The language of the prairie: Frank Lloyd Wright's prairie houses

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Abstract. The following parametric shape grammar generates the compositional forms and specifies the function zones of Frank Lloyd Wright's prairie-style houses. The establishment of a fireplace is the key to the definition of the prairie-style house. Around this fireplace, functionally distinguished Froebelean-type blocks are recursively added and interpenetrated to form the *basic compositions* from which elaborated prairie-style houses are derived.

The grammar is based on a corpus of eleven houses from the Winslow house, the evolutionary precursor of the style, to the Robie house, considered by many as the culmination of the style.

Much has been written about prairie-style houses—their balance, their debt to *Beaux Arts* and Japanese design traditions, and their *organic* qualities. However, such descriptions do not explicitly inform us as to how prairie-style houses are constructed, and consequently provide little help in designing new members of this style. The power of a grammar, such as the one given here, is that it establishes a recursive structure from which new designs can be constructed. Three new prairie houses generated by the grammar as well as a step-by-step generation of one of these designs are shown.

"Consistency in grammar is therefore the property—solely—of a well-developed artist-architect. Without that property of the artist-architect not much can be done about your abode as a work of Art. Grammar is no property for the usual owner or the occupant of the house. But the man who designs the house must, inevitably, speak a consistent thought-language in his design. It properly may be and should be a language of his own if appropriate. If he has no language, so no grammar, of his own, he must adopt one; he will speak some language or other whether he so chooses or not" (Wright, 1954, pages 182-183).

Introduction

The architecture of Frank Lloyd Wright's prairie-style houses has long been considered mysterious and difficult to decipher, largely because of a misfocusing of attention. Some commentators have been sidetracked by the richness of the decoration and the materials in these designs, and consequently have underestimated or even ignored the importance of their underlying spatial composition; others such as Hitchcock (1942) and Giedion (1967), although showing a perceptive verbal insight into the spatial organization and massing of the prairie-style houses, have no formal, visual methodology for analyzing these designs in detail. Architectural historians have typically been more interested in tracing sources of influence and technological advances in building construction than in uncovering and elucidating the compositional structure of designs. Thus, even though it is widely accepted that it is the spatial composition of the prairie-style houses that most distinguishes them from other contemporary designs, there has been little rigorous investigation in the past seventy years on how this spatial composition works.

MacCormac (1974) was right in the idea that there is a consistent underlying structure informing Wright's work. Like Manson (1958), he recognizes a Froebelean influence on the architectural organization of the prairie-style houses. However, MacCormac's idea of simply concatenating Froebelean-type building blocks only as a means to describe the componental features (pillars, walled spaces, and so on) of

prairie-style houses—sometimes as solids and sometimes as voids—underestimates the spatial consistency of these designs. Further, MacCormac's analysis is paralyzed by acknowledging 'order' only in the identification of proportionally equivalent Froebelean units, as if order must in some way be tied up with measurable geometry rather than in recurrent spatial relationships. This is a trap that influential historians such as Giedion (1967) have also fallen into—perceiving order only in grids and proportions and not seeing that *organic* architecture like Wright's prairie-style houses has a consistent, rational underlying organization of a deeper, more fundamental kind.

In this paper, we show that the composition of Wright's prairie-style houses is based on a few simple spatial relations (Stiny, 1980b) between parameterized three-dimensional building blocks of the Froebelean type. These spatial relations provide the basis for a *parametric shape grammar* (Stiny, 1980a) that defines a language of prairie-style houses with hipped roofs. Designs in this language consist of arrangements of blocks to which porches, terraces, and other ornamentations and articulations have been added.

The corpus of prairie-style houses

The parametric shape grammar for prairie-style houses developed below is based on a corpus of eleven of Wright's designs shown in figure 1. Designs in this corpus were chosen to cover a variety of plan types—single-storey, double-storey, double-height living spaces, and so on. An exterior view and the main and bedroom floor plans for each of these designs are given.

To facilitate the definition of the grammar, certain superficial details of the houses in the corpus are not considered. As a result of this 'defocusing' process, the block-like spatial structure of the houses in the corpus is brought into sharper relief. The designs derived in this way from the ones in figure 1 are used as the basis for the grammar; they are shown in figure 2.

In each design in figure 2, the fireplace and direction of the hearth are shown. The design is divided into *function zones* denoted by the tones in the drawings. These zones include a *living* area consisting of, for example, a living room, dining room, library, and entry and reception area; a *service* area consisting of kitchen, pantries, servants quarters, and main floor bedrooms; and a *bedroom* area consisting of upper-level bedrooms, bathrooms, and so on. Roofed porches, terraces, and balconies are also identified.

Each function zone corresponds to a block or arrangement of blocks which may or may not be ornamented by indented or cutoff corners. Such blocks and arrangements of blocks are easily identified as the spatial units of the designs.

Lines between different function zones correspond to walls in the designs. Lines within the living zone distinguish articulations of the space; in the houses in the corpus, they correspond to walls (rarely), screens, or changes in ceiling level. Lines within the service or bedroom zones approximate a simplified spatial organization reflecting the diminished importance of spatial articulation in these areas, as observed in the corpus examples.

In the houses of figure 1, basements appear to be simple downward projections of the main floor level; they are shown in the designs of figure 2 as attachments of this type below the main floor level. The Baker and Roberts houses do not have basements, but have instead so-called double-height living spaces in which main-floor living zone and upper-level bedroom-zone blocks are combined to make a single living-zone unit.

Stacking the layers of blocks described above and adding a simple hipped roof results in the external form sketches drawn below the designs of figure 2.

The composition of the designs drawn in figure 2 can readily be seen to be based substantially on Wright's (1953) own prescription for prairie-style houses. First, Wright identifies the fireplace as the logical center of the design:

"Instead of lean, brick chimneys, bristling up from steep roofs to hint at 'judgment' everywhere, I could see necessity for one only, a broad generous one, or at most, for two, these kept low down on gently sloping roofs or perhaps flat roofs. The big fireplace below, inside, became now a place for a real fire, justified the great size of this chimney outside. A real fireplace at that time was extraordinary. There were then 'mantels' instead. A mantel was a marble frame for a few coals or a piece of wooden furniture with tiles stuck in it and a 'grate', the whole set slam up against the wall. The 'mantel' was an insult to comfort, but the *integral* fireplace became an important part of the building itself in the houses I was allowed to build out there on the prairie. It refreshed me to see the fire burning deep in the masonry of the house itself" (Wright, 1953, pages 136–137).

Next, he outlines the functional organization of the lower floor and its requisite composition following from a simplification and consolidation of areas:

"So I declared the whole lower floor as one room, cutting off the kitchen as a laboratory, putting servants' sleeping and living quarters next to it, semi-detached, on the ground floor, screening various portions in the big room, for certain domestic purposes—like dining or reading, or receiving a formal caller. There were no plans like these in existence at the time and my clients were pushed toward these ideas as helpful to a solution of the vexed servant-problem. Scores of doors disappeared and no end of partition. They liked it, both clients and servants. The house became more free as "space" and more livable, too. Interior spaciousness began to dawn" (Wright, 1953, page 139).

Last, in Wright's discussion of the nature of organic architecture, three additional compositional ideas which apply to prairie-style designs are enumerated:

"First—To reduce the necessary parts of the house and the separate rooms to a minimum, and make all come together as enclosed space—...
Second—To associate the building as a whole with its site by extension and emphasis of planes parallel to the ground ...
Third—To eliminate the room as a box and the house as another ..."
(Wright, 1953, page 141).

The grammar now developed generates prairie-style houses as drawn in figure 2. In particular, block arrangements corresponding to the different levels and function zones in designs are constructed and then stacked to produce completed designs. In many ways, the grammar may be viewed as a formalization and elaboration of Wright's compositional principles for prairie-style houses as given above.

The grammar of the prairie

In this section, a parametric shape grammar that defines a language of designs such as those drawn in figure 2 is presented. Readers unfamiliar with the shape grammar formalism are referred to Stiny (1980a).

Preliminaries

The main vocabulary elements of the grammar are three-dimensional rectangular Froebel-like blocks that correspond to the volumetric spaces in prairie-style houses. As the dimensions of these spaces may vary from design to design, the blocks are parameterized as shown in figure 3. In particular, the height of blocks is fixed, but their length and width may vary as indicated. To simplify the presentation of the shape rule schemata in the grammar, explicit parameterization is omitted.
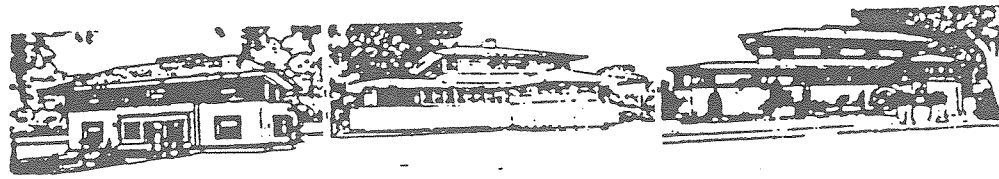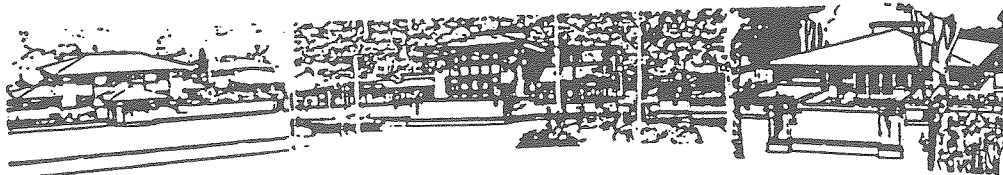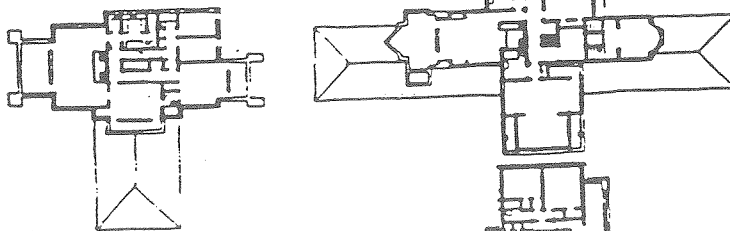
(a)
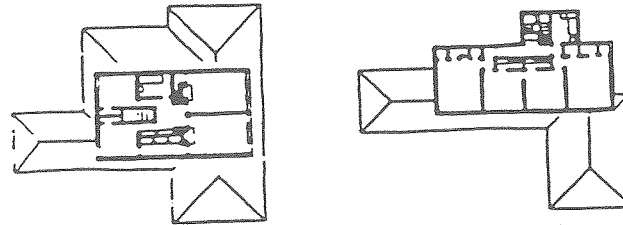
(b)
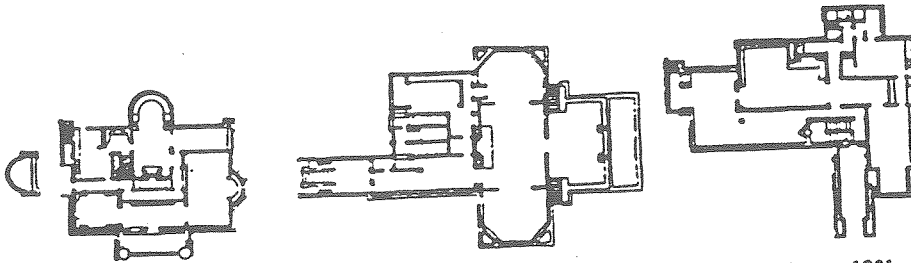
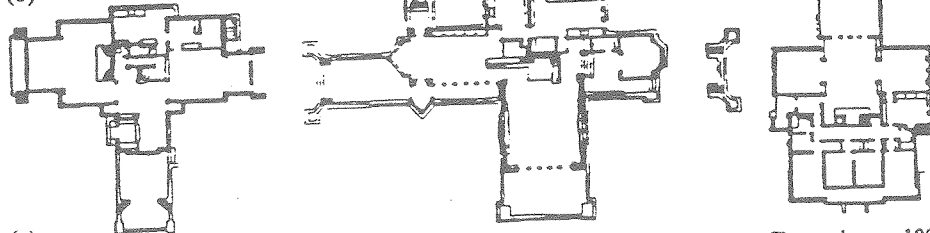(c)   Winslow house, 1898   Henderson house, 1901   Thomas house, 1901

(a)

(b)

