more scrambled and out of order, the effect will be that, when being read, incoherence in the unfolding will occur, and important structure will be lost. In short, less than a trillionth of all the 6×10^{23} possible sequences actually work well enough to allow smooth unfolding. This underscores the difficulty of finding a *good* sequence for such an unfolding process.

It is not possible, at present, to give a precisely defined way of identifying the sequences which work, although some progress has been made in this direction. That is to say, we do not yet know a purely mathematical procedure which can identify the sequences which work.

However, the sequences which work can be identified experimentally by a well-defined procedure. If one applies a sequence of steps to a given context, and if one then observes the unfolding process, it is possible to identify, unambiguously, whether the process engendered by the sequence at any time contradicts itself — that means, whether one is forced to backtrack, because step B which comes at a certain point

in the sequences forces one to undo the results of the previously taken step A. By doing experiments on test cases, it is possible to winnow out, and ultimately to eliminate the bad sequences, thus gradually finding one's way to the few sequences which have the property that no such backtracking occurs as the project unfolds. One technique for finding good sequences is to identify bad *sub*sequences, and eliminating all sequences which contain these bad subsequences. There are a variety of ways of getting to the good sequences, and it is very hard work. But, with time, it can be done.

Since the identification of backtrack-free sequences can be made experimentally, it is clear that the concept of backtrack-free sequences is — in principle — well-defined even though in practice hard to discover.

The important thing is that such backtrack-free sequences are relatively stable. Once discovered, a backtrack-free sequence remains backtrack-free for nearly all contexts. Thus the backtrack-free sequences lie at the core of the theory of living process.

8 / A GENERATIVE SEQUENCE FOR APARTMENT BUILDINGS IN PASADENA

In the next seven pages I show a backtrack-free sequence of this kind, constructed for a limited class of apartment buildings. My colleagues and I were asked to write a zoning ordinance for the city of Pasadena, California, an old town with a nice history recently ruined by an influx of ugly multi-family apartment buildings. The zoning ordinance was to set guidelines for a new class of apartment buildings, which — it was hoped — would respect tradition by making courtyards and gardens, and building relatively low compact apartments around these gardens.

What surprised nearly everyone associated with the project was that it was possible to write a successful and fairly simple generative se-

quence for apartment buildings of this type.[5] The sequence was of such a nature that it allowed the creator, or designer, to produce a design for a particular site by an unfolding process that automatically met the necessary conditions for a good apartment building.

To get the sequence, a pattern language similar to the languages illustrated later (chapter 13), was first constructed for these multi-family apartment buildings, then re-formulated as a generative sequence.[6] In its sequence form it gives the user a process of unfolding in such a way as to allow a building with good plan, volumes, and organization to be made, very easily, to fit the particular conditions of any given site.

This generative sequence is given below. It is printed here in more or less the same language that we wrote for the ordinance, and asks the user (the applicant for a building permit on a new site) to follow the instructions while laying out his apartment building.

The sequence has eleven steps. The steps are designed to go smoothly, one by one, so that the applicant can fill out the application forms easily and with a minimum of interpretation.[7]

The process is also designed to facilitate the actual design and planning of new development projects, and to encourage new projects of high quality. A builder who wishes to check the possibility of a project on a new site can pencil out a feasible project within a short time, simply by following the steps in the order given. This will then enable him to create a project which meets all legal requirements, and to examine the possible results of a conforming project, both quickly and economically.

Since the sequence is based on what we consider as essential patterns, one can say that any successful apartment building, for this context, *must* meet these conditions. The sequence is therefore essential, functional, and does not merely satisfy legal requirements. It goes — my colleagues and I believe — to the root of a successful apartment building in Pasadena.
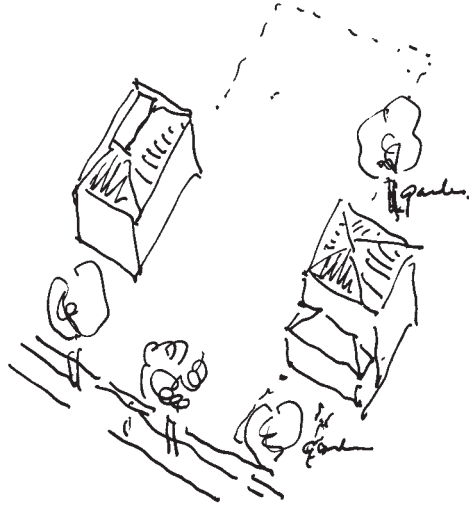

Step 1: Mapping the site to show its good points

STEP 1

MAP THE CONTEXT AND SURROUNDINGS.

