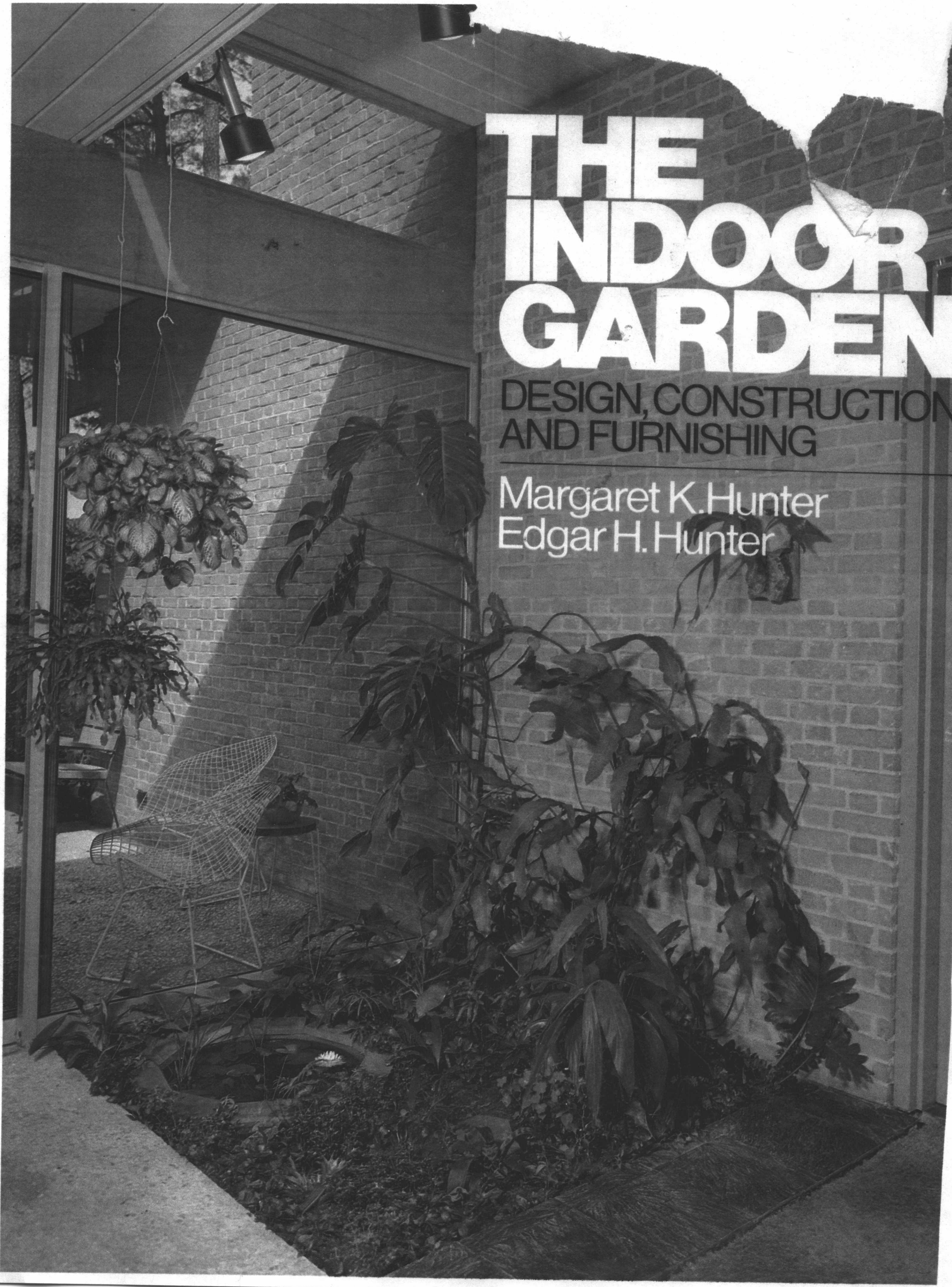

THE INDOOR GARDEN

DESIGN, CONSTRUCTION AND FURNISHING

Margaret K. Hunter
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Cover photograph by Fred Rola

Here is a first-of-its-kind book with complete information on the design and construction of indoor gardens . . . the plants to use in this "live furnishing" of a building . . . and their care. All types of indoor gardens are covered from the simplest home version —using inexpensive materials —to a public indoor water garden, rain forest, woodland, food producing, or desert garden. Specific data is included on:

- Construction details in plan and section for a variety of structural systems and locations
- Special consideration of indoor gardens for children, the elderly, and the handicapped, with a questionnaire to determine design parameters
- Extensive information on plants for indoor use, including many exotic varieties of flowering plants and trees
- Guidelines for planning the plant environment with recommendations on natural and artifical light, growing media, water and fertilizer, and a new system of hydroponics adapted for indoor use

Numerous illustrations including many striking photographs demonstrate the effective use, construction, and care of indoor gardens and suggest ideas for your own design.

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THE INDOOR GARDEN

Symbiosis: The intimate living together of two dissimilar organisms in a mutually beneficial relationship.

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To our clients who have made it possible to practice our craft — and who have enriched our lives with friendships.

The Indoor Garden

To enlarge the circle of domestic pleasures . . . to quicken observation . . . to strengthen family ties . . . to cheer the loneliest with amusements . . . and help the soul in its aspirations by conducting it away from disturbing scenes.

From: *Rustic Adornments for Homes of Taste,* Shirley Hibberd, 1856

Preface

The current enthusiasm for indoor plants and the increased awareness of ecology in general indicates that there is a need for specific directions for the design, construction, and furnishing of indoor gardens.

The Indoor Garden will be useful to architects, interior decorators, and builders as well as growers of tropical plants and the specialty shops that sell them. The prospective home owner can explore the many locations for and types of plant space possible by referring to the photographs, drawings, and details. Remodeling can be planned to include a built-in plant space. The chapter on gardens for the senior and handicapped persons can be used by convalescent or retirement homes to encourage their architects to include this feature in their plans.

The construction of indoor gardens, with details and illustrations of the completed buildings, is thoroughly discussed. The important adjunctive aspects such as light, heat, humidity, growing media, and plants which may be used, as well as a chapter on managing the plant space, are included. The best locations in public and private buildings are discussed and many are illustrated.

The earliest of the indoor gardens included here was built in 1946 in Hanover, New Hampshire. The latest was completed in 1976 in Raleigh, North Carolina. All buildings were designed by the architectural firm of E. H. and M. K. Hunter, A.I.A., Raleigh, North Carolina. The architecture spans 30 years, and the needs of people for a close relationship with plants have increased in this time. Commercially available equipment has vastly improved since the first of these gardens was designed, especially in the area of artificial lighting. Some features that we designed earlier to be custom made are now on the market. Awareness of the toxic effects of insecticides in outdoor use has made it imperative to find natural pest controls for indoor gardens.

It is possible to garden indoors with plants in scattered pots. It is also possible to create a mini-climate totally disassociated from the outside climate. Rooms in a house or a public building can be climate-influenced by an adjacent area filled with plants. Most important is the fact that plants seen through a window do not evoke the same response as physical proximity between plants and people. In order to bring about this proximity there must be some compromise between the conditions with which people are willing to live and the conditions that a plant must have to live. There are some plants living outdoors in almost every climate in the world; thus there are some plants that can adapt to every human living condition. Much of the pleasure of growing indoor plants, however, comes from planning conditions that are as much as possible like those native to the plant and in watching the successful growth that ensues.

MARGARET K. HUNTER
EDGAR H. HUNTER

Raleigh, North Carolina
November 1977

Contents

Why Indoor Gardens?

The history of indoor gardens is a long one, either because of man's naturally symbiotic relationship with plants or the opposite attitude of defiance of nature. There is evidence that the Roman atrium was well furnished with flowering plants in hanging pots and baskets and that the Romans built greenhouses of sheets of mica to let the sun in and used heat given off by manure to winter-force the vegetables and exotics collected on their campaigns. Glass rooms known as "orangeries," in which citrus trees were grown, began to appear in country estates in early seventeenth-century England, and at Mt. Vernon George Washington had a plant room in which he raised exotics.

PLANT HUNTERS

Plant hunters of the past and present are responsible for the great variety of ornamental plants from around the world now available to the indoor gardener. Egyptian queens sent their gardeners to other countries to gather their flora, and the armies of Greece and Rome collected exotic plants in the lands they conquered. The Crusaders brought unfamiliar varieties back to England, and Columbus returned from his voyages with seeds found in the New World.

During the seventeenth and eighteenth centuries the crews or passengers of colonizing and merchant ships often included a botanist for the purpose of identifying plants of possible value, as food or medicine or to accommodate the demand for unusual species from abroad. One of the most fascinating men of this era was William Dampier who collected extensively while plying his "trade" of piracy off the coast of South America. He escaped hanging and retired to England to write *A New Voyage Around the World* (1697) in which he was the first to describe the avocado, the sapodilla, and the star apple, discovered in Panama.

Botanists of the eighteenth century like John Bartram of Philadelphia and his son William exchanged plants with others from abroad. George Forster, in his book, *A Voyage Round the World,* published in 1777, tells of the tropical plants he discovered as a member of the scientific expedition commanded by Captain James Cook in 1772.

David Fairchild, who in the 1930s was responsible for introducing many varieties of crop plants in cooperation with the U.S. Department of Agriculture, was fascinated by the flora of the tropics and made numerous discoveries among tropicals from which we benefit today. Many are to be seen in his famous Florida garden.

Perhaps the ultimate in plant hunting was accomplished by Alfred Byrd Graf whose years of searching for ornamentals for indoor culture culminated in his magnificent book *Exotica,* first published in 1957 and now in its ninth edition. This compendium of photographs and verbal descriptions of plants from all over the world was assembled by Mr. Graf during his years with the firm of Julius Roerhs Co. of Rutherford, New Jersey, importers and wholesalers of ornamental plants. It was while visiting their magnificent greenhouses — some 40 feet, high — in which tropical trees and plants are housed, that we realized the great potential of tropical plants as an element of design in architecture.

EARLY INDOOR GARDENING

Special heating systems had to be devised for the nurture of exotic plants. One system, known in the seventeenth and eighteenth centuries, was comprised of a series of coiled brick flues imbedded in brick walls. In a more common method hot coals were packed in large holes in the floor. Records show that this system was in use as early as 1684. Hot-water heating systems were introduced in Holland in the early nineteenth century, although France lays claim to the use of hot water for this purpose in 1777. Hot-air heating was first installed to protect indoor plants in England in 1802, and long trays of fermenting tree bark heated and humidified the orchid houses of the nineteenth century.

Many of these systems were developed expressly for the purpose of growing tropical plants indoors. Glass roofs to catch the sun appeared in England in 1717 and eventually led to such extravaganzas as Paxton's Crystal Palace (1851).

In the United States plants have been grown in kitchen windows since the days of the early settlers and bay windows full of green things flourished along with Victorian architecture. However, it remained to modern architects in Scandanavia to introduce the integration of permanent gardens into indoor spaces.

Books of instruction on horticulture indoors, such as John Abercrombie's *Gardener's Pocket Dictionary* published in 1786, *Every Man His Own Gardener,* 1767, and the *Hot House Gardener,* 1789, also by Abercrombie, enticed the wealthy to greater efforts in the care of exotics. Many other books dealt with greenhouse culture, but by 1824 Claudius Loudon had included a section, "The Proper Treatment of Flowers in Rooms," in his comprehensive book *The Greenhouse Companion.* In 1839 Commander James Mangles printed a book called *The Floral Calendar* which contained information on heating systems, plant stands, flower pots, goldfish, seeds of exotics, and a variety of "decorative appendages" for growing plants on windowsills.

Moving through the house among green growing things and flowering plants gives a lift to the spirit on this foggy winter day. This garden is also shown on page 8. The plan is on page 4 and detail, on page 7. This garden can be at floor level, for travel is parallel to it at all times.

Photograph by Jack Roche

MAN AND PLANTS

The symbiotic relationship between plants and people is seldom fully realized by the average person. Without plant life man could not survive; without animal life plants could not. Each is necessary to the other for the breath of life. What plants need to carry on their life processes man discards as a result of his. What man needs for his life process is a product of the growth pattern of plants. This miraculous cycle is repeated countless times a minute to make our life on earth possible.

In the process of building their structures plants must utilize carbon dioxide. Water and carbon dioxide combine in the chloroplasts (minute bodies in the leaves). Triggered by light (energy), the chlorophyll (green pigment) absorbs heat, water, and carbon dioxide to form a sugar (glucose). Oxygen is given off in the process.

From glucose plants produce starches and fats and with the nitrogen, sulfur, and phosphorus taken up by their roots can make protein. In the absence of light plants use a small amount of oxygen and give off some carbon dioxide.

Man must breathe oxygen, which enters the bloodstream through the lungs, unites with body tissues, and oxidizes them. This oxidation produces the heat that keeps body temperatures uniform. In this process carbon dioxide is formed, carried back to the lungs, and expelled.

To a certain extent plant growth and health can be improved by higher levels of carbon dioxide, although many other air pollutants will impede growth. This principle cannot generally be applied in the indoor garden for plant health, for it is undesirable to introduce CO_2 artificially into a closed human environment. A common occurrence in today's social life, however, would be automatically beneficial. A large party, held in the same room with plants and in the presence of sun or strong artificial light, could produce enough "hot air" to raise the CO_2 level and give the plants a special lift. Conversely, the often stale air at a party would be made fresh by the oxygen given off by the plants.

In any discussion of the carbon dioxide-oxygen cycle, or of the transpiration of water from plants into the air, a paramount feature of plant leaves are the stomates, the minute openings in their surfaces. These stomates are surrounded by guard cells that control their opening and closing. Some plant varieties have stomates on both the upper and lower surfaces of their leaves; others have them only on the lower.

The degree of opening of stomates is determined by the water content of the guard cells. When the guard cells are full of water, stomates are open; with water decrease, the guard cells come together and the stomates close. The guard-cell moisture is determined by the amount of water taken up by the roots and pulled upward from one plant cell to another. Guard-cell moisture us also affected by the relative humidity of the air.

The residential indoor garden should be located where it can be experienced constantly by the family. When it is designed as an integral part of the home, it will involve children as well as adults in the enjoyment and care of the plants.

Humidity in the air is measured as "relative humidity" – the percentage of actual water vapor in the air at a given temperature compared with the maximum amount the air could hold at that temperature. The rate of water loss in a plant increases with decreasing relative humidity.

A healthful and comfortable level of humidity may be maintained indoors in a dry climate or during the winter heating months in a cold climate by manipulating the watering of a plant space if the space is large enough. A few scattered pots of green things are of little positive value in room humidification. Transpiration, or the exchange of water with the atmosphere, is affected by the radiant energy (light) to which the leaves of the plant are exposed. It occurs mainly when the stomates are open. If the plant is not properly watered, the stomates close to prevent the escape of water and the leaves wilt. At the same time this action prevents the carbon dioxide-oxygen cycle from taking place and the plant will soon die of starvation.

Pots set into a bed of good soil will even off the highs and lows of water available to the plants. This arrangement is infinitely preferable to isolating plants in pots, for, shown by the action of the stomates, growth stops with lack of water. The jerky grow-stop situation provided in a single pot that has been allowed to dry out, then watered, takes strength from the plant.

While carrying on these life processes plants will more than compensate for the work required in their care by their contribution to humidity modification, by raising oxygen levels, and by cleaning the air of pollutants.

Aesthetically, the well-designed, built-in plant space is vastly preferable to an array of separate plant pots. When plants are well grouped, the indoor garden should resemble the natural plant colonies found outdoors.

To humans the grass often seems greener somewhere else. If the building is in a damp, cool climate, the occupant may yearn for the brilliant sun of the desert and its myriad cactus forms. Conversely, if he is a desert resident, the lush, cool green of more temperature areas or the warm tangle of the jungle may have appeal. Outside soils may be too acid or too alkaline to grow favorite plants. The indoor garden, controlled microcosm that it is, will allow plants foreign to the building's outdoor climate to thrive.

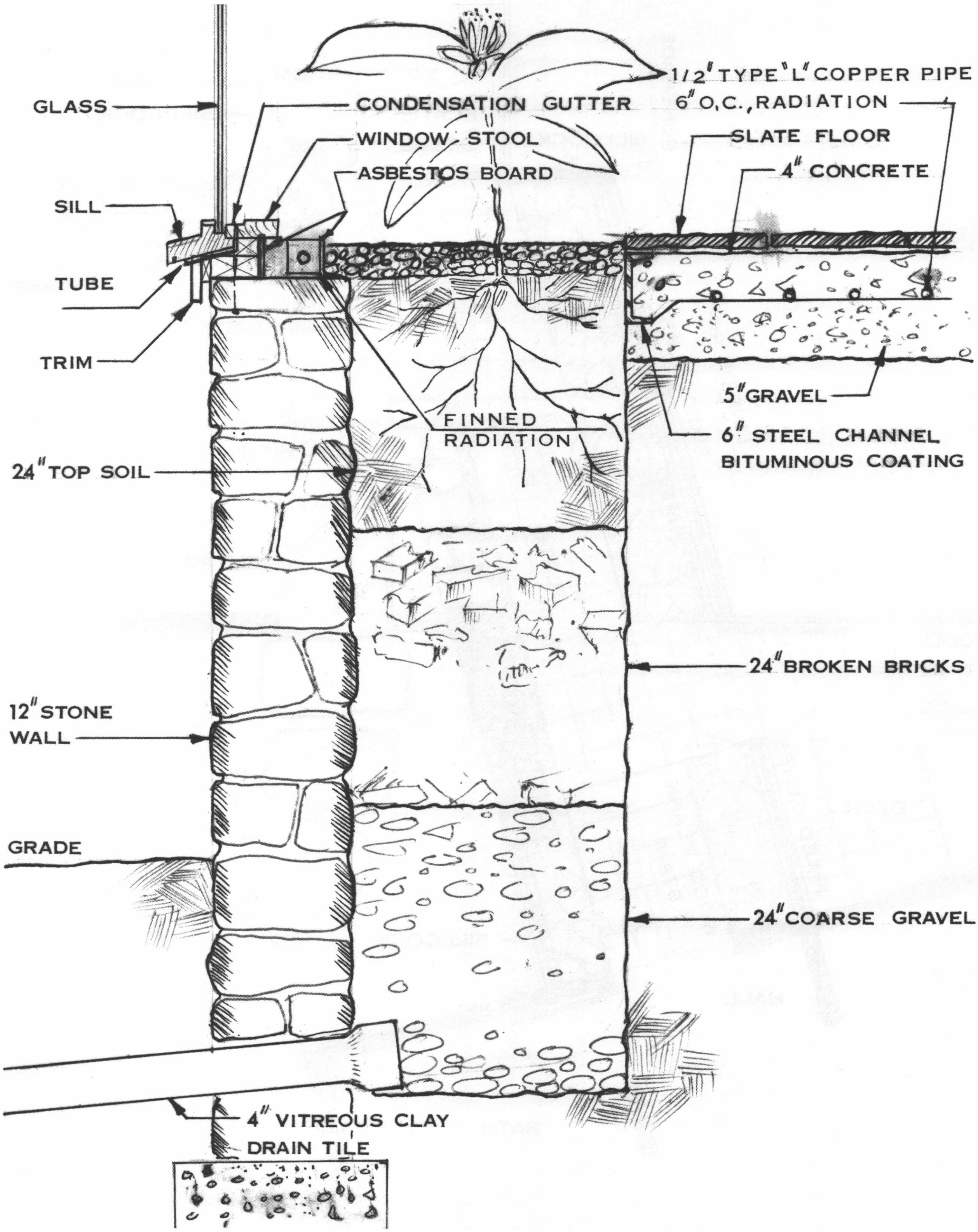
Children can better learn about plant life and its care in the intimate relationship that the indoor garden has to humans in a closed environment. The indoor garden can give the elderly or handicapped person something to look forward to — the opening of a bud, the new growth on a healthy plant, or a few hours work tending a patch of green.

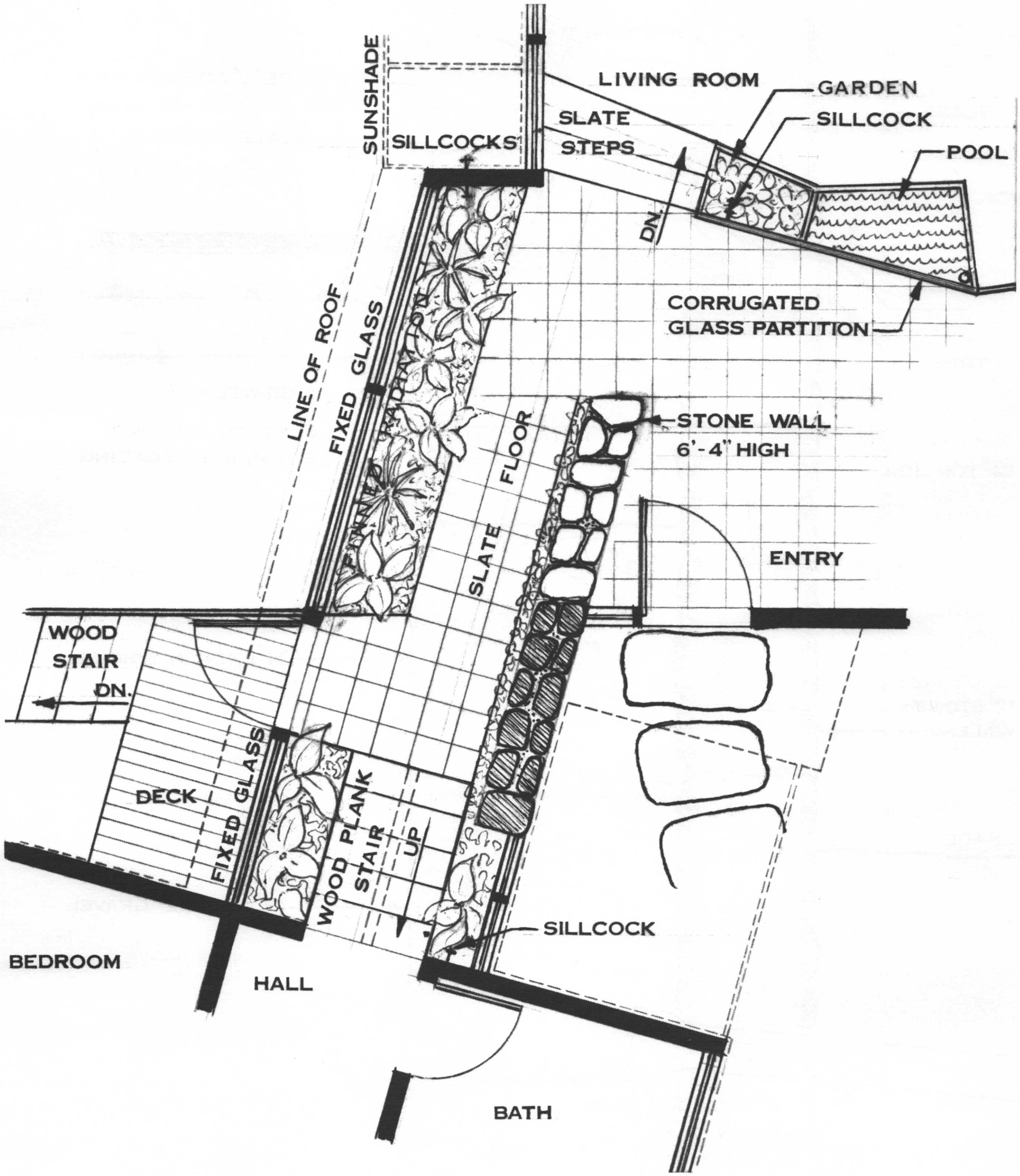
The indoor garden can be a major design element, one that depends on several factors: client desire for and ability to handle plant materials, type of site, general building function and design, and budget. The garden can be small enough to water by hand or large enough to make mandatory the installation of a hose bib and out-of-sight storage for the hose or a buried automatic watering system.

Well-designed lighting systems may have to be developed for visual effect or to compensate for less-than-ideal natural lighting.

Last, the design of an indoor garden should fit into and augment the owner's life pattern; it should not become his taskmaster nor should some neglect leave him with his own private desert. It should provide mental refreshment and visual pleasure as the occupants of the building follow

This section shows the construction of an on-grade indoor garden with a stone retaining wall.


1/2" TYPE "L" COPPER PIPE
6" O.C., RADIATION
GLASS
CONDENSATION GUTTER
WINDOW STOOL
ASBESTOS BOARD
SLATE FLOOR
4" CONCRETE
SILL
TUBE
TRIM
5" GRAVEL
FINNED
RADIATION
6" STEEL CHANNEL
BITUMINOUS COATING
24" TOP SOIL
24" BROKEN BRICKS
12" STONE
WALL
GRADE
24" COARSE GRAVEL
4" VITREOUS CLAY
DRAIN TILE



Photograph by Joseph W. Molitor

This indoor garden stretches along the corridor that leads from the entrance hall at the left to the bedroom wing at the right. General space lighting is concealed in a recess in the top of the stone wall. There are no plant lights. The roof overhang shown at top allows the winter sun to enter but cuts out most summer sun at this latitude of 44° north. A Monstera deliciosa flanks both sides of the stair. These plants bloomed and fruited because they were planted directly in the deep soil of the garden; they cling to the stained wood wall with their adhesive aerial roots. In a few years they had traveled along the bedroom corridor to reach the light of the Lucite dome in the ceiling of the bedroom wing hall. The recess in the slate floor at the base of the stone wall forms a narrow slot of soil for growing ivy up the wall. Stephanotis is also trained up the wall and is in bloom. Staghorn fern and a Cattleya potted in Osmunda are hung on the wall where they can be sprayed by hose and also allowed the drying out period necessary to them. Dieffenbachia forms a foil for the flowers of Ixora, and Clivia miniata. Cymbidium orchids and various foliage plants live in harmony here. Detail, page 7.

their daily routines and act as the focus of an awareness of the functions of the plant world and supply those rare elements of joy and surprise that are missing from so many aspects of life.

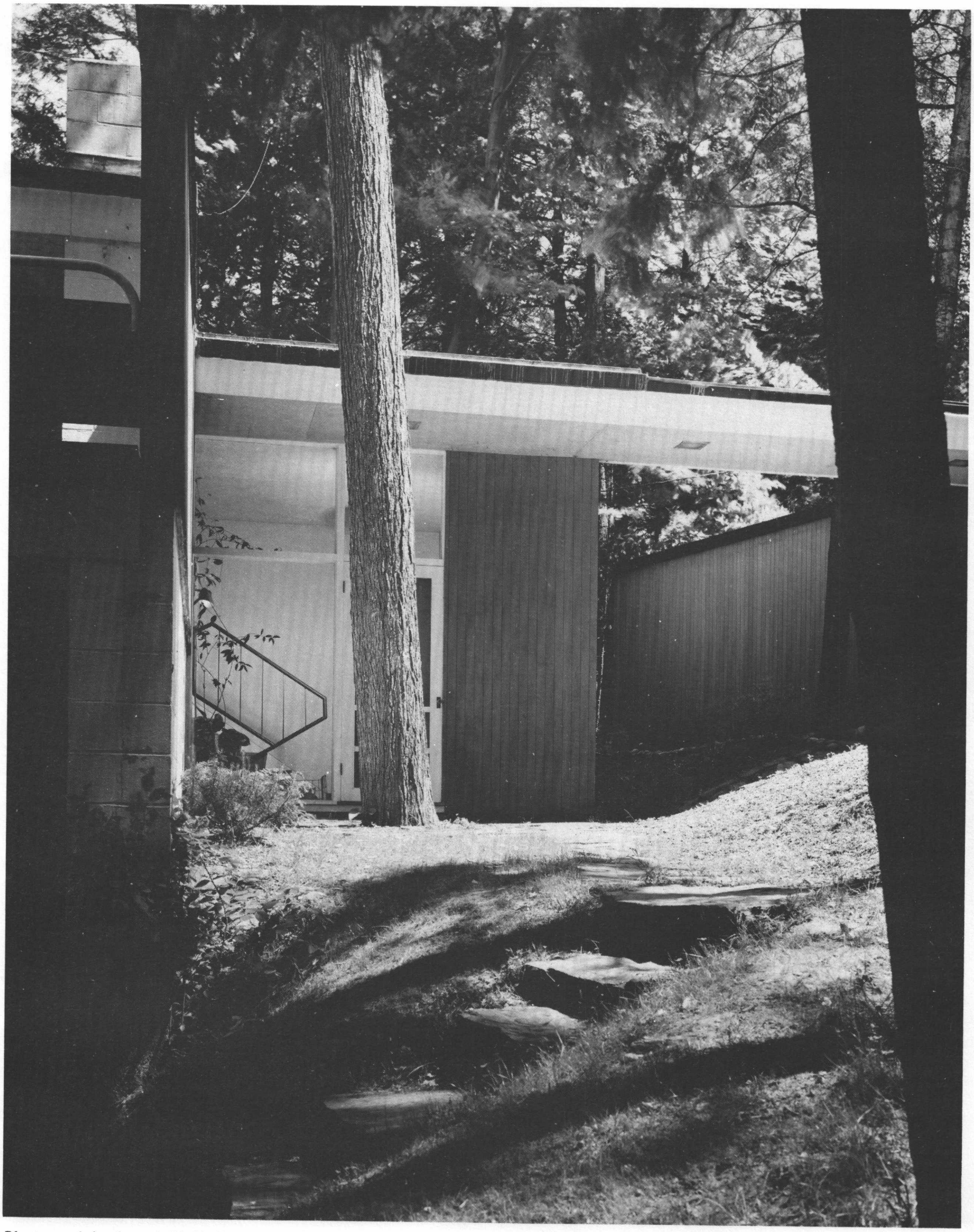
Indoor Gardens in New Construction

The newly watered indoor urban garden gives off a fragrance that will remind one of woodland walks. People are attracted to plants, especially blooming plants, and will often visit a building just for the pleasure of enjoying an island of nature amid the steel and concrete. Because of this response, many public buildings are incorporating live rather than plastic plantings in their designs. The development of better plant growth lights has made this possible. Concurrent with this progress has been the proliferation of sources of plants that will grow in these spaces and the training of specialists in their placement and care. The architect must design public or commercial building plant spaces for ease of maintenance, and plants must be kept in top condition. A sickly plant space is far worse than none at all, and much of the responsibility for its success or failure rests on the designer.

LOCATIONS IN PUBLIC BUILDINGS

Planning for the location of the indoor garden in a new building should be given equal priority with planning for other spaces. In a commercial or public building a plant location is a feature of the main entrance, where a plant space or water garden offers the visitor a pleasant welcome. Plants emphasize the location of a donor's plaque; they function as a feature of a well needed for interior lighting or as a strip of green along a windowed passage between rooms. Plants are an excellent transition between outside landscaping and the indoors, a softening element in a large lobby, a colorful treatment of a stairwell or lunch area, and a relaxing influence in a conference room during long deliberations. An indoor garden can subtly warn of a free-standing stair or other difficult-to-see obstructions to safe movement. It can also serve as a visual warning of an unexpected change in floor level and can attract attention to a particular feature of a building or make less visible a functional element that otherwise would not be aesthetically acceptable. Large plantings can form acoustical or

The visitor is welcomed into this home by an indoor garden that is visible as the house is approached.



Photograph by Joseph W. Molitor

Photograph by Joseph W. Molitor

visual barriers between spaces and will absorb appreciable amounts of noise and dust.

The lives of apartment dwellers are largely removed from growing things. The apartment designer should consider the fact that occupants often fill their apartments with plants to compensate for this lack. A far better solution to the problem of staining and other damage caused by watering and fertilizing potted plants is a permanent garden with good drainage and a supply of water nearby. Apartments that face directions that do not provide good natural light should be equipped with built-in fluorescent fixtures to promote plant growth. Tenants who do not wish to garden indoors should be provided with a cover for the plant box for use as a display surface for whatever collections they may have.

The apartment lobby, although often not much more than a wide passage, can benefit from the relief of green plants. The narrow lighted garden shown on page 81 is a good example.

Interior landscaping should never be used to correct bad design. Too often the result is as bad for the plants as it is for the occupants. The design and location of a plant space should be made to look intentional, not as a decorative afterthought to fill an otherwise useless space.

RESIDENTIAL LOCATIONS

Passion flowers bloom in this indoor garden at a college for women. An indoor garden at the entrance echoes one immediately outside the window at the main entrance to the Fine Arts Building. The garden is a focal point of the area in which hangs a portrait of the past president for whom the building was named. A plaque is placed beneath it. Begonias, with varied leaf and flower forms and geraniums are the foreground planting. Dieffenbachia and a small Monstera occupy the first level of the background. The Passiflora caerulea vine is trained up the wall and extends its graceful tendrils into the light fixture. Cove lighting shown on page 12 washes the wall both up and down and lights both garden and portrait.