(c)   Little house, 1902   Willets house, 1902   Cheney house, 1904

Figure 1. The corpus: eleven prairie-style houses designed by Frank Lloyd Wright; shown are
(a) exterior view (Baker house not available), (b) bedroom floor plan (Winslow house not available),
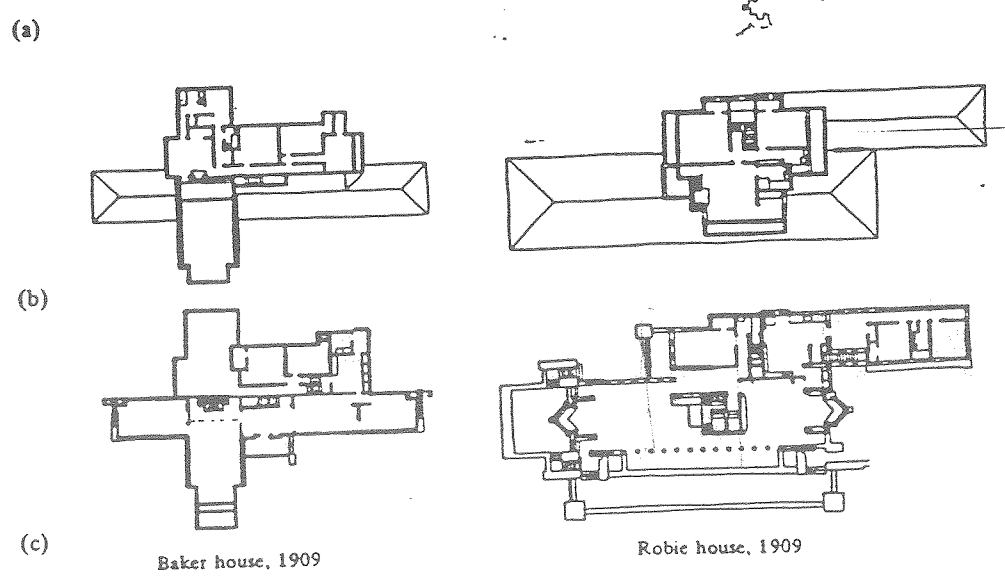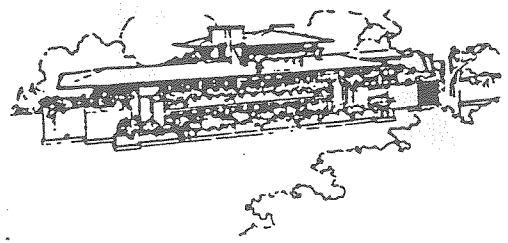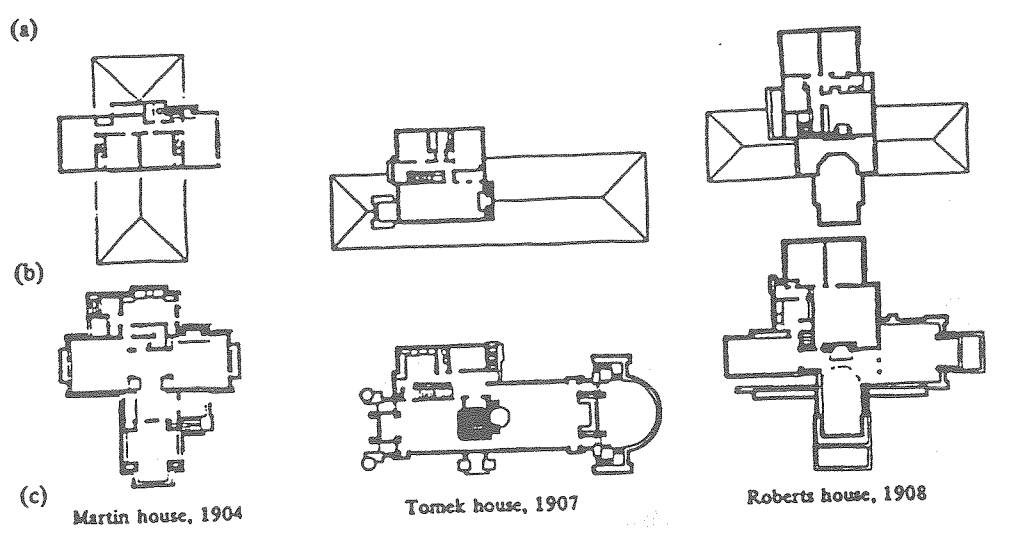(c) main floor plan (exterior views are from Wright, 1910).

(a)

(b)

(c)

| | | |
| Martin house, 1904 | Tomek house, 1907 | Roberts house, 1908 |

(a)

(b)

(c)

| | |
| Baker house, 1909 | Robie house, 1909 |

Figure 1 (continued)

(a)

(b)

(c)

Winslow house   Henderson house   Thomas house

(a)

(b)

(c)

Little house   Willets house   Cheney house
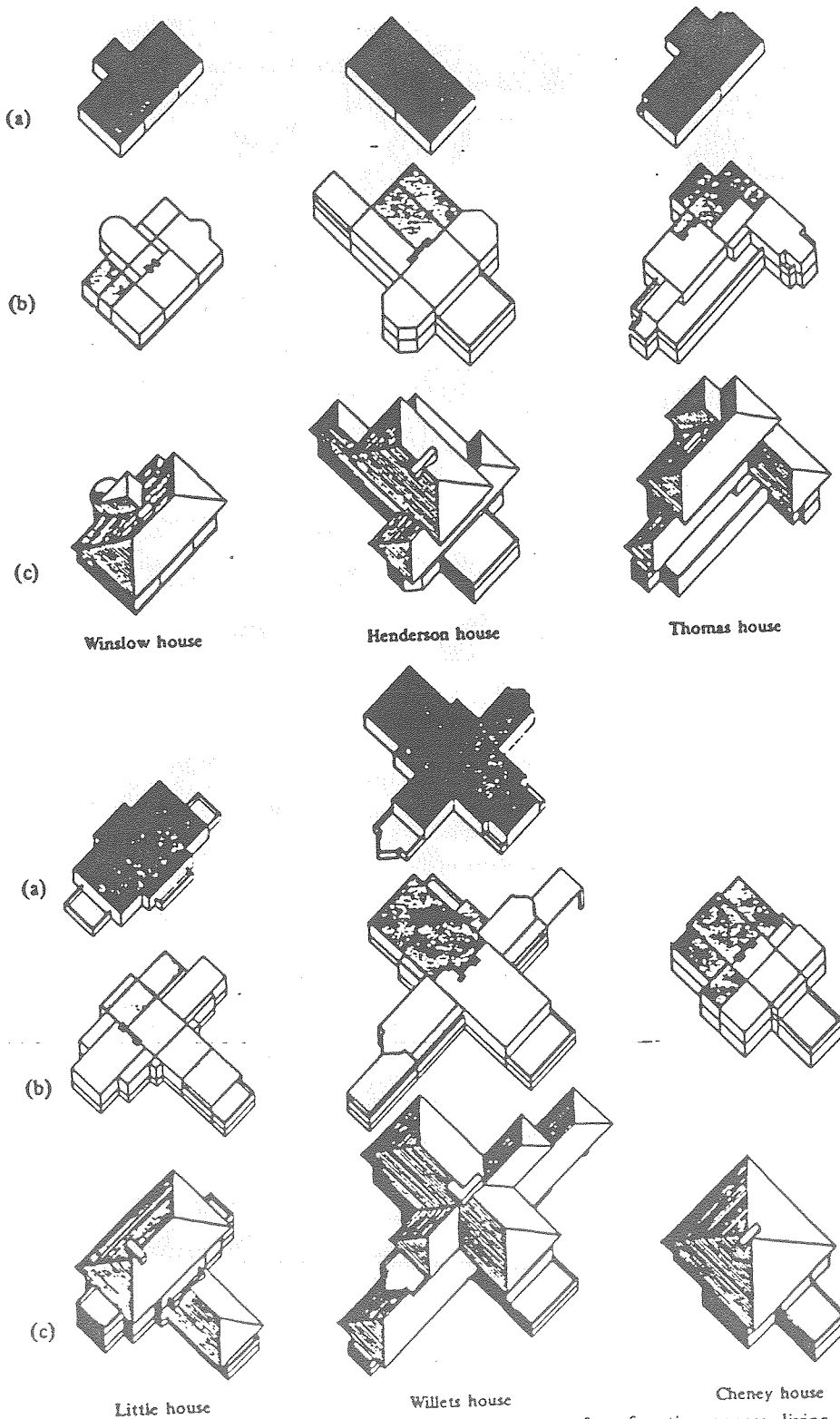
Figure 2. The houses of figure 1 defocused and reduced to four function zones: living   ,
service ▨ , porch   , bedroom ▨ . In (a), the bedroom level is shown; in (b) the main
floor level; and in (c) the external form.

Martin house   Tomek house   Roberts house

Baker house   Robie house
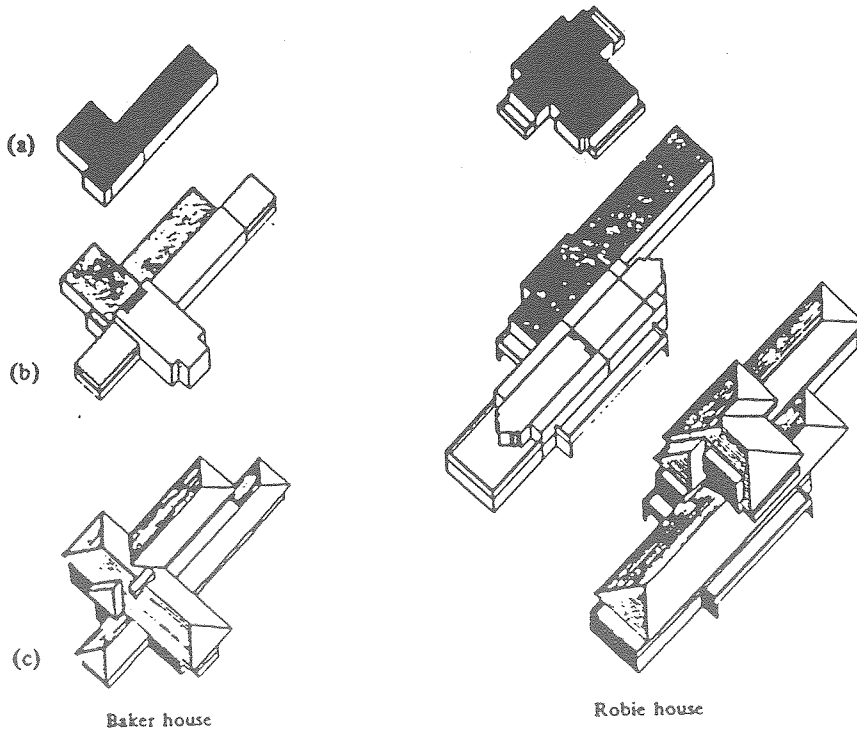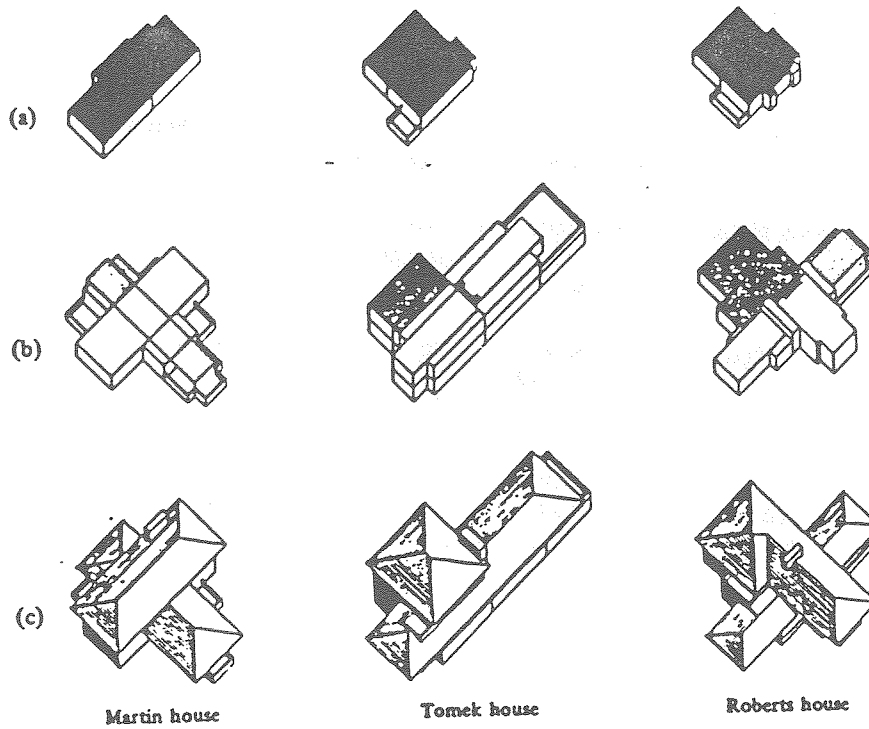
Figure 2 (continued)

Unless otherwise stated, variables in these schemata are understood to be essentially as given in figure 3.

It should be noted that hidden lines in blocks are not drawn so as to avoid Necker-like ambiguities. Thus, for example, the block comprised of twelve maximal lines drawn in figure 4(a) is represented as shown in figure 4(b). In those few cases where hidden lines are required for a complete specification of shape rule schemata, they are represented by dotted lines.

Following the conventions of figure 2, functional assignments to blocks are indicated by grey tones in shape rule schemata and designs. Such grey tones are treated as discrete symbols; each corresponds to a distinct symbol uniquely associated with a face of a block.

To show the perimeters of designs, that is, exterior walls, double-thick lines are used. Such lines correspond to labelled ones as indicated in figure 5.

