# The Responsive House

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# Specifications for an Organic and Human Building System

Christopher Alexander and Max Jacobson

Introduction. For the past several years, we at the Center For Environmental Structure have been trying to create a process of building which leads, once again, to environments that can be described as organically whole, or alive.

What do we mean by such terms? We do not mean that the environment will literally look like a biological organism, any more than a lovely mountain cabin looks like a tree, a stream, or a rock. Nor do we mean that the environment will act like a biological organism, any more than the same cabin literally speaks to us or has an intentional animate life of its own. We mean that the environment - the social and physical environment together - form a living system;[1)] and that like any living system, this one can be more alive or less alive, more whole or less whole. This idea is more fully described elsewhere,[2)] but we are already sure that objective indices of the state of health of environmental settings can be specified.[3)] When we use the terms organically whole, or alive, we are referring to the state of health of the social and physical systems which together make up the environment.

We have found that a building process which is able to make buildings which are organically alive needs four elements.

1) A common pattern language: A process for building which can improve and evolve through public debate. Our first attempt at such a pattern language

is almost complete and will be published at the end of this year.[4] The patterns in the language are physical solutions which resolve conflicting human tendencies, conflicts which frequently recur in the existing environment.

2) User design. Users must once again design their own environment, using this common pattern language to inform their work. Only then can they feel competent, responsible and mature. They know their own needs and the particulars of their own problems better than any professional designer.[5] Our experimental work has shown that laymen can make competent house designs using an explicit pattern language.

3) Repair and piecemeal growth. Every act of building must be thought of as repair of the existing environment. The idea of building anything once and for all, or building all of a new facility prior to occupancy, is directly opposed to the way of nature. Nature is continually involved in ongoing, piecemeal growth and repair. It is not enough to have users initially designing their environments; it must also be possible for people to improve their existing environments gradually through repair.[6]

4) After several years of work with these ideas, it has now become clear that the organic process of building we envisage requires a fourth element: a human building system specifically designed to support the pattern language, user-design, and piecemeal growth and repair. After trying to work with currently available building systems, we have been forced to the conclusion that no building system now available is compatible with these three concepts. Yet we know that many traditional building systems used to be compatible with them; so it must, in principle, be possible to have such a system. In this paper, we will discuss the task of developing such a building system, and will give a list of specifications which it will have to meet.

## 1. Compatibility with the pattern language.

Several of the patterns in the current pattern language are particularly sensitive to the nature of the building system, and are difficult, if not impossible, to realize with presently available systems. Here are some examples.

Light on Two Sides (1969).[7] This pattern discusses the fact that any social space or room should have daylight on two sides to prevent glare and a general atmosphere of "gloominess." If the arguments and data presented in this pattern withstand the test of professional criticism and debate, far-reaching changes in our building practice will be needed. To let every room get light from two sides, buildings will have to be much thinner; and they will need much more wall surface per unit area.

It is clear that many current building systems do not allow this to happen. The most obvious examples are the large office and commercial buildings which have very large spans and minimum surface area per unit floor area. In such a building, only the spaces at the four corners of each floor can be lit from two sides (About 15% of the total interior space in a medium sized building). Even in tract home construction, the trend toward use of 25-30 foot wooden trusses leads to box-like plans in which a third of the spaces are lit from one side only.

Sheltering Roof (1972). This pattern sets forth the argument that man has a deep psychological need to feel the presence of a building's roof as a protective element. Specifically, it specifies that it must be possible to see the roof, to reach out and touch the overhanging eaves. In the case of flat roofs, the users should be able to walk out onto it and use it as a balcony, walkway, porch, or garden.[8)9)] The roof's presence must be felt throughout the entire building - on the ground floor one can see the eaves serving as the windows' and porches' "eyebrows," while in the attic the whole form of the room takes the shape of the roof overhead and dormer windows stick out beyond the roof line.

Most current building systems ignore this need. Big office buildings hardly ever step back from floor to floor to allow contact with the roof surfaces. In conventional house building the pitch of the roof has either disappeared altogether (with no compensating use of the flat roof), or been given a shallow token slope with eaves that are far too high to touch.

Alcoves. A series of patterns deal with the need for various types of alcoves - small intimate spaces which open into larger, more public spaces. For example, the pattern "Family Room Alcoves" (1968) discusses the conflict that exists between the desire for a family to remain in close contact and the individual members' desires to carry on separate activities during the evening hours. The pattern specifies low-ceilinged alcoves around the family room, with partial views between them, each being between one and two meters deep. Other patterns which call for alcoves are "Window Place" (1972), "Master Bedroom Alcoves" (1969), "Corridors Which Live" (1970), "Activity Pockets" (1968), and "Reception Alcoves" 1969).

Since alcoves are typically at the outside edges of larger spaces, it is often the outside wall of the building which has to form them. This puts considerable demand upon the building system. Curtain-walls don't allow it. Most pure wall-bearing structures (like concrete block) don't either, since wall crenelations on the upper storeys would have to be carried straight down, putting too much constraint on the lower floor plans.

Columns at the Corners of Social Spaces (1971). Social spaces range all the way from nooks and alcoves (around 15 square feet), up to large meeting rooms (10,000 square feet or larger). In traditional systems, each one of these spaces was defined by structural members, and we believe that this connection between space and structure fills crucial psychological needs.

Yet many modern systems make this either impossible or structurally superfluous and irrelevant. For example, most modular systems (and all fixed-span modular systems) are incapable of allowing the structure to follow the social spaces. The same goes for typical concrete column-and-slab and steel frame construction.

Thick Walls (1967). This pattern discusses the problems caused by hard, smooth wall surfaces that are difficult to personalize, and specifies that wall surfaces need to be "thick" and "carvable" so that as time goes on each wall will begin to receive shelves, niches, and nooks according to the users' needs. The thickness of the walls is needed too, for sound and heat insulation, for storage space, as well as providing subtle transitions between one space and another as one passes through the thickness of the separating wall.

But current building practice treats the wall as a skin whose main function is to seal the inside from the outside. Again, curtain-walls are obvious offenders. Stud walls and concrete block walls are hardly better - the first because of its thinness and the second because of its hardness. The new use of wood panel systems for home construction is completely incompatible with this need for thick walls. So are the molded plastic and dome technologies. And imagine the fate of the poor man who tries to hang up a picture in a pneumatic house!

Ceiling Height Variety (1968). Every social situation has an appropriate ceiling height. If the ceiling height is wrong, the situation gets disturbed. Roughly speaking, the ceiling height over a given social group should be proportional to the horizontal diameter of the social group.

