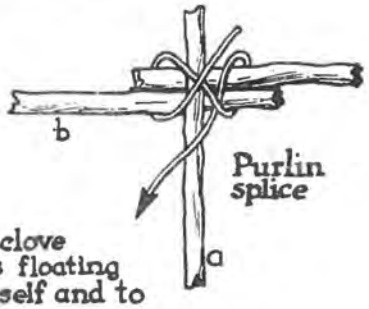
Note: Spacing between fixed purlins is 3 two-finger distances plus the diameters of 2 purlins.
a-*Vertical Support rod*- b-*Floating purlin*
f-*Fixed purlin.*

LOCATION AND SPACING

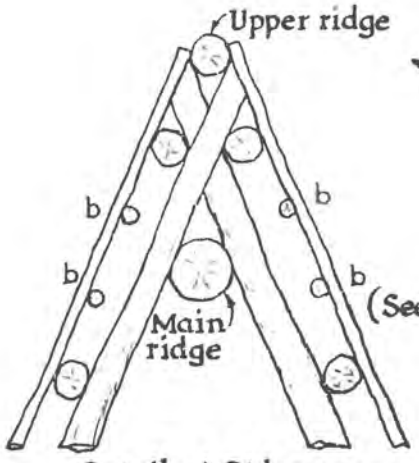




A series of clove hitches binds floating network to itself and to fixed purlins.

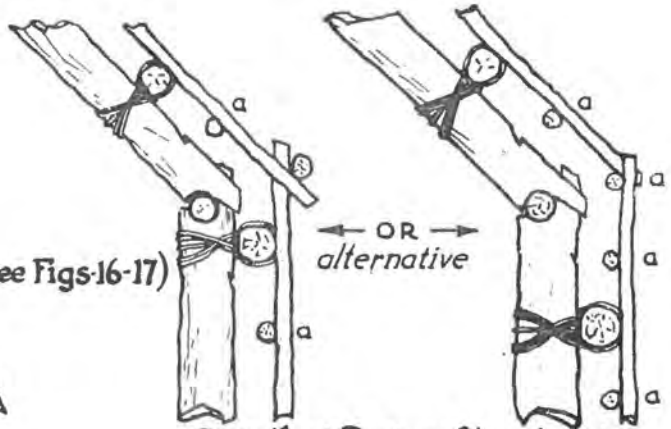


TYING



Detail at Ridge area.

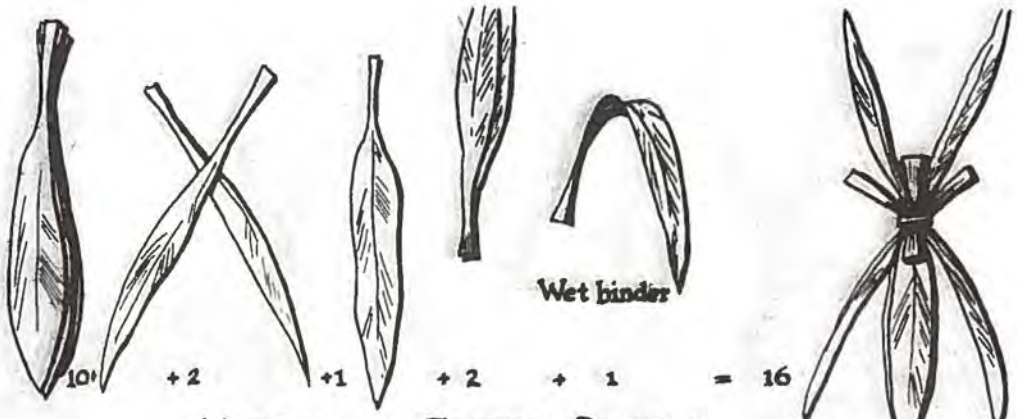
(See Figs-16-17)



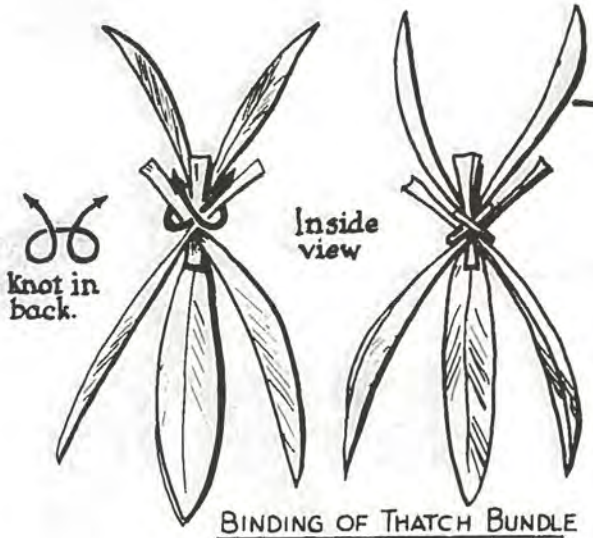
Detail at Post-rafter joint.

PLATE 10.

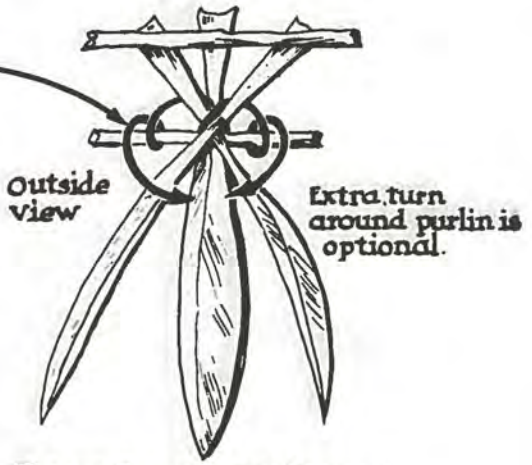
HAWAIIAN WALLED THATCHED HOUSE
THATCH NETWORK



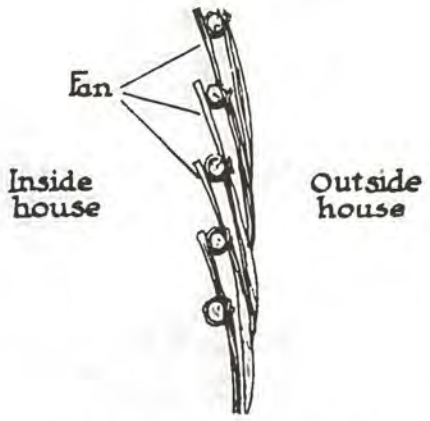
MAKE-UP OF THATCH BUNDLE



BINDING OF THATCH BUNDLE



TIE OF BUNDLE TO PURLIN



VERTICAL SPACING OF FANS

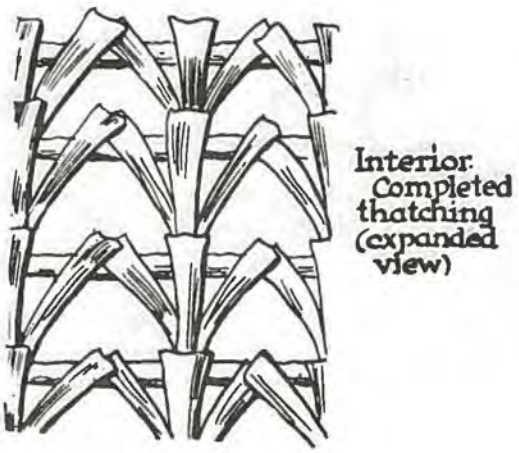
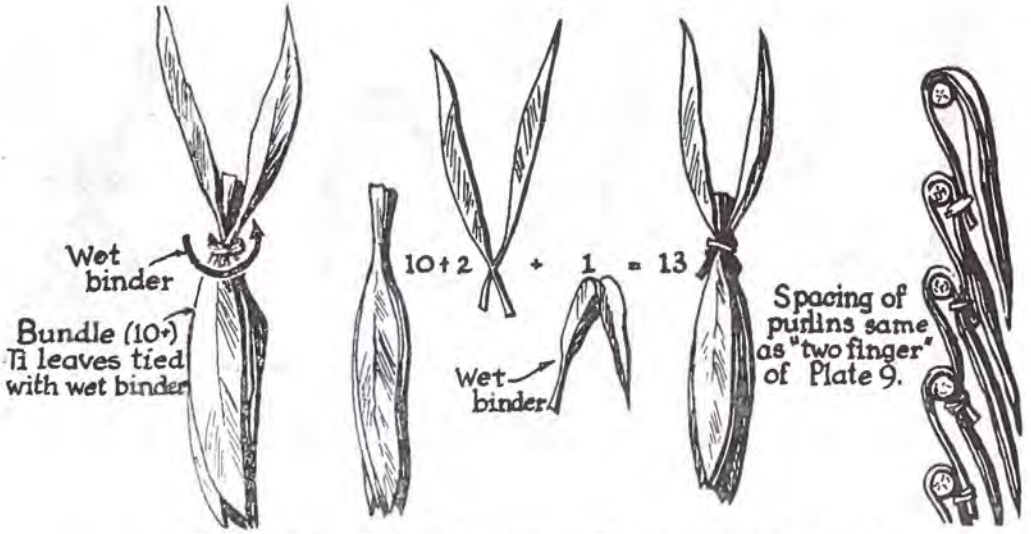
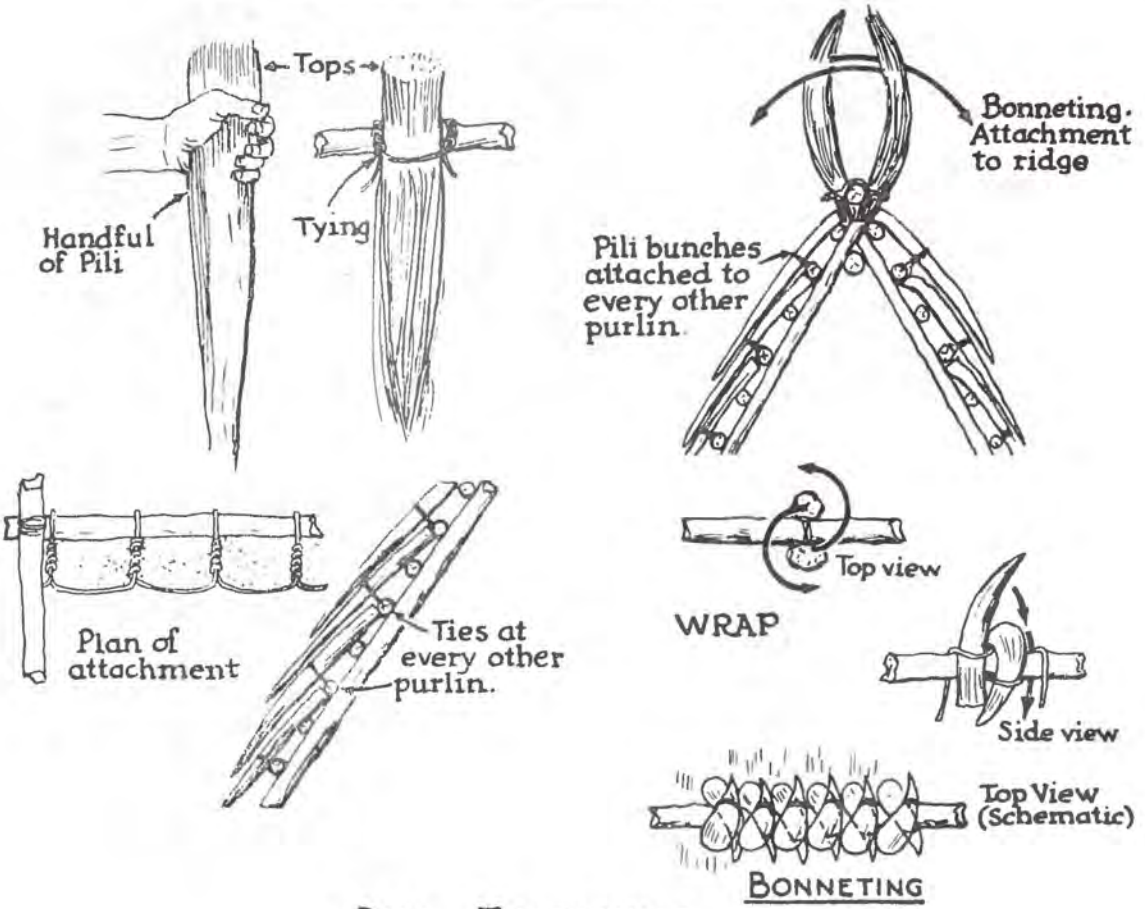


PLATE 11.

HAWAIIAN THATCHED HOUSE
CROSSED TI LEAF THATCHING



TI LEAF THATCHING – TOPS CONCEALED



PILI THATCHING

PLATE 12.

HAWAIIAN THATCHED HOUSE
THATCHING — MISCELLANEOUS



Fig. 23 - Bonneting pili. See Plate 12.



Fig. 24 - Braiding pili thatch on corner.



Fig. 25 - Fishnet cover to "dress" pili thatch.



Fig. 26 - House framing model at Honaunau Bay.



Fig. 27 - Half-size model of Hale-o-Keawe at Honaunau Bay.



Fig. 28 - Peeling off a banana sheath from trunk.



Fig. 29 - Removing pulp from inside banana sheath with 'opihi shell.

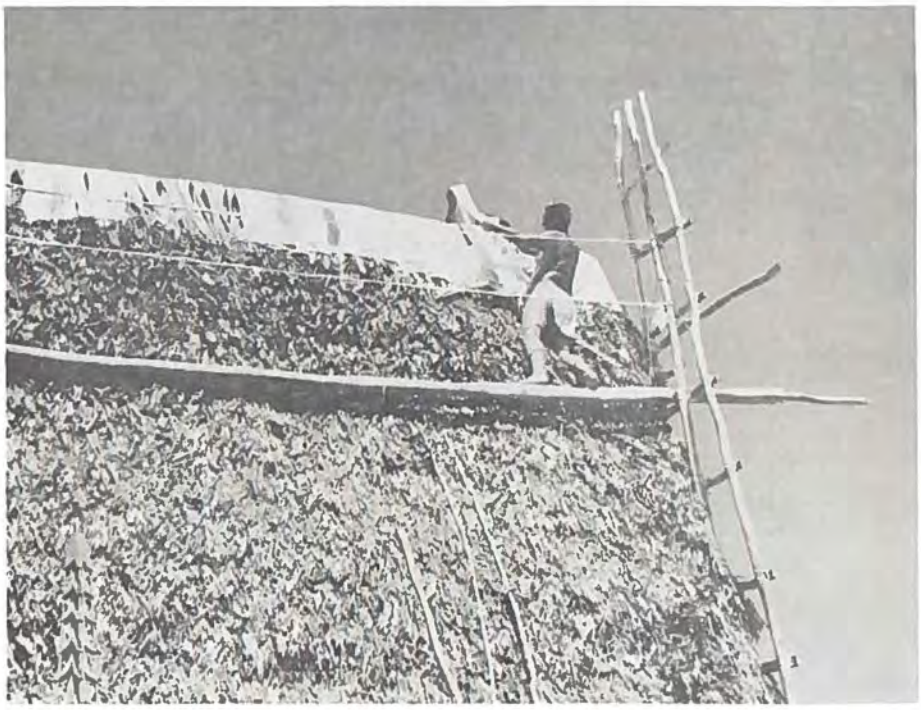


Fig. 30 - Overlapping banana sheaths as rain cap on ridge.



Fig. 31 - Trimming frond of 'ama'u fern.



Fig. 32 - Applying fern bundle as trim to ridge.



Fig. 33 - Small curved-rafter house with pili thatch.

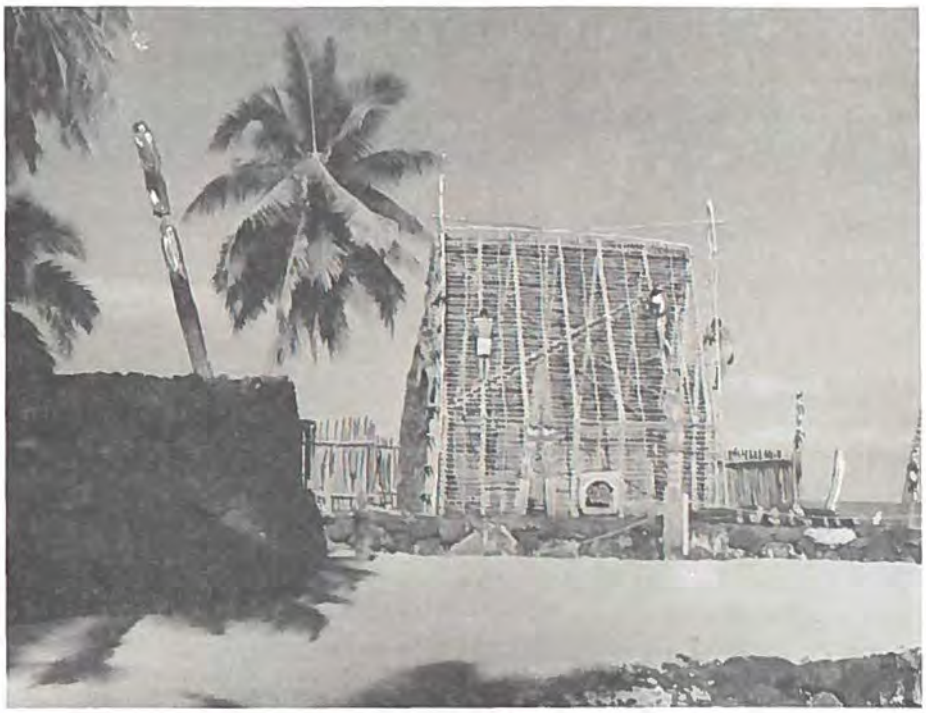


Fig. 34 - Framework with exterior scaffold for large walled house

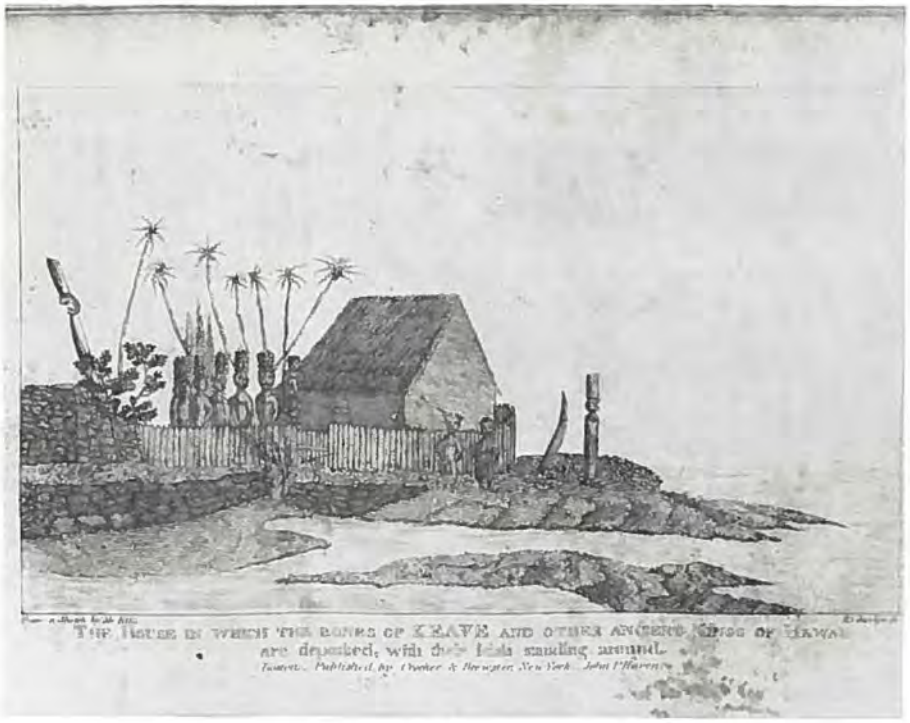


Fig. 35 - Woodcut (after Ellis 1823 sketch) of Hale-o-Keawe in a Boston edition of 1825.