All of the drawing conventions specified in this section are employed to simplify the presentation of the shape rule schemata in the grammar and the designs that they apply to generate. The schemata are of two kinds: the first apply to generate the underlying compositional forms of prairie-style houses; the second apply to ornament these compositional forms to produce completed prairie-style houses. In this sense, the grammar generates prairie-style houses to correspond to the analysis of the designs given in figure 2.
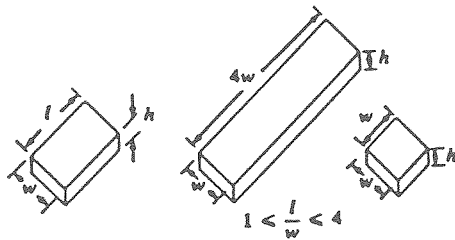
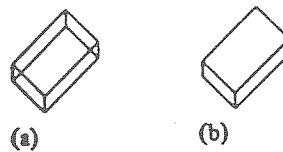Figure 3. Parameters for the main vocabulary element.

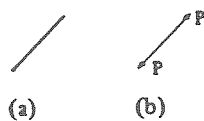Figure 4. Graphic conventions for hidden lines.

Figure 5. Graphic conventions for perimeter lines in designs: the double-thick line (a) corresponds to the labelled line (b).

Basic composition of prairie-style houses
In Wright's prairie-style houses, the fireplace is the logical center of the design. Around the fireplace, rooms radiate outwards toward the prairie. These simple conventions for design are encoded and elaborated in shape rule schemata 1–18 specified in figure 6. These schemata apply to generate the underlying compositional forms of prairie-style houses.

Schemata 1 and 2 apply to the initial shape of the grammar, consisting of the symbol * associated with the point (0, 0, 0), to establish a fireplace. Schema 1 produces a single-hearth fireplace, schema 2 a double-hearth one. Notice that schemata 1 and 2 can be used to locate a fireplace at any point on a site and thus allow for site planning.

Once a fireplace is established, a living zone can be added in any one of the four ways determined by schemata 3–6. A service zone is then added to the living zone by an application of schema 7. In this way, the *core unit* of a prairie house is fixed.
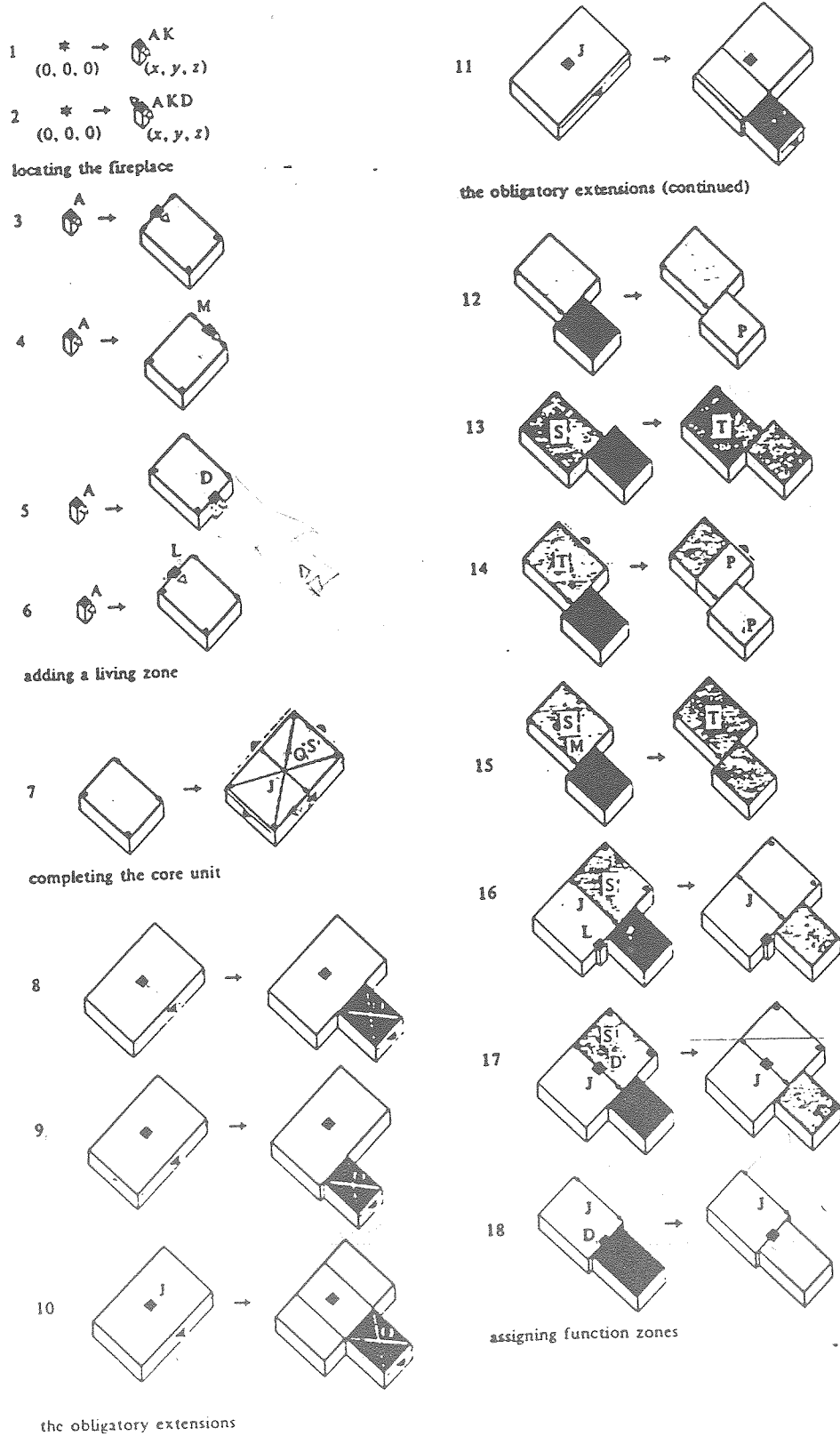
1   $*$ → AK
    $(0, 0, 0)$ (x, y, z)

2   $*$ → AKD
    $(0, 0, 0)$ (x, y, z)

locating the fireplace

3   A →

4   A →   M

5   A →   D

6   A →   L

adding a living zone

7   →   Q S
        J

completing the core unit

8

9

10   J   →   U

the obligatory extensions

11   J   →

the obligatory extensions (continued)

12   →   P

13   S   →   T

14   T   →   P   P

15   S   →   T
     M

16   S
     J   →   J
     L

17   S
     D   →   J
     J

18   J   →   J
     D

assigning function zones

Figure 6. Basic composition shape rule schemata.

The application of schemata 1–7 is illustrated in figure 7. The core unit so produced is distinguished by associating the symbol ● with each of its corners. The core unit may later be extended upwards by the addition of an equivalent unit to form a bedroom level. The labelled lines surrounding the core unit indicate the four possible directions of outward growth for the continuation of the design. Growth is obligatory on the sides of the core unit which are marked by the lines labelled by the symbol ▲. Growth is optional on the other sides of the core unit which are marked by the lines labelled by the symbol ♠. The symbol O is associated with the diagonals of the core unit; this labelled shape is required for subsequent schemata applications.

Obligatory additions to the core unit are fixed by schemata 8–11. Any of these schemata apply exactly once to each side of the core unit marked by a line labelled with the symbol ▲. (Optional additions to basic compositions depend on occurrences of the symbol ♠; these are fixed by ornamentation schemata specified in the next section.) Schemata 8 and 9 allow for blocks to be concatenated with the core unit; schemata 10 and 11 allow for blocks to interpenetrate the core unit. Notice that interpenetration is possible on only one side of the core unit, as schemata 10 and 11 erase the symbol J. This restriction eliminates the possibility of overarticulation in compositions. Whenever schema 8 or 10 applies, the addition to the core unit is aligned with an axis running through the fireplace; this axis must fall within the middle third of the block that is added. Whenever schema 9 or 11 applies, the addition is positioned to one side of the fireplace, and may extend to the center of the fireplace. In all cases, no addition may extend past the corner of the core unit. The length of an interpenetrating block must be at least as great as the width of the core unit it crosses. All added blocks, interpenetrating or not, are smaller than the core unit, but no less than a quarter of its size. Since each added block is smaller than the core unit, the fireplace is maintained as the hierarchical center of the design.

Figure 8 shows the application of schemata 9 and 10 to the core unit drawn in figure 7.

Once the basic form of a prairie-style house has been established as detailed above, schemata 12–18 can be used to assign functions to functionally undistinguished zones indicated by black-toned areas. These schemata reflect Wright's tendency to group services together so that they do not interrupt living zones. This planning device is
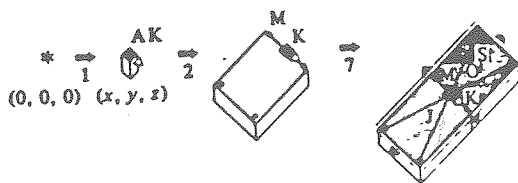

Figure 7. Generation of a design. Shape rule schemata are applied to the initial shape to establish a core unit. Numbers under the double-stemmed arrows indicate the schemata applied.
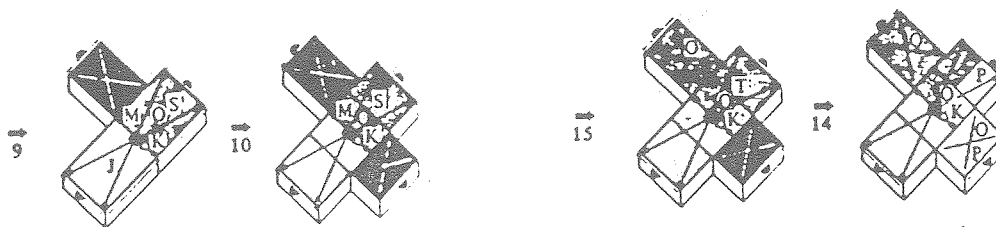

Figure 8. Generation of a design continued: obligatory extensions to the core unit are fixed.

Figure 9. Generation of a design continued: functions are assigned to functionally undistinguished black-toned blocks.
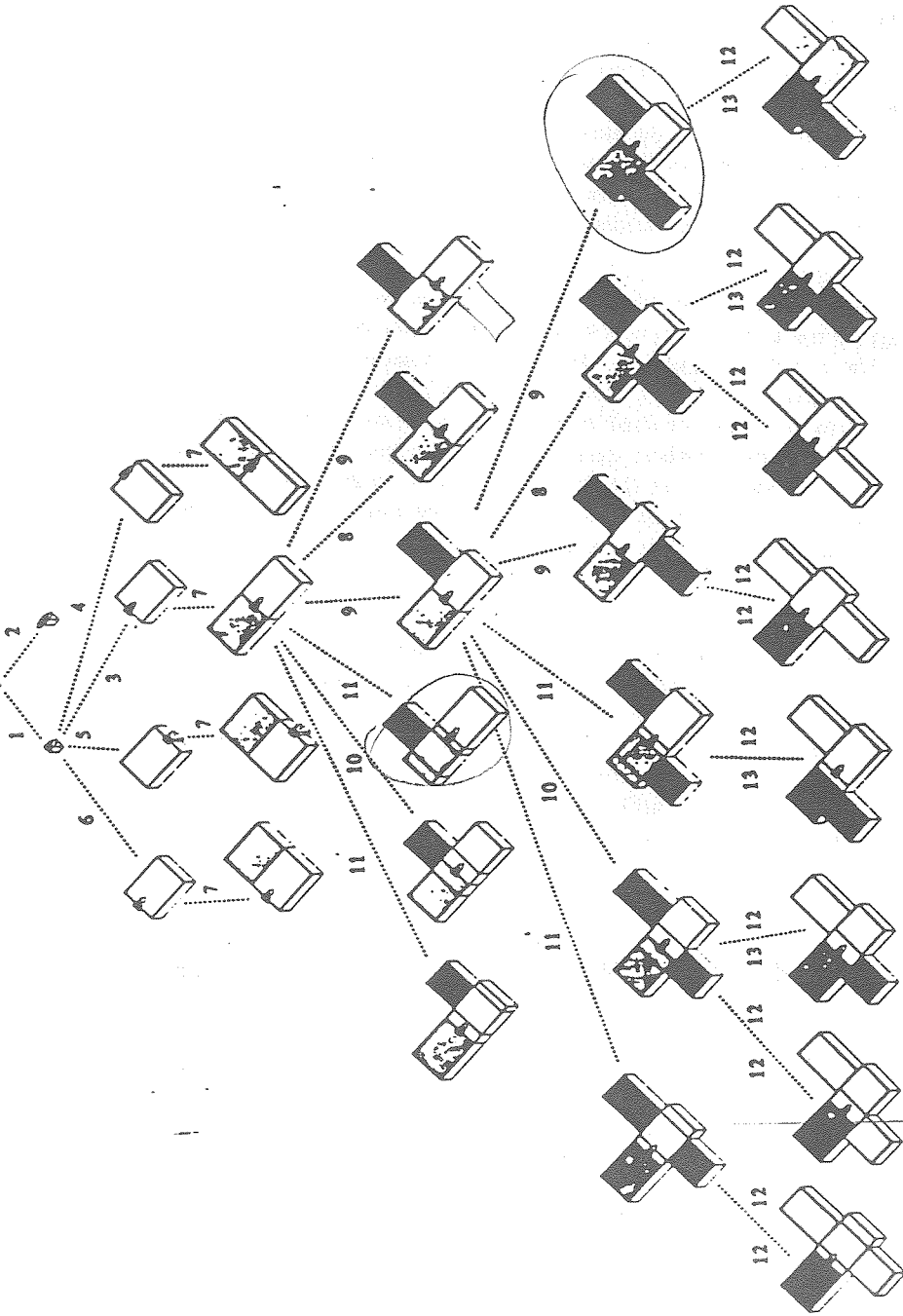
Figure 10. Part of the tree showing admissible sequences of shape rule schemata applications used to generate basic compositions. Numbers on the branches indicate the schemata applied.

essential to Wright's aim of reducing the necessary parts in prairie houses so as to
attain interior spaciousness. More precisely, schema 12 allows for a block with no
specified function to become part of the living zone whenever at least half of its
width is connected to the living zone. Similarly, schema 13 allows for blocks to
become part of the service zone. Schemata 14-18 then apply to ensure that function
zones correspond appropriately to fireplace location and orientation in the core unit.
    Figure 9 shows the application of these schemata to the design in figure 8, thereby
assigning functions to functionally undistinguished blocks.