Many traditional building systems had this pattern in them. Vaulted systems had it, for example, since the height of a vault is proportional to its span. Trussed systems also had this feature (when no ceiling was superimposed) since the depth of the truss varied with the span. But modern concrete slab buildings have a uniform floor-to-floor depth regardless of the social spaces within them. In these buildings, it is only possible to get the pattern by suspending ceilings at different heights; and this violates the psychological need for structure and social spaces to be congruent. The same trouble occurs in houses, when uniform long-span timber trusses span all the way across the house, and interior spaces are formed by partitions.

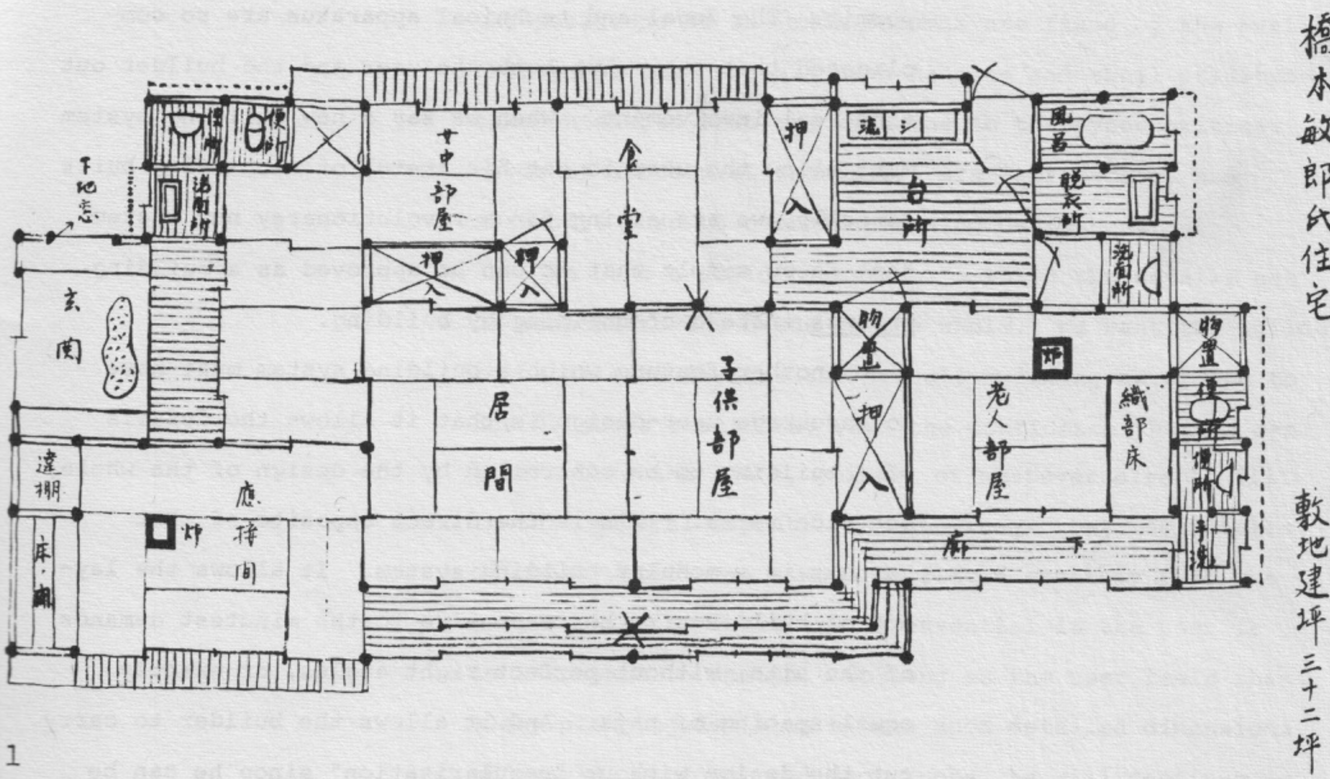
This small number of examples should show that patterns often have profound implications for the choice of a building system. We have found that no existing building system is compatible with the patterns we know to be important.

We turn next to the kinds of requirements that must be put on a building system to enable users to design their own buildings.

## 2. Compatibility with user design.

The main feature which a building system must have, to allow user-design, is an explicit, conceptually simple set of rules which tell a person exactly how to turn a schematic sketch into a functional working drawing. We say "functional" since we do not mean an elaborate conventional working drawing, but any drawing which the builder can build from.

This was commonplace in the traditional Japanese house design process. The family fixed the arrangement of rooms which they wanted. Only three additional rules were then needed, to turn the room plan into a working drawing.[10] Such a drawing is shown below (Fig. 1).




1

There is no need for an architect in such a building process since the user-designer can specify all the relevant details that the builder needs. And since the functional working drawing he makes is far less detailed than today's typical working drawings, the builder will be able to express his own creative capacities as he carries the plan through to completion. He will determine the exact sizes of structural members, grades of materials, and levels of workmanship. Just as user-design gives more wholesome and fitting plans, so true builder-participation will stimulate the builder to the same levels of responsibility and expressive power which were common in traditional societies.

Current building practice doesn't normally allow the user to make a simple drawing and have it built directly, because buildings are too complicated. Governments take on the responsibility for judging the worthiness of designs before construction, and this means that drawings showing every detail must be submitted for a building permit. The legal and technical apparatus are so complicated that they shut both the user and the builder out from real involvement. When we say a new building system must allow the user to get his sketch of a building built directly, we are asking for a revolutionary new system that is so simple that it can be approved as a building <u>process</u> instead of building by building.

Another feature which a building system must have to encourage user-design is that it allows the details of a building to be controlled by the design of the whole, not vice versa. This is the direct opposite of what happens in a modular building system. It allows the layout of buildings to be responsive to the minutest demands of the site, without perfect right angles, or exactly equal spacing of bays. And it allows the builder to carry out the design without "regularization" since he can be confident that the details can be fitted into the larger decisions about entrances, room corners, and so on.

The straight-jacket of modularization can perhaps be made more clear by analogy with painting or biology. In a painting, for example, the life of the whole stems directly from the fact that the thousands of daubs of different color, size, and shape are all laid down in response to the overall image as it develops. In the growth of an organism, each tiny cell takes on a form that is subject to the overall form of the surrounding cells. This is the source of "aliveness" in organic forms. If all the cells were exactly alike it would be impossible for the organism to be alive; the same goes for a painting.