Fig. 36 - Woodcut (after Ellis 1823 sketch) of Hale-o-Keawe in a London edition of 1826.



Fig. 37 - Woodcut (after Dampier 1825 sketch) of Hale-o-Keawe in a London edition of 1826.

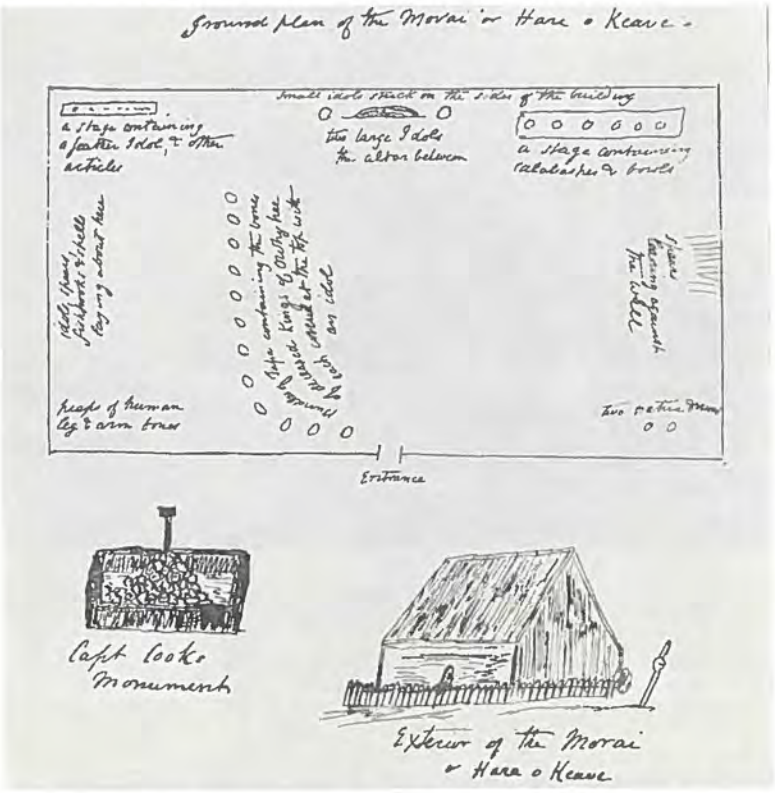


Fig. 38 - Sketches made by Andrew Bloxam in Kona in 1825.



Fig. 39 - Pavement of Hale-o-Keawe platform, restored.



Fig. 40 - Restored Hale-o-Keawe platform open for post hole.



Fig. 41 - Preliminary fitting of a joint, wall post and plate.



Fig. 42 - Adjustment of intermediate posts, back wall.



Fig. 43 - Visual levelling of back wall plate with ocean horizon.



Fig. 44 - Park Ranger interprets work in progress for visitors.



Fig. 45 - Fitting of inside lip of wall post to accomodate rafter.



Fig. 46 - The temple crew: L. to R. Simmons, Kekuewa, Apple, Sasaki, Grace, Puou.

high arched opening into the reconstructed Hale-o-Keawe is not open to the public. The stockade of sharp pointed pickets inhibits entry to the temple courtyard. In keeping with Hawaiian practice, women, even in this age of non-discrimination on the basis of sex, are not permitted on the platform, and both men and women are excluded from access to the temple to reduce vandalism, fire hazard, and souvenir taking.

Over the years, pili grass thatch has been plucked from the grass house on exhibit in the Bishop Museum, Honolulu, thereby exposing thatch purlins on both sides of its door (Apple 1970). Excluding the public from the temple platform at Honaunau is justified in order to protect government property. Such exclusion also helps to preserve the historic scene and lessen the chance of giving offense to the Hawaiian people.

Thatch Networks Assembly

Thatch purlins--upon which thatch was tied--consisted of two types, according to the method of attachment. The fixed thatch network was lashed direct to posts and rafters and consisted of horizontal purlins slightly thicker than those of the floating network. The fixed network could be used for climbing and for standing upon when working aloft. The floating network consisted of horizontal purlins and of vertical support rods which were bound to each other and to the fixed network.

> The space between the posts at the sides and ends is now closed up with sticks, larger than a common-sized walking-stick, which are tied with cinet in horizontal lines, two or three inches apart, on the outside of the posts, and extending from the ground to the top of the roof. A large house, in this stage of erection, has a singular appearance. (Ellis 1827: 315)

> The next business is to prepare a foundation for the thatch. This is done by lashing small round sticks, at intervals of five or six inches, to the posts of the sides and ends, from the ground to the ridge pole; to these the thatch of grass is tied by strings made of the fibres of cocoa-nut husk. (Stewart 1828:138)

Additional functions of the combined networks were to stiffen the house and distribute stress evenly about the framework (see "Diagonal Bracing Assembly" above). Hiroa (1957:90-91) noted that the purlins, "were never in one piece but were joined at some part of their course, probably to maintain an even thickness. Rods of the same length as the house would have been too thick at one end and so have spoiled the even appearance of the woodwork." Splicing of both horizontal purlins and vertical rods is shown on Plate 10. Other applicable Plates are 4, 9, and 13; and Figures 4, 5, 6, 10, 11, 16, 17, 18, 19, 20, 22, 27, 34 and 46.

Fixed Thatch Network

Thumb-sized or bigger sticks were attached horizontally across posts and rafters, beginning from the ground or platform. As attachment proceeded upwards, men stood on those installed below. The back wall was covered first, then the front and then the ends. Each horizontal row along the back

and the front extended an inch or so beyond the end-planes to form support for and to space the purlins placed on the ends. When the fixed thatch purlins were installed at the ends, they were not lashed to the ridge posts but only to the gable end posts and corner posts. Kamakau (1870:137) warned of disaster if the thatch network is lashed to the ridge posts.

Spacing of the fixed purlins determined the spacing of the completed networks and was based on the type of thatch to be used. Fixed purlins were spaced apart so that when the required number of floating purlins were added between them the result was evenly-spaced purlins from ground to upper ridge. Space between fixed purlins was the diameters of the intervening purlins plus the required number of distances between purlins. If "two finger spacing" was called for (see Plate 10), the spacing between fixed purlins was three two-finger distances plus the diameters of two purlins. Once this distance was computed, men carried a short cord with knots tied at the appropriate distances, and used this cord to space the fixed purlins.

One consideration was to avoid placing a lashing: fixed thatch purlin to wall post, on top of or adjacent to a lashing: wall post to wall plate, the most decorative lashing on each wall post. The lowest horizontal fixed purlin on the back wall must be placed so that a higher fixed purlin does not have to be tied over or next to the

post-plate lashing. Then the lowest purlin on the front wall is placed the same distance above the platform. If rows of purlins on both front and back wall were equidistant from the ground, then the rows of end purlins were parallel to each other and to the ground. Slanting purlins resulted in slanting thatch.

"Two finger spacing" was specified by Kamakau for the purlins of a chief's house; for houses thatched with clusters of ti leaves (both with tops concealed and tops crossed); dried banana "bark" (an unidentified part of the plant); or with pili grass for a smooth appearance. Spacing was double this width for dried sheaths of banana trunks, for pandanus and sugarcane leaves; and even farther apart for purlins on poorly built houses to be thatched with sedges, rushes and pili with a rough appearance (Kamakau 1870:136).

But what did Kamakau mean by "two fingers"? Were index and middle fingers held side-by-side; or were they extended; or were the index and little fingers extended straight out or extended? Four different distances are possible. A full size mock-up of posts and purlins was made to test the spacings. Each spacing was tested by thatching with the crossed ti leaf thatching (see Plate 11). The "two finger spacing" shown on Plate 10 was chosen. Narrower spacings more than doubled the numbers of ti leaves used; added to the difficulty of tying leaves to the purlins; and furthermore, the interior design was not attractive.

Wider spacing lost the concealment of the purlins when viewed from inside.

Lashings of the fixed purlins to posts and rafters were visible from the inside regardless of the kind of thatch and/or lining used. The lashing: fixed thatch purlin to wall posts/rafters, was decorative, and is diagrammed on the bottom half of Plate 9. No documentary evidence existed for the throttle, but one was used in the experimental archaeology. It was needed for a firm lashing of purlins which supported men. It was not possible to confirm the correctness of this addition, until disassembly of two original lashings on the Bishop Museum's exhibit house during repairs in February 1970. Both lashings disassembled contained throttles. The museum house also contained a minor difference between the lashings used on wall posts and those used on rafters. Those on the posts contained five "wraps," those on the rafters, three. Finished lashings on the posts appeared as in Plate 9, 6; those on the thinner rafters, as in Plate 9, 5. Throttles were added to both on the museum house.

Pueo was used by Kamakau as one of the terms for any lashing, but specifically always to the lashing of a thatch purlin. The fixed thatch purlin itself was always called 'ahopueo, with 'aho being the general term for purlins, including the floating ones, and as a part of specific names for component members of the thatch networks (Kamakau 1870). (See Plate 13, top left.)

Floating Thatch Network

The floating thatch network, composed of sticks thumb-sized or a little smaller, consisted of horizontal purlins and vertical support rods laced to each other and to the fixed purlins by running clove hitches (see Plate 4, i, j; Plate 10; Figs. 6, 10, 11, 16, 17, 19, 22 and 27).

Installation proceeded from the ridge downward. This direction proved most practical, although the Museum house floating purlins may have been installed from the bottom up (Hiroa 1957:94). Downward installation was specified by Kamakau (1870:138). Men found the downward installation more practical during experimental archaeology because (1) their own weight helped tighten the running clove hitches with a downward pull, whereas if they installed floating purlins in an upwards direction they had to pull up against gravity; and (2) footing was more secure and easier to find without having to select a foothold from both floating and fixed purlins. When floating purlins were installed from the top down, foot positions could be found by feel alone.

If wall posts were widely spaced, thin vertical support rods were placed between posts as well as along post-backs. At the point where rafter met post, the horizontal purlin added at the place where wall met roof could be placed either inside or outside the vertical rods. This option was offered in order to obtain a smooth transition of the thatch from roof to wall. Apparently it was a matter of

pride that this juncture be smooth and free-flowing, not a distinct line. Here, the added purlin was placed (see Plate 10, lower right) to enhance visually the transition. Its location either inside or outside the junction of wall-rod and roof-rod probably depended both on the pitch of the roof and the type of thatch to be used. Other details are unknown.

Waialeale (1870:4) said that if rain falls from a clear sky while purlins are being attached, and a rainbow appears above the roof, this was a sign that the ruling chief will first occupy the house and the owner will receive many benefits (1870:4). This appears to be at variance with the concept that a sacred chief put a house other than his own out of commission if he entered it.

Sources for information on thatch networks, in addition to the Museum house were Kamakau (1870:136-138); Waolani (1919:650); Hooili (1919:642-644); Bingham (1847:116); Ellis (1827:315); and Stewart (1828:138).

When thatch networks had been installed, all protruding ends of wall plates, rafter tops, thatch purlins, and any other timbers which might interfere with the installation of smooth thatch, were trimmed. Figures 13, 14, 17, 22, 27 and Plate 10, bottom, show trimmed ends to facilitate smooth thatching.

Exterior Scaffold

The interior scaffold permitted access to the interior and in large houses was used from the planting of ridge posts through to the ridge-bonneting or sewing-on of fern trim. The fixed thatch network was used for access to the exterior until it was covered by thatch or lining. Thatch was installed from bottom up, and ladders or exterior scaffold were needed to reach and thatch all that part of the house above reaching-limits from ground or platform level. Ladders which leaned on the roof were lashed from three parallel poles and cross-pieces. Three-pole lashed ladders appeared to be more secure than two-pole ladders, and were observed in use in the South Pacific in 1968.

The ladders were lashed to the ends of the house, and long timbers were laid across rungs to give side to side mobility for thatchers (see Figs. 19, 30, 32 and 34). The horizontal poles were moved up as needed. Materials needed for ridge work were hauled up by ropes.

On the Hale-o-Keawe restoration, so much attention was devoted to the ridge area that horizontal timbers were secured on both sides of the ridge. Those timbers on the side away from the ladder (see Fig. 19) were supported on horizontal poles lashed across the ends. Tops of the ladders were braced with temporary timbers. Thatching of the top at the ends of the house was delayed until the ridge work was completed.

On smaller walled houses, one or more logs were hung at appropriate distances below the ridge along the sloping roof for workers to climb and stand upon. The logs were hung from ropes attached inside the house and passed over the main ridge to hang outside and be tied to the log or logs.

On houses smaller than the Hale-o-Keawe, ladders were moved about as necessary. The elaborate scaffolding which incorporated the ladders was not needed. Ladders were made of 'ohi'a poles. Those observed in the South Pacific had poles of sturdy bamboo and rungs of an unidentified wood.

Thatch Assembly

This discussion is limited to the types of thatch done during field study. These were (1) crossed ti leaf; (2) ti leaf with tops concealed; and (3) pili thatching. Details of other thatchings and linings may be found in Hiroa (1957: 102-106).

Durability, and perhaps leakability, of thatch depends on thickness. The thicker it is the better. The first director of Honolulu's Bishop Museum, Dr. William T. Brigham, first visited Hawaii in 1865 and during his travels stayed in and saw many Hawaiian thatched houses. He wrote

> . . . the durability of the roof or wall and its impermeability depend much on the thickness of these successive layers. We have seen that in the Fijian house the thickness is very great, much exceeding any I ever saw on the Hawaiian group, but then it must be remembered that I saw this work here [Hawaii] only in its decadence. (Brigham 1908:97)

Thatching followed the usual procedure: back first, then front, ends last. In a house to be trimmed with fern, the upper foot to two feet of the ends were not thatched, but left open as vents to be covered only with fern trim.

Ti Leaves

As used by Kamakau (1870) lau'i means a ti leaf or leaves which are dead, having fallen off the plant naturally, and usually dried further after falling and before gathering. Green ti leaves pulled from the plant and dried are not usable, nor are green ti leaves themselves. "Dead and dried ti leaves" was the phrase used in broadcasting specifications for the hundreds of thousands requested for the Honaunau project. Rainfall upon dead leaves scattered on the ground under ti plants does not affect the leaves' utility, unless any have been wet so long or repeatedly that disintegration has begun.

To be usable, the dead and dried ti leaves must be properly soaked. Leaves destined for binders are completely submerged; those for the rest of the bundles are soaked so as to include only stems under water. Water can be fresh, salt, or brackish. The fishponds at Honaunau were used for large quantities, but leaves were also soaked on occasion in barrels and tide pools. In placing leaves in the fishponds, about 100 or so were bundled with stems lying all one way, bound with string, and then the bundles were placed stems-down in shallow water. In the fishponds, rise and

fall of the tide alternately wet and exposed the stems. If the stems had been submerged all the time, the rise of the tide would have subjected the leafy portions to alternate wetting and drying, a process which weakened the leaves. Soaking time was 48 hours. A longer soak made the tops (stems) too soft to remain erect in the thatch bundle. Binding-leaves, including the two "rabbit ears" of each bundle, were totally submerged for 12-24 hours. Their strength while wet was remarkable, and they could not be pulled apart by the hands of a muscular man. When dry, ti leaves may be easily torn.

After lau'i preparation had been rediscovered, Apple made three pairs of ti-leaf sandals in ten hours with his unskilled hands; and a ti-leaf raincoat in eight hours, following directions left by Hiroa (1957:213-215, 249, 250-252). Appreciation of the versatility of lau'i was gained. Sandals and raincoat were used in the interpretive program of the City of Refuge National Historical Park.

Makeup of the thatch bundle (pe'a lau'i) for crossed ti leaf thatching and binding of the bundle to the purlins are delineated on Plate 11. For concealed ti leaf thatching-tops (stems) (pe'a lau'i po'ohuna), see Plate 12, top. Not illustrated is the first step. The soaked stem was flattened and straightened by drawing each leaf over a straight edge, such as the edge of a table. The widest and longest leaves were used for the three which form the decorative cross of

each bundle. Figures 18 and 20 show the decorative pattern achieved for the lining; Figures 27, 28 and 30 show the bushy exterior.

In the experimental archaeology, assembly line production kept two days' supply of leaves soaking. The day's supply was taken out of the water as work began. The morning was spent in making up bundles, the afternoon in tying the bundles on the purlins, and in setting leaves to soak for two days hence. The thatching team consisted of four men. Three men worked outside and applied the bundles. The fourth man worked inside and straightened and adjusted the "fans." An average day saw the four men make up 254 thatch bundles and add them to the purlins. Each bundle consisted of 16 leaves. More than 4,000 leaves were put to soak each day. Those dead and dried ti leaves were donated, and came from all of the Hawaiian Islands. (Donors are listed in the Appendix.)

Approximately 390,000 dead and dried ti leaves were used to thatch the restored Hale-o-Keawe; or slightly less than 25,000 bundles of 16 leaves each applied to the purlins. This was approximately 372 leaves per square foot of exterior area.

The National Park Service method of affixing the crossed ti leaf thatch was based on the standard federal work week and a crew of four men. Kamakau (1870:140-141) indicated that the Hawaiian method was to make up the thatching

bundles in advance and stockpile them until enough had been prepared to thatch the entire structure. The crossed stem portions of the bundles, including the two "rabbit ears" of the bundle used to tie the bundle to the purlins, were then resoaked to make the tops (stems) pliable and to wet "rabbit ear" ties. Thatching then became the order of the day for all available hands.

Re-creation of the ti leaf thatching methods was a result of constant feedback and consultation between the experimental archaeology team at Honaunau and Hawaiian-English translator Mrs. Dorothy B. Barrere of the Bishop Museum. The solution of the process took more than three years of intermittent attention. Kamakau's description was far from giving step-by-step instructions. The process was evolved a step at a time, with many retracings to start over again from the last successful step. Many attempts at translations were necessary. The process was re-created to satisfaction before restoration of the Hale-o-Keawe began.

Pili

The better pili houses had a thin layer or veneer of grass next to the purlins which was offset and reversed (heads up, root ends down) to form a lining which hid the rest of the thatch and made a smooth-looking interior (R. Apple 1970; Brigham 1908: Plate XXVII; Hiroa 1957: Fig. 68, p. 99). Although not tried in experimental archaeology, the technique appears easy. The offset put

root ends of the lining layer about six inches below the top of the rest of the handful of pili. The rest of the handful of pili had root-ends up. This lining hid the root ends which otherwise would be seen if thatch bundles were applied without it.

The normal thatching used was root ends-up for the whole bundle. This placed the flower ends hanging down to permit rain to drain off. In harvesting, it was important that root ends all be faced one way, and careful transportation to the house site in this manner facilitated thatching. The thatcher could reach into the stockpile of grass to grab a handful without worrying about the orientation of individual stalks.

Bingham described pili thatch as "grass bound on in small bundles, side by side, one tier overlapping another, like shingles" (1947:116). While small bundles (actually handfuls) formed the thatch, care was taken to make a smooth exterior which showed neither handfuls nor rows. The tying and plan of attachment both horizontally and vertically shown on Plate 12 are designed to form a smooth exterior. The thatch purlins for this smooth exterior were set at "two finger" distance apart, and the grass, depending on its length, was attached to every other, or to every third, purlin. The intervening purlin(s) formed a backing for the grass to support it in place thereby achieving the smooth exterior. Poorer houses had purlins set apart at double

the "two finger spacing," and no doubt the tiers were evident. Thatching began at ground level, and worked up to the ridge.

Plate 12 delineates pili thatching techniques. (Applicable figures are 23, 24, 25 and 33.) The thatcher's left hand held the bundle in place as the right hand thumped it, hit it with fist, and then both hands kneaded the handful into shape to match in thickness and compaction the adjacent one already fixed. During this action the right or left hand held a ball of cordage, fixed end of which came from the turns about the tight cord which held in place the adjacent handful. Depending on the character of the cordage, the free end of the binding cord might be left hanging while the thatcher prepared the next bundle. If the turns which bound the last bundle did not loosen when the pull was released, then it was safe to let the free end hang. But if the cord slipped, then tension was kept on the free end. The extra turns of cordage about itself insured a straight face along the row of bound handfuls. Without the turns each handful would have taken on a rounded shape. To produce a fine finished product, each handful, in addition to being pounded and compacted, could also be combed with a short stick to remove loose grass stalks and to align those slightly askew. When not in use, the stick was thrust between the thatcher's malo and his body (see Hiroa 1957: 103).