Catalogue of basic compositions
Schemata 1-18 apply to generate the *basic compositions* underlying prairie-style
houses. A diagrammatic representation of some admissible sequences of applications
of these schemata is given in figure 10. Here, different sequences of schemata
applications are specified by following different paths in a rooted tree.
    In total, schemata 1-18 can be used to generate eighty-nine basic compositions for
prairie-style houses. No one of these designs can be changed into another by some
assignment of values to variables in the schemata applied to generate them. These
compositional forms are enumerated in the catalogue of figure 11. Each design in
this catalogue can be ornamented as specified below to produce a completed prairie-
style house.

Ornamentation of compositional forms
The basic compositions for prairie-style houses enumerated in figure 11 can be
elaborated in various ways to produce completed designs. These ornamentations are
determined by applying the shape rule schemata specified in figure 12. Some of these
schemata, for example, those that add roofs or basements, apply obligatorily to
obtain final designs from basic compositions; others, for example, those that add
porches, terraces, or extra blocks to corners of basic compositions, are used optionally,
thus allowing individual basic compositions to lead to a number of design variations.

Henderson, Willets, Baker   Cheney
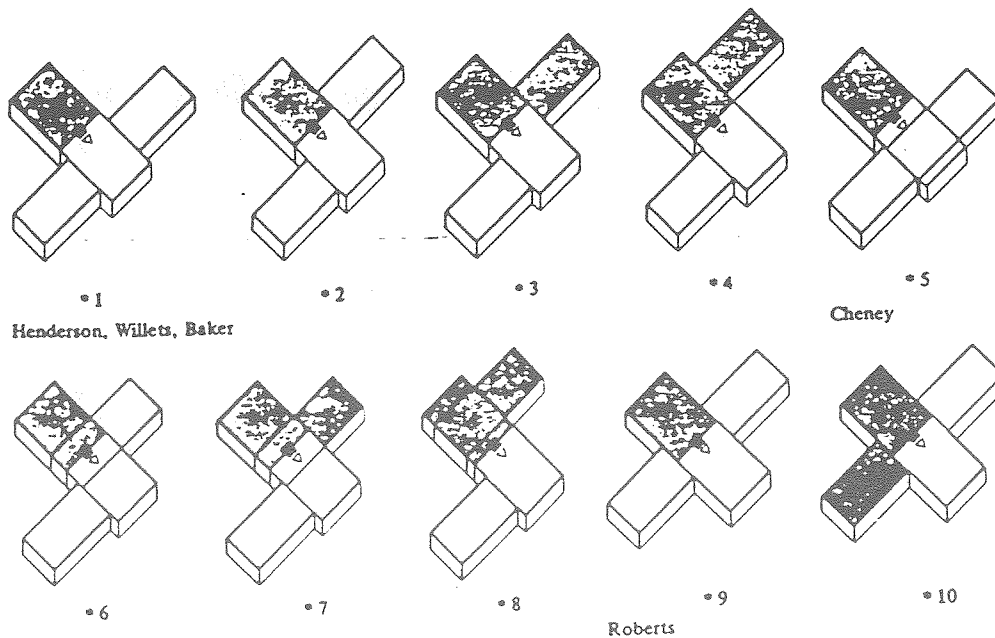
Roberts

Figure 11. Catalogue of basic compositions. The basic compositional form for each house in the
corpus is identified. The asterisk indicates that the layout is suitable for double-height living-zone
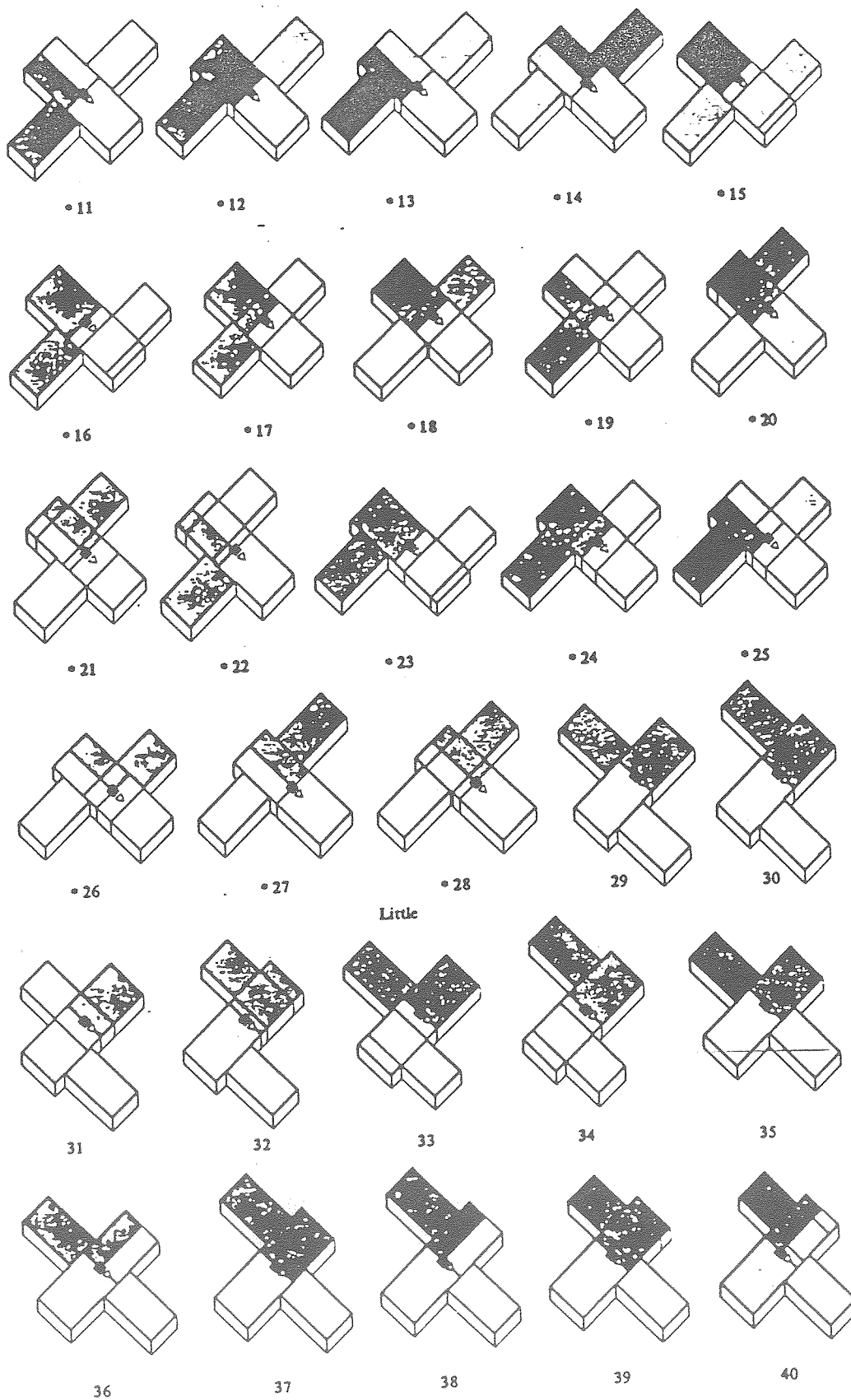arrangements.

• 11   • 12   • 13   • 14   • 15
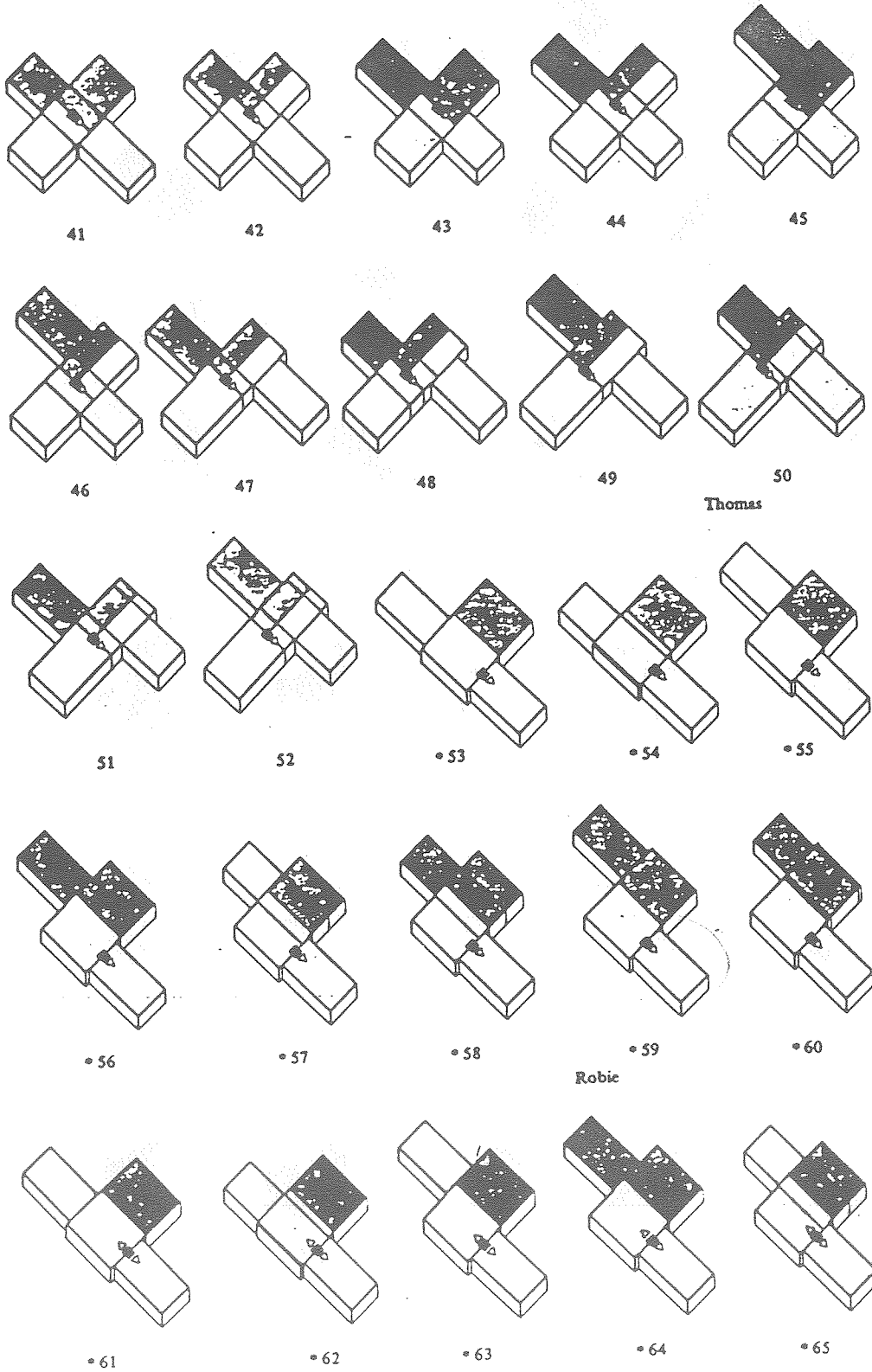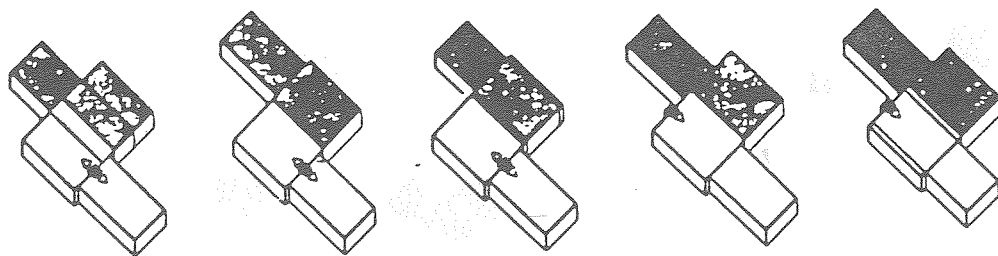
• 16   • 17   • 18   • 19   • 20

• 21   • 22   • 23   • 24   • 25

• 26   • 27   • 28   29   30

Little

31   32   33   34   35

36   37   38   39   40

Figure 11 (continued)