To begin the layout process, and to make sure that your project does something useful for the neighborhood, it is necessary to start by understanding the essential structure of what exists around the site, both on your lot and in the immediate vicinity.

Draw a map at a scale of 1 inch equals 50 feet. The map must show your lot, two lots on either side, the back 50 feet of the lots behind these five lots, and the front 100 feet of the five lots across the street. On this drawing, survey and identify:

(1) Lot boundaries.

(2) Footprints of all buildings on surrounding lots. Each building or part of building must be shown with its approximate height in feet.

(3) All gardens on surrounding lots. Examine how big they are, where they are located, what their shapes are. In particular, you must identify adjacent gardens which are worthwhile sitting and looking in their direction and enjoying them.

(4) Beautiful open space in the street, which helps to create the atmosphere of the neighborhood.

(5) Parking structures on surrounding lots.

(6) Big trees on your site or on the street, and on adjacent lots.

(7) Existing driveways and back-alleys on nearby lots, with special reference to any possible pattern of access in which these existing driveways and alleys might serve the back of your lot.

(8) Setback dimensions on adjacent lots.

(9) Any windows on next-door buildings facing your lot, which serve living areas, and must have good light preserved.

(10) Groups of doors or other entrances on next-door lots, which create a pattern of movement and pleasantness that must be preserved, and which may form the basis of a new space or focus in your project.

(11) Walkways and entrance paths on surrounding lots.

STEP 2

DECIDE BASIC ARRANGEMENT OF PROJECT AND ITS OUTDOOR SPACE TO ENHANCE SURROUNDING PROJECTS AND THE NEIGHBORHOOD.

The character of the neighborhood which is described in this ordinance can only be obtained when each individual project is made to work together with its adjacent lots. The beauty and character which the city hopes for will only arise as a result of coherent relationship and connection between parcels

with regard to gardens, courtyards, parking, build-ings, and driveways.

In particular the following types of connection between adjacent lots are all critical:

(1) Connection between position of gardens or open spaces, either in the interior or front of the lot, to form larger gardens and open spaces.

(2) Spatial cooperation between adjacent building volumes, to maintain the coherence of open space and light access, and to permit growth of relatively long stretches of building volume parallel to the street.

(3) Sharing between driveways and back alleys, with the possibility of obtaining easement on adjacent driveways, to reduce the number of driveways.

(4) Connection between parking lot positions, to improve accessibility from driveways and alleys.

(5) To achieve these types of connections, examine the context of map with regard to the following matters:

(6) Identify next-door gardens with which the proposed garden on your lot can connect to create a larger garden; or any beautiful open space along the street on adjacent lots, which is worthwhile preserving and extending by your acts.

(7) Examine the position and configuration of building volumes on adjacent lots and consider the possibility of placing your volumes in a way that creates continuity of building volumes along the street.

(8) Consider the possibility of obtaining easement for the use of existing driveway on adjacent lot.

(9) Examine the configuration of existing parking on adjacent lots, to see if any possibility exists for combined use of parking, or combined access to parking.

(10) After considering these possibilities, and before beginning the detailed design and layout of your project, *it is necessary to get a single basic vision of the position, size, and nature of main garden.*

Step 3

DECIDE BASIC ARRANGEMENT AND POSITION OF MAIN GARDEN.

The garden must be large, no less than 28 feet by 45 feet. In addition, choose the position for this large main garden which does the most possible to connect with existing spaces on next–door lots, and which also does the most possible to provide a balanced variety of space in the neighborhood.

There are numerous ways according to which the main garden can do this:

(1) If there is an existing large interior garden on the adjacent lot, the proposed main garden should be placed adjacent to it so that the two spaces work together.

