THE ENTANGLED AMERICAN HOUSE

(Blueprints, National Building Museum, January 1994)

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A visit to an ordinary dwelling or apartment building under construction in any neighborhood in the United States, just before the sheetrock is hung, is a good way to assess the state of entanglement in American house-building.

Imagine what we will see (Fig.1). Amidst the normal jumble of building-in-progress, the smell of sawdust, remnants of wiring insulation, dried mud and debris on the subfloor, and empty styrofoam hamburger containers, a keen observer will see the exposed wall and ceiling cavities crammed full of parts. Immediately evident is an almost unbelievably confused array of installed pipes of varying types and sizes for supplying and carrying away fluids, air ducts of several shapes for moving air, thousands of feet of wires for electric power and communications, and, in some jurisdictions and some building types, sprinkler lines for fire suppression.

Fig.1 The entangled service systems in the floor cavity of a normal residential project, 1993.

It was only five generations ago, around the time my grandfather was in his teens, that plumbing and central heating, and later wiring, became commercially available at reasonable costs and were promoted by architects and developers for use in apartment buildings and houses. [1] These entrails now dominate housing processes in ways unimagined at that time or even thirty years ago.

A State of Entanglement

In virtually all construction types, multi-family and detached, wood frame and concrete, the technical and organizational entanglement of American residential building has reached a critical state. The overall lack of order of the relation of resource distribution parts to the rest of the buildings they serve is an indication of the problem.

Fig.2 A balloon frame house in 1935.
(*The Architectural Record,* August 1935.)

What we can see of the interweaving of parts lacks the clarity and elegance still attributed to wood framing or other structural systems. Today, walls and floors of sticks of wood or substitute materials -- the main elements of the beloved and ordinary 2x4 system which first came into use in the 1830s in Chicago [2] (Fig.2) --- are filled to overflowing. Many of the wooden or steel structural elements are fastened in place and then pipes, wires, and ducts knitted haphazardly into them. This is especially destructive now in traditional wood-frame construction, where holes are bored on-site as needed and, often at random by each trade, frequently with no coordination.

Each part of these service and structural systems no doubt represents, in itself, the best product for the least cost, available from the world-wide building products industry, each installed by a different trade and each serving a perceived need.

This interweaving process seems to have worked up to now for four main reasons: the remarkable structural redundancy and forgiveness of wood or steel framing, the expectation that the next stage of work in this conventional chain of events will cover any depredations of the previous player, the relatively low cost of materials, and the availability of skilled workers. None of these can be taken for granted today.

Because the cavities between wall studs in all construction types and floor joists in framed buildings have been available by nature of frame construction, they have been filled in no particular anticipatory order in a historical progression by the first to get there. Trade jurisdiction work rules, starting in the craft guilds but having migrated into the work force in general, followed the emergence of new parts and processes, dividing the work accordingly. Now, separations of work patterns, incrementally added over decades, are as antiquated and convoluted as the paradigm of house building they accompany.

This entanglement is the fault of no one in particular, making it difficult to establish cause or to measure responsibility. It is therefore difficult to remedy. In an important way, the diffused responsibility for this "system" is both its liability and its strength: it is a living system controlled by no one trade or company but is shared and gradually improved by all who use it.[3]

The Interplay of Technical and Organizational Patterns

The situation of entanglement would not be so much a problem if it were only technical in nature. However, as with many situations made visible by observing technical hardware, the issues are not divorced from their organizational and social ambiance. Now, the entire constellation of actors - manufacturers, designers, constructors, regulators, and users - is likewise enmeshed, producing conditions ripe for poor quality, higher costs, disputes, and loss of decision flexibility. Among the many social and organizational forces at work, five stand out.

Demographic Shifts

Most of us have read about or directly experienced the rapidly shifting demographics in our neighborhoods and regions and the changes of household types and sizes accompanying the larger statistical perturbations. In part because of these social dynamics, housing developers today build for specific market niches and unit mixes in their projects. The way buildings are organized today, building income may suffer, and operating costs increase if piecemeal or even substantial upgrading or “repositioning" of a building is needed to maintain its attractiveness in the market.