41   42   43   44   45

46   47   48   49   50

Thomas

51   52   ° 53   ° 54   ° 55

° 56   ° 57   ° 58   ° 59   ° 60

Robie

° 61   ° 62   ° 63   ° 64   ° 65

Figure 11 (continued)

66   67   68   69   70
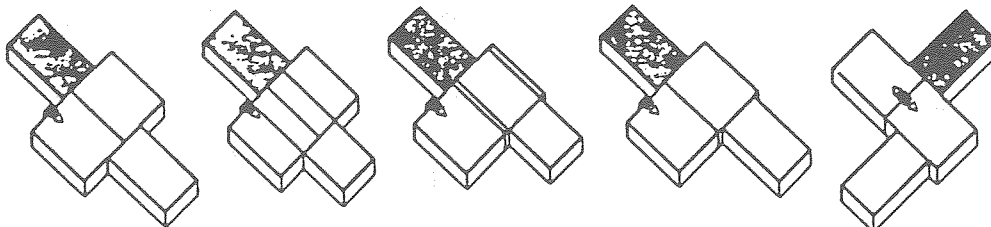
71   72   73   74   75

Martin
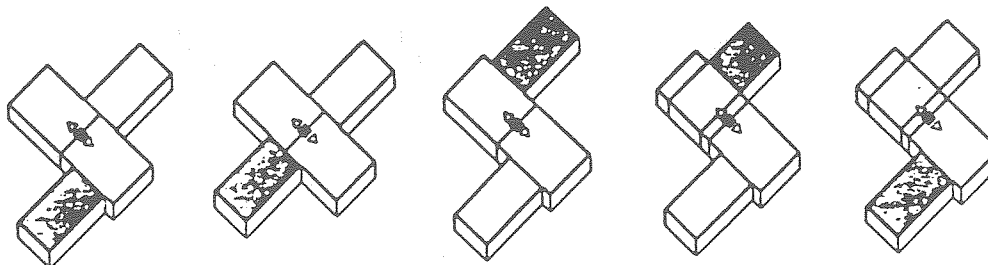
76   77   78   79   80
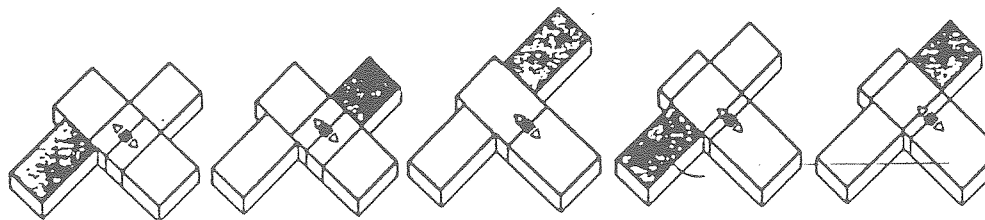
81   82   83   84   85
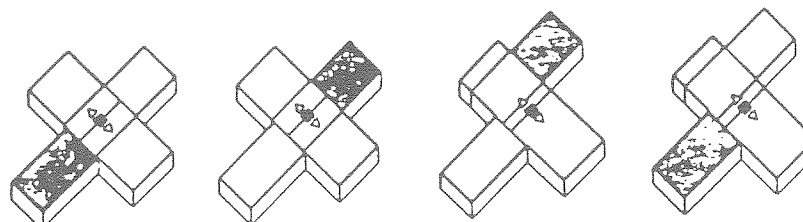
86   87   88   89

Winslow

Figure 11 (continued)

19

20

21

22

adding to concave corners

23

24

25

adding porches

26

interior details: main floor

27

28

29

30

31

32

33

34

interior details: main floor (continued)
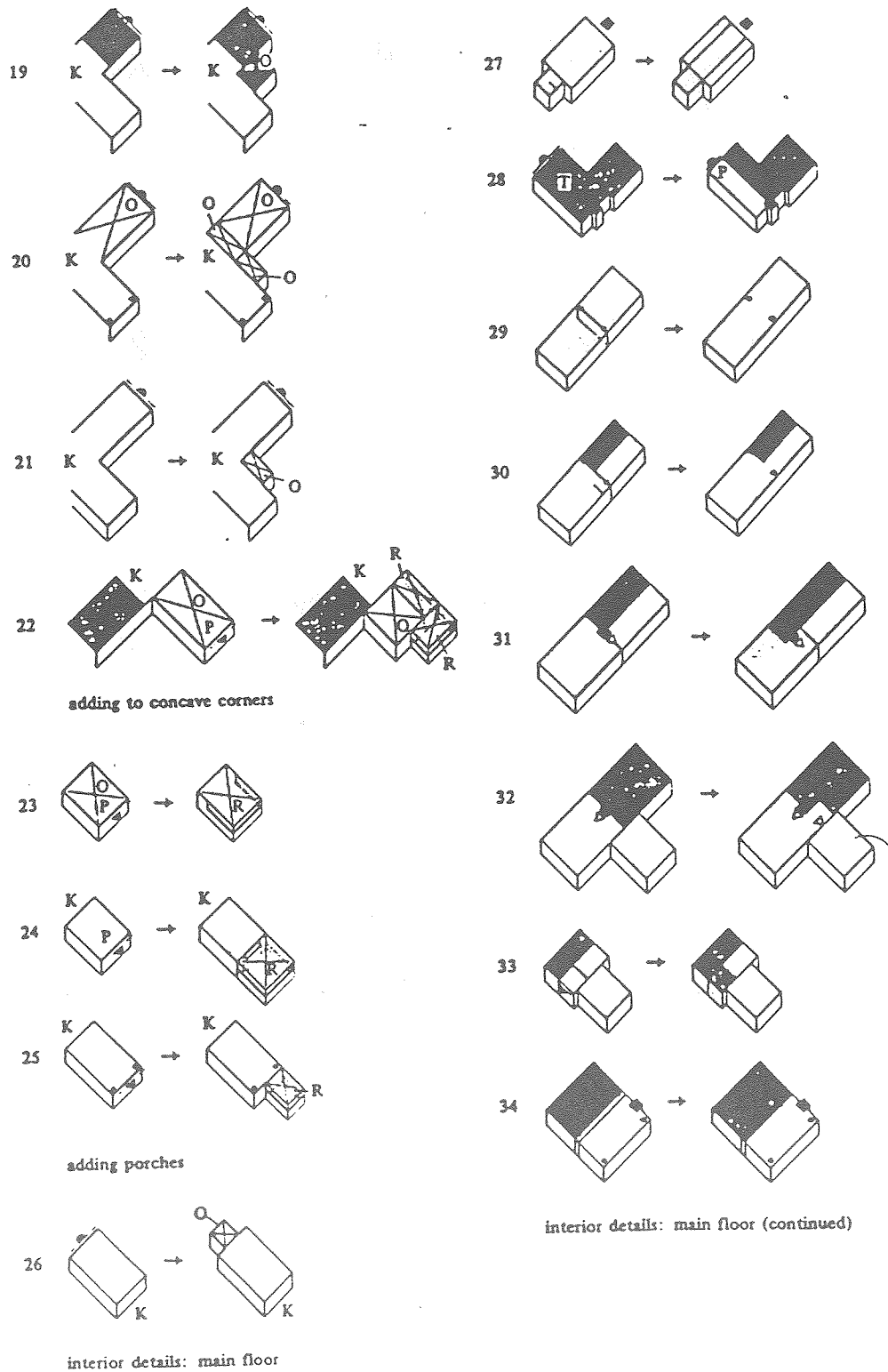
Figure 12. Shape rule schemata for the ornamentation of basic compositions.

35

36

37

38 FB

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basement formation

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42

43

44

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46

47

adding terraces

48

49

50

51

52

53

exterior details: main floor

54

55

creating portes cocheres

56

57 → $\langle s_\phi, \{(0, 0, 0) : J\} \rangle \rightarrow \langle s_\phi, \emptyset \rangle$
58 → $\langle s_\phi, \{(0, 0, 0) : S\} \rangle \rightarrow \langle s_\phi, \emptyset \rangle$
59 → $\langle s_\phi, \{(0, 0, 0) : T\} \rangle \rightarrow \langle s_\phi, \emptyset \rangle$
60 → $\langle s_\phi, \{(0, 0, 0) : P\} \rangle \rightarrow \langle s_\phi, \emptyset \rangle$

erasing main-floor nonterminal labels
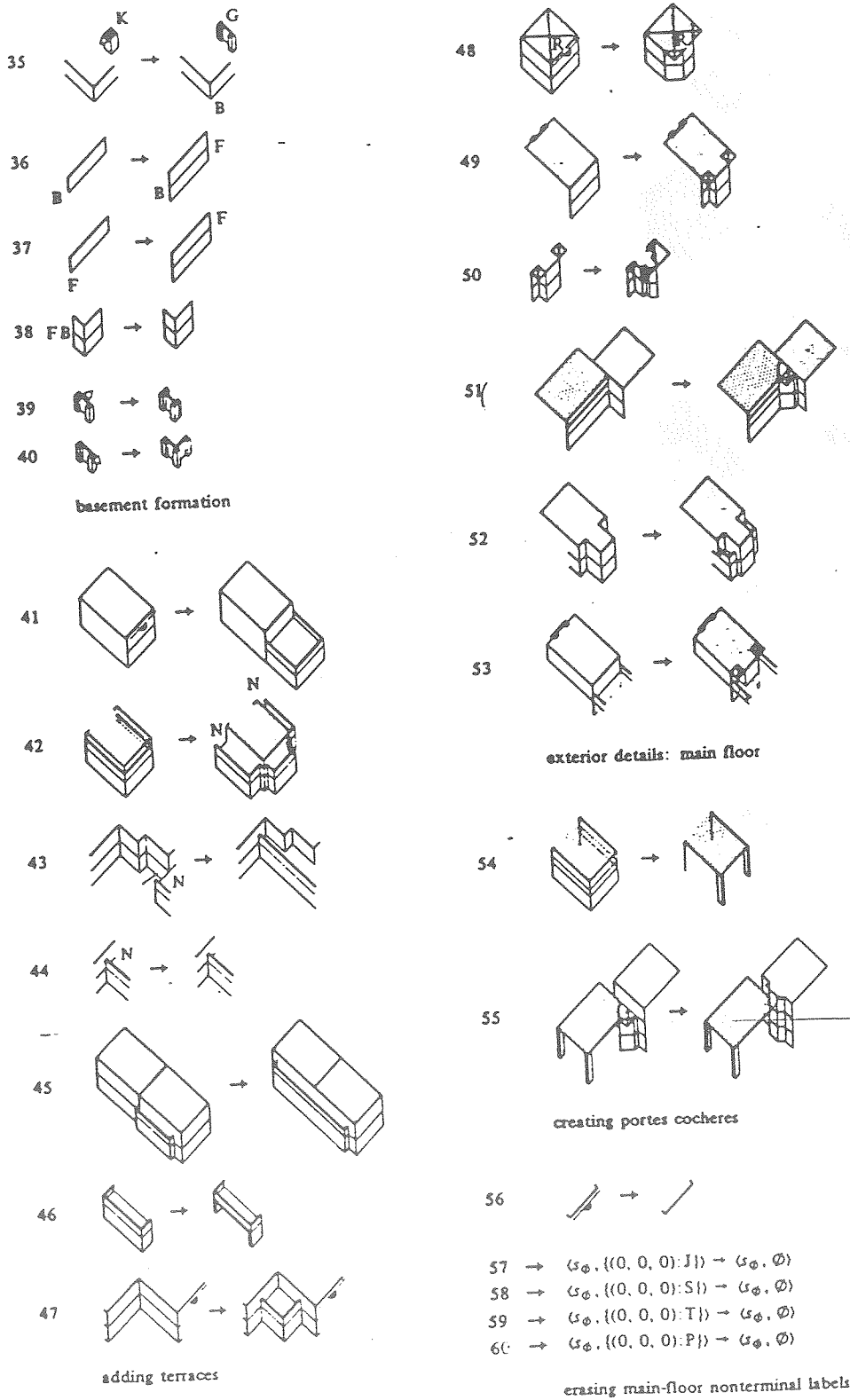
Figure 12 (continued)
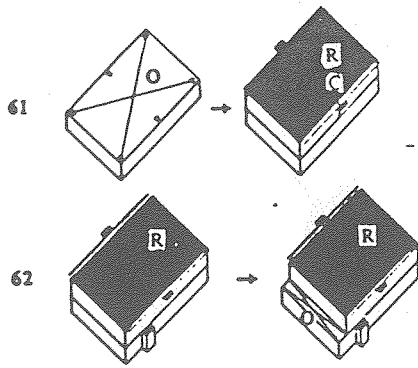
establishing the bedroom floor

making double-height living rooms (continued)

erasing bedroom-floor nonterminal labels
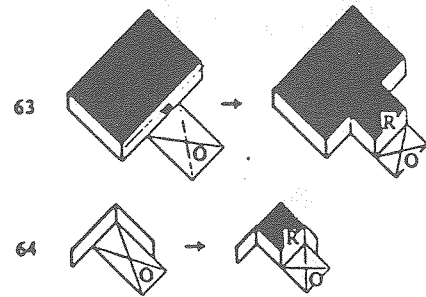
bedroom-floor extensions

details: bedroom floor

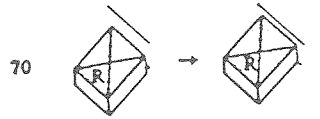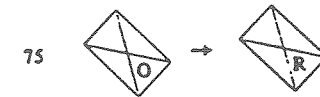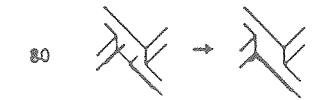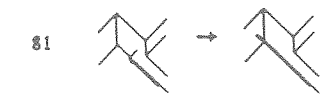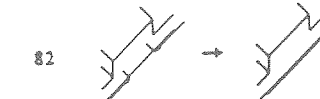making double-height living rooms
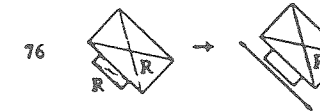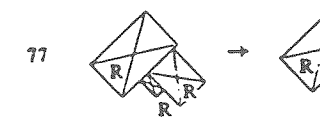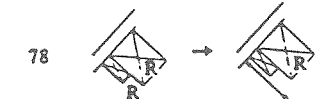
establishing roof eave lines

Figure 12 (continued)

Blocks may be added to the external concave corners of basic compositions by the application of schemata 19–22. In all of these schemata, values are assigned to variables so that the added shape does not project beyond the existing external walls of a basic composition. (Notice that in the Cheney and Winslow houses, these added blocks completely fill in the concave corners of the basic compositions to produce an external rectangular form.)