Like shingles, rows of thatch were applied from the bottom up. The tops of the upper and last row were so set as to be just below the upper ridge pole. The gap between the sides was closed by bonneting.

Harvesting of pili before mechanical mowers, sickles or scythes became available was done by pulling up the grass, roots and all. Dirt which clung to roots was knocked or cleaned off before the plant was thrown upon the pile to be transported to the house site. A thatching handful included a number of plants, root ends up. Binding cords were tied below root ends, of course (Apple 1970:4).

Variables in estimating quantities of pili necessary to thatch a given area include the length of the grass and the desired thickness of the thatch. With these variables in mind, it is estimated that 100 cubic feet of harvested pili will thatch 125 square feet of house.

Finishing Operations

Bonneting Pili

One layer of bonneting is shown on Plate 12. This layer was attached to the upper ridge pole. Two men did the work, one on each side of the ridge. Each man held a binding cord. The cord was attached to the upper ridge pole and was used to bind the handful of pili with its root ends down. This is a reversal of the usual thatching position of root ends up. The binding cord was passed around the handful, over the top of the pole, down the opposite side

from thatcher "A" and came back to "A" from the bottom of the upper ridge pole. When the handful of pili was secured (no turns about the cord were necessary) and the cord was tight, thatcher "A" took the flower ends of his handful of pili and pushed them toward thatcher "B". Thatcher "B" received them, and simultaneously pushed the top of his handful toward "A". Each grabbed the top of the other's bundle. "A" took the top of the handful given him, and further bend it over until it was snug against the ridge pole and covered the base of his handful. A stone could be used to pound and compact each bent-over handful. His cord went around the bent top to hold it in position. The cord was passed under the ridge, up and around, to come out again, ready to bind the bottom of the next handful. The men worked in pairs, each binding the bottom of a handful of pili and binding the bent-down top of the opposite bundle. A single length of cord bound a number of bundle bottoms and tops before it was fastened to the pole and another roll of cord started. It was possible for one experienced man, a journeyman bonneter, to sit astride the ridge and do the bonnet-work alone. This was done at Makaha valley in 1970.

When one row of bonneting was complete from end to end of the upper ridge pole, an additional pole could be laid on top of the first bonnet and lashed in place to the upper ridge pole or to the bonneting cords. The supplementary

pole ('aho lolo or lolo 'iole in Hawaiian) was bonneted in the same manner as the first. Several additional layers of bonneted poles could be added in the same manner. They decorated and raised the ridge section, and thus would have been reserved for houses of chiefs. They may also have served to provide additional protection against leaks. The ridge was the place most likely to leak.

Brigham (1908:95-96) believed that the hipped roof became popular because of its short ridge section, and that closure of the ridge against leaks was an art known only to a few men.

Braiding Pili

Braiding, or plaiting, certain sections of a house thatched with pili was both decorative and practical. The braiding of the lower area of the bonneting helped tie down the bent-over thatch handfuls, led off the rain, and resisted wind which might lift up pili flower ends along the ridge. Corners were braided to keep stray stalks from scratching passing bare-skinned humans who turned the corner close to the house. Bare-skinned humans also passed in and out of the doorway, and doorway sides were braided. Freshly harvested pili accepted braiding, but pili stored more than a few days did not braid well. It was too stiff.

Each descending handful of braid incorporated additional stalks as it lost stalk ends which had run their length. It was a running braid of constant thickness which utilized only

the surface of the pili and incorporated available grass at each point.

When braiding was completed, a fish net could be draped over the entire house and weighted down along its lower extremities with rocks. This can be compared to a hair net. After several days, the net was removed to reveal a smooth, flowing exterior. Again, freshly harvested pili accepted dressing with a net, while dry grass resisted setting.

Banana Sheath Rain Cap

"The thatching of the ridge thatched with clusters of ti leaves, a hale pe'a lau'i, or one thatched with lauhala or sugar cane leaves was different from that of a house thatched with pili grass, . . . or other grasses. The ridge of a hale pe'a lau'i could not be plaited as the spaces (hakahaka) would become passageways for the rain, so they were thatched with 'ama'u fern (lala 'ama'u) tied on with cords of 'ie, or coconut husk fibers ('aha), or of coconut sheath fibers (lolo niu)" (Kamakau 1870:134).

For the first step in trimming with ferns, Kamakau (1870:139, 143) listed a rain cap dried of banana trunk layers (pa'a'a mai'a). Trunks of banana plants ("trees") were cut to sufficient length so their layers could be draped over the ridge. For the restored Hale-o-Keawe this length was 68 inches. Layers (sheaths) were peeled off by hand. About ten sheaths came from each trunk, and their widths diminished as the diameter of the trunk was reduced

(see Fig. 28). Each layer was scraped (see Fig. 29) on its inside to remove pulp and juice and to thin the layer. An 'opihi shell was the scraper.

When dried banana trunk layers were used for lining, Kamakau (1870:139) specified they were placed in the sun to dry, then set up as a lining sandwiched between the thatch purlins and the pili. It became evident in experimental archaeology that sheaths dried in direct sunlight shred and split, but sheaths dried in the shade harden in their drying positions. In both situations, the almost-white layers turned brown and shrank in width. Side-to-side shrinkage during drying--which took about five days in the shade--exceeded 60 percent and approached 75 percent. A six inch-wide, freshly scraped sheath dried to a width of about two inches; a sheath ten inches wide when peeled and scraped dried to about four inches; a 14 inch-wide sheath reduced to six inches. Future experiments may find another variety of banana plant whose sheaths have less shrinkage. Once dried, sheaths resisted bending, were hard and stiff, and to Kamakau were "as shiny as dress silk." Sheen was evident on the dried layers. Drying experiments indicated that sheaths for rain caps were dried in place across the ridge--probably shaded by the fern trim--and that the side-to-side shrinkage characteristic of the sheaths was behind Kamakau's statement that the sheaths were packed thickly.

The freshly scraped layers, while still wet and pliable, were hauled up to the roof and draped across the ridge, over the upper ridge pole, from back to front (see Fig. 30). Layers were spread from end to end of the ridge, each sheath overlapped the previous one to leave only about two inches of the lower one exposed. Eight layers were found necessary; that is, the covering was eight layers thick.

Their position when dried conformed to the contour of the ridge area. The eight layers insured that as the sheaths dried and shrank, there were no openings through which rain could drip. As a rain cap, thickly applied sheaths bridged the opening between the back and front sides and diverted rain drops to the outside of the lower ti leaf thatch.

To hold the slippery rain sheaths in place as they dried, thin cords sewed the sheaths to the upper ridge pole. The sewing began at one end of the roof, and the stitches ran diagonally over the sheaths and ridge and directly under the ridge (between the upper ridge pole and the main ridge pole) to return for the next diagonal stitch. A needle of split bamboo, about 28 inches long, with a notch to catch the cord, was used to pass the cord under the upper ridge and penetrate through the sheaths. The needle was flat and was pushed through in vertical position to spread the fibers of the sheaths and not tear them.

When the sheaths were in place, battens were added to hold down the sheaths as they dried as well as to form a base for the fern trim (see Fig. 32). The battens ('aho holo) were about thumb size and spliced as necessary to run the entire length. They also were sewed on. Five battens were attached to each side of the ridge about four to five inches apart. The lower two on each side required a man on the interior scaffold to return the needle, but the upper three were above the main ridge and the long bamboo needle passed between the space above the main ridge and below the upper ridge pole and passed directly to the other side. The top three battens on each side were installed simultaneously using the same cord.

Sufficient manpower, planning and experience would have permitted the freshly scraped and pliable banana sheaths to be sewed in place, to add the battens, and apply the fern trim on the restored Hale-o-Keawe in one day. This would have insured that the banana sheath rain cap could have dried under the shade of the ferns. Inexperience with the materials and techniques, plus a standard federal weekend, forced an expedience to meet this situation. The banana sheaths dried in place on the ridge under black plastic sheeting. The plastic sheeting was left on from late Wednesday May 29, 1968, through early morning of Tuesday June 4, 1968, an interval of five days. An inspection of the sheathing dried in place showed that the eight layers

were sufficient to close the gap against rain.

Fern Trim

A frond of 'ama'u fern has a central stem with frondlets on each side (see Fig. 31). If held horizontally, bottom down, the branch from side to side is convex; each side curls down to prepare a frond for use in a bundle, one side is cut off. Half of the fronds had one side cut off, the other half the other side. This permitted all eight fronds in each bundle to curl the same way, with four thicker ends of the central stems at each end of the bundle. Cords at each end bound the bundle. Trimming of one side of each frond was done in the forest as soon as the frond was cut from the fern. Trimming after the frond had dried even partially was more difficult; and, when a frond was fully dried, the trimming activity, in addition to being difficult, caused the loss of some of the dried ends. Each tied bundle of eight half-fronds was about two feet and a few inches long. Some bundles of longer ferns were almost three feet long. Reversal of half of the fronds in each bundle made for a uniform width of about a foot. Dispatch in trimming fronds, assembling them into bundles, and sewing them in place on the battens at the ridge was necessary, because dried bundles tended to disintegrate in handling. Fronds were best handled when freshly cut, and left to dry in place as trim. Stockpiling of fronds or bundles proved wasteful.

Each bundle, with curl up toward the sky and curling inward, was sewed to the lower side of a batten. The long bamboo needle enabled workers to make about four stitches along the length of each bundle to secure it to the batten. The lower side of battens was chosen so that the curl would hide the battens from below. A second bundle was then attached below the first to double the bundles and thicken the trim. (Only one was used on the restored Hale-o-Keawe and this proved to be too thin.) Two bundles should be placed above the lowest batten, with curl facing down, to hide the batten and blend the trim to the thatch. In a vertical line up the ridge area, on either side were ten or more bundles of fern, with the lowest two curled downwards and the upper eight curled upwards. The upper bundles extended above the ridge with their curls touching the upper bundles of the opposite side.

The arch of the ridge was reproduced in the arch of the fern trim. This arch was accented and made to appear greater through shaping of the fern trim above the arch. The trim above the ridge was cut more towards the ends than at the center. Such shaping was done after all the trim had been applied and while the ferns were still green. An expert could do the job well.

After the fern trim had been added to the ridge, the upper foot or two of the house ends, which had not been thatched with ti leaves, was covered with fern bundles.

Again the lowest bundles curled down, and those above curled up. This left covered vents at the upper ends of the house to permit ventilation. Battens, four on each side of the corners from ridge down to the ground, were then sewed on top of the ti leaf thatch. Bundles of fern were sewed to the battens, with curls in appropriate position (see Fig. 50).

Fern trim continued to symbolize rank well into late monarchy times, even though frames were usually hipped. Houses of members of the reigning Kamehameha family carried this traditional symbol of sacredness until the late 1800s (Brigham 1908: Figs. 66, 72, 94, 95).

Thatching Sources

Both Kamakau (1870:134) and Waialeale (1870:6) indicate that houses thatched with sugarcane leaves as well as houses thatched with ti leaves might be trimmed with fern. Kamakau also listed lauhala. Hooili (1919:646) gave a variation on Kamakau's technique, which was described above. Hooili split the central stem to get two usable halves of each 'ama'u frond, and laid one half over the other so that they had an even width for their entire length. He mentioned no bundles of fern, but either assembled the fern on two long sticks on the ground and placed the preassembled trim on ridge and corners; or else assembled the trim directly in place on the house. This latter method resembles Kamakau's technique, but apparently did not use bundles.

In the early 1790s, Vancouver (1967: I, 175-176) saw fields of pili grass on fire, feared that they were signals of a native uprising, and did not believe the Hawaiians' explanation that such burning produced better and more quantities of grass for thatching (Menzies 1920:31-32, 34; Manby 1793:16-17). Missionaries Ellis (1827:47, 153, 159, 313, 315); Stewart (1828:290; 1830:367); Bingham (1847:115, 116); Bond (1927:128, 145-146) and Lyons (1945:39) contributed information on thatching. British naval captain Byron (1828:120) and missionary Stewart (1828:290) attest that fern trim was among the features which distinguished high chiefs' houses from those of commoners.

Hawaiian sources for thatching were Kamakau (1870:134-136 passim; 1964:135); Waolani (1919:650-651); Waialeale (1870:4, 6); Kaawa (1865); Hooili (1919:644-646) and Malo (1951:121, 124n).

Scaffolds, Floor and Door

Scaffolds were no longer needed once the bonneting or fern trim was completed. Longer timbers of the interior scaffold might have to be cut apart inside the house to permit removal via the doorway. Once the interior scaffold was removed, the floor of small pebbles or dirt could be spread. Probably any pili grass left, was used for the first covering of hay over the finished floor. On this mats were spread for sitting and sleeping.

The few house furnishings of the unadulterated Hawaiian house are listed in Malo (1951:78, 122-123; Campbell (1967: 130-131); Valentine (1875:38); Freycinet (1829:6-7); Bond (1927:137, 158); and Ellis (1827:138, 320, 373, 377-378); and are discussed by Brigham (1908:121-194) and Hiroa (1967:107).

Brigham (1908:99-100) discussed doors, and it appears that unelaborate door closures of houses of commoners and lesser chiefs were just mats. Any door closure installed at this point of assembly would not be incorporated into the frame. (See "Elaborate Door Assembly," above.)

Malo (1951:121, 124n-125n) and his translator-editor give the most detail about birth-of-house ceremonies. They were discussed in "The Gods Watch" section of Chapter I. Such ceremonies are referred to by Kamakau (1870:133, 146); Marin (ca. 1815:112); Ellis (1827:319) and Hooili (1919: 646-647). The heart of such ceremonies was the cutting of the tuft of thatch over the doorway, the symbolic cutting of the umbilical cord of the house to signify its birth.

CHAPTER IV

STRUCTURAL ACCULTURATION

Hawaiian thatched structures of the late 1700s and early 1800s were products of centuries of development. Hawaiians used available materials to build Polynesian houses and temples suited to their climate and to social-religious needs.

The invading Western culture started to make its inroads in 1778, but did not greatly modify Hawaiian structures until 1819. Then, with the death of Kamehameha the Great and the subsequent overthrow of the taboo system, a drastic change in social-religious conditions occurred, undoubtedly a result of forty-one years of acculturation. This change eliminated one whole class of Hawaiian structures--the major temples. But two such temples (Hale-o-Lono in Waipio Valley and Hale-o-Keawe at Honaunau Bay, both on the Island of Hawaii) survived for a few years longer. Many of the massive, dry-masonry platforms of Hawaii's major temples still stand in 1970.

After 1819, changes in thatched Hawaiian houses and their eventual elimination may be charged to the increased influence and acceleration of the invading and conquering Western culture, spearheaded by Christian missionaries. Doors into thatched Hawaiian structures were raised from crawl-in to walk-in size. Openings in walls were cut to

admit light and air. Commoners raised their ridgepoles so they could stand inside their houses, and generally enlarged their thatched structures. House frames changed as hipped roofs were substituted for gabled. Corrugated iron or board ridge caps replaced grass bonnets. Nails replaced lashings. Imported materials and architecture found increased favor. Finally, the thatched house vanished from Hawaii.

By 1910, some isolated coastal village houses still reflected a blend of Hawaiian and Western architecture. They had walls of thatch and roofs of corrugated iron (Jackson 1966:44, 55, 56). With the abandonment of isolated coastal villages (Jackson 1966:76; Coulter 1931:3, 5). Western architecture triumphed. Abandoned village sites dot many of the remote coastal areas of the Hawaiian Islands. (One such is Kaunolu village, near the southeast cape of Lanai Island. It is a Registered National Historic Landmark.) In 1879, the last "grass thatcher" (probably a bonneting expert) died at Waimea, Kohala district, Island of Hawaii (Lyons 1945:206). Those who built traditional grass houses at Ki'ilae Village, South Kona, Hawaii Island, were dead in the early 1900s (Jackson 1966:51-56). In 1935, a few reliable informants were still alive in the Ka'u district of the Island of Hawaii, but only one was left in 1950 (Handy and Pukui 1958:ix). Concurrent with the deaths of the last Hawaiians who knew the skills of their house-building ancestors, Western structures supplanted Hawaiian

before the mid-twentieth century. Thatched Polynesian houses abound in Tonga, Western Samoa, American Samoa and the Society Islands in 1970, and many alive in these island groups are proud of their skills. But Western structures have invaded and are becoming more and more popular. The few thatched structures found in Hawaii in 1970 were built for exhibition purposes and most are suspect as to authenticity. They are not used as dwellings but as landscape features, and most incorporate imported or introduced materials and methods.

The structural types, built entirely of native materials and of Hawaiian design found in Hawaii in 1778--and the ways of Hawaiian life which evolved them and found them suitable--have gone. The task of rebuilding representative Hawaiian structures became an exercise in experimental archaeology.

From Cook to Bingham

Captain James Cook, British Royal Navy, discovered the Hawaiian Islands for the Western world in 1778. The Reverend Hiram Bingham, in 1820, led the pioneer Christian missionary company to Hawaii for the American Board of Commissioners for Foreign Missions in Boston. Cook explored; the missionaries came not only to live in Hawaii but to "aim at nothing short of covering these islands with fruitful fields, and pleasant dwellings and schools and churches, and of raising up the whole people to an elevated state of Christian civilization. . . ." (Missionary Album 1969:17). The

"pleasant dwellings" portion of their charge is of interest below in "Bingham and his Brethren." But the pioneer mission company which arrived forty-two years after Cook found the pagan temples destroyed as well as other important, if minor, innovations in Hawaiian architecture. There were a hasp and hinges on a royal door, some window-like openings and doors in a gable end of more modern royal palace structures; but essentially the mass of houses in Hawaii in 1820 were still low, windowless thatched structures with crawl-in doorways. Far more important as evidence of forty-two years of Western contact were the rare predominately-Western structures interspersed among the traditional Hawaiian ones. These reflected imported skills and the influence of a few Western residents on Kamehameha the Great who, before his death in 1819, had united all the Hawaiian Islands into the Kingdom of Hawaii. These influential foreign residents built a few Western-type structures for themselves, with Kamehameha's permission. Other westerners built a few Western-type structures for Kamehameha's dispersed palace complexes. Such a structure was the mortared stone treasure house at Kailua-Kona, with the arched doorway, built ca. 1812 (see Kotzebue 1821: I-323). There were other royal stone houses standing by this time in Honolulu, one mortared with mud (Ii 1959:120). Another royal structure was the "brick palace" of Kamehameha the Great at Lahaina, Island of Maui, built sometime between 1798 and 1802 (Fredericksen and

Fredericksen 1965:3). Francisco de Paula Marin built a wooden storehouse for Kamehameha the Great at Kealakekua Bay in February and March 1813 (Marin ca. 1815).

After 1790 the foreign population grew. Many were transients, some were settlers. About sixty were in residence on Oahu Island 1809-1810 (Campbell 1967:118; Kuykendall 1957:26-27). Many probably lived as those did about 1847 at Kohala, Island of Hawaii, with Hawaiian "wives" and occupied "houses built in the same manner and in no way superior either within or without" to the Hawaiian population at large (Bond 1927:137).