If these statistically targeted buildings are not entirely obsolete, facing abandonment or mistreatment, they at least may not make a good fit with the next statistical cohort of households. While in a very large aggregate sense all of these mismatches may even out, in any one building or locale the discontinuity can have telling but difficult to measure negative effects on household well-being, contributing to a sense of powerlessness over the place of dwelling at a very personal level where dwellings mean the most to us as inhabitants, an effect often felt in the community at large.[4]

Decision Deferment
We also know that, in housing developments that take several years from planning to occupancy, developers seek to defer the costliest decisions and most-likely-to-change decisions as long as possible. They want to keep their options open in order to quickly change unit mixes and layouts when new household formations appear in their market research. These are the costliest decisions. But the impulse to delay sends ripples through the entire chain of actors, pushing all action to the last possible moment, compressing an already difficult and entangled process. Unless well organized, this decision-deferment process, which is desirable for some, can cause major cost and construction management conflicts for others.

Control
Many households want a direct say in major interior layout, fixtures, and equipment decisions, no longer content with moving into dwellings someone else has decided have "good layouts and feel." This may be a case of households wanting to reclaim "territorial control" of housing decisions from experts remote from the realities of living in the house being built, experts who, often lacking other means, base decisions on statistics rather than actual individuals. Organizing for variety without driving up costs is a constant challenge for builders and development teams. Many are pushing variety as fir as they can within the present paradigm of housing production efficiency.[5]

Change
Industry statistics show clearly that expenditures on house renovations, adaptations, and upgrading are mounting beyond $100 billion each year in the U.S. market.[6] These commitments to dwelling adaptation are more difficult and expensive for both professionals and do-it-yourselfers to realize because of the entanglements of parts and the parties involved, as discussions with contractors or building owners and inhabitants reveal.

Organizational and Supply Chain Reconfigurations
Finally, many industries are reorganizing their supply chains in response to new concepts of value creation. Ikea is an example of a large organization, with sophisticated supply chains in tow, that offers a new division of labor, including customers taking on certain key tasks of assembling well designed but lower-cost products. The Hechinger Company and Home Depot represent other organizations restructuring to new demands. They offer surprisingly comprehensive design and construction services and the logistics to make it happen. The concept of “mass customization" is now discussed among industry forecasters, including the Global Business Network in California. Robert Reich, Secretary of the Department of Labor, discusses the concept of “multi-disciplinary work cells” in a recent book.[7] The United Brotherhood of Carpenters and Joiners now takes interest in new cross-trade affiliations to alleviate jurisdictional disputes, and is exploring various proactive training and apprenticeship programs that they believe may be needed in the future, as unions seek market recovery in residential construction.[8]

The latter reconfigurations, taking place nationally and internationally, are good examples of responses to new social, economic, and technical conditions having a direct bearing on housing processes.

An important threshold seems to have been crossed in a fascinating incremental process accomplished without anyone trying or perhaps even noticing. No one has sufficient autonomy to act, change the direction of their decision path, or adapt what is already built, without engaging -- often in conflict -- dozens of other actors, each controlling some physical parts, each with their own problems and priorities.

This is truly a situation of loss of freedom across the board, not at all what we have expected from our way of building houses and the mythic democratic, market-driven housebuilding culture that has grown up with it. This loss is significant because it is happening in a political economy in the United States that we have traditionally associated in very strong terms with household level control of housing activity and housing improvements. Paradoxically, in a society stressing individual rights and responsibilities, we find that control of design decisions by occupants, apart from expensive custom-designed single family houses, is considered a nuisance or disturbance by many housing experts who take an inside-out view of the market.

This view, which still holds a constricted view of efficiency and is based on obsolete concepts of standardization and unified expert control, is very much at odds with the very nature of healthy housing activities.

A Short History of Entanglement

Early American Houses

American houses built in the eighteenth and nineteenth centuries are a good background against which to trace the evolution of our present entanglement, because then, neither electricity, plumbing, nor central heating were present (Fig.3).