(2) If there is a beautiful front garden in the street, or a
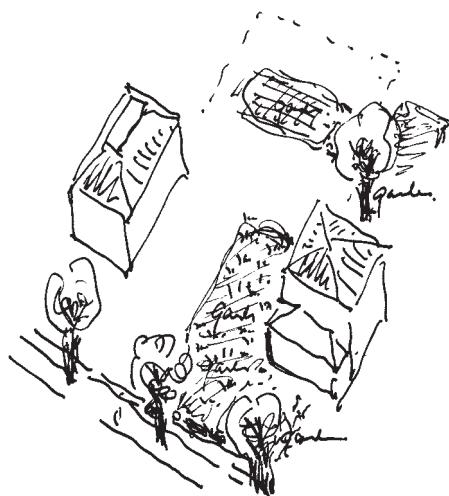
Step 2: First idea of where the gardens go, to connect the project to the neighborhood around the site

broad lawn with the front of the buildings at least 30 to 35 feet back from the sidewalk, the proposed main garden should connect with existing front gardens on at least one side, so as to form a "long" garden along the street.

(3) If there is a need for a deep open space on the street, part of proposed building frontage should be located at least 75 feet back from the sidewalk, so as to form a "deep" garden on the street. In this case, the front garden must be enclosed by existing buildings of adjacent lots on at least one side.

(4) If there is a need for a spacious internal courtyard on the block, proposed main garden should be an internal courtyard entirely contained within the lot. This is mainly possible on a lot wider than 80 feet, and is difficult on narrower lot.

(5) If there is a beautiful tree or stand of trees, the proposed main garden should be placed so that the trees form a focal point of the main garden.

(6) If there is an apartment building on an adjacent lot, with entrances facing the proposed building, the main garden should be placed so that those entrances are on the edge of a large shared space which includes the main garden.

(7) If there is a single-family house next door, the main garden should be placed so that there is a large space next to the house, for light and view.

(8) Of course the way which the main garden can best improve the positive qualities of the existing place depends on the specific site itself.

Step 4

CALCULATE NUMERICAL PARAMETERS.

Once the position and size of the main garden are approximately clear, calculate areas which will be devoted to building volume, parking, and driveways.

1st INDIVIDUAL PROJECT

2nd INDIVIDUAL PROJECT

3rd INDIVIDUAL PROJECT
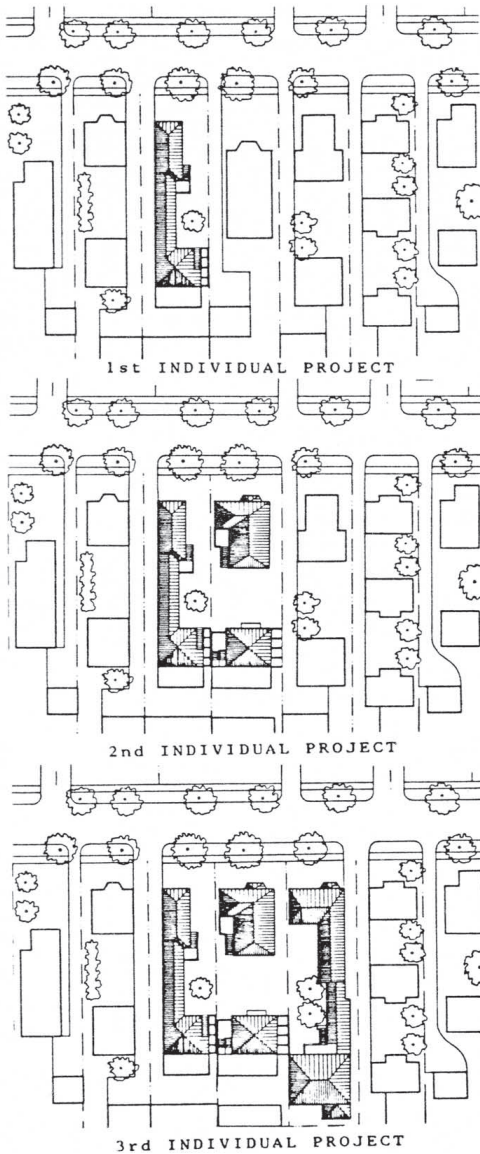
A sequence of three developments, on adjacent lots, showing how each new apartment building is asked to "join hands" with existing ones to create useful and lively outdoor space, gardens, and shared parking and driveways.