The three most influential resident westerners to Kamehameha the Great were: Welshman, Isaac Davis; Spaniard, Francisco de Paula Marin; and Englishman, John Young (Kuykendall 1957:27). Davis, who died in 1810 and lived in Honolulu

> was married to a native woman, by whom he had no children. By a former wife he had three, two of whom were left under the charge of Mr. Young of Owhyhee. His house was distinguished from those of the natives only by the addition of a shed in front to keep off the sun; within, it was spread with mats, but had no furniture, except two benches to sit upon. He lived very much like the natives, and had acquired such a taste for poe [poi], that he preferred it to any other food. We had, however, at all times abundance of pork, goat's flesh, and mutton, and frequently beef sent by Young from Owhyhee; and in the mornings and evenings we had tea. His wealth, consisting of mats, feathers, and cloth, the produce of the island, and a large assortment of European articles, which he had acquired by trading with the ships that touched here; these were contained in a large storehouse, built of stone, adjoining his dwelling. (Campbell 1967:98-99)

In 1817, Kotzebue recorded of Honolulu, Marin's house and his non-native plants and animals, this paragraph:

> The houses in Hana-rura, which are sometimes joined together in long rows, and sometimes lie scattered, resemble those of Owhyee. Some Europeans who have settled here, live in houses, which may pass for a kind of medium between those of Europe and of this country. The Spaniard Marin, who has built a stone house, is to be recommended to everybody who visits the island Woahoo. He has introduced many useful plants, to the growth of which he pays attention, and is the only one who possesses a tolerably large herd of oxen, cows and sheep. . . . A naked islander every evening drives home Marin's herd, among which are several horses which he has got from America. (Kotzebue 1821:332-333; see also Ii 1959:120 for mention of Marin's stone house.)

John Young, whose Hawaiian name was Olohana, seems to have been involved in every event of importance in Hawaii from 1790 through 1820. He was governor of Hawaii Island from 1802 through 1812, and then remained resident chief on his lands at Kawaihae until his death at about the age of ninety in 1835. His grave is among those of the high chiefs at the Royal Mausoleum on Oahu. Young received at Kawaihae Hawaii's first cattle in 1793 and first horses in 1803; safeguarded Kamehameha's arsenal; completed the Russian fort which gave a Honolulu street its name; piloted foreign ships around the islands; and advised Kamehameha the Great in the king's dealings with westerners. Young was among the chosen few who buried Kamehameha the Great in an undisclosed place in 1819. He was also present a few months later to carve the meat at the meal when Kamehameha II abolished the Hawaiian religion, ended the taboos, and

ordered the temples destroyed. The 1820 decision which permitted the pioneer company of Christian missionaries to land and live in Hawaii was based on Young's advice. His granddaughter, Queen Emma, was married to Kamehameha the Great's grandson, Kamehameha IV (R. Apple 1970b:20-22).

Probably the earliest structure, and the only early predominately Western structure with walls still standing, is John Young's principal house at Kawaihae, Kohala district, Island of Hawaii. Coral blocks from the reefs at nearby Puako were brought by canoe between August and December 1798. Mortar and plaster was made from sand, burnt coral and mixed with poi and hair, probably from goats.

> Have begun four buildings. My house the cook house and storage room the house for the children and tahus [guardians] and near the small temple a house for storage. My house at the small rise below the great temple [Pu'ukoholā] more suitable then the ravine which washes away withe [sic] Whymea floods. The great one [Kamehameha] comes to use my cook house several times. I make biskits and cook a lamb Have all enjoyed feast. (Young 1798-1799)

Young recorded in March 1799, "I finish plastering all houses and have whitewashed the fences around the animal pens. It is as in Wales." His wife, a relative of Kamehameha the Great, preferred to live in a grass house adjacent to Young's. In September 1799, Young repaired his leaking roof with small sticks and pili. Evidently the house had mortared and plastered walls, with a thatched roof. He also recorded that "two sheep eat one of native huts while we go to catch turtles for food" (Young 1798-1799).

Kotzebue saw Young's housing complex on November 22, 1817, and wrote, "We now saw Young's settlement of several houses built of white stone, after the European fashion, surrounded by palm and banana trees; the land has a barren appearance, . . ." (Kotzebue 1821:1-296). Young befriended many of the missionary families who came later. Missionary wife Mrs. Laura Fish Judd spent a night in the house of aging John Young in 1828, shortly after arrival in the islands.

> Here we were entertained by old John Young, an English runaway sailor, who had been many years on the islands, and had assisted Kamehameha in his conquests. He had married a native woman of rank, has a fine family of sons and daughters, and is considered a chief. He lived in a dirty adobe house, adorned with old rusty muskets, swords, bayonets, and cartridge boxes. He gave us a supper of goat's meat and fried taro, served on old pewter plates, which I was unfortunate to see his servant wipe on his red flannel shirt in lieu of a napkin. I was surprised to see how imperfectly Mr. Young spoke the native language. We were sent up a rickety flight of stairs to sleep. I was afraid and requested Dr. Judd to look around the room carefully for concealed dangers, and he was heartless enough to laugh at me. Sleep was out of the question; I was afraid of the wind, which sometimes sweeps down the gorge of the mountain, and got up at midnight, went down to the grass house of Mrs. Young, which was neat and comfortable. She is a noble woman. She lives in native style; one of the sons is with the king, and the daughters are in the train of the princess. (L. Judd 1928:36)

Bingham and his Brethren

Bingham led the pioneer company of Christian missionaries in 1820. This was followed by eleven other companies, the last arrived in 1848. The companies were composed of

"ordained ministers of the Gospel, physicians, teachers, secular agents, printers, a bookbinder and a farmer," as well as wives and children of the same (Missionary Album 1969:3, 7-12).

Bingham resided twenty-one years in Hawaii, and wrote a book about Hawaii in 1847. In it he probably expressed the combined judgment of the total mission family about thatched Hawaiian houses, and coequally blames thatched houses and the sun--which shone down on hatless Hawaiian heads--for the state Hawaiians found themselves in during the period from 1820 to 1841.

> They cannot be washed, scoured, polished or painted to good purpose, nor be made suitable for good furniture, pantry, or wardrobe, nor for the security of valuable writings, books, or treasures. Nothing, therefor, would be more natural than heathen people occupying such habitations, and going bare-headed in the sun, should feel a depression or heaviness, --a tendency to listlessness, and even lethargy, which demands the stimulus of tobacco, rum or awa, to give a temporary relief, or to add a zest to the few low pleasures within their reach. (Bingham 1847: 116)

Unadulterated Hawaiian houses and temples suited unadulterated Hawaiians. Westerners reared in the temperate zone with snowy winters, under a culture system which matured in Europe, wanted shelter from the elements--for themselves, livestock and goods. Such shelter came in the forms of clothing and structures. Western structures could be washed, scoured, polished and painted. Such activities to both the inside and outside of Western style structures were a part of the Judaeo-Christian religious complex, and

best expressed by the once oft-repeated admonition, "Cleanliness is next to Godliness."

As most of the eighteen mission stations on five major islands--Kauai, Oahu, Molokai, Maui and Hawaii--were manned, the first quarters assigned the newly arrived mission family by the resident chief were large chief-style walled thatched houses. The Thurstons in 1820 started the first established station at Kailua-Kona and were assigned by King Kamehameha II to quarters in the former royal palace. Mrs. Thurston termed it "the best in the land" (Thurston 1934:47). She and her husband turned-to on the second morning, "giving a thorough sweeping to the thatch above, and the ground below, spreading down new grass and new mats, putting up two high post bedsteads of Chinese manufacture, lent them by Kamamalu, the queen, and bringing in such articles as would be a substitute for furniture" (Thurston 1934:38). By 1832, the Thurstons had a two-storied wooden house (Thurston 1934:85n).

Each mission station had a similar sequence, with a new station often starting with a grass house at the same time an older station had acquired a Western house. For instance, The Reverend Daniel Toll Conde, his wife, and young son arrived in remote Hana, Maui island, in 1838. "The people of Hana . . . they have by order of the Governor, built two native houses, with yards around them," (Pleasant, n.d.) for the expected missionaries. Conde and his family arrived in Hana on the schooner Hooikaika:

We found the house a mere shell. It was thatched with grass and not with much care. It had one puka [door] only and was without a pani [door closure], this was the only place of ingress and egress. A ground floor, spread with lauhala mats, soft and springy under foot. . . . As already hinted, a grass or lauhala thatched house had been set up for us about 12 by 20 ft., without doors or windows--merely an open place in one side to get into it, and with only a ground floor. I went to work myself and made two doors and as many windows and set them in position, and divided the house into two rooms by a mat partition--one for a sitting and sleeping compartment, the other to take our frugal meals in, also to receive callers in. The former I floored with loose rough boards and carpeted it with course native mats.

After tastefully arranging our various articles of furniture brought with us . . . our front seemed pleasant and homelike. For a kitchen or hale kuke, we used a small building situated a little distance from the dwelling home. Thus completed and adorned, our home, especially the interior was much admired and complimented by the people. They came from all quarters to see their kumus [teachers]. They would crowd and lean against our house in such numbers and with so much force as nearly to crush in its sides, darken the windows with their faces peering in to get a glimpse of the wahine haori and keike [white woman and child].

We would admit them into the reception room in companies of eight or ten, detain them a few moments, . . . when they would retire and another similar company would come in and be treated in like manner. A part of almost every day for weeks this practice was observed. . . .

For about three years consecutively, we lived in a grass house, or rather two, one after the other, neither of them really impervious to rain. After occupying the first, less than a full year, it was consumed by fire, with nearly all our furniture and all our clothing, except what was attached to our person. The fire originated from a spark blown by a kona wind (makani kona) out of a small portable iron furnace placed just outside of our little kitchen built in a wrong direction from and in too close proximity to our house. As the spark touched the dwelling house in a very short time the whole exterior surface from bottom to top was ablaze. . . . The dwelling house of Mr. and Mrs. Ives (our associates) located near by, suffered the same fate, eventually, but most of their goods, also doors,

> windows and loose flooring were saved by the crowd while our house was being consumed. (Conde 1887:172-178)

The Conde and Ives families lived for several months in another grass house, while new thatched houses were being built for them. Conde spent the first several weeks in his new house making it "habitable." By 1841, Conde had a stone house with lime mortar and with a roof of thatch. The thatch was replaced by shingles years later (Conde 1887:181-183; Pleasant n.d.).

Bingham commented on the beginning of the sequence for the main Honolulu station "The king . . . offering us such a shelter as the grassy huts of the country afforded, and such protection as in their rude and degraded state he could give" (Bingham 1847:95). Bingham, in Honolulu April 19, 1820, was promised three native houses. It took four months for them to be built. The largest was fourteen feet long, thirteen feet broad, its walls were three feet high, and the ridge was nine feet above the ground. It had no floor but the ground was spread with mats. There were three holes cut through the thatch for windows (neither sashes nor glass), and a door without "bolt, lock or bar." It had something few other initial mission dwellings had--mats to cover the walls, presented in part by ruling chief Kaumualii of Kauai island. "They have a colored straw woven in which gives them, particularly in the evening, the appearance of neatly papered walls" (Bingham 1847:95,

116, 117; Stewart 1828:83). The "rudeness" of thatched walls viewed from inside their houses was an affront to the New England missionaries (Stewart 1828:290). By August 1821, with the king's permission, Bingham and his family had built a frame house, which still stands in Honolulu.

Not only the Protestant missionaries, but the Catholic ones as well, first lived in grass houses. In 1828, for $8.00 a month rental, the first priests secured in Honolulu three thatched houses--one for sleeping (with mats), one for stores and work, and a third for a chapel--and a well in the middle of a stockaded yard (Yzendoorn 1927:35).

Stone, wood and adobe walls replaced some thatched walls in mission compounds. The Thurstons and Binghams built of wood, Condes of stone, and the Gulicks, of Koloa, Kauai, of sun dried adobies composed of mud and dried grass. Rain melted away the first bricks, and later ones utilized goat hair for binding (B. Judd 1936:60; C. Lyons 1892; Frear 1938:14-26; Malo 1951:124).

But in spite of the missionaries' intense desire to vacate native houses and move into Western ones, "to set an example" for the Hawaiians, the official mission historian Dibble noted that even in 1834, fourteen years after the commencement of the mission, the majority of its members were still living in native thatched houses (1909:145).

Fires in grass houses became increasingly more frequent with occupancy by westerners. Fires had always

been a hazard, but except for those caused by lightning (Kamakau 1964:72) had usually been deliberately set by either Hawaiians (Malo 1951:172-173; Ii 1959:14, 29; Kamakau 1961:197; Menzies 1920:28) or by westerners (Samwell 1967: 626, 1172, 1211; King 1967:520, 562, 562n-563n, 563, 617, 622; Corney 1896:91). With westerners and their new activities in and around grass houses, accidental fires became commonplace. Gulick's grass house on Kauai burned down in 1835 (B. Judd 1936:54-57), blamed on hot tobacco in a pipe of a Hawaiian cook; Conde's fire came from a spark from an outside cooking stove; but the burning of Honolulu's grass church in 1824 was blamed on arson (Stewart 1828: 175-176, 217; Marin ca. 1815, 30 May 1824). In 1821, Marin's diary notes several fires which burned down houses of other westerners.

While the missionaries were trying to improve their own homes (and were building thatched churches to be replaced as soon as feasible with New England-style wood and stone ones), a few high chiefs were acquiring Western-style houses, perhaps for status and for the approbation of the missionaries and other westerners.

> Besides these original dwellings, Honoruru can boast of several very commodious wooden houses, brought in separate parts from the United States. One of these, lately erected by the queen, Kaahumanu, she has offered to Lord Byron as a shore residence while he remains at this Island [Oahu]. A few stone buildings have also been lately erected, the largest and most commodious of which belongs to Kariamoku, and is as yet scarcely finished. (Byron 1828:120)

The prime minister's house (Kariamoku) in 1825 was two stories high with a balcony in front of the second story windows. Queen Kaahumanu's wooden house was bought, at high price, from an American speculator (Byron 1828:120; Ellis 1827:18). When Byron, in 1825, visited in Hilo, Hawaii island, there being no Western-style house available, Kaahumanu appropriated for his use a new thatched house recently erected for a chief. It had a mat covered pebble floor, a pandanus leaf lining, doors at each end, and several "windows" cut through the thatch. It stood on the banks of the Wailuku river. For her own use, Kaahumanu had five temporary huts erected near the house assigned to Byron (Byron 1828:167).

Byron had returned to Hawaii the bodies of Kamehameha II and his queen Kamamalu, who had died in England. The Honolulu palace of Kamehameha II in 1824, before he journeyed to England was described as fifty feet long, thirty feet broad, eight feet high walls and 30 feet at the ridge. It had a row of pillars down the center to support the ridge pole. Between the pillars hung chandeliers of cut glass. It apparently was predominately Hawaiian style, with Western appurtenances and perhaps framing (Stewart 1830:100).

Kamehameha III's Honolulu palace was described in 1837 as a "very humble domicile," built of posts and rafters, thatched with grass, the floor covered with mats, and little Western furniture or furnishings to be seen

(Conde 1887:171; Hinds 1968:117). Ten years later Kamehameha III still occupied his thatched house, but had an adjacent stone building "of tolerable size . . . but it consists chiefly of reception rooms" (Walpole 1849: II, 247).

In 1837, "The mixture of European buildings with the houses of the natives gives Honolulu rather a singular appearance." Many of the houses of the English and Americans "were very pretty and well furnished." But the observer noted "little change" in the Hawaiian thatched houses. Their interiors were "very snug and comfortable," with the ground covered with mats. But one innovation noted was that a hanging screen "parts off a portion for sleeping." The houses were suited to extremes of temperature, the 1837 observer noted, and were cool in warm weather, and warm on cool nights (Hinds 1968:116, 117), an observation borne out inside thatched houses built in experimental archaeology in the late 1960s.

Houses in the dual styles of architecture were even more pronounced in Honolulu in 1869--neat grass houses interspersed with those of foreign residents. Hawaiians sat on mats outside their grass houses and ate poi from calabashes (Bird 1964:18). By 1870, Honolulu had its first all-concrete building, and parts of downtown Honolulu were becoming a slum. Rats and termites were a problem, especially to the wooden frame Western houses. There were few brick

or coral-block buildings. Small wooden buildings and shanties crowded into certain sections of the city to house Chinese and Hawaiians so they could walk to work or to seek employment. Honolulu was beginning to go high rise in 1869, since obviously more people could be accommodated in two story wooden buildings than in "pup tent" size or walled grass houses on the same city plots (Greer 1966).

Collected works of historic illustrations of Honolulu and Hawaii recently published indicate no grass houses in downtown Honolulu after 1890, and few in rural Oahu or the outer islands. Most of the grass houses depicted after the 1850s had hipped frames, while few were evident in earlier sketches of Hawaiian house groups (Scott 1968:39, 44, 82, 91, 575, 601, 616, 694, 739, 838, 840, 841; Feher 1969:177, 183, 214, 223, 228, 232, 256, 288, 354, 378). The techniques of bonneting grass for a rain-proof ridge apparently were either too difficult or the art was rapidly passing away, for many of the ridges of the few gabled and more numerous hipped roofs photographed were capped with foreign materials (Feher 1969:227, 270, 288, 297, 350, 359, 378).

Honolulu, by the 1940 census had less than 109 housing structures classified as "other" exterior material in contrast to 38,443 with wood exterior and 799 with concrete exterior. "Other" exterior material included such materials as stone, cinder block, tile, metal, adobe and composition

shingles. No grass houses were present (U.S. Dept. of Commerce 1940; Oswald Bushnell, personal communication).

By 1940, according to the U.S. census, less than 0.2 percent of the housing units in all of the Hawaiian Islands were of surface material other than wood or concrete. Wooden structures took up 98 percent of the total. This contrasts with 100 percent of the housing units in Hawaii with exterior "grass" surfaces in 1778.

While Honolulu, Hilo, Lahaina, the port towns, experienced population growth and accelerated change in dwelling structures, the rural missionaries despaired. In 1847, the Reverend Elias Bond, at Kohala district, Island of Hawaii, wrote that there was no hope for material advance with the existing grass houses. According to Bond, grass houses insured a common herding at night. There were no cooking utensils, tables, chairs or dishes, and the houses were too small, even though they were larger in 1847 than formerly (Bond 1927:137). By 1860, Bond said that in some grass houses there were $40 bedsteads which occupied a third or more of the floor space. But they were only looked at, not used. The few tables and settees were also for show and not use. Parts of houses "unoccupied by the family calabashes and baggage, nets, canoe gear, saddles and trappings for horses and bullocks, constitute the common dormitory of both sexes and for conditions of the household." Under these conditions, there could not be private

devotions, or any privacy for adults. ". . . any act in the performance of which nature itself dictates and craves seclusion from the common gaze," is the closest the Reverend Bond could come to saying that adults engaged in sexual intercourse in the common dormitory. "Hence comes the early corruption of children . . ." (Bond 1927:158).

While Protestant missionaries were exhorting Hawaiians to improve their housing, among other things, Hawaiians were diminishing numerically. Fertility was low, mortality was high. In 1849, there were an estimated 17 births and 98 deaths per 1,000 Hawaiians. The 300,000 Hawaiians of 1778, were by 1850 down to 84,000. Decline continued to a low of just under 57,000 in 1872 (Schmitt 1968:33, 41, 69).

A Western legal system was formerly imposed in 1850 by the passage of the "Penal Code of the Hawaiian Islands." Many of the crimes enumerated by the code were mysterious and new to Hawaiian commoners and could be committed unwittingly; others made crimes of Hawaii's age-old practices, such as the hula, gambling, kava drinking and comparative sexual freedom. In their own land Hawaiians were at the bottom of the economic ladder. Cash was needed to pay any fines imposed, and for taxes. Alternatives were jail, or labor on public works to work out the taxes (Apple 1965:47).

Hawaiians suffered loss of numbers. They needed but lacked cash. Foreigners were prominent in their government. Their kings could not produce heirs. Representatives

of foreign governments first seized, then released Honolulu. Hawaiians abandoned their coastal settlements to move inland to work; many went to the port towns for work, action, fun and forgetfulness. Protestant missionaries told the Hawaiians that their ancestors were wrong; that everything Hawaiian was wrong. Even their thatched houses, which could be built with materials gathered free, were under attack.

In contrast to Honolulu, Ki'ilae village sat astride the coastal end of the boundary line which separates Keokea from Ki'ilae in rural South Kona, Island of Hawaii. The abandoned village, part of which now lies within the City of Refuge National Historical Park, was one of the last isolated coastal villages where a few Hawaiian families chose to live a life more closely like that of their ancestors than to leave their homeland and adopt more Western ways. Study of Ki'ilae village started with interviews of former residents in 1963 by Apple, was followed by National Park Service archaeological excavations and research by Miss Frances Jackson, historian, under contract with the National Park Service in 1966.