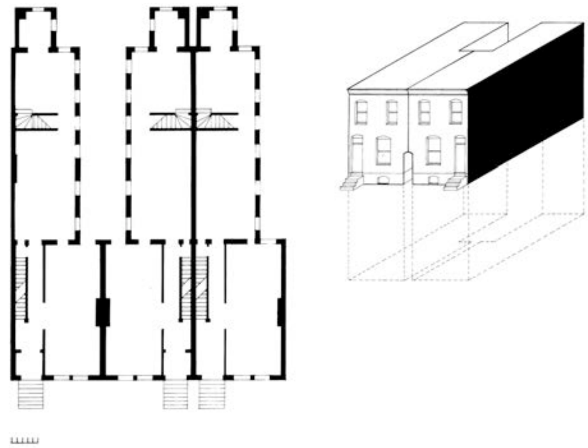


Fig. 3 Plans of nineteenth century rowhouses in Reading, Pa., showing with kitchen or bathroom at the rear. (Steven Holl, *Rural & Urban house Types in North America*, pamphlet Architecture 9, New York, 1982.)

In these early houses, which people could afford to build, often following principles of compositional clarity and formal simplicity brought from European traditions[9], the few spaces were organized in such a way that they could be and were used for many household activities. Often, sleeping, living, bathing, and cooking occurred in one space in a time-sharing approach. It was normal to have change of use in harmony with the seasons and, of course, change of activity patterns when a new family moved into a house. This was accomplished by the repositioning of furniture and storage elements such as wardrobes, armoires, and the like. Rooms were labeled "hall," "north parlor," "south parlor," "chamber," etc. Few could afford to build use-specific rooms. Indoor toilets and bathrooms were nonexistent, and kitchens were found in any room where a fireplace provided a place to cook or located in a shed attached to the back of the house.

Houses of the Industrial Revolution

Daring the last half of the nineteenth century, indoor plumbing for water distribution and drainage was gradually and then rapidly introduced into houses and apartments, accompanying rapid urbanization, gradual increase in household affluence, and justified fears of threats to public health, safety, and welfare. This was supported by the development of inexpensive, mass-produced, cast-iron and lead piping, and public water systems. The first vented trap to remove sewer gases from toilet rooms was introduced in 1875, the introduction of the first really sanitary water closets took place about 1890, and publicly funded sewers and waste treatment plants were built in the same era. These public and private initiatives enabled bathrooms to migrate, in stages, from the privies in backyards to attached toilet rooms tacked onto the back of houses, and finally to take their place inside, even in multifamily apartment buildings.[10] (Fig.4) Building regulations in most large cities required indoor plumbing by the end of the nineteenth century.[11] Even so, 45 percent of households did not have complete indoor plumbing as late as 1940.[12]

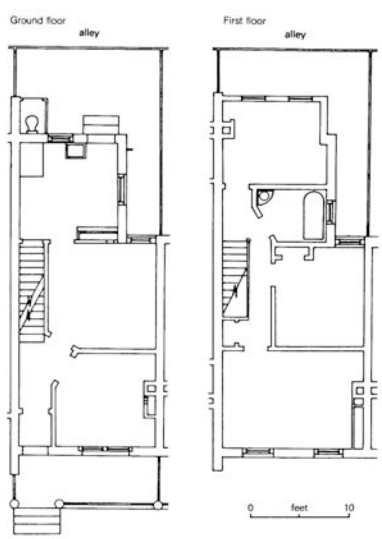


Fig.4 A plan of a Philadelphia mechanic's house in the early twentieth century, showing a kitchen in the rearmost space, a toilet attached to the back of the house, and a bathroom without toilet on the second floor. (Parish, H.L., *One Million People in Small Houses,* Philadelphia, 1911.)

Other pipes brought natural gas to give illumination, still other pipes brought steam for heat. In the period between 1900 and 1920, wires began twining through walls and floors and behind baseboards, replacing gas as a means of illumination and serving a burgeoning supply of electrical appliances plugged into convenience outlets.[13]

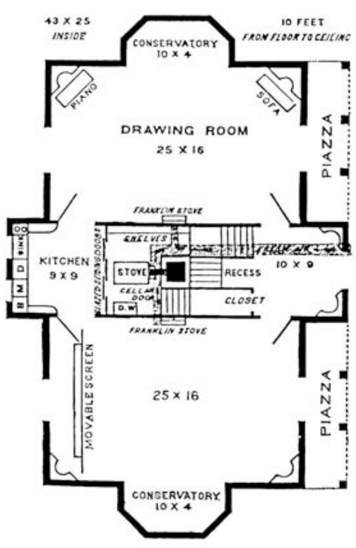
The mechanical removal of odors and humidity, and the addition of cooling to the technical services load, with the need for more equipment and distribution lines and ductwork, waited until decades later to make an appearance inside houses as standard features. Then, these developments happened quickly, in the span of several generations, following World War II.