The transition from outdoors to indoors is made more gracious by locating an indoor planting at the entrance. This little garden will add a feeling of spaciousness to an often quite dismal area, the first to be seen by those who enter. Floor coverings suitable to an entrance hall, that is, materials water resistant and easily cleaned, will also lend themselves to the needs of a plant space.

The living room is most often chosen as a plant-space location because it is generally situated to take advantage of the best natural lighting and because the plants can be enjoyed by the family for much of their indoor-living time.

The dining room is another location to be seriously considered for it is by the nature of its furnishings a rather formal room and can benefit from the softening influence of plants.

A small garden of herbs or vegetables built into a kitchen window will thrive in the warmth and moisture natural to the area, and blooming plants will distract from the sometimes long hours spent in the kitchen (see page 31).

Bathrooms are becoming larger and their fixtures, more attractive. Here, as in the kitchen, humidity is at a level to suit many tropical plants. An interior hall, necessitated by the plan, can be made visually larger by the use of a narrow planting lighted by special plant lights. A bedroom is perhaps the least desirable location for an indoor garden because of the plant life process in which carbon dioxide is given off at night. If it is deemed imperative to locate a garden in a bedroom, provision should be made for closing off the space at night (see page 37). Many horticulturists, however, feel that this carbon dioxide release is not significant.

In any residential indoor garden to be built away from ground level the weight of the soil when wet must be added to the computations for structural members (1 cubic foot of average soil equals 80 pounds). Waterproofing of the planting area must be made a part of the design.

CONSTRUCTION OF THE PLANT SPACE

The most successful indoor public or private gardens are constructed as a recess in the floor, open down to natural grade (see page 7). Drainage in this situation is as nearly perfect as possible. Salts leached from the soil, water, or fertilizer will sink to the lower layers of broken brick and gravel, away from the roots of the plants. The soil will need to be changed less often but must be added to and turned with a spade once a year as the natural decay of its organic matter allows it to compact.

The on-grade plant space is sometimes not feasible and another method such as a boxed plant space must be used. For permanence, lack of emission of toxic substances, and easy cleaning fabricated stainless steel is the best material. Its relatively high cost is offset by its long life and invulnerability to puncture damage.

A second choice of metal for a fabricated box is copper, which is easily formed but has some disadvantages. The soldered joints must be well made, for large rocks dropped carelessly into a box of this softer material could result in considerable distortion. Certain elements in soft or acid water may affect its surface appearance by causing salts to form at the edges of the soil.

Most other metal alloys cannot be used because elements in the soil, water, or fertilizers attack them and may give off toxins that will impede growth or even kill the plants. These alloys will themselves develop pitting and consequent leakage.

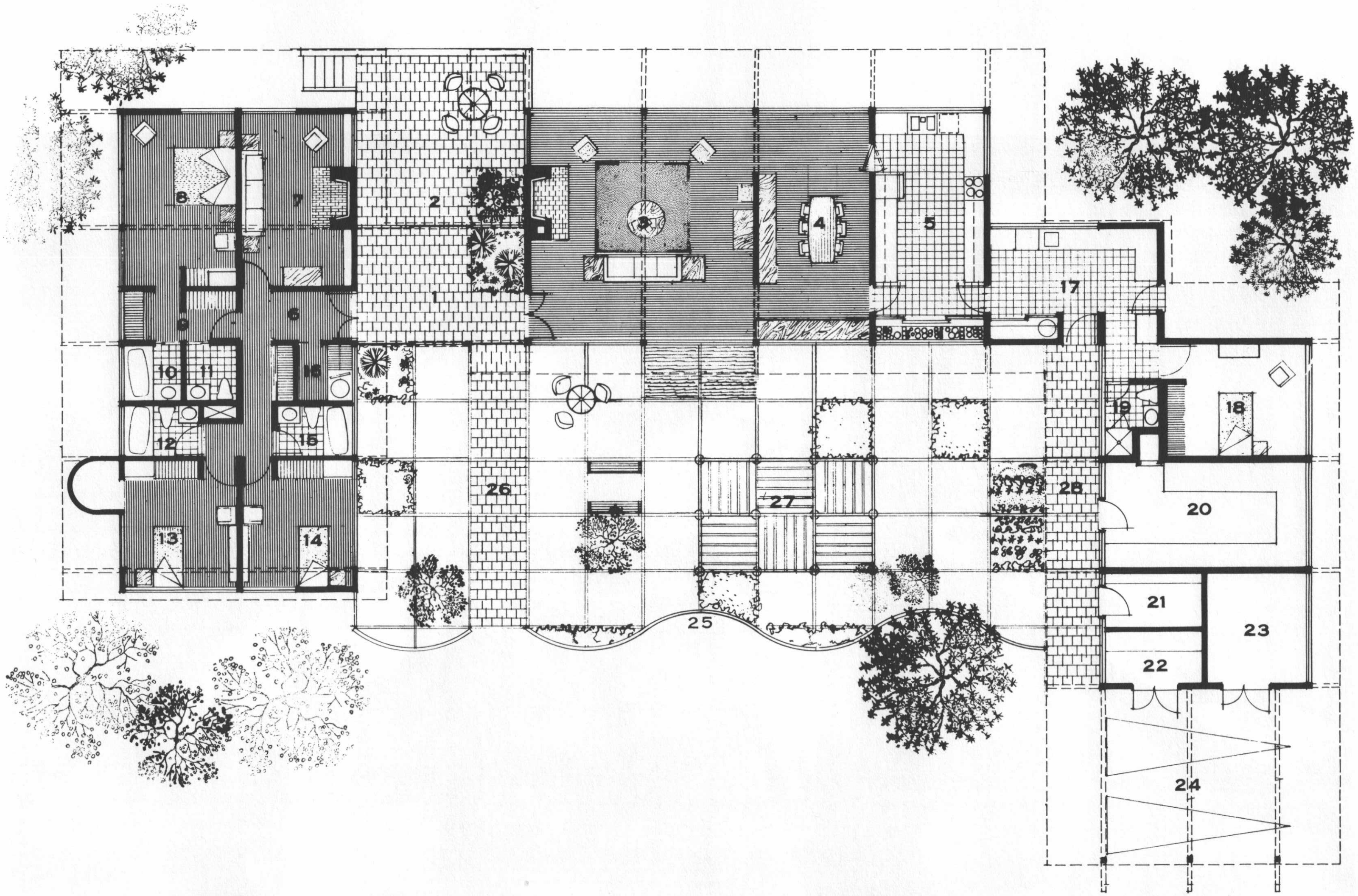
Fiberglass or urethane may be shaped to a specified design. For the residential indoor garden commercially available fiberglass boxes intended for use as outdoor pools may be adapted to this purpose. They are obtainable from water-plant specialists or from the manufacturers of ornamental outdoor fountains. Pools come in sizes ranging from 3 x 4 to 4 x 6 feet, or larger on special order. For an unusual shape or size the designer should consider having the garden cast in fiberglass at a boatyard or formed in place in urethane.

Because of site and construction conditions, an indoor garden of concrete formed in place may be the best solution.

ORIENTATION

For economy of energy it is desirable to orient the plant space to take advantage of maximum winter sun compatible with the comfort of the building's tenants and its function. It is possible, however, to raise a healthy indoor garden in a location that benefits from only a few hours of sun if the plants are chosen from forest underfloor tropicals or from the ferns and plants that grow in more temperate climates. These plants function well in a good level of light but little direct sunlight. They do require some sunlight to live, however, unless artificial lights are substituted.

Photograph by Fred Rola



KEY TO SPACES

LIVING WING
- 1 *Conservatory*
- 2 *Deck*
- 3 *Living room*
- 4 *Dining room*
- 5 *Kitchen*

BEDROOM WING
- 6 *Entry*
- 7 *Study*
- 8 *Master bedroom*
- 9 *Dressing*
- 10 *Master bath*
- 11 *Lavatory*
- 12 *Girls bath*
- 13 *Girls bedroom*
- 14 *Boys bedroom*
- 15 *Boys bath*
- 16 *Linen room*

SERVICE WING
- 17 *Scullery*
- 18 *Bedroom*
- 19 *Shower*
- 20 *General storage*
- 21 *Garden storage*
- 22 *Workshop*
- 23 *Tool storage*
- 24 *Carport*

GARDEN
- 25 *Serpentine wall*
- 26 *Entrance walk*
- 27 *Garden court*
- 28 *Service walk*

If the architect is able to choose the ideal orientation in a cool climate, he will probably provide the indoor garden with natural light from a south or southwest window. When much light is reflected, as in a desert location or from light-colored pavement in a warm climate, a northeast orientation may be required for certain types of plant. The function of the building, energy conservation, comfort of the occupants, and the needs of the varieties of plant to be grown should determine the orientation of the indoor garden. Planning natural light for plant spaces is further explored in a later section (see page 63).

MATERIALS

Surface materials for walls and floors in proximity to an indoor garden should be water- and stain-resistant. They should neither support fungus growth or molds nor warp or buckle with high humidity. Masonry floor surfaces such as slate, brick, tile, terrazzo, or concrete are recommended. Teak should be used when wood flooring is desired because of its natural water-repellent quality. Other varieties of wood may be considered only if a heavy plastic finish is applied and edges are sealed. Vinyl floor coverings withstand water and dirt spills well.

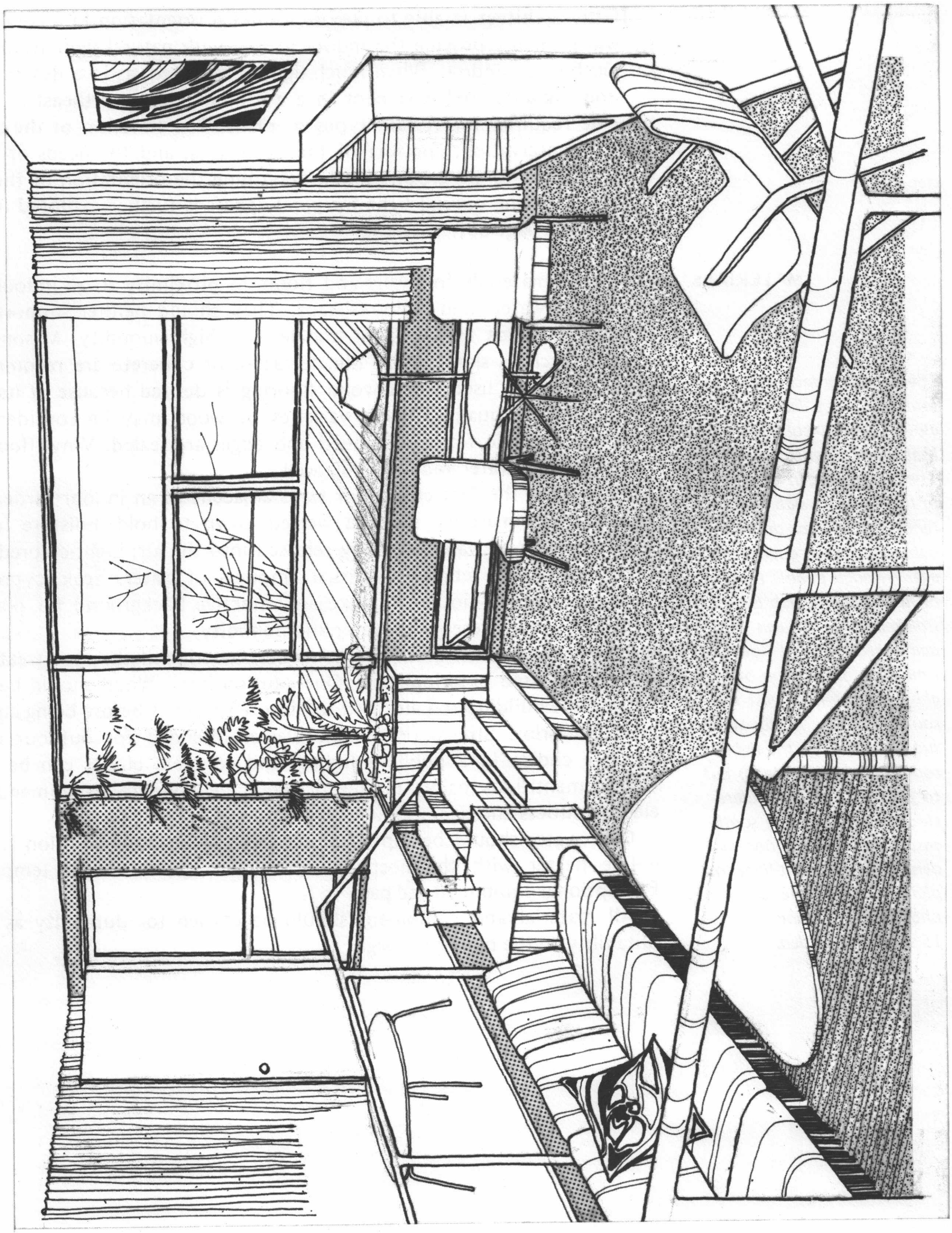
Masonry is the first choice for walls adjacent to an indoor garden. When watering, the masonry may be wetted down to hold moisture for more even humidity as water is slowly released into the air. Light-colored, underbaked brick will retain substantial amounts of water. Teak, cypress, and redwood paneling not only make an attractive background for plants but wear well in the presence of water and humidity.

Other woods such as fir are adequate materials if they are treated with a creosote-based exterior stain. One caution here. Wood should be dipped outside the building and air-dried to dispose of fumes before being employed in the interior. Stucco or cement plaster intended for outdoor use is a possible choice in a public building, and concrete blocks can be painted with cementitious paint. Plaster or wood ceilings are recommended. All electric outlets and lights should be waterproof.

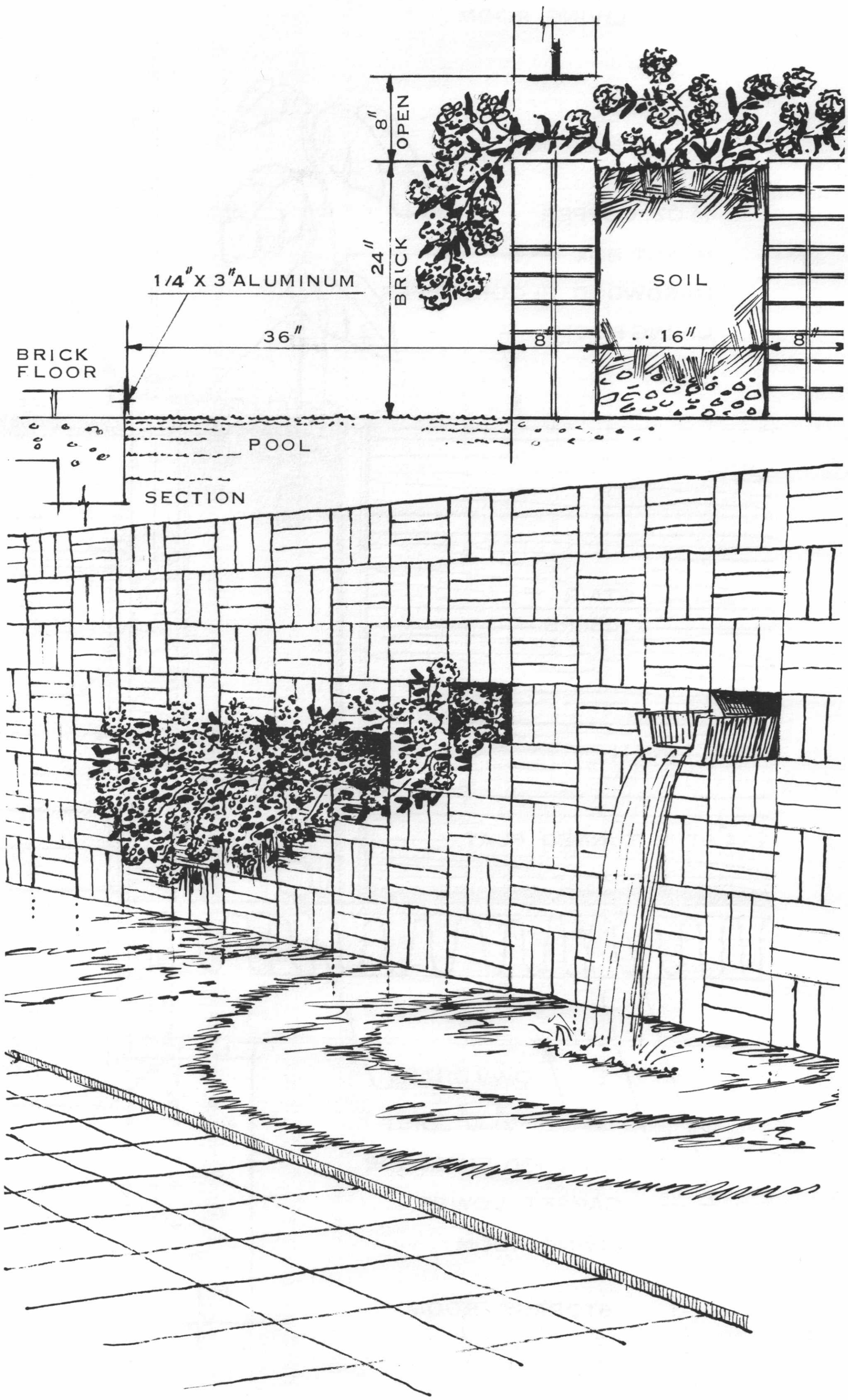
Cold water should be piped to the area. A desirable addition is a small in-line heater with thermostatic control for correct water temperature. For optional equipment see page 167.

All material and equipment should be chosen for durability as well as suitability to the building design.

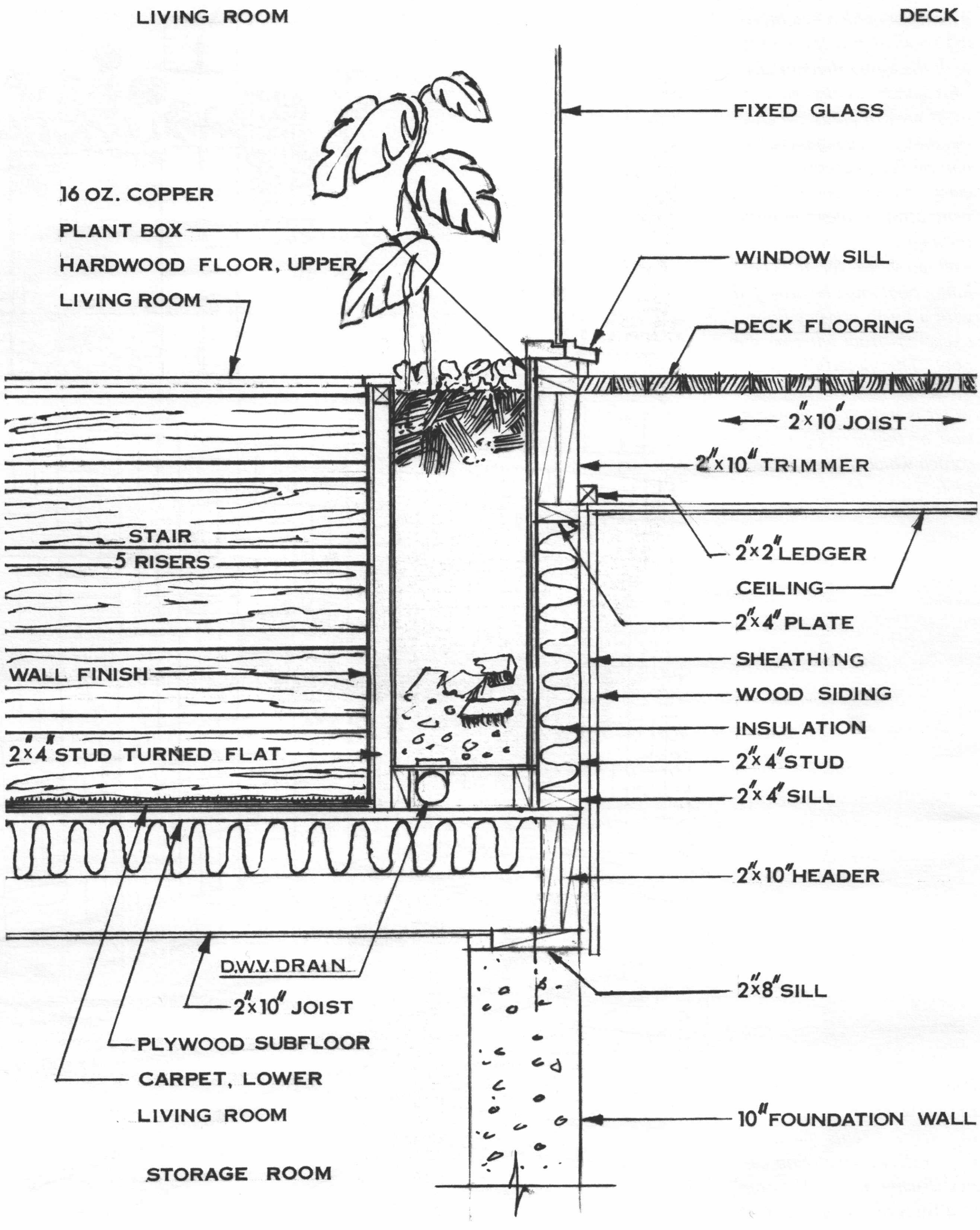
The brick entrance walk of a southern home leads to a glass-enclosed conservatory that serves as entrance hall. The indoor garden is recessed in the concrete slab and extends several feet down to natural grade for good drainage. A rough pebble topping on the concrete slab is the finished floor. It can be dampened freely at watering time. The orientation of the glass walls is northeast and southwest. The hotter west sun is cut off by the living room wall which extends out to protect the deck. Clerestory windows at the southeast edge of the indoor garden give it excellent light for plant growth. The cover photograph and one on page 15 show this garden.



An indoor garden in a meeting room shares its bounty with the lobby that adjoins it. This garden is lighted by plant growth lights, whereas the lobby has a high level of natural light because of the glass entrance doors. This light attracts plant growth through the opening in the wall provided for it. The lobby pool must be provided with a lip to prevent floor sweepings from entering the pool. The waterfall equipment for recirculating the water is hidden in an extension of the meeting room garden which also serves as a table.



(Opposite). The location of the living room garden in this home accents the stairs from the two levels and carries visually across the room as a transition to the out of doors.


LIVING ROOM
DECK
FIXED GLASS
16 OZ. COPPER
PLANT BOX
HARDWOOD FLOOR, UPPER
LIVING ROOM
WINDOW SILL
DECK FLOORING
2"x10" JOIST
2"x10" TRIMMER
2"x2" LEDGER
CEILING
STAIR
5 RISERS
2"x4" PLATE
SHEATHING
WALL FINISH
WOOD SIDING
INSULATION
2"x4" STUD TURNED FLAT
2"x4" STUD
2"x4" SILL
2"x10" HEADER
D.W.V. DRAIN
2"x10" JOIST
2"x8" SILL
PLYWOOD SUBFLOOR
CARPET, LOWER
LIVING ROOM
10" FOUNDATION WALL
STORAGE ROOM

(Opposite). The garden by the stair serves as a transition between the deck and living room levels (see page 18). It is drained to the outside.

Photograph by Joseph W. Molitor

This formal home is the background for fine antiques. The front door to the left and beyond the stairs opens to show the visitor the indoor garden opposite. This garden is echoed outside by another which is seen through the glass exterior wall (see detail, page 126). Although keeping to the theme of formality, this stainless steel plant space, enclosed in wood, contains plants of many different textures which accentuate the quiet surfaces around them. A hose bib is installed in the wall common to the kitchen and drainage is provided by a copper pipe from the bottom of the plant space.

Construction for Existing Buildings

The recycling of existing buildings to new uses or remodeling them for their original purposes will become more frequent in coming years as all aspects of energy and resource conservation are explored.

The remodeling of a building often presents an unusual opportunity to include an indoor garden. The architect should examine all remodeling commissions with a view to enhancing the design with indoor plantings.

Suitable water-resistant materials, already discussed, should be used in the vicinity of the garden and piping for watering is an essential. Natural and artificial lighting, heating, cooling, and humidification are discussed in later sections.

Designs for plant spaces in remodeled buildings can be as varied as the buildings themselves. Most of the details shown for new buildings are adaptable to the old.

HOTELS, APARTMENTS, AND OFFICES

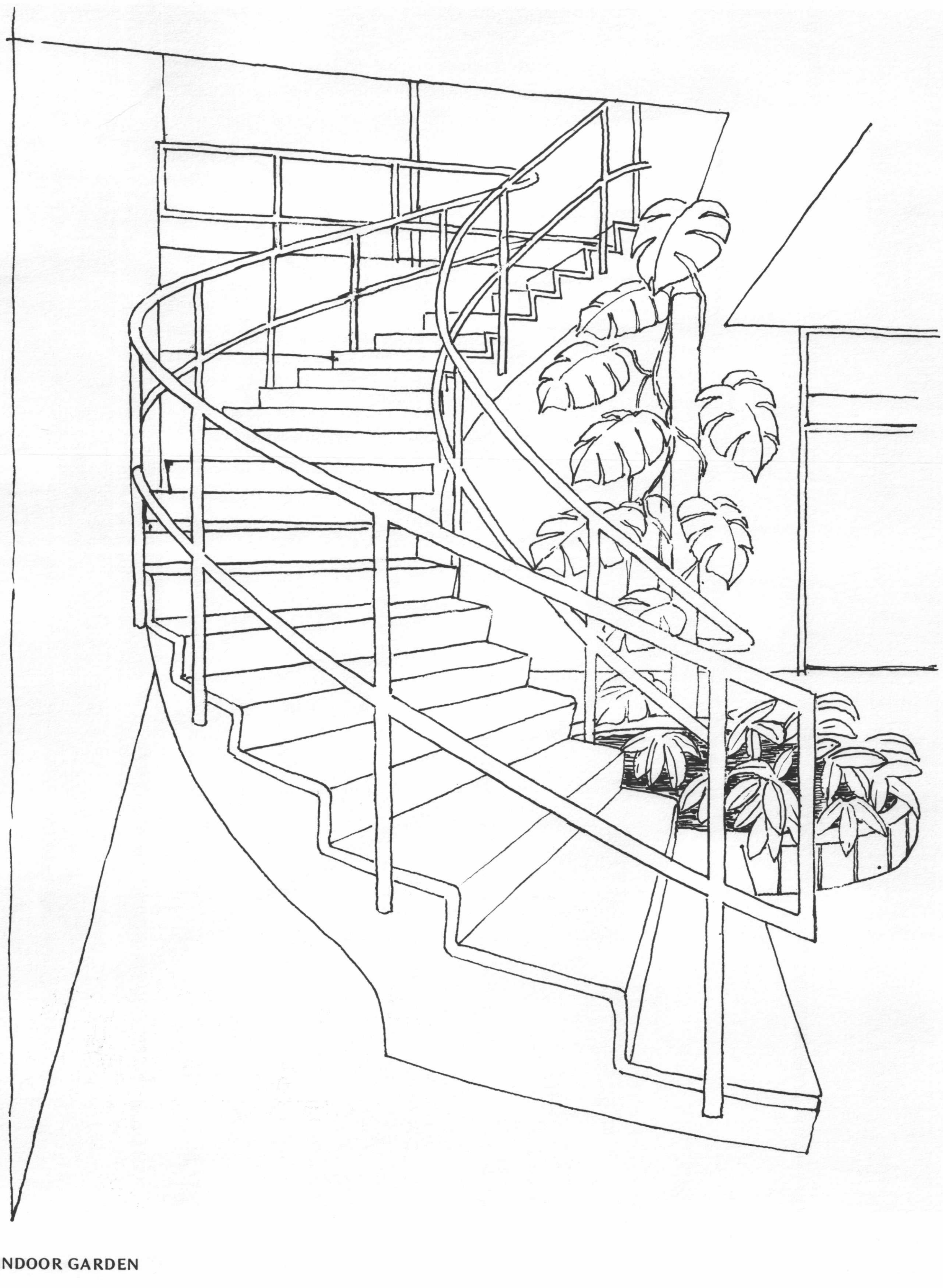
Many fine old hotels have in the past been razed, but the latest trend is toward remodeling them to suit the motel concept or to adapt them to apartment or office occupancy. A large, gracious, high-ceilinged lobby was a feature of the old hotel. This space is difficult to put to new use because of the obvious need for access to elevators and other areas that it provides.

An indoor garden with a dropped ceiling to accommodate plant lights and at the same time to fill some of the lobby space will add to the desirability of the property (see page 109). The garden and dropped ceiling can be free standing. A water garden filled with plants that accept only artificial light should be considered. If space permits, a wall can serve as a background.

The lobbies of apartments, office buildings, and theaters can be considerably improved by the dynamics of a garden.

Here is the perfect location for an indoor garden. This graceful stair in a college building provides architectural lines in sympathy with plant forms. The edge of the upper floor can be utilized for installation of lights to augment the natural daylight that reaches the space.

Photograph by Joseph W. Molitor



The dining rooms of old hotels were often dark and cavernous. A woodland garden with moving water would do much to lighten the atmosphere. If a hotel is being remodeled the architect would do well to visit one of the most beautiful hotel dining rooms in the world – in San Francisco's Sheraton-Palace Hotel – where a glass ceiling in a light well allows container-grown plants to flourish. Even if the food were bad, which it is not, guests would come for the pleasure of dining in its verdant surroundings.

SCIENCE BUILDINGS

A remodeled science classroom should certainly contain a built-in garden as an educational tool. Here at different window locations hydroponic gardens can be installed for nutrient study (see page 133), or the raised window garden shown on pages 37-38 can be adapted to classroom use. The detail on page 41 could serve as a replacement for one of the laboratory tables, with plant lights hung experimentally above it. Although major plant experiments are usually conducted in the institution's greenhouse, it is obvious that a more proximate location for some experiments would have great advantages in maintaining interest in the subject of study.

The science museum, often not well attended and containing only dead things or reproductions of the living, could benefit from the dynamics of a real indoor garden. It would be a welcome addition to remodeling. A four-sided case prominently situated in a lobby could house the following in separate but joined exhibits:

1 A rain forest garden
2 A desert garden
3 A woodland garden
4 A water garden

Living and reacting exhibits are needed (and not all have to be live snakes) to keep the public interested.

HOMES

Many fine old Victorian or "American free style" houses now being remodeled in inner cities present an excellent opporunity for the construction of indoor gardens because of their high bay windows, turrets, and other imaginative architectural features. The familiar turret room with its curved south-facing window can be converted into a fine garden space.

The living room of a typical "Cape Cod" cottage can be extended visually by adding an indoor garden which includes a path to the terrace outside (see page 27). The large window in the remodeled barn, shown on page 30, is ideal for growing miniature tomatoes and herbs or to fill with flowers. Because it is located over the kitchen sink, the standard faucet spray head can be used for watering. The warm and humid kitchen air is especially conducive to healthy plant growth.

Remodeling a bathroom (see page 29), which in an older house is quite often large, is another opportunity to plan a strip window plant space in which orchids and other tropicals will thrive because of the warmth and humidity. The real indoor garden is preferable here to assorted free-standing pots which may fall and damage the fixtures. This little garden should be provided with pebbles as the holding medium or top layer and an overflow drain.

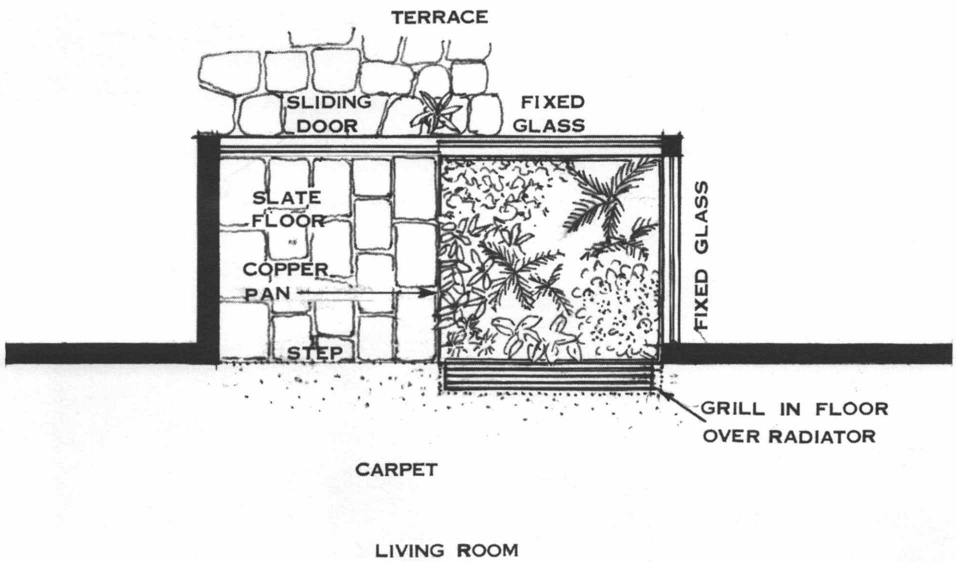
The need to add more bedrooms or other living spaces to the typical tract house can result in a bonus of an indoor garden. If a plant space is used to form a hyphen between old and new parts of the house, light will not be excluded from the end rooms (which are often underlighted anyway), for they will still be lighted by the existing windows facing on the garden. This planted passage then becomes a pleasant transition between wings. It may be built on grade or in a space formerly occupied by a concrete-floored carport. A suitable detail is shown on page 28.