Very few of our current building systems allow for the details to be executed in response to higher order actions. In any strict modular system, the global design is fixed by the conditions which the details impose on it. The overall shape of a geodesic dome does not come from the site and the client but from the system of struts and connectors. In a curtain-wall office building, the positions of the main columns are fixed by the available panel dimensions. Even tension and shell structures take on shapes that are more due to the hyper-critical needs of structural integrity, pre-fabrication, and assembly, than to overall planning decisions.

We seek a building system in which the details can be adapted to the needs of the whole. We want the builder to be able to lay out the overall building according to the client's instincts, with the confidence that he can later place the 2X4's, joists, or whatever else to fill in this general layout. The knowledge that the details of construction can always be fitted smoothly into the larger planning decisions is essential if the user is to take part in design. So long as the user feels that every planning decision hinges upon detailed dimensions of panels, windows, and door knobs, he will continue to rely upon professional designers.

Another point. Some users will want to help in the actual work of building, and many of them will want to repair their buildings after they move in. It will be best then, if the building system allows the user many different degrees of participation. A few will build for themselves; more will contract out the difficult initial stages and finish the building themselves; others will help the contractor all the way along; many will want to supervise the initial layout phase; most will do repair and modification work themselves.

This range of participation implies that the construction process must be radically simplified, to include more non- and low-skilled labor. Carpentry and bricklaying, for example, require labor from highly skilled trades, and are thus beyond the average user's capacity. The same is true of concrete formwork and steel welding. The building system we seek will allow low-skilled, machine-intensive participation in about the same way that a rented chain-saw lets an average suburbanite cut a year's firewood in a day.

Another question concerns level of finish. Available building technologies demand hi-skilled labor even to obtain a moderate level of good workmanship. Formica work, cabinetry, and drywalling simply cannot be done by low-skilled users without the result looking very amateurish. If users are to take part in the building process itself, it is crucial that the building system be capable of wearing different levels of finish with equal dignity. For example, traditional Japanese mud-and-wattle wall panels could be left in their raw and rustic initial form, could be roughly leveled, or could be further refined to create a perfectly plane and uniform surface. Each level of finish had its own character and integrity. Contrast this kind of option with today's emphasis upon "optional parts." One is an optional <u>process</u> - the other an optional <u>product</u>.

User-design would also be encouraged if the design process were more integral with the construction process. In today's building systems, the spaces only appear when the building is finished. Concrete column and slab construction is one of the best examples. The spaces don't appear until the very <u>end</u> of the building process, when the non-structural interior and exterior panels are put in place. But user-design is much easier when the spaces <u>precede</u> the structure in the building process. This means that the user can make a full-scale mock-up towards the end of his design process; and then use the mock-up as the beginning of the actual construction.

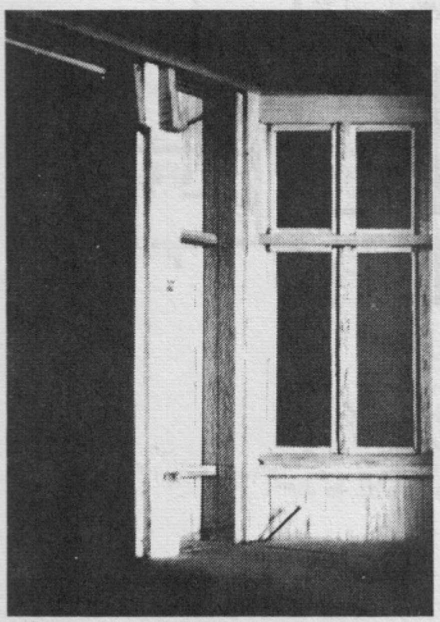
The need for full-scale mock-ups is not a crutch for the lay designer. In some European cities, for example, builders are required to erect full-scale bamboo framework mock-ups of projected office buildings so that the townspeople can see their impact on the city, before the building itself has gone too far. We have found, over and over again, that people cannot visualize spaces accurately unless they put up some sort of rudimentary structure - bamboos, sheets, string, or 2X4's as a mock-up. If the nature of the building system somehow lends itself to this kind of mock-up, so much the better.

We have discussed some of the requirements which a building system must meet if it is going to allow users to design their own buildings. But can laymen actually use a pattern language with construction patterns to design their own buildings? Our preliminary experiments suggest that it is feasible, and that it does create the organic architecture we are looking for.

For the sake of experiment, we developed a post-and-beam system, abstracted the rules which governed its use, and introduced these rules into the pattern language in the form of five construction patterns. We found that laymen could indeed use this language to produce a functional "working drawing."

In this experiment we were more interested in testing the capability of lay designers than in proposing a final building system. Yet, the simple wood post-and-beam building system we used includes many of the principles we have discussed in this paper. The usual post-and-beam system was modified to eliminate the need for modularity, and to make spaces appear at the very beginning of construction. It was designed so that Thick Walls, Columns at the Corners, and Low Ceilings were generated automatically. Other patterns like Family Room Alcoves, Window Place, and Sheltering Roof became cheap and easy to build.

Below we show a picture of a model built with this system and some examples of house designs done by laymen using the pattern language (Figs. 2 - 6). Having seen that laymen can, in fact, use a pattern language to produce functional working drawings, we now turn to the third and final group of demands which we are putting on the building system we seek.