(1) First obtain context restrictions on size of garden and building heights, as a result of adjacent projects. Then calculate the maximum possible volume of built space, by considering setbacks, garden size, and building height restrictions, in combination with number of parking spaces and parking type. At the end of this step, you should have a definition of the areas which will be devoted to the following:

(2) Main garden

(3) Other open space

(4) Surface and/or half-depressed parking

(5) Underground parking (if any)

(6) Driveways

(7) Footprint of building at grade

(8) Building footprint built over parking

(9) Total area of built space

(10) Number of units

(11) Number of parking spaces

(12) Assume, at this stage of the calculation, that the building has two stories overall. Later adjustments will be made to correct for volume and building height.

STEP 5

LOCATE PARKING AND DRIVEWAY.

Locate required parking in a position where it cannot be seen from the street. After getting the numerical parameters, choose the parking type in relation to these numerical parameters. Once parking type is clear, it is possible to decide the position of parking, and on position and type of driveway.

(1) All at-grade parking, when aggregated, must be located at the rear 40% of the lot. There are limited exceptions.

(2) All naturally ventilated underground parking must be located at the rear 50% of the lot. There are no exceptions.

(3) Mechanically ventilated parking must be located under building volumes. It should not be built under the main garden, with some exceptions (30% of the main garden).

(4) If possible, acquire easement on any driveway on an adjacent lot. The City encourages the acquisition of easements for the use of adjacent driveway, and makes it permissible to meet parking access in this fashion. If either of the two adja-
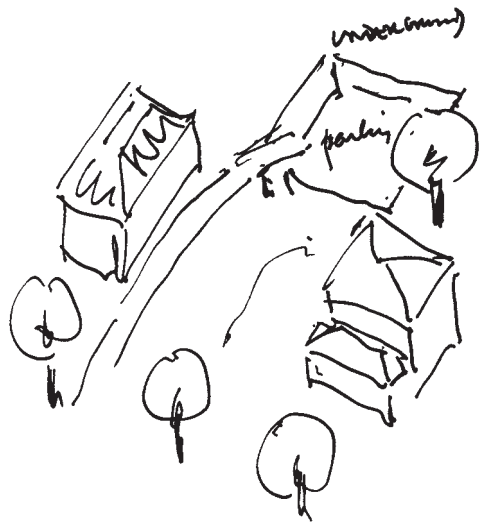
Step 5: Placing the parking, in a way that is not obtrusive for the street

cent lots has a driveway which is capable of providing access to the rear of your lot, then you may be able to share the use of this driveway, if the owner will agree to give an easement. It is recommended that there be a negotiation between yourself and the adjacent property owner, in which you try to plan your main garden and building volume so as to protect your neighbor's property values, in exchange for a driveway easement. If you succeed in obtaining an easement for the use of an adjacent lot driveway, then you are entitled to a density bonus as specified on the density charts.

(5) If no easement is available, you must provide a new driveway. If you have chosen not to use an existing driveway, then you must provide an eight to ten foot driveway. No more than one driveway is allowed per lot. Locate the new driveway along the property line.
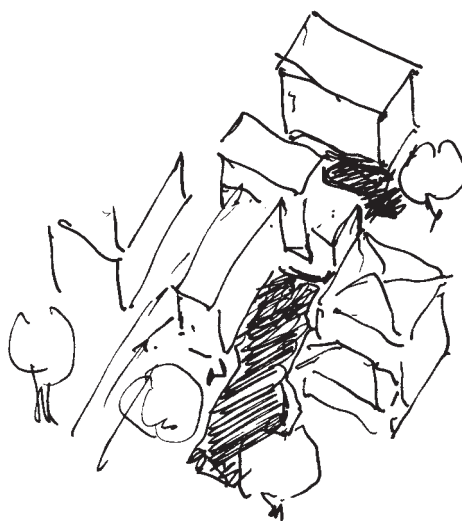
(6) All other details of parking layout are to be worked out later.