Adding a bedroom and bath to a split-level tract house can also extend a usually small upstairs living room into a garden room. In most plans this extension replaces the carport (see page 33). The new indoor garden is constructed on the concrete floor (see page 34).

Many remodeled plant spaces will not be on-grade. Therefore the architect must include adequate drainage in his design (see page 126). The wood floor under the garden should be covered with 30 mil sheet vinyl-chloride flashing to prevent possible water damage. The structure must be computed to carry the weight of the soil when wet; moist top soil weights 80 pounds per cubic foot. (Six inches of top soil would give the normal loading of 40 pounds per square foot.)

Even if the indoor garden were the single new element designed to improve an existing building, it would attract favorable attention to a structure that might have little else to recommend it aesthetically.

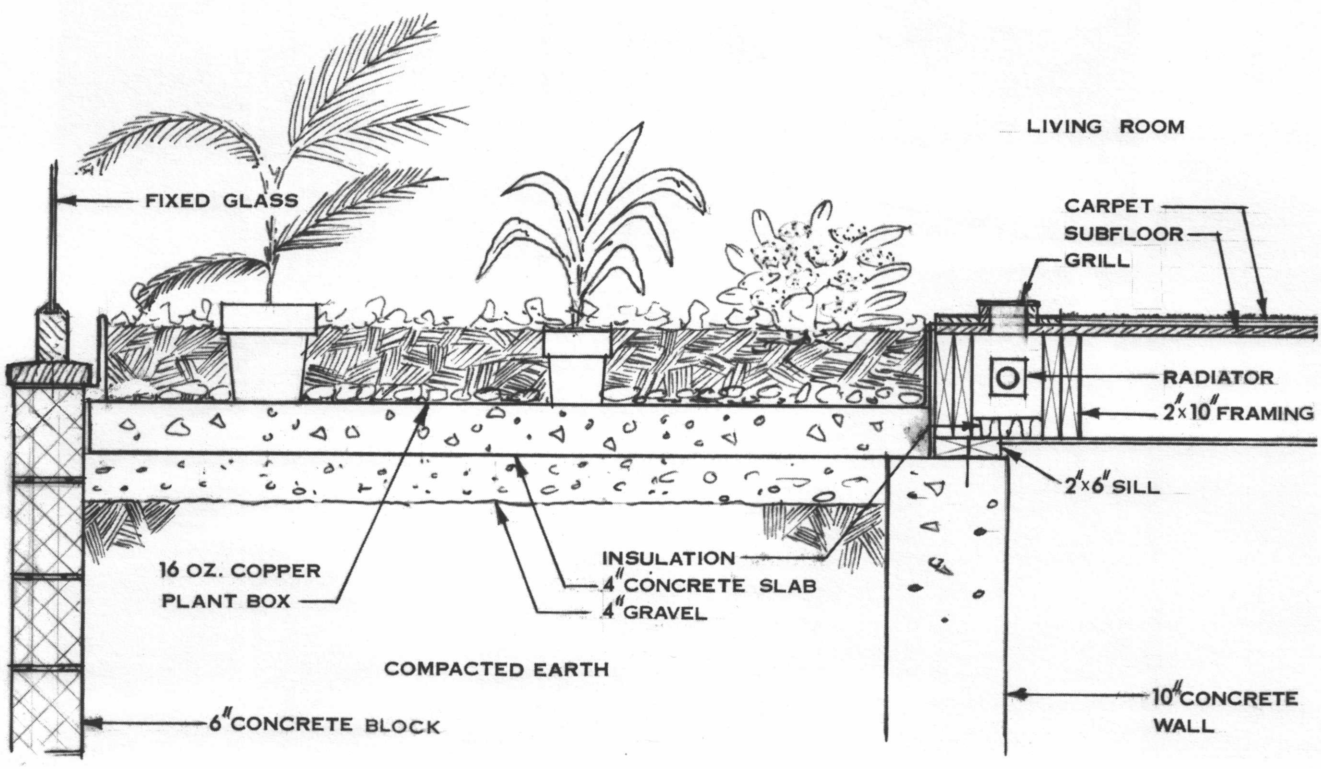
This indoor garden visually extends the living room in this remodeled "Cape Cod" house. A slate floor next to the garden makes a transition from the carpet in the living room to the flagstone terrace outside. The left panel of glass is a door which, when opened, slides across and stores over the panel at the right. Clivia and three varieties of palm give the garden an interesting texture. Chrysanthemums provide the blossoms. Finned radiation is hidden behind a handsome wooden grill at the edge of the indoor garden. This room was originally long and narrow. The addition of the plant space not only breaks up the long wall but also gives a feeling of better proportion by carrying the eye from the plant space to the out of doors.

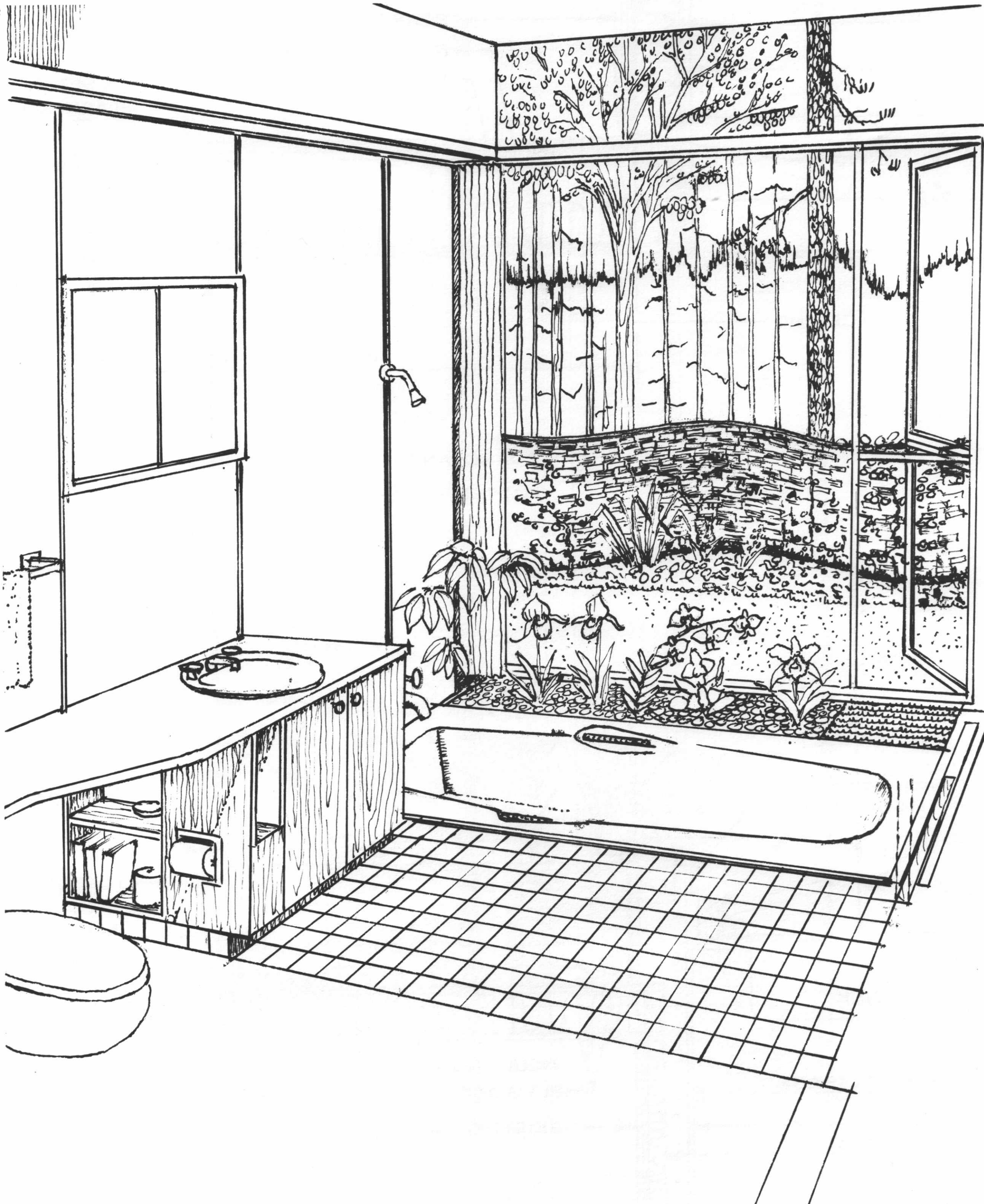


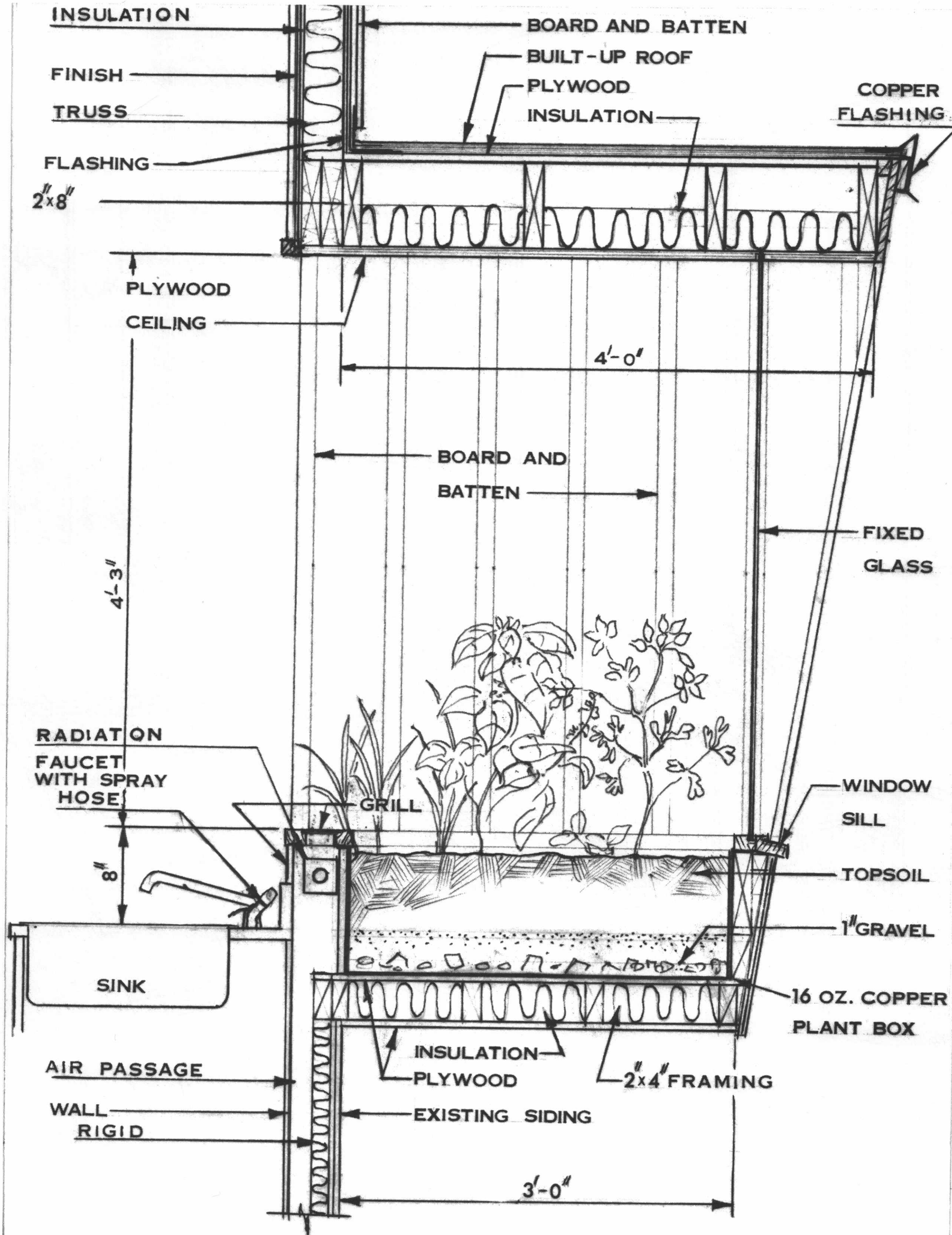
The garden in a bathroom gives bathing a tropical atmosphere. Pebbles prevent splashing soil and flowers benefit from the humidity at bath time.

The plant space in a remodeled house is beside the slate walk leading through the sliding doors to the terrace.

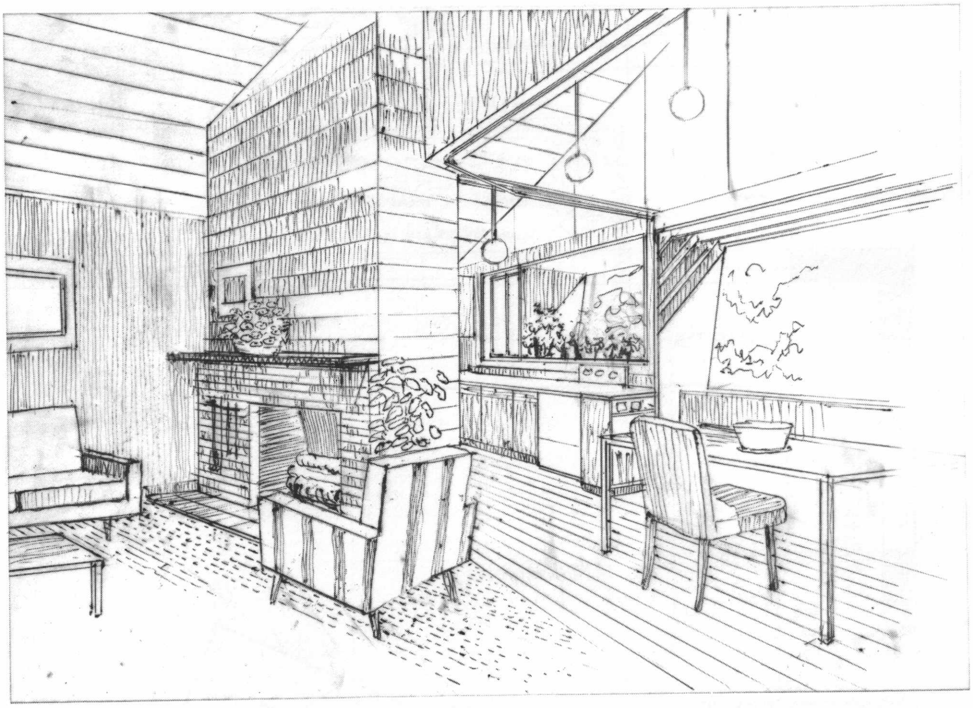
This section through the remodeled living room garden shows the heating system used.



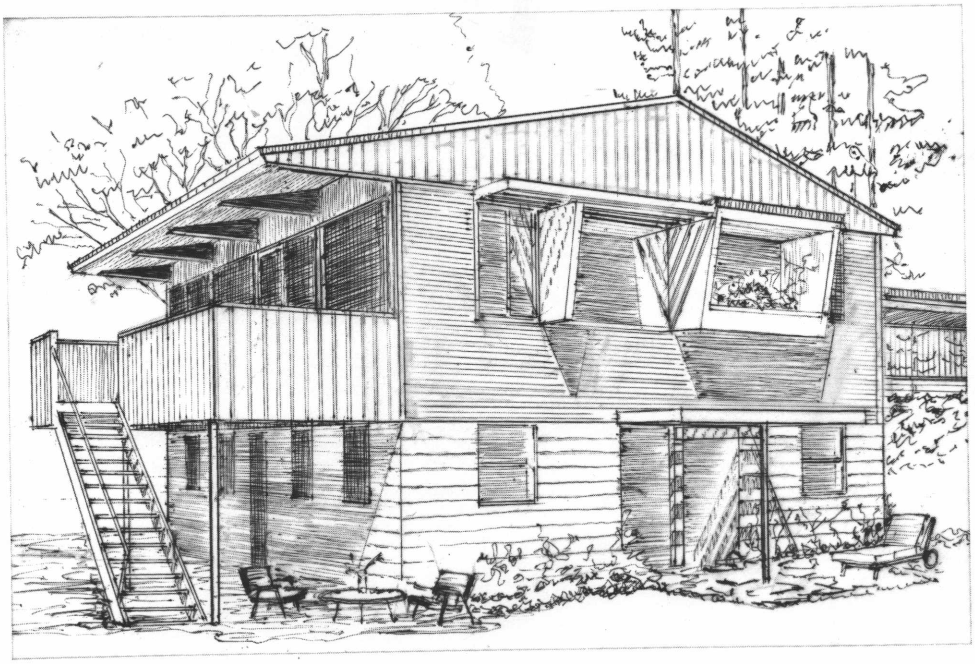


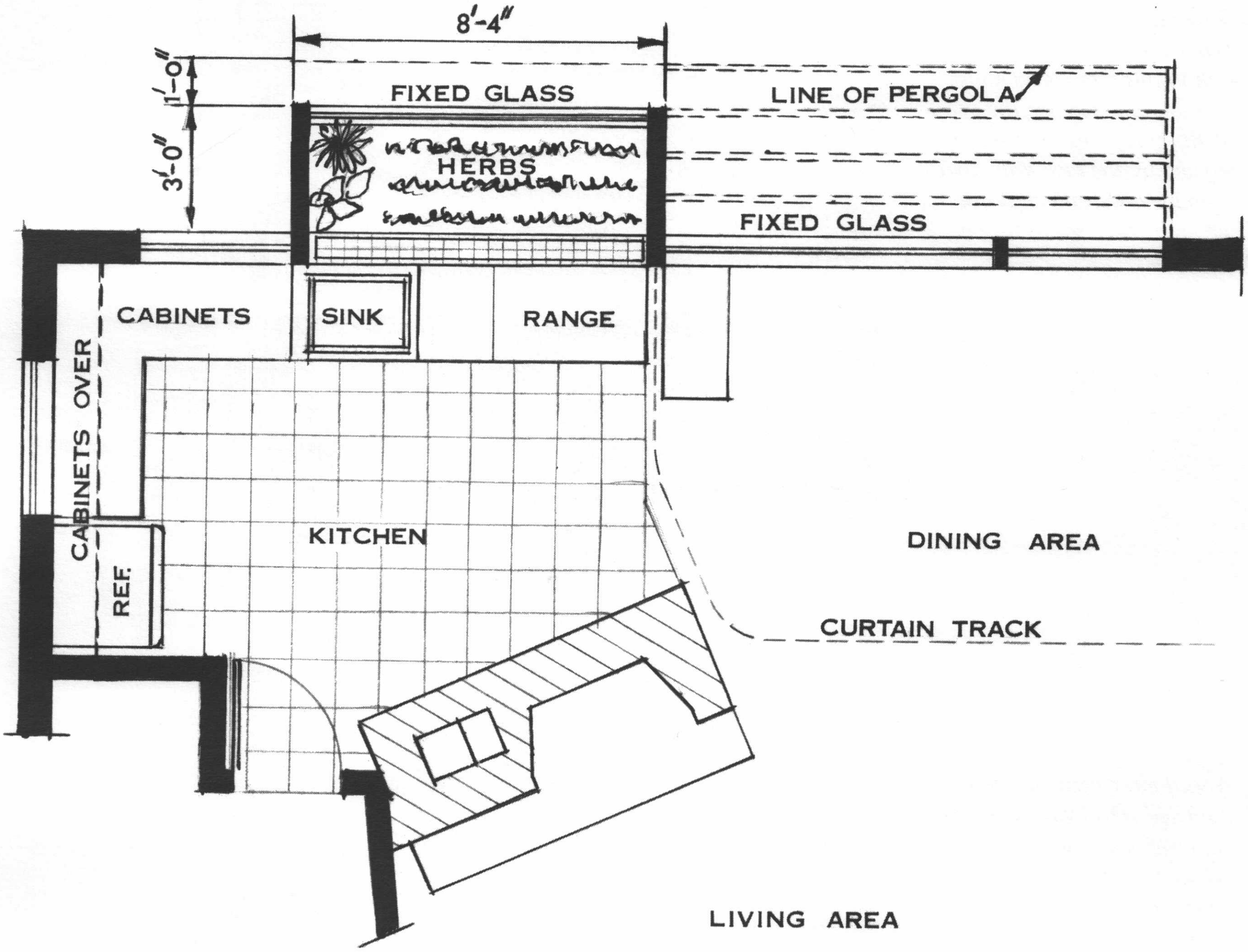

INSULATION
FINISH
TRUSS
FLASHING
2"x8"
BOARD AND BATTEN
BUILT-UP ROOF
PLYWOOD
INSULATION
COPPER FLASHING
PLYWOOD
CEILING
4'-0"
4'-3"
BOARD AND BATTEN
FIXED GLASS
RADIATION
FAUCET WITH SPRAY HOSE
GRILL
8"
WINDOW SILL
TOPSOIL
1" GRAVEL
SINK
16 OZ. COPPER PLANT BOX
INSULATION
PLYWOOD
2"x4" FRAMING
AIR PASSAGE
WALL
RIGID
EXISTING SIDING
3'-0"

Growing herbs and tiny tomatoes next to the kitchen sink in this remodeled house is made practical by the use of the spray head for watering and by the heat grill that supplies a curtain of warm air over this south-facing window.



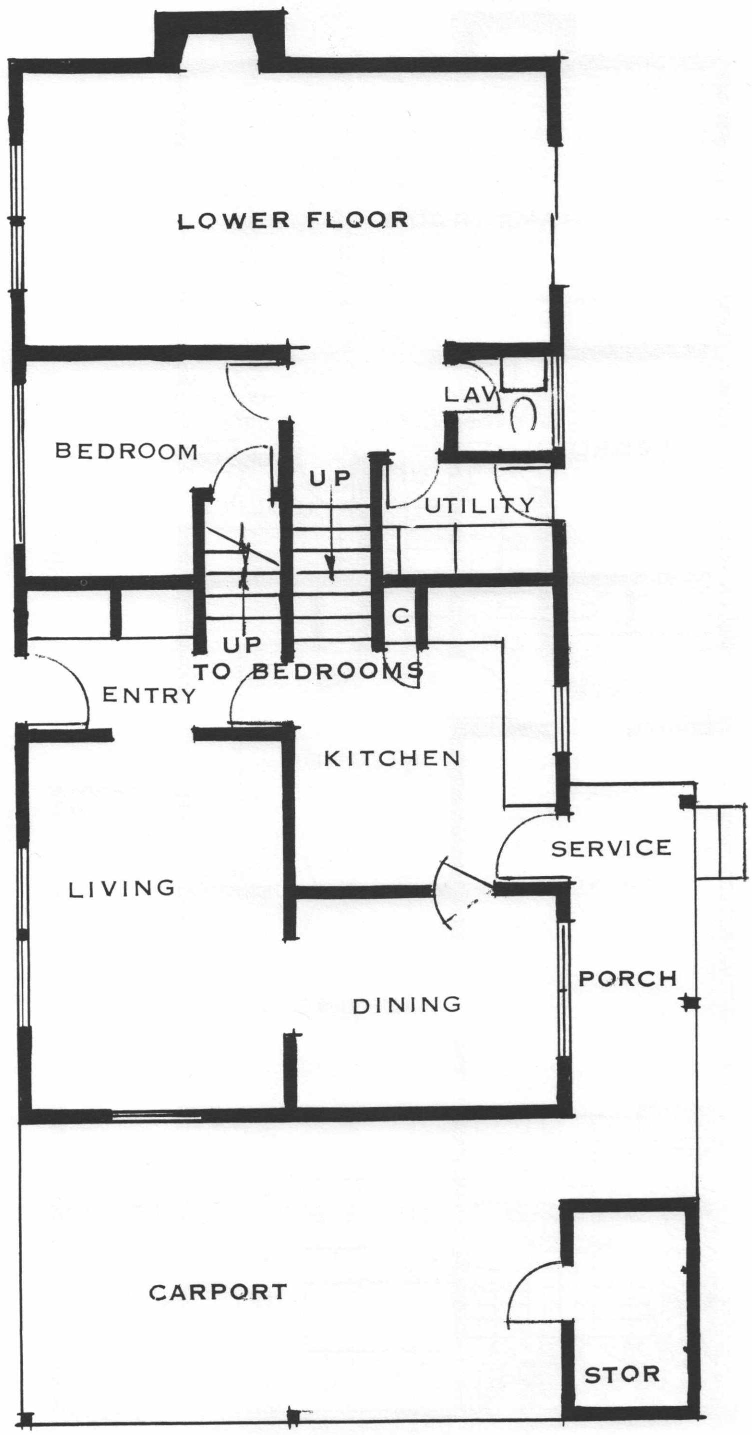
A well-built barn can be remodeled into living quarters. Its clear spans lend themselves to a free choice of room shapes and sizes within the outer shell. The kitchen garden (detail on page 30) projects forward from the face of the building to take the sun and to add a design feature to this south elevation. The sun is an active participant in this design, for it casts a variety of patterns through the pergola and as the shadow of the kitchen garden moves across the face of the building. A garden in a kitchen is perhaps enjoyed more often than one in any other location. Its presence here ensures its care and the owners' continuing pleasure.



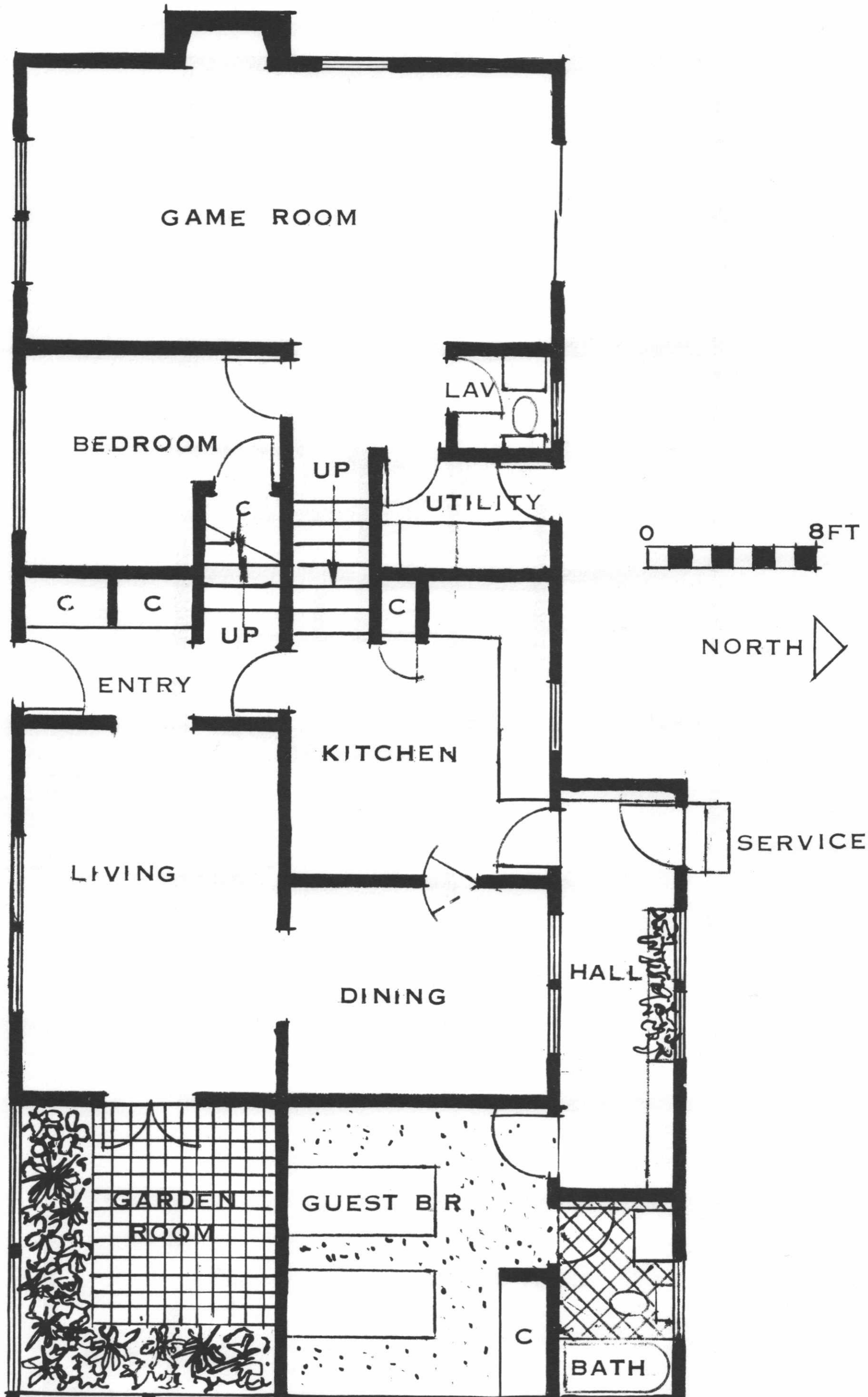


Remodeling a barn can produce some attractive free interior shapes. Locating a kitchen garden next to the sink provides fragrance and pleasure while going about kitchen chores as well as quick access to useful herbs.

TYPICAL SPLIT LEVEL HOUSE



ADDITION TO HOUSE



Special Gardens for Special People

FOR SENIOR CITIZENS AND THE HANDICAPPED

Far from becoming less interested in gardening, the man or woman of retirement age who has always gardened actively out of doors may at last find the time to carry on a cherished hobby. Following the life cycle of a plant often provides the only future-related activity available to an older person. This is also true for the younger person who is handicapped. Sharing experiences and information about their gardens will bring the aging or handicapped together in a common interest. It is imperative therefore that the benefits of indoor gardening be made more fully available to them.

Physical Limitations

For senior citizens and the handicapped physical limitations often make outdoor gardening difficult if not impossible. It is then the architect's job to design an indoor garden that will fit their special needs.

In approaching this design problem, the architect should, as always, know his client well. By careful questioning (and without rippling his own strong muscles) he must become acquainted with the client's specific disabilities and, whenever possible, his prognosis, although both can often be determined by talking with another member of the family. It is especially difficult for an older person to admit his failings and the possibility of their increase. The younger handicapped person is likely to have a more realistic view of his capabilities.

Because of the new OSHA regulations, the capabilities and restrictions of the handicapped have recently been restudied. The parameters listed below and shown on pages 38–42 are those that apply to the indoor garden.

For the Wheelchair Person

1 *Getting up or down.* Moving out of the chair is often difficult, sometimes impossible, without help.
2 *Reaching.* The reach forward is limited to the depth of the wheelchair plus about six inches; thus the wheelchair must have knee space under

the garden. A comfortable total reach forward is 30 to 38 inches. Reaching to the side may be difficult.

3 *Lifting.* Heavy things should never be lifted from the floor by the wheelchair occupant because he can pick things up only from the side, with the risk of twisting his back. He may be able to move lightweight objects.

4 *Movement to the side.* This will require the wheelchair occupant to move backward before repositioning himself or to travel parallel to the garden until he reaches a desired location. A distance to the rear of five feet is required for this move.

5 *Height.* The top of the indoor garden should be 30 inches high; provision for knee space is shown on page 37.

For the Stand-up Gardener

1 Bending slightly forward for any extended period may be uncomfortable or impossible.
2 Low storage that requires bending to reach objects should be avoided.
3 Storage may be provided in wall-hung cabinets to a reach height of 6 feet, 10 inches.
4 No discomfort is experienced in side movement or reaching to the side.
5 Lifting objects from the floor should be avoided.