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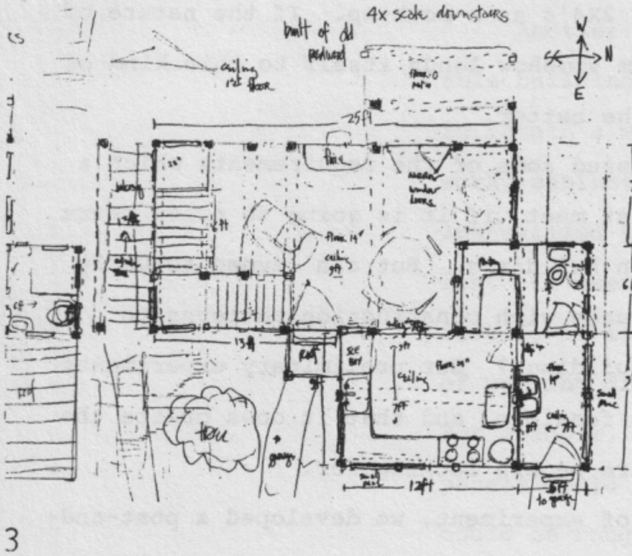
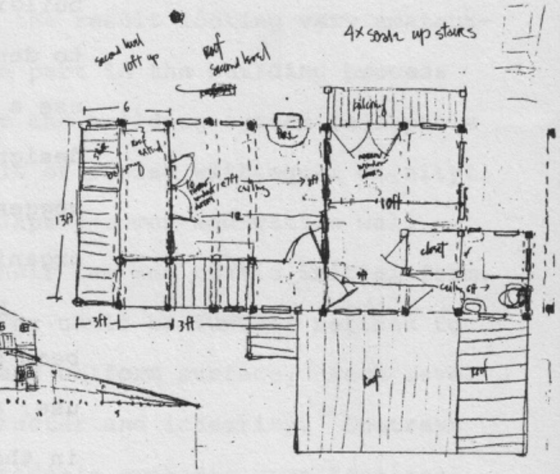
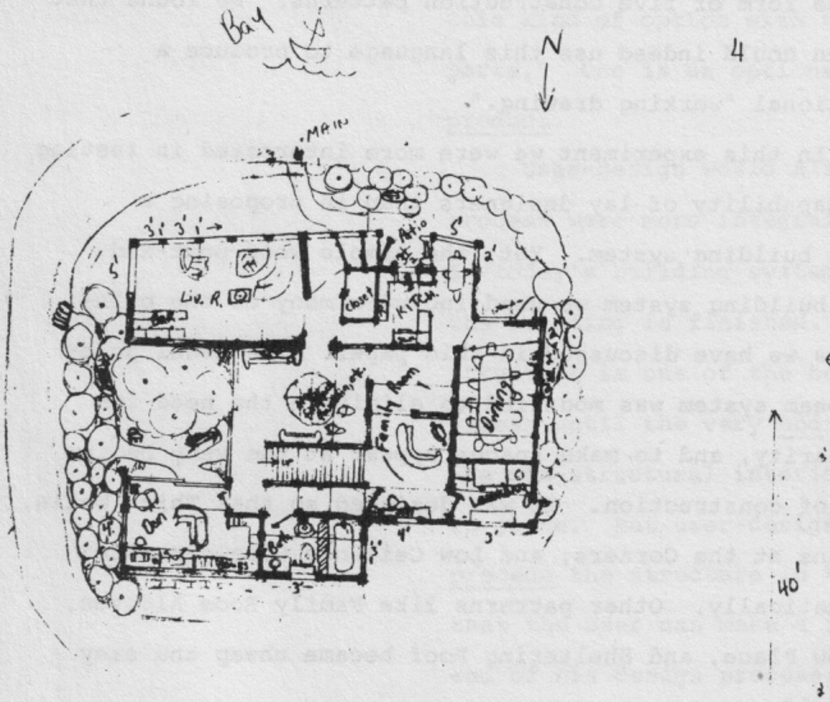

4x scale downstairs
built of old redwood
25ft
13ft
12ft
garage

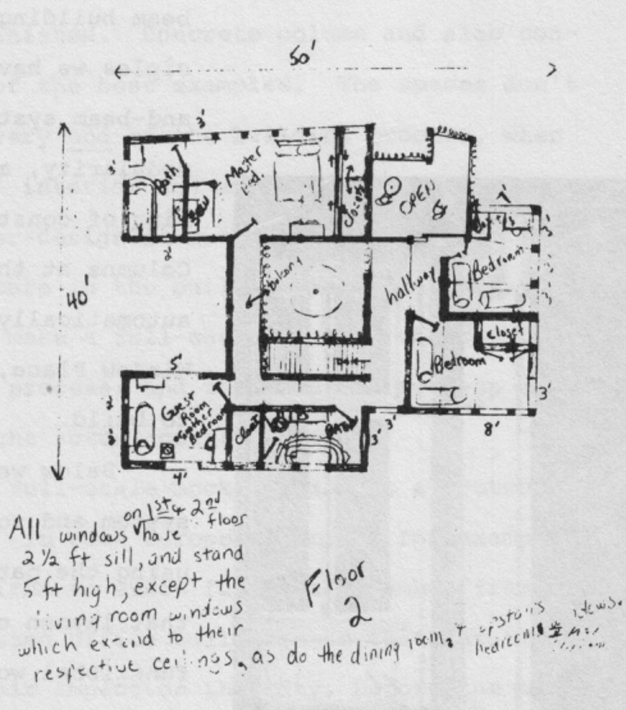
3


4x scale up stairs
second level loft up
Roof second level
closet

4


Bay
N
Liv. R.
Patio
Closet
Kitch
Family Room
Dining
Den
Floor 1

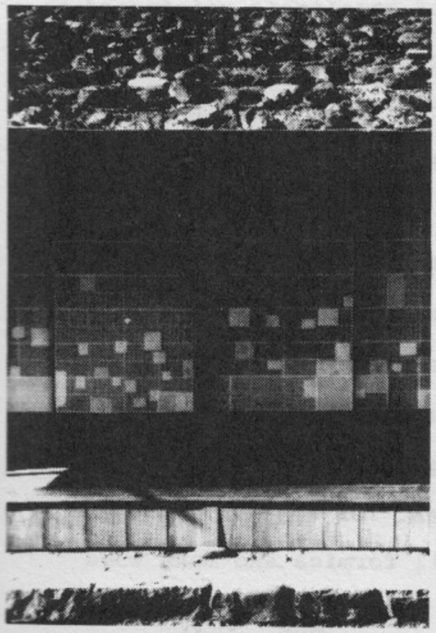
5


50'
40'
Bath
Master Bed.
OPEN
hallway
Bedroom
closet
Bedroom
8'
Floor 2
All windows on 1st & 2nd floor have 2 1/2 ft sill, and stand 5 ft high, except the living room windows which extend to their respective ceilings, as do the dining room, & upstairs bedroom windows.

6

## 3. Compatibility with repair and piecemeal growth.

A building cannot be organic or alive unless it is built gradually and repaired constantly during its lifetime.



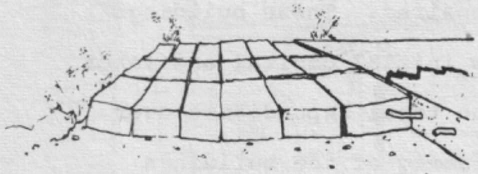
7

It is useful to remember that traditional buildings last for centuries not because they are so sound, but because they are continually repaired. These buildings are built with a relatively low initial capital and labor investment - low relative to the total expenditure over their lifetime. The physical fabric of the buildings disintegrates slowly all the time and is constantly being countered by the users' reconstruction and repair (Fig. 7). And this never-ending dialogue between growth and decay means that the actual form of an individual building keeps changing over time and becomes more and more finely adapted to the particulars of the site and to the users' needs.