Step 6: Placing the building volumes to help form the gardens, and to contain the right number of apartments

STEP 6

DECIDE ON LOCATION OF BUILDING FOOTPRINT AND DEFINE ROUGH SHAPE OF BUILDING VOLUMES.

Now locate and shape the buildings according to the beauty of the garden and the character of the street. Locate the building volumes in a way that provide substantial enclosure to the garden. The maximum width of building volumes is 35 feet. You must therefore surround the open space defined in step 3 with long narrow volumes of building. At least 60% of the perimeter of the garden must be enclosed by buildings. At the same time, allow for connections and passages between gardens and open spaces. In addition, if appropriate to the configuration of the main garden, try to place one of your building volumes parallel to the direction of the street, to enclose the garden and contribute to the shaping of the street front. Bear in mind that in order to give good daylight to apartment units, and to enclose outdoor space effectively, the maximum width of building volumes is 35 feet. At this stage you may assume that this volume has an average height of two stories.

(1) While locating and shaping your building volumes make sure that your interior garden is visible from the street. Interior courtyards and gardens should be experienced from the street, and be visible from it, so that they contribute to the beauty and liveliness of the street. Some interior gardens will be wide open on the street and some will feel secluded, connected to the street through a passage. This type of variety is extremely desirable. At the time your project reaches this step, the feeling of the whole street, from the point of view of visibility of gardens, has to be assessed. The new building should be open or enclose its garden towards the street to a degree that contributes mainly to the liveliness and character of the street as a whole.

(2) Pay attention to the front setback line. Limited amount of single-story building volumes are allowed to project forward of existing front setbacks of adjacent buildings. These volumes or portions of volumes must be built in such a way that the front is 10 feet from the property line.

(3) If there is no other building on your side of the street, within 200 feet in either direction, that projects forward beyond existing front setbacks, then you are strongly encouraged to place part of your building out to within 10 feet from the front property line.

(4) You may build closer than 5 feet to the rear and side lot line in order to create continuity of building volumes, and are encouraged to do so, provided that you meet requirements concerning light access to windows in adjacent buildings. There are two major reasons for allowing and encouraging zero setbacks. No open space is wasted on leftover strips of unusable space. And the fact that a building volume can be on a side lot line allows for connection between adjacent building volumes. So, it is possible to introduce building volumes parallel to the street together with building volumes perpendicular to the street, thus enabling the formation and enclosure of gardens and courtyards.

(5) Make sure that minimum separation requirements between proposed and adjacent buildings are satisfied. If you have placed the building volume closer than 5 feet from side or rear lot line, you must pay attention to existing major windows and entrances of adjacent buildings.

(6) Now, re-calculate your total building volume again, and adjust story height in different parts of the building volume. Throughout the building volume you have defined, the average building height will need to be two stories, to get the maximum allowable density.

(7) In order to bring the building volume into line with the allowed development, the following adjustments must now be made. Any building volume projecting beyond adjacent front setbacks must be one story. Any building volume within 50 feet of the street, for at least 50% of its length along the street, must be softened by one-story porches, alcoves, room extensions, or galleries. Any three-story construction needed to complete the full allowable density, must be placed on the back 30% of the lot (see standards). Three-story construction may be built over parking.

STEP 7

REFINE THE GARDEN SHAPE IN RELATION TO BUILDING AND ADJACENT GARDENS.

Now embellish, adjust and refine the size, extent and shape of the main garden, taking into account the following: The main garden is to be aggregated in the form of a single rectangular entity of space, as specified by the open space standards. Seventy percent of the main garden must be on natural ground, not over subterranean parking.

(1) There are limited exceptions, specified in the ordinance.
(2) It is also important that the main garden can be enlarged and extended by other developers on the neighboring lots on either side. To make this possible, the main garden must always touch at least one side lot line, except in cases where the lot is more than 80 feet wide.
(3) Place secondary gardens to encourage connection between gardens. There must always be some garden touching one of the two side lot lines. Where this requirement is fulfilled by the main garden, there need not be any secondary garden. All required open space can be used for the formation of the main garden.
(4) On a lot which is less than 80 feet wide, where the main garden must touch one side lot line, a secondary garden is not required. On a lot more than 80 feet wide, if the main garden does not touch at least one side lot line, a secondary garden must be created along one of the lot lines.