The Reverend James Ely was the first Protestant missionary to be stationed in South Kona, and the 1822 headquarters of the South Kona mission was eight miles north of Ki'ilae village and its small bay. Mission headquarters were first at Kaawaloa, on the north shore of Kealakekua Bay, where Captain Cook had been killed in 1779. Later, as the Hawaiian

population shifted, headquarters moved to the south shore, at Napoopoo. A second mission station was started in 1834 at Kealia, two miles to the south of Ki'ilae. Because of remoteness, lack of Western housing, difficulty of access by both trail and canoe, no Western missionary family ever lived there. The closest Protestant churches to Ki'ilae village, usually served by licensed Hawaiian preachers, were at Honaunau Bay, two miles to the north, and at Kealia, two miles to the south. (Kealia area in 1970 is better known as Hookena.) A Catholic church was established at Honaunau in the 1840s, and later at Kealia. The Reverends Cochran Forbes and John D. Paris left these records of conditions and life in South Kona in 1845 and 1853:

> Not a house of worship or a school house in the whole district of South Kona! . . . The natives were all living in grass huts along the sea shore [1845]. (Paris 1926:36)

> There are not forty families in the Church whose whole wardrobe and household furniture, taking it together, would amount to twenty dollars. The whole property of a family, in this region, usually consists of a canoe to about one family in three, worth from ten to thirty dollars; a hog or two, and a few fowls, a grass house, worth from ten to forty dollars; a few mats, in value perhaps three or four dollars; a few calabashes, say worth two dollars; a shirt apiece for each male, and sometime one pair of pantaloons; a loose-dress for each female, with a few tapas to sleep in. They rarely have seats in their houses, and still more rarely any dishes or pots, except one wooden dish for the whole family. Their mats form seats, tables, and often beds.
>
> Axes are very rare. A few have fish-nets, and but here and there one. A few of them own goats; perhaps twenty persons in the whole district of four thousand souls, who own twenty goats apiece.

> There is not one native blacksmith among the whole four thousand who can purchase bellows and tools. There is not a native carpenter who owns a set of tools, to my knowledge, on this island, the whole population of which is thirty thousand, or more. Here and there one owns a saw and an adze; rarely any, except canoe-diggers, and the tools they have usually belong to some chief, for whom they work. A few of them have doors to close the entrance to their houses. But a lock is almost as rare here as a comfortable dwelling [1845]. (Cheever 1850:220-222)

> But there are signs of improvement & progress among our people. A number are purchasing farms, & fencing them & seem to be inspired with new life in putting in order & cultivating them. Orange & other fruit trees are being planted extensively, & are beginning to adorn our hills & valleys--a little better class of houses, with enclosed yards ornamented with flowers, & a variety of fruit and shade trees, begin to appear. The people are much better clad & appear more tidy & cleanly on the Sabbath. Mothers seem to bestow more time, & take better care of their children [1853]. (Paris 1853)

Ki'ilae and Keokea are ahupa'a, that is, land divisions which extend from the sea into the uplands. Ahupua'a were established in prehistoric times and are recognized legally today. Residents of an ahupua'a traditionally worked in and got all their sustenance and raw materials from within their ahupua'a boundaries, which included, in many cases, designated offshore waters. The ancient economy was based on agriculture and fishing. A typical self-sufficient ahupua'a of Kona had its living zone along the coast and, moving inland, zones were (1) a relatively barren pahoehoe lava area, with patches of pili; (2) an agricultural zone with intermittent occupancy of shelters where taro,

breadfruit, sweet potatoes, sugarcane, and the like were grown; and (3) a forest zone where canoe trees, timber, cordage materials, and bird feathers were collected (Apple 1965:21-24). Both Ki'ilae and Keokea ahupua'a were typical Kona ones, narrow strips which extend from sea to upper mountain slope.

Ki'ilae ahupua'a was given to John Young by Kamehameha the Great, and when Western land concepts resulted in registration of land ownership, his heirs (including the descendants of Isaac Davis whose children were adopted by Young) took ownership. Tax records of 1890 indicate that there were no frame houses in the ahupua'a of Ki'ilae, which by 1890 had permanent settlements, especially coffee farms and some ranching operations, as well as a portion of the early "belt" road around the island. (In South Kona, the belt road was only an unimproved horse trail.) These settlements, farms and "road" were in the agricultural zone, approximately two miles inland and at 1,000 feet elevation above sea level. Footpaths connected the agricultural zone with Ki'ilae village on the coast (Apple 1965). In 1896, there were seventeen taxable inhabitants in the Ki'ilae ahupua'a, probably most living inland in the agricultural area. By 1906 there were only three taxable persons living in Ki'ilae. This implies that the other residents had no property worth taxing.

About 1900, there were about 100 persons living in Ki'ilae village on the coast, representing perhaps ten extended families. By 1913, there was just one family, representing six individuals of several generations. Members of the last family abandoned Ki'ilae in the 1930s because of "nothing to do, no work."

Ki'ilae village's population waxed and waned in the period 1900-1930 as families living inland occupied their traditional beach lands for short periods of fishing and enjoyment of beach living. But these were not considered permanent residents, nor did they consider themselves to be permanent residents. They occupied lands which had been traditionally occupied by their families for generations. When a family abandoned intermittent occupancy of their land and improvements, frequently the improvements, if better than those of the permanent residents, were appropriated and occupied by a family of permanent residents. The last family living in Ki'ilae village lived in what they considered to be the best house. Some male family members of the last family came home only for weekends. They held jobs away from the village and access to Ki'ilae village was time consuming and arduous.

Fishing and its related activities were the principal cash producing occupations of the permanent residents. The senior adult male was the head fisherman. Related activities were outrigger canoe making from single logs, net making and mending from line bought from a store,

and the making and repairing of other gear. Fishhooks were either bought, or made from wire which was bought. The principal cash product was 'ōpelu (a mackeral scad), which was either sold fresh or dried. ('Ōpelu remains the principal commercial fish of the area in 1970 for local residents.) Drying of the fish in the hot sun on black pahoehoe lava flats was the job of the children. The children also sold the fresh and dried fish to residents living inland, frequently missing school at Kealia to do so. Cash obtained went for fishing materials, cloth, corrugated iron roofing, and a small portion for flour to make pancakes. Most of the food was traditionally Hawaiian, grown and prepared by the permanent families. Frequent trips were made inland to tend garden plots and bring the products back home. A few Ki'ilae families had donkeys. They were not ridden but used to transport freight. Corrugated iron, bent to fit over the donkey's back, and square tin cans of fresh water were the heaviest loads hauled down to the beach, and "square" cans full of fish for sale were the usual loads taken inland.

Thatched houses of pili were the predominate house type. Some former residents thought that about 1890 the traditional grass houses of their ancestors were changed in their frames from unpeeled logs to sawed wood available commercially. Some also thought that peeled logs were first used in the houses about 1890. Doors were walk-in

size. The first frame house was built about 1896 by H. John Ahu, head of the most prominent family of Ki'ilae at the time. The house was taken apart sometime in the 1930s and reassembled at Honaunau village, about two miles north along the coast. It still stands in 1970 in Honaunau village on a lot identified as Tax Key 8-4-12-6 and is used intermittently by a Hawaiian family whose principal home is inland. There were a few other all-frame houses after 1900, but apparently they were cannibalized after abandonment to repair other houses. By total abandonment time in the 1930s, the all-thatch houses, which stood inland of the beach trail, had disintegrated. The few frame and hermaphrodite houses all stood on the ocean side of the beach trail on the "better" lots.

A few houses had wooden floors, but most had floors of pebbles. These had pili and mats spread on them for sleeping. Furniture was scarce. Openings, some without frames, existed in the grass houses. Some of the frame houses had glass in the frames, but none had curtains. Hermaphrodite houses had walls of pili thatch and roofs of corrugated iron. Potable water was the village's greatest problem. There was one brackish well, but potable water was usually hauled from inland, or caught from the roofs in barrels or cisterns (for the better houses). This need for water was the reason for the strong desire of Ki'ilae village families to acquire roofs

of corrugated iron. The rare rains could be used to collect potable water. The ocean was used for bathing, and sea water and water from the brackish well was used for washing clothes. The brackish well water was also sometimes used for drinking and cooking.

In 1970, abandoned Ki'ilae village consists of about a dozen house lots each enclosed with stone wall fences. Various dry-masonry house platforms, crypts, animal pens and other structures stand within and without the lot enclosures.

CHAPTER V

HALE-O-KEAWE

Bones of Contention

By foot and canoe, the Reverend William Ellis of the London Missionary Society, inspected the perimeter of the island of Hawaii in 1823. He was one of a touring committee of Christian missionaries whose purpose was to survey the island for sites for potential mission churches. Honaunau had many Hawaiians in residence and Ellis recommended it as "a most eligible place for a mission station, . . ." (1827:159).

Brackish drinking water gave Ellis intestinal difficulties, and he stayed two days at Honaunau to recuperate. This delay gave him time for "the more minute examination of whatever was interesting in the neighbourhood. . . . The principal object that attracted our attention was the Hare o Keave (the House of Keave), a sacred depository of the bones of departed kings and princes . . ." (1827: 152-153).

The journal by Ellis of his tour of the island of Hawaii was popular and has gone through many editions, several in this century. Information given on the depository of royal bones and the adjacent ancient Hawaiian place-of-refuge at Honaunau has served scholars as a basic source for the concept and practice of refuge in the pre- and

proto-historic Hawaiian civilization (see M. Apple 1967).

A sketch by Ellis of the Hale-o-Keawe in 1823 was the basis of hand-engraved cuts used in the several editions. The cuts vary in detail. Some of this may be attributed to new cuts made to substitute for ones worn through use. Another explanation for the variances among cuts may be that the cut used in the Boston edition of 1825 was based on a sketch by Stewart, who copied it from the Ellis original in Honolulu (Stewart 1828:226-227). This Ellis sketch, probably filtered through Stewart as well as through an engraver, is reproduced as Figure 35; the original Ellis sketch, as filtered through the eye of an engraver and contained in the first London edition of 1826, is reproduced as Figure 36. Both were chosen as being as close as possible to the original Ellis sketch, which has not been located.

Ellis was the first known Westerner to visit Honaunau after Liholiho (Kamehameha II) abolished the traditional Hawaiian taboo system late in 1819, which among other things resulted in the destruction of the surface structures of most major temples. Two temples were spared and stood intact. These were the Hale-o-Keawe, Honaunau, Kona district, and the Hale-o-Liloa, Waipio valley, Hamakua district, both on the island of Hawaii (Ellis 1827:152-153, 365-366). Several images stood for a few years on at least one

other temple platform, although its houses and altars were gone (Byron 1828:162).

Among those Westerners who preceded Ellis to the Hale-o-Keawe was Captain James Cook, R.N., who was venerated there as the Hawaiian god Lono on January 19, 1779, following similar ceremonies near Hikiau temple at Kealakekua Bay (Samwell 1967:1162). An image seen by those with Cook within the Hale-o-Keawe was stolen in 1825, and is now in the British Museum, London (King 1784: III-160; see Bishop Museum Negative No. 16 Bc 1(b), Ethno-photo file).

Those after Cook, but before the abolition of the taboo, included Archibald Menzies, naturalist with Vancouver, who spent the nights of February 28, 1793 and February 6, 1794, at Honaunau (Menzies 1920:86-87); and John Young in May 1819 (Documentation withheld by request).

This structural history is concerned only with the results of the end of the taboo, not the causes. Those interested in the causes should consult Ellis (1827); Bingham (1847); Dibble (1909); Kuykendall (1957); Webb (1965); Young (1967); Daws (1968); Young (1798-1819); Marin (ca. 1815); Freycinet (1829); Malo (1951); Ii (1959); Kamakau (1961); and others.

The end of the taboo in Hawaii late in 1819 resulted in the immediate destruction of the major temples (Marin, Nov. 6, 7, 1819) with two exceptions. Why were these two spared? And once spared, why do they not still stand?

Since organized Christianity did not arrive until 1820, the retention of the Hale-o-Keawe and the Hale-o-Liloa in 1819 indicates a special status for these temples, a status still important to Hawaiians even during a time of social change (Ellis 1827:152-153). The explanation lies in their contents. Both temples contained ancestral bones of the reigning family.

Prior to 1819, the Hale-o-Keawe, with its deified royal bones of kings and princes, functioned in relationship to the adjacent place-of-refuge (pu'uhonua in Hawaiian) at Honaunau. Kelly (1957a) reviewed the historic worldwide concepts and practices of asylum, especially those of the Polynesians, and concluded:

> All the elements of Hawaiian pu'uhonua are to be found in other Polynesian areas. These had been transported to Hawaii as part of the general cultural knowledge of a Polynesian background. They were elaborated upon, and adapted to local needs and conditions. There is no evidence to justify looking to Israel or to other areas for the seeds from which the Hawaiians developed their concepts of asylum as represented in the pu'uhonua of Honaunau. (Kelly 1957:90)

It should be noted that in prehistoric times, there were many refuges in Hawaii--at least five others in simultaneous use on the island of Hawaii, and at least one on every other major island (Kelly 1957b:113-136). Kelly also summarized the role that the Hale-o-Keawe played in the pre-1819 Hawaiian civilization.

> Much more important than physical protection was the supernatural protection and sanctity of the surrounding area. Thus, each pu'uhonua site was

> closely associated with a heiau [temple]. The heiau of the pu'uhonua at Honaunau at the time of European contact was the Hale-o-Keawe. This association with religious structures indicates that a pu'uhonua as that at Honaunau was not merely a place of physical refuge, but more specifically a sanctuary. In a thatched house on one of the heiau platforms were kept the bones of deceased high chiefs, now deified. This was not a burial, but rather a deification. Hawaiian burials per se were quite different (Westervelt, 1904, p. 150). The powerful mana of these deified chiefs continued after life to surround the area and to afford protection to anyone entering the enclosure. The sanctuary at Honaunau was under the protection of the deified chief, Keawe, and the one at Waipio Valley under Liloa. (Kelly 1957:85)

Deified bones were last added to the Hale-o-Keawe in 1818 and were those of a son of Kamehameha the Great (Corney 1896:86-88). Most, if not all, of the twenty-three deifications were accompanied by human sacrifices (Barrere 1957:61; R. Apple 1966:17-19).

Barrere studied fragments of tradition, traced genealogies and examined archaeological evidence. She accepted the tradition that the Hale-o-Keawe was built either for or by Keawe-i-kekahi-alii-o-ka-moku, great grandfather of Kamehameha the Great, who lived ca. A.D. 1650, but added:

> Regardless of who actually built it, the Hale-o-Keawe was a heiau [temple] from its inception, since it is established that the bones therein were objects of deification and worship. Also, no bones of women were deposited there, which would have been the case if it had been established merely as a resting place for the bones of a family. (Barrere 1957:52)

Barrere studied the genealogies of the names associated with the bones, and identified fourteen, and possibly

sixteen, of the twenty-three chiefs who were direct descendants of one chief. This common factor underlay nearly two-thirds of the names and led Barrere to conclude that the Hale-o-Keawe was primarily the depository of bones of a closely related family of high chiefs. Of the two doubtful names, Barrere believed that they were alternate names for known descendants. The remaining names were believed to be of persons linked to the family through marriage. Six of the chiefs were of the generation immediately before the Keawe for whom the temple was named (Barrere 1957:70-76).

All of the sets of royal bones were disjointed and wrapped in tapa. Some of the tapa coverings were wrapped around woven caskets (kā'ai in Hawaiian) of sennit, "with the skull in the upper part, the body bones in the lower" (Pukui and Elbert 1957:100; Barrere, personal communication Nov. 24, 1961). Some of the woven caskets were adorned with feather helmets and masks, rows of shark's teeth, and tufts of human hair (Byron 1828:199).

Mana of the deified bones within the Hale-o-Keawe gave spiritual protection to the refugees within the adjacent place-of-refuge. The need for refuge ceased in 1819.

Obviously, the role the bones played in the operation of the refuge also ceased in 1819. Whatever other roles they played, the sacred relics of deceased ancestors of the reigning Kamehamehas were important enough to insure

retention of the structures which housed the bones, even during the general destruction of the major temples in 1819. The Hale-o-Keawe at Honaunau contained twenty-three sets of royal ancestral bones and the Hale-o-Liloa at Waipio held those of Liloa, Lono-i-ka-makahiki, and possibly others.

Access by land to the Hale-o-Liloa was difficult. The steep cliffs of Waipio valley made descent and ascent hazardous and arduous. Access by canoe to Waipio valley was hazardous due to frequent high seas and surf. Even during the seasonal calm periods, seas and surf were capricious. Natural factors appear to have isolated the Hale-o-Liloa during pre- and proto-historic times (see Ellis 1827:365-366). Even in 1970 the approach to Waipio valley, where the ruins of the Hale-o-Liloa lie buried, is considered difficult.

Access to Honaunau, however, was comparatively easy. The trails to Honaunau were rocky, barren, dry and hot, but never hazardous. Barefoot Hawaiians apparently used them without complaint. Kona's offshore waters were good for sailing by both Hawaiian canoes and Western ships. Few storms whipped up whitecaps. Honaunau bay offered safe haven for canoes and small craft, but was too deep and open for protected anchorage for the larger Western ships. Four miles to the north, Kealakekua bay offered relatively good shelter for large vessels.

The bones in the Hale-o-Keawe gave spiritual strength to some living members of the Kamehameha family, those who called on them for added mana. This posed no problem until some members of the ruling family, those in power, accepted Christianity. Then the bones became bones of contention.

The bones may even have played a part in a purely Hawaiian dispute, when traditionalist Hawaiians revolted against Liholiho in 1819 in an effort to restore the abolished taboo and the way of life it represented. Geographically, the Hale-o-Keawe was behind the forces of, and in the territory controlled by, Ke-kua-o-ka-lani, just four miles south of his base on Kealakekua bay (see Ellis 1827:107-113; Kamakau 1961:209, 224, 225, 226, 228, 232, 233, 261). Ke-kua-o-ka-lani was killed at the battle of Kuamo'o, thus ending the major organized resistance to Liholiho's abolition of the taboo.

Despite an acculturating Hawaii, some individual chiefs and chiefesses continued to adhere as closely as possible to the old ways. This was difficult after the major temples were destroyed and the gods banished. Those of the traditionalist persuasion and of the Kamehameha lineage still had the Hale-o-Keawe, however. Worship of the ancestral bones, and offerings to them, continued. Some of those participating in this relic veneration were nominal Christians. Chiefs and chiefesses who had accepted

Christianity in full measure considered this practice pagan and objectionable. Further, the reactionaries may have been an embarrassment to these royal family converts (Bingham 1847:426).

Virtual rulers of Hawaii during the minority of King Kau-i-ke-aouli (Kamehameha III, son of Kamehameha the Great) in the 1820s were queen regent Ka-ahu-manu, favorite wife of Kamehameha the Great, and her prime minister, Ka-lani-moku. Both were devout Christians and in the first small group of Hawaiians admitted to full church membership, in December 1825 (Kuykendall 1957:123). In the third group of Hawaiians admitted to membership in the Congregational church (in 1828) was another member of the Kamehameha line, high chiefess Ke-ka-ulu-ohi, a wife of Kamehameha the Great in his old age, a wife of Kamehameha II, and who was prominent in governmental affairs after the death of Ka-ahu-manu in 1832 (Kamakau 1961:208, 250, 300, 331, 334; Kuykendall 1957:164n, 167, 263n). In the late 1820s, however, Ke-ka-ulu-ohi was known to venerate the bones in the Hale-o-Keawe and send offerings to them, regardless of her pending full communicant status in Honolulu's Kawaiahao church (Bingham 1847:426).