In contrast, current building technology is based on the notion that participation in the natural process is to be avoided at all costs. Buildings are either designed to last only a few years with the idea that they can be torn down then; or they are designed to last forever, and made of materials which never have to be repaired. In the first case (ticky-tack construction) the buildings decay too rapidly via normal use to be repaired. In the latter case (concrete and steel) the buildings are made of such terribly hard, permanent, and monolithic materials that slow modification is again out of the question. In both cases the outward forms are rigidly immutable, and never have a chance to get better, or more subtly adapted to peoples' needs.

In both cases, living and working in buildings are seen as destructive activities - buildings are only thought good when they are new, fresh out of their wrapper. It is all part of the consumption society. Buy it new, sell it or throw it away the moment it is used. <u>The environment cannot become healthy, or alive, until we begin to conceive the process of using a building as a creative, reparative activity</u>.

If our buildings are made of monolithic reinforced concrete then repair and modification are out of the question. Yet when the same material is used in the form of human-scaled bricks or blocks, repair can happen. Would you rather repair a patio made of individual bricks, or one made of a continuous sheet of concrete? (Fig. 8)



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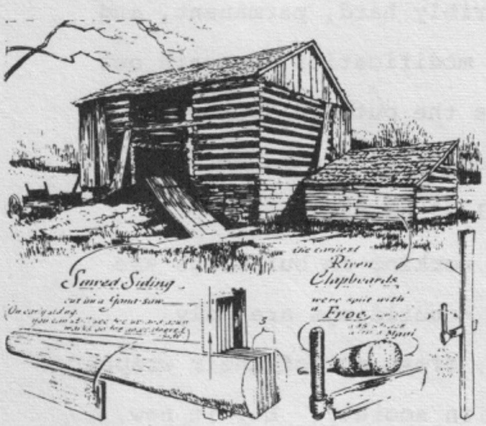
One objective question to ask of any building system is "Do the normal everyday marks of use spoil it or give it a <u>patina</u>?" Compare plate glass and leaded windows. A crack ruins a large sheet of glass; a new pane enriches a window made of many small panes. Or compare formica and wood table tops. Burns spoil formica and make wood more beautiful.

The fact that so many of our modern materials tend to be spoiled by use, instead of taking on a patina, is caused by our tendency to "technologize" our building materials, i.e., to create materials which do a very good job of solving a very narrow range of problems. While natural materials possess a wide range of moderately adequate properties, technology is used to create materials with superior properties, but in a very narrow range. Thus, formica is superior only in terms of "wipeability," and this is obtained at the expense of many many other useful characteristics.

The tendency for modern materials to be spoiled easily is made worse by the fact that the materials are not allowed to speak their own language. Compare the processes of making wood shingles with a froe, and with a saw. The froe chips away shingles. The chipped shingle is as good as a sawn shingle, yet the role of the machining is kept to its bare minimum (Fig. 9).

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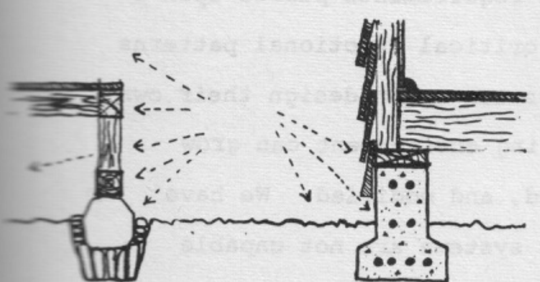
We see then that one of the most obnoxious qualities of our present building technology is its demand for an almost neurotic level of non-productive perfection. We have recently heard that the frieze-work of Greek temples was designed so that the natural accumulation of dirt would fall in the shadows, accentuating the relief rather than defacing it.

The environment will not be continually repaired by the users unless it is transparent, an observation first made by Paul Goodman.[11)] This means that when a man looks carefully at a building, he can understand precisely how to reproduce it somewhere else. Compare stud construction with post-and-beam construction on this score. It is virtually impossible to understand stud construction without taking the building apart destructively. But post-and-beam is completely clear and "transparent," even to a casual observer. A Canadian student at the Center once remarked that in all the really good buildings he could think of, one could look at the foundation and know how to complete the building (Fig. 10). It is obviously impossible for users to repair their own buildings unless they are transparent in this sense.



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Finally, ongoing repair will be impossible unless the components of the building system are easy to handle. We must be careful not to propose building systems which depend upon super-human machines like cranes and bulldozers (which most current building technologies rely upon). They require highly-skilled labor to operate, and are so expensive that they make user-repair and modification almost impossible.

To begin thinking of the entire construction process as repair, requires reorientation of our current ideas about the economics of construction. The idea of continual repair and piecemeal growth clearly implies much smaller chunks of building at one time. At first glance, this might seem to fly in the face of well-established economics of scale. Yet we recently learned that, in Sweden at least, the cost of administration represents fully two thirds of the building costs in a house, because of the very large size of the firms which build the homes. Large organizations make things in the total more expensive, not cheaper.

And we suggest reconsidering the bald assumption that buildings should be as cheap as possible. If the users are continually involved in the creative repair of their buildings, then the buildings' final monetary value in terms of materials and labor may be enormous. We need a building system which enables generations of users to create a very expensive building indeed, over a very long period. This in turn means that we need new methods of financing which replace lump sum loans by incremental loans.

## 4. Specifications For an Organic and Human Building System.

We have now discussed the requirements placed upon a building system in order that critical functional patterns can be realized, that the users can again design their own buildings, and that the resulting environment can grow slowly, be continually repaired, and modified. We have seen that our present building systems are not capable of meeting these requirements. We now summarize our discussion, with a list of specifications that any new building system must meet in order to produce an organic and human environment.

Pattern language.

1. It must be possible to build narrow buildings, with a high wall to area ratio, so that rooms can all have daylight on two sides. (Light on two sides)

2. It must be easy to build steeply pitched roofs, with dormer windows and roof gardens set into them, without expensive flashings. (Sheltering roof)

3. Ceiling heights must be able to vary throughout the building, in a way which is integral with the structure, not "fake." (Ceiling height variety)

4. It must be easy to form alcoves at the edge of larger spaces, again in a way that is integral with the structure. (Alcoves)

5. Structural columns must occur at the corners of all social spaces. (Columns at the corners)

6. Walls must be thick and "carvable" to let people make them "their own." (Thick walls)

User-Design.

7. It must be possible to derive an explicit, conceptually simple set of rules which tell how to turn a schematic design into a functional working drawing.

8. More expressive control must be handed over to the builder, so that he takes creative charge of details, and doesn't simply work like an automaton, from machine-like drawings.