Functionalism

The migration indoors of bathrooms and kitchens attached to their resource tethers, taking place from the 1880s onward, coincided with the Victorian concept of dividing indoor space into distinct "functional" territories.[14] Particularly with the detached house, this concept of spatial order related directly to specific uses was a distinct departure from long traditions. These traditions were rooted, in many cases, in the principle of types, in which "functions" or "uses," and even "territorial distributions," would be decided independently by those who inhabited buildings.[15]

Thus, during the Industrial Revolution, house design experienced an important evolution. From spatial and geometric orders offering a certain capacity for a variety of habitation patterns, house design took on functional determinism. This way of thinking locked in specific uses by two means: the arrangement of walls tightly wrapped around the spatial requirements of an activity, and the attachment of resource tethers serving these specialized spaces. In short, spatial arrangements and uses, distributed for reasons established by convention even prior to the introduction of mechanical systems, were now captives both of "arrangement and dimension based on function" and the resources needed to serve them. Thus, for example, cooking equipment went into spaces previously called "kitchen" prior to the use of gas and electric appliances, and bedrooms became special purpose spaces by the introduction of built-in closets, replacing wardrobes and movable cabinets, which had previously allowed any space to be a sleeping room.

There were efforts, however, to radically re-think the distribution of services in houses in ways independent of the particular distribution of functions or uses in a house. In 1869, for instance, Catharine Beecher's proposal for an American Woman's House clustered all services in a central core serving all rooms in the house, each claiming adjacency to the central core.[16] (Fig.5)



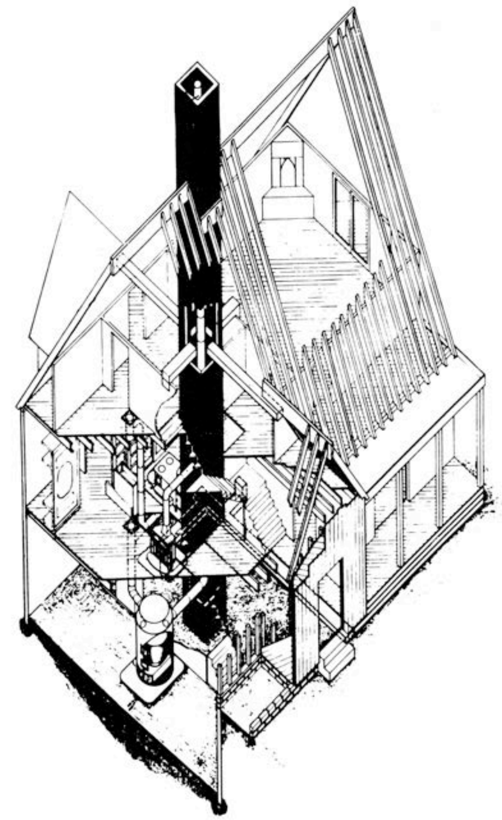


Fig.5 Drawing of the central utility core proposed by Catharine Beecher in 1869. (from *The American Woman's Home,* Catharine E. Beecher and Harriet Beecher Stowe, 1869, in Russell, Barry, *Building Systems, Industrialization and Architecture,* Wiley, New York, 1981.)

Much later, but in the same spirit of efficiency and rational planning, Richard Buckminster Fuller's first Dymaxion House of 1927 had a central mechanical and structural core from which services were to be distributed to surrounding living spaces. He made this proposal while criticizing what he called the International Bauhaus Movement's superficial approach to mechanical systems, an approach that, he said, “never went back of the wall-surface to look at the plumbing....” This was an important but seldom voiced criticism of a movement that had been precipitated in the first place by the invasion, before 1914, of houses and streets by mechanical services.[17] The criticism was accurate, but the proposal seems to have missed the mark, given what is known today. (Fig.6)

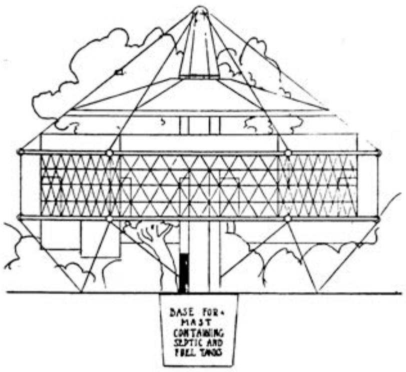


Fig.6 R. Buckmiunster Fuller's Dymaxion house, showing a central service core. (*Building Systems, Industrialization and Architecture,* Wiley, New York, 1981.)