Porches are often used in prairie-style houses to mediate between enclosed interior spaces and the prairie. Porches are roofed, but may not have another floor built above them. Schemata 23–25 apply to basic compositions to add porches. Schema 23 allows for a porch to replace a block previously added as an extension to a living zone; schemata 24 and 25 attach porches to the end of living zones. Notice that once a porch has been added that the outward growth of a design in that direction is terminated.

Schemata 26–34 make small adjustments to designs generated by applying schemata 1–25. Such adjustments are concerned mainly with the functional organization or decorative articulation of living zones in designs.

The application of the ornamentation schemata discussed above is illustrated in figure 13.

creating balconies

$$(s_\phi, \{(0, 0, 0): \bullet\}) \rightarrow (s_\phi, \emptyset)$$

erasing nonterminal labels

roof formation

roof formation (continued)

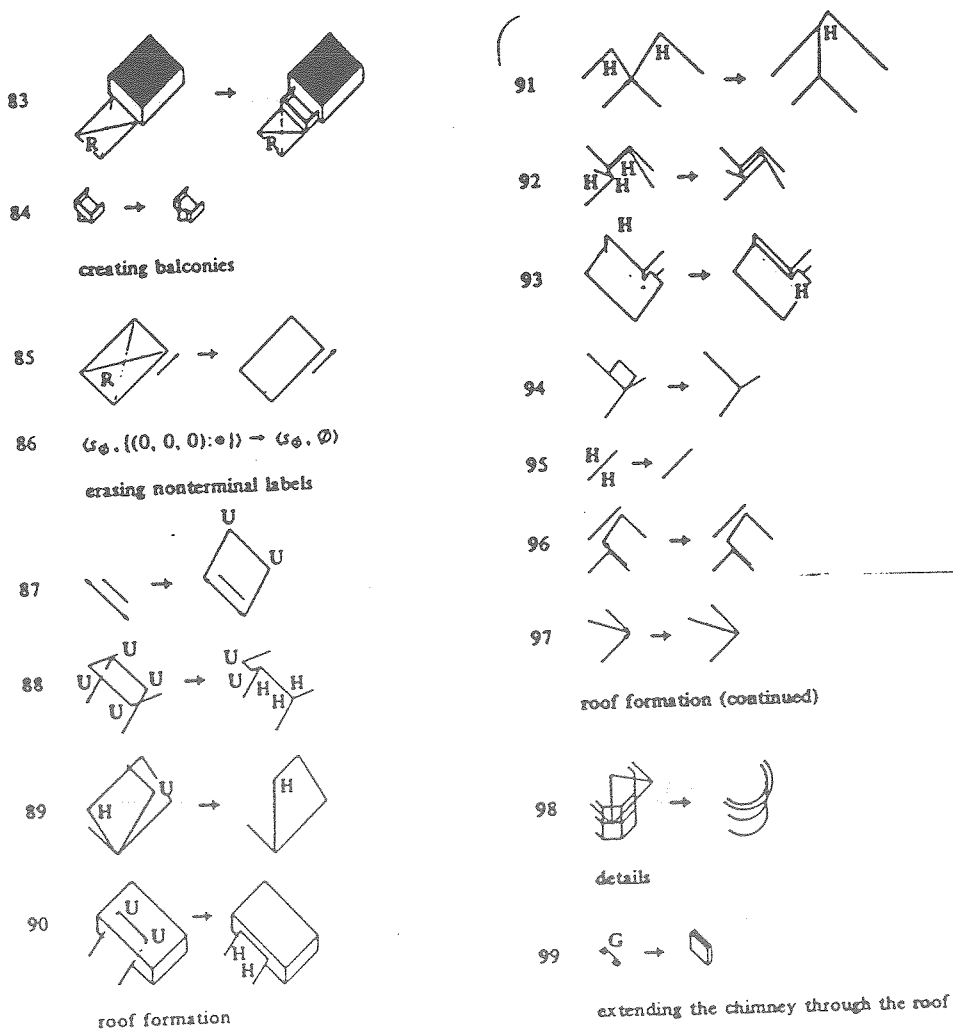details

extending the chimney through the roof

Figure 12 (continued)

Prairie-style designs, with the exception of those with double height living spaces, must have basements. Schemata 35-38 add the visible portion of basements to designs. Schema 35 initiates this process, and in so doing details the fireplace. In those cases where multiple hearths are used, schema 39 or 40 is subsequently applied. The complete formation of a basement is then carried out by applying schemata 36-38.

To emphasize the outward extension of a prairie-style design, terraces of various types may be added by application of schemata 41-47. Terraces can be added to designs with or without visible basements. Variations in basement height are accounted for by the parameters associated with these schemata.

Other characteristic decorative details in prairie-style designs are added by schemata 48-53. These schemata embellish main-floor living zones.

A porte cochere may also be added to a design. This option is provided for by schemata 54 and 55. Schema 54 applies to change a porch with three free external edges into a porte cochere; schema 55 then applies to add optional detailing.

Lines and labels used to control the basic composition and ornamentation process of the main-floor living zone specified by schemata 19-55 are erased by applying schemata 56-60.

The recursive application of schemata used to form basements and erase labels is illustrated in figure 14.

A block may be added above the core unit in a basic composition in accordance with schema 61 to begin the generation of a bedroom floor. When this schema is applied, the symbol O associated with the core unit is erased; the symbol R is then used to label the bedroom floor, indicating that this area must be roofed and that no floor can be added above it. In special cases, the newly added bedroom core unit can be reduced in size as specified by schema 62.

Growth of the bedroom floor may only occur on the faces of the bedroom core unit marked by the line with the symbol ▬ associated with it. Such extensions are carried out in accordance with schemata 63 and 64. Notice that these schemata do not permit the bedroom floor to cantilever over the main floor. Whenever schema 63 applies, the width of the added block must be equal to the width of the block described
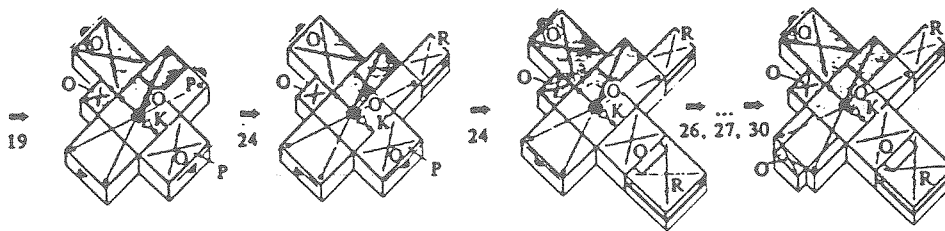

Figure 13. Generation of a design continued: the design is ornamented with blocks in external concave corners, porches, and various interior details.
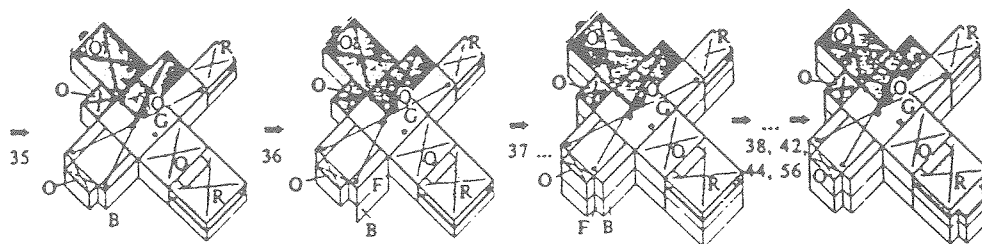

Figure 14. Generation of a design continued: a basement is specified and a terrace is added.

beneath it, but its length may vary. Schema 64 adds blocks in concave corners; the dimensions of these blocks are fixed as in schema 63.

Schema 64 extends the chimney through the bedroom floor; it must be applied to two-storey designs. Schema 66 allows external corners of bedroom floors to be replaced by decorative balconies.

The application of schemata 61–66 is illustrated in figure 15. Here, schemata are recursively applied to add a bedroom floor to the design in figure 14.

Double-height living spaces occur in designs without basements. In this case, schema 67 is applied to initiate the generation of these spaces. Creation of a double-height living space involves not only the incorporation of part of the bedroom zone into the living zone, but also a contraction of the resulting double-height block unit by raising the height of the bottom floor. In this way, a split-level is produced on the main floor. Further, within the newly formed double-height space, a balcony is cantilevered from the fireplace.

In the corpus examples of this type—the Roberts and Baker houses—the living-zone areas adjacent to the double-height living space are also raised. Schemata 68–70 apply optionally to achieve such floor-level adjustments. The remaining parts of such designs are in two levels, with the lower one approximating the basement of regular double-storey designs.

Designs with double-height living spaces are completed by applying schemata 71–73. Schema 72 allows for the formation of decorative corners to double-height spaces. Schema 71 extends the perimeter as required, and schema 73 raises the perimeter to correspond with the new double-height form. Schema 74 erases a now unneeded labelled line for all two-storey designs.

Before a design or any part of it can be roofed, the symbol O must be changed to the symbol R. Whenever this change has not been previously made by the application of one of the schemata discussed above, schema 75 is applied.

The next step in the formation of the roof is the creation of eaves lines by the application of schemata 76–82. These lines are indicated by the arrowheads at their endpoints. Schemata 76–82 cover all possible configurations pertaining to the formation of hipped roof eaves in prairie-style house designs.

Balconies are sometimes used in prairie-style designs not only for decorative purposes or where functionally desirable, but also to complete designs where the inclusion of a small, isolated piece of sloping roof would appear clumsy. Such cases are provided for by schema 83. This schema may also be applied to ease the transition between main and bedroom floor roofs. Notice that the width of these balconies is fixed by the width of the units below them, but their lengths may vary. Schema 84 allows for decorative embellishment of these balconies.

Schemata 85 and 86 erase labels that are no longer needed.

The application of the eaves formation schemata just discussed is illustrated in figure 16. These schemata are applied to the design of figure 15.
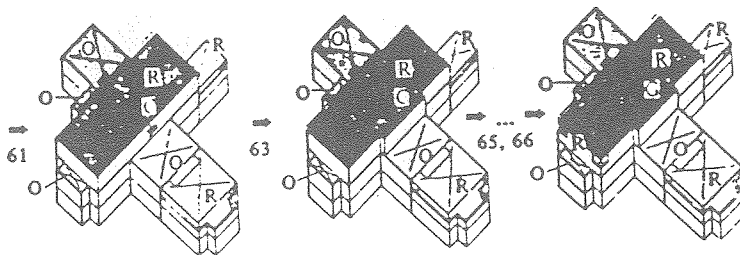

Figure 15. Generation of a design continued: the bedroom level is added.

Schemata 87–99 complete prairie-style designs by adding roofs and the external portions of the chimney. The application of these schemata to the design in figure 16 is shown in figure 17. This design is in the language defined by the grammar.
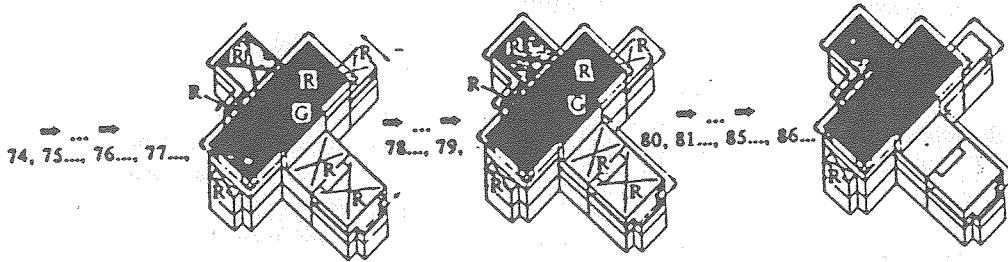

Figure 16. Generation of a design continued: the eaves line is established and unused labels are erased.
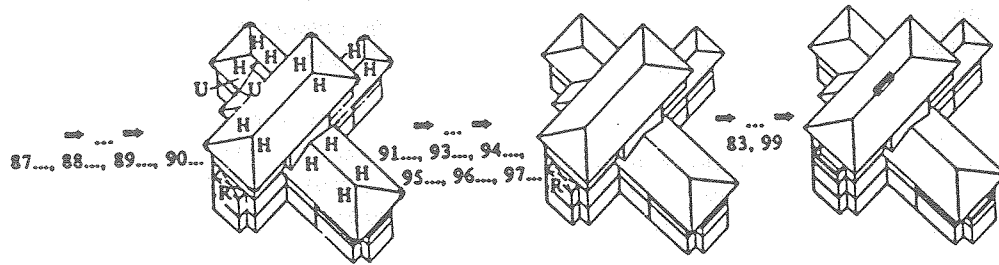

Figure 17. Generation of a design continued: a balcony is added, the roof is formed, and the chimney is extended. The design is now complete.