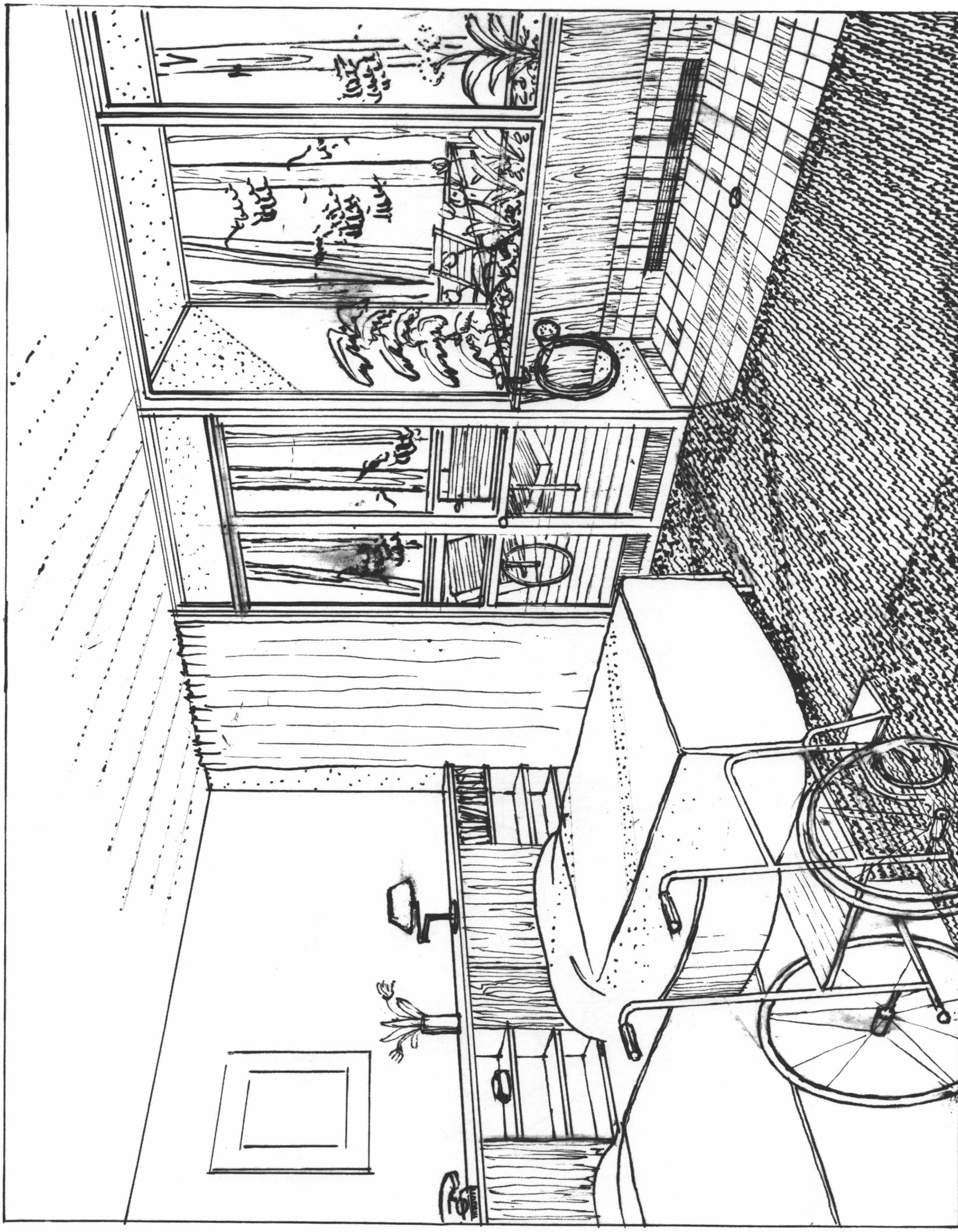
In all cases the wheelchair gardener's work should be done from a sitting position and the design should allow for adequate knee space. An easily controlled water source should be at hand, in which situation electric equipment should be specially protected (see page 37).

Not all older gardeners are confined to wheelchairs. Many can garden best from a standing position, although stooping and bending may be painful. The working height of the standup garden must be adapted to the height of the person who will use it. He should be able to work standing straight. For some the standard 36-inch kitchen-counter height is too high or too low for the greatest comfort. The height will vary two to three inches up or down, depending on the stature of the user. The plant space itself can be drained (see page 41) or watertight (see page 42). If a watertight design is used, an outlet must be provided high on the side of the garden through which water can flow without dripping on the floor. Watering equipment should be immediately at hand and adjacent storage supplied for fertilizer and tools. Hydroponics may be the solution to this special type of garden because of the lighter holding medium (lifting) and the possibility of automated controls for nutrients, temperature of water, and air entrainment. Nutrient-mixing vessels and growing media must also be stored nearby. A rolling cart that can be moved to the source of supply will eliminate much lifting and carrying.

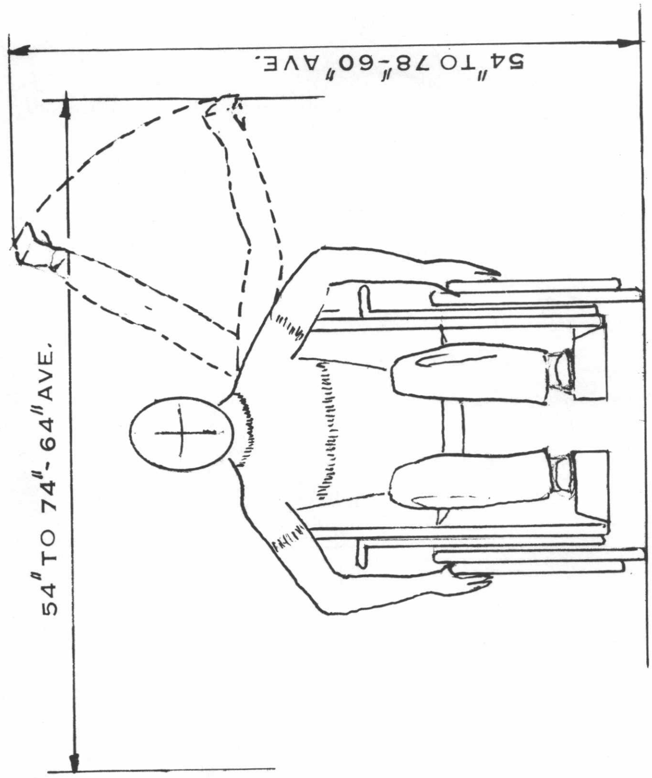
Where Should the Garden Be?

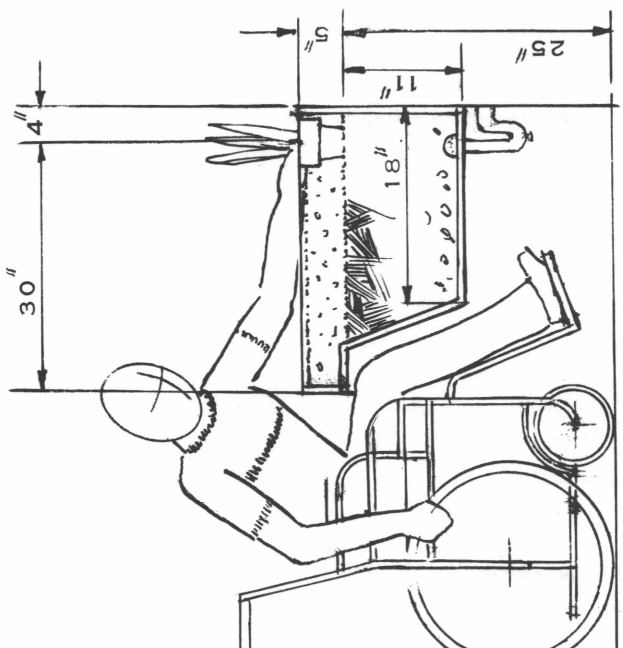
The location of this permanent garden is dictated by building design and orientation as well as by its aesthetic contribution.

An important resource of indoor gardening is the oxygen given off by



The wheelchair garden.


54" TO 74"- 64" AVE.
54" TO 78"-60" AVE.


30"
4"
18"
11"
5"
25"

plants in the presence of light. Because the elderly, or sedentary, person often suffers from bodily oxygen deprivation, the advantage of living with plants is apparent. One permanent garden location to be carefully considered is the bedroom, for at night living plants deplete the oxygen in the air and give off a small amount of carbon dioxide.

It would be feasible to design a bedroom wheelchair garden if sliding glass or plastic panels, resembling Japanese shogi, were used to close it off at night (see page 37). It may be necessary to heat this space to compensate for the fact that it is shut off from room heat at night. The heating system should be provided for in the design layout.

In private residences and in the homes of convalescents and retirees this garden would bring the outside in for the person whose life may be largely confined to a bedroom. Lighting is especially important because it will not only dramatize the plant space and benefit the plants but will also prolong their oxygen-producing periods.

In the Institution

The garden "core" or atrium plan is especially suited to the needs of the handicapped or older person who has been institutionalized. This plan provides the greatest number of rooms with a view if there is a double-loaded corridor in which some rooms face the core and some, the outside. The core-facing rooms can be assigned to bedridden patients who will enjoy the color and light of the garden.

With summer shading and a firm water-resistant, nonslip flooring, the core garden can be furnished with raised sections separated by aisles planned for ease of wheelchair movement. Some of the garden plots may be allotted to patients who are interested in working them. Several large permanent plantings should be included in the atrium to encourage work on the individual gardens and to make it attractive at all times.

Some convalescent homes assign patients to floors according to their ability to pay. Premium-priced rooms on these floors may have indoor gardens like the one shown on page 37. This garden can greatly benefit wheelchair patients whose minds are active and who often find reading tedious or tiring as a full-time occupation. The institution will also benefit because patients will be happier, less demanding, and less restless.

The ubiquitous high rise for the elderly removes many people from a way of life they valued in their younger years. Often among their deprivations is the pleasure of tending a garden. If we are to pack our elderly into what for many of them is an abnormal situation that they may regard as a holding tank for death, we must offer them some compensation. The introduction of indoor gardens, well equipped for ease of maintenance, could be an outlet for the longing to care for living things that is so much a natural part of life. This ever-increasing portion of our population should be better served than they are at present. One small way to compensate is to expose them to the vitality of living plants that can be cared for easily and successfully in the indoor garden.

Comfort, convenience, and safety are the most important aspects of this wheelchair garden.

In the Private Home

The selection of a feature adaptable to indoor gardening in a home occupied by a senior citizen is a challenge. The once popular bay window is an ideal location; its main requirements are that it face south, that flooring and adjacent wall materials be resistant to water stains, that the planting surface be raised so that the handicapped can work comfortably, that water be supplied to the area, and that convenient storage be located nearby.

An indoor light garden may be designed for installation in a closet adjacent to a bedroom in which a patient may be confined to bed and wheelchair. In planning the lighting for this space, not only must it provide good growing stimulants for the plants but it must also be aesthetically pleasing and safe to work under. Some plant lights have a dangerous emission of ultraviolet light that precludes their use in a restricted space. The architect should remember that in the "closet" garden the pleasure will be in tending rather than viewing. The exposure to possibly harmful rays in concentrated amounts must be considered.

A "sun room" or porch with a southern exposure and the wider entrance hall of an older house are also adaptable. A pair of French doors facing south is another possible garden setting.

INDOOR GARDENS FOR THE DISADVANTAGED

Public schools have "enrichment programs" for the disadvantaged. The term disadvantaged is not usually understood to be more than a description of those who lack affluence. The more truly disadvantaged in our society, however, are the blind, the deaf, the mentally retarded, and the emotionally disturbed. The custodial care of this group is much discussed and studied; means of opening new avenues for their participation in the working and recreational aspects of living receive little attention.

The Benefits

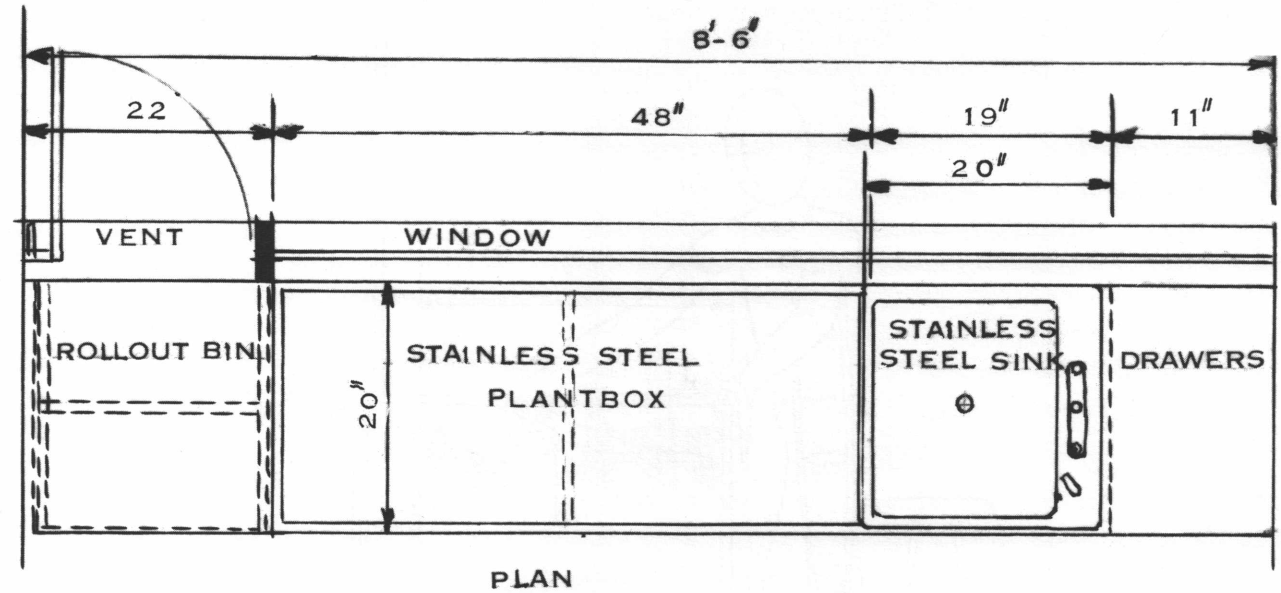
Gardening indoors encourages an attitude of looking toward the future; it may lead to training that could mean a way of earning a living and it can be used as a scientific educational tool. An indoor garden may provide the blind with a better understanding of the world around them, the deaf with visual pleasure, the mentally retarded with the satisfaction of learning and accomplishing easy tasks, and the emotionally disturbed with a nonabrasive situation that will give them some stability in an environment that seems to offer them little security.

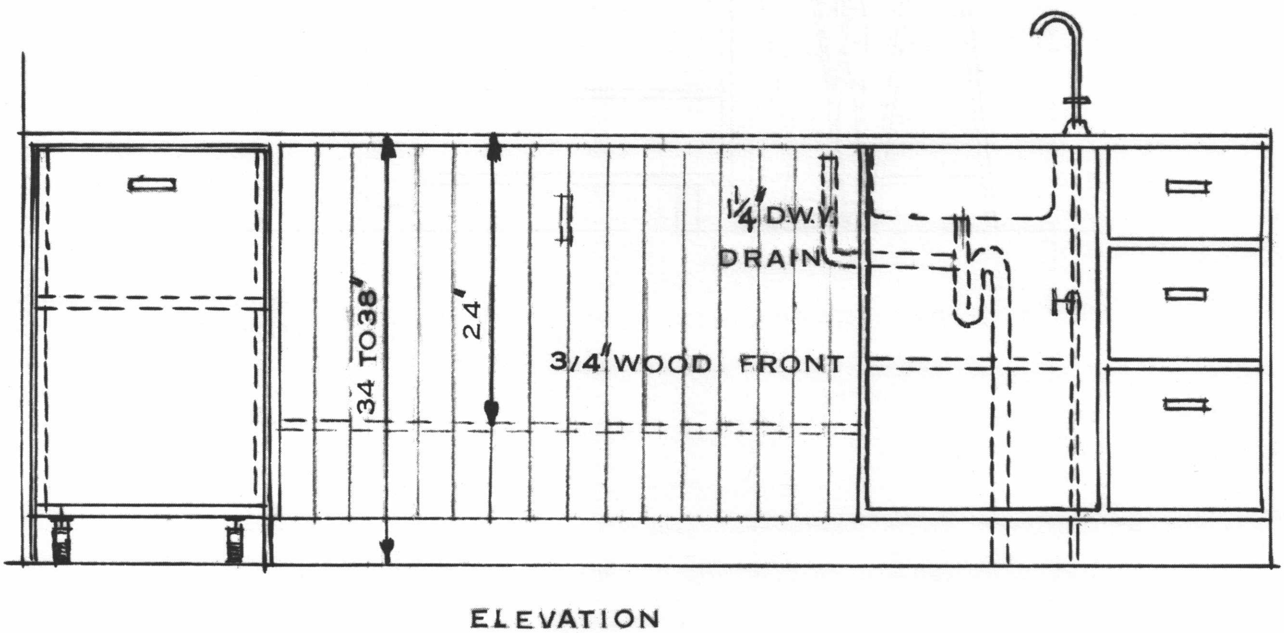
DESIGN FEATURES

Some special characteristics of indoor gardens for these disadvantaged people are discussed here.

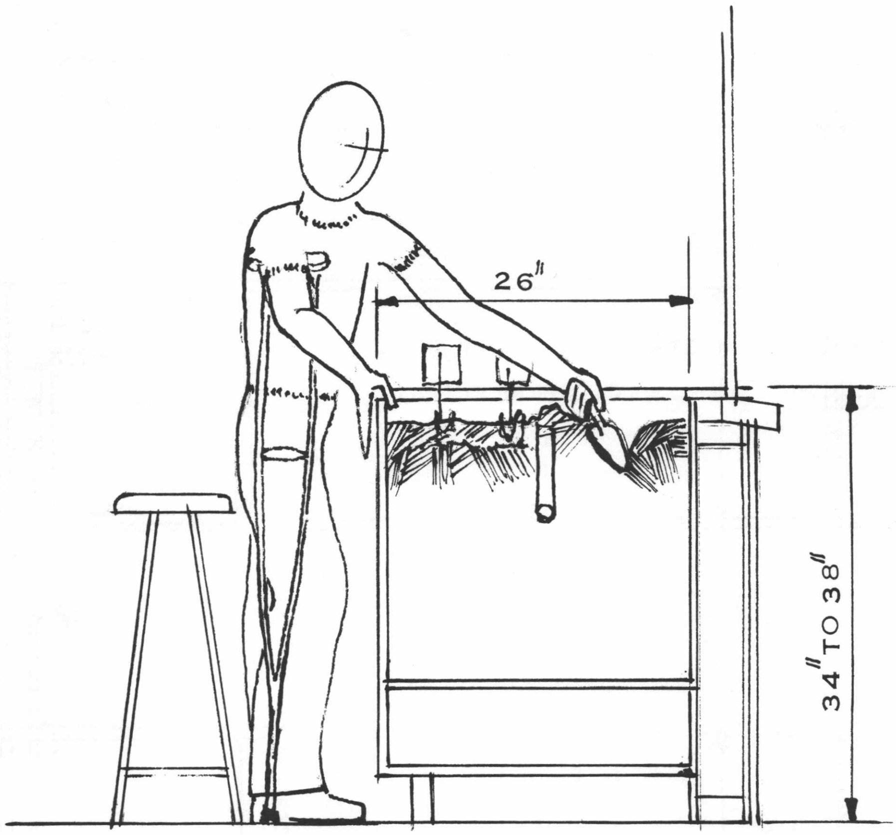
For the Blind

The blind generally have highly developed senses of touch, smell, and hearing. The tactile differences between rock, moss, and smooth, hairy, and spiny leaves and the textures of soil, sand, and gravel should be part of the experience of gardening. Driftwood, shells, and tree bark of various textures will also introduce tactile interest. Ease and safety of movement will dictate a raised garden, for barriers must be avoided. The sound of a





A stand-up garden has water, supplies, and equipment easily at hand. The roll-out bin obviates leaning over to obtain supplies. The deep bottom drawer diminishes reaching down because large, lightweight objects can be stored in it.



The handicapped person will enjoy working with plants in this indoor stand-up garden only if the architect plans for his special needs.

waterfall dropping into a pool will add to the pleasure taken in this garden as will the fragrance of flowers, leaves and the soil itself. Proximity of tools and supplies and their marking for identification by touch will help to make the handling of a plant space more efficient.

For the Deaf

The color of flowers and the contrast in texture and shape of plants and rocks will provide visual and tactile stimulation. Although the sound of water may not be heard, water can be seen and touched. Physical barriers are not critical as they are for the blind and the location of the indoor garden can be the same as for those who can hear.

For the Mentally Retarded

Simple, repetitive tasks are well within the capability of many retarded people. To complete a task successfully and be rewarded by a sense of accomplishment is an experience rarely afforded the retarded. Safety and simplicity are the essentials in an indoor garden for this group. For safety the garden must be raised above floor level and sharp implements should be excluded. Only totally nonpoisonous plants should be chosen. Water supplies should have automatic controls and soil and fertilizers must be premixed. Plantings should include some quick-result annuals, and some edible vegetables may be grown. The degree of retardation will dictate whether this garden is just for pleasure, or whether it can be used to train the retarded for future greenhouse or outdoor garden work.

For the Mentally and Emotionally Disturbed

There are many forms of mental distress and many gradations within these forms. Mildly psychotic, depressed, or autistic patients may be helped by working with plants in a controlled indoor environment. The same orientation that aids the elderly may help the disturbed. As in gardens for the retarded, some quick-result annuals as well as some fail-proof long-lasting varieties should be planted. Safety precautions should be carefully and subtlely designed.

Check List

When planning institutional housing for the physically disadvantaged, the architect should interview the managers of the institution to determine the restrictions that may be placed on his design. For an indoor garden for these special people the following is a check list of pertinent questions:

1 What can the plant space contribute?

- A Hope and recreation?
- B Training toward entering the work force?
- C Therapeutic daily activity?
- D How will the plant space affect others who may not participate in its care?
- E Are there provisions for the maintenance of the indoor garden as an architectural feature?
- F Are there qualified personnel to help the disadvantaged to participate?

2 Physical limitations.

A patient's bedroom in the "core" plan of a convalescent home.

A What is the best working height for indoor gardens?

1 Is safety involved in moving about?
2 Is reaching, including distance perception, difficult?
3 Are bodily movements controlled or erratic?
4 Is there a tendency to drop things (this might indicate a floor location).
5 What hazards to others must be recognized?

B What convenience and safety features should the watering system include?
C How can fertilizers and tools be handled for greatest safety?
D What access to equipment can be permitted?

3 Other limitations.

A How might the patient injure himself or others?

1 Accidentally?
2 Purposely?

B What would his attitude be toward sharing the garden with others?

INDOOR GARDENS FOR CHILDREN

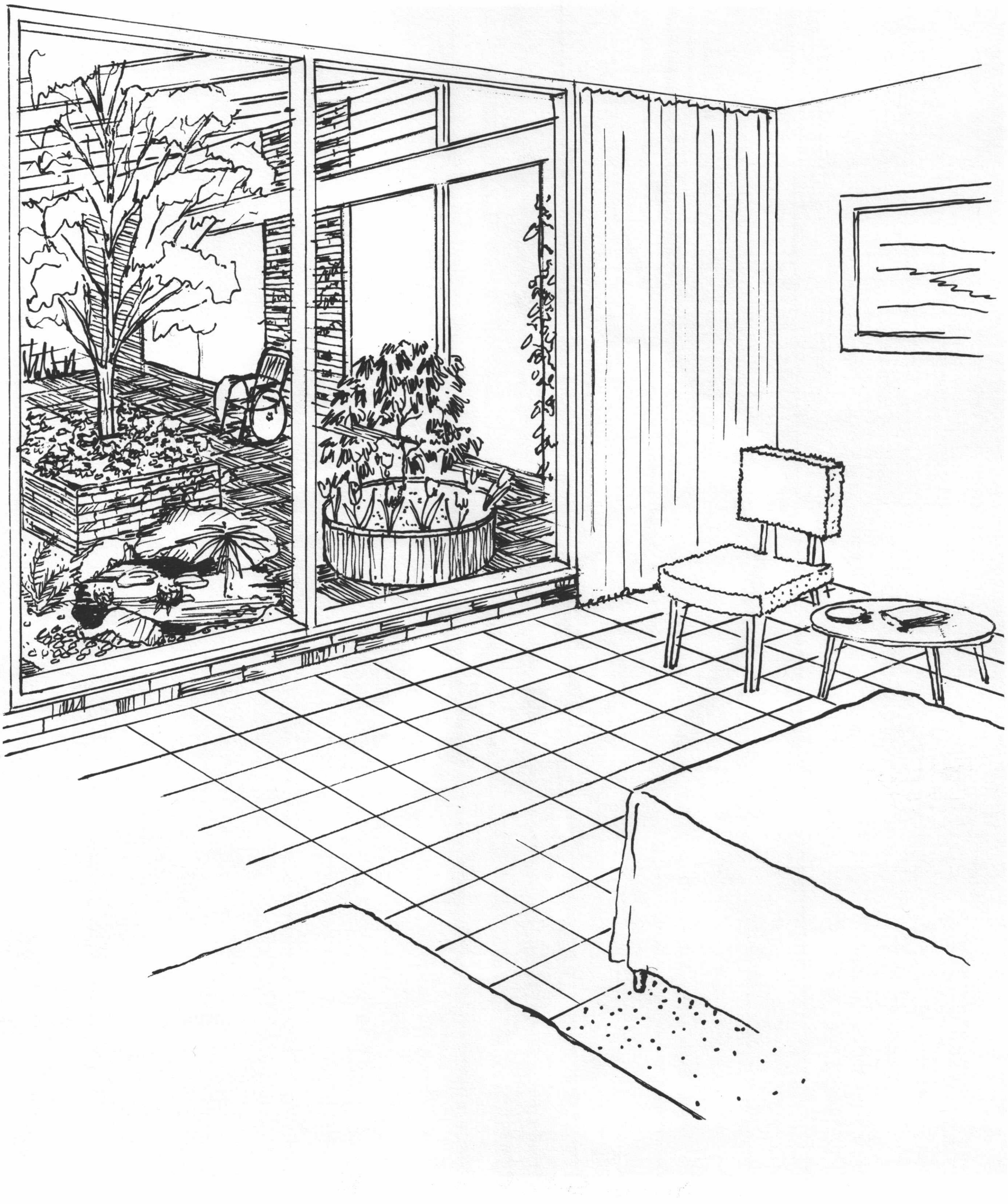
Children are certainly neither elderly nor handicapped, but their need for indoor gardens designed specifically for their own pleasure and education is strong, especially in urban areas in which naturally growing plants are rarely enjoyed except on visits to the park. A knowledge of plants will contribute to the understanding by these children of the urgency of protecting the environment.

Education

Kindergarten through fourth-grade students will be interested in growing flowering, carnivorous, or touch-responsive plants (such as the sensitive plant). From the fourth grade on through high school the indoor garden can be a means of studying specific plant forms, of conducting experiments in nutrition, possibly by using hydroponics, and of studying the effects on plants of water, light, pollution, and humidity. Basic experiments in physics and chemistry can be arranged to coincide with regular studies in those subjects.

Water Gardens

Access to water for small children often comes under the heading of "hazard" in the adult attitude toward its availability. Yet children are fascinated by it,its sound, its texture, and its "coolth," as one child put it. Real education deals with the self-controls that are necessary to living compatibility with other people. Many educational systems in the country



Photograph by Robert E. Keene

This young gentleman has been watching the buds form and unfold and he cannot understand why beautiful "Doris" cymbidium is not also fragrant. At three years Chris does understand that watering and feeding a plant will produce something pretty. He asks how the fat bees can get in and out and wonders why they don't stay there because there is such a nice room down inside the flower. It is important to teach children that plants are living things and to have them respond with a caring attitude. A special plant, or a section of the indoor garden, can, with help and advice from an adult, be given to a child to manage. The child's response is usually one of interest because he senses the enthusiasm of the adult.

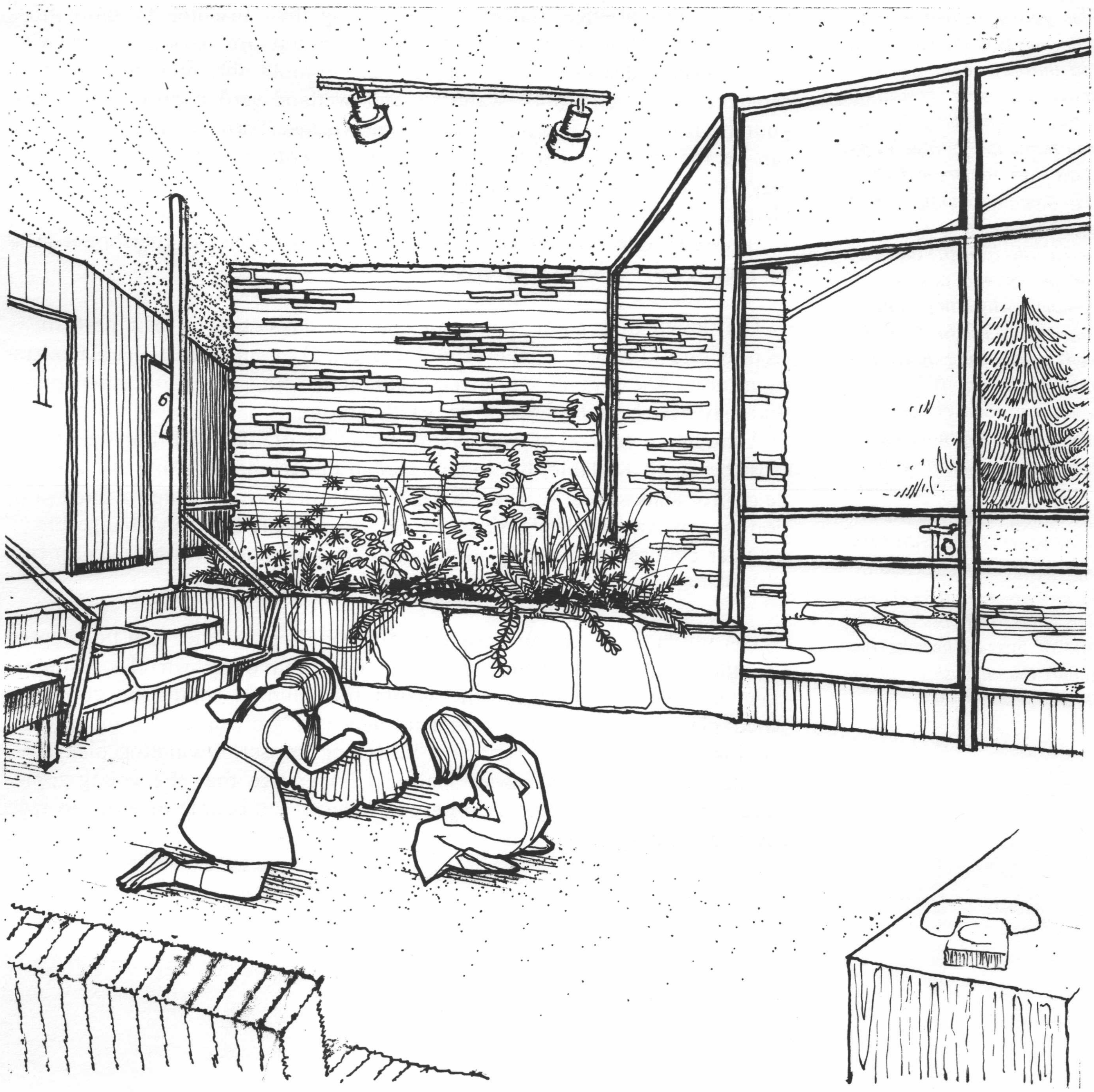
recognize this premise and are implementing their teaching to allow more freedom of action in the teaching situation but are backing it up with the necessary discipline. In schools that promote this humanitarian concept the water garden or waterfall and wetland garden provide the very young with visual, aural, and tactile knowledge. Turning on the waterfall can be the reward for successful accomplishments for which other rewards may not be so obvious. Groups in a class can learn to work together to plant and care for the garden. The success of this work, however, will require a knowledgeable teacher or member of the maintenance personnel as a back-up for the children's efforts.

The design of a plant space can take the physical form of a permanent architectural feature of the school (page 12), a smaller individual classroom unit, (see page 20), or a removable unit with a drain and water source that may have been installed in an art classroom.

Although a source of water and adequate drainage are important and must be made available, the indoor garden design should allow for as much flexibility as possible. A waterfall and pool will have to occupy a fixed position, but the variety of plantings around them should be easily changeable.

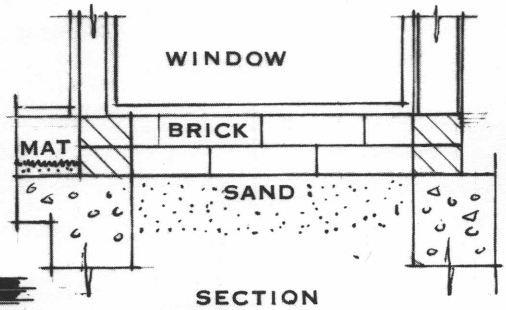
Older children and young adults can participate in scientific experiments with plants in the indoor garden described on page 149.