These early efforts at promoting a "standard, functional" mechanical core for all houses can still be seen in standardized floor plans in so-called "low cost housing schemes" in which bathrooms and kitchens are repetitively back-to-back, an arrangement argued to be more efficient and less costly than any alternative. While this efficiency argument may have held at one time in circumstances of bureaucratic management, it has certainly not been particularly relevant as a "standard" in the American experience, except when organizations based on bureaucratic control have built for an economic class denied control of the act of dwelling. Even here, doubts are beginning to surface about the correctness of those assumptions, given the realities of housing dynamics.

Early Years of Experimentation

The building technology and architectural journals of the 1930s, following directly on the new and widespread availability of resource distribution systems in houses, are fall of evidence of tremendous experimentation with improvements in house building. This surge of work, almost all of which sprang from private initiative, lasted until the Second World War and took place during the Great Depression when relatively few new buildings were built. Aside from the experimental work, much of the practical efforts of the time were spent correcting and modernizing existing buildings with current mechanical systems, efforts that accelerated after the Housing Act of 1937 and the formation of the Housing and Home Financing Agency in the same period. (Fig.7)

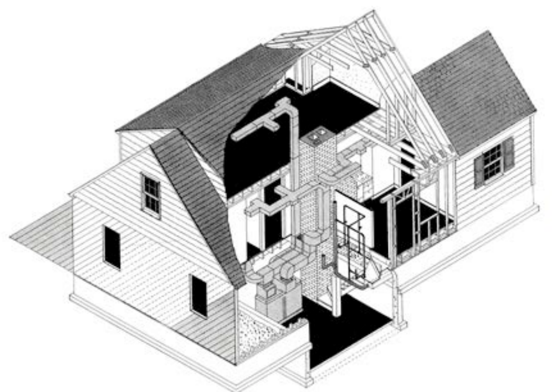


Fig.7 An integrated house from the Modern Housing of Washington, D.C., development. --"In its construction, modular design, standardized plans, a studied production "flow pattern," and novel construction practices combiune to effect substantial cost-and time-savings..." (*The Archtiectural Forum,* November 1937.)

Despite or perhaps because of the newly introduced resource systems, these published experimental efforts from the 1930s reveal a curious lack of attention to these systems. With only a few exceptions, published accounts in the architectural press of the time focused hard on new ideas for the space-defining elements of houses, their construction, and appearance: walls, floors, roofs, foundations, and all the elements of which they are made. At the same time, most ignored or only grudgingly accommodated the pipes, ducts, and wires needed to make the houses liveable.

In these schemes, if cavity walls of new materials and shapes were proposed - and many were - the new resource systems must have been assumed to go between, inside, and through the cavities. Some explicitly stated that this was the intention. When solid-core prefabricated walls and floors were proposed - and there were and still are many - there is seldom any mention of where wiring, piping, and duct work are to be placed. Presumably, they are placed in dropped ceiling plenums in basements, hidden in closets, or otherwise "put in afterwards."

The reason these newly present systems largely escaped the attention of the architectural and building inventions of the 1930s is worthy of speculation in more depth than can be accomplished here. But whatever paradigm was at work then is still at work today: these non-architectural elements will be put in later, after the important work - usually, in architectural thought, the structure and spatial enclosure - is completed, or, they will be "integrated."

The Post-War Period

Many fine histories of housing design, technology, and production chronicle the period World War II and the early 1970s when the now infamous Operation Breakthrough project of the federal government closed its books. After that, the literature becomes markedly thin, as though all the enthusiasm of the previous fifty years had dissipated.