9. The building process must be so simple and reliable that it can be approved as a process by Local authorities, so that detailed drawings of individual buildings no longer need to be submitted for approval.

10. At each stage of the building process it must be possible to place and shape structural elements in response to the positions of those larger elements which have already been put in place.

11. The user must be able to take part designing the building to any extent he wants: helping to build it, helping to finish it, taking full responsibility for building it, or repairing it occasionally.

12. The process must require a minimum amount of hi-skilled labor.

13. The building system must be able to wear different levels of finish with equal dignity.

14. It must be possible to build full-scale mock-ups in the last phase of design, and then possible for them to become part of the building's final fabric.

Repair and piecemeal growth.

15. All building elements are light enough to be carried by one or two men, without help.

16. Building elements are not blemished by use, but take on a patina instead.

17. The fabric of the building is structurally redundant so that parts can be added and taken away without endangering its stability.

18. Materials must display their own color and texture, and machining kept to a minimum.

19. The building must be transparent, in the sense that anyone who looks at it can see at once how it is made.

20. The building process must not rely on the use of complex or expensive machines on site.

21. The building process must not require a large managerial and technological organization.

22. Budget and financing must provide for long-term piecemeal construction and repair of buildings, not merely for an initial capital budget.

A tree grows under the dual influence of inner generic patterns and external particulars, and by continuous growth and repair. That is what we mean by organic growth. A building process which will allow towns and buildings to grow organically in the same way as the tree, must at least meet these 22 specifications - and probably many others too.

Max Jacobson is a researcher at the Center for Environmental Structure in Berkeley, California

Christopher Alexander is the founder of the Center for Environmental Structure in Berkeley, California

## Footnotes

1) Barker, R.C., Ecological Psychology: Stanford University Press, 1968. Barker introduced the term "behavior setting" for such a system.

2) Alexander's forthcoming book The Timeless Way of Building (in press).

3) Jacobson, et al. Center For Environmental Structure, "A New Method For Assessing the Health of Environmental Settings," paper in preparation.

4) Center For Environmental Structure, A Pattern Language - First Edition: to be published by Harvard University Press in December, 1972.

5) Alexander, op. cit.

6) The idea of repair and piecemeal growth is discussed both in Alexander's book and in A Planning Process for the University of Oregon, C.E.S., (in press).

7) This pattern, along with all the others that are mentioned in this paper will be included in A Pattern Language. The dates in parentheses refer to the writing date of the individual pattern.

8) "Building Stepped Back" (1968) also discusses this use of flat roofs.

9) Rand, G., "Children's Images of Houses," in Env. Des.: Research and Practice, Proc. of EDRA 3/AR 8, U. of Calif., L. A., January, 1972. Rand shows that the roof is a primal element of the archtypal house, even for children raised in hi-rise apartments.

10) Engle, H., The Japanese House, Chas. E. Tuttle Co. Rutland, Vt., 1964.

11) Goodman, Paul and Percival, Communitas.

## Graphics

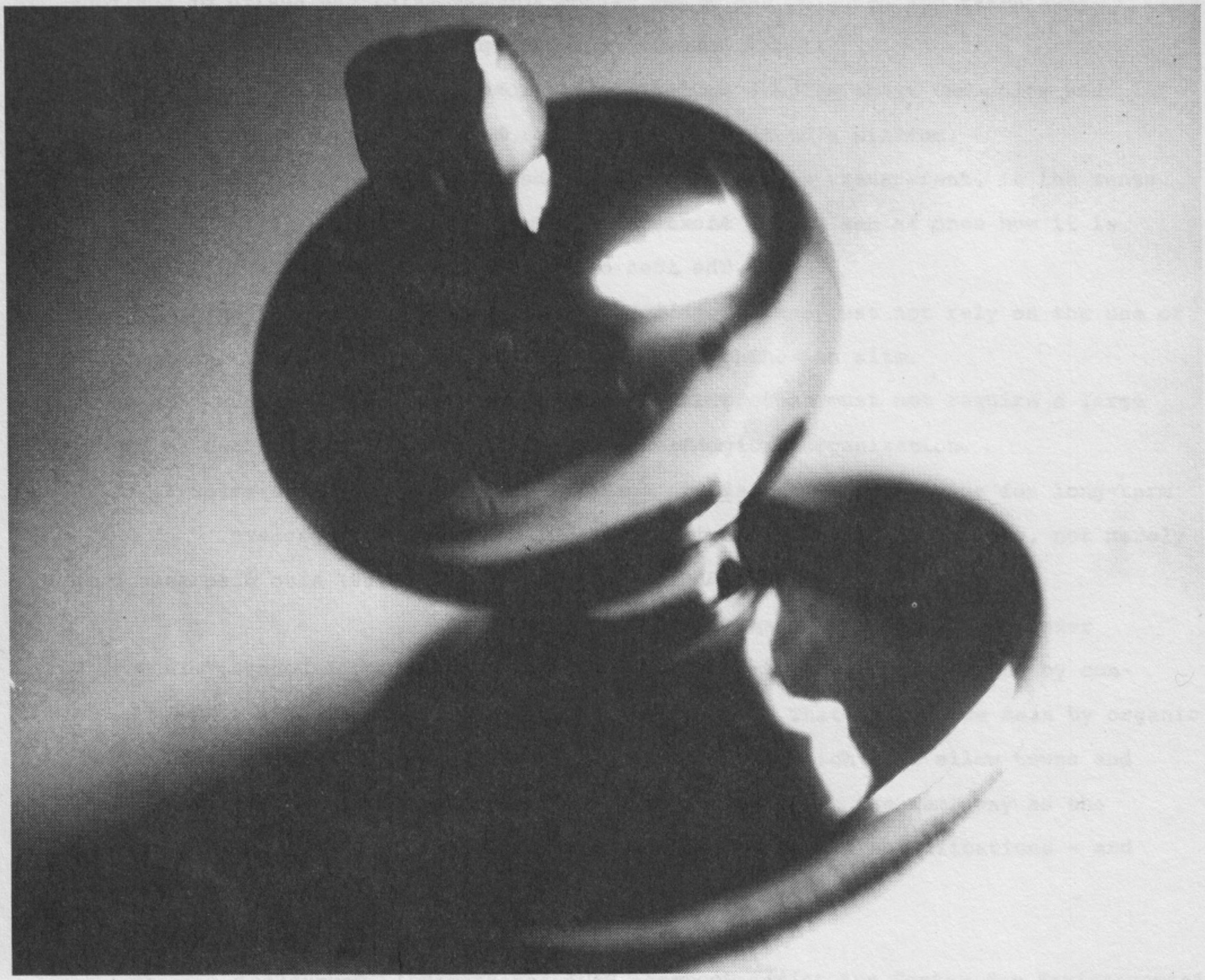

Engle, H., The Japanese House, Chas. Tuttle, Vermont, 1964.

