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RECONSTRUCTING THE BALLOON FRAME: A STUDY IN THE HISTORY OF ARCHITECTONICS

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"After an immeasurably long evolution, traditions (a continuous addition of new purposes and means of production) together with art (born of the human sense of beauty) gradually elevated the basic forms of supports, walls, and rafters to art-forms [*Kunstformen*].... Moreover, if one examines all the art-forms from historical periods, an almost unbroken series of gradual developments from the date of their CONSTRUCTIVE origin until today can easily be proven, notwithstanding all the stylistic epochs."

Otto Wagner, *Modern Architecture*, 1902

The beginnings of timber construction must be older than the *Homo sapiens*, the Modern humans. Even before, whatever the proper meaning of construction implies, we know that our earlier ancestors have been nesting on tree branches with some modification of the natural environment. The higher apes' nest building activity, arranging and weaving the branches into a stable round platform then cushioning it with broken off twigs, sticks and plucked leaves, for a night's rest, may not be 'construction' in the conventional sense, nevertheless it is a conscious constructing activity that is well beyond just heaping up materials. According to Fruth and Hohmann, nests can also be considered "the foundation for all future tool use ability", where higher cognition, and technological skills "served as the spring board for the great leap forward in the hominid evolution" (**1**). It is likely that this very first environmental alteration is the beginning of a long journey in the history of construction.

Early human shelters, in places where environmental conditions were favorable to tree growth, understandably included some form of wood construction. As rudimentary forms of construction and building technology matured with time and experience, concept of framing and various other techniques developed. Until the modern times, in the crafts tradition, mastery and refinement of these techniques was mostly the result of empirical methods, and intuitive understanding of structural behavior and the nature of the material. This process of formation, or the evolution of timber construction, has been a gradual and, overall, a progressive

1. Fruth and Hohmann (1996, 225-40, 238).

change and development towards an economy of materials and labor. This is a significant achievement of the human intellect and an important step towards rationalization of design decisions.

Balloon frame is a method of construction that became the major way of building using timber in the last hundred and fifty years, especially in northern America, more specifically in the United States. An overwhelming majority of residential buildings --single and multiple residence, one to three stories-- in the U.S., as well as a significant number of nonresidential --institutional, commercial and office-- buildings are balloon frame construction, or its derivative, western platform framing. Despite its prevalence and popularity, due to its simple and economical manner of construction, and flexibility allowing different styles and forms, there is an equivocalness surrounding its origins and development. As a result of the void created by the inaccurate information and conflicting interpretation, there are unanswered questions regarding the production of buildings employing balloon frame and its ecological soundness, as well as questions related to its history and culture. The purpose of this study is to raise questions regarding the inventor(s) of the balloon frame and propose an alternative perspective looking into the matter, so that a consistent account of balloon frame takes its place in the tectonic culture. It is also meant to argue that the evolutionary nature of building technology, especially in the crafts tradition, can only allow gradual change and development rather than discontinuous step-function-like changes relying on heroic inventions and design innovations. Central to its argument is the premise that change and development in building technology is the cumulative result of past experiences and that these changes do not proceed independently. Innovative and creative aspects lie in the development of an existing form, or process, rather than in 'invention' per se. Collective nature of this process, involving various interests and contributing groups, is another dimension which challenges the idea of the internal evolutionary logic of the building technology and the 'heroic inventive genius' of one individual. The latter is an idealized vision of an architectural history, or for that matter of the architect, in which individual designers or inventors perform supposedly in a vacuum. However, it is not sustainable in the face of a more comprehensive inquiry, since unfortunately, this romanticized and sanitized vision of architectural history leads to ignore all things outside a set agenda.

While tectonics refers largely to the art of assembling materials used in construction and also to the earthbound nature of building, the tectonic culture, in a broader context, consigns itself to an aesthetic judgment as well as the economy of the artifice produced. It is the simultaneous existence of both art and craft in this production, which requires the presence of technological, aesthetic and social categories in its analysis. Any account of tectonics, by its nature, transcends the mere mechanical assemblage of materials in the narrow sense, acknowledging social and aesthetic implications in its evolution. Developments and innovations in tectonic culture have long gestation periods, between the initial germination and the final existence, which is almost always incomplete because there is some room for more development with the changing conditions.

Balloon frame stands out as an icon of tectonic culture and a power of dominance in the realm of building construction. In addition to being the major material artifact in construction, it is also a cultural representation. It

2. Field, (1942, 3-29); Sprague (1983, 35-62).

3. Giedion (1967, 1941, 351).

4. Pierce (1937, 202, n. 149).

5. Robinson (1846, 57-8, 58).

6. Robinson (1847, 216-8).

fills the urban and rural landscapes throughout America, dwarfing every other construction method and constituting a significant portion of the $500 billion building construction industry. Hence, balloon frame has become more an economic and cultural entity than it is a construction method and a technical device.

> If a question can be put at all, then it can also be answered.
> Ludwig Wittgenstein, *Tractatus logico-philosophicus,* 1922

INVENTION OF A FICTION

There are two different claims regarding the invention of the balloon frame in Chicago. One is attributed to George Washington Snow and the other to Augustine Deodat Taylor. Both arguments have been covered quite extensively in two articles (**2**), therefore, rather than repeating what has been published already, only those points relevant to our argument are referred to here. Walker Field argues, in an article published in 1942, that it was Taylor who should be given the credit for inventing the balloon frame. Paul E. Sprague, in a 1983 contribution to a volume focusing on the technology of historic buildings in America, follows Giedion's footsteps, in much more detail, declaring Snow as the inventor. These are legitimate scientific hypotheses, but the supporting evidence is weak, ambiguous or contradicted by other evidence. In his *Space, time and architecture,* after scorning the "characteristic ...negligence with which contemporary history is treated" (**3**), referring the vagueness with which architectural sources credit the inventor of the balloon frame, Giedion takes it on himself to answer the questions of 'who' and 'when': George Washington Snow (1797-1870) is the inventor; it was first used in St. Mary's Church in Chicago in July 1833. At the same time, Giedion also acknowledges Field's Harvard thesis, with the same title as his published article, which "shows how difficult it is to give George Snow full credit for the invention of the balloon frame. Further investigation seems to be necessary" (352, n.10).

The very first written reference to the balloon frame is in a letter by Caroline Clarke of Chicago to Mary Walker on 1 November 1835. As quoted in Pierce, she depicted "balloon buildings" "built of boards entirely -not a stick of timber in them except for the sills" (**4**). The first mention of the balloon frame in a publication appeared in *The American Agriculturist* in February 1846, in a continuing series of articles on "A cheap farm house" by Solon Robinson. There, Robinson set his objective "to accommodate the new settler and poor man, with a plan by which he can get a home without building himself out of a house" (**5**). His mention of the balloon frame was very much in line with what he was trying to do with the series: "As in all my design I aim at great economy of cost, convenience of arrangement, and occupancy of all the room for some useful purpose". Along with mention of the balloon frame, went a ground plan and an elevation:

> "It is particularly intended for the new settler, and to be built on the *baloon* [sic] *plan*, which has not a single tennon [sic] or mortice in the frame, except the sills; all upright timber being very light, and held together by nails, it being sheeted upon the studs under the clap boards, is very stiff, and just as good and far cheaper than ordinary frames" (57).

A year and a half later, writing on the subject, he stresses some of the points made earlier on the new method of construction, "particularly designed for what is well known about Chicago as a 'balloon frame', ... for it is a great saving of expense"(**6**) Then, he described it for the sake of

7. Robinson (1855).

8. Woodward (1859-1861); (1865); (1867).

9. Woodward (1865, 151).

10. Woodward (15, 226); (1865, 166).

11. Field (1942, 17).

12. Van Osdel (1883, 17).

13. Van Osdel (1883, 36).

those "eastern readers" who may not understand it, emphasizing once again that *"there is not a tenon nor mortice in the whole frame"*, giving detailed information on materials, connections and nailing. Robinson did not mention anyone by name as the inventor of this new construction method. Later, in 1855, in a lecture delivered in New York City, he drew attention to the significance and merits of the method itself, rather than the mention of any particular name who could be credited with such an innovation:

> "If it had not been for the knowledge of balloon frames, Chicago and San Francisco could never have arisen, as they did, from little villages to great cities in a single year. It is not alone city buildings, which are supported by one another, that may be thus erected, but those upon the prairie, where the wind has a sweep from Mackinaw to the Mississippi, for there they are built, and stand as firm as any of the old frames of New England, with posts and beams sixteen inches square."

Robinson's lecture was reported in the *New York Tribune* (**7**). During the same year, Gervase Wheeler's *Homes for people in suburb and country* was published wherein Wheeler included extracts from Robinson's lecture, in the part titled "Novel modes of building" (409-14).

George E. Woodward, an architect and a civil engineer, is someone who advocated the use of the balloon frame and publicized its merits and advantages more than anyone else. He published a series of articles in *The Country Gentleman* between November 1859 and June 1861 on the subject, and elaborated on it quite extensively in the two books on architecture and construction of houses,(**8**) which followed these articles. In the first of the fifteen articles he writes, "Who the originator was is not known; the system is not patented" (313). Elsewhere, he reemphasizes this point: "The early history of the Balloon Frame, is somewhat obscure, there being no well authenticated statements of its origin. It may, however, be traced back to the early settlement of our prairie countries, where it was impossible to obtain heavy timber and skillful mechanics..." (**9**). In one of the earlier articles in *The Country Gentleman*, he reiterates the point from a different perspective: "The existence of the balloon frame for wooden buildings seems to have been called forth by necessity, and not by the mechanical skill or inventive genius of any one individual" (14, 387). Throughout these writings Woodward champions the new method of construction because of its "simple, effective and economical manner of construction, has very materially aided the rapid settlement of the West, and placed the art of building, to a great extent, within the control of the pioneer"(152). For Woodward the balloon frame is worth pursuing because of its economy, strength and structural indeterminacy, stylistic versatility, adaptability to irregular forms, *and ease of construction without skilled labor* (**10**)(**Figure 1**).

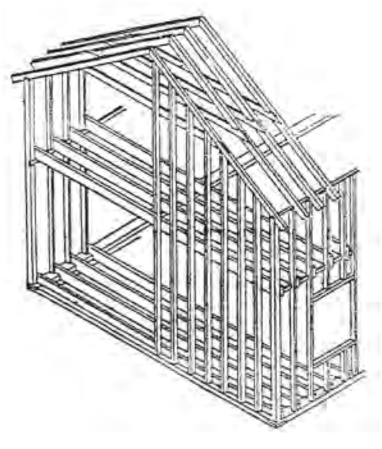


Figure 1. The first three-dimensional drawing of balloon frame in publication (Woodward, 1860, 226).

The next two persons referring to the balloon frame in print are Charles Cleaver and John M. Van Osdel, who both credit Snow for originating the idea. Field quotes Cleaver on Snow's contribution but also adds that this view was not universally accepted, nor was it definitely established (**11**). Van Osdel, "the pioneer architect of Chicago", came from New York, arriving in town "early in the spring of 1837," according to his own account (**12**). In the second of the six part series, published in *The Inland Architect and Builder* between March and August 1883, he wrote that, "Mr. Snow was the inventor of the 'baloon [sic] frame' method of constructing wooden buildings, which, in this city, completely superseded the old style of framing with posts, girts, beams and braces" (**13**). Beyond this conclusive remark regarding Snow's role, Van Osdel does not substantiate Snow's

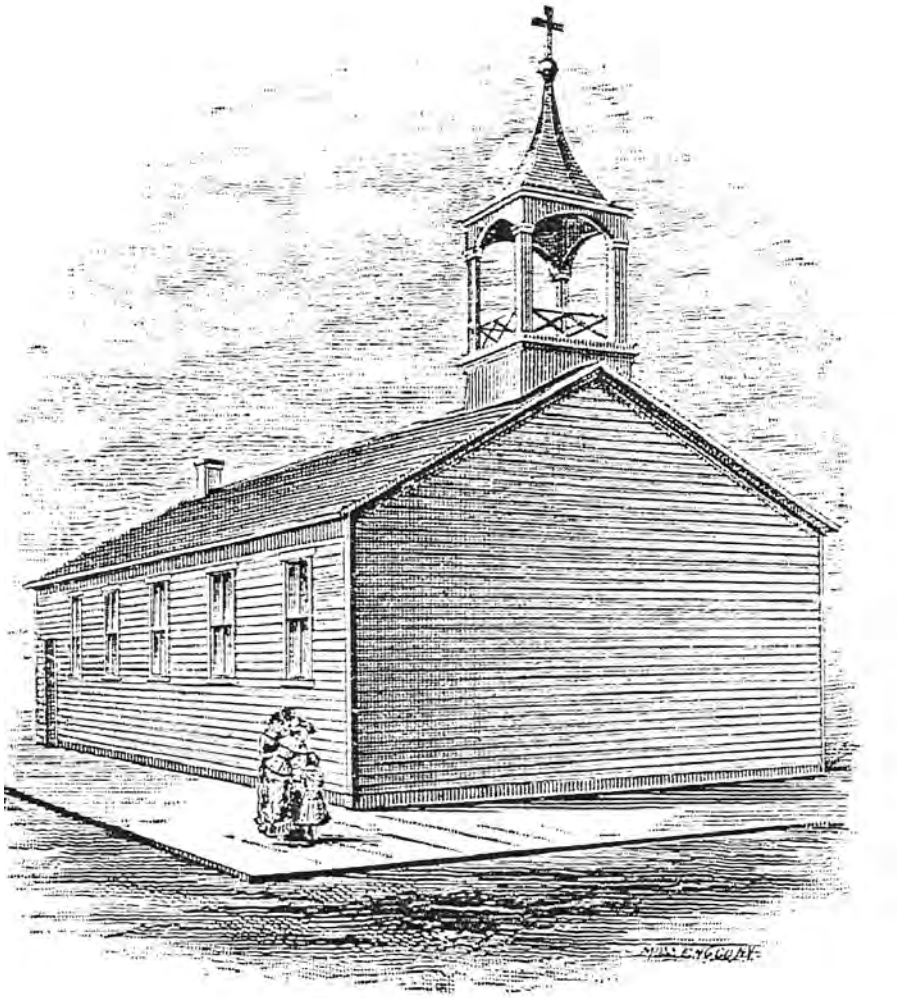


Figure 2. St. Mary's Church, Chicago, 1833 (Andreas,1884, 291).

invention in any form. There is no elaboration as to how Snow developed his idea and how he communicated it to builders to put it into practice. In spite of his civil engineering background, nowhere is it mentioned that he was directly involved with construction. Certainly it is very probable that his "technical training," as Giedion surmises, "may have led him to the invention of the balloon frame," (**14**) but there needs to be slightly more convincing evidence than just the statement of Van Osdel, who was not even a first hand observer, as to how Snow did it. We are also in the dark as to what Snow's role was in the construction of St. Mary's Church, claimed to be the first balloon frame building. Similar to Robinson and Woodward, very positive about the new method, Van Osdel writes that the "great rapidity in the construction and large saving in cost, compared with the old-fashioned frame, brought the balloon frame into general use. It is conceded that a frame with every part spiked together offers greater resistance to lateral force than any other method of construction" (**15**). His next, and only other, reference to Snow, is that "Geo. W. Snow established the first lumber-yard in 1839..." (**16**).