A careful reading of efforts that were recorded reveals only passing references to the creeping entanglement involving pipes, ducts, and wires. This absence is understandable, since, until the widespread introduction of forced air for heating in the late 1940s and air conditioning in the late 1960s, the technical repertoire had not changed markedly for over forty years. (Fig.8, 9) For example, by the 1940 census, fewer than 58 percent of households had central heating.[18]

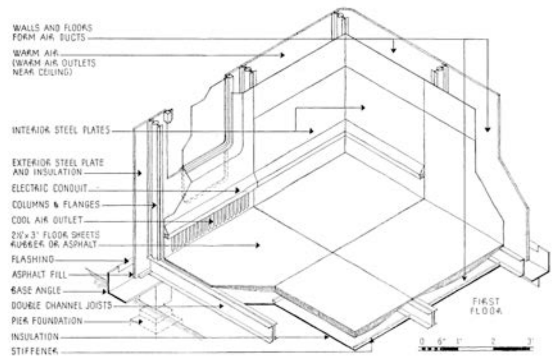


Fig.8 A diagram of a Van Ness Steel House. *(The Architectural Record, 1935.)*

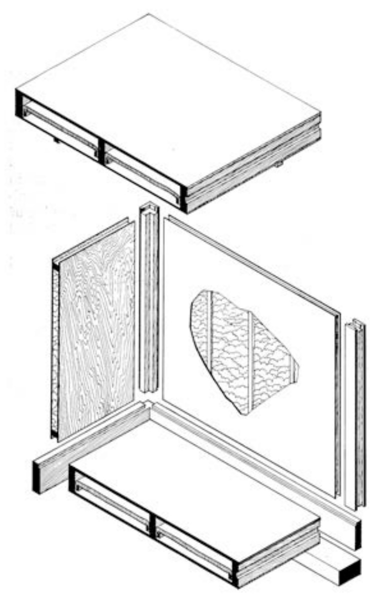


Fig.9 A prefabricated all-wood house assembly. *(The Architectural Record,* August 1935.)

When resource systems are mentioned at all in the housing innovation literature during the period after 1972, the discussions are frequently framed in terms of systems integration. This is a concept that has directly or indirectly dominated much of the research thinking about housing and other building technology since the 1960s.[19]

The basic principle of integration is to put as many subsystems as possible into one unified, preferably mass-produced assembly. This was, and in some quarters still is, thought to be the key to better results. In fact, this approach can be described as an effort to rationalize and standardize the physical positioning of parts currently found in practice: pipes, wires, and ducts within floors and walls. In a significant departure from daily practice, however, many proposals for systems integration suggested that the interweaving of parts could be standardized to enable mass production of elements so configured, independent of any particular project. In what now seems a curious linkage, this strategy was thought to be a way to achieve "flexible" and "adaptable" housing schemes.[20]

Whereas placement of service lines within walls and floors could, on a project-by-project basis, meet the highly variable demands of construction and market requirements until recently, efforts to standardize this intricate interweaving - and thus reduce me variety of configuration - could not possibly succeed. No one wanted to build standard floor plans in large enough numbers to make an investment in such mass-produced, high value-added, integrated component production worthwhile.

This was especially so as increasingly complex systems were introduced in the last twenty years: humidification and dehumidification depending on the season, more sophisticated and complex heating and cooling systems, central vacuum systems and other appliances and fixtures each requiring several service hook-ups, more power and communications cabling, a diversification of power or energy sources, ventilation systems, fire suppression sprinkler systems, and the like.

By the late 1980s, faith in systems integration had largely waned, with the exception of such rare industry development efforts as General Electric's Living Environments Project and the follow-up IBACUS consortium. Systems complexity had increased, demand for variety had continued unabated, but no new paradigm emerged on the screen of the American housing industty to help sort out and simplify the tasks.

Shedding the Limitations of Functionalism and Entanglement

The principle direction of thinking dominating housing technology up to now, can be called the *unibody / integration* view. This view corresponds closely to attitudes held in currency by many industry leaders, writers, and academics up to the 1990s, but is now obsolete. It is fundamentally a static, technical view in the narrow sense, trapped in a model of centralized control and standardization. Because of this, it is unsympathetic to the full reality of healthy housing processes in the United States.

The *unibody / integration* perspective ignores one old reality and one new idea in housing, which the state of entanglement we have now reached compels us to see in a new light. Recognized together, these two concepts may hold promise for shedding the limitations of functionalism and entanglement.