STEP 8

LAY OUT DETAILS OF PARKING.

Put in enough details of parking, even at this early stage, so that number of available parking spaces and adequacy of driveway widths and turning radii will be near enough right so that later development of the design will not upset the way that everything has been worked out.

(1) Locate parking spaces, following the design standards specified in the ordinance.
(2) Design driveway and curb-cuts following the design standards specified in the ordinance.
(3) If driveway is adjacent to the main garden, give it detailed position and treatment to protect the garden.
(4) Shape parking space as positive and usable space.

STEP 9

DIVISION INTO APARTMENTS

Within the overall building volume which has been established, the apartments permitted by the ordinance, may now be identified.

(1) First define the location of the apartments. Cut up the total volume into apartments in such a way as to define the best and most pleasant apartments. There should be no attempt to make apartments of standard shape. Rather, each apartment should take a shape which is appropriate to its unique position in the building volume and with respect to daylight, access to outdoors, and entrances. The living room or main room of the apartment should have a garden view if possible.
(2) Provide for access from the parking to the apartments through the garden. The pattern of circulation which is created, should encourage very simple access from the parking lot, through the main garden, to the apartments.

STEP 10

PLACE AND SHAPE APARTMENT ENTRANCES

Place entrances facing main garden. In as many cases as possible, the apartments should have access from the main garden.

(1) Provide apartment entrances from the street. At least one, and possibly two apartments should be entered directly from the street side, with entrances visible from the street.
(2) Make apartment entrances individually identifiable. Some entrances to apartments may be embellished with porches, stoops, steps, or stairs. This should be done only for those cases where this element helps the overall structure.
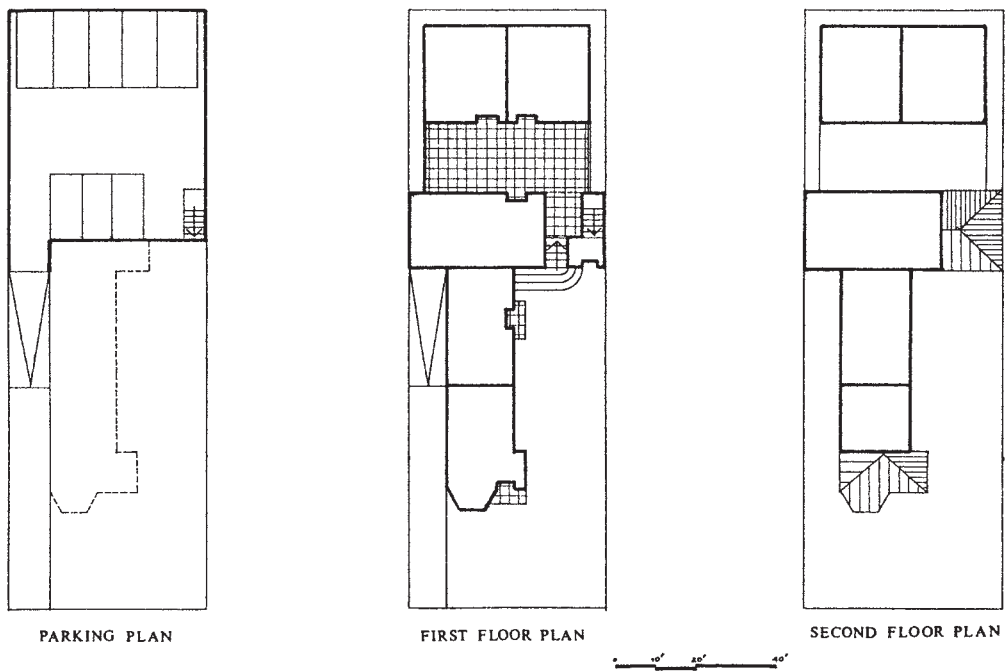
STEP 11