The building, which is credited with the first use of the balloon frame, as has been mentioned above, is St. Mary's Church, completed in October 1833 (**Figure 2**). There seems to be no dispute over this fact: proponents of both Snow and Taylor are in agreement. Sprague immediately affixes

14. Giedion (1967, 1941, 352).

15. Van Osdel (1883, 36).

16. Van Osdel (1883, v: 1, n: 6; 80).

that "Snow's experiment in building took place in 1832 and was quickly given the apparently derisive name of 'balloon' construction" (**17**). He does not, however, support this claim. For Snow being the inventor, Sprague's references are Giedion and Field. The latter is a surprise, and is also confusing, for Field is painstakingly trying to show that it was not Snow but Taylor who should be credited with the invention of the balloon frame. Giedion's primary sources for Snow's invention are Van Osdel, Andreas, and *Industrial Chicago* (**18**). Of these three sources, only the first is an independent source for the last two either quote Van Osdel as reference or liberally use the information provided by him. Field's critical view of Van Osdel's claim that it was Snow who invented the balloon frame is partially based on "the unsupported word of a late arrival who did not set down his record until fifty years after the event and thirteen years after Snow's death" (**19**). Also, the account of St. Mary's Church from its inception in early May, with the arrival of Father St. Cyr, to its occupancy and dedication in October, is well documented (**20**). Field uses Andreas, whose detailed account of the St. Mary's Church is given, as the primary source to buttress his case. In brief, Taylor, a carpenter who came to Chicago about a month after Father St. Cyr's arrival, was put in charge of the construction of the one story and eight by eleven meter (twenty-five by thirty-five feet) church. "By September, three carpenters were at work, Augustine Taylor, master builder, his brother Anson, and Deacon Wright, staunch Presbyterian. The following month witnessed the dedication of the building, located on the southwest corner of present day State and Lake streets" (**21**). Taylor is also mentioned as one of "the principal builders," "in the city in the spring of 1837" at Van Osdel's arrival. Here, again, as in Snow's case, there is no concrete evidence that it totally was Taylor's idea, nor that it was really the very first time such a construction method was practiced. Field's argument in favor of Taylor, being "eminently qualified to initiate such an important innovation in building methods," and that "throughout his life, he was known as a builder," (**22**) falls short of being more convincing than Giedion's conjecture regarding Snow. As Field aptly observes, "there is no record of Snow having personally erected any buildings whatsoever, and only one known instance in which Snow is connected directly with a building operation, even as a client" (**23**). While this is true, at least within the available documentation, it is not impossible for someone who is not involved in the practice of construction directly to come up with an innovative construction idea. Furthermore, Snow was not far removed from construction; both his background as civil engineer and his business in lumber, real estate, and contracting kept him quite close to construction, if not directly in it. More than a question of direct involvement, there is insufficient evidence to lead to a decisive conclusion.

Condit, in his review of two books in 1957, where he referred to "the invention of the structural technique known as the balloon frame" (**24**), he declares Taylor to be the inventor. In his *American Building Art: The Nineteenth Century*, published three years later, he does not provide much more information regarding its origin than he did in the book reviews. Neither in the reviews, nor in his book, does he give a source, making it difficult to follow his course of reasoning. Elliot very briefly refers to the balloon frame in his book, *Technics and Architecture*, mentioning that in 1832, it was Snow who "introduced to Chicago a method of framing buildings that used light pieces of lumber, ... and relying more on nails than the traditional mortise-and-tenon connections"(**25**). More recently, Peters in *Building the Nineteenth Century* writes in a note that "the balloon

17. Sprague (1983, 36). The experiment in 1832, which Sprague mentions, refers to building a mill with balloon frame. There is no other information on it.

18. Van Osdel (1983); Andreas (1884); *Industrial Chicago* (1891).

19. Field (1942, 7).

20. Andreas (1884, 290-1); Pierce (1937, 225).

21. Pierce (1937, 225).

22. Field (1942, 23).

23. Field (1942, 21).

24. Condit (1957, 484-7).

25. Elliott (1992, 18).

26. Peters (1996, 428, n. 87).

frame cannot reliably be traced to single event, although popular myth claims that it was invented in Chicago in 1833"(**26**).

Tracing the origins of the balloon frame to a single event, as Peters tersely points out, is far from convincing. Treating the flow of events as discontinuous and independent incidents inevitably leads to questions of plausibility and cogency. It is paramount to go beyond the 'who' and 'when' in spite of the temptation and the convenience of the clear-cut and sanitized quality of the answers that these forms of questioning may provide. Perhaps one can question the form of inquiry, which is partially responsible for the ambiguity surrounding the origins of the balloon frame. While 'who' and 'when' address a certainty, it undermines the possibility of a collective contribution taking place in a time span, as well as disregards the continuity element of a technological development. Both 'who' and 'when' search to single out individuals and single events, denying the artifact a history and oversimplifying the entire process. Yet most developments, especially in construction, are built on experience and knowledge that are collective and cumulative rather than single incidents. Similar to most technological developments, the balloon frame has a history and did not fall from the sky, nor was it applied to a building overnight. Proposing that the balloon frame has a history and suggesting that it has continuity are not radical steps. However, it deviates from the mainstream of romanticized novelty search. If the balloon frame has a history and if it can be shown that it is a phase in a long line of development, then the whole argument regarding the 'who' and 'when' is effectively meaningless.

The determinate characteristic of the form of questioning certainly poses a problem when the nature of the development is indeterminate and has many variables netted in a relationship much too complex to be reduced to a single event and credit an individual. A more fruitful form of questioning, especially in the case of a new application of an existing practice, is one that includes the circumstances that nurtured the development of such an innovation. What are the reasons and conditions for its emergence and development? How did it come into existence? What are its antecedents? How does it differ from the preceding examples? Even in the case where there may be major role players in the evolution of the balloon frame, their contribution and these questions cannot, in the final analysis, be answered independently.

Origin and development of the balloon frame are questions of technical change that takes place in a social environment with a technological capacity and that are also related very strongly to the dynamics of the culture and economics. The inability of 'who' and 'when' lie in the fact that this form of questioning does not necessarily paint the more comprehensive picture of the social and economic conditions which set the context for the change. Nor do these questions paint a picture that is fair to all the anonymous contributors in the process of its development. Both forms tend to freeze the time with a specific moment and a single event, and bypass the evolutionary dimension of a social process wherein the cumulative nature of technological innovations is overlooked. This form of questioning also, by emphasizing specific actor(s), credits the individual(s) as if they exist in a hallow container and as if nothing existed previously, therefore forcing an interruption of continuity. On the other hand, questions that search for the conditions that lead to innovations and changes in method of production, and the specific reasons for the particulars of the innovation seem to be more fitting and productive.

> A given civilization contains both permanent and the changing. It is rooted in one place and may survive clinging to its territory for centuries on end. Yet at the same time, it accepts certain borrowings from other civilizations, near or far, and exports its own cultural goods. Imitation and influence operate alongside certain internal pressures working against custom, tradition and familiarity.
>
> Fernand Braudel, *The Wheels of Commerce; v. 2, Civilization and Capitalism, 15th-18th century*, 1982

SETTING THE STAGE

It is estimated that in 1833 the population of Chicago was 300-350 (**27**). In two years, the population increased ten times, and by 1840 it reached 4479. In the next five years this figure almost tripled, and by mid-century it climbed up to 28,960. The population was over a million a decade before the turn of the century. This was the trend in the population growth when George Washington Snow, a 'civil engineer" who came to Chicago from New England in 1832 became "a pioneer of the vast lumber yard business for which Chicago has become distinguished." [196] Although the sole "honor of establishing a lumber yard, the first in the young village which was destined later to become the metropolis of the West" does not belong to Snow, Capt. David Carver's involvement "was but for a short time, and not for permanency..."(**28**). Giedion informs us that Snow purchased Carver's Lumberyard in 1835 (**29**). Although we have conflicting reports for the beginning date, Snow's lumber business, according to Hotchkiss, grew from small beginning of 30,000 bd. ft. in 1833 (or 1834) to 32,000,000 bd. ft. in 1847 and to one billion bd. ft. by the time of his death in 1869 at the age of 72. His widow saw the business reach two billion bd. ft. before her death in 1891. Snow "owned considerable land and conducted a real estate business. He was a building contractor, as well as a general contractor and financier"(**30**). Unsurprisingly, he is cited among the "leading merchants and lawyers of the town"(**31**).

Chicago, claimed to be the birthplace of the balloon frame, composed so favorable a context for a technical innovation such as this that its development and very popular use generated an American identity with the new construction method. Rapid increase in the population required rapid residential construction, among other things. Residential construction must have land on which to build. Irresistibly, such a high demand for buildable land and real estate brings its cost with it. Very naturally and immediately, land became a tool for investment and speculation. Canal lots, 25 by 30 m. (80 by 100 ft.), which were bought for $33 in 1829 found purchasers at $100,000 seven years later (**32**). Lots, not even in the business area, which were sold for $50 in 1830 were purchased for $250 in 1834 (**33**). Lots selling for $5000 in 1837 were resold, doubling the price in less than two months. "The lust for profit," Pierce writes, "was so great that property outside of Chicago also entered the market ... providing additional tracts for enterprising salesmen, who also engaged in platting new 'additions' within Chicago itself" (**34**). It is under such conditions we see that the infant balloon frame being employed in the much-needed residential construction industry, which has to produce in great quantities and rapidly, to satisfy the existing deficiency and steeply rising housing needs.

27. Hotchkiss (1894, 33).

28. Hotchkiss (1894, 196).

29. Giedion (1967, 1941, 352).

30. Giedion (1967, 1941, 352).

31. Pierce (1937, 372).

32. Andreas (1884, 137).

33. Pierce (1937, 58).

34. Pierce (1937, 58).

It is not surprising to find a labor scarcity in Chicago, as most everywhere else in expanding America. It was especially difficult to obtain labor for the industrial sector as a whole. Its supply was close to a perfect inelasticity. Habakkuk traces the reasons for the inelasticity partly to abundance of land, difficulties in internal transportation, and America's geographical remoteness from the areas of abundant population (**35**). Sudden, a sharp increase in demand for labor brought about a rising wage level. However, this was different from the general cost of the labor, which at the time was expensive to start with as manufacturing was supplanting crafts. Comparing England and America, Habakkuk writes that the dearness and inelasticity of American labour "gave the American entrepreneur with a given capital a greater inducement than his British counterpart to replace labour by machines...It was where the more mechanised method saved labour that the American had the greater inducement than the English manufacturer to adopt to" (**36**). In the building construction industry, a slight modification to Habakkuk's thesis may be in order. It was not really machinery that was replacing labor in the construction sector as it was in other manufacturing industries. It was indirectly the machinery used in the lumber industry and nail manufacturing industry that were making considerable contribution to transforming construction methods. Developments in machine technology enabled a different path for labor. Instead of the skilled carpentry previously required in construction this technological progress allowed the employment of semi-skilled, or even unskilled, labor. It has been the common argument, since the wide use of the balloon frame itself, that it was both a material and labor saving method of construction, which reduced the labor time compared to the craft tradition and also relaxed its requirements for skilled craftsmanship. As for the material saving aspect, that depends on how it is viewed. Compared with the gradually declining traditional construction method there was a slight advantage only because the use of timber in the traditional method was very generous to start with. Almost profligate use of material had its reasons at the time, both tectonic and traditional. Overdesign was necessary because of technological incapacity and safety concerns. Therefore, it may be correct to say that the balloon frame was a material saving method, if viewed in absolute terms. However, the new method of 'light framing' was not as 'light' as it could be, nor has it developed to be as 'lean' and 'ecologically friendly' a method of construction as it could be. While saving on labor the housing industry made use of the riches of available resources and continued a system that still consumed material in large quantities. A material-intensive technique was in the process of replacing a labor-intensive one.