The first old reality is the fact that as dwellings change, they undergo gradual, fine-grained adaptation to remain current and healthy, a process often initiated by households or for their benefit, making for a widely distributed pattern of control. This is pervasive, constituting a viral economic and social activity, only partially accounted for, and is certainly not a heroic activity concerned with style or winning awards. Further, this characteristic of housing has long eluded those professions blinded by an obsession with self-expression and the belief in the superiority of professional values.

The second somewhat new idea is the principle of levels, which concerns the way the built environment organizes itself hierarchically according to the distribution of control over it.[21]

This later concept is evident in nonresidential projects such as office buildings and retail facilities, where it has been conventional practice for some time in the U.S. to organize on the basis of levels. In these projects, a "base building" is constructed, consisting of loadbearing elements, shared spaces, and common mechanical systems. This part of the whole is designed to last longer than any activity at the "fit-out level," about which each occupant may decide and for which each is individually responsible.

The facts of change and distributed control converge in the levels concept. The base building is meant to be "fixed" relative to the more variable fit-out. One party (the aggregate of individual occupants or a separate entity) controls the base building, and a number of independent parties each controls its own "fit-out," retaining a degree of technical and legal autonomy and responsibility set out in the agreements of occupancy.

This approach is applied as a matter of course in the office and retail section, taking many forms. It may have merit in U.S. housing as well, to liberate a process now so entangled. A model of this practice has been patiently moving forward in the Netherlands, dealing with a difficult mix of government and market forces. Hundreds of housing units have been built using it.(Fig.10) According to people doing the work there, a new stage of application has now been reached. New multifamily residential projects, as well as renovations in both the subsidized and private markets, are being built. In them, base buildings are being "fitted out" with units meeting household preferences, at a cost equal to the *unibody / integrated* approach, which is conventional there too and equally outmoded. These projects offer developers the new benefit of matching rather than anticipating user requirements and getting the work done more quickly than before. They demonstrate how variety, previously considered to be the source of higher cost and more difficulty, can actually be more efficient.[22]

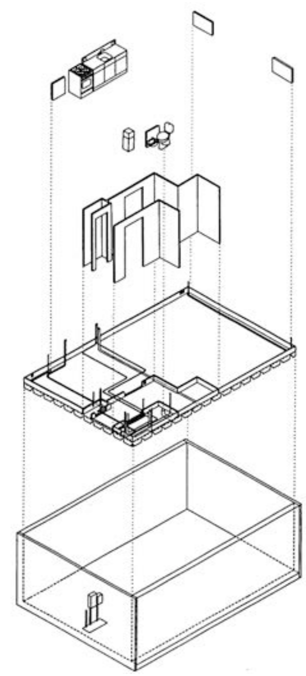


Fig. 10 A diagram of a dwelling organized on the principle of base building and fit-out. All installations specific to the dwelling are in the fit-out, except for the main supply and return pipes and ducts. This approach is applicable to both new cvonstruction and renovation. Matura Netherlands. (from *Entangled Building?* (ed) E. Vreedenburgh. OBOM, Technical University Delft, The Netherlands, 1992.)

This base building/fit-out approach also has an interesting dimension that should satisfy architectural formalists and functionalists alike. Well-designed base buildings can be constructed following sound and enduring principles of built form, offering capacity and giving opportunity for a wide variety of territorial distributions and functional layouts. Thus, architects and builders can literally "give" form and space to others who then have the freedom to put the given forms to use in their own and changing ways. It is an important kind of organized hand-off in a complex process, one which may now be able to respect the fundamental need for historical continuity at the level of the building as part of the public environment, while respecting the need for continuous though slow cultivation of the interior spaces in respect to evolving household needs.

A Turning Point in Housing

A real turning point in meeting the problem of entanglement in American housing will come when several events occur. First, wiring, piping, and duct management following the unibody/integrated paradigm in currency today - "just put the pipes and ducts in the cavities or anywhere they will fit" - will have to become an economic burden to most actors in the housing game, especially builders and users. It may already have reached this point, both in initial construction and in down-stream alterations.

Second, there will have to be widespread recognition of the ubiquity and magnitude of investments in altering existing dwellings as a percentage of total investments in housing. This data is relatively well known, but our building traditions are only slowly waking up and adjusting to this reality.

Third, the unibody/integration model will have to be displaced by the levels model as a normal basis for organizing complexity. Despite the many differences between commercial projects and housing - many fundamental differences in their respective places in our social, economic, and cultural fabric - the base building/fit-out strategy is a useful model that should be carefully studied and tested in housing practice.