DESIGN DETAILS OF GARDEN

Embellish the garden with various details that will make it a pleasant, social, and useful place for individuals, and for the inhabitants as a group.
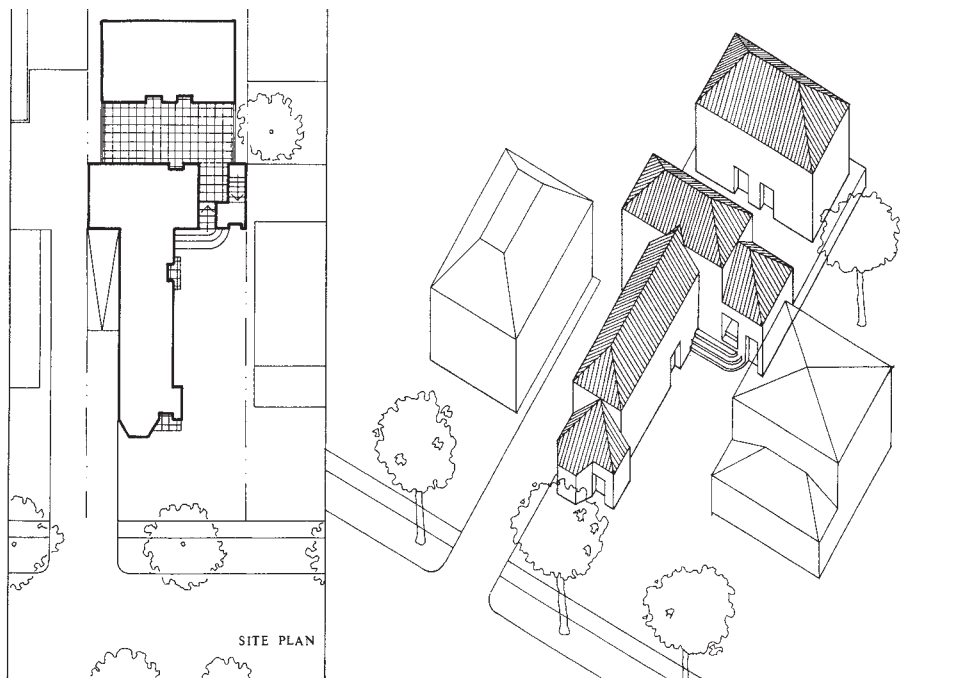
(1) Locate path from street to units.
(2) Locate path from parking to units.

PARKING PLAN   FIRST FLOOR PLAN   SECOND FLOOR PLAN

Parking, and first and second floor plans, showing individual apartments and their entrances

SITE PLAN

The finished building

(3) Place low walls, trellises, hedges, trees, etc. to provide additional enclosure for main garden.

(4) Place low walls, trellises, hedges, along building front.

(5) Define position of major trees in the main garden and secondary gardens.

(6) Locate lawn areas, paved areas, and benches in the garden.

(7) Define position of trees along the street.

(8) Define special embellishments for the front garden and areas along the street or connecting with the street.

9 / UNIQUENESS OF DIFFERENT APARTMENT BUILDINGS GENERATED BY THE SEQUENCE

Uniqueness of each apartment building generated by the sequence, is clearly visible.

On the pages 313–16, we see a few examples of the variety of apartment buildings that can be created by this generative sequence. These are different apartment buildings, designed for a wide variety of site conditions (lot width, orientation, and so on) that occurred in the city of Pasadena. Each of these designs was made for a specific lot in Pasadena, and is unique to that lot. The lots vary in width and depth. They vary in the density for which they have been zoned. They vary in orientation. And, of course, they vary in the character of street which lies beyond the lot, and which must somehow be helped, made more whole, by the insertion of the new apartment house.

The buildings show a surprising variety, all containing the same key invariant features specified by the generating sequence, but nevertheless each unique according to its context.

Dimensional factors are interesting. There is no hint of modular rearrangement in these designs. Rather, the building widths and configurations are pushed, pulled, squeezed, to form well-adapted structures for the conditions that exist on each lot. The variety which occurs, rather more like true organic variety, shows