Sloane, E., An Age of Barns, Funk and Wagnalls, N.Y., 1967.

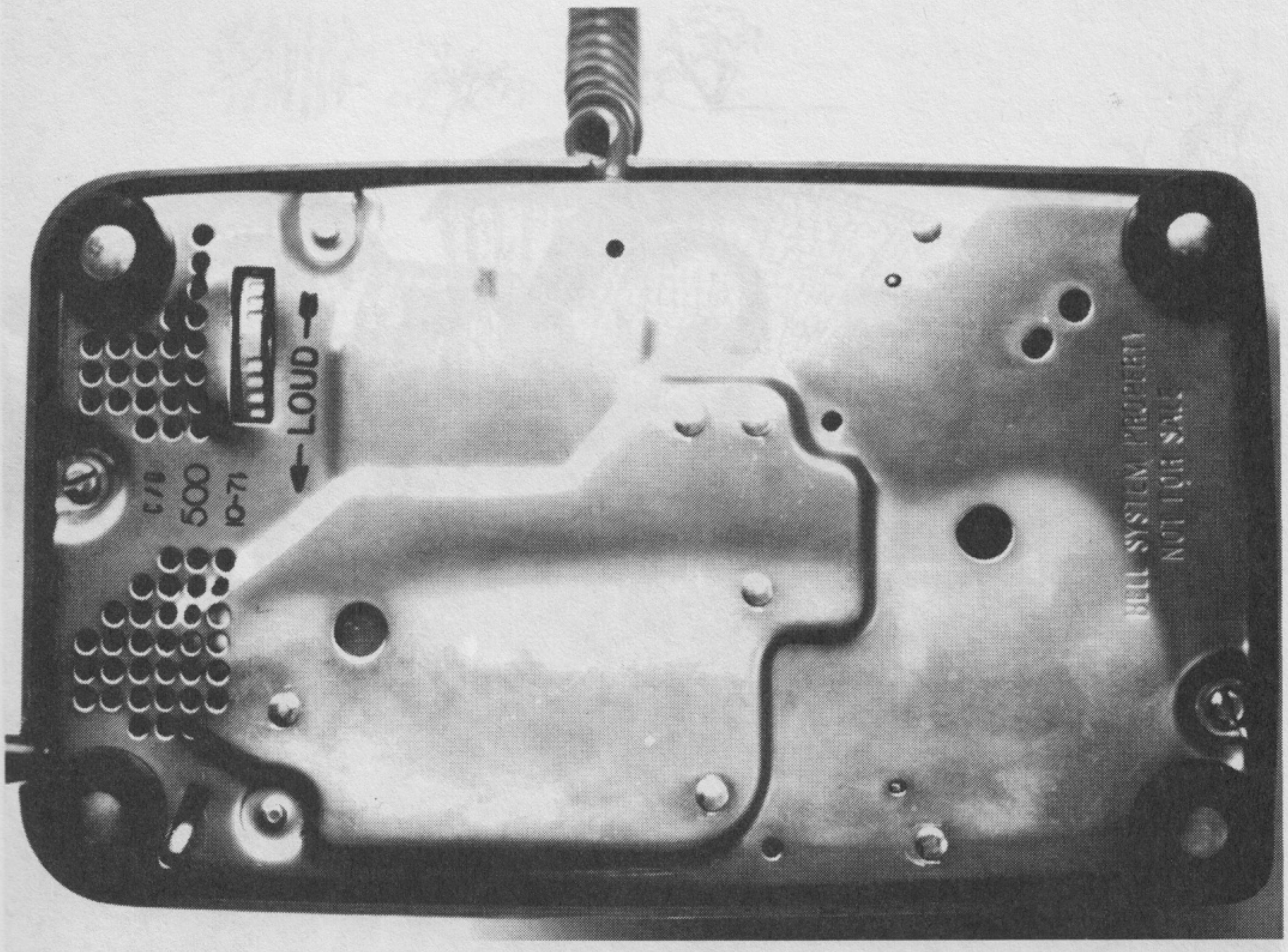
Shoemaker, A. L. (ed.), The Pennsylvania Barn, Penn. Folklore Society, no date.

Excerpts from Max Jacobson's oral presentation:

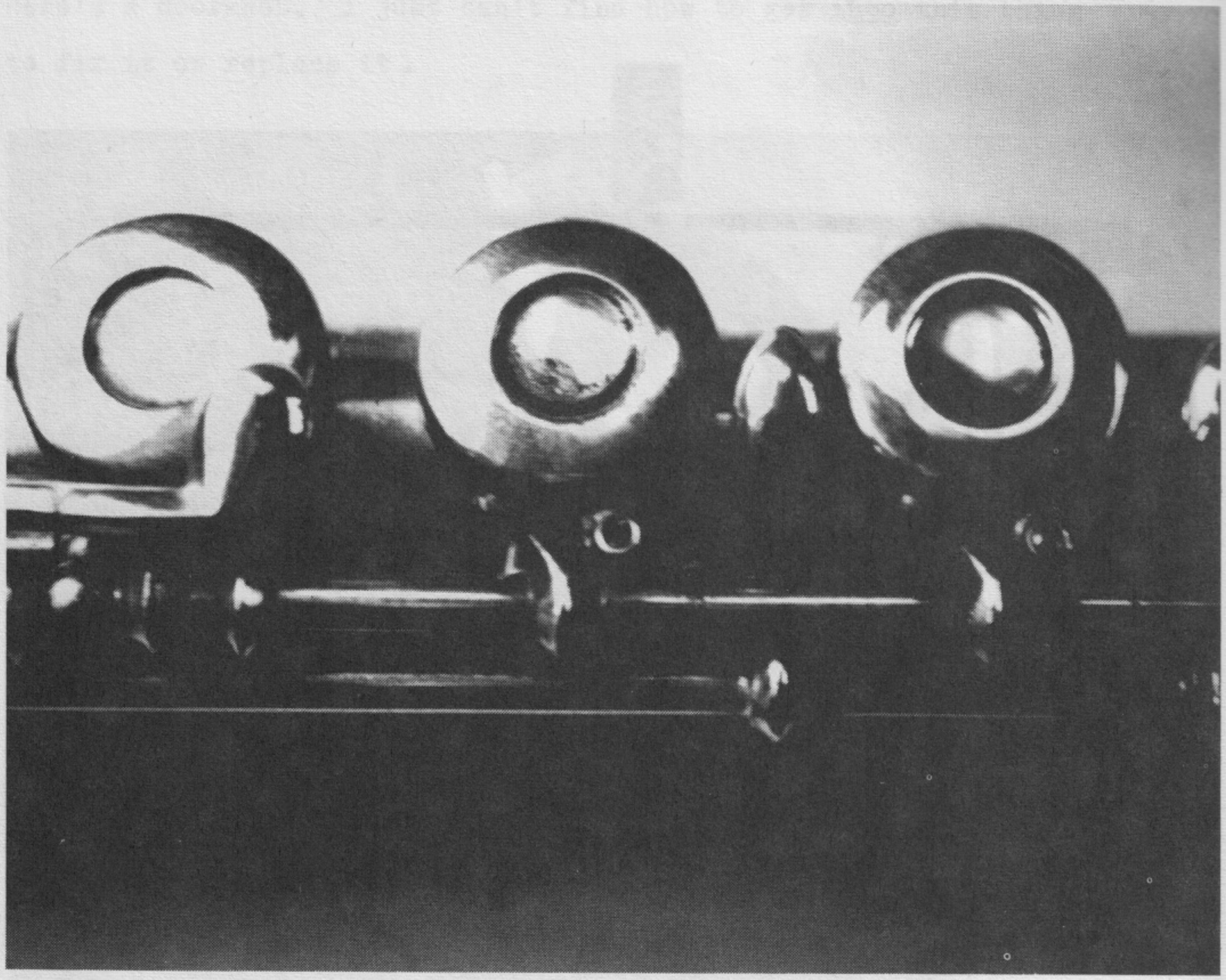
"I went around my house and took pictures of things I can't fix . . . Here's a doorknob. I just can't find how to get into this thing to fix it or replace it.