Catalogue of two-storey designs
The catalogue of figure 18 enumerates two-storey designs derived from the basic compositions of figure 11 by applying the smallest number of schemata necessary to
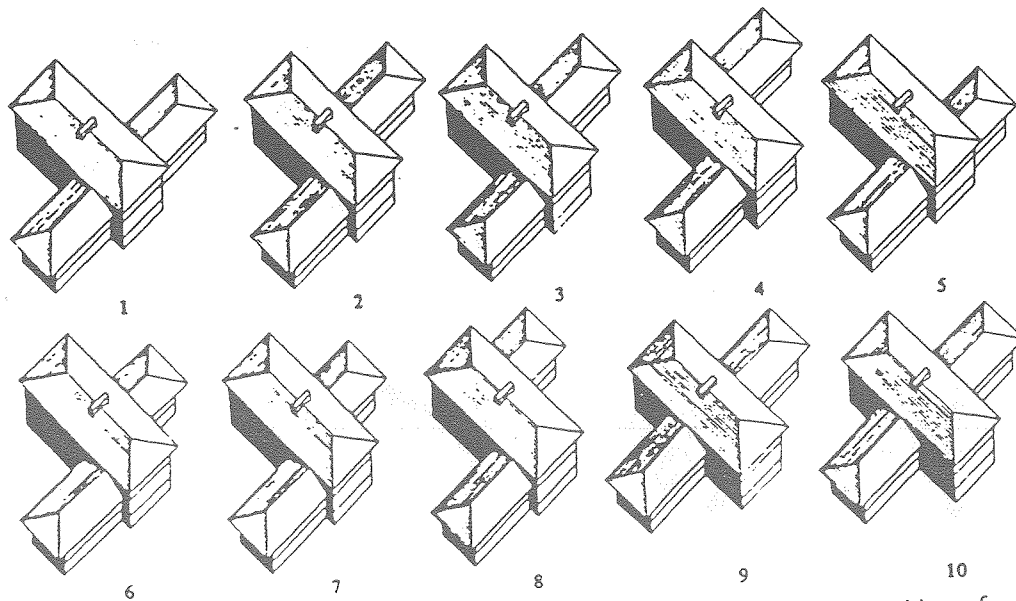

Figure 18. Catalogue of the 'simplest' two-storey designs derived from the basic compositions of figure 11. The shading is added for clarity and is not produced by the grammar.

11 -12 13 14 15
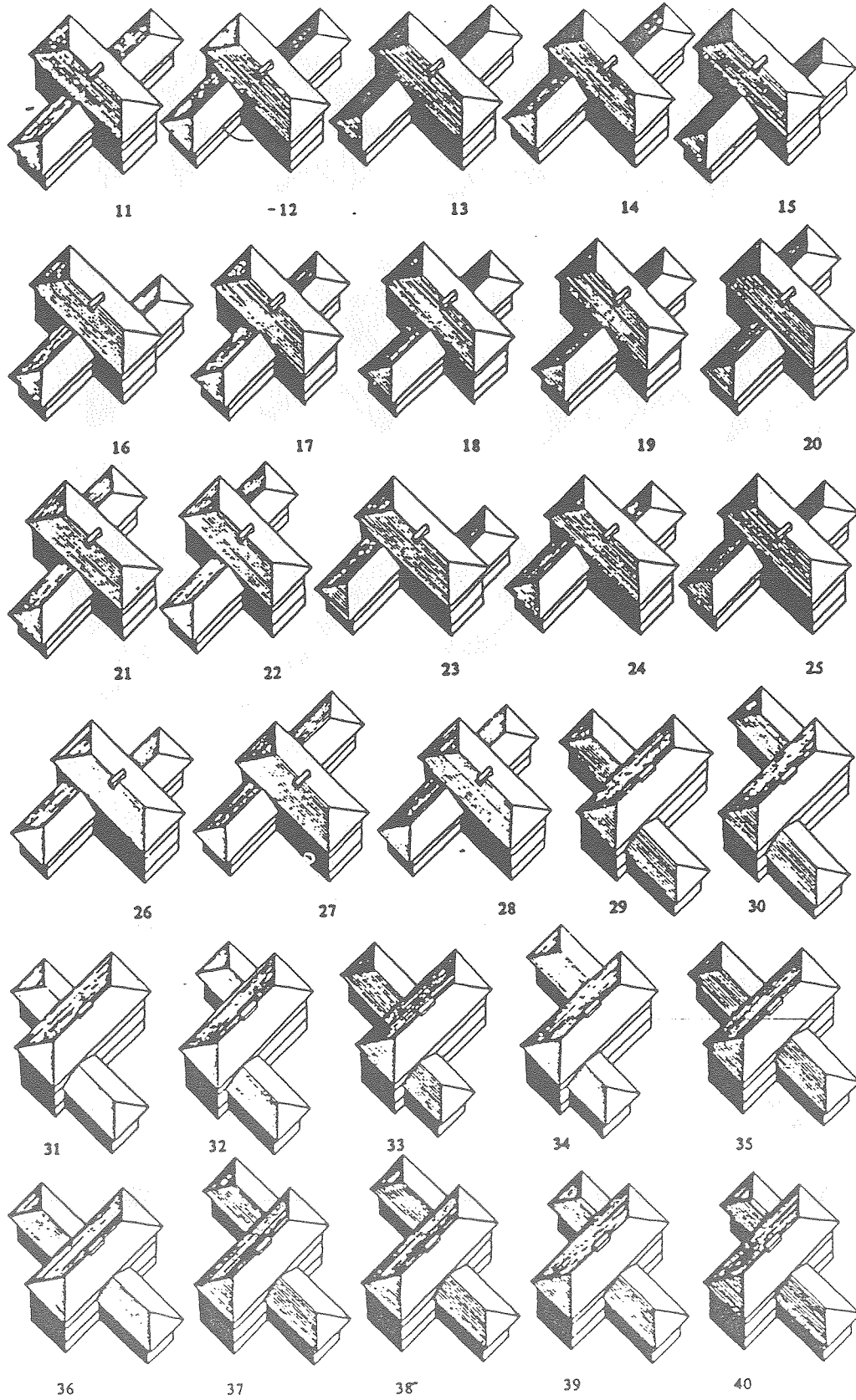
16 17 18 19 20

21 22 23 24 25

26 27 28 29 30

31 32 33 34 35

36 37 38 39 40

Figure 18 (continued)

Figure 18 (continued)

66 67 68 69 70
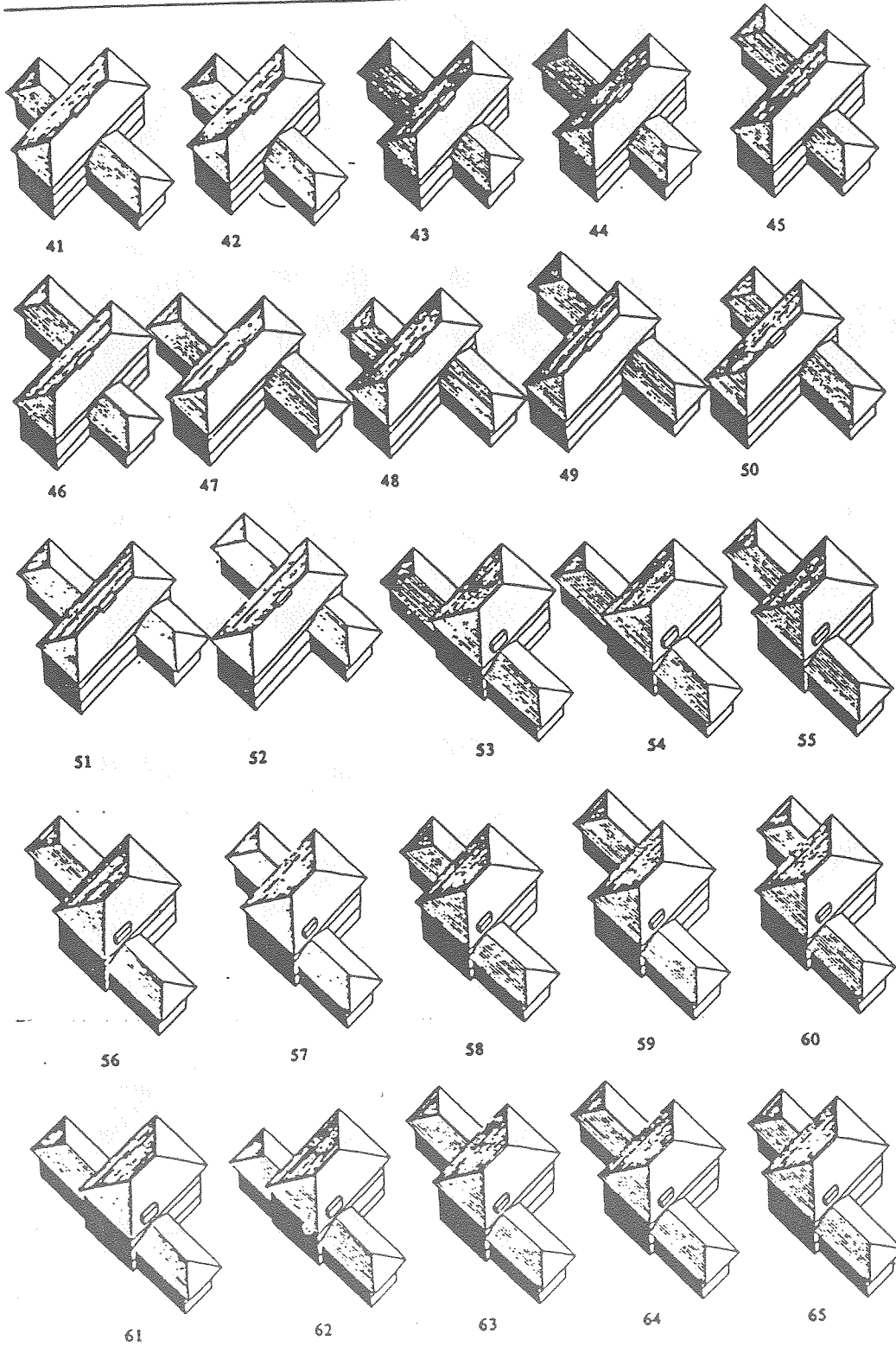
71 72 73 74 75

76 77 78 79 80
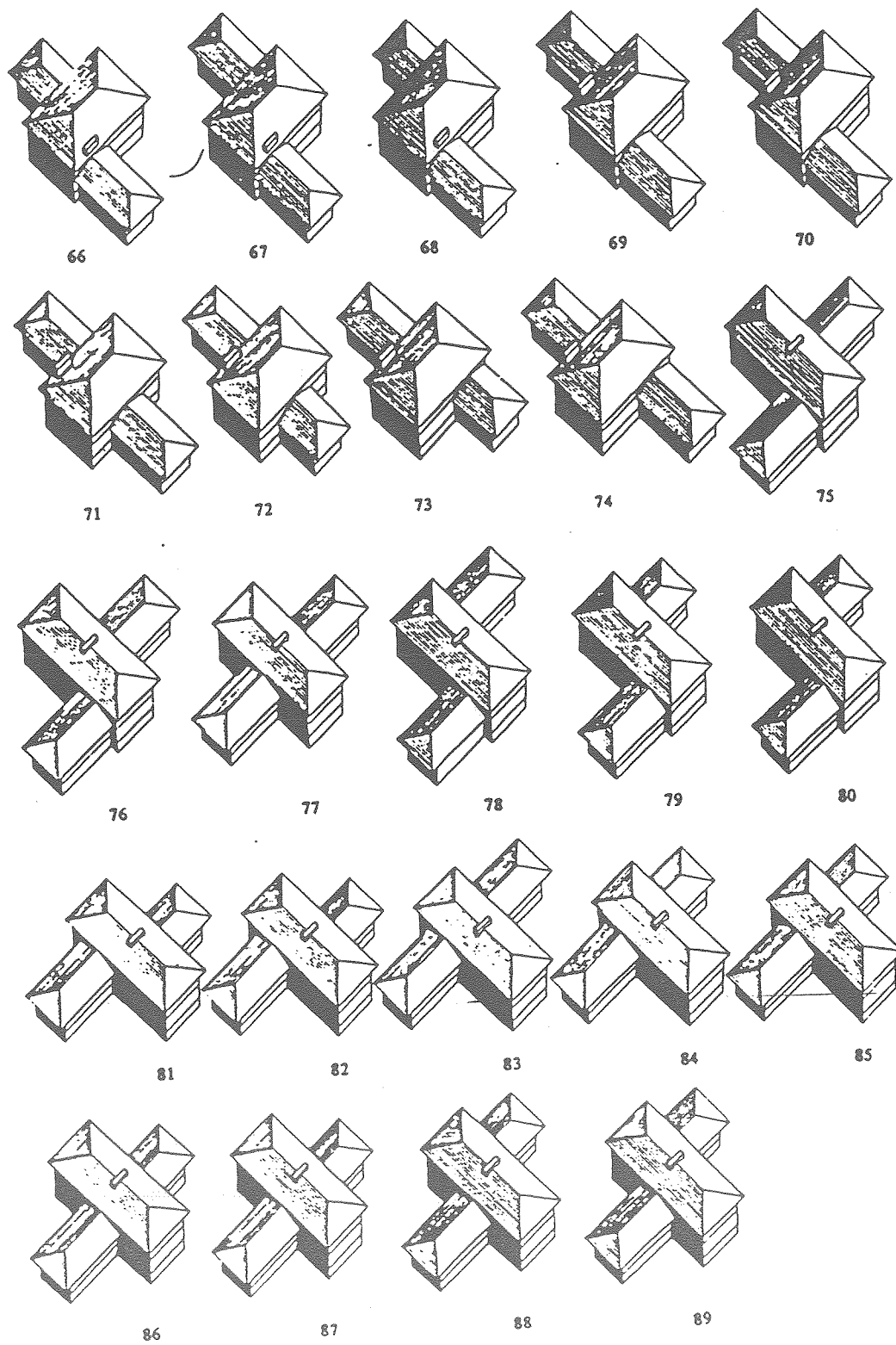
81 82 83 84 85

86 87 88 89

Figure 18 (continued)