Queen regent Ka-ahu-manu and prime minister Ka-lani-moku faced opposition to their program to make the Congregational brand of Christianity the state religion. High chief Boki favored Roman Catholicism and promoted it

when politically safe to do so. Apparently high chiefess Ke-ka-ulu-ohi's opposition was less obvious, but she may have been the unofficial leader of an underground movement of second-line chiefs who objected to the power Puritanism and its proponents from New England were wielding in government. Many of the second-line chiefs, such as Kuakini, governor of the island of Hawaii, reluctantly went along with the Ka-ahu-manu policy. Kuakini supported both Roman Catholicism and the reactionaries while a communicant in good standing in the Congregational church. Kuakini built the first Congregational and the first Catholic church structures in Kailua-Kona (Damon 1924:8-11; Ives 1841; Byron 1828:202).

Kuakini, also known as John Adams, stood about six feet seven inches tall and weighed more than 350 pounds. Although he walked with a limp, he represented to some Western observers the strong, typical Hawaiian high chief. He was a good host to many Westerners. Kuakini liked his imported liquor and the comforts of Western civilization. In 1837-1838 he built a frame and stone residence (Hulihee palace) at Kailua-Kona. It still stands. Kuakini was the brother of queen regent Ka-ahu-manu. The local Congregational mission families disapproved of many of his gubernatorial and personal actions (Freycinet 1829:4, 8; A. Bloxam 1925:43; Ives and Ives 1845; Ii 1959:30; Stewart 1830:137; Kotzebue 1821: I-298, 299; Vancouver 1967: II, 161).

His relations with prime minister Ka-lani-moku were probably strained, for Kuakini once stole the affections of the favorite wife of Ka-lani-moku (Kamakau 1961:197).

No physical description exists for Haiha Na-ihe, national orator and high chief, who lived on his lands at Kealakekua bay and owned much of the lands in South Kona and Kau, island of Hawaii. He was probably the second most important chief in residence on the island of Hawaii. Among his inherited responsibilities was the custody of the sacred bones of royalty in the Hale-o-Keawe and in burial caves. His reputation for back sliding from the Christian life never reached the proportions that Kuakini's did, but there were strong suspicions that his beliefs in Christianity were not as steadfast as those of his wife. Kuakini's back sliding leaned toward the material things of the Western world; Na-ihe's toward traditional Hawaiian culture.

Na-ihe was married to Kapiolani, the high chiefess who in 1824, as a Christian convert, defied the Hawaiian volcano goddess Pele at the traditional home of the goddess at Kilauea volcano. Kapiolani was a strong supporter of Christianity, and like Ka-ahu-manu, tried to persuade the Hawaiian people to abandon their pagan beliefs and accept Christ as their savior by joining the Congregational church. Congregational mission families lauded Kapiolani, but they damned her husband with faint praise. It is noted that

Na-ihe did not accompany his wife on her approbation-seeking trip to the volcano (Ellis 1827:259-260; Bingham 1847:426, 427; L. Judd 1828:75; Stewart 1829:231, 232, 237; Ely 1827; Vancouver 1967: III, 47; Haleole 1919:104; Kamakau 1961:190, 206, 221, 226, 227, 250, 273, 277, 302, 305, 306, 380, 393).

The house of Na-ihe and Kapiolani at Ka'awaloa, Kealakekua bay, near where Cook was killed, was masonry and frame; near it they built a chapel, schoolhouse and home for a resident missionary and his family. Before they induced the Reverend Ely and his family to man the station, they sent a canoe on many a Sunday to Kailua-Kona to bring a missionary to Ka'awaloa to preach a sermon and then returned him to his home before nightfall.

In 1819, Na-ihe hosted both Ke-kua-o-ka-lani, the leader of the army which opposed abolition of the taboo, and Queen mother Ke-opu-o-lani, mother of Liholiho (Kamehameha II), and strong supporter of the taboo abolition, shortly before Ke-kua-o-ka-lani was killed. Both were at his home at Ka'awaloa for fruitless peace talks before the battle of Kuamo'o.

Haiha Na-ihe was both guardian of the deified ancestral bones and supporter of the Congregational church. He supplied the army of Ke-kua-o-ka-lani who opposed Kamehameha II simultaneously with his entertaining the party of delegates who represented the king. He was a party to councils in Honolulu which step-by-step helped destroy his beloved

Hawaiian civilization. He ran his lands, and the people resident thereon, in the old style, but used his power to foster church attendance. He punished adulterers by putting them to work building trails needed by the new order (Ely 1827). His strong wife was set on destroying the Hawaiian gods and the symbols which represented them, while he was duty bound to preserve at least the symbols. Na-ihe was a man caught in the middle of strong opposing forces at home, on his lands as district chief, and at court as a member of the royal council of chiefs.

Queen regent Ka-ahu-manu's first known attempt to eliminate the Hale-o-Keawe and the deified bones inside, came in 1825. It was partially successful. The bones remained, however, inside the temple. No Hawaiian, not even herself, was yet in a strong enough position in Hawaiian society to personally touch the Hale-o-Keawe with an aim toward its elimination. She assigned some non-resident Westerners to do it. They were Lord Byron and the officers of the H.M.S. Blonde, highly placed representatives of the British crown.

Invited to visit the Hale-o-Keawe and authorized by the prime minister to take some of the "ancient gods, and other articles deposited . . ." Lord Byron anchored the Blonde in Kealakekua bay. Kuakini and Na-ihe accompanied the party of officers to the Hale-o-Keawe on July 25, 1825.

The resident guardian, a lesser chief probably named Kua-hi-ia, with the backing of Kuakini and Na-ihe, stopped the looting short of the bones. But most of the temple appurtenances, such as images, spears and calabashes, were taken. Many are now in European museums.

The next day, July 26, 1825, the Blonde's botanist, who had not gone with the first party, made a private, but obviously authorized, raid on the temple and took some of the temple images from the courtyard. Macrae noted that everything of value had been taken from inside the Hale-o-Keawe, leaving "only quantities of human bones" (Lo'e 1919; Byron 1828:198-202; A. Bloxam 1925:73-77; R. Bloxam 1923: 79-80; Macrae 1922:71-79; Emory 1957:12-30; R. Apple 1966).

Illustrations of the Hale-o-Keawe in 1825 were made at the time of the looting. Descriptions by Lord Byron (1828); Andrew Bloxam (1925); Rowland Bloxam (1923) and James Macrae (1922) also resulted. One illustration was by the Blonde's artist Dampier, reproduced as Figure 37. It probably represents a stylized rendering of the structure in accordance with a prevailing artistic formula. The background appears to be of Kealakekua bay, four miles to the north of Honaunau bay. The other sketches (Fig. 38), by Andrew Bloxam, show (1) "Capt Cooke Monument," the temple where Cook's body was believed to have been prepared for deification; (2) an exterior view of the Hale-o-Keawe which varies from that of Dampier; and (3) the only known plan of

the interior arrangement. This plan is in agreement with the description of the interior written by Ii (1959:139).

After July 1825, although the temple had been looted, the sacred bones of the ancestors and relatives of the royal family remained inside the Hale-o-Keawe. What had been taken to England were objects of secondary importance to the Hawaiians. Carved images of wood, wooden bowls, wooden spears and knickknacks were apparently more desirable souvenirs to Westerners than human bones. Hawaiians valued the bones more than temple adjuncts. Hawaiian willingness to dispose of temple appurtenances was shown in 1779 when Cook was permitted to buy for ship's firewood the wooden stockade about a major temple at Kealakekua bay. Cook's sailors took some images as well, but Lieutenant King questioned their inclusion. King returned a valued small image, and left standing two large images on the temple platform at the request of the priest-in-charge (King 1967: 516; Samwell 1967:1174; see Kamakau 1961:203). Thus, when Kuakini, Na-ihe and the temple guardian permitted the officers of the Blonde to take images and other valued articles from in and around the Hale-o-Keawe they established no precedent. The difference was that the Hale-o-Keawe was one of the last two temples. Ka-ahu-manu and Ka-lani-moku obviously hoped that the bones would also be taken to England, far enough away to eliminate them as a threat to the establishment of Congregational Christianity in Hawaii.

The sacred bones in an accessible place may also have posed a political threat, and have been a rallying symbol to those opposed to Ka-ahu-manu's policies.

One political opponent was high chief Boki, governor of Oahu island and brother of prime minister Ka-lani-moku. (Kamakau 1961:285, 288, 290). From Ka-ahu-manu's standpoint, the deified bones in a temple which stood on traditionally sacred ground, easily reached by canoe or land, posed a threat to Christianity, her relations with Christian missionaries, and perhaps to her power. Even she, however, never advocated destruction of the sacred bones.

In late December 1828, or early January 1829, Ka-ahu-manu went to the Hale-o-Lono in Waipio valley and removed the deified bones of Liloa and Lono-i-ka-makahiki, and perhaps others, and took them with her to Kona. Transportation was probably by sea. At the Hale-o-Keawe, Ka-ahu-manu oversaw the removal of the deified bones of the twenty-three royal ancestors and relatives of the Kamehamehas. They were placed in two crude coffins. In this she was encouraged and supported by two companions--the Reverend Samuel Ruggles and his patroness, chiefess Kapiolani. Kapiolani's husband, Na-ihe, did not accompany Ka-ahu-manu to the Hale-o-Keawe, and he refused to supply boards for the coffins.

The coffins, with their sacred contents, were placed inside a taboo lava tube in Kealakekua cliff and left in

the care of Na-ihe (L. Judd 1928:43; Clark 1829; Bingham 1847:426, 427; Kamakau 1961:322-323. Ka-ahu-manu had accomplished her purpose. No public objections were voiced except by Boki, who spoke against Ka-ahu-manu in councils. He cited her treatment of the royal ancestral bones as evidence of misdeeds which made her unfit to rule (Kamakau 1961:285). But Boki was unable to dislodge Ka-ahu-manu from her position of power.

Out of sight, but not out of mind. Overt attention to the bones ceased, but the knowledge of their existence and of their location was retained in royal circles.

Ka-ahu-manu apparently intended that the temple structure be destroyed immediately after the bones were removed. She left orders for the buildings to be razed. Without personal knowledge to the contrary, some of those who knew of the orders reported that it was done, and this assumption was repeated by others as fact (L. Judd 1928:35; Kamakau 1961: 322-323; Emory 1957:32; Barrere 1957:77; Alexander 1890). But a month or so after Ka-ahu-manu saw the bones withdrawn, and after she had returned to Honolulu, missionaries Ephraim Clark and Levi Chamberlain sailed in a canoe past Honaunau "in full view of the celebrated house of Keawe" (Clark 1829). Missionary Stewart visited the temple on November 17, 1829, in company with King Kamehameha III (Stewart 1832:244); and as late as October 1841, the Reverend John D. Paris found the "heathen temple still standing" (Paris 1926:19).

Yale astronomer Chester Smith Lyman may also have seen what was still standing of the Hale-o-Keawe on December 2, 1846, but his report is ambiguous (Lyman 1846). By 1851, however, no ruins of the temple structure itself were recognizable (Cheever 1850:39), and subsequent reports by visitors make no mention of even a house frame (see Hill 1856:178-185; see R. Apple 1966: appendix Z for list of known visits in the period 1852-1889). Apparently the Hale-o-Keawe was left to disintegrate through natural forces after 1829. Perhaps no Hawaiian would touch it, because over the centuries it had absorbed mana from the deified bones inside. If Ka-ahu-manu had remained at Honaunau, her orders would undoubtedly have been carried out.

The sacred bones, deified relics of ancestors of the Kamehameha dynasty, did not rest in peace. In 1858 an assemblage led by King Alexander Liholiho (Kamehameha IV, grandson of Kamehameha the Great) went aboard the British warship Vixen which anchored in Kealakekua bay on January 24. The next night, by torchlight, coffins were removed from the lava tube and placed aboard the Vixen. The coffins were probably taken to Honolulu and placed in the Royal Tomb in what are now the grounds of Iolani Palace.

Although both Honolulu weekly newspapers had representatives on board the Vixen, little about the move appeared in the press. Royal censorship was probably exercised. Also aboard was high chief Ke-ku-anao'a, governor of Oahu island

and guardian of the royal tombs. The coffins were consigned to his care.

During the reign of King Lot Kamehameha (Kamehameha V, grandson of Kamehameha the Great), in 1865, caskets and coffins from the Royal Tomb in downtown Honolulu were moved at night to the newly built Royal Mausoleum in Nuuanu valley, Oahu. Two English- and one Hawaiian-language newspapers reported the move to the Mausoleum and agreed on the list of inscriptions on the caskets and coffins. Names of those from the Hale-o-Keawe were not included, but at least two of those from the Hale-o-Liloa were. Perhaps archaeological excavation of the Royal Tomb in the Iolani Palace grounds will reveal if the coffins with the royal bones from the Hale-o-Keawe are there. The coffins made at Honaunau were probably crude compared with more modern ones, and perhaps left behind as containing bones unworthy of deposit in the Royal Mausoleum. The present location of the bones is unknown (Stokes 1930). Ke-ku-anao'a may have placed them where he hoped they would never be found. Or perhaps Na-ihe may have switched bones soon after Ka-ahumanu placed them in his care. In trying to trace the bones, Barrere (1957:80) concluded, "Ho'okoe 'ia no kekahi--something has been withheld."

Structural Data

If Barrere's conclusion that the Hale-o-Keawe was built either for or by Keawe-i-kekahi-alii-o-ka-moku is

accepted, then an approximate date for the building of the temple is A.D. 1650. Unknown are such things as: how many times it was rethatched; how many times, if any, the frame was replaced or repaired; and what, if any, additions or alterations were made to the temple and its adjuncts. The Hale-o-Keawe described by Ii (1959), who saw it when it was in operation, and by Ellis (1827), Byron (1828), the Bloxams (1923; 1925) and Macrae (1922), who saw it after 1819, was the temple as renovated about 1812 by Kamehameha the Great (Kamakau 1961:203; Ii 1959:103, 122; Ellis 1827:157). It was this temple which was reconstructed in 1967 and 1968 by the National Park Service, and it represents the Hale-o-Keawe probably at an elaborate stage. It is also possible that it was more elaborate after 1819 than in 1812-1819, for some of the sacred images from other major temples may have been added after 1819 to those already on the Hale-o-Keawe. Certainly some changes were being made in the 1820s, for a well carved, wooden image with a carved baby in its arms, seen by Lord Byron in 1825 (1828:199), had not been there in 1823. Such an unusual image would have been noticed and included by Ellis in his detailed descriptions. Perhaps images made for other temples and hidden away in 1819 were later located at Honaunau bay.

Maintenance of the temple--such things as thatch repair--apparently stopped in 1829. The comparatively empty temple and its courtyard, made of bio-degradable materials,

disappeared through neglect and natural forces sometime in the period 1841-1851. Most tsunamis do not affect the location of the Hale-o-Keawe (Ladd 1969:175), but possibly the tsunami of 1877 did some damage to the platform and adjacent sea walls (Emory 1957:37). Winter high seas were the probable cause of damage to the platform of dry masonry, shown in an 1889 picture (Ladd 1969:175; Bishop Museum Negative No. 28800 taken 1889 by William T. Brigham). By 1902, the Hale-o-Keawe's platform and vicinity was a heap of stones.

An unauthentic and misleading restoration of the platform was made in 1902 under the direction of Walter A. Wall (Ladd 1969:166-169; R. Apple 1966:43-44, Appendix AA). Archaeological excavations by Stokes in 1919 did not include any restoration, but raised questions as to the authenticity of the 1902 work (Ladd 1969:182; R. Apple 1966: 44; Stokes 1919). In the 1920s, when the land which included the Hale-o-Keawe and its adjacent place-of-refuge was under lease from the estate of Bernice P. Bishop (last recognized member of the Kamehameha dynasty) to the County of Hawaii for a park, county crews under Julian R. Yates did repair and maintenance in the platform's vicinity (R. Apple 1966:45; Yates 1964; Emory 1957:34-35). The United States of America took possession and jurisdiction of the area, as the City of Refuge National Historic Park, on July 1, 1961 (Federal Register, July 1, 1961),

persuant to an Act of Congress approved July 26, 1955 (Public Law 177, 84th Congress, 69 Statute, 376).

In an attempt to understand the Hale-o-Keawe, its physical history and its roles, several studies were funded by the U.S. Department of the Interior. These were "The Natural and Cultural History of Honaunau, Kona, Hawaii," by Honolulu's Bishop Museum in 1957 (under contract) and studies by National Park Service employees Apple and Ladd. Apple utilized ethno-historical and historical sources for a pre-restoration study (R. Apple 1966); and Ladd did a pre-salvage report (1969); as well as archaeological excavation and restoration of the platform of the Hale-o-Keawe (1967). This dissertation is another product.

Ladd concentrated on the dry masonry platform. He located the original platform's side and top, and restored them, together with adjacent features. Ladd reported

> Armed with the historical data and field experience in working with Hawaiian stone structures, the 1902 restoration was systematically excavated. Fortunately, Mr. Wall in his restoration did not disturb any of the underlying foundations of the prehistoric structure but, protected them by adding platforms to the side, front, and on top. (1967:68)

The platform and its vicinity were restored by Ladd in 1966 and 1967. In 1967 and 1968, the Hale-o-Keawe surface features were restored by Apple.

Enough structural data specifically concerned with the Hale-o-Keawe could not be found in literature to restore the Hale-o-Keawe. The scope of the research project expanded

to include data about all Hawaiian structures. This formed, among other things, a body of information which could be used to supply the missing details during the restoration of the temple. The entire project was in keeping with the National Park Service Restoration Policy, applicable portions of which are quoted below.

NATIONAL PARK SERVICE RESTORATION POLICY

> General Restoration Policy. The motives governing these activities are several, often conflicting: aesthetic, archeological and scientific, and educational. Each has its values and disadvantages.
>
> . . . In attempting to reconcile these claims and motives, the ultimate guide must be the taste, judgement and expert knowledge of the man in charge.
>
> Complete records of [structural] evidence, by drawings, notes and transcripts should be kept, and in no case should evidence offered by the monument itself be destroyed or covered up before it has been fully recorded. . . .
>
> In no case should our own artistic preferences or prejudices lead us to modify, on aesthetic grounds, work of a bygone period representing other artistic tastes. . . .
>
> Where missing features are to be replaced without sufficient evidence as to their own original form, due regard should be paid to the factors of period and region in other surviving examples of the same time and locality. . . .
>
> It is a fundamental principle that research should precede actual development work. . . . The Service should be capable of instantly proving the authenticity of its work. . . . Collaboration of all technicians engaged in research on the character, features, and history of a given site, is essential if the best results are to be obtained. . . .
>
> In every case, regardless of the relative importance of the historic structure and regardless of the

> activity to be undertaken, the key word is integrity. (U.S. Dept. of Interior 1963: I-3; 1-9)

Since the restoration of the Hale-o-Keawe, policies which govern restorations have been restated and updated, but the basic policies quoted above held firm (U.S. Dept. of Interior 1968).

In the pre-restoration study (Apple 1966) attention was called to the non-agreement among eye-witnesses to the actual size and location of the temple platform. This matter was resolved when archaeologist Ladd found outlines of the original platform and its upper surface. Ladd established the approximate dimensions and orientation of the temple on the platform. The Ellis drawing, as in the 1826 edition (Fig. 36), was the drawing selected as representing the truest depiction of the Hale-o-Keawe. Ladd restored the platform, and at Apple's request, installed built-in holes which were to hold the bases of house posts and temple images. Holes for the courtyard images proved to be in their correct locations, but locations of the holes for the house posts proved to be in error. The state of the knowledge about Hawaiian thatched houses during Ladd's restoration of the platform in 1967 was such that the unusual thickness of thatched Hawaiian walls was not known. Ladd reported

> To aid in the reconstruction of the House of Keawe, plywood casings were installed to accommodate the house posts. This was done so that the platform need not be taken apart



Fig. 47 - Semi-circle of images in restored courtyard.



Fig. 48 - Restored courtyard with fence detail.