There were rich natural resources, which meant abundant timber. In the case of construction, it implied almost a readymade material. Capital and labor had to adjust accordingly. The inelastic supply of labor and the infant stage of capital did not leave much choice. Capital had to be put into use to combine labor with resources. In residential construction, cheap timber enabled American builders to economize on labor and capital. The cost involved in this development was an environmental one, which at the time did not seem to be anyone's concern. For instance, by the end of the nineteenth century much of the pine forests on the Michigan peninsula had been depleted since these were some of the main sources of timber for building construction, as well as for ship building industries in the Midwest. Economic priorities of the time called for rapid and massive residential construction so that much-needed large populations could

35. Habakkuk (1962, 15).

36. Habakkuk (1962, 17).

be housed and provide the necessary labor power for all the growing industries.

The lumber industry had an early start in America. It is reported that the first water-powered sawmill in America dates back to the 1630s (**37**). However, it was not until 1646 that a patent was given for a sawmill: "the first patent issued in America for a mechanical invention, ... by the colony of Massachusetts to Joseph Jenks for improved sawmills and scyths" (**38**). Because of the wide use of timber in various industries and lack of substitutes for it, especially in the early days, settlers in New England and other parts of the coast, who heavily depended on the material, adopted and developed more efficient ways for working the lumber than hand tools. It was mainly consumed in building construction, shipbuilding, furniture manufacturing and heating. All along the coast from New England to Maryland and Virginia it not only became a flourishing domestic business, but also an important export item (**39**).

Around Chicago, a number of sawmills were already in operation in 1832 (**40**). If the population of the village, which was only 60 in 1831, is taken into consideration, settlers must have been very much aware of the prospects for the lumber industry at the time. Most of the timber was brought in from Michigan across the lake. David Carver, who Andreas reports as the first lumber merchant in Chicago, transported lumber from St. Joseph, MI to Chicago as early as 1833, and unloaded directly on the bank (**41**). In the case of St. Mary's Church: "The lumber arrived, Anson Taylor, a brother of Augustine Deodat Taylor, with his own team, hauled it from the schooner to the site of the prospective church" (**42**). The lumber was consumed so rapidly and in such great quantities that the newly started industry was not able to satisfy the demand in full. As some of the sawmills were improving on their machinery, for example, through the addition of shingle machines, the supply of the needed lumber was not always adequate since some mills "sawed out such timber as grew adjoining, consisting of oak, elm, poplar, white ash, etc. Of such 'lumber,' in its green state, most of the houses were built, and the reader can easily imagine what these structures must have looked like after the summer's heat had warped and twisted the material" (**43**). Intense lumbering of the pine forests in Michigan commenced immediately after an 1836 treaty with the Indians, which ensured the white settlers lumbering rights north of the Grand River. In 1837, the first sawmill in Muskegon on the Michigan peninsula began operation, to be followed by others in order to increase production to satisfy the steeply climbing demand, especially in Chicago. With "the rapid increase of saw-mills in Michigan" (**44**), the number doubled from 491 in 1840 to 986 in 1860 (**45**). It should also be added that by 1900, the lumber industry on the Michigan peninsula waned and the last mill in Muskegon closed in 1910 due to destruction of the pine forests.

Figures given in Hotchkiss in relation to receipts and shipments of lumber and shingles in Chicago between 1833 and 1893 are very telling. When we look at these in terms of quantity of lumber per person, in Chicago alone, it starts with a very meager 0.22 m^3 (86 bd.ft.) in 1833, reaches a peak of 9.6 m^3 (3831 bd.ft.) in 1855, and with some fluctuations between 1855 and 1885, but floating around 6.3 m^3 (2510 bd.ft.) on the average, drops to 4.3 m^3 (1710 bd.ft.) in 1890 (**46**). Comparing these figures with the total required timber for the construction of a 100 m^2 (1100 ft^2) house, which is 23.6 m^3 (10,000 bd.ft.), gives a sense of scale. Also, compared with the national average consumption, per capita, from the beginning to the third

37. *Industrial Chicago*, v: 2, 353; Bolles (1881, 1878, 498-9).

38. Rosenberg (1975, 37-62).

39. By the middle of the eighteenth century, America was exporting in relatively large quantities to the West Indies, Montreal and Quebec, and Great Britain. Exports were not only raw lumber, but toward the end of the century they even included "shingles", "ship-knees", and even "house-frames" (Bolles, 1881, 1878, 501).

40. *Industrial Chicago*, v: 2, 355.

41. *Industrial Chicago*, v: 2, 356.

42. Andreas (1884, 290).

43. Andreas (1884, 566).

44. Van Osdel (1983, 17).

45. Rosenberg (1975, 57-61).

46. Hotchkiss (1894, 193).

	United States				United Kingdom			
	consumption (in thousands)		per capita consumption		consumption (in thousands)		per capita consumption	
Year	(cu m)	(bd ft)	(cu m)	(bd ft)	(cu m)	(bd ft)	(cu m)	(bd ft)
1799	750	300,000	0.15	58	257	102,703	0.03	10
1809	1,000	400,000	0.15	57	305	121,916	0.03	10
1819	1,375	550,000	0.15	59	613	244,745	0.04	17
1829	2,125	850,000	0.17	67	798	319,306	0.05	20
1839	4,010	1,604,000	0.25	98	1,075	430,267	0.06	23
1849	13,480	5,392,000	0.60	239	2,563	1,024,565	0.13	50
1859	20,073	8,029,000	0.65	259	4,493	1,796,596	0.20	79
1869	31,890	12,755,543	0.82	328	6,048	2,419,390	0.24	95

Table 1. Lumber consumption for the United States and United Kingdom.

After N. Rosenberg, "America's rise to woodworking leadership," in *America's wooden age: Aspects of its early technology*, ed. B. Hindle (Tarrytown, NY, 1975), Table 1: 56.

quarter of the nineteenth century consumption in Chicago is outstanding. Rosenberg's comparison of lumber consumption for the U.S. and the U.K. after the 1850s is rather striking in the sense that in America consumption per capita is about three and half times more than that in the country from which most of the construction techniques were imported (**Table 1**). Granted that lumber consumption in Chicago, or the United States for that matter, was not all for residential construction, but residential construction was one of the primary consumers of lumber in the nineteenth century.

In addition to the social and economic demands, industrialization of nail manufacturing was crucial to the development of the balloon frame. Nails have been in use for centuries. The method of forging, producing hand-wrought nails, was used throughout the seventeenth and eighteenth centuries and even in the early periods of the nineteenth century (**47**). There was definitely use of nails in frames and trusses as early as the beginning of the thirteenth century in England (**48**). During the Colonial period nails were imported to America. It was after the Revolution that America became more independent and started utilizing local sources for the supply of nails. Toward the end of the eighteenth and the beginning of the nineteenth century there was a critical transition in the technology of nail manufacturing, from wrought to cut nails, that is from hand-made to mass-produced nails, which lowered the prices considerably with more efficient production (**49**).

In brief, this is the picture of America and particularly of Chicago at the birth of the balloon frame: rapidly increasing population in need of housing, fast growing industries with a high demand for labor, scarcity of industrial labor, rich natural resources, soaring land speculation, fast capital formation. One other thing that needs to be painted on this canvas to give a more detailed picture is the transition from artisan production to capitalist production. Limiting ourselves to residential construction, the house builder, until the early nineteenth century, operated according to crafts regulations. He was paid for piece-work by the patron. Labor relations of apprentice and master in artisan production were organized by the building crafts. With the transition to capitalist production came the gradual disappearance of the traditional apprentice. The 'worker' was to be paid by the capitalist employer, in most cases not the client. As wage labor took the place of 'traditional' labor, time-rate replaced piece-rate. While this was to effect labor relations drastically, another traditional pattern of construction was being slightly modified in America, especially in the

47. L.H. Nelson (1968, 203-213); Williams (1987, 77-8).

48. Nails for fastening studs (*stodnayl*) , boards (*heuesbord*) were sold by the hundreds. For instance, 1100 '*stodenaill* and *ouesebordnail*' were bought, in 1368, for 5s. Salzman (1952, 307).

49. There were twenty-three patents granted for nail-making machinery before 1800. Most notable of these was one granted, in 1795, to Jacob Perkins of Newburyport, whose water-powered machinery for cutting and heading nails is said to have produced 200,000 nails in a day (Bolles, 1881, 1878, 220). While Rosenberg rightfully draws attention to the possibility that figures may be slightly exaggerated (Rosenberg, 1975, 43), Bolles reports that the newer machines were developed to the point that there was one in 1810 which had a capacity to make a hundred nails a minute (Bolles, 1881, 1878, 220). By 1833, American nails were five cents a pound, which was the same as the duty on the imported nails. In 1842 the cost of American nails was two cents below the duty. In the second half of the nineteenth century, when nail manufacturing in America went through its second important technological transition, from cut to wire nails, such nails were "definitely in the builders' vocabulary" (Nelson, 1968, 212). Rather slow increasing preference of wire over cut nails was due to the holding power of cut nails, nevertheless "the relative cheapness, ease of handling, and the variety of specialized wire nails" (Nelson, 1968, 213) gained the acceptance of the builders.

rural areas. 'Self-build' became even more popular and easier with the new method of construction.

Since the birth of the balloon frame, its development, and production of the built environment were not isolated from everything else in the society, it is essential that we see the picture in relation to other factors. These include the social relations that the built environment realized, as well as its consequences in the long term. The transition from a predominantly crafts tradition and agricultural society to one in which manufacture dominates and urbanization process is in full force is not just a matter of economics, nor merely a housing problem. It is connected to politics, values, possibilities, and constraints. It is the mode of life and social relations that are in transformation as well. With the accumulation of capital in the USA, industrialization and urbanization started setting priorities differently than in colonial days.

> The prevalence of artifactual continuity has been obscured by the myth of the heroic inventive genius, by nationalistic pride, by the patent system, and by the tendency to equate technological change with social, scientific, and economic revolutions. However, once we actively search for continuity, it becomes apparent that every novel artifact has an antecedent.
>
> George Basalla, *The evolution of technology*, 1988

ANTECEDENTS

It is far from clear whether or not the *Homo habilis* had some sort of dwelling, which can be considered even semi-permanent construction, despite the fact there are sites of major kills where leftover tools and chips from tool-making are much more common than others, signaling potential shelters. This evidence suggests the possibility of some sort of habitation but they are far from demonstrating the existence of a particular form of construction per se. Over a million years later, post-holes, although evidence is still ambiguous, suggest that the honor of the earliest (c. 400,000 BC) recordable housing frame construction may belong to our more advanced ancestors, the *Homo erectus*. Oval plans of huts depicted by the positions of post-holes in Terra Amata, a site near Nice, France, measure 15 m by 6 m. This being the case, the practice of timber framing, in one form or another, is almost as old as half a million years. Certainly by the time of the *Homo sapiens* (c. 90,000 BC) we come across complex living or storage structures utilizing timber frames.

Experimentation with different materials to frame a building is tectonically quite distinct from stacking up materials, as in masonry construction. Wood or bone, the intention is to erect a skeleton that is the structure, and to fill in the enveloping surfaces to create both favorable indoor conditions and to provide some stiffness for and between the frames. This is the beginning of trabeated structural system, which transfers the forces through primarily the framing components as opposed to the surface structure systems, which transfer the forces more uniformly in the planes of the load bearing surfaces (**50**).

Tool industries reaching a level more diverse and advanced, beyond the simple burin (pointed or chisel like flint tool) and end-scrapers (*grattoirs*), enabled the Neanderthals to erect larger and more stable frames than their predecessors. It also allowed them to experiment with different building materials. When wood was not available, for example, mammoth bones

50. Examples of true a trabeated structure system would be the Stonehenge and the Greek temples, where the lintel or the beam (or the architrave) sits on the columns without a rigid connection. Here, whatever vertical force, including its own weight, needs to be transferred through the beam to the columns, it has to be the moment (or bending) resisting capacity of the beam that is going to transfer the forces; and the columns transferring the forces as concentrated axial forces. Whereas the load-bearing wall is going to transfer the loads accumulated on it as axial force, almost evenly distributed along its length. The two force distributions display different structural behavior characteristics. In a real framed structure, where connections are rigid, forces acting on the members are resisted mainly by bending of the members. The geometry of the overall structure and individual members, structural properties of the materials (or flexural rigidity and stiffness), and bending stresses generated by the loading conditions determine how the frame resists the loads acting on it. Until the second half of the nineteenth century, without the analytical understanding and tools, 'code of practice,' which essentially provided the rules of proportion, was established empirically. With experience, proportions and assembly techniques were refined in favor of economy of materials and construction. This seems to be the general trend in the culture of timber framing and walling. However, at times depending on the availability of materials and the level of technology, constructional and structural problems could be overcome with unnecessary high consumption of material.

were used as substitutes by the people of Gravettian cultures (c. 25,000 BC) in Europe at sites such as Pavlov and Dolni Vestonice, in the Czech Republic, and Kostenki and Gagarino, in Ukraine. A similar practice of frame construction with the use of bones is also recorded farther east in Siberia at Mal'ta and on the Angara, in Cis-Baikalia, both, sites of the Paleolithic mammoth hunters. Later (c. 13,000 BC) there seems to even be specialization in the use of specific bones for particular parts of dwellings: at Mezhirich in Ukraine huts made from mammoth bones clearly demonstrate this kind of selective and designated use (**51**).

Addy, in his *The evolution of the English house*, looking at the word 'timber' etymologically, tells us that the old English verb 'to build' was *timbran*, to 'timber.' This suggests that timber construction in England, as expected, has been a very long tradition. However, as Innocent draws our attention, it "does not imply that all buildings, at that early time, were of timber: it was originally applied to buildings of any materials, but in the course of time the word, and its allies in other Teutonic languages, were used for building in wood, because the term for construction became identified with the material most generally employed" (**52**). In any event, all the evidence leads to the fact that the use of timber for construction starts from the very early days of tool-making.