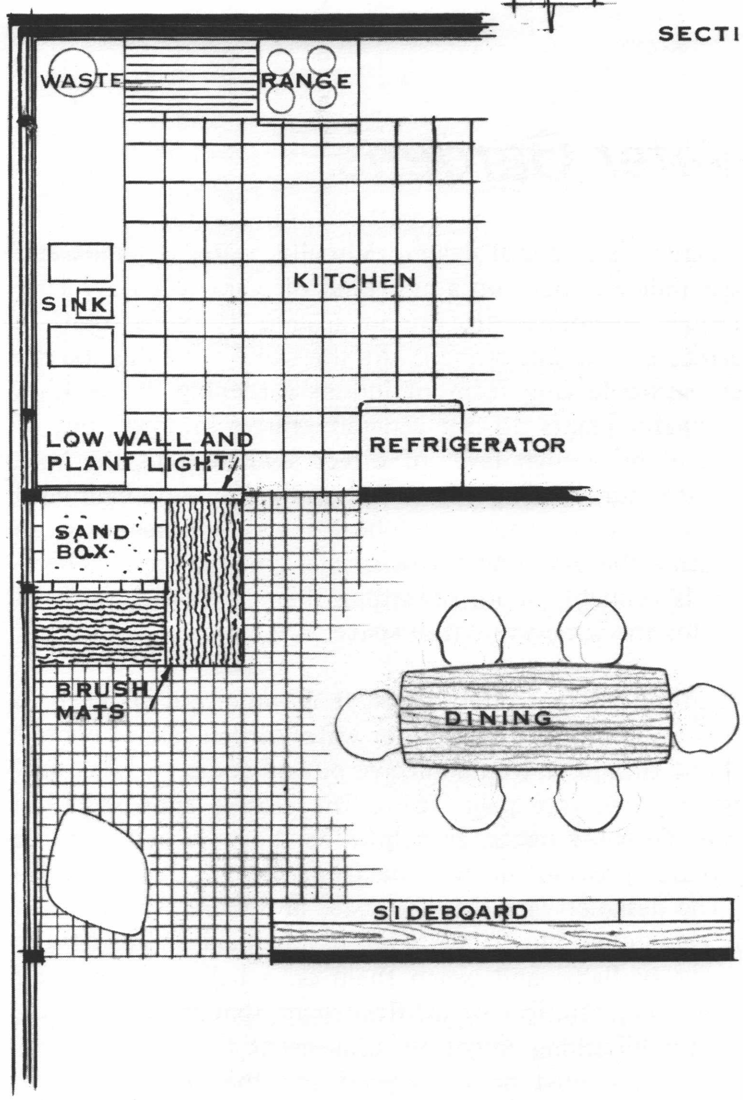
The sandbox (page 49) designed as a child's play place can be adapted to indoor-garden use when sand play has been outgrown. To stimulate their interest in caring for the plants the children should be consulted when plans are made. The subtle influence of growing up in an intimate relationship with plants can have a lifelong impact. Dwindling plant life, as man paves over his world, makes it imperative that the young appreciate the symbiotic connection between plants and people in order to take action as adults to ensure its healthful continuance.



A doctor's waiting room benefits from an indoor garden because it is aesthetically pleasing and also warns patients of a change in floor level.

An indoor play space to convert to a garden. When building their homes, young couples may wish to provide a child's indoor sandbox which can be converted later to an indoor garden. The two thick cocoa brush mats shown will hold a quantity of sand, are removable for emptying and will absorb water spills. A removable handle is provided on the hose bib. The brick edge is for children to sit on.





Indoor Water Gardens

An indoor water garden is a special delight. Visually, water is serene and refreshing and its use indoors opens up a new kind of plant to enjoy. To a minor extent water will evaporate into the air around it, and a fountain will increase this effect on the atmosphere. At the same time the aquatic garden is the most nature-defying form of indoor gardening. Water lilies and other flowering water plants do not generally thrive in shade out of doors, for they depend on a high level of direct sunlight plus the light reflected from the water surrounding them. To supply the same high level of overhead light necessary for their good health was impossible in an inhabited building before the development of special growing lights. Therefore a water garden is probably more rewarding than any other form of indoor garden occupying the same amount of space.

In choosing a location for the indoor pool, it is important to keep in mind that under the best conditions the indoor water garden cannot benefit from the same amount of sun it would receive out of doors. A solar roof with a south-facing window, (see page 56) is the closest approximation to natural conditions. Growing lights, as helpful as they are in extending "daylight" hours, do not provide the full spectrum of light demanded by most water plants. The designer who plans to place an indoor water garden outside the natural parameters must investigate the artificial lighting types and direction of focus of lights and weigh them on a balance with their effect on humans. A concentration of artificial light that might produce good plant growth and blooming might be unpleasant for people in adjoining areas. These factors must be considered and the people-function of the building must take precedence.

Locations for indoor aquatic gardens are somewhat limited. The owner of a house, of course, may install a pool wherever he pleases as long as the safety of family and friends is considered. The architect should keep in mind the weight of water (64.5 pounds per cubic foot) in his structural calculations.

The small aquatic world of this indoor pool is a microcosm that depends for success on the harmonius interrelation between plants and fish. Water lettuce and one water lily which is about to bloom provide the plant life. Goldfish show their colors against the stainless steel of the pool which is equipped with a hose bib in the back wall and an overflow drain pipe that will not allow water to overflow onto the pandanus squares covering the floor. The stainless steel plant space was fabricated in one piece with a division between the soil-filled garden and the pool. Each section is supplied with a drain. Papyrus, a philodendron, a tiny orchid, Clivia miniata in bloom and the leaves of Anthurium magnificum provide good textural contrast. The clerodendron reaches for the plant growth light. See detail, page 52.

Photograph by Jack Roche

52) may be soldered into a straight-sided shape. Copper should not be used, for in some water acids will release salts that are injurious to fish. Aluminum is a poor choice because it will pit and darken. Other metal alloys that react electrolytically with copper (piping) or other metals with which they may come into contact will also form salts injurious to fish.

A lobby pool.

The miniature residential indoor pool in which tiny delights such as the Margaret Mary or Dorothy Lamour water lilies or the water snowflake and water poppy will grow can be no more than a galvanized washtub painted with a rubber-based or epoxy paint to seal out the toxins. When sunk into the soil it may be edged with tile or a custom-built wooden frame A large wooden tub can be used in a similar way after curing (see jacket).

A reinforced concrete pool is most suitable for a permanent and long-lasting water garden. The pool may be built above grade (see page 56), at grade level, or recessed in the soil. If it is sunk below ground, a graduated level or curved bottom that provides for both deep and shallow water plants is good design. To form this type of pool place steel mesh on preformed soil levels and use special sprayed concrete or 10-pound density urethane to form the shell.

"CURING" THE POOL

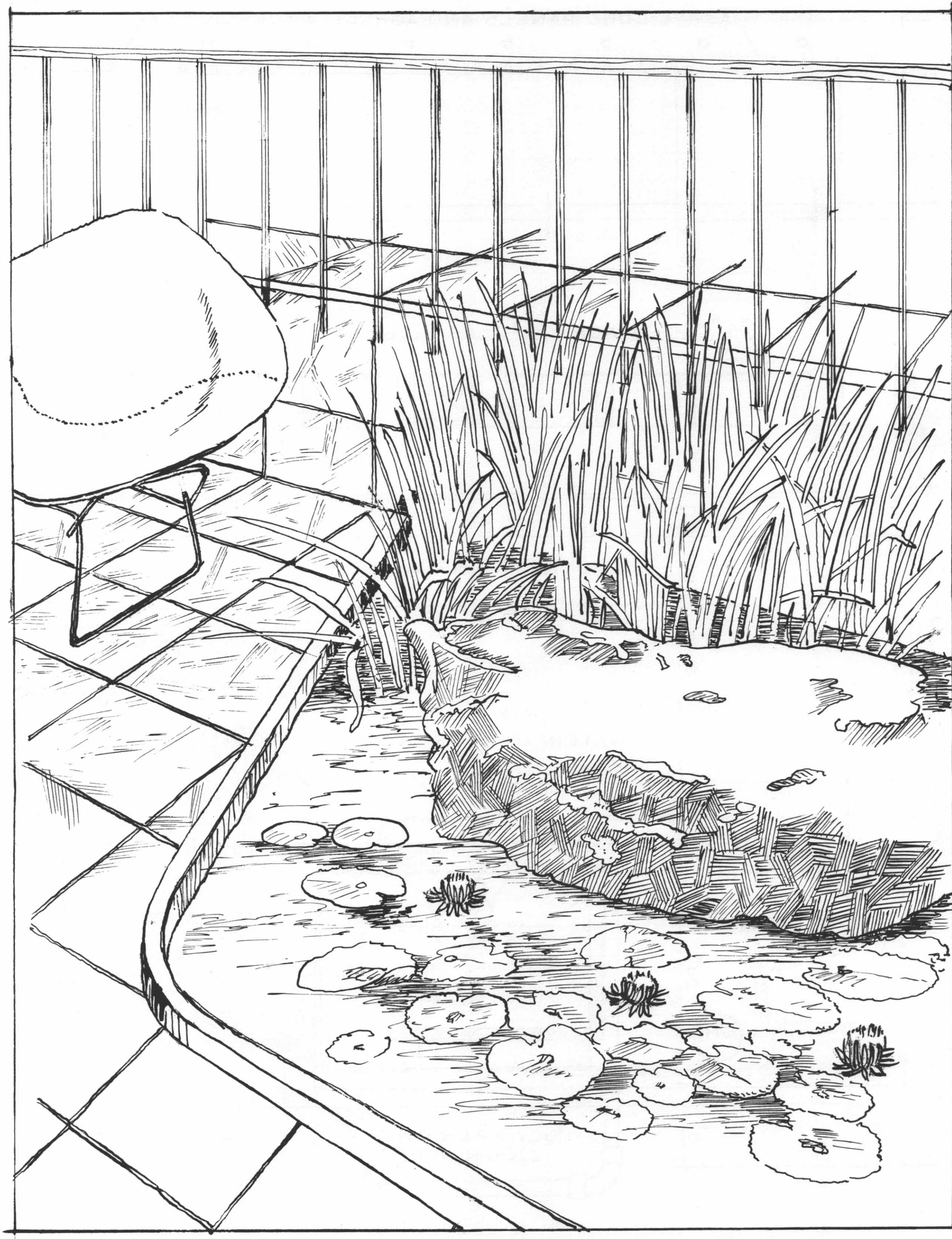
Plastic and stainless steel pools do not need curing. If a wooden tub is used, it must be treated with copper napthanate, do not allow this material to get into the inside and do not use creosote or penta treatments. To cure the wood inside a large lump of unslaked lime should be left in the water-filled pool for four days, after which time the pool should be thoroughly rinsed before planting and final filling. Do not use wood containers that have held oily or toxic material.

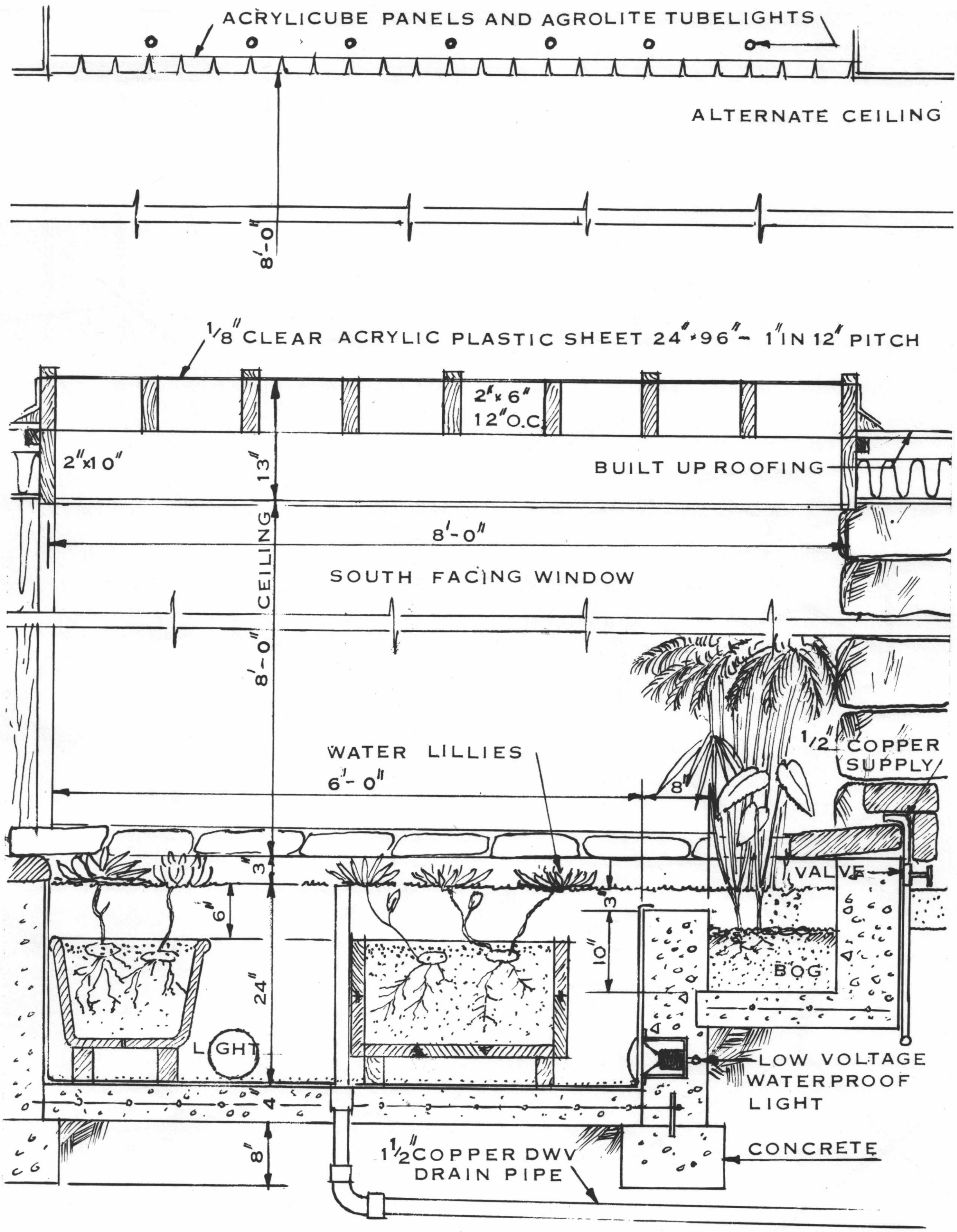
To cure a concrete pool (after the concrete has set for 14 days, during which it should be covered with plastic to retain moisture) fill the pool full, leave it filled for a week, empty, and refill. Leave it for a second week. Empty the pool and with a solution of one quart of vinegar to 10 quarts of water, scrub the interior twice with a stiff brush. Rinse carefully between scrubbings with a strong stream of water. Do not use chemical masonry cleaning solutions. When the curing is completed, the pool may be painted with a special nontoxic fish-pool paint, available from water-plant specialists, or left unpainted and planted immediately. Curing of new concrete is necessary to dispose of the alkalinity it releases.

LIGHTING

Indoor water gardens are divided into two categories according to lighting. One that we call the "lily pool" simulates conditions and uses plants that would flourish in an outdoor pool. This type requires a high level of natural light plus extra hours of artificial indoor light. The second type is called the "aquarium pool" because the aquatics that can be grown in it will accept less natural and more artificial light and still be successful.

Water lilies require a high level of light for successful growth and blooming, whereas many green water plants will thrive under artificial light alone. Suggested ceiling designs are shown on page 56 to suit either of these plant





ACRYLICUBE PANELS AND AGROLITE TUBELIGHTS
ALTERNATE CEILING
8'-0"
1/8" CLEAR ACRYLIC PLASTIC SHEET 24"×96"– 1" IN 12" PITCH
2"×6"
12" O.C.
2"×10"
13"
BUILT UP ROOFING
8'-0"
SOUTH FACING WINDOW
8'-0" CEILING
WATER LILLIES
6'-0"
8"
1/2" COPPER SUPPLY
3"
VALVE
6"
3"
10"
BOG
24"
LIGHT
LOW VOLTAGE WATERPROOF LIGHT
4"
8"
1 1/2" COPPER DWV DRAIN PIPE
CONCRETE

The lily pool with a sun roof or alternate plant-light ceiling.

requirements. Window orientations should be similar to those of other indoor gardens, that is, south or southeast facing with proper overhang. For water lilies it is possible to use a southwest orientation in a cool summer climate or one in which the building's occupants will not be made uncomfortable by the heat captured from it. For economy of energy air conditioning should not be made to compensate for heat buildup caused by improper orientation of windows. The designer must take all these matters into consideration when planning an indoor water garden.

Water-plant specialists and fountain manufacturers carry an assortment of regular and low-voltage lights. The catalogues list automatic timers and transformers and give instructions for their proper installation. It is most important to avoid overlighting the indoor pool from the bottom. Water should be allowed to hold some of its mysteries and, of course, this source of light is unnatural for plants and fish. Larger formal pools may be dramatized by underwater lights, but the small pool or one imitating nature usually does not benefit from this treatment.

An overhead light ceiling (see page 56), bulbed with one of the special plant-growth fluorescents or designed for one of the high intensity incandescents (see page 109), will help to simulate outdoor water-plant conditions. If the ceiling is not available as a light source, the lighting should be planned for greatest intensity and spread. The closer the source of light, the more energy-efficient it will be. Any lighting system planned for terrestrial flowering plants will help water plants to bloom.

"LILY POOL" PLANTS

Indoor water-garden plant choice must be based on the size of the pool. It is aesthetically important that some of the water surface be left uncovered by water-plant leaves. It is safe to assume that even the more modestly growing water lilies will cover 2 square feet of water surface with their leaves and flowers.

Tropical water lilies need 5 to 7 hours of sun; night-blooming tropicals require the same.

Some Recommended Varieties of "Lily Pool" Plants

Margaret Mary. Day-blooming, tropical, star-shaped, miniature. Blue blossom about the size of a quarter. Blossom held above the water. Leaves about 4 inches in diameter. Will do best with sun but will bloom under plant growing lights. Needs 5 to 6 hours of light per day. Vivaparous.

Dorothy Lamour. Miniature hardy day bloomer; yellow, 1 inch in diameter, fragrant, shaped like a half-opened rose. Vigorous leaves are 4 inches in diameter and bright green striped with brown. Prodigious and fragrant bloomer; same requirements as above.

Potted Lotus. Developed especially for pot culture (20-inch pot). These lotuses will grow with their roots submerged in the pool or outside the pool if kept well watered. Up to 6 feet tall with 2-foot leaves and 5-inch fragrant blooms. Colors available are Mikado-rich pink, Goddess-white, Mandarin-yellow, and Vesper-white tipped with red.

Two other proven varieties of water lily are the following:

Dauben. A small, vivaparous, fragrant, pale lavender lily.

August Koch. A huge, pale violet, fragrant, and profusely blooming variety is suggested for indoor pools.

Water poppies will bloom in the lily pool of an indoor garden, and water hyacinths will remain attractive and sometimes bloom.

Hardy water lilies doing well with the minimum of sun, that is, 4 hours, should take well to indoor conditions in which available sunlight is augmented by artificial light to the required number of hours:

Chromatella. Canary yellow, free blooming.

Comanche. Rose overlaid with apricot changing to bronze. Flowers held above water.

Gloriosa. Carmine rose, fragrance of apple blossom; small pads, quick bloomer.

Rose Arey. Brilliant pink, fragrant. Blooms 7 to 8 inches in diameter.

Some of these plants have been tested by Three Springs Fisheries, Lilypons, Maryland, for use in indoor pools.

Special Note

To keep water lily blooms open for a special occasion, put a drop of paraffin or candle wax at the point at which stamens, sepals, and petals meet. Night-blooming lilies will often stay open on cloudy days.

"AQUARIUM POOL" PLANTS

These aquatic plants require little sun for blooming or will not bloom at all in indoor conditions. They will, however, grow well under special growing lights.

Some Recommended "Aquarium Pool" Plants

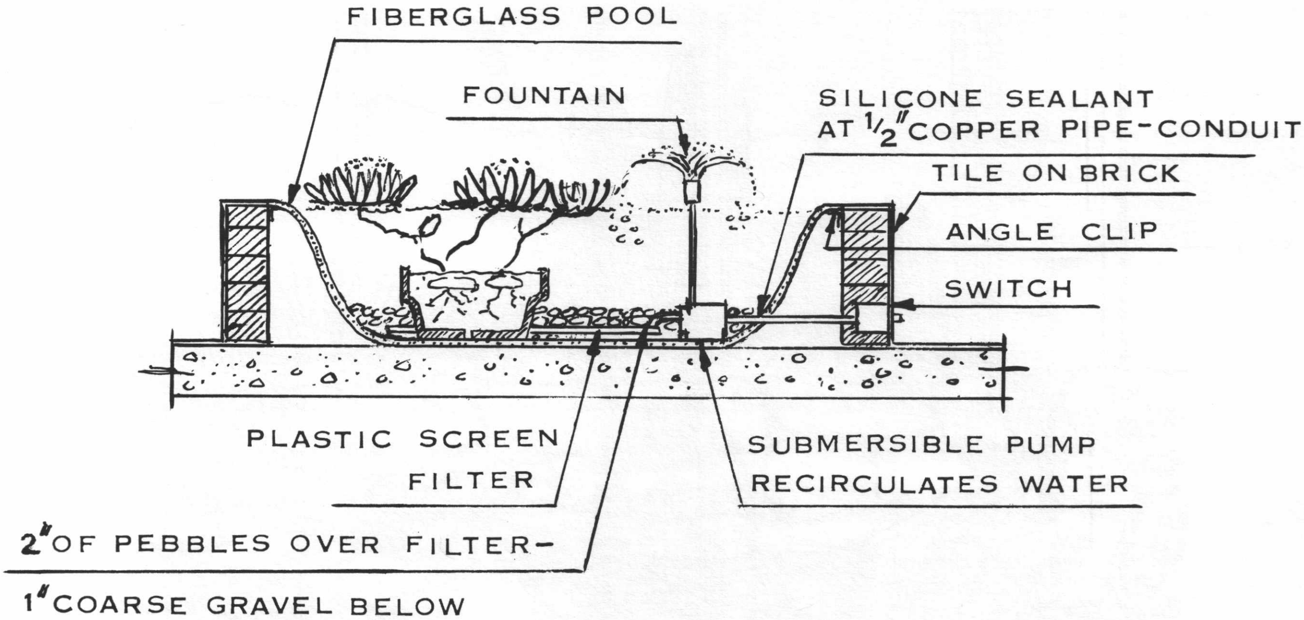
Taro (Elephants Ear). Different varieties range from 1½ to 4 feet tall. Large ornamental leaves. Root growth at water level.

Watercress. The edible type. Assists in oxygenating the water. Should be rooted under 2 or 3 inches of water. Likes cool water.

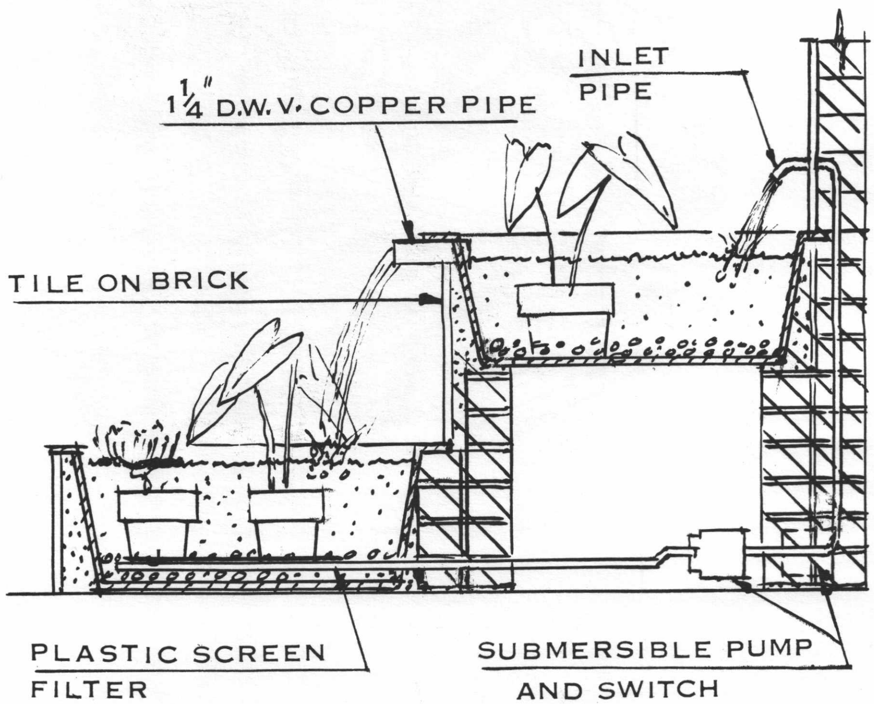
Water Lettuce. Bluish green, ruffled, velvety leaves. The size and shape of a head of bibb lettuce. Can be used as a floating plant or anchored in soil.

Papyrus. Palmlike sedge. Low light level will keep growth in check. Plant in bog conditions.

Horse Tail Rush. Thin, leafless, graceful rush; grows 4 feet tall. Plant in soil.



A standard fiberglass pool is built in with a tile-faced brick surround. Additions such as the recirculating pump are related to good pool health and ease of management.



Umbrella Palm. Has grassy leaves held in an umbrella shape. Resembles papyrus in form. Will grow in constantly moist soil or in 2 to 3 inches of water.

Water Clover Drummondii. A floating plant that does well over deep water. Similar to other clover except that its leaves and stalks are hairy.

Water Milfoil. Dark green, feathery. Called parrots feather. Underwater plant oxygenation.

Sagittaria. The familiar aquarium oxygenator with straplike leaves.

Eel Grass. Long trailing ribbon foliage. Most effective in circulating water in which streamers move gracefully.

Cabomba. Fine foliage, eaten by fish. Good oxygenator.

Mares Tail. A spiked-leaved plant 6 inches to 3 feet tall. Root in pool bottom or low pot.

CONTAINERS, SOIL, AND FERTILIZERS

Authorities recommend removable containers for water plants rather than a bed of earth at the bottom of the pool. Removable containers make planting, cleaning, treatment of ailing plants, and pool repairs an easier matter. Containers also limit the amount of fertilizer needed and make it directly available to the plant.

Recommended containers are made of polyethylene plastic, 15 inches in diameter and 8.5 inches deep or 19 inches in diameter and 9 inches deep. Wood or plastic pails, also obtainable have the advantage of a handle for lifting. If the container can be seen after the pool is planted, it would be desirable to obtain an attractive, well-constructed wooden box like those sold for patio planters that will hold about a bushel of soil for tropical lilies; a ¾-bushel capacity will accommodate hardy lilies and ½ bushel or smaller will take care of other water plants and miniature lilies. New wooden containers should be "cured" by soaking them in a solution of unslaked lime and water for 4 days. Fish and water lilies do not tolerate the exudates of new wood. Never use a redwood container, for curing will not destroy the exudate so injurious to fish and plants. Never use a container that has oily or chemical material on it.

When mixing soil for aquatics, do not include woods soil, leaf mold, rotted wood, sand, bog muck, or peat moss. A good formula for aquatic plants is one part clay soil, one part dried cow manure, and eight parts good garden soil. (Avoid the use of other animal manures.) If the soil is too light in texture, growth will go to leaves. To this mix should be added ½ pound of 10-10-10 fertilizer per bushel of soil. The organic gardener will prefer to mix 2 cups of raw bone meal or 1 cup of dried blood and 2 cups of ground phosphate rock per bushel of soil mix. The proportion of ground potash rock should be 4 cups per bushel to increase this food so important to water lilies.

Stimulating contrasts and visual relief from the high level of light and heat outside this desert office building give the indoor fern and water garden an extra importance. The cool, humid atmosphere in the air-conditioned building is a welcome refuge from the hot, dry outdoor air. These windows face north to keep the sun from penetrating. Fluorescent plant lights keep these forest dwellers in good health. The Margaret Mary water lily will also grow and bloom under these lights.

WATER AND WATER TEMPERATURE

Tropical lilies do best in a temperature of 70°F, although they will perform well up to 80°. Below 70° the tubers may go into the resting stage. Hardy lilies will bloom best between 65 and 75°F, and fish do best in a pool that ranges in temperature from 60 to 70°F, although some will live in water in a range of 50 to 80°F. Thus it would seem that the ideal temperature is 70°F. Automatic pool heaters with temperature-sensing devices are available from aquatic-plant specialists.

Because water, as well as the soil they are planted in, is the growing medium for water inhabitants, its quality is paramount. Our water supplies are full of chlorine and sometimes fluoride and other unexpected pollutants. "Fresh" cold water should not be added to a pool. Fish will die and plants may be killed or go into shock. Before filling the pool the water should be "aged" by leaving it standing for about 5 days; the pool may be filled with distilled water or aerated for 1 hour for each 10 gallons of water.

Healthy pool water will not be entirely clear. Minute living organisms provide the food for plants and fish and are a result of their life processes. A faint greenish tinge will indicate good pool health.

OTHER POOL INHABITANTS

Fish and water plants have the same symbiotic relationship that exists between terrestrial animals and plants. A pool without fish will soon deteriorate.

The pool should be stocked with ordinary goldfish in this proportion: 1 inch of fish (not including the tail) for every 20 square inches of water surface. More exotic fish should have 25 square inches of surface for each inch of fish. Understock rather than overstock because the fish will be healthier in a less crowded environment.

Special snails that do not eat foliage are needed to keep the pool sides clean of algae. Some of these snails are quite colorful. Do not gather snails from the wild. Tadpoles also function as a pool-cleaning crew, but when they become frogs they may wander away from home and be found in unwanted places.

Specialists in aquatics and tropical fish can supply these components of the healthy pool.

MANAGEMENT

Water lilies and most other water plants, if in healthy growth, are bothered by few insects or diseases in the controlled indoor environment. Aphids may be dislodged by hand or by a strong stream of water. The fish will eat them. Leaf miners and leaf rollers are rare and can be controlled indoors by handpicking. An oversupply of snails can be attracted to a cabbage leaf and destroyed. There are probably fewer management problems for the indoor water garden than for any other, with one exception. Adults like to touch water, children like to play in it, and everyone seems to enjoy throwing things into it. Keeping a pool clean of external debris may be the greatest problem encountered and should be taken into consideration in all plans made for it.

Natural Light

Light is the greatest activator of living things on earth. It sets in motion the plant processes that support man. For the indoor garden light must be well planned for plant growth as well as for the building's function.

The quality of light can determine man's emotional response to his living situation, and although he cannot effectively control the quality of light out of doors indoors he can manipulate it to his needs.

The architect can control the method and amount of entry of natural light into a building and design artificial light to compensate for long dark winters and for the smog or rain-clouded sections of the country. He can also provide specific area lighting for plants in buildings that must be deeply shaded to keep out the heat of the sun.

Natural light is self-powered, but artificial light must be bought. New ways of storing free natural light to convert it to artificial have been developed. The solar cell can gather and store the sun's energy as electricity, which can then be used to power auxiliary lighting for indoor gardens when the sun is not shining.

THE MAJOR RESPONSES OF PLANTS TO LIGHT

Photosynthesis

Light triggers the basic food-producing mechanism in plants. Carbon dioxide and water are combined in the presence of light by chlorphyll to form carbohydrates the basic food for plants. In this process oxygen is released. In daylight the plant's respiration process uses up a small amount of oxygen. Darkness stops photosynthesis and the plant continues to take in oxygen and give-off small amounts of carbon dioxide.

Phytochrome

A blue pigment that controls plant growth and flowering is a protein that performs as an enzyme. There are two reversible forms: one absorbs red light at the 660-nanometer peak; the second absorbs far red light at the 735-nanometer peak. The ratio of the 660- and 735-nanometer output of a given light source also determines the ratio of the two forms, of phytochrome; consequently the growth changes response. Thus the choice of electric light bulbs should be based on the ratings of the bulbs to be used in this respect. This information is ordinarily available from manufacturers. Although actual elongation of a plant is one growth aspect related to phytochrome, it is equally important that stems, leaves, and roots be strong, and the results should be rated according to the dry weight per unit of length. This is most important in the indoor garden, for a rangy weak growth is undesirable. What is wanted are healthy plants that will flower and fruit.

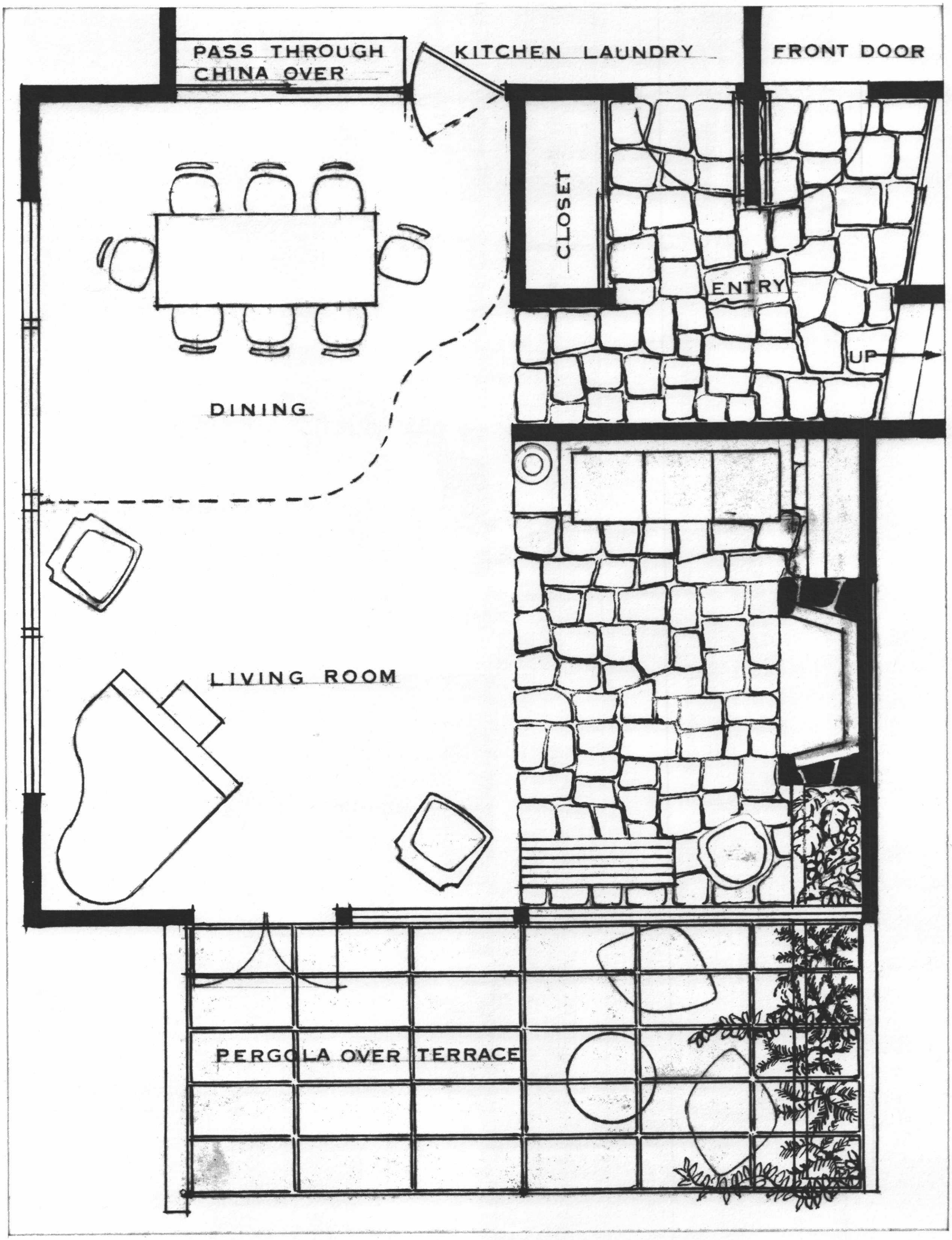
Photoperiodism

Photoperiodism is the reaction of the plant to the relative length of day and night. Plants differ in length of day and night needed for flowering and growth. Tests in Nigeria on tropical plants have shown that as little as 15 minutes variation in day length can prevent or induce flowering.

For the designer of the indoor garden it is important to realize that room lights in areas adjacent to the plant space, although not affecting photosynthesis, may change day length for plants. There are long-day plants (some may flower on 12-hour days) and short-day plants (which will flower on any day length shorter than the critical, which may be 14 hours or more). Day neutral plants are those that flower on a wide variation of day length (4 to 24 hours of light). The architect or client may wish to investigate this matter further. References for study of photoperiodism and phytochrome response are given in the appendix.

For the serious scholar of temperate zone flora some studies that have been underway for more than 10 years at Montana State University, Bozeman, indicate that rather than merely the simple long day, short day, and day neutral explanation of flowering in plants there is a factor of accumulated solar-thermal units that affects the blooming time of a given plant. This concept could provide a reliable method of estimating the rate of development of some plants, particularly early season events of deciduous shrubs and trees. These solar-thermal units seem to be accumulated in the plant structure or at least measured by it, as if money were being put into the bank, but accumulations are begun only after the chilling requirement of the plant has been satisfied. When a certain number of STUs are accumulated or recorded by the plant, it will bloom. The implications of the solar-thermal unit measurement for the indoor gardener when studies include tropicals are not known. The results of this work, as it applies to certain outdoor plants, are to be found in Circular #251 published by the Montana Agricultural Experiment Station, Montana State University, Bozeman, March 1971. A companion work, "World Maps of Potential Evaporation, Transpiration, Plant Development, and Spring Greening and Autumn Browning, Based on the Solar-Thermal Unit Model," could be useful in combination with A. B. Graf's *Exotica*. The *Exotica* lists the country of origin of many tropicals. On the basis of this information and the Montana University world maps it might be possible to extrapolate the required solar-thermal units for the flowering of specific plants.

This living room garden matches the depth of the stone fireplace and extends the garden visually to an outdoor planter. Both inside and outside, it makes the transition from living room to bedroom level more graceful as this hillside house steps up the slope.


PASS THROUGH
CHINA OVER
KITCHEN LAUNDRY
FRONT DOOR
CLOSET
ENTRY
UP
DINING
LIVING ROOM
PERGOLA OVER TERRACE

Photograph by Joseph W. Molitor

Phototropism

Phototropism is the response of a plant to unequal light on opposite sides. This will affect the indoor-garden furnishing layout. A flowering plant with strong phototropism response should be placed so that when in bloom it is not turned away from the viewer.

ORIENTATION CHARACTERISTICS

The characteristics of natural light from each compass direction are quite distinctive:

North. Even light of uniform intensity (except when the sky is overcast). Arctic latitudes would have more summer north light, less winter. The reverse is true at subtropic latitudes.

Northwest and Southwest. Have similar characteristics as have orientations that are shaded by trees or when the direct sun is blocked out by nearby buildings. To increase the light level for north, northeast, and northwest elevations light-reflective materials outside windows or mirrors inside are effective.

East. In remodeled buildings in which functional overhangs do not exist an east orientation may provide the best light for plants. It is cool and less intense than south light and less heat enters the building. In winter the sun rises in the southeast and in summer in the northeast.

Sunshine lights this indoor garden. A ceiling light fixture dramatizes the plants at night. This photograph was taken soon after the garden was planted and plants are still small. Here at the end of September at latitude 44° north the sun is beginning to warm the room to compensate for the cool outside weather. As winter comes the sun will penetrate more deeply into the room to contribute to the heating of the house. The area around the house is lightly wooded and a pergola has been used to shade this south window instead of a solid overhang. There is some dappled shade from the trees and the plants will have sufficient light for good growth.

South. On cloudless winter days a south window will receive six hours or more of sun. In summer, because the position of the sun is higher, the south-oriented window will receive little direct sun; in late fall, winter, and early spring, because of the lower angle of the sun, the sunlight will penetrate a south-facing room. In all latitudes except the subtropical a southern exposure will contribute to real savings of energy on sunny days in winter and drastically cut the need for artificial heating, thus providing the building with a passive solar system.

West. West sun, which starts as hot, harsh light, later in the day becomes deeply penetrating. It is the least controllable and penetrates equally in summer and winter. In winter it can be desirable, but in summer this orientation will raise temperatures to an uncomfortable level or cause the use of more energy to compensate for the heat buildup. Vertical roll blinds, preferably hung outside the windows will provide extra comfort from west sun but they also deprive plants of needed light. West sun will be too hot for plants other than cacti or succulents. If the humidity can be kept high, some tropical fruits, vines, and flowers such as camelias and some citrus will do well. For humans, however, heat coupled with humidity equal discomfort and tropicals and humans alike will do almost as well with a south-facing window and less humidity.

SOLAR ANGLES

The solar charts on pages 72, 73, 74 show the angles of the sun in three latitudes of the Unites States for the four seasons. They can be used to determine the depth and orientation of building overhangs to provide optimum winter and minimum summer sun. The design of building overhangs or pergola shading can be adjusted to provide the ideal conditions for a variety of plants whose needs have been studied. For humans also the automatic shading or lack of it will provide for lower energy use.

VERTICAL SHADING

It is important to remember that in warmer latitudes late winter and early spring may have some unseasonably warm days when the overhang cannot cut out the sun at its lower angle. Provision may have to be made in the more southerly latitudes for vertical shielding from the early spring-early fall sun penetration when heat build-up becomes a problem. Several good systems are designed to augment the aesthetics of the indoor garden window as well as to fulfill a practical need.

Horizontal Sliding Shading

A commercially available window valance which incorporates a heating unit and a track for draw curtains is worth consideration for windows adjacent to plant spaces. Some valances also combine lighting and curtain tracks. Most curtain fabrics, however, with the exception of fiberglass, are not recommended near soil and water. Horizontal sliding woven wood curtains can be made water resistant with a variety of treatments both in color and natural finishes, and handsomely textured flexible aluminum draperies fold into a compact space when not in use. Only a small amount of light will penetrate them. The sliding curtains are stored in the open position along sections of wall next to the windows.

If horizontal travel curtains are installed outside, they must be provided with rain- and windproof pockets for storage when not covering the windows.

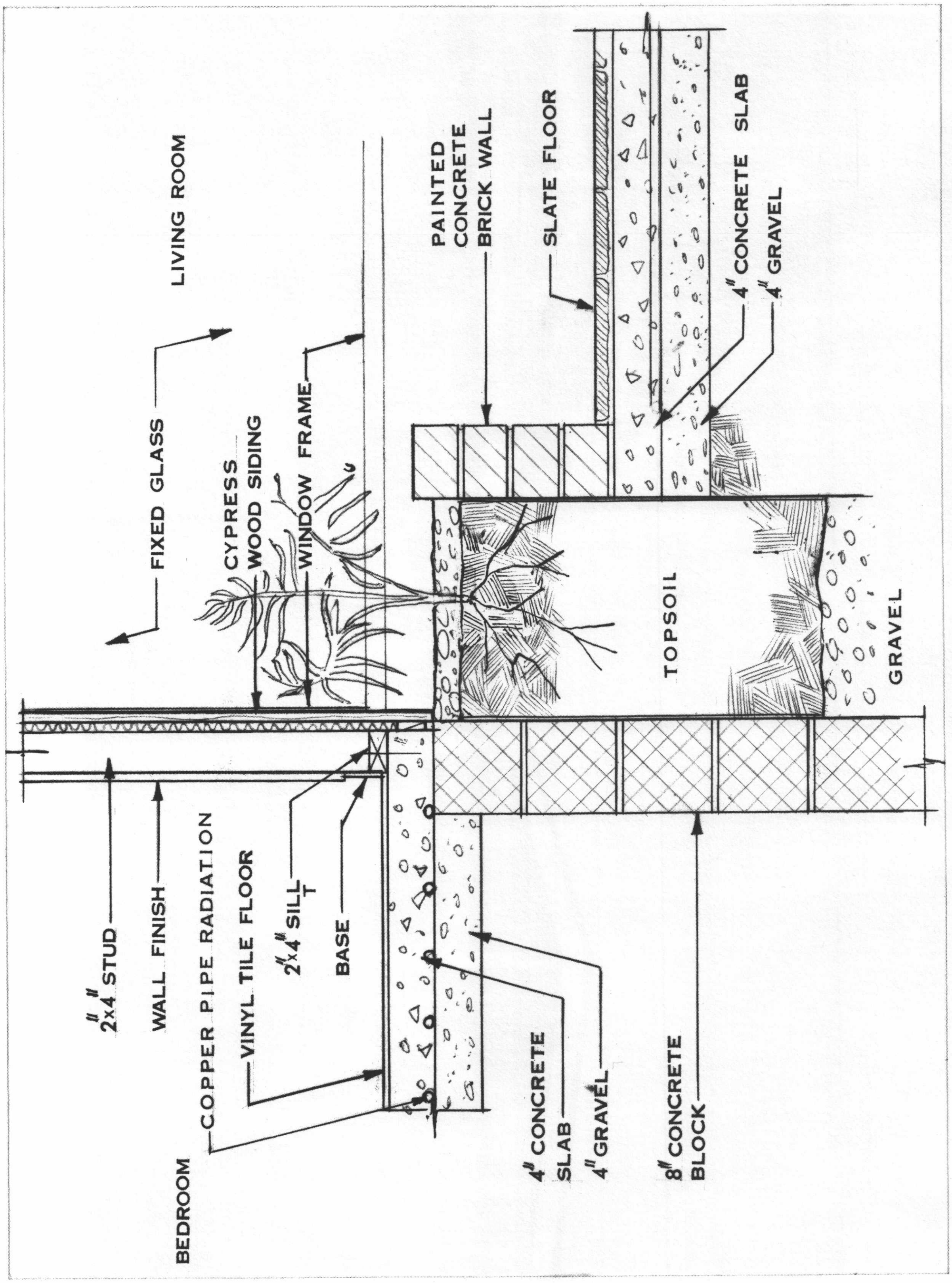
Roll-up Shading

Interior roll-up shades have several advantages over the horizontal sliding type. They will store well out of the way of the hazards of water and soil and can be hidden in pockets over the windows. These blinds can also be installed on the outside to stop excessive heat from entering through the glass. Because they roll up tightly, they will not be torn off by the wind, and if end guides are installed they will not flap during a sudden storm. The materials for these blinds, which are available in great variety, include miniature venetian blind slats, fabric, translucent flexible plastics, "decorator" or plain narrow wooden slats, and the familiar bamboo.

GENERAL

In certain situations the sun roof may be the best source of natural light, in which case shading for summer, ventilation of unwanted heat, and movement of air must be provided for (see page 110).

In choosing an orientation, the height and proximity of nearby buildings and location of major trees must be considered. Evergreens will affect the amount of light received year round in much the same way. Deciduous trees, early or late leafers, will variously affect sunlight at different times of the year. If outside building elements (decks, terraces, adjacent walls), are light colored, there will be enough light to support plant health in summer in spite of the lack of direct sun.



This garden helps to make the transition between levels on a sloping site.

Photograph by Fred Rola

An outward-reaching indoor garden seeks extra sun for its plants. The photographs on pages 29-179 show this dining room garden at different stages of growth some years apart and at different times of year. The detail, page 130, shows the method of construction and location of the garden. The shading of the windows by overhang is demonstrated here in early summer. The splayed garden element adds interest to the long southern elevation.

The effectiveness of natural light may be increased by the use of mirrors wherever they are adaptable to the design. Well-placed mirrors make a formal setting for plants and are responsible for a more even distribution of light. Phototropism (the tendency of plants to face the strongest light) may be diminished. Mirrors should never take direct sunlight on their surfaces for the concentration of light may be too great.

The distance between plants and the light source is important. Plants with lower light requirements should be placed farther from the light source than those requiring maximum sun; for example, neither epiphytic nor terrestrial orchids can tolerate the sun's direct rays but they do need good light, for in nature they grow in sunlight filtered by the green leaves of the forest. Several studies are underway to determine the influence of "green" light on the development of exotics found on the forest floor or sheltered by tropical trees.

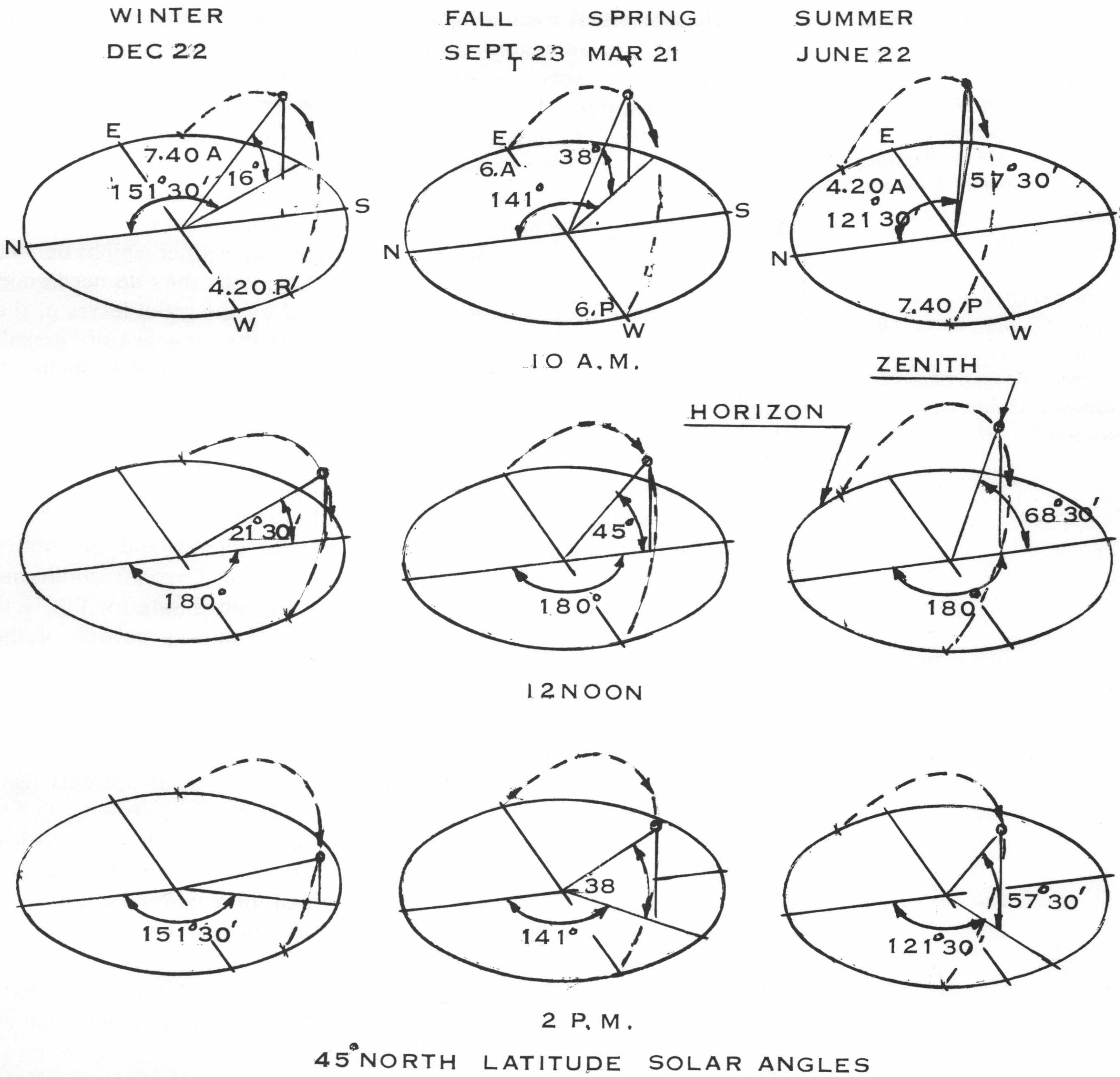
In hot climates ideal indoor garden orientation is northeast to east. In colder climates, in which some winter thermal benefit, as well as a good light for plant growth, is desired inside the building, southeast or south is preferred if overhangs are provided to cut out hot summer sun.

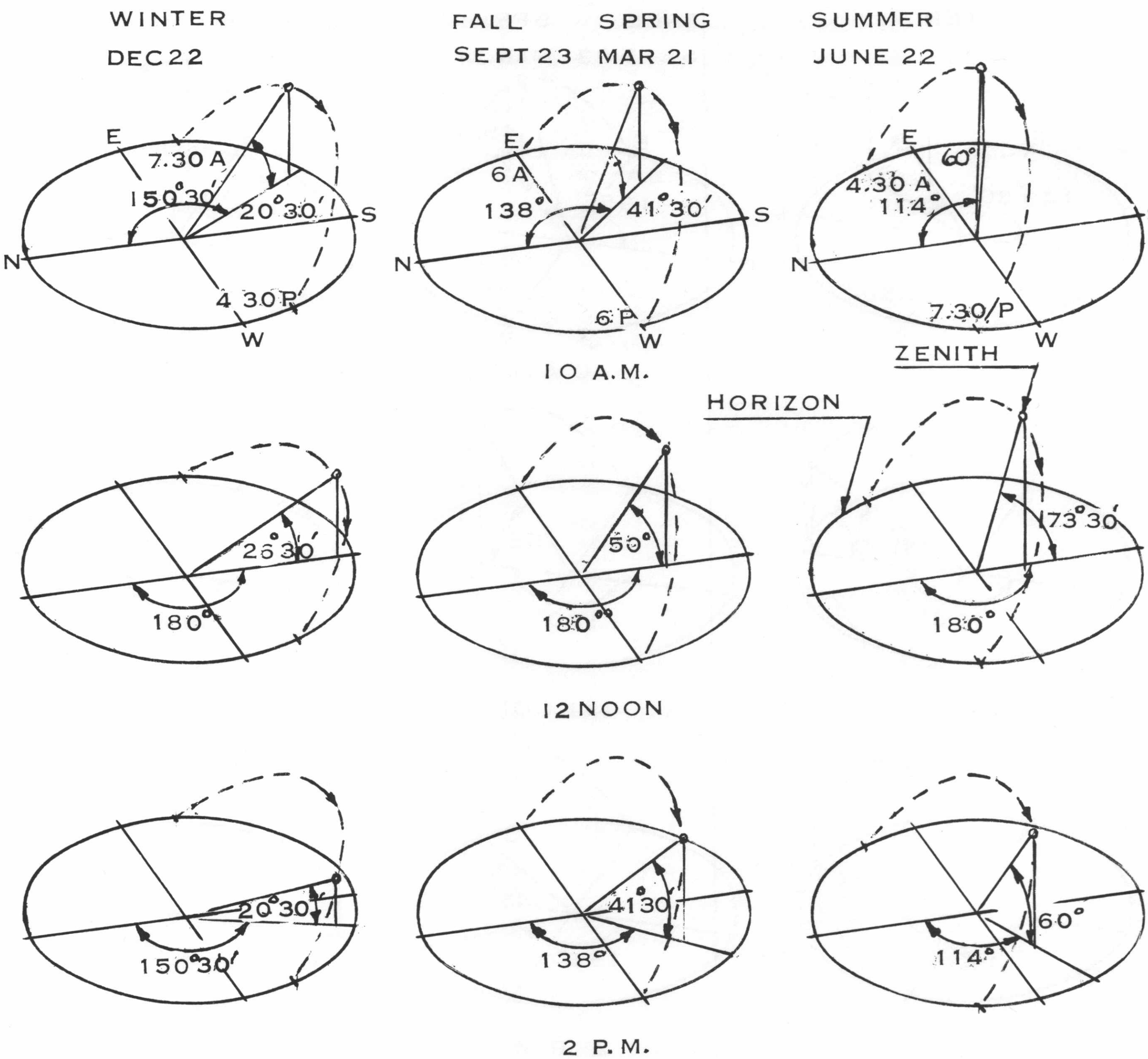
In northern latitudes not only is the sun less intense and the winter day shorter but there are more cloudy days as well. Overcast diminishes the red light absorbed by plants. It is helpful to compensate for this lack. Incandescent lighting may be used to provide the missing portion of the spectrum. Fluorescent lights also produce some red light.

Overcast days are brighter overhead than at the horizon; the opposite is true on sunny days (except the area around the sun). In a northern latitude, then, it is worthwhile to consider a sun roof (see page 75) to obtain optimum winter light. However, if deep snow on this roof prevents light penetration, no advantage will be obtained over a vertical source.

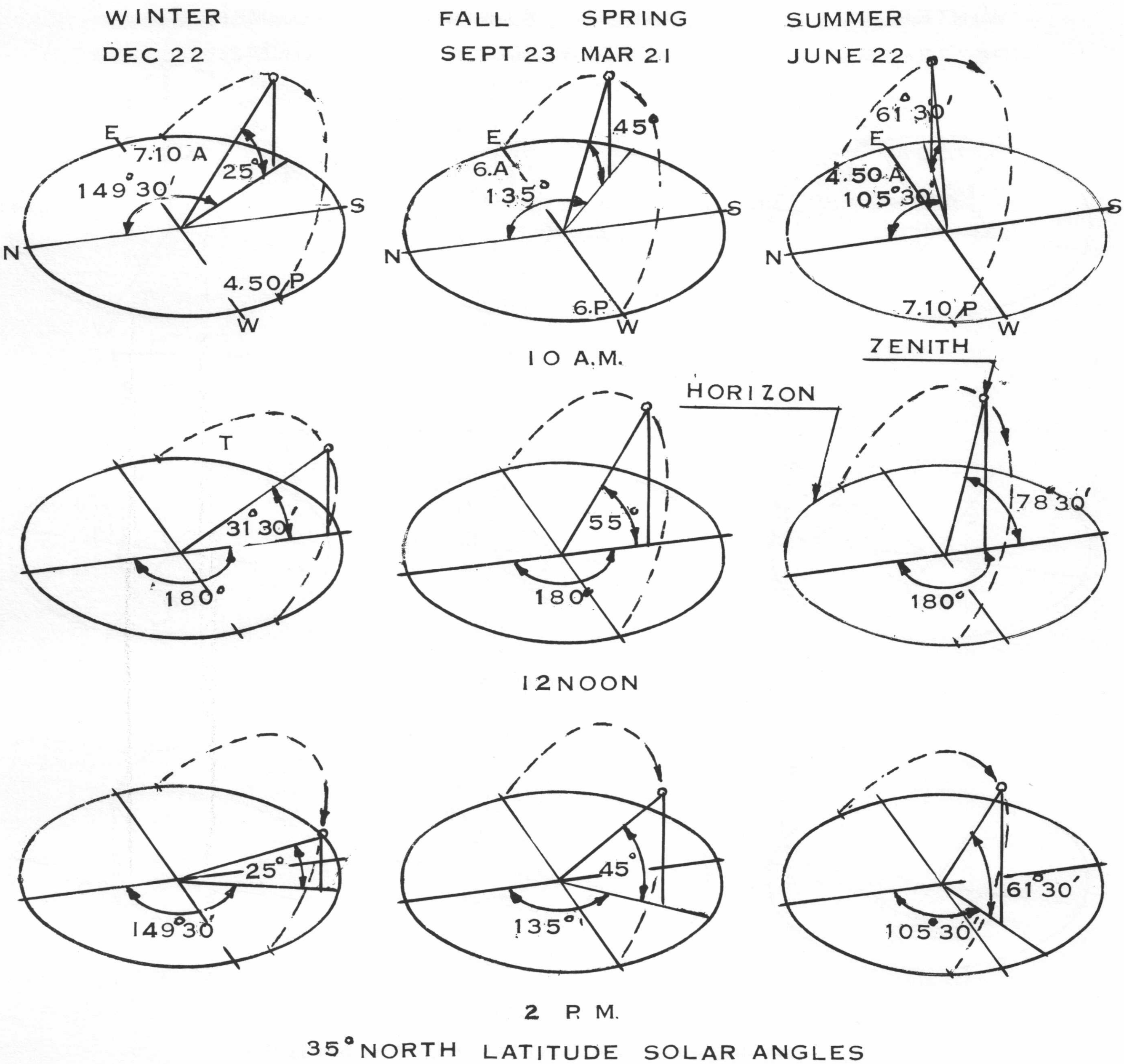
Sunlight usually enters a building through glass, although some critical areas may be windowed with heavy-duty plastics. It is desirable to install clear, untinted glass adjacent to an indoor garden for maximum sun benefit. Soiled glass can reduce the intake of sunlight as much as 10%, and muntins, the wood or metal divisions between panes, can appreciably reduce the amount of light plants receive. For large areas the architect will specify ¼-inch plate or insulating glass for severe climates. For areas of less than 50 square feet 3/16-inch sheet glass is a better choice.

Orientation, light reflecting off outside surfaces (or off snow or water), shading by overhang, and cleanliness and clarity of glass will all affect the quality of light transmitted. In planning for natural light, these influences must be taken into account to achieve success with plants in the indoor garden.


WINTER
DEC 22
FALL
SEPT 23
SPRING
MAR 21
SUMMER
JUNE 22
E
7.40 A
16°
151°30′
S
N
4.20 P
W
6.A
38°
141°
6.P
4.20 A
57°30′
121°30′
7.40 P
10 A.M.
ZENITH
HORIZON
21°30′
180°
45°
68°30′
12 NOON
151°30′
38
141°
57°30′
121°30′
2 P.M.
45° NORTH LATITUDE SOLAR ANGLES



40° NORTH LATITUDE SOLAR ANGLES


WINTER
DEC 22
FALL SPRING
SEPT 23 MAR 21
SUMMER
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6.A
135°
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61°30′
4.50 A
105°30′
7.10 P
10 A.M.
ZENITH
HORIZON
T
31°30′
180°
55°
78°30′
12 NOON
25°
149°30′
45°
135°
61°30′
105°30′
2 P.M.
35° NORTH LATITUDE SOLAR ANGLES

A sun roof in an enclosed entrance with a saffron-colored corrugated fiberglass roof gives the effect of sunshine in all weathers. Here a background of philodendrons is brightened by spring flowering bulbs.

Photograph by Jack Roche

Artificial Light

The science of artificial lighting for indoor plants is inexact at best. Our understanding of the effect of the full range of the sun's influence on plant growth is incomplete and we have not yet discovered how all the elements of sunshine affect plants and people biologically.

The development of artificial lighting for plants to be grown indoors has been concerned with the determination of the quality of sunlight that affects root growth, top growth, flowering and fruiting, and resting periods.

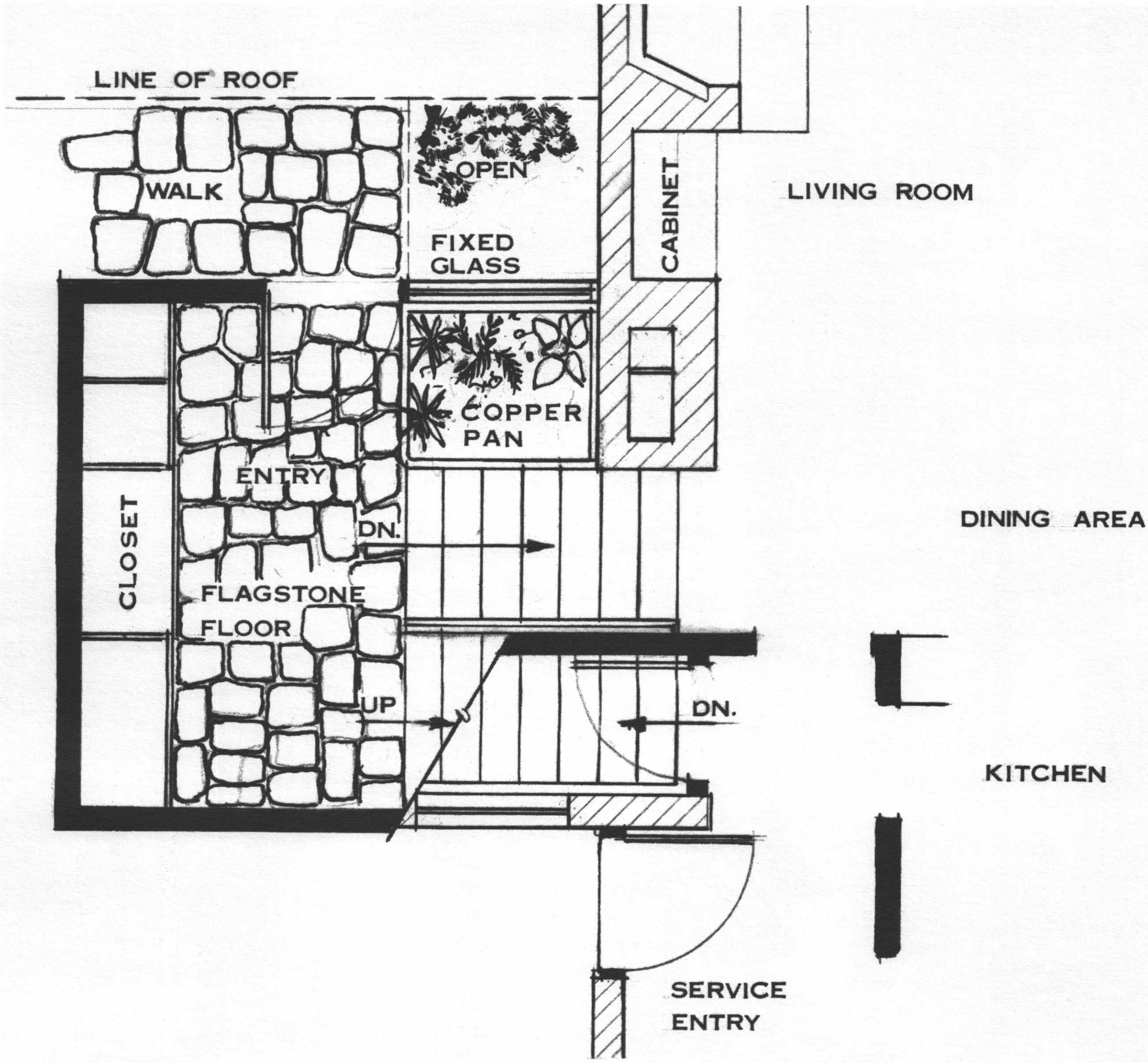
In addition to the regulation of plant growth by the sun's various rays, there is also the matter of short and long days which influence plant development; that is, the control of flowering and fruiting by adjusting the length of day to match the plant's inherent response to the hours of sunlight received. It is interesting to note here that the term "long day" is old fashioned and that after the terms long and short "day" became common in scientific literature it was found that the inherent response of plants is to hours of darkness rather than hours of sunlight. Plants actually measure the duration of the dark period. Thus we have the apparent contradiction, when two kinds of plant are grown on a 14-hour day, that one may be long day and the other short because the long-day plant will not flower on any day length less than the 14 hours and the short-day plant will not flower on any day longer than 14 hours.

Because of commercial interest in raising food and flower crops indoors, there is on-going work in the development of indoor "sunlight" by the major lighting manufacturers. Some of the results of this work are applicable to the noncommercial indoor garden. Many commercial and scientific installations use high intensity lamps initially intended for street lighting.

The architect will not need to concern himself with background research on the subject but only with the equipment, and its characteristics, currently available for use in design. He should, however, understand the

As an entrance feature of a split-level home this indoor garden protects the front-door swing and makes a feature of the stairs down to the living room. The plan (page 78)shows this relationship. The detail is similar to that shown on page 91. An incandescent plant growth light features the plants.

Photograph by Joseph W. Molitor


LINE OF ROOF
WALK
OPEN
FIXED
GLASS
CABINET
LIVING ROOM
COPPER
PAN
ENTRY
CLOSET
DN.
FLAGSTONE
FLOOR
DINING AREA
UP
DN.
KITCHEN
SERVICE
ENTRY

The plant space in this entrance protects the stairs from the door swing and makes the space visually larger.

basic principles in order to provide his client with a system that is aesthetically pleasing, beneficial to plants, and economical to operate.

In designing an indoor garden, the architect will not always have to count on artificial lighting for the entire lighting, but he should provide lights that will add to the attractive qualities of the plants in their settings, increase the "daylight" on cloudy days, and also extend the day length in winter months.

Shopping malls are favorite plant locations. The design of a mall can incorporate a light well for the collection of natural light. If there is none, however, an otherwise desirable area for an indoor garden can be lighted artificially.

Shopping malls are often open 12 hours a day, and even when closed to the public are lighted for reasons of security. This location dictates the need for a careful choice of plants in the day-neutral category. Most tropicals require a much shorter day length than is obtainable in a mall or in many other public buildings.

To help alleviate the problem of after-hours light spill from night-time safety lights the architect should consider a ceiling-mounted curtain track that follows the shape of the indoor garden on which to hang a dense black or dark-colored fabric, such as velour, to obtain the required number of dark hours when the plants are not on public view. A pocket for out-of-sight storage of the curtain should be provided. The rain forest case, shown on page 148, could be equipped with a track mounted on the exterior so that the curtain could be removed when the building is open to visitors.

When lighting indoor gardens artificially, the designer is not attempting to duplicate the conditions in a commercial greenhouse nor is he limited to the requirements of a home-lighted plant stand designed for use in little or no natural light and which often interfere with the aesthetic effect of the plants. In most cases artificial light in a home garden merely supplements natural light or is used to augment the beauty or visibility of the plants. Thus the factor of distance of the light source from the plants is not paramount. It does, however, affect the efficiency of the lighting system. Light becomes less efficient in the use of energy and in beneficial effect on plants as it is located farther away from them.

Because plants vary in height and density and because, it is expected, they will continue to grow, it is unwise to imitate laboratory or commercial greenhouse conditions in an indoor garden. In the one-crop greenhouse or laboratory lights, depending on the kind used, are placed 1 to 3 feet above the plants for greatest efficiency. Some of that efficiency will have to be sacrificed in the interests of appearance and because of the variety of plants grown in a room situation.

Because they give off little heat, cool white (or special plant growth) fluorescent lamps can be placed amoung the plants if waterproof lamp holders are provided. The ballast in this case would be remotely mounted. These lights can be supplemented by incandescent lighting fixtures (see page 96) equipped with the 75-watt Spot-Gro bulb developed by Sylvania or similar products of other manufacturers. To prevent heat buildup near the plants small-wattage bulbs instead of one high-wattage lamp can make up the incandescent contribution to fluorescent lighting. These small bulbs will give better heat distribution and avoid the problems of overconcentration of light.

PLACEMENT OF LIGHTS

Lamps should not "blind" or otherwise cause disorientation or discomfort. This is especially critical in the use of high wattage incandescent, mercury, metal halide, and high pressure sodium lamps that are concentrated in a point source. The point source light has an advantage over the broader fluorescent source because it is amenable to reflection optics and can be shielded without much loss. In the design for an indoor garden this would mean that the light source could be beamed toward and restricted to the area of the plant space, or even to an individual plant, and that it would not spill out onto the area of pedestrian travel or adjacent areas needing other types of lighting.

It is important to balance light sources of different spectral quality in the plant space with other lighting in adjacent areas. Cool white fluorescent lamps will make incandescent and sodium vapor lamps appear to be excessively yellow. Incandescent and sodium vapor lamps really are yellow and only retinal compensatory factors make them look white. Some contrast is unavoidable, but the use of special plant growth fluorescents will make it less striking.

It is easier to balance the differing spectral qualities of lamps in a large public indoor-garden installation than it is in a residential indoor garden. Incandescent reading lights set the general color tones of most rooms. Fluorescent light is often used in a bathroom or over work areas in a kitchen. In the latter areas the plant-growth fluorescent lamps are compatible.

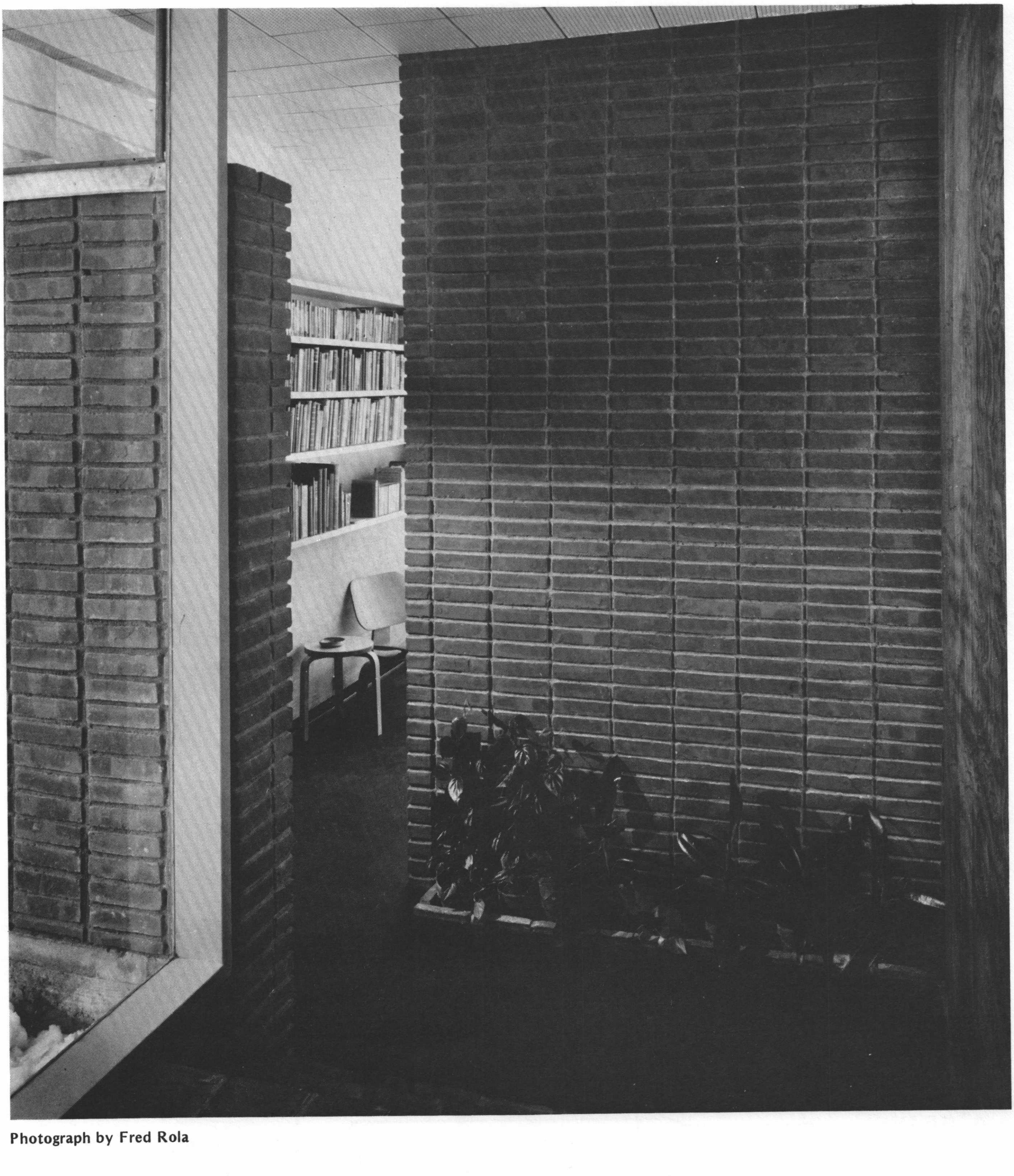
In lighting a "reading light" area or entrance hall, however, a mercury vapor light bulb such as Wonderlite or a plant growth incandescent would be used in preference to fluorescent for its compatibility with other lighting.

The handsome little light fixture designed for the circline fluorescent lamp (see page 87) should be considered for spectral balance with incandescent lamps. The shading of the lighting fixtures (page 88) may also sufficiently confine the light to the plant space so that, although it is different in quality from other room lights, it would limit its area of influence to the garden.

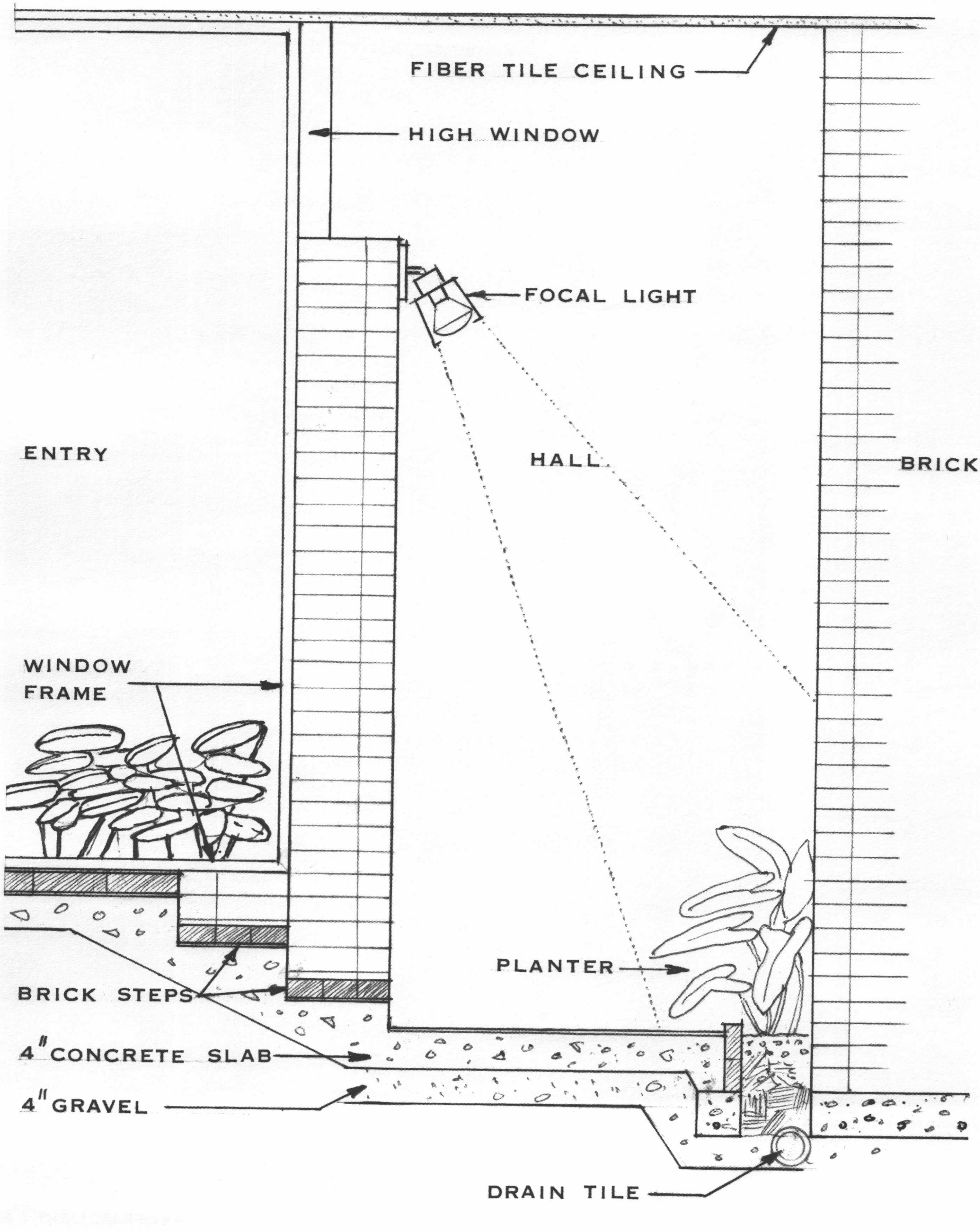
Incandescent light sources should be directed only toward the plants and should never interfere with pedestrian travel.

The goals, then, for a good plant-space lighting system are, first, that it be attractive and, second, that it augment natural daylight, or compensate for its lack, for improved plant growth.

An indoor garden located in an interior hall contains Philodendron cordatum and small Ficus elasticas. Both plants will do well with artificial light and little care. The green foliage contrasts well with the stack bond red brick wall.



Photograph by Fred Rola


FIBER TILE CEILING
HIGH WINDOW
FOCAL LIGHT
ENTRY
HALL
BRICK
WINDOW
FRAME
PLANTER
BRICK STEPS
4" CONCRETE SLAB
4" GRAVEL
DRAIN TILE

CHOICE OF LAMPS

An inside garden along a corridor is lighted for plant growth and to feature the leaves of low-light-level plants against the wall.

Many kinds of light source, from incandescent through the full range of fluorescent tubes, are photosynthetic activators of plants. The difference between them is their spectral distribution, that is, the amount of red, far red, and blue light available to the plant, which operates the photosynthetic system and controls the phytochrome response for strong growth and flowering.

Blue light regulates the plant's production of carbohydrates. Red light activates the absorption of nutrients and the plant's other responses to light. Far red and red light regulate stem length, seed germination, and leaf size, and far red light works to control the plant's response to red light rays. These members of the light spectrum act and react on one another in complicated ways. Blue and red work together to initiate photosynthesis; red and far red may act antagonistically to control photoperiodism and photomorphogenesis. Red is equivalent to exposure to daylight and far red causes plants to respond as they would to darkness.

Although sunlight has all the spectral components necessary for plant growth, its components are utilized at various degrees of effectiveness. Therefore, although green light will operate the photosynthesis system, red and blue do it much better. Plants use what they have. The search for the best artificial light for indoor plants has been concentrated on developing light bulbs with economy of energy and long life (all lamps decrease in output with age) and for lamps that produce necessary growth stimulants. Although the incandescent lamp supplies red and yellow, it is deficient in blue light. Regular fluorescent lights provide the blue, green, yellow, and red range. A combination of cool white fluorescent and 10% incandescent light has been used for some years. This is a system that is easy to adapt to the average living situation. The tables on pages 86, 89, 90 list currently available lamps. Metal halide, high-pressure sodium, and mercury vapor lamps have been used so far in commercial installations, but the housing is not aesthetically pleasing for other purposes. The Wonderlite, by Public Service Lamp Co., a self-ballasted mercury-vapor light, will fit the 150-watt porcelain socket fixture shown on page 99. Sylvania is working on the development of high-pressure sodium lamps with more tailored spectra for plants.

DATA ON LIGHT BULBS

The excellent tables on pages 84–85, 93, 97, 98, researched and compiled by H. M. Cathey and L. E. Campbell of the USDA, Agricultural Research Service, Beltsville, Maryland, contain input power conversion figures for the architect's consulting engineer (Table 5, page 93). Because plant lighting is a specialty in electrical engineering, these figures will be most useful to the electrical engineer who designs the building's electrical system. It will also be useful to the architect who designs his own electrical systems for smaller work.

For the architect probably the most unusual and hard to come by data are listed in Table 8 (Color Rendering of Plants, People, and Furnishings, page 98). In the design of lighting for plants it is important to consider its effect on human complexions and room furnishings adjacent to the indoor garden. This table has that information. Wonderlite is not included

Table 2 **Comparison of Bulbs for Plant Growth**

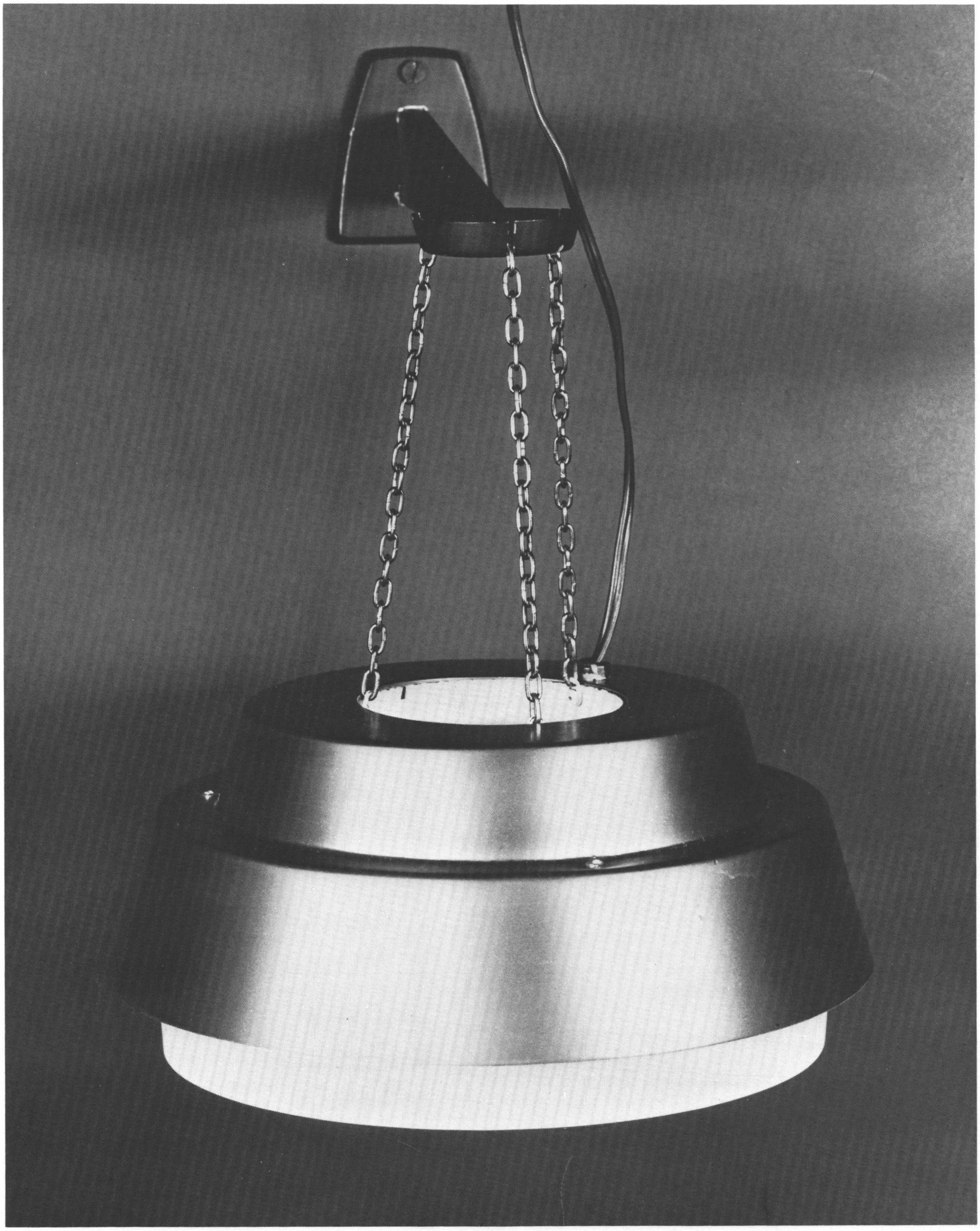
Incandescent Bulbs	Maker	Wattage	Base Size	Approximate Hours of Life	Approximate Initial Lumens	Special Features	Special Uses
Krypton	Durotest	90	Medium	2500	1290	Extra brightness	
ATC	Durotest	100	Medium	4000	1290	Long life	
Armored Hercules	Durotest	Stand	Medium	Various		Shatterproof, thermal-mechanical	Where water may hit a hot bulb
or Tuff-skin	G.E.	Stand	Medium	Various 150 = 1000	Low		
Reflector floodlight R-30	All manufacturers	50,75 150	Medium	2000	150–1870	Suitable for protected places	Not water-proof
Projector floodlight PAR-38	All manufacturers	75,150	Medium skirt		150–1740	Pyrex glass, weatherproof	Where water is a factor
Show Case (clear)	All manufacturers	25,40	Medium	1000	248,430	Long and narrow; fits standard base	When arrangement parallel to fluorescent tubes is desired
Spot Grow Reflector spot	Sylvania	75,150	Medium	2000	Not given	Developed for plant growth; missing blue range of light	Best used in conjunction with cool white or other special fluorescent
Duro-lite plant light	Durolite Lamps, Inc.	75,150	Medium	Not given	Not given	Developed for plant growth	May be used alone or with cool white fluorescent

specifically designed for measuring artificial light; for example, General Electric's model 214 with three ranges—10-50fc, 50-250fc, and 200-1000fc—with a X10 multiplying cover. To use this meter Dr. Cathey says:

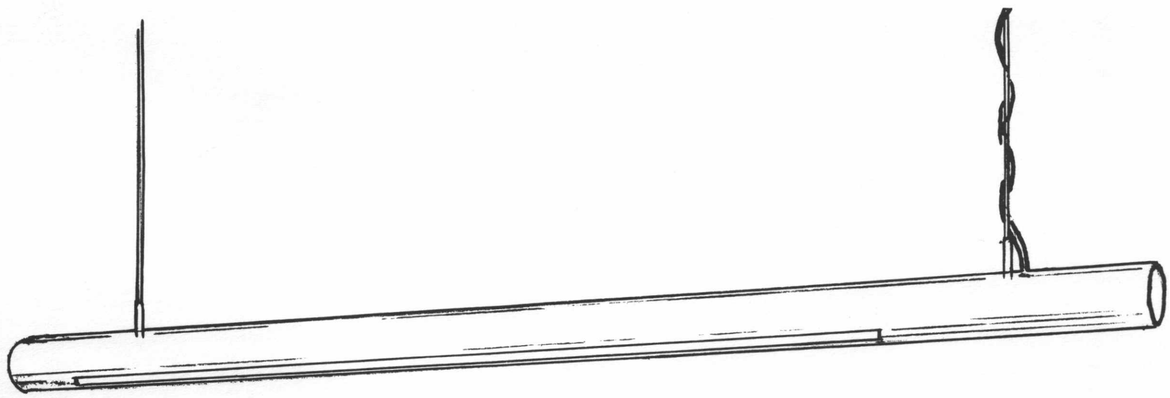
> Place the top of the meter parallel to the surface being measured for light, then shift switch position from high to medium to low to determine the intensity of light in footcandles. Take several readings and average the results.

A few other light meters are available for measuring footcandles of artificial light. Often the one at hand will be a photography meter not intended for this purpose and thus less accurate. Directions for the use of the photographer's meter for footcandle measurement converted from the camera

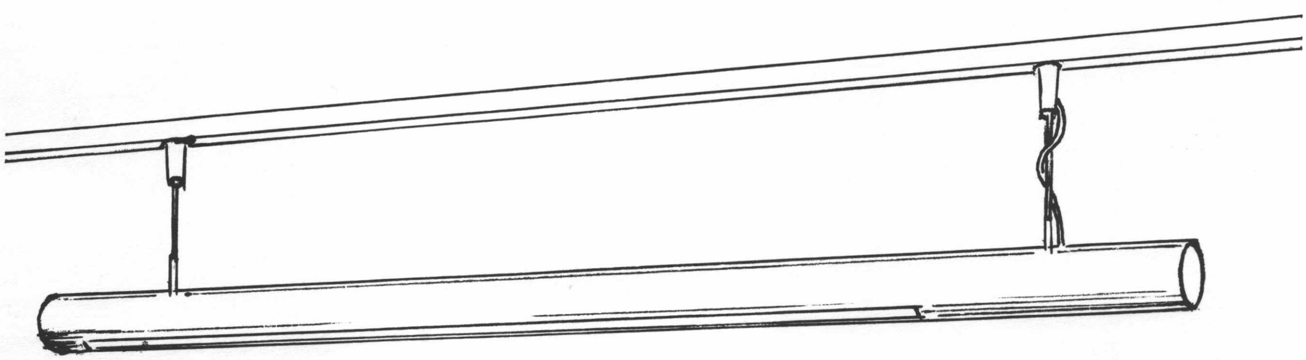
This fixture can be wall bracket mounted in proximity to plants. A plug-in cord has an integral ballast. The bulb for which the fixture was designed is the fluorescent 'Circline" type. Source: Sylvania Inc.



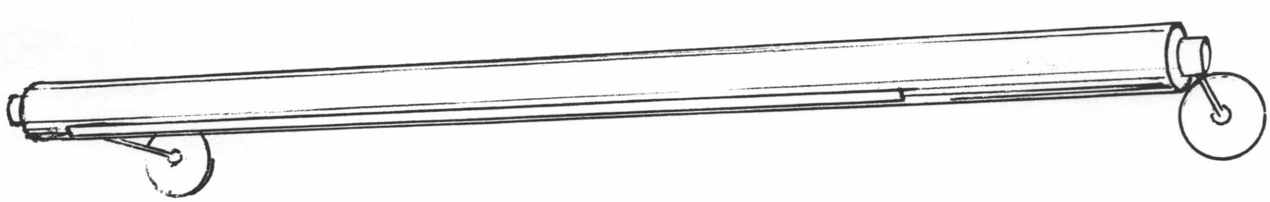
Photograph courtesy of GTE Sylvania, Inc.



PENDANT FLUORESCENT FIXTURE BY LIGHTOLIER



TRACK MOUNTED



WALL BRACKETED

Table 3 **Comparison of Bulbs for Plant Growth**

Fluorescent Bulbs	Maker	Wattage	Length (inches)	Approximate Hours of life	Approximate Initial Lumens	Special Features	Special Uses
Agrolite	West.	15 20 40	18 24 48	7,500 9,000 20,000+	410 600 1600	Developed by West., for best spectral power for overall plant growth	Specially designed for plants
Deluxe cool white rapid start	Major manufacturers	15 20 30 35 40 50	18 24 36 42 48 60	7,500 18,000	610 1530	Best of general-use fluorescent lights for plant growth	Plant growth better if combined with incandescent
Deluxe cool white mixer	Major manufacturers	35 60	48 96	20,000 12,000	2000 4000	Economy in energy use; 18% less light output	Plant growth better if combined with incandescent
Deluxe cool white, all-weather, rapid start	Major manufacturers	110 160 205	48 72 96	9,000 9,000 9,000	4400 7100 9700	For water and temperature hazard situations	Plant growth better if combined with incandescent
Power Twist, cool white	Durotest	40–215	48–96	20,000	+750 over comparable lengths	Fits standard ballasted fluorescent fixture; longer life; higher output	Plant growth better if combined with incandescent
Wide spectrum Gro-Lux	Sylvania	8–215	12–96 or Circline	6,000 to 10,000	125–7200	Fits standard fixture; good spectrum balance	Specially designed for plants
Vitalite	Durotest	15–215	18–96			Heavy on ultraviolet	Specially designed for plants

Many light fixtures for fluorescent bulbs are not suited for use with the new specialized plant growth stimulating bulbs. These fluorescent fixtures can fill the requirements by shielding bare bulb light and allowing adjustment of distance from the plants. Source: Lightolier.

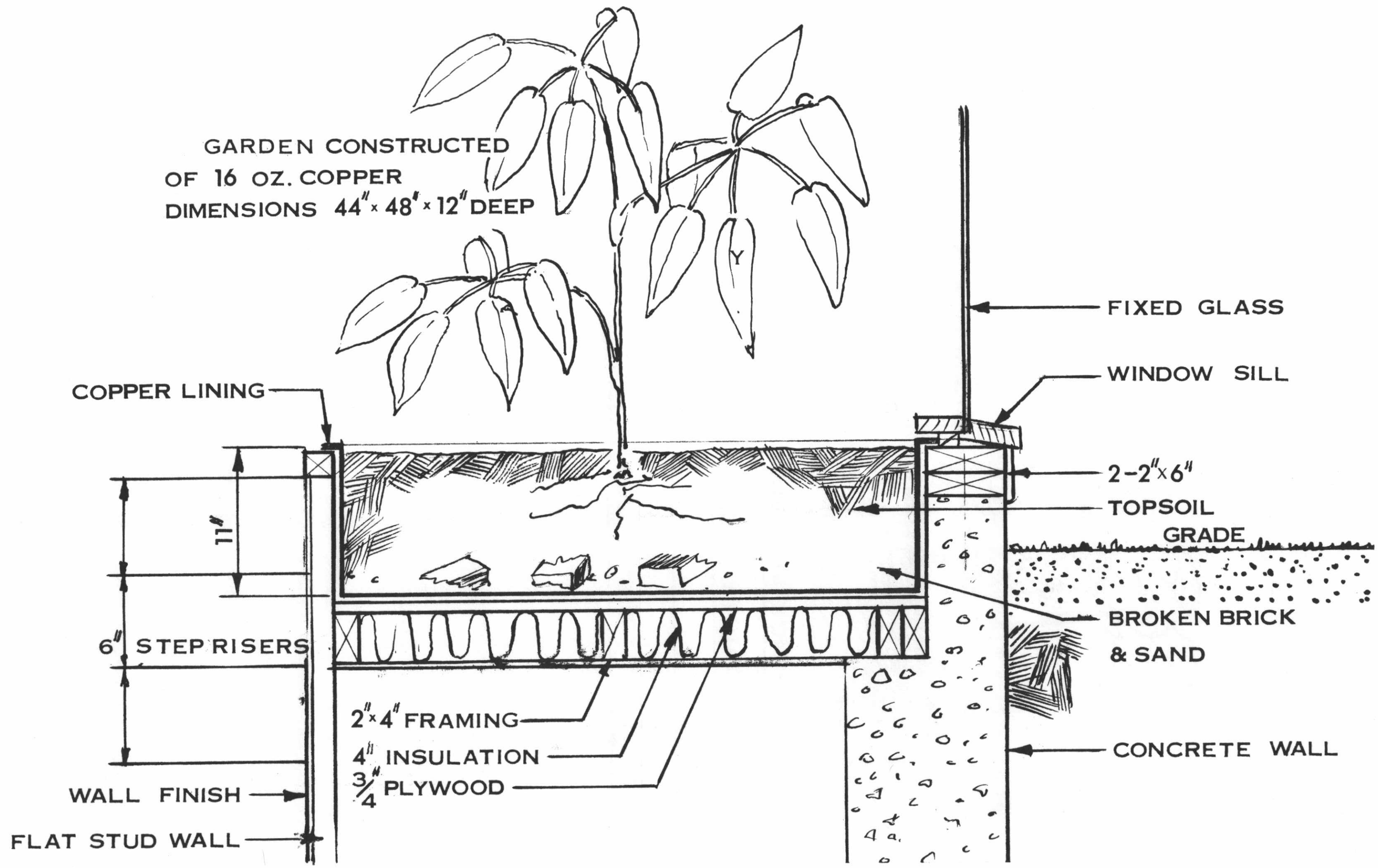
opening obtained are usually included in a chart that comes with the meter or can be obtained from a camera shop.

Table 1 is directed to the designer as well as the manager of the indoor garden because it details the growth patterns stimulated by the various plant lamps on the market. Again, the Wonderlite mercury vapor lamp is not included because it has only recently become available. When tested, it may rate better for growth than the Deluxe mercury lamp.

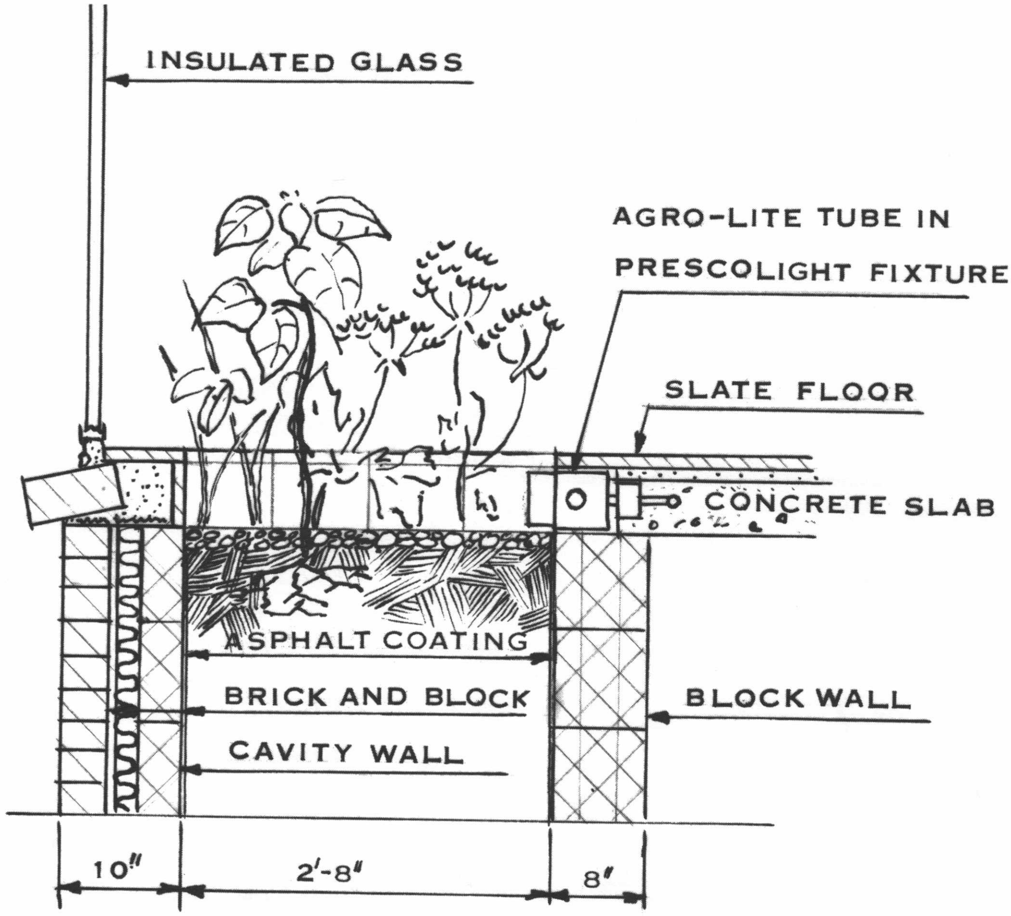
Table 4 Comparison of Bulbs for Plant Growth

Special Bulbs	Maker	Length (inches)	Lowest Wattage	Base Size	Approximate Hours of Life	Approximate Initial Lumens	Special Features	Special Uses
Lucalox	G. E.	7 3/4	100	Mog.	12,000	9,500	Long life; require special electric system, high-pressure sodium lamps	Where *strong* "white" light is not undesirable; excellent growing lamp
Ceramalux,	West.	8 5/16	150	Mog.	16,000	16,000		
Lumalux (High Pressure Sodium)	Sylvania		150	Mog.				
Self-ballasted mercury deluxe white	West.	11 1/2	450	Mog.	16,000	9,100	Long life; will fit in regular porcelain socket; must not exceed fixture wattage rating	Where brilliant light is acceptable; deluxe white fine for plants
	G. E. Heidt	8	160	Medium skirt	20,000	2,700		
	Heidt	8	160	Medium	20,000	2,700		
	Durotest	8	160	Medium	20,000	2,700		
Metal halide	G. E.	11 5/16	400	Mog.	15,000	34,000 (vertical)	Separate mercury or metal halide ballast necessary; see manufacturer's special instructions	Strong white plant light for special installations
	West.	11 1/2	400	Mog.	15,000	34,000		
Wonder-lite	Public Service Lamp Co.	7 1/4	160 R-40	Medium	12,000	3,250	Combines incandescent and mercury qualities; use only in porcelain socket	Where a livable light is desired; important feature is that it will fit standard fixtures for R-40 bulbs with porcelain sockets
		7 1/4	300 R-40	Medium skirt	14,000	6,750		
		12 3/4	500 R-57	Mog.	16,000	11,780		
		12 3/4	750 R-57	Mog.	16,000	21,000		
		13 7/8	750 R-80	Mog.	16,000	21,000	Corning safety glass "Nanex" protects against breakage in situations in which misting is used	

Tables 2, 3, and 4 list technical information supplied by the manufacturer's catalogues.



A section through a plant space showing the garden above grade on a wood floor.



A light source located at the edge of the plant space makes an attractive nighttime effect and also aids plant growth. Side or top natural lighting should augment this source for plant health.

Table 5 For the Consulting Engineer: Input Power Conversion of Light Sources[a]

Lamp	Input Power Total (watts)	Lamp (watts)	Total Lumens per Lamp	Total Lumens per (watt)	Visible Radiation (%)	Nonvisible Radiation (%)	Conduction and Convection (%)	Ballasts Loss (%)	To Convert to Watts per Meter ^{2} (400–850 nm) Radiation Divide Footcandles by
Fluorescent									
Cool white	46	40	3,200	70	20	32	35	13	32
Warm white	46	40	3,250	71	20	32	35	13	32
Gro Lux	46	40	925	20	13	35	39	13	14
Gro Lux-WS	46	40	1,700	37	15	35	37	13	21
Agro-lite	46	40	1,900	41	15	35	37	13	23
Vita-lite	46	40	2,180	47	18	33	36	13	25
Discharge									
Mercury deluxe	440	400	22,000	50	13	62	16	09	34 (all types Hg)
Metal halide	460	400	34,000	75	20	54	13	13	28
High-pressure sodium	470	400	47,000	100	25	47	13	15	27
Low-pressure sodium	230	180	33,000	143	27	25	26	22	43
Incandescent	100	100	1,740	17	07	83	10	0	10
Incandescent-mercury	...	...	...	18-25	...	...	...	...	15

[a]Values compiled from IES Handbook, manufacturers' data, and published information.

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Incandescent plant growth lights, such as "Spot-Grow" and "Plant Lite", will fit a 75- or 150-watt rated fixture designed for an R40 lamp. Prescolite has a variety of fixtures for this use (see pages 99-100) as have several other manufacturers. Sylvania has developed a special fixture for their "Spot-Grow" lamp (see page 96).

Several lighting-fixture manufacturers, including Nessen Lamps, are designing special fixtures suitable for use in residential and public buildings that will house metal halide or separate ballasted mercury lamps.

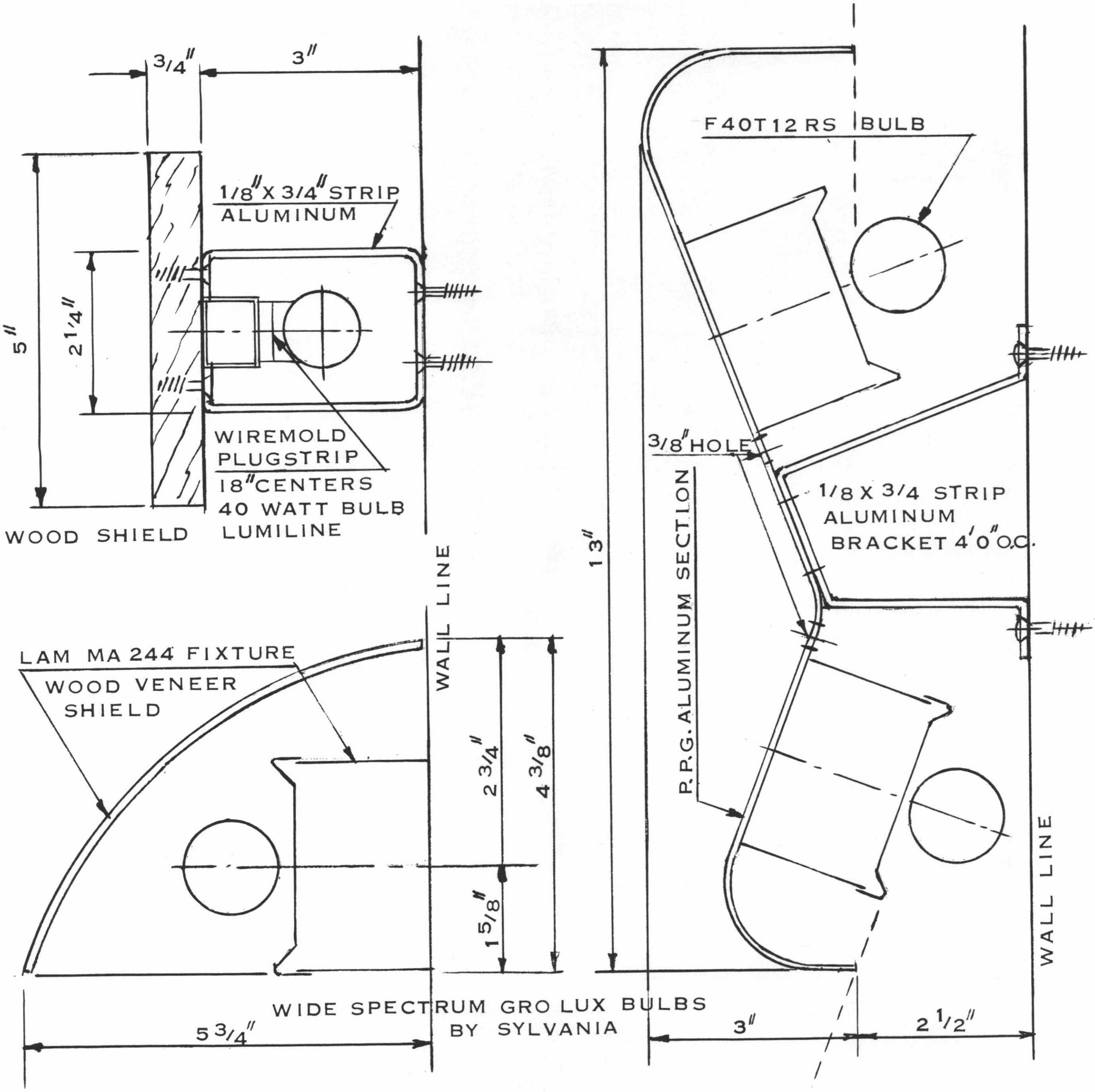
Good design for housing fluorescent tubes has not been consonant with their widespread use. Sylvania has developed an attractive fixture to accommodate their Gro-Lux circline fluorescent lamp (see page 87) as well as their Spot-Gro incandescent light (page 96) which can also be used in many standard fixtures. The architect may have to assemble his own indoor-garden fluorescent light fixtures from parts supplied by such firms as Lam Lighting. Lam lighting produces a variety of handsome shielding systems for fluorescents (see page 95). An outdoor fluorescent fixture (e.g., by Prescolite) will have the built-in waterproof qualities needed in many plant space locations (see page 114). Lightolier has a well-designed fluorescent fixture called Litetube. These fixtures are available as pendant-suspended, track-mounted, and stem units for well mounting and come in many strong or subtle colors (page 88).

It is important to recognize that a translucent acrylic cover over a fluorescent lamp, such as Agrolite, will affect its efficiency but according to authorities probably not change its spectral distribution.

All light fixtures for the indoor garden should be UL rated for outdoor use.

The light fixtures that will hold the plant growth bulbs must be well chosen, for they are an important part of the total design of the indoor garden. Too often lighting is the stepchild of architectural design, but in the indoor garden it is of first importance for visual effect as well as plant growth.

Here are two shields for wall-mounted fluorescent lights and one for the incandescent lumiline lamp which is occasionally desirable when a cove light is needed to balance reading lights. The aluminum section is shown in use over the garden and portrait on page 95. This design adapts a standard aluminum section to light-fixture use. Lam Lighting's wood veneer shields offer handsome lamp shielding.


3/4"
3"
5"
2 1/4"
1/8"X 3/4" STRIP ALUMINUM
WIREMOLD PLUGSTRIP
18"CENTERS
40 WATT BULB
LUMILINE
WOOD SHIELD
WALL LINE
LAM MA 244 FIXTURE
WOOD VENEER SHIELD
2 3/4"
4 3/8"
1 5/8"
5 3/4"
WIDE SPECTRUM GRO LUX BULBS
BY SYLVANIA
F40T12RS BULB
3/8"HOLE
P.P.G. ALUMINUM SECTION
1/8 X 3/4 STRIP
ALUMINUM
BRACKET 4'0"O.C.
13"
3"
2 1/2"
WALL LINE

Photograph courtesy of GTE Sylvania, Inc.

Table 6 For the Indoor Gardener: Approximate Footcandles for Equal Radiant Energy (400–850 nm) for Selected Lamps

Lamp		fc	fc	fc	fc
Fluorescent					
Cool white	CW	100	200	500	1000
Warm white	WW	105	210	525	1050
Gro-Lux—plant light	GRO-PL	47	94	235	470
Gro-Lux-WS	GRO-WS	68	136	340	680
Agro-Lite	AGRO	74	148	370	740
Vita-Lite	VITA	80	160	400	800
Discharge					
Mercury (all types)	HG	108	216	540	1080
Metal halide	MH	87	174	435	870
High-pressure sodium	HPS	88	176	440	880
Low-pressure sodium	LPS	137	274	685	1370
Incandescent	INC	35	70	175	350
Incandescent-mercury	INC-HG	50	100	250	500
Sunlight		55	110	273	546

Table 7 Approximate Number of 40 Watt Fluorescent Lamps Required for Equal Energy Output (400–850 nm)

3	Cool white or warm white
4	Gro-Lux-WS, Agro-lite, and other wide spectrum lamps
5	Regular Gro-Lux and plant light

The adjustable bracket can be wall- or ceiling-mounted. The housing fits the incandescent bulb neatly. The fixture can be box-mounted or plugged into an existing electrical outlet. Source: Sylvania Inc.

Table 6 shows the footcandles from other lamps that give approximate equal energy and plant responses. For example, to equal 100 footcandles of cool white fluorescent requires 55 footcandles of sunlight, 47 footcandles of Gro-Lux, 68 footcandles of Gro-Lux wide, and 35 footcandles of incandescent.

It should be noted that cool white and warm white are the most efficient of the various fluorescent lamp sources. Table 7 shows the approximate number of 40-watt fluorescent lamps required for equal energy output and plant growth effectiveness.

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Table 8 For the Interior Designer: Color Rendering of Plants, People, and Furnishings

Lamp		General Appearance on a Neutral Wall or Surface	Complexion (Acual Appearance of Skin)
Fluorescent			
Cool white	CW	White	Pale pink
Warm white	WW	Yellowish	Sallow
Gro-Lux—plant light	GRO-PL	Pink white	Reddish
Gro Lux—WS	GRO-WS	Light pink-white	Pink
Agro-lite	AGRO	White	Pink
Vita-lite	VITA	White	Pink
Discharge			
Mercury (all types)	HG	Purplish white	Ruddy
Metal halide	MH	Greenish white	Grayed
High-pressure sodium	HPS	Yellowish	Yellowish
Low-pressure sodium	LPS	Yellow	Grayed
Incandescent	INC	Yellowish white	Ruddy
Incandescent-mercury	INC-HG	Yellowish white	Ruddy
Atmosphere (the effect or general feeling of a room)		Flower Color or Colors Improved or Strengthened	Grayed (undesirable)
CW	Neutral to cool	Blue, yellow-orange	Red
WW	Yellow to warm	Yellow, orange	Blue, green, red
Gro-PL	Purple to pink	Blue, red	Green, yellow
Gro-WS	Warm	Blue, yellow, red	Green
AGRO	Neutral to warm	Blue, yellow, red	Green
VITA	Neutral to cool	Blue, yellow, red	Green
HG	Cool	Blue, green, yellow	Red
MH	Cool green	Blue, green, yellow	Red
HPS	Warm	Green, yellow, orange	Blue, red
LPS	Warm	Yellow	All except yellow
INC	Warm	Yellow, orange, red	Blue
INC-HG	Warm	Yellow, Orange,	Blue

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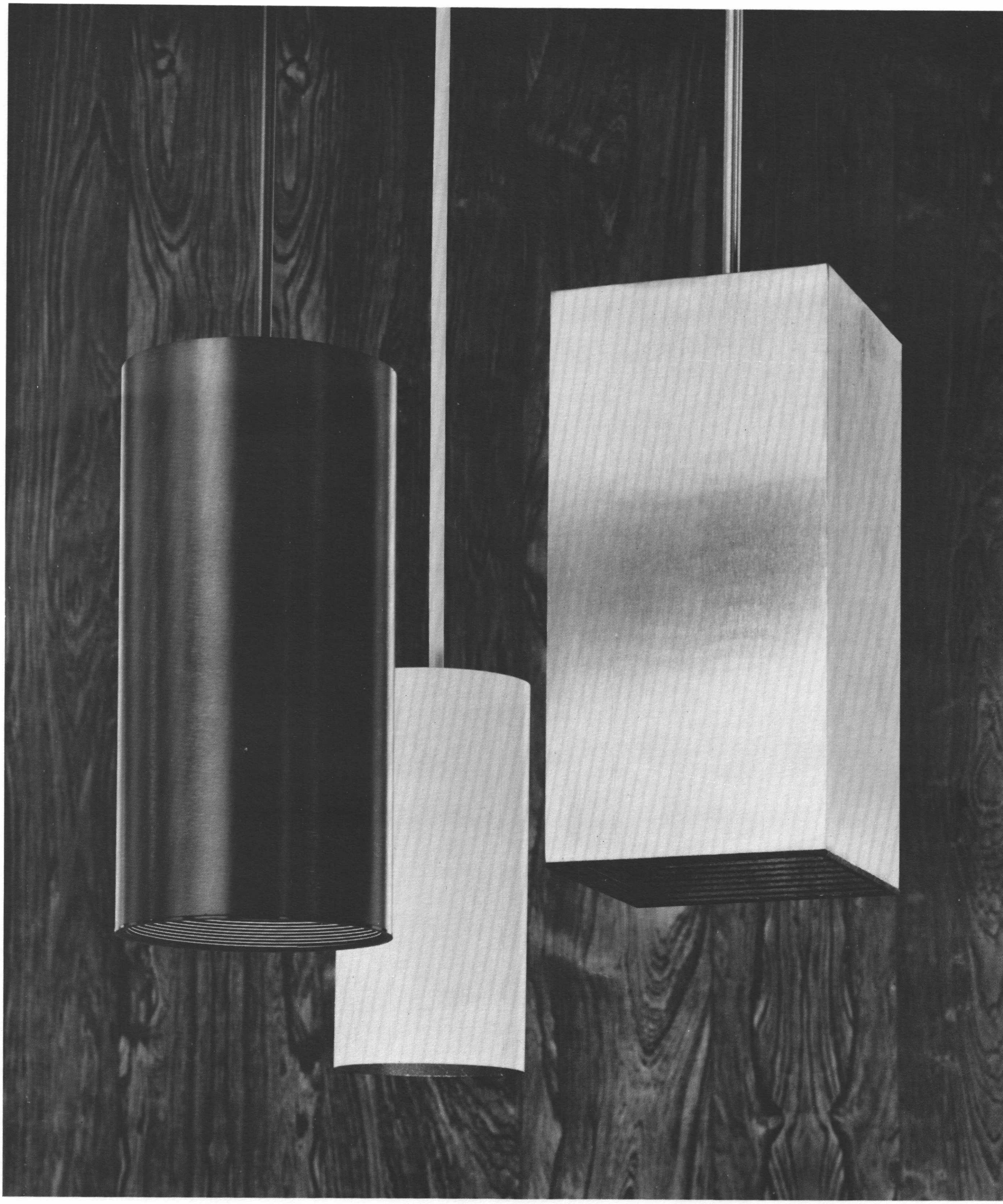
Three track lights provide a variety of choice for such lamps as Wonderlite, Spot-Gro, and other incandescent plant growth lights. Source: Prescolite.

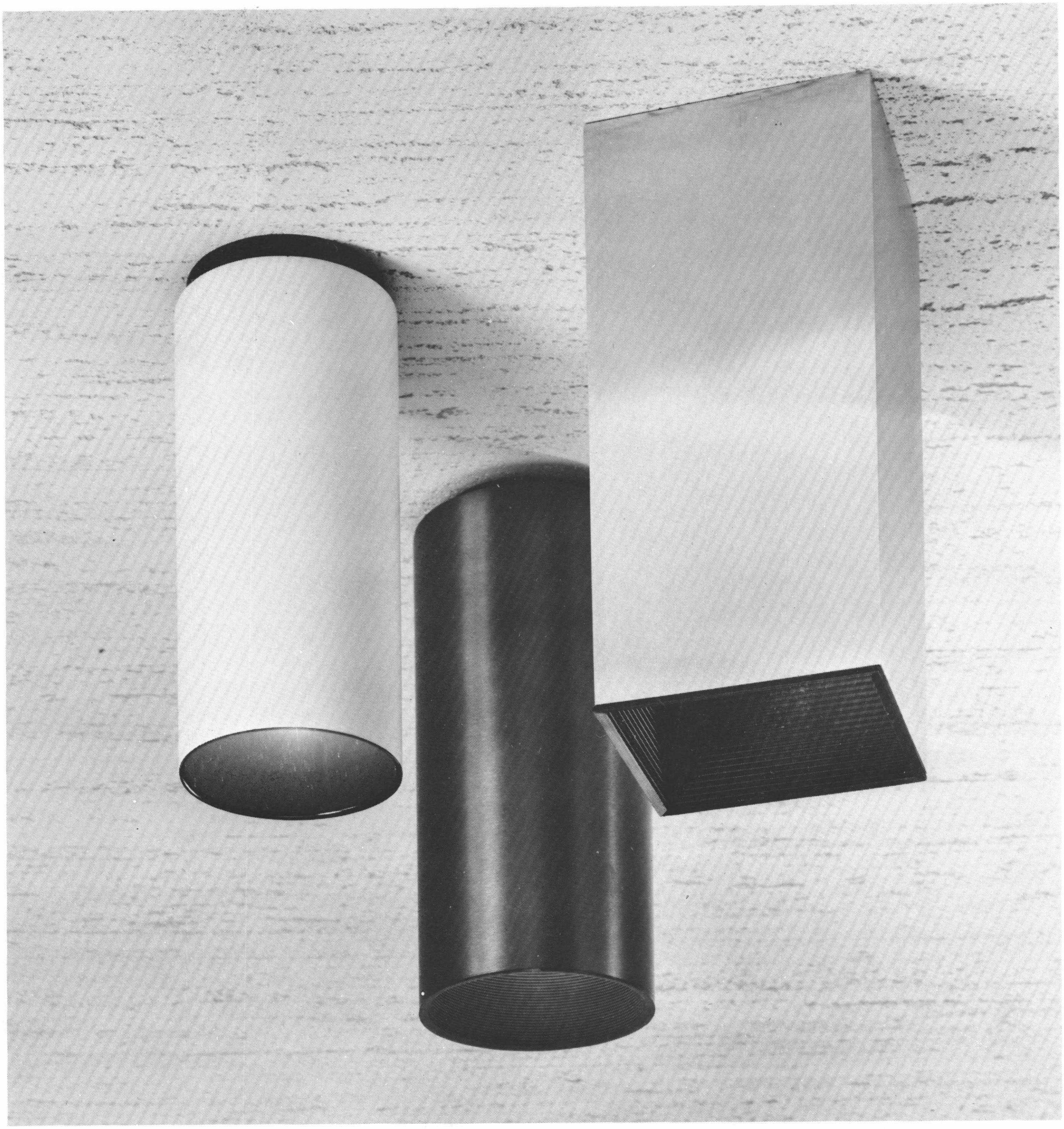
Photograph by Herrington Olsen, courtesy Prescolite

Photograph by Herrington Olsen, courtesy Prescolite

These well-designed lights are completely adjustable and slide along an electrified track usually mounted on the ceiling. They will accept special and incandescent bulbs in various sizes and are ideal for feature lighting or plant growth stimulation. Source: Prescolite.



Photograph by Herrington Olsen, courtesy Prescolite



Photograph by Herrington Olsen, courtesy Prescolite

Downlights, ceiling-mounted, are for incandescent bulbs in a variety of type and output. Source: Prescolite.

Heat, Cooling, Humidity, and Ventilation

Superficially, it would seem wasteful, in view of our fast diminishing energy supply, to consider a warm indoor climate for plants when many people are being made uncomfortable by the lowered temperatures in buildings.

In general, plants, and humans also, will do better in a cooler indoor climate than in an overheated house, apartment, or public building in which air dries out quickly in winter.

TEMPERATURE AND HUMIDITY

Humidity is the amount of water held by air in vapor form. The warmer the air, the more moisture it can hold.

Plants are adapted to a climate not only in relation to hot or cold temperatures but to temperature in relation to humidity. Therefore plants for the indoor garden that are compatible in their needs in this respect can determine the temperature and humidity of the space. In most buildings, however, human requirements must determine these conditions; thus they control the plants that may be grown.

Plants in large groupings will increase the area's humidity and the growing medium will also transmit moisture into the air. To a certain extent plants benefit from proximity to other plants, a situation that maintains more even moisture levels in their vicinity. People benefit from good humidity levels in winter, for they are more comfortable at a lower temperature when the humidity is at 50%. No man-produced energy is required to cause evaporation of water into the air from plants and soil. This is added comfort at lower winter temperatures; thus a large group of indoor plants growing in soil can result in a real saving of energy.

GLASS: HEAT LOSS, HEAT GAIN

Heat loss through glass at night is more than made up on winter days by heat gain from the sun through a south or southwest window. Solar light waves change frequency on passing through glass and heat is trapped inside in a form that will not reradiate (e.g., unheated cold frames will trap and hold heat for seed germination). This is a passive solar system in operation.

Wide differential temperatures, inside to outside, place additional demands on the indoor climate control system. This system must be designed by the architect to be fully responsive to outside weather. Heat flows from a higher to a lower temperature and can be conceived as "positive pressure"; lower temperatures are "negative pressure." The greater the differential from inside to outside temperatures, the greater flow of heat; thus "heat gain" in summer and "heat loss" in winter.

Methods for control of heat gain and loss through glass are discussed under Natural Light (see page 68) and should be used in conjunction with this section when planning the heating and cooling system for an indoor garden.

THE "CARRIERS" OF HEAT

Both air and water can be heated and distributed in a heating system. Steam heat, much used in earlier years in homes, schools, and public buildings, is seldom specified for a new building today. New studies of its efficiency in relation to other vehicles for heat distribution may, however, lead to a reconsideration of steam use. Electric resistance heating enjoyed a period of popularity during the years when the cost of electricity was low and efficiency of energy use was not considered important.

MOVING THE HEAT "CARRIER"

Hot water must travel through pipes, pulled on its way by pumps run by electricity. Hot water may be heated by oil, coal, gas, wood, electricity, geothermal heat, or solar radiation. It can be delivered to an indoor garden in a variety of ways.

Steam is heated many degrees hotter than hot water by the same fuels and is circulated by vacuum or pressure through pipes and radiators.

Hot air is moved by electrically powered fans through ducts. Cooled air can also use these ducts for air conditioning, and moisture can be added to the circulating air. Dust may be trapped in filters.

Electric resistance heat travels through wiring which is heated by the resistance of the wire to the free passage of electricity.

CHARACTERISTICS OF HEATING AND COOLING SYSTEMS

Hot Water

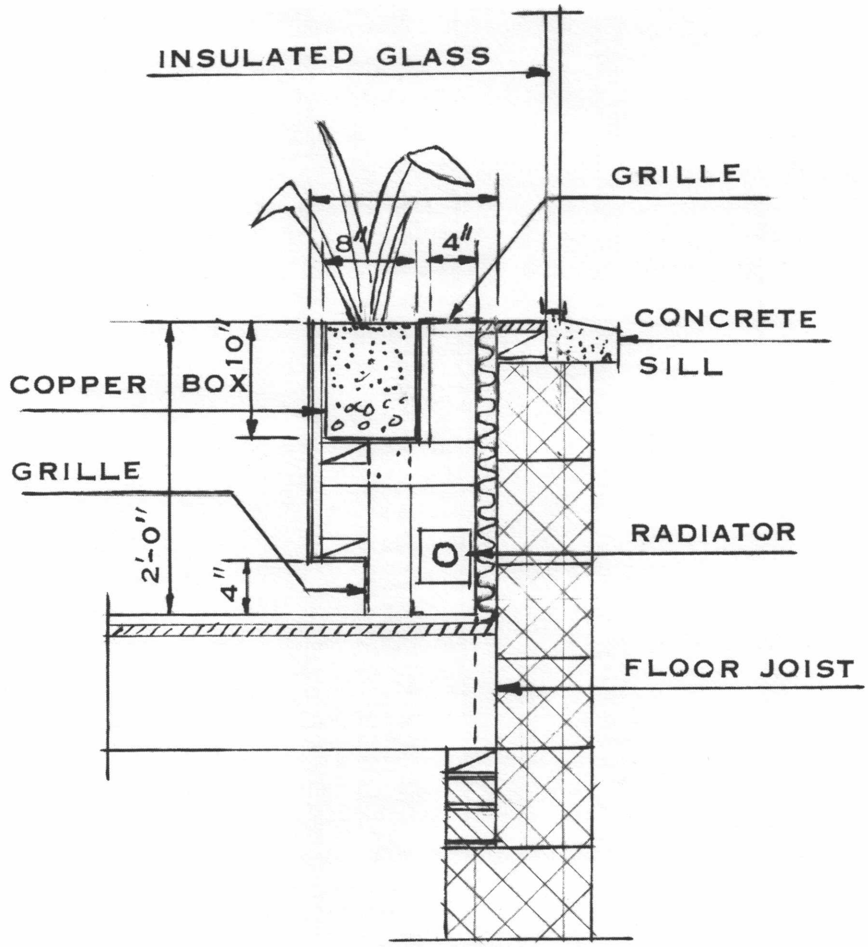
1 Hot water is adaptable to several types of delivery system:

   A It is circulated in pipes installed in a plaster ceiling or laid in a concrete slab in the floor. This is radiant heat and is nonconvective. Radiant floor or ceiling hot-water heat warms one of the largest areas of the room and spreads even heat throughout.

   B It may also be delivered by finned radiation or other convective heat distributors.

2 Hot water occupies fewer cubic feet of building volume than a hot air system; for example, less space is wasted that might be used otherwise.

3 Its first cost is often higher than other systems.



Convectors provide a curtain of warm air at this living room window garden which is adaptable to many locations.

Photograph by Jack Roche

4 It is most efficient in fuel use with a well-designed system.
5 It is even heat, especially desirable in areas with long heating periods.
6 Radiant hot-water floor and ceiling systems do not circulate dust. They do not contribute to air movement.
7 Heat lag occurs because the floor or ceiling material stores and gives off heat for a period after the hot water stops circulating. In cold climates this is most desirable. In warmer climates the lag may lead to occasional overheating.

Hot Air

1 The most common delivery system is through ducts. Air is moved by fans through these ducts to an outlet in the room. There must also be an air intake to return air to the plenum chamber for reprocessing.
2 Ducts require many interior cubic feet of space to distribute air.
3 The greatest advantage of a hot air system is that the same distribution system (using a cooling coil instead of a heating unit) will circulate air to cool a building.
4 Moving air circulates dust and bacterial particles. To some extent frequently changed filters will ameliorate this situation.
5 The low-velocity (or high-velocity in badly designed