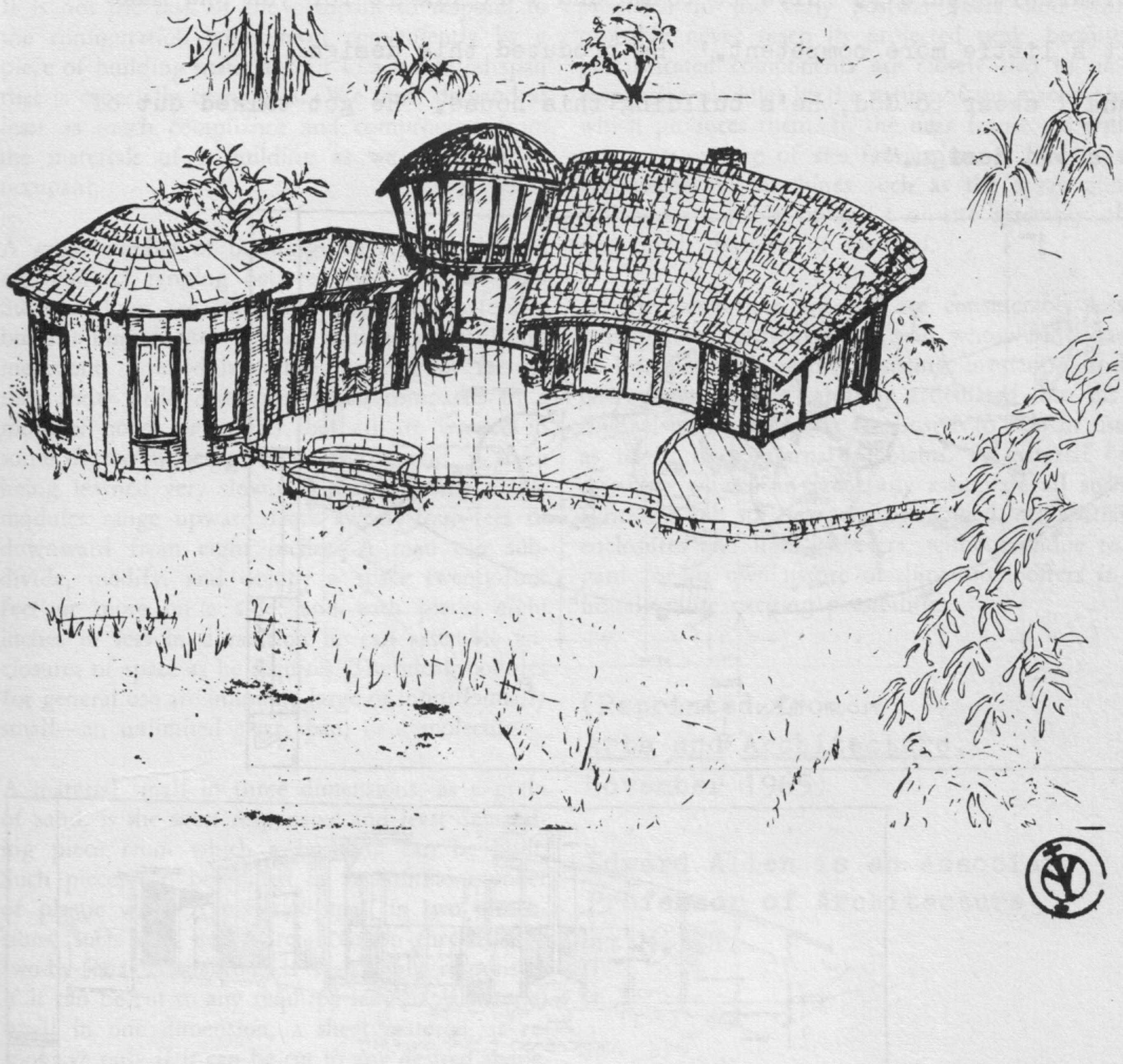
"I'd really like to get inside a telephone to see how it works. But when you turn it over, here's what it looks like. It's designed to be indestructible by the curious.



"Here's a complicated mechanical device--a flute--which is neverthe-less totally transparent and potentially repairable.



"This is a house design done by a fellow who's a carpenter, and he's a pretty competent person. He wanted to design a house for himself, so he did. He drew this in plan, and in perspective.



"He began to get just a little bit nervous about technical details, and he wanted some advice, so he went to an architect who looked at his design and said, 'Look, this is like the first quarter of Architecture 1. Give it to me and I'll fix it for you and make it a little more competent.' He produced this design, and I swear to God, he's building this house. He got talked out of his own design."