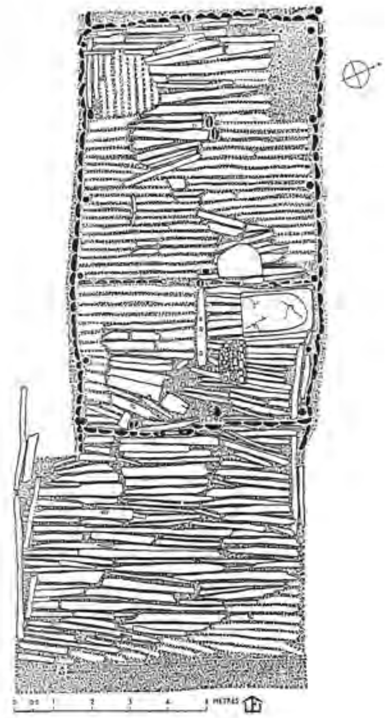
Until the sixteenth century there were primarily four kinds of wooden house built in Europe. The 'roof house,' (*Dach hutten*, or also known as 'raftered houses') a conical form, or a simple A-frame in long rectangular huts, constructed with larger tree branches and covered with turf can be considered an earlier archetype of the timber frame that was to be developed. Earth-dug huts, covered with tree branches and turf roofs, which seem to be almost a universal response to earlier housing needs practically in all cultures with suitable environmental conditions, gradually transformed into multi-story frame construction with walls. The Magdalenian hut demonstrates the striking similarities between the timber construction of the Upper Paleolithic culture of much of western Europe, (c. 13,000-10,000 BC), and the Anasazi pithouse, the earliest free-standing, fully constructed dwellings in the American Southwest (c. 200 AD). Given the similar tools, materials, experience and conditions, it is not much of a surprise to see a resemblance in the construction methods and building types of two different cultures very much apart, both in time and space (**53**). As crude as some of these structures, on both sides of the Atlantic, may sound, it was a long way from the small poles supported by rocks for walls and larger poles in the center to hold up the small ones on the periphery, as was the case of the shallow dwellings found, for example, at Terra Amata. The phase following the Ice Age introduced almost a different construction category with refinement and sophistication that eventually led to the more frame-like-structures with larger members.

After the close of the Ice Age, dwarf vegetation in northern parts of Europe started being replaced by trees as the temperature rose. Over the five millennia, starting around 10,000 BC, was a period when afforestation of the area also introduced much wild life which attracted the hunting people of the southern regions, at least in the summer months. What seems to be the summer camps of the hunters of the Mesolithic tribes from the south provide some information, primarily through the post-holes, although still imprecise, that timber framework was one way of constructing. Later in the Neolithic period, dwellings with rectangular plans, subdivided into a number of rooms, indicate the use of mortised timber frame.

51. Childe (1944, 40-4); Childe (1949, 77-86); Crossley (1951, 74-83); Davey (1961, 32-48).

52. Addy (1910, 1898, 106); Innocent (1971, 1916, 107).

53. Davey (1961, 32-48); Balcombe (1985, 48-50); Barley (1986, 16-39); Stea and Turan (1993, 89-100).



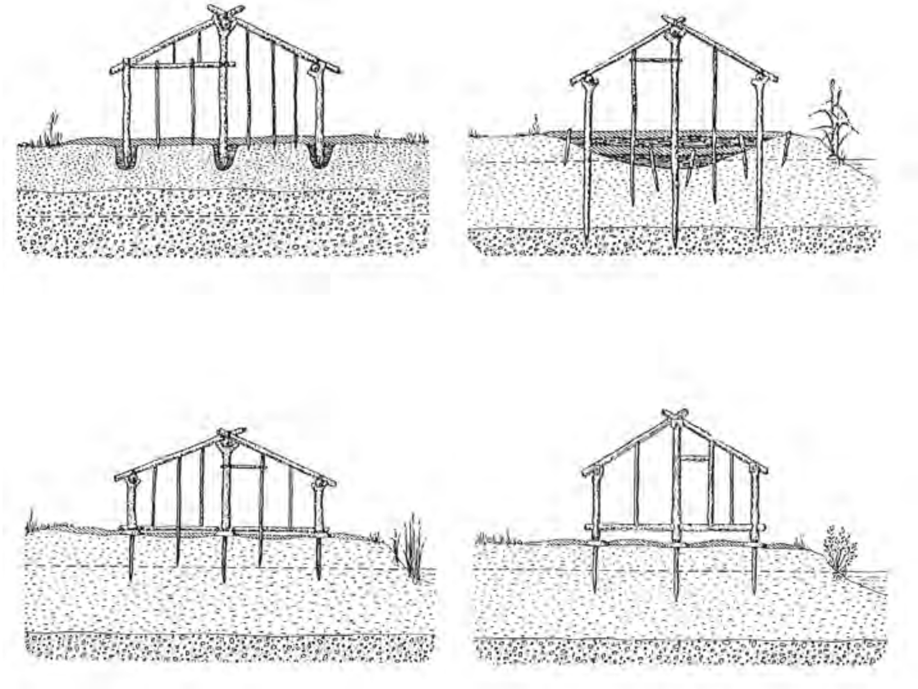


Figure 3. Neolithic hut at Aichbuhl (c. 4000 BC)(Davey, 1961, 37).

Figure 4. Evolution of the Swiss pile dwellings (Muller-Beck, 1972, 230-1).

Archaeological remains of Neolithic huts excavated in the moor settlements at Goldberg, Homolka, Aichbuhl, Riedschachen, Koln-Lindenthal, Ariusd, Brzesc Kujawski, Strelice (c. 4000 BC) with spans over three meters (in some cases close to five meters) reveal quite clearly a system of timber framing (**Figure 3**). Four separate and distinct Neolithic settlements excavated on the shores of Lake Burgaschi in the Swiss midlands exhibit the evolution of the Swiss pile dwellings, in the course of three millennia from 5000 to 2000 BC and deserve a closer look (**54**).

In 5000 BC, conical shaped individual huts ('roof houses') were assembled on the shores of lakes and along rivers with reinforced loam and rubble floors. By 4000 BC common practice in southern Europe was gabled rectangular houses with semi-rigid frames that had the load bearing posts driven into ground. Timber construction at Burgaschi, used approximately a millennium later, combined these two techniques with the addition of reinforcing piles driven under the loam floors (**Figure 4**). Much needed rigidity of the joints for stability seems to be understood by the dwellers: reinforcing the earth with loam and rubble is intended as much for protection against water as it is for structural stability, where at least the foundations are made more rigid than the other joints of the frame. Potential stability problems, which could arise due to the semi-rigid upper joints, were partially reduced with the structurally sound load bearing posts driven quite deep into earth. A structural problem due to technological incapability - lack of tools to work the available materials- is overcome, though not completely, by a foundation detail. By about 2000 BC wooden floors, partially resting on the earth beneath and partially supported by the wooden plates sitting on the piles driven into ground, appears to be the innovative tectonic addition. Since the primary function of this development was for protection from ground water and dampness, problems associated with structural stability must have remained.

54. Davey (1961, 32-48; Muller-Beck (1972, 226-32).

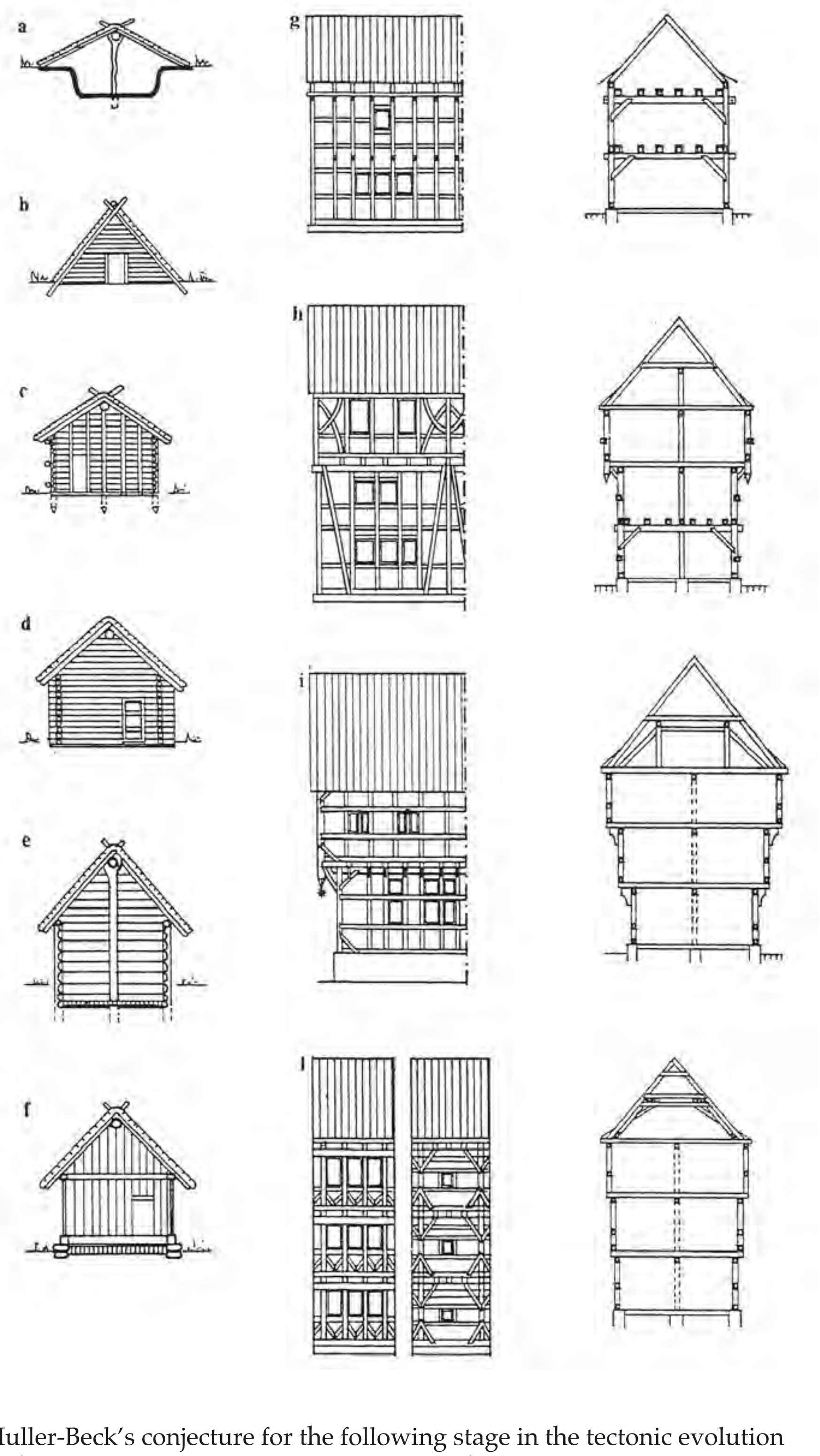


Figure 5. Evolution of timber construction (Benedetti and Bacigalupi, 1991, 49).

Muller-Beck's conjecture for the following stage in the tectonic evolution of the pile dwellings is an elevated floor with mortised timber framework providing the necessary rigidity at the joints. This conjecture of innovative tectonic detail of laying cross-timbering for the floor is similar to that used by the dwellers of Meare Lake settlement, near Glastonbury, in Somerset, England, who had about the same level of technology as the Swiss pile dwellers at this particular stage of the evolution of timber construction.

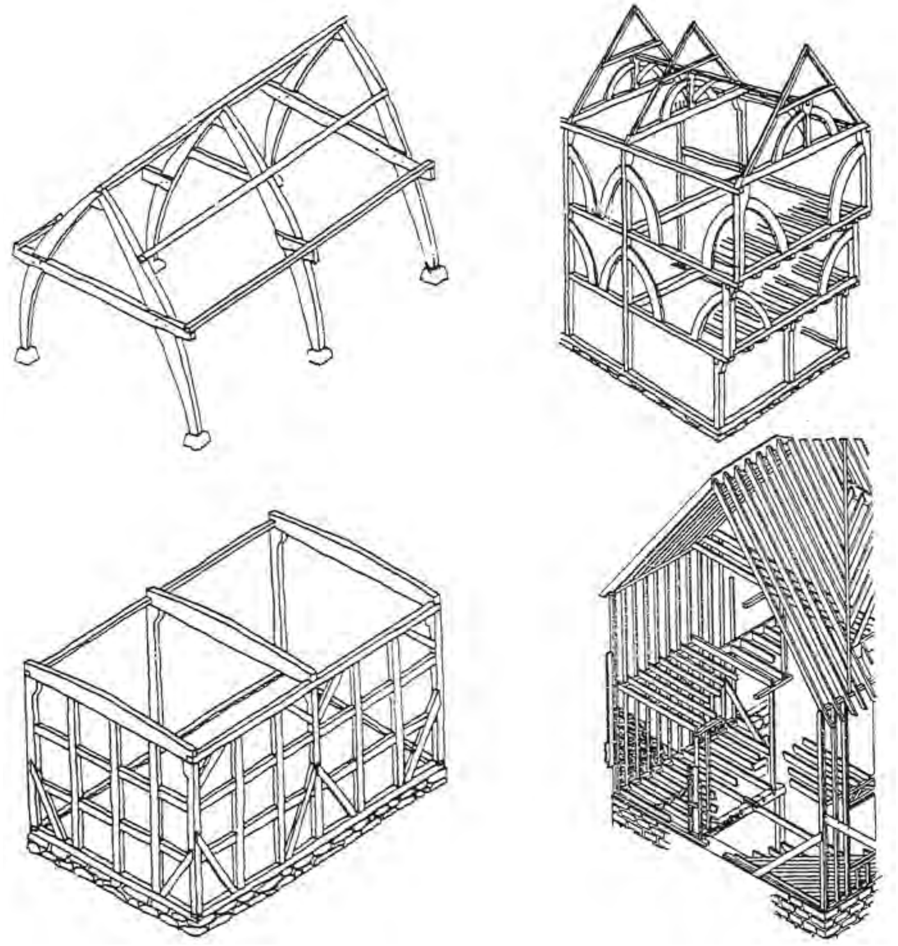


Figure 6. Four different types of timber construction (after Brunskill, 1978, 1971, 55, 57); and Hamilton, in Singer et al. (1958, 1954-84, v. 5, 467).

Similarities between the mortised timber framing in the huts of Meare Lake settlement and Muller-Beck's conjecture for the dwellings at Lake Burgaschi are remarkable. They also suggest an evolutionary pattern that is congruent with the spatial form, technological level and social relations.

Tree barks and interwoven branches or wattle, daubed with clay, filling the spaces between the posts, and thatch covering the roof over the branches resting between the beams composed the envelope of the building held up by the timber framing. It is obvious that part of the enveloping components behaved as stiffeners for lateral as well as longitudinal stability. Wherever this method of surface stiffening was not sufficient, additional posts were used for buttressing against high winds.

Different solutions in timber construction, as technology and experience allowed, have been developed in subsequent phases of history (**Figure 5**). A gradual line of progression can be traced in the development of the timber frame. Though not a linear development, the common denominator in this long and slow process is a perpetual search for the necessary stability and stiffness with less material and less laborious means.

Structural requirements for the more complex construction have constantly challenged the existing technology and practice. The post-and-lintel method of construction seems to be the beginning of what was to follow many millennia later, namely the rigid frame. Structural limitations and deficiencies of post-and-lintel construction, problems primarily associated with stability and stiffness, were handled with materials and connection details that were the precursors to the later solutions. Grass, reed, thatch and straw found their use in building construction very early as tying materials to make semi-rigid connections, and as wall components to stiffen the surfaces in and between the frames.

Multiple bay frame construction inhabited during the Neolithic times developed into a multiple story cruck frame by 500 AD in the hands of the Anglo Saxons, as well as the peoples of Europe (**Figure 6**). Smaller pieces of timber bracing and tying the two crudely shaped tree trunks forming an A-frame and also the other wood components connecting a series of the cruck frames constituted the primary structure providing the required stability and stiffness. The main triangular frame, called the cruck, connected with smaller pieces of timber, both in its own plane and between the planes of the other cruck frames, was a considerable development over the simple A-frame of the 'roof house.' The 'cruck house' allowed more than one story as well as easing construction details for more livable space, without sacrificing on structural stability though at the cost of considerable waste of timber. This method of construction continued for about a millennium until wood became scarce and more expensive.

The 'jetty house' method of construction started about the eleventh century and developed simultaneously with the 'cruck house.' In this system of construction, builders used smaller pieces of wood (**55**). Upright pieces were cut to be a floor height and together with the shorter horizontal pieces they formed the plane of the frame (**Figure 7-9**). Load transfer of this type of construction was achieved through the plane itself rather than the one strong frame of the previous types. In other words, loads were distributed more uniformly throughout the plane, utilizing the structural elements more efficiently.

The newly evolving structural composition also allowed overhangs (hence, 'jetty house') to keep rain off the walls below, as well as enabling the use of smaller timber sections for beams due to cantilevering which substantially reduced bending stresses and the resulting deformations. When a six-meter span beam is extended half a meter with a cantilever over the supporting wall below, bending moments developing in the beam can be reduced to about one-third of the unjettied values. This is a very significant reduction, which results in smaller sections. Charles attributes this development to the structural economy achieved: "the history of the jetty again emphasizes that the timber-frame tradition can be understood only in terms of the persistent trend towards economy of means, especially in the erection process, and refinement of the skill of the carpenter, as architect, craftsman and builder" (Charles, 1967, 64). Empirical understanding of this behavior in the absence of analytical methods and calculations must had been a guiding factor in relatively efficient use of timber as a structural material. However, use of the jetty for its structural advantage is not a convincing argument for everyone. Harris, for one, does not believe that carpenters were aware of it (1979, 56).

Further material saving was achieved with the development of the 'box frame house' starting about the end of the fifteenth century and developing concurrently with the previous two methods of construction. The 'box frame house' employed longer pieces of timber, as tall as two stories. Spacing in between the upright pieces was farther apart than the ones in the 'jetty house.' Together with the horizontal pieces, bracing and framing the upright posts, they formed more of a 'cage' than the cruck or the jetty

55. Addy (1910, 1898, 1-78); Jackson (1912, 1-17, 63-83); Innocent (1971, 1916, 1-90); Oliver (1929, 27-41); Crossley (1951, 109-21); R.A. Cordingley (1961, 73-129); Smith (1965, 133-58); Charles (1967); Hewett (1969); Smith (1970,122-47); Brunskill (1978, 1971, 52-9); West (1971, 13-118); Blaser (1980); Benedetti and Bacigalupi (1991,135-54); Smith (1992); Comite International D'Historie de L'Art (1997).

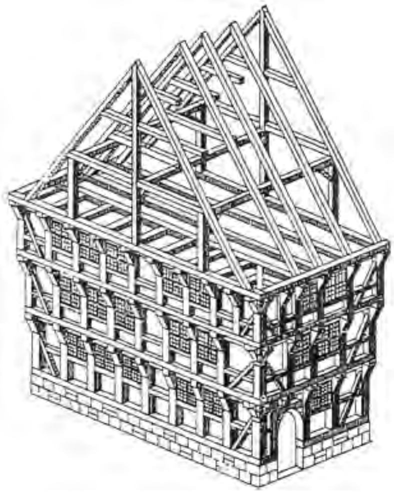


Figure 7. A typical box frame (Comite International D'Historie de L'Art, 1997, 39).

Figure 8. Jettied construction (Comite International D'Historie de L'Art, 1997, 21).

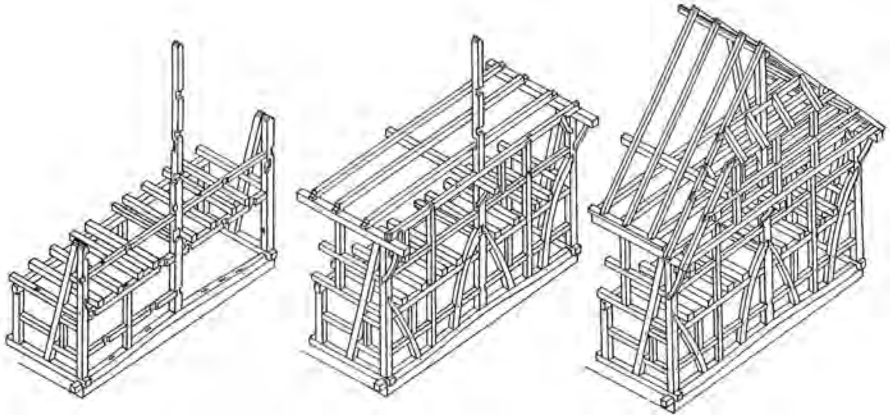


Figure 9. Construction of the structural frame (Benedetti and Bacigalupi, 1991, 56).

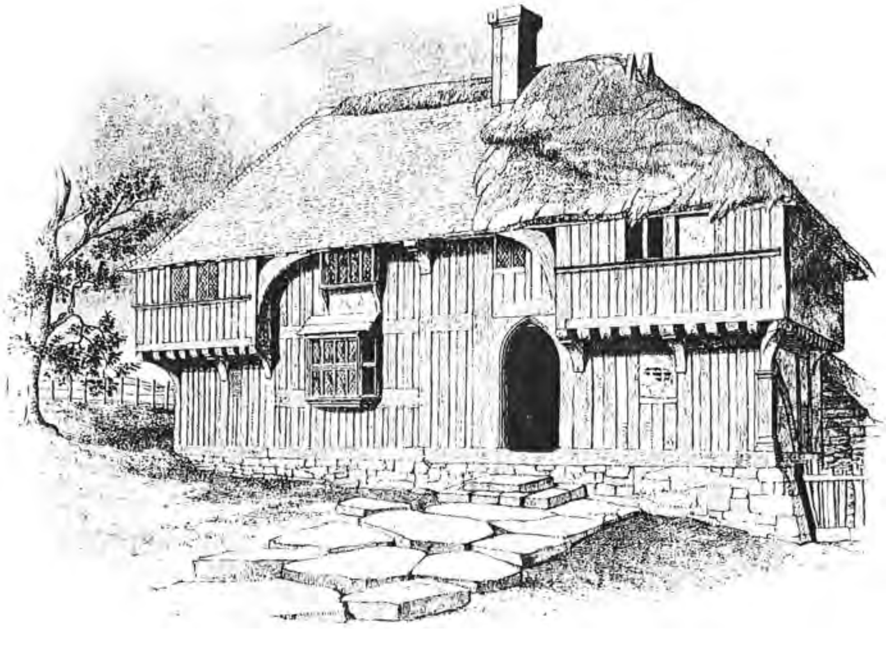
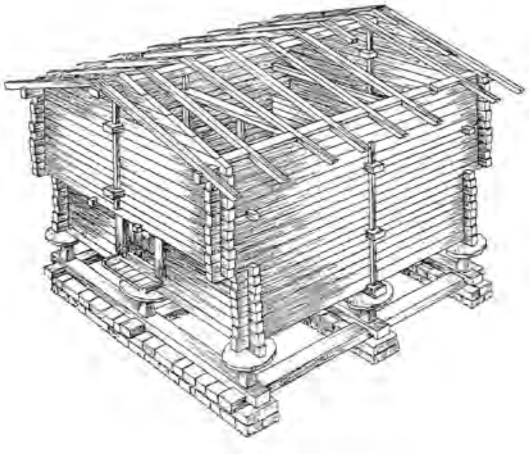


Figure 10. A woodcut from sixteenth century showing timber construction (Comite International D'Historie de L'Art, 1997, 11).



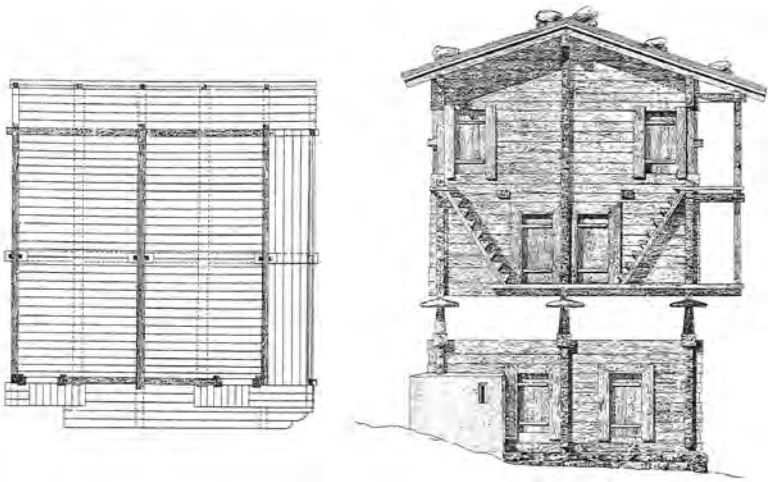


Figure 11. A granary barn, log construction (Blaser, 1980, 40).

Figure 12. A typical log construction with rectangular timbers, jointed and shaped by an axe (Blaser, 1980, 46).

house. Powell referred to "putting together these great timbers of our domestic cage" as a "dramatic work" (Powell, 1952, 1920, 11). All the work involved in the joinery with only the hand-tools, was certainly an art to be learned, developed and mastered over many years (**Figure 10**). In addition, we share West's assertion that this "dramatic work" was also "a masterpiece of local cooperation and organisation of the times" (West, 1971, 60). As opposed to the variations of the timber walling that we observe in the 'jetty house' -square panels, vertical panels, or the interrupted sill- the "box frame house" displays a more uniform walling pattern, primarily the square panels. Obviously there are hybrid forms of construction alongside the "pure" techniques.

While in all four types of construction the structural result, with the daub or plaster infill between the timber pieces, is something more than just a two dimensional enclosure, the structural skeleton in the 'box frame house' is the closest to a true three dimensional structure. Techniques of joinery developed so much that achieving full rigidity at connections was no problem. The three dimensional skeleton of the box frame house was a very rigid structure. Moxon, in his *Mechanick exercises*, first published in 1677, alluded to the 'cage' quality in his definition of joinery: "Joinery, is an Art Manual, whereby several Pieces of Wood are so fitted and join'd together by Straight-line, Squares, Miters or any Bevel, that they shall seem one intire Piece"(**56**). The 'cage' quality that comes with this three dimensionality of the "one intire Piece" is not far from the "balloon" attribute that the timber frame gains in its next stage of development. In addition to the "Mortesses and Tennants," described in detail, Moxon also mentions the use of "a Nail or two" in the joinery (Moxon, 1677, 134).

There are two other main types of timber-based wall construction in addition to the one mentioned so far: horizontal log construction, and post and plank construction (**Figure 11, 12**). In the first one, the wall is composed of solid timbers laid on each other, and jointed at the corners. Structurally this method of construction is quite similar to a load bearing masonry construction. Because of the connection details at the corners it is a three dimensional structure with much more rigidity and stiffness than typical masonry structures. Technically the horizontal log construction is more a surface structure than it is a frame. The latter type is a heavy frame composed of posts with heavy planks slotted between them. While technically the post and plank construction may fit the definition of a frame

56. Moxon (1703, 1677, 63).

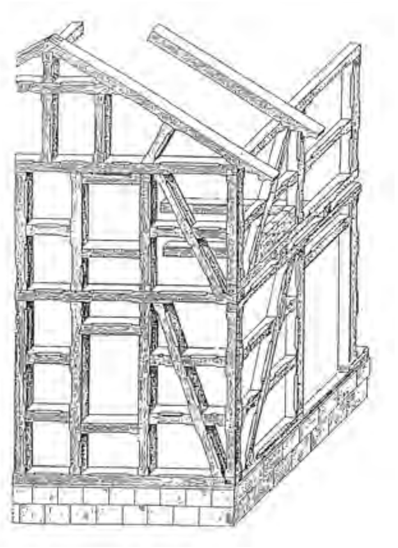


Figure 13. A common type of close-stud house in England in the thirteenth century and onwards.

structure more than the horizontal log construction, stiffness provided by the heavy planks makes this type behave more like a surface structure rather than a frame. Timber frame in which the structural frame is separate from the infill material is quite distinct from these two types wherein there is almost a monolithic surface structure that generates totally a different structural behavior from that of a frame.

Looking at cases of timber frame usage in residential construction, we come upon numerous vernacular examples from very early times. Most of these examples do not approach the balloon frame in ease of construction, but they are not all examples of mortise and tenon joints either: use of nails in connections is quite common. Heavy, or half-timber, frames are in a category different from the lighter ones (**Figure 13**). In the course of several centuries even the heavy frames went through several changes and were transformed from the original. This transition has to do with the cost and availability of the material, as well as the changing technology. Even in the sixteenth century there was enough concern over material shortages that the Tudor economists were already looking for alternative solutions: "The depletion of our timber resources, which so alarmed Tudor economists, was already beginning to be felt and was producing its effect on domestic architecture" (**57**).

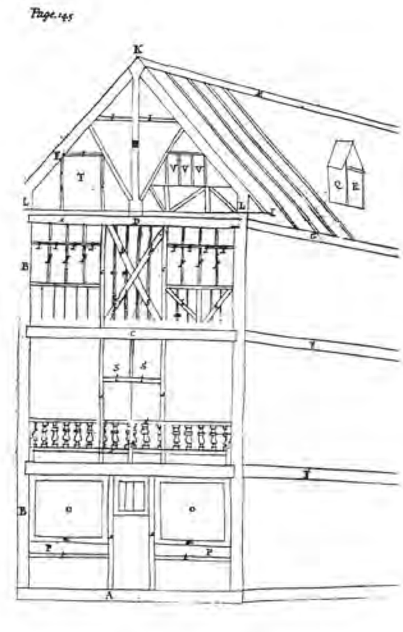
In the USA the use of timber framing, especially in residential construction, was popular from the early times. The framing systems and the construction methods imported from Europe were in a state of transition from the beginning of colonization and a synthetic Euro-American building technology was developing. Laborsaving changes together with reduction of decorative half-timbering were some of the early developments. As Upton observes, "many elements of the traditional frame were eliminated, or made less complex, both on an individual basis, as in the total absence of bracing in some poorly-built houses, or, more important, as a characteristic practice"(**58**).Labor requirements changed drastically: it was not so much a reduction in labor per se as it was a change in the nature of the labor required.

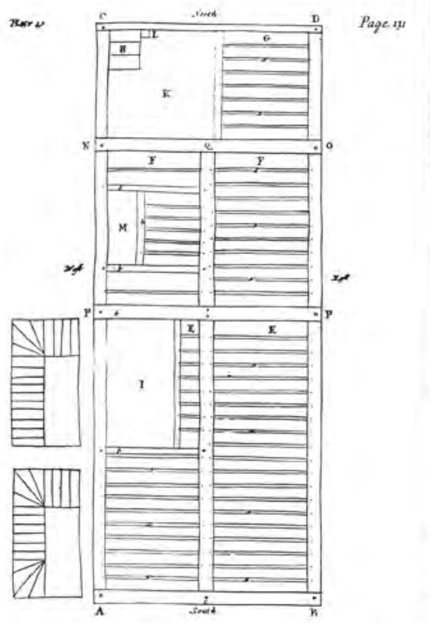
Tredgold's description and discussion of partition frames, in his influential *Elementary principles of carpentry*, published first in 1820 with subsequent editions, clearly indicate the attention he was trying to draw to "so much neglected" partitions. With a better understanding of structural behavior, tectonic requirements and structural design in wood were in a transformation towards a tectonics incorporating less material, simpler connections, and smaller sizes for structural members. This trend was not unique to the nineteenth century. A century earlier a similar trend was exhibited in Price's *The British carpenter*, originally published in 1733 (**59**). The tectonics of both the partitions and the floor joists described there were definitely the incipient forms of what is used today. Connections in trusses display a very similar tendency: connections were simpler than the traditional mortise and tenon. The use of large iron nails was a search for an alternative in this direction. Even in the seventeenth century, lengthy sections on joinery and carpentry (63-116 and 117-166 respectively), in Moxon's *Mechanick exercises*, are clear indications of serious concern for and persistent attempt to direct the construction industry towards a leaner and more economical system. Attempts to simplify the connections and to increase the stiffness of the components, such as the partition or floor system, with shorter and lighter members, are represented in the works of Moxon and Price. The developments in the tectonics of partitions

57. Salzman (1952, 209).

58. Upton (1981, 35-93, 43).

59. Tredgold (1837, 1820, 107); Price (1759, 1733).





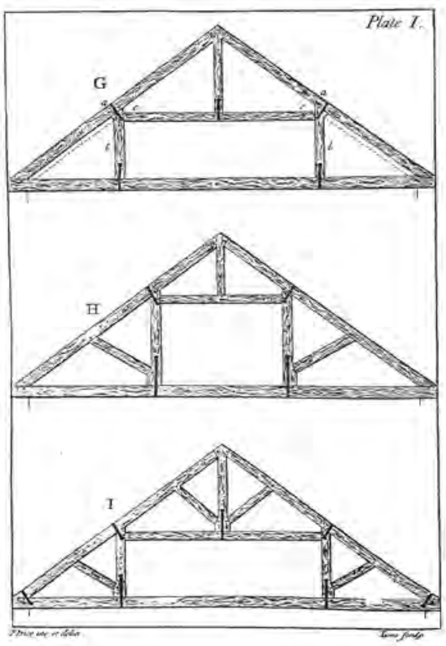
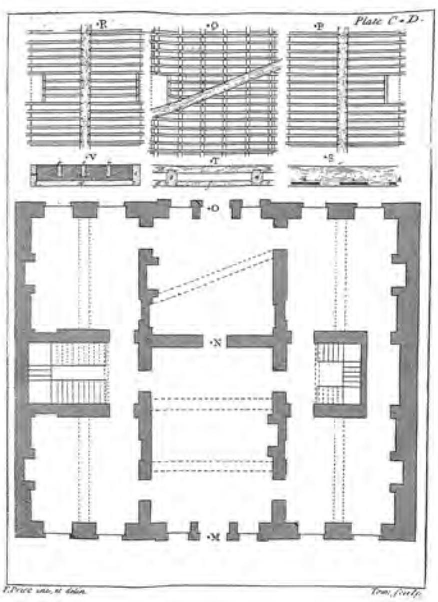


Figure 14. Section of a house (Moxon, 1703, 1677, Plate 11).

Figure 15. Floor joists (Moxon, 1703, 1677, Plate 10).

Figure 16. Roof trusses (Price, 1759,1733, Plate I).



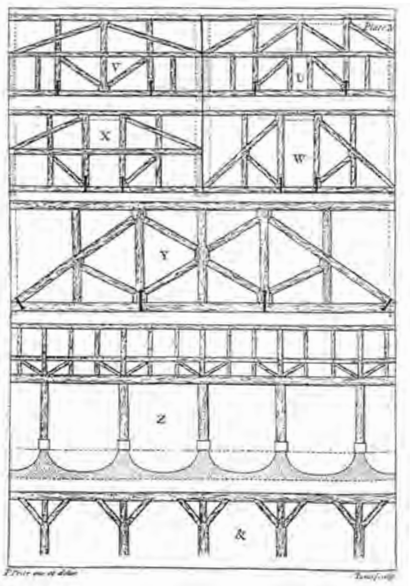


Figure 17. Floor joists (Price, 1759, 1733, Plates C and D).

Figure 18. Partitions (Price, 1759,1733, Plate N).

and connections over a time span of one hundred and fifty years are remarkable. Also striking is demonstrating how certain concepts and details develop over time within the givens of cultural and technological capacity. Moxon's and Price's treatments of the subject seem more intuitive and relying primarily on the practice of the time (**Figure 14-18**). Structural advances that were about to come added one other more scientific dimension to Tredgold's approach to structural behavior. While Tredgold, with every effort, tried to lighten the structure, he was careful to distribute the load as uniformly as possible (**Figure 19, 20**). His concern with openings, in the wall elements such as doors or windows, led him to make different recommendations for different combinations: "A partition ought... to be capable of supporting its own weight; for even when doorways are

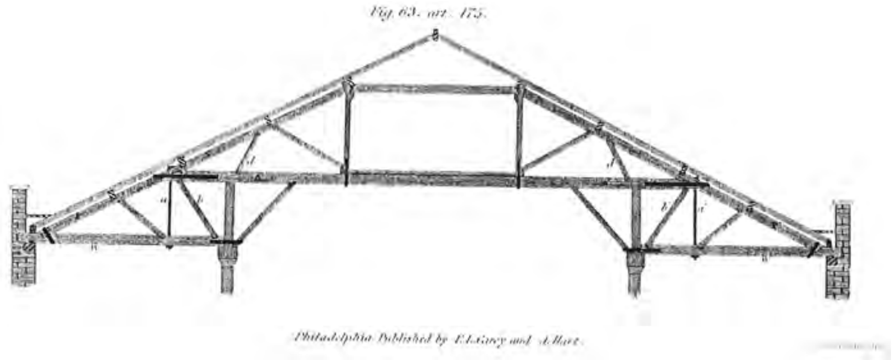


Figure 19. Roof truss (Tredgold, 1837, 1820, Plate 9, Figure 63).

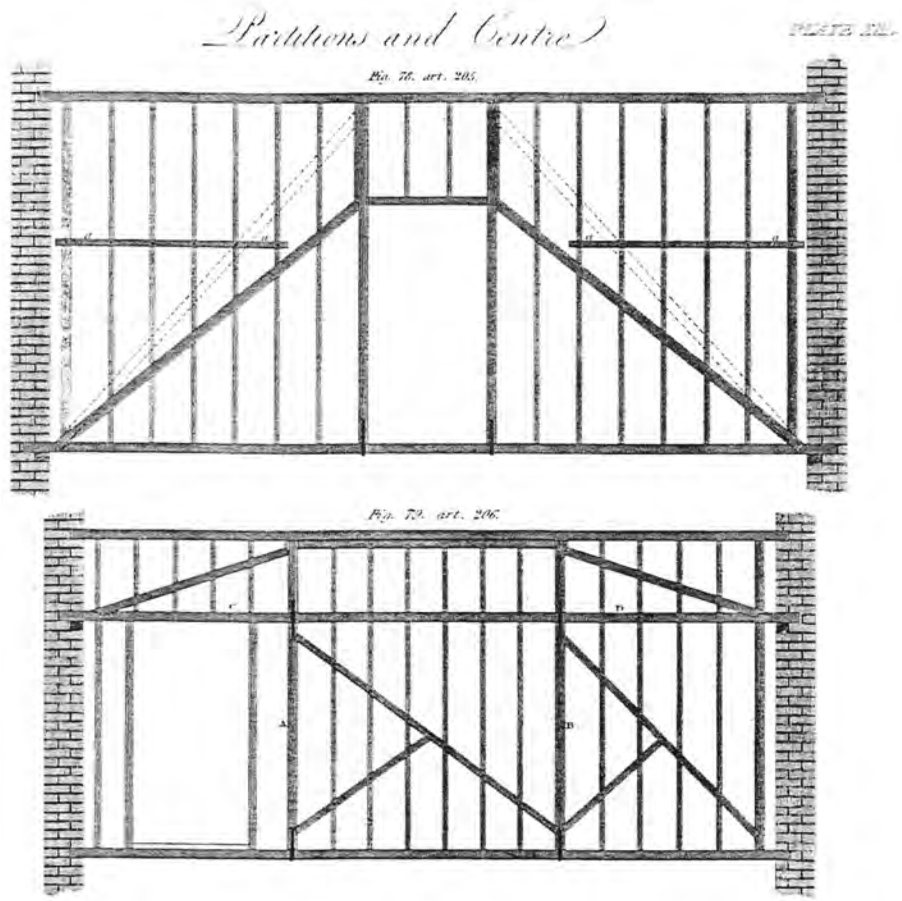


Figure 20. PartitionsTredgold (1837, 1820, Plate 13, Figure 78, 79).

so placed that a truss cannot be got the whole depth, it is almost always possible to truss over the heads of the doors" (Tredgold, 1837, 1820, 108). "Strength and lightness" are the ultimate solution Tredgold is striving for. Drawings and descriptions of Tredgold's partitions manifest developments tectonically superior to the traditional frame. Tectonic developments demonstrated by Price about ninety years earlier had evolved to a turning point in construction, displayed by Tredgold as clear evidence of incremental progress. The first edition of Tredgold's treatise was published in 1820, indicating that the "new" practice he was trying to refine must have been in use, if not widely, at least for several decades with some variations.

Jackson, at the beginning of the twentieth century, stated that "two-by-four-inch spruce studs are an invention of a more architecturally anaemic age," yet we come across them as the "single quarters" at the time of Moxon. It is quite apparent that the use of studs in partitions, possibly not for the exact same function that they serve today, is almost as old as the timber construction itself. "The originals of this type of wall are simply fences composed of tree trunks of trees set upright, close together, and in a line" (**60**).

Although they make no mention of the balloon frame per se, two important American publications (**61**) appeared toward the middle of the nineteenth century shortly after Tredgold's treatise (which was published in Philadelphia in 1837, based on its second London edition of 1828). Both Benjamin's (first published in 1830) and Hatfield's (first published in 1844) books must have been well received since several new enlarged editions subsequently followed. Both books display drawings of braced wall frames similar to Tredgold's partition, where the members are slender and regularly placed, or in Jensen's terms "more delicate and efficient than those earlier versions" (**62**). Evenly spaced studs are not "nonstructural," however, as Jensen claims them to be [43], they are very much part of the structure, distributing the forces as uniformly as possible. Concern by the authors for bracing the studs, or uprights, indicate the structural character of these members. The "strength and lightness," as Tredgold emphasized, is one of the advantages of the new frame over the traditional post-and-beam. The new combination of framing was aiming for individual members to resist forces uniformly and equally, therefore more efficiently (**63**). Both Benjamin and Hatfield, we believe, like Tredgold, were aiming to refine an existing construction system and process already in use, most probably not so widely at the time.

Tectonic implements of such a system in America, in the eighteenth century, were indeed in use. Simple braced frames, used for most of the wood houses in Tidewater, Virginia, are an American version of what we just described as the construction tendency in England -use of members like the large summer beam to shorten the span of the floor joists notwithstanding. The structural concept of creating planes with more but smaller members, rather than creating a hierarchical order of heavy and light members, is certainly what the builders in Tidewater were putting into practice (**64**). A combination of mortise and tenon joints together with 'nailed' joints shows more confidence in the new industrial product, the cut nails. What is achieved is a three dimensional structure rather than a two dimensional one, or a plane structure, that provides an overall stiffness which decreases the importance of each individual connection because of the structural indeterminacy created by the method of assembly, and by tectonic details. Detail requiring time and skill gave way to a solution that required plenty of material, with no more than crude workmanship. In this instance, the tectonic elegance of "the strange-looking and complicated but really brilliant joints"(**65**) was among the things lost. Economic necessities, despite the loss of the handsomely hand crafted connections, led to the emergence of the newly developing construction. Changes taking place in box framing, originally from England and central Europe, are characterized by Upton as "a tendency to use wood more freely than in Europe, but to devise ways to minimize its preparation" (**66**). Generous use of wood in construction is also witnessed in some of the examples that Upton provides from New England to Virginia.

60. Jackson (1912, 13); Moxon (1703, 1677, 139); Innocent (1971, 1916, 110).

61. Benjamin (1835, 1830); Hatfield (1850, 1844).

62. Jensen (1971, 40-50, 42).

63. This understanding may not be as explicit in Hatfield's treatment of the vertical components, such as the partition frames, or as his treatment of horizontal members under bending. However, his search for an empirical formulation of the "resistance to cross strains," that is the present concept of 'moment of inertia,' is a demonstration of his conceptual understanding of structural behavior. His formulation "the greater the depth of a beam in proportion to the thickness, the greater the strength," may lack the precision of the engineering principle used today, but certainly it is not far off (Hatfield, 1850, 1844, 145, 147).

64. Glassie (1975); Buchanan (1976, 54-73).

65. Isham and Brown (1965, 1900, 214).

66. Upton (1981, 40). Influence of the English tradition on early American residential architecture can be seen more specifically in the tectonic categories of the half-timber frame, the weatherboard, the plank-frame, the shingle, and the board and batten (Foley, 1980, 11-31). Examples of exposed half-timbering are not very numerous. The rest of the tectonic influences can be seen in many different forms with some variations from their English origins (Jackson, 1912, 84-99; Oliver, 1929, 42-59). The horizontal weatherboard siding was used quite extensively with boards "an inch or little over, in thickness, nailed vertically from the sill to the plate" (Isham and Brown, 1895, 79). The posts and the studs made it relatively easy for this system of boarding. They were about 20 cm. (8 in.) wide and 3 to 6 m. (10-20 ft.) in length (Buchanan, 1976, 73, n. 1). According to Isham and Brown (1895), the boarding was generally, though not always, protected with clapboards or shingles. (Isham and Brown, 1895, 79) Whether the space between the posts and studs was filled with wattle and daub or brick, in time, the use of clapboards on the outside of houses developed. Unlike the sawn weatherboards, the clapboards were split or rived, about 10-12 cm. (4-4.5 in.) in width, although the earlier ones, in Isham and Brown's (1895, 79) conjecture, were even wider than the weatherboards. In their later use, the clapboards were shorter than the sawn boards. The extremes of the winter and summer conditions of New England were harsh on the exposed materials, causing shrinkage and expansion. "The remedy was found in a sheating of feather-edged boards overlapping each other, and hence we see the clapboards nailed directly to the studs" (Isham and Brown, 1895, 87).

> Technical change has been primarily evolutionary, in small increments, significant only in the aggregate. But there has been a wave of change, so diffuse and made up of so many small parts that it can hardly be called an innovation in the usual sense at all. It might better be called the industrialization of building.
>
> Donald Schon, *Technology and Change: The New Heraclitus*, 1967

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Among the salient tectonic features of the balloon frame are smaller member sizes, nailed connections, semi-independent planar wall and roof units, distribution of forces in the plane of the frames, and relatively light, three-dimensional structure. Floor-length vertical members are placed with spacing, which varies between 30-40 cm (12-16 in), and they form the plane of the frame by being connected to the top and bottom horizontal members with nails. Each frame, carrying the loads of the floor above and/or the wall above, or the roof trusses, transmits the forces as a planar surface structure rather than larger forces concentrating on single posts at corners or 3-4 m intervals. Wall frames are independent from each other and the structure of the roof system. Together with the joist system used for floors, walls and the roof form a three dimensional, rigid structure with a seam-like continuous nail connection as opposed to rigidity achieved by separate frames or trusses forming bays and linked by wall-plates, cross-rails and sill-beams with heavier connections. The assembled whole is rigid as opposed to the rigidity of individual components and their joinery (**Figure 21**).

Advances in structural theory in the first half of the nineteenth century were great leaps forward compared with the piecemeal attacks made on isolated problems in the previous centuries. Certainly innovative thinking in mathematics, especially the development of calculus in the eighteenth century, was one very important catalyst in this progress. Claude Louis M.H. Navier's all-embracing work on a general mathematical theory of elasticity, in France, was focal and fundamental. It was the works of Charles Augustin Coulomb, who used an accurate reasoning in determining the location of the neutral axis of a member under flexure and the moment of internal forces, and Thomas Young, whose lasting contributions lie in shearing deformation and introduction of the modulus

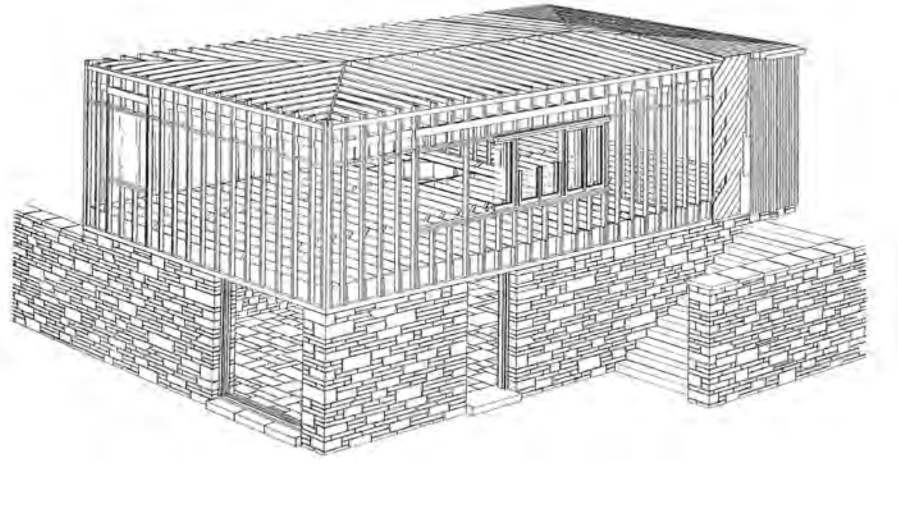

Figure 21. Design of a wooden house on a balloon frame. Course in structure and material at the Illinois Institute of Technology in Chicago, under Mies van der Rohe (early 1940s)(Blaser, 1980, 27).

67. Hodgkinson (1824, 225-88); Barlow (1837); Moseley (1843, 486-580); Fairbairn (1854); Westergaard (1930, 226-46); Hamilton (1952, 374-419); Charlton (1982).

of elasticity, that Navier based his theory of elasticity. Very much informed about the theoretical developments in France and England Henry Moseley, a clergyman and professor of natural philosophy and astronomy at King's College in London, published the first comprehensive treatise on engineering mechanics. Moseley's research in applied mechanics and lecture notes that composed the highly mathematical *The mechanical principles of engineering and architecture,* published in 1843, kept abreast new developments. While Moseley was building upon the works of Coulomb, Navier and his mentor Jean Victor Poncelet, and contributing to the development of theory of engineering mechanics, able engineers like William Fairbairn, Eaton Hodgkinson, and Peter Barlow were carrying out important experimental work (**67**).

Filtering down to practice from theoretical level is generally slow and quite difficult, especially when the practice is a crafts tradition. On the other hand, it is very hard to remain indifferent to all the scientific and theoretical advances taking place in strength of materials and behavior of structures, especially when there are social and economic pressures and incentives. Tredgold's work, in spite of some confusion in matters regarding theory, is important in establishing a bridge between theory and practice. In the tradition of earlier publications, such as those of Moxon and Price, Tredgold's book was intended not only to record the existing crafts tradition, but also to expand the limits of the contemporary practice of building construction with recommendations based on the theoretical and experimental work, which he was so conversant with. Its value lies in matters concerning practice rather than being a theoretical treatise. It is an attempt to surpass the existing traditional practice of timber construction with the backing of experimental and theoretical research of the time. Tredgold's treatment of timber frame construction brings to the study of building tectonics the objectivity and the empirical technique of scientific attitude. In his book all of the tectonic features of the balloon frame that are considered major developments over the past practices are clearly spelled out, illustrated, and strongly recommended for more economical construction and lighter structure, and for the use of a larger public. His emphasis on the economy of structural material and construction is very much in accordance with his definition of civil engineering as "the art of directing the great sources of power in Nature for the use and convenience of man," which was adopted in the charter of The Institution of Civil Engineers in 1828.

More than the previous centuries, the nineteenth century with its industrialization and urbanization set up its conditions such that there was a pressing exigency for housing masses in short time. Timber construction technology could afford and allow such a development because there was a demand for it and the adequate means more than before. The general trend of development in terms of lighter structure and less laborious construction methods was getting a boost from two directions: from economic side, an urge for a frugal construction method; and from technological side, knowledge and possibilities for implementation to achieve such a goal had never been more favorable. Desire to reduce costs in any form has been on both the owner's and the builder's agenda. But it has never been so spelled out as crop economy was being displaced by cash economy. And, in the mean time, the wage earner was replacing the traditional builder. In America, "planters' requirements for a simplified, economical system of framing that minimized joinery and took full advantage of the structural

68. Carson et al. (1988, 113-58, 134).

69. Kniffen and Glassie (1986, 159-81, 160).

70. Hubka (1986, 426-32, 430).

71. Carson et al. (1988, 117).

72. Kniffen and Glassie (1988, 160).

73. George (1986, 336-64, 349-50).

74. Hewett (1969, 20).

75. Carson et al. (1988, 133).

quality of riven clapboards," (**68**) for example, was not an isolated case, nor unique to the country or the region.

Kniffen and Glassie are quite right in their assertion "that no significant method of wood construction employed in America before 1850 was developed here. Techniques were modified, and even perverted, but their European ancestry is certain" (**69**) Since people coming to America carried their culture with them, there is nothing surprising about it. Nor is it surprising that this culture would go through changes within the new environmental and social conditions. Everything from construction to aesthetic issues had precedents and it were these 'models' that they had to fall back on when building in the new country and revise the 'model' within the different boundary conditions. As Hubka asserts, the vernacular mode of design brings solutions "by relying on past precedents, …by disassembling or decomposing existing forms and composing new forms out of the abstracted ideas of bits and pieces of existing forms, …by reordering the hierarchy of ideas… contained within the known grammar or tradition of existing structures" (**70**).

That "these were houses with antecedents" and that "they were architecture remembered from home"(**71**), are very much part of the tectonic culture as well as the evolutionary process. For Kniffen and Glassie the "antecedents reach back at least to the European Neolithic"(**72**). A more recent association that "the English regional origins of first-generation woodworking artisans in New England" (**73**), was also a determining factor in the artifact continuity. "The implication of the historical succession of timber buildings," which Hewett described in detail and illustrated generously in *The Development of Carpentry, 1200-1700*, was taking place, this time in America with a different mode of cultivation of the "joints of various categories [that] were developed and refined over long periods of time"(**74**). The same process continued in the new country only with different set of conditions. Changes and development to appear in the culture of timber construction in America were subject to the new boundary conditions, which were very effective in the reformulation of the problem and reevaluation of priorities. In the new settlements major construction materials were abundant, at least in the early stages. Yet skilled labor, or even unskilled labor was scarce. On the other hand, demand for faster construction method to house the large number of workers needed in the blossoming industrial production, rapid urbanization and the new farming communities was very strong. Lowering "costs by requiring less carpentry" (**75**) was one operative way of dealing with the problem, both financially and with respect to time involved in the preparation of the members of the frame and its erection.

What we see from both Price's and Tredgold's, and even as early as 1677 in Moxon's, treatments of the subject matter are that there is clear tendency for lighter frames with less laborious construction means, including the use of nails at connections, without endangering the structural integrity and hence the safety expected of the structure. A careful reading of these early discourses shows us that the essence of balloon frame, which is expressed in its salient tectonic features, was a concept long predating the St. Mary's Church in Chicago, built in 1833. Transformation from tree trunks as studs to 5x10 cm (2x4 in) was a very long and arduous process. Availability of materials, capacity of technology and exigencies of society shaped the transformation first from tree trunks to half-timber construction, then to balloon frame as a "result of that continuous trend in the direction of economy in the use of materials, combined with specialisation of function"(**76**). This is the essence of the evolution we observe in the culture of timber construction. From primarily a simple roof structure, there developed a wall system with an independent roof component, and also, formed a flooring system, which when assembled, with even the simplest nail connection, is capable of forming a rigid three-dimensional structure.

The evolutionary character of timber construction, with all its failures and achievements, is evident in the history of building. It does not always follow a linear trajectory, nor do they all conform to established types, but Innocent's assertion that there is "progressive economy in the use of materials" (Innocent, 1971, 1916, 50), is valid in the broader culture of timber construction. That "carpentry forms once invented do not die out as a result of later developments unless they become uneconomic or, through change in the source of material, can no longer be made"(**77**), is another dimension of the artifactual continuity in the development of craft tradition. In comparing the cruck and the post-and-truss buildings, Robert Reyce in his *Breviary of Suffolk* (1618), says the wastage of timber has enforced "a new kind of compacting, vniting, coupling, framing and building with almost half the timber which was wont to be vsed, and far stronger as the workemen stick nott to affirme, but the truth thereof is nott yet found outte soe"(**78**). Typically, craft tradition produces buildings that are the results of piecemeal development. However, a broader perspective displays a trend that is generally progressive in character, and toward a more refined system of construction. Numerous surveys and monographs are convincing testimonies to the evolutionary character of timber construction (**79**).

How true is the historic originality granted to balloon frame? A method of construction that has been employed for centuries in different contexts with slight variations has been celebrated for being an innovation that practically converted construction in timber from a "complicated craft, practiced by skill labor, into an industry"(**80**). Especially in a field like architectural technology wherein collective significance of the activity and cumulative effects of small improvements are essential, can a single person or a culture be the sole author of the balloon frame? It is true that the balloon frame is more economical regarding the use of material than its predecessors. Is this 'economy' still valid after a century and half with modern standards and technology?

Operating within the heroic theory of inventions, Giedion, Field, Sprague, Condit and others attribute the balloon frame to single individuals, namely Snow or Taylor. It is very possible that both of these gentlemen made some, or even significant, contributions to the development of the new construction method. However, crediting them as the inventors of the balloon frame and singling out one event is to deny all the development prior to it. Both the developments in the last, at least, ten millennia demonstrated by the actual practice, and the changes clearly exhibiting the trend for lightness and labor-saving methods in Moxon's, Price's and Tredgold's publications are implications that the timber frame has developed in an evolutionary process and has a history. Its culture has developed as a result of the technical, artistic and intellectual pursuits. Quality of refinement and development that the culture of timber construction experienced has been transmitted from one generation to the other. Accretion resulting from such cultivation is the strongest evidence for continuity in the culture of timber construction. To reduce this dynamic

76. Innocent (1971, 1916, 112).

77. Charles (1967, 4).

78. Reyce, 50, quoted in Innocent (1971, 1916, 76, n. 1).

79. Most of the references cited earlier, especially those following n. 48 above are good examples showing the evolutionary character of the timber construction.

80. Giedion (1967, 1941, 347).

process to one fixed incident is anti-history and oversimplification. Partially our culture's craving for novelty and reverent homage paid to individuality is to blame for this line of thinking. It is inconceivable that historians, or historiographers, were ignorant of the previous developments that led to the balloon frame.

One other dimension of such reduction is the facile assumption that changes in building construction bear no relation to the society, which produced it, and that it is the internal evolutionary logic of the building technology, which is the major power behind such changes, are at the basis of the propositions that favor single events as technological 'inventions.' An improvement, development, or alteration, taking place, is treated as an independent, self-contained entity, fetishizing the balloon frame. The evolved adaptive changes in vernacular tradition have two characteristics: the unchanging, or slowly changing, conditions prevail for long spans of time; and the form of building and construction method copied from precedents, at times with minor changes, undergo a gradual transformation as a result of these alterations. Continuity in form and appearance is a function of the time and copying features. Even in the case where alternative ways of doing the same thing were available to the carpenter, they were not inclined to adopt those alternatives (**81**). That certain carpentry forms "do not die out as a result of later developments unless they become uneconomic or, through change in the source of material, can no longer be made" (**82**), as Charles comments, is a general trend we come across in vernacular architecture. Both of these cases are contrary to the assumption that there is an internal evolutionary logic of building technology. Neither of these features, time and copying, is independent of the conditions of existence. Social and technological contexts are the prime movers of changes and developments that can be implemented.

Giedion's description of Snow being "... something of a jack-of-all-trades," agrees with Basalla's characterization of the nineteenth century American "inventor-entrepreneur" who often carried out "the creation, selection, and development of a technological novelty"(**83**). Snow's lumber business, established in the very early years of Chicago's growth and transition from a mere village to a city, had been quite successful from the beginning, flourishing into large dimensions even with today's standards. Contractor, financier and businessman, Snow, with large investments in real estate, was very close to construction industry. However, there is hardly evidence showing Snow's direct involvement with construction per se. Although "Taylor is definitely established as the builder of the first balloon frame structure," Field admits himself "it is more difficult to assign responsibility for its invention," his claim that "Taylor was much more qualified to be the inventor of a new type of wooden construction" notwithstanding (**84**).

Development of any construction process, especially if it is the continuation of a traditional system practiced over centuries in vernacular architecture, involves the interaction of many individuals as well as a community of technologies. On the one hand, developments taking place in the lumber industry and in nail manufacturing, and on the other a better understanding of structural behavior and materials, both through experience and scientific endeavors, are all important contributing factors. Furthermore, when these factors are coupled with economic necessities and incentives, as well as with production relations in transition, there is a possibility for the emergence of novelty. However, with so many factors involved in an artifactual change, it is not a single invention that

81. Harris (1989, 1-8).

82. Charles (1967, 4).

83. Giedion (1967, 1941, 352); Basalla (1988, 151).

84. Field (1942, 20 and 21).

is in question but complex combinations of a variety of technological developments. That the heroic conception of invention obscures the origin and development of a technological innovation, which Hunter convincingly argues in the case of the steamboat (**85**), is also valid in the case of development in the timber frame.

Development of timber frame has taken place over several millennia, in different social relations, cultural conditions, and environments. It is only a fraction of our overall cumulative technological development whose diverse components are interdependent. It is an evolutionary process toward "a *new combination* from the 'prior art,' as Gilfillan put it. The 'prior art' characterizes the very nature of the development we outlined above. There is constant development, sometimes very slow and other times relatively more rapid, in the little details, as a result of experience that enhances perception. This aspect is even truer for a practice such as construction, which is mostly a vernacular process, and where continuity depends very much on tradition. Gilfillan's "new combination" or "recombination of elements" (Gilfillan, 1970, 1935, 10), is also "a perpetual *accretion* of little details, probably having neither beginning, completion nor definable limits"(**86**), which suggests an artifactual continuity, with small improvements over time.

Usher provides us with the actual process wherein the emergence of novelty occurs. Slightly different from Gilfillan's conception of technological change, Usher adds "the act of insight" as the individual's contribution to the process (**87**). His *cumulative synthesis approach* outlines four steps: 1. *Perception of the problem*, in which an incomplete or unsatisfactory pattern or method of satisfying a want is recognized. 2. *Setting the stage*, in which the elements or data related to the problem are assembled. 3. *The act of insight*, in which the essential solution of the problem is found. This step goes beyond "the act of skill" generally expected of a trained craftsperson or professional. 4. *Critical revision*, in which the newly perceived relations and recombination are effectively worked into the broader context to which they belong. The process of cumulative synthesis is a cyclic continuation of the above process combined with multiple other processes similar to it, wherein individual elements of novelty are included in the development of more strategic technological change.

Both Gilfillan's and Usher's approaches to invention and innovation are views opposing the emergence of novelty as creation *ex nihilo*. A common characteristic embedded both in the theory of heroic inventions and originality emerging from nothing is the concept of novelty itself. Schon draws our attention to the highly positive emotive meanings our culture attributes to novelty, the new, innovation, and creativity. At the same time, he points out that inability to distinguish fantasy from reality and inability to form structures that could be the basis for perception of reality are also aspects of the disruptiveness of novelty. Technological changes that take place are not entirely novel per se, since "new concepts do not spring from nothing or from mysterious external sources. They come from old ones" (**88**). This is what Schon describes as the "displacement of concepts," in which the old concept is applied according to the terms of the new situation; thus in order to function as intended models for new instances, old concepts are viewed in new ways. It does not mean that there can be no novelty. A creation or the emergence of novelty is based on new combinations but not in the sense of emergence from nothing. According

85. Hunter (1973, 25-46).

86. Gilfillan (1970, 1935, 6, 5).

87. Usher (1962, 1929, 56-83).

88. Schon (1963, 98-102, 192).

89. Barnett (1953, 181).

to Barnett "it must have antecedents, and these are always traceable, provided that enough data are available for an analysis"(**89**). An innovation is, therefore, a creation only in the sense that it is a new combination, in which a union of ideas -perception, cognition, recall, and affect- is realized.

To sum up the development of balloon frame, there were pressing labor issues in the nineteenth century as well as very inelastic demand for housing. Traditional methods of construction were not sufficient and tectonically inadequate to respond to the pressing demand for housing. The process of urbanization and industrialization in many sectors had major impacts on the transformation of social relations as well as on mode of production. New rules as to what controls the construction industry, as in other industries, were being shaped. What this meant for residential construction was to decrease the cost of building. Without much capital investment for improved construction techniques, the level of skilled labor that the crafts tradition required was practically the only variable of the equation that could be changed. Rapidly improving nail manufacturing technique was a strong catalyst in this process. And to a lesser degree, some reduction in material requirements, though often quite insignificant, could be brought in.

The balloon frame was the outcome of the evolutionary process at the intersection of industrialization and urbanization. The 'critical revision' leading to it was in the making more than a century by this time. Under the broader search for the use of less material and labor, artful detailing of joinery, replaced by hammer-and-nail connection, was certainly a turning point just like the transformation from cruck building to box frame construction was centuries ago. The problem of connection has been redefined with each improvement and consequently the new set of rules and techniques. 'The act of insight,' regarding the connection, more specifically the transformation from the elaborate mortise and tenon joint to the simpler nail connection was also supplemented by the promulgation of authors like Moxon, Price and Tredgold, and later by Benjamin and Hatfield. Industrialization, at least indirectly, was knocking on the door of traditional construction method. The effective practice of balloon frame at a large scale was only possible with the availability of nails at low cost, which subsequently raised the hopes and possibilities for adequate housing for masses. But did the balloon frame rise to the occasion, or is there a desire as yet unsatisfied?

It is only appropriate to ask what, if any new aspirations disclose themselves in the present state of building activity which is dominated by the balloon frame. The past century and a half the balloon frame has been the predominant method of timber construction in the United States with some development and refinement since it gradually replaced the heavier timber frame construction. At this point in time, do we simply repeat the solutions, with the expected improvements along the way, or are there unmet or new needs and possibilities leading to new fulfillment? We can say, without cause for controversy, that the balloon frame enabled faster construction as well as stripping away of differences, through the practical need to treat everyone's house construction alike. The latter can even be interpreted in Frank Lloyd Wright's spirit of democracy "truly democratic expression of our democracy", despite the fact it was used in a slightly different context. On the other hand, while the carcass may be the same, the dressing of it can vary so much that the notion of equality stops there. As a matter of fact, the divide in housing quality between the 'haves' and 'have-nots' is even greater than before. While this is a problem of a different nature and magnitude, tectonic culture is an important variable in its formulation and solution.

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BALON ÇERÇEVEYİ YENİDEN KURMAK: ARKİTEKTONİK TARİHİNDE BİR ÇALIŞMA

Bu yazıda birbirlerine yakın iki sav koşut olarak geliştirilmeye çalışılıyor. Birincisi, ahşap çatkı düzeninde, yoğunlukla kuzey Amerika'da yaygın olarak kullanılan "balon" çerçevenin ortaya çıkması kimi yazarların göstermeye çalıştıkları ya da savundukları gibi bir kişinin yoktan var ettiği bir yapı türü olamaz. Balon çerçevenin yaratıcısı olarak sözü edilen kişi(ler) katkıda bulunmuş olabilir, ancak bu biçimlendirme sürecini tek başlarına oluşturmadılar. Tek yaratıcı savını destekleyen belgeler ne yeterli ne de tutarlı. İkincisi, özellikle çatkı gibi çok değişik etmenlere bağımlı bir teknolojik etkinlik ve biçimlendirme sürecinin yaşadığı yeniliklerde kişisel başarılardan çok, zaman içinde gelişen süreklilik ve ortak katkılar söz konusu olabilir. Böylesine bir oluşum ancak uzun bir sürecin sonucunda, bir gelişmenin ürünü olarak ortaya çıkabilir.