The reality of technical entanglement is being recognized in many industries and countries. It is given many different names, "sorting out, "design for assembly," "disentangling," "base building/fit-out," "working on levels." There are, however, advantages beyond those gained in solving technical problems, critical as they are to improving the state of the art in housing. The concepts of levels and the principle of disentanglement also enable us to rethink again the organizational question of the balance between the community and the individual, mediated as always through the control of the built environment.

A visit to a multifamily residential project under construction and organized this new way offers a tangible image. Opening the front door, our future occupant sees an enclosed but bare space, with columns or bearing walls at certain locations, and exposed vertical plumbing and ventilation lines in a cluster. With the assistance of a designer, or by referring to several prepared model-unit designs, an interior design is prepared matching our household's preferences perfectly. Because a sophisticated computer software program is used, the design is transmitted directly to an off-site facility where all specified parts - including walls, equipment, cabinets, fixtures, piping and wiring, and heating and cooling equipment - are prepared or organized. Accompanied by a trained, four-person installation crew, this package of parts is transported to the building, or delivered just-in-time from other suppliers, one week alter the order has been placed. In a carefully choreographed sequence, parts are brought into the dwelling space and installed. After one week, carpet installers arrive, followed by drapery hangers, and the furniture is brought in. The elapsed time between the initial visit to the bare space and completed fit-out and occupancy is less than three weeks for an average size dwelling, at a cost equal to that had the conventional approach been used, and offering the additional advantage that future changes will be easier to accomplish."

This scenario represents a new paradigm. The question is how to shift paradigms, in an industry and a process characterized by individual parties acting individually. We need to learn how to intentionally embark on a new concept pathway, on which each wall find opportunities unavailable if the path isn't established in the first place. This would be a rare event in the building industry.

References

1. Wright, Gwendolyn. Building the Dream, A Social History of Housing in America. Pantheon Books, New York, 1981.
2. Gideon, Sigfried. Space, Time and Architecture, The Growth of a New Tradition. Harvard University Press, Cambridge, 1963.
3. Habraken, N. John. Transformations of the Site. Awater Press, Cambridge, 1988.
4. Gallagher, Winifred. The Power of Place. Poseidon Press, 1993.
5. Author's personal interviews with major homebuilders.
6. National Association of Homebuilders. The Future of Home Building; 1991-1993 and Beyond. Washington, D.C., 1991.
7. Reich, Robert, Tales of a New America, Random House, New York, 1988.
8. Author's personal conversations with Edward Gorman, Carpenter's Health and Safety Fund of North America, United Brotherhood of Carpenters and Joiners.
9. Holl, Steven. Rural and Urban House Types in North America. Pamphlet Architecture 9, New York, 1982.
10. Nielsen, Louis S. Standard Plumbing Engineering Design. McGraw-Hill, New York, 1963.
11. Ventre, Francis E. "Building Regulation." Dictionary of Art, McMillan, New York (upcoming).
12. Two Hundred Years of U.S. Census Taking: Population and Housing Questions 1790-1990. Bureau of the Census, Washington, D.C., Nov.1989.
13. Nye, David E. Electrifying America, Social Meanings of a New Technology, 1880-1940. MIT Press, Cambridge, 1991.
14. Wright, Gwendolyn, op cit.
15. Habraken, N. John. Type as Social Agreement." Biannual Asian Congress of Arthitects, Seoul, 1988.
16. Russell, Barry. Building Systems, Industrialization, and Architecture. Wiley, New York, 1981.
17. Banham, Reyner. Theory and Design in the First Machine Age. Praeger, New York, 1960.
18. Two Hundred Years of U.S. Census Taking: Population and Housing Questions, 1790-1990. Bureau of the Census, Washington, D.C., Nov.1989.
19. Bender, Richard; Wilson, Forrest (ed). A Crack in the Rear View Mirror. van Nostrand, New York, 1973.
20. Kendall, Stephen. "Flexible Design, Encyclopedia of Housing, Garland, New York (upcoming).
21. Habraken, N. John. “Culuvating the Built Field,” Places. MIT Press, Cambridge (upcoming).
22. Kendall, Stephen. "Open Building for Housing. Progressive Architecture, Nov.1993.