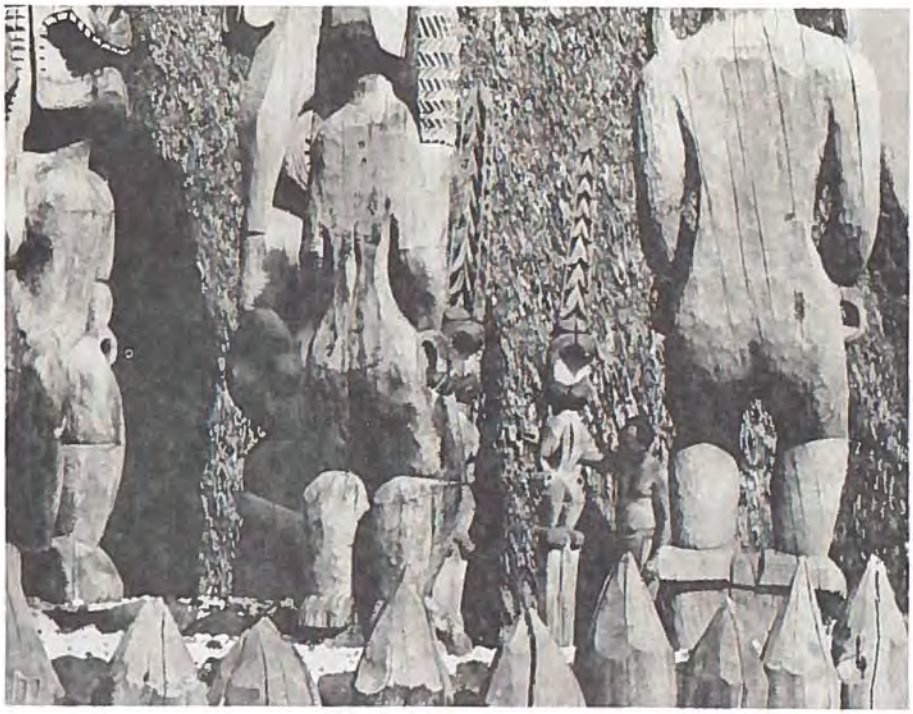


Fig. 49 - Rear view of restored major courtyard images.

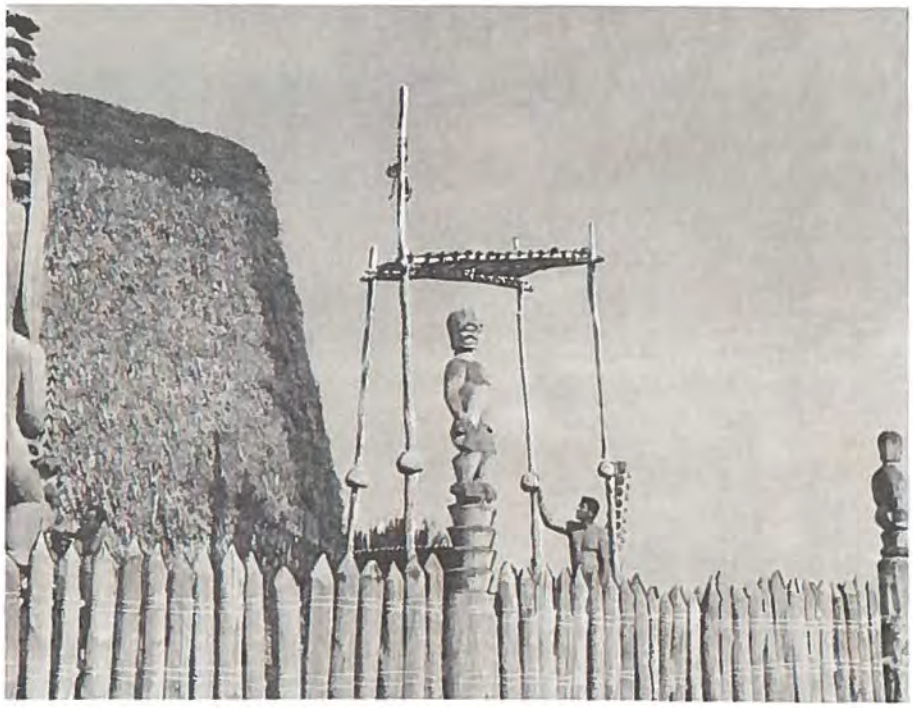
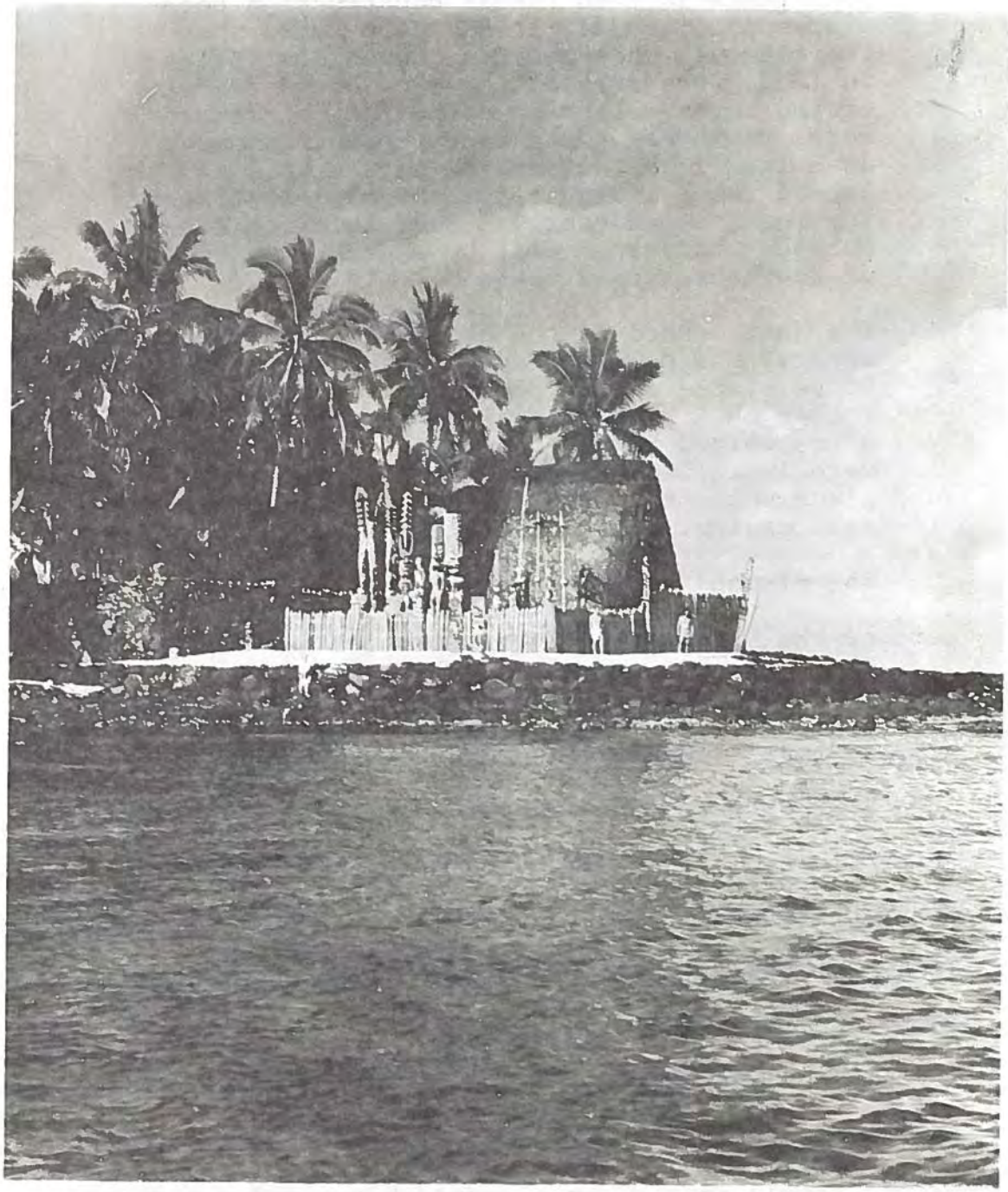


Fig. 50 - Restored altar; fern trimmed edges of restored Hale-o-Keawe.



Restored Hale-o-Keawe, June 28, 1968, Honaunau Bay, Kona.

> again for the actual construction. However, since the installation of the casings, and some research into actual construction techniques and methods, it has been found that the original measurements, again Rev. Ellis in 1823, were probably made on the outside of the house rather than the inside. Therefore, the house posts were probably as much as 3 feet from the outside of the wall as around the building i.e., the ti leaf thatching forms a pad nearly 3 feet thick on the outside. A change will be made at the time of the house construction.
>
> The same method as the above was used for reserving a hole for each of the seven images to be placed in the courtyard. However, rather than plywood casings two 55-gallon oil drums welded together form the sleeve, these were installed with the top just below the placement. An image will be installed in each casing. (Ladd 1967:72)

The plywood casings installed by Ladd were removed as part of the excavations for post-holes in their correct locations, and assembly of the Hale-o-Keawe proceeded as detailed for a large walled house in Chapter III.

Ladd's insertion of double oil drums for image holes were utilized. They were treated as giant post holes, with their bottoms filled to the correct depth to accommodate the lower portions of the hand-carved images in the semi-circle described by Ellis.

In addition to the ti leaf thatched Hale-o-Keawe proper, the restoration of the heiau surface features involved carved temple images, an elevated altar and a wooden palisade. Their restoration, combined with Ladd's restoration of the platform, sea walls, and associated terrain, resulted in restoration of the Hale-o-Keawe temple complex

as an interpretive feature in the City of Refuge National Historical Park. Apple's administrative duties as Superintendent of the Park made the restoration work intermittent. The entire surface restoration project began August 28, 1967 and ended June 28, 1968. In 1966, hand carving of the temple images had started, under the direction of Jacob Lindberg-Hansen, who will report on this phase. Carved images went into the stockade, courtyard and the area outside the stockade. Figures 47, 48, 49 and 50 show details; Figure 51 shows the completed temple complex.

Specific eyewitness details which concern structural features of the Hale-o-Keawe are listed in Table IV. Missing details were supplied from sources used in Chapters II and III. Apple's field books, which contain information such as depths of post holes and day-to-day log, are in the Bishop Museum, Honolulu.

TABLE IV

STRUCTURAL FEATURES OF HALE-O-KEAWE

Detail	Eyewitness Source	Remarks
House:		
Foundation	Ellis 1827:153-155 A. Bloxam 1925:73-77 Ladd 1967:27	paved with large smooth stones for court-yard. Waterworn pebbles for house floor.
Timbers	Ii 1959:137-139 L. Judd 1928:35	Posts and rafters were of Kauila wood. Ii mentions Kauila wood for Hale-o-Keawe came from "uplands of Napu'u," which has since been identified as near Puuanahulu, North Kona. A few Kauila trees still grow in the vicinity. With Kauila a rare and endangered species of native woods, 'ohi'a was substituted. See Table II.
Cordage		Probably Olonā. Not manufactured today. Nylon substituted. See Table III; "Cordage," Chapter II.
Thatch and Lining	Ii 1959:137-139 Ellis 1827:153-155 Macrae 1922:71-79 Byron 1828:198-202 A. Bloxam 1925:73-77 R. Bloxam 1923:79-80	Crossed ti-leaf thatch. See "Thatch Assembly, ti leaves," Chapter III.

TABLE IV (continued) STRUCTURAL FEATURES OF HALE-O-KEAWE

Detail	Eyewitness Source	Remarks
Gable roof	Figures 35, 36, 37, 38	See "Gable Roofs," Chapter II
Door	Ellis 1827:153-155 A. Bloxam 1925:73-77 R. Bloxam 1923:79-80	See "Elaborate Door Assembly," Chapter III
Fern Trim	Figures 35, 36	See "Finishing Operations - Banana Sheath Rain Cap, Fern Trim," Chapter III
Courtyard:		
Altar	Ellis 1827:153-155 A. Bloxam 1925:73-75	Apparently built after 1823 and before 1825. Only described by A. Bloxam. Restored as described.
Images	Ellis 1827:153-155 see Figures 35, 36, 37. Byron 1828:198-202 A. Bloxam 1925:73-77 R. Bloxam 1923:79-80 Macrae 1922:71-79 L. Judd 1928:35 Figures 35, 36, 37, 38	This technical and artistic aspect of restoration was directed by Jacob Lindberg-Hansen. His report is in preparation.

TABLE IV (continued) STRUCTURAL FEATURES OF HALE-O-KEAWE

Detail	Eyewitness Source	Remarks
Stockade	Ii 1959:137-139 Ellis 1827:153-155 A. Bloxam 1925:73-77 R. Bloxam 1923:79-80 Macrae 1922:71-79 Lyman 1846:21 Figures 35, 36, 37, 38	'ohi'a logs used

CHAPTER VI

CONCLUSIONS AND THEORETICAL CONSIDERATIONS

Some conclusions were drawn, some theoretical considerations were presented, and some historical narration given in the body of the text in Chapters I through V. If these were ignored, the text to this point could be considered a builder's guide to the Hawaiian thatched house, both in its pristine and adulterated forms. Chapter VI discusses the theoretical aspects of the Hawaiian thatched house and attempts to interrelate its architecture to the lives of the Hawaiians and others who utilized it.

Pollack (1962:197) stated that "The study of architecture, as an archaeological procedure . . . is founded upon the principle that the building remains reflect certain aspects and attributes of the culture or cultures which created them." The study of pristine and adulterated Hawaiian architecture should yield more than a builder's guide. It should be made to reveal aspects and attributes of the pristine Hawaiian culture and of its adulteration in protohistoric and historic times. Theory should be layered over synthesized ethnohistoric research and field archaeology.

This dissertation is mostly concerned with the first level basic unit, the individual structure, as conceived by Trigger (1970:239) in his study of settlement patterns.

Trigger's second level was arrangement of individual structures within a community; and his third level was the arrangement of communities within a landscape.

Ethnographic literature does not appear to contain much pertinent information concerning Trigger's second and third level of settlement patterns. The expanded villages of Kealakekua Bay for the visit of Captain Cook in January 1779 are mentioned on page 12, followed on page 13 with a description of the rapid rise of temporary structures to form a new settlement in a remote area. Temporary structures probably left few traces. Migration and population change in historic times altered the regional settlement patterns (Trigger 1970:255), and the houses changed with the movements (pages 215-217). Cities such as Honolulu and Lahaina grew as the Hawaiians shifted their homes. Archaeological surface mapping of the Hawaiian islands area by area is a more likely source for information on arrangements of communities within the island landscapes; and detailed studies of valleys such as Waipio on Hawaii; Halava on Molokai; and Makaha on Oahu; and of individual ahupua'a such as Lapakahi, Kohala district of Hawaii; may yield basic data on the arrangements of structures within a viable community in ancient Hawaii. Archaeological investigations are underway in all but Waipio.

Chiefs' housing complexes (pages 5 and 19) had structures within their stockades, and structures without

(page 21). Their arrangements fall within the purview of layout of structures within a community, Trigger's second level. None are described in any detail in this dissertation, and no such stockade ruin has yet been identified in the field. Such structural remnants may yet exist; certainly some of the standing stone wall complexes in remote areas of the islands may represent a rearrangement of a chief's housing complex for other purposes in historic times. It is speculated that such a ruin would, if unmodified, be in a coastal area and contain today a major dry-masonry wall about six feet high surrounding an area which contains five or more house platforms of various sizes. Smaller house platforms would be congregated at a distance of forty yards or more outside three sides of the major walled area. The fourth side of the walled rectangle would probably have contained the single gate to the inside and the major trail which linked this complex with other communities. In the vicinity would also be temple platforms, canoe launching sites, animal pens, and remnants of short trails.

An attempt to resurrect Hawaiian thatched houses, their use, construction and adaptation, has been done in this study. As resurrected, Hawaiian thatched houses are a group of non-portable (and except for platforms, non-existing) artifacts. Spaulding (1970:219) views an artifact group as "exhibiting a consistent assemblage of attributes whose combined properties give a characteristic

pattern, . . . classification into types is a process of discovery of combinations of attributes favored by the makers of the artifacts, not an arbitrary procedure of the classifier." The discovery of the basic classification of Hawaiian house types came late in the synthesizing process and is believed to reflect the combination of attributes favored by the ancient Hawaiians. ". . . chiefs' houses had walls while those of commoners did not" (pages 17 and 18). Differing heights of a walled house were variations due to the status of their occupants (page 16: "high chief--high ridge"). Lower classes of chiefs, such as a master canoe maker, had ridges well below those of the chiefs they served, but still above those of commoners (page 17). Commoners could not stand in their houses.

Chiefs and commoners were the two classes of society used in this dissertation. This is a theoretical, but not an imposed arbitrary classification, and seems as far as structures are involved to be a classification practiced by the ancient Hawaiians. Within the chiefly class there were structural variations in size, materials and methods, of course, and certainly some options were available to commoners for both their permanent and temporary structures.

In this paper, chiefs include ruling chiefs and high chiefs with staff associates and servants, who were higher chiefs in their own right; priests and professionals who tended toward "white collar" specialities in the service

of the higher chiefs; journeymen and craftsmen, such as canoe and adz makers, fishermen and messengers; paddlers who served the above--those who tended more toward "blue collar" specialities in the service of higher chiefs; and include those traditionally called in the Hawaiian language ali'i, kahuna and kanaka. Within this chiefly classification there were many degrees of sacredness with associated height, size and perquisites in housing (pages 21, 22). Most of what has come down in the records is concerned with the structures of these chiefs.

Commoners include the balance and bulk of the population, the basic producers and laborers, and the few "slaves." These were traditionally called maka'ainana or hu, and kauwa (Barrere 1961:20-21).

In addition to the structural classification based on house walls (or on their absence), and of the compression of several social classes into two, other conclusions were reached in Chapters I through V. Some selected conclusions are listed below; some are elaborated upon; some new conclusions are reached; and some other theoretical considerations are introduced.

1. House structures were similar on all Hawaiian islands (page 36).

2. Houses of major temples were structurally similar to those occupied by high chiefs (page 36).

3. The gable roof was the pre-contact style of the Hawaiian thatched house for chiefs, temples and commoners (page 42).

4. The hipped roof was a foreign introduction which became popular in later historic times (page 42).

5. Without a system of measurement against a standard (meter, inch), Hawaiians used parts of the human anatomy, string or sticks to determine measurement. There were no interchangeable parts, nor mass-production tolerance standards (pages 82-83, 99, 101, 110, 125, 126, 130-131, 136, 137).

6. Upper size limits of chiefs' walled houses were set by the usable lengths of timbers to form the component frame members. Practical length limits were the available timbers for wall plates and ridges (pages 49-50). The technique of splicing or joining timbers through overlapping and binding was practiced in the application of thatch purlins (pages 158, 174), and doweling was practiced in canoe assembly, but neither technique was apparently used to lengthen timbers to be used to frame a house.

Size limitation--ridge height and plan dimensions--was primarily and usually set by the status of the chief for whom the house was built. Available timber length only set the upper limits of houses for the higher chiefs.

In considering higher chiefs, who vied for supremacy among themselves, there is no surviving information which

correlates house size with status except in a general way. The highest chief had the highest ridge. It is not known, for instance, how much lower was the ridge of the next lower chief. Was the highest chief he with the most mana, or he who had fought his way to the highest administrative position, over, or with the cooperation of chiefs with higher mana? A case in point is Kamehameha the Great. Did his ridge height rise as he conquered islands to found the historic Kingdom of Hawaii? Did his son and heir, Liholiho, who had more mana than his father, rate or have a higher ridge than Kamehameha the Great during the latter's lifetime? In the higher echelons of Hawaiian chiefdom, was ridge height a symbol of born status or acquired supremacy?

7. A high chief possessed at least one complex of permanent thatched houses, each house reserved for a specialized use (page 5).

8. Hawaiian chiefs' houses were palaces when compared with the pup-tent size of commoners' huts (page 15).

9. Stockades surrounded high chiefs' housing complexes and major temples. Such stockades and their surrounding areas were taboo to commoners (page 19).

10. The higher the rank of the chief, the larger would be his stockade and the more numerous his houses (page 21).

11. Houses once occupied, but not needed for a foreseeable time by a high chief, were burned to the ground.

This step eliminated the possibility that the mana they had acquired could be contaminated (page 32).

12. Hawaiians used their houses for storage, shelter and security. The windowless, thatched structure, usually with only one door, a low one, satisfied these functions (pages 3, 4). To its owner, such a house was an integral part of his life; a component in the interrelated patterned organization of his activities. It was part of an integrated whole. His house changed as his way of life changed. Paralleling the structural changes in the Hawaiian thatched house were changes in the Hawaiian society. Its demise coincided with Americanization of Hawaii.

13. Security was an important function of the thatched Hawaiian house for commoners and lesser chiefs (page 8).

14. Shelter as a function of the Hawaiian thatched house differed between chiefs and commoners (page 7).

15. Worksite or temporary shelters for such people as farmers, canoe makers, women who scraped bark, salt makers, fishermen and those away visiting or on temporary duty, served the same purposes as permanent houses (page 10).

16. Doors were on the front side of chiefs' structures and so low as to require a crawling posture to use. Doors, including those of commoners, were religiously significant (pages 27, 28, 36, 156, 157, 199).

17. Joints of the thatched, walled Hawaiian house were mechanically sound. Nails or dowels were not needed.

18. Men assembled structures; women assisted only in the off-site preparation of certain materials (page 82). The ethnographic literature emphasizes disparity between the sexes in ancient Hawaii. No authentic gable-ended structures have survived (only some of their dry masonry platforms). Without the ethnographic record, any surviving structure by itself would probably not be able to indicate the sex differentiation which existed in the ancient Hawaiian civilization. This holds true for conclusions concerning such things as monogamy, patriliny, and religion. Men, women or any combination could have assembled Hawaiian walled thatched houses.

19. Seasonal temperature variations were widest on the northern islands and most pronounced on higher elevations on all islands (page 13). On the Kona coast of the island of Hawaii diurnal temperature variations in winter at beach level were such that grass houses would provide warmth at night (page 215). Air moved in and out of thatch, which did not form a solid wall but was pneumatically permeable. Grass houses were also cool and comfortable during the heat of summer days and well-insulated against direct sunlight (personal knowledge).

20. The unpartitioned interior of a single house did not permit individual privacy. Group privacy was afforded inside the unpartitioned houses. The larger houses of chiefs permitted ample individual space, but the pup-tent size of commoners' houses permitted only crowded body-contact, prone or seated, occupancy. Individual privacy was

apparently not a desired or usual state in ancient or historic Hawaii (see Trigger 1970:245; pages 217-218).

Small commoners' houses suggest that each house could shelter or secure in close confinement a portion of a kinship organization, perhaps a nuclear family, during inclement weather or taboo periods. An estimated capacity for an average commoners' house would be a maximum of five or six people, if one or two were small children.

Whiting (1964) calls attention to the observed effects of climate on sleeping habits. On warm nights or days in Hawaii, the climate was such that individuals probably preferred to sleep apart. Chiefs had ample room within their roomier structures to sleep apart when desired. The highest occupant in status would have the raised bed of mats to himself. Others present would be on duty or sleeping on the lower floor. Commoners probably preferred to sleep outdoors where there was ample room to spread their individual mats. For periods of inclement weather or during taboo periods which required security, commoners would be forced into close proximity within their small houses (page 7).

21. Performance characteristics of native Hawaiian materials were known, and the best were reserved for the structures built for chiefs. Thus a social difference was marked by material form.

22. Timbers intended for temples and high chiefs' houses were selected for their perfection. This search

for perfection in house timbers was reserved for a major temple or for one or a few units of a high chief's housing complex. Storehouses and other utility buildings in a high chief's complex were built of non-sacred woods, but probably of the best quality available (pages 65-66).

23. The hewing in the forest and the delivery of selected timbers to the site for an important structure were major religious events (pages 67; Kelou Kamakau 1917:V, 8; Haleole 1919:80-82; Ii 1959:43; Kamakau 1964:97; Malo 1951: 166).

24. Materials were prepared and stockpiled before assembly (pages 95, 184-185, 195).

25. Trigger (1970:244) calls attention to a widespread significance and symbolism attached to center posts of structures. A human sacrifice, later in early historic times, a substitute offering, was probably placed under the center post of a major Hawaiian structure (pages 95, 139).

26. If a chief's house was built with the proper observances and prohibitions, it was believed that the Hawaiian gods favored the owner; but if these were neglected, the gods punished him. (Listed observances and prohibitions may reflect some assimilated Western superstitions.) It was believed that a kingdom could be lost if the royal architect built improperly; or won if he was right (page 31). Back components of a house were installed before front components (pages 22, 23, 29, 31). This was the basic observance.

27. Religion permeated all Hawaiian activities, according to the ethnographic literature. House construction was just one of these activities. Temple and chiefs' house building activities were religious acts to Hawaiians (page 30).

28. Krause and Thorne (n.d.:26-27) theorized concerning "primitive" architecture and noted the limits imposed by design and material. By extension of one of their concepts, the surviving house platforms by themselves could reveal to an archaeologist the carrying capacity of the superstructures and the nature and availability of building materials. The scope and extent of such platforms could reflect such factors as the number of people who could be sheltered, their status, or the ceremonial functions of certain platforms. Thus, even without the ethnographic literature, the physical remnants of the ancient Hawaiian civilization could reveal certain aspects of the culture.

29. Krause and Thorne (n.d.:26-27) also noted the concept of linearity, and such is applicable to Hawaiian thatched houses.

Linearity means a functionally interdependent sequence of steps. It also implies that a concept of the completed structure existed before the first step--gathering and preparation of materials--began. Linearity in architecture means that certain steps must precede others, and that these steps impose limits on the subsequent ones. One obvious

step is that the frame must come before the roof. A light frame cannot support a heavy roof. Builders must be aware that a roof of thatch gains weight when wet and prepare a suitable frame. The "Order of Erection" section of Chapter III (pages 87-90, 93) incorporates the concept of linearity.

Steps taken early in the assembly process determined the final result. The proper alignment of lashing notches to serve the lashing: wall-post to plate (pages 107-108, 131, 133) resulted in a neat line of decorative lashings seen from inside the house. Post selection and their placement determined the planes of both fixed and floating thatch networks, and these in turn determined the neatness and smoothness of the thatch (pages 96, 97, 109, 125, 131, 136, 150, 174, 175, 176, 178-179, 186, 187). Properly fitted wall plates kept the finished thatched lines between roof and walls parallel to the horizon (pages 102, 109, 110).

30. From concept to completion of a finished Hawaiian walled thatched house, there were numerous mental and physical steps taken. These steps were necessary to produce the finished product. The complexity and numerousness of the steps imply both thinkers and workers. The steps to complete just one house indicate a complex civilization with capacity for planning, administration, management, organization, division of labor and the proper balance of personnel to assembly time (pages 79-81). These steps were necessary to rebuild the Hale-o-Keawe, and for each of the other structures

built. The capacities of modern governmental and industrial organizations were needed to complete modern reconstructions of thatched Hawaiian houses. Such capacity must have been available in ancient Hawaii.

31. A powerful, central government was needed to command the resources and personnel necessary to build the Hale-o-Keawe. Yet, judging from its platform size, it was a small temple complex compared to others. The largest surviving massive dry-masonry platform is that of Piilanihale temple, Hana, Maui Island, with plan dimensions of approximately 45 feet by 350 feet. It contains one wall about 65 feet high. The dry-masonry platform of Pu'ukohala temple, at Kawaihae, South Kohala district, Hawaii Island, is at its widest dimensions approximately 170 feet by 90 feet in plan. The restored Hale-o-Keawe's platform is approximately 50 by 50 feet. Little information has been retained concerning Piilanihale, but the ethnographic literature gives some details about Pu'ukohala and Hale-o-Keawe.

The ethnographic literature and historical accounts indicate that prior to 1800 there were many parallel powerful central governments which were consolidated into the historic Kingdom of Hawaii by Kamehameha the Great. Both Pu'ukohola and the Hale-o-Keawe were associated with Kamehameha the Great. Much of the surviving information is concerned with the most successful and recent ruling chief, his ancestors, relatives and their activities. Kamehameha

the Great built Pu'ukohola (ca. 1791) as a temple to his war god to assure success. Temples built by other chiefly families apparently did not warrant too much attention after their subjugation by Kamehameha. Piilanihale temple is one of many which represents an era prior to the time of Kamehameha the Great and reflects local organizational competency at an earlier time. The many standing dry-masonry temple platforms on the Hawaiian Islands support statements in the ethnographic literature concerning the antiquity and existence of many parallel central governments.

32. The reconstructed Hale-o-Keawe temple at Honaunau Bay represents the temple ca. 1812, when major temples were rehabilitated under the powerful all-island government of Kamehameha the Great (page 246).

33. The presence of so many temples and chiefly structures scattered throughout the islands at the time of first contact indicates widespread civilization ruled by chiefs who could command large investments of time and materials. This implies a surplus of food and goods to support an overhead organization.

34. Harris (1968:4) puts forth a theory he calls "cultural materialism," based on techno-environmental and techno-economic determinism. Harris holds that similar technologies applied to similar environments tend to produce similar arrangements of labor in production and distribution and that these in turn call forth similar kinds of social

groupings, which justify and coordinate their activities by means of similar systems of values and beliefs. Harris held that this was a macro theory, an analog in anthropology to the theory of natural selection in the natural sciences.

In the micro universe of the Hawaiian Islands, by 1778, each parallel independent government could be considered to have similar technologies applied to similar environments. They had similar kinds of social groupings and justified and coordinated their activities by means of similar systems of values and beliefs. In Hawaii, the similar technologies had a common source; the founder group or groups. The process of diffusion was also at work. Yet the intra-island and inter-island physical barriers which separated the central governments were real and tend to support the theory of cultural materialism, even if on a small geographical scale.

35. The end of the taboo in Hawaii late in 1819 resulted in the immediate destruction of the surface structures of the major temples, with two exceptions. Since organized Christianity did not arrive in Hawaii until 1820, the retention of the Hale-o-Keawe and the Hale-o-Liloa in 1819 indicates a special status to Hawaiians for them. Both temples contained ancestral bones of the reigning family. The deified bones continued to play a part in Hawaiian royal affairs after their removal from the temples ca. 1830 (pages 229-230, 235, 242-245).

36. Maintenance of the Hale-o-Keawe ceased or was reduced after ca. 1830, and the empty structure had disintegrated through neglect and natural forces by 1851 (pages 246-247).

37. High chiefs, and to some extent lesser chiefs, had mobility. They traveled about, along and between islands, crossing traditional land division boundaries. In contrast, commoners usually stayed within the boundaries of their ahupua'a, the basic land division. Chiefs tended to move clockwise or counter-clockwise about an island; commoners moved inland and seaward within their pie-shaped piece of an island (page 11).

38. Doors and stockades are the only evident physical security and defense aspects of the study. Stockades were physical barriers. The low door controlled entry from intruders.

39. After 1819, changes in Hawaiian houses and their eventual elimination may be charged to the increased influence and acceleration of the invading and conquering Western culture, spearheaded by Christian missionaries (page 200).

40. Missionaries and some of the other Westerners who lived in Hawaiian walled thatched houses did so out of necessity and only until they could import materials and resume their accustomed ways in houses of familiar architecture and materials. The Hawaiian thatched house

forced an unaccustomed life style and surroundings on them. There was a limit to the alterations Westerners could make to a thatched Hawaiian house. Their alterations included raising the doors, making windows, and installing board floors and partitions, in an attempt to make them as Western as possible. Western uses of Hawaiian thatched houses differed from those of the Hawaiians.

41. Cockroaches, centipedes, scorpions and other insects found suitable homes in house thatch. Their presence may have been a factor in the discomfort experienced by many occupants. The peskiness of pests was a by-product of the Western invasion of Hawaii (see Brigham 1908:97).

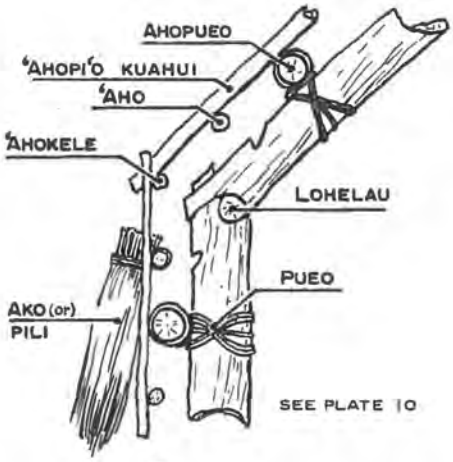
42. Cultural persistence in Hawaiian architecture lasted until about 1920, about which time the thatched Hawaiian house passed from the scene (pages 197, 201). By this time, Hawaii was an incorporated American Territory.

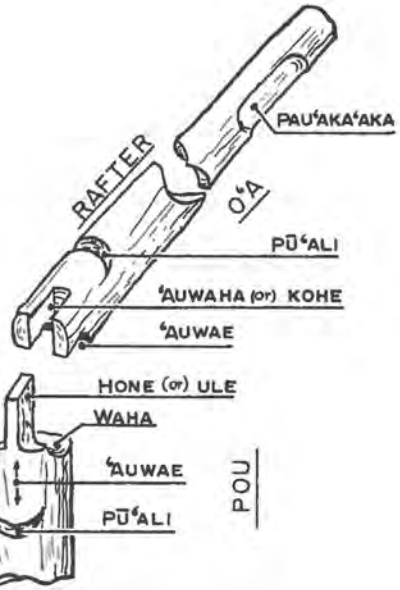
43. Technology in architecture mirrors the social change in Hawaii. In the time before 1778, there was a complex interrelationship between house structures and the isolated island environment. Materials and tools came from the natural environment of the islands and were used to produce shelters not only from that environment but to serve social needs of the people which built them as well. Technological change became possible when new materials were introduced into the isolated island ecosystem.

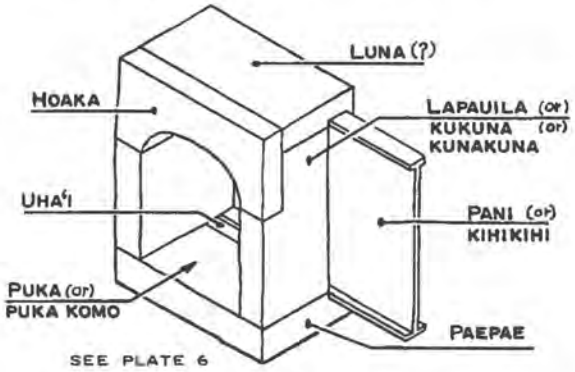
44. Opportunities for technological change began in 1778-1779 when Cook offered, and the Hawaiian readily accepted, great quantities of wood-working tools made of iron.

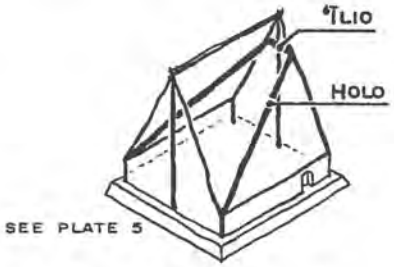
Customs tend to be internally consistent, and change together in structured systems. This was one technological change incorporated readily by the Hawaiians, and apparently without related changes in other aspects of the culture. The imported iron tools were used to shape house joints to build traditional houses, and to carve temple images. This substitution of iron for stone adzes and chisels is an index of Hawaiian capacity for selective social adaptation. Hawaiians appear to have been overwhelmed by the later numbers and nature of introduced ideas and technology. Societal disintegration resulted.

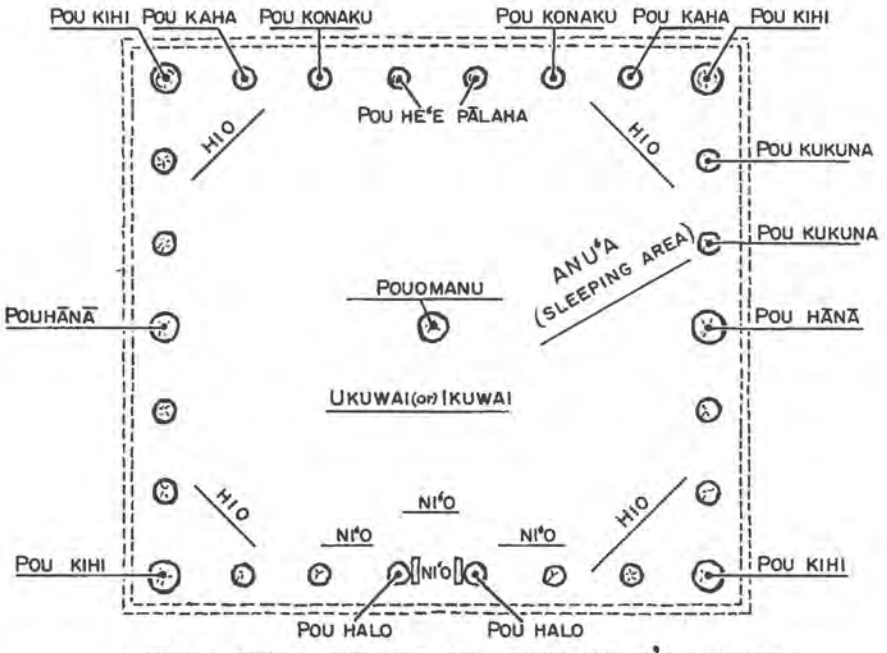
45. The ancient Hawaiian civilization set high chiefs apart and accorded them god-like status. Finally, for those who search for cosmogonological overtones in the status and facilities the Hawaiians gave high chiefs, it is suggested that perhaps the stockades around temples and high chiefs' housing complexes represent egg shells--a visualization of the cosmic egg from which the ancestors of Polynesian chiefs were believed to have come by Cosmogonists. Or did the thatched house represent a womb, with the crawl-in size door a symbolic vagina?











NAMED POSTS AND AREAS — HIGH CHIEF'S HOUSE

PLATE 13

HAWAIIAN NAMES OF STRUCTURAL MEMBERS

APPENDIX A

APPENDIX B

DONERS OF MATERIAL AND SERVICE IN THE RESTORATION OF THE HALE-O-KEAWE, 1966 THROUGH 1969

ISLAND OF NIIHAU

Anonymous

ISLAND OF KAUAI

Anahola Hawaiian Homesteaders
Boy Scouts of America
Hale O Na Alii
Hi Y Clubs
Hui O Kaahumanu
Kauai Canoe Club
Kauai Hawaiian Civic Club
Kaumualii Hawaiian Civic Club
Kokee Job Corps Camp
Order of Kamehameha
University Extension Girls

ISLAND OF OAHU

Anonymous
Kuahiwi Apple
Makalika Apple
Dorothy B. Barrere
Bernice P. Bishop Museum
District I, State Association of Hawaiian Civic Clubs
Kenneth P. Emory
Dr. and Mrs. George H. Mills
Robert E. Van Dyke

ISLAND OF LANAI

Lanai Hawaiian Civic Club

ISLAND OF MOLOKAI

Molokai Hawaiian Civic Club

ISLAND OF MAUI

District III, State Association of
Hawaiian Civic Clubs
Haleakala National Park
John Wilmington III

ISLAND OF HAWAII

Ala'e School
Peg Apple
Bishop Estate
Boy Scouts of America Troops
Honaunau School
Kona Hongwanji Church
Robert Chapman
Fourth Grade, Konawaena Elementary School
Mrs. Maude Greenwell
Hawaiian Civic Club of Hamakua
Hilo Hawaiian Civic Club
Slim Holt
Honaunau School
Honomalino Farms
Hookena School
Kahuku Ranch
Joe Kamagaki
Moke Kekuewa
Kona Hawaiian Civic Club
Konawaena School
Gordon MacKenzie
McCandless Ranch
Fred Medeiros
Hansa Moyata
Mrs. Roy Onaka
Pukaana Church
Norman Sakata
Larry Sasaki
Nancy Wallace
Meleana Warfield
Lum Won

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