produce a completed design. Where the exterior views of some of these designs are the same, their interior composition differs. It should be noted that for each of the designs in figure 18 there is a corresponding single-storey design. Further, for those basic compositions marked by an asterisk in figure 11, it is also possible to produce double-height living-space designs. Figure 19 shows the three kinds of design alternatives that can be derived from basic compositions. Thus, there is a grand total of 238 designs in the language defined by the parametric shape grammar developed here that can be obtained from the basic compositions of figure 11 *without* applying optional ornamentation schemata. Of course, the application of these optional schemata greatly increases the number of possible designs.
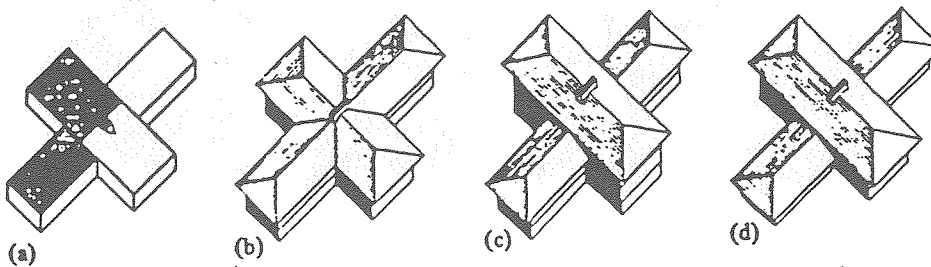

(a)   (b)   (c)   (d)

Figure 19. At least two, and in some cases three, types of designs can be derived from any one basic composition. For example, the basic compositional form (catalogue number 10) shown in (a) may lead to (b) a single-storey design, (c) a double-storey design or, (d), a double-height living-space design.

Three new designs

The shape-grammar formalism (Stiny, 1980a) is probably the most compelling means now available to represent our detailed understanding of the composition of designs in existing languages of architecture. Once a shape grammar has been developed for a given corpus of designs, it can be used to generate the designs in the corpus and *new* ones in the same compositional style. Such new designs allow for the design implications of the rules of composition encoded in the grammar to be explored, and for an informed comparison of our intuitive understanding of a style and its formal definition.

Three new prairie-style designs are shown in figure 20.

The first of these, the *Stiny* house, has the hearth directed across the core unit. One obligatory extension (behind the hearth) adds a block to one side of the fireplace; the other (in front of the fireplace) interpenetrates a block on axis with the fireplace. Porches, articulations—including the addition of blocks to two concave corners behind the fireplace—a second floor, and a basement ornament the basic composition. The completed design results when the roof is added. (See figures 7–9 and 13–16 for the details of this composition.) Figure 21 shows an exterior sketch of the Stiny house.

The *Mitchell* house employs a seemingly extreme arrangement of blocks in which the obligatory extensions are made at opposite ends of the core unit. Terraces, corner articulations, a balconied second storey, and a basement complete the design.

The *March* house is a double-hearth, double-height living-space design in which a porte cochere is used. The design was composed by combining features not seen together in typical corpus examples. The result is nevertheless a convincing prairie-style design.

Detailed plans for the Stiny, Mitchell, and March houses are also shown in figure 20. Even though no shape rule schemata were given in the grammar to produce these plans, it is easy to imagine ones that would do so.
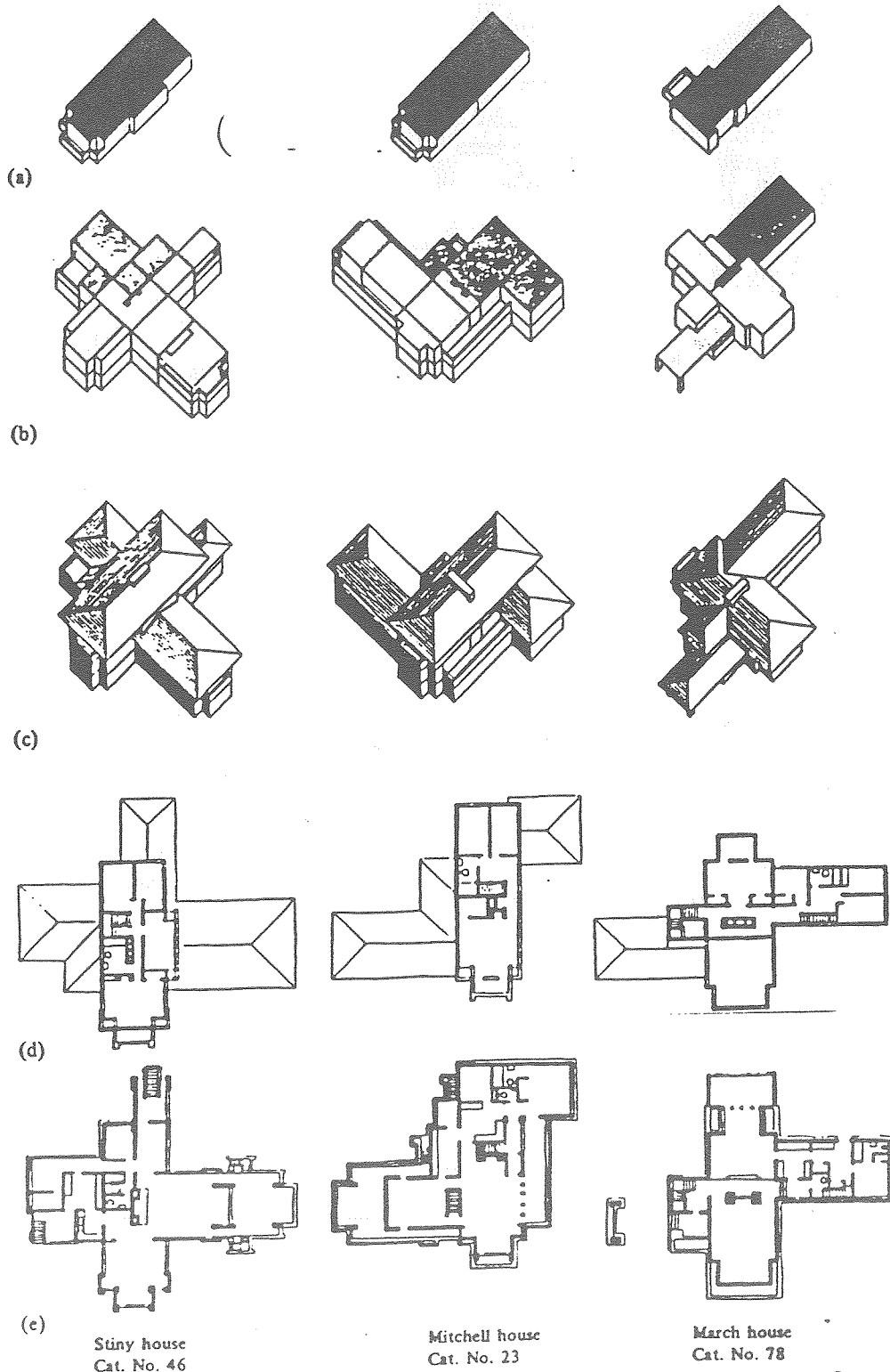
Figure 20. Three new designs as generated by the grammar: (a) bedroom level, (b) main floor level, (c) external form; and the detailed plans (d) bedroom floor plan, (e) main floor plan.
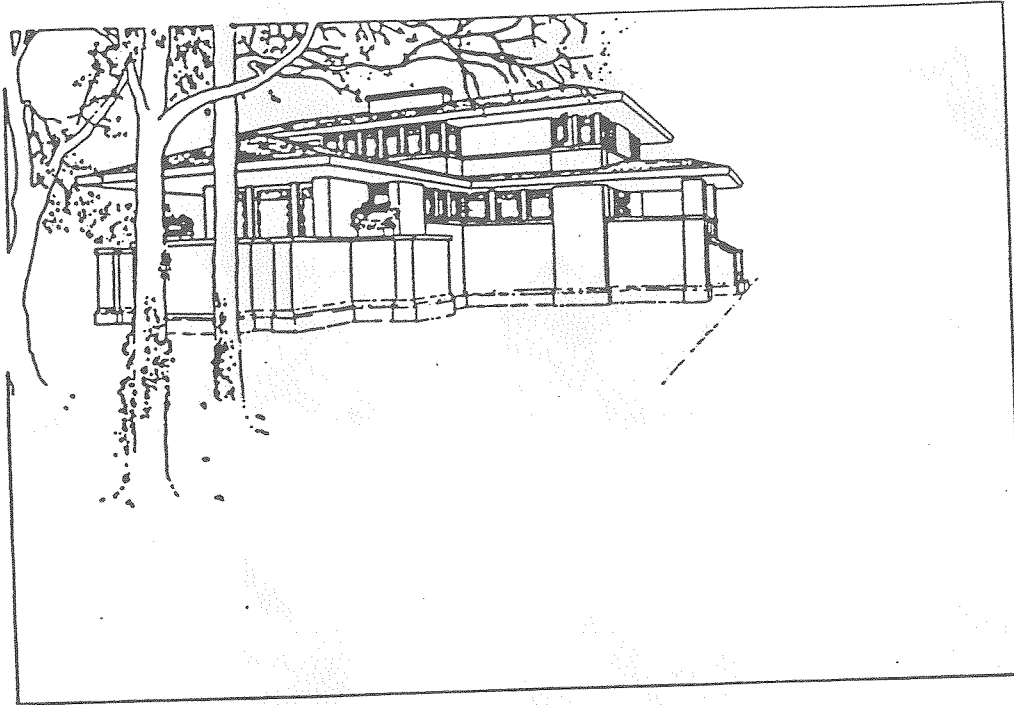
Stiny house
Cat. No. 46

Mitchell house
Cat. No. 23

March house
Cat. No. 78

Figure 21. The Stiny house 1981.

Discussion

In this paper, we have developed a parametric shape grammar that generates prairie-style houses in the style of Frank Lloyd Wright. In summary, we make the following observations:

The fireplace is the generating center of the prairie house. Most prairie houses, and all of those in the corpus of figure 1, employ one fireplace. Designs like the D D Martin house, however, employ many generating fireplaces creating a veritable prairie village of distinct but interacting prairie-style designs. Such villages could be generated by the grammar by beginning with an initial shape that leads to more than one fireplace.

Functionally distinguished Froebelean-type blocks are added around the fireplace to produce the basic compositions shown in the catalogue of figure 11. The core unit in these basic compositions establishes one axis of growth, and the blocks added to it establish two subordinate axes of growth. When these subordinate axes are coincident, cruciform plans result (for example, the Willets and Little houses); otherwise, asymmetrical plans are produced (for example, the Robie and Thomas houses).

Elucidation of the notion of *balance* in prairie-style houses has confounded historians such as Hitchcock who find themselves forced to describe it as *occult*. In terms of the grammar presented here, however, it is clear that all the designs share the same principle of organization and that the balance of prairie designs follows from the basic compositions of figure 11. Indeed, because all additions to a basic composition are controlled by it and cannot extend beyond it, elaborations and ornamentations of the basic composition merely reinforces its existing balance. A completed design in the language defined by the grammar, whether it is a basic form (figure 18) or a more highly ornamented design, is simply an arrangement of interdependent layers of blocks about a fireplace with three observable axes of growth.

The development of this grammar clarifies our understanding of the composition of Frank Lloyd Wright's prairie-style houses. Probably more importantly, though not stressed in this paper, the grammar illustrates the application of the shape grammar formalism to three-dimensional material, and thus its direct application in the design of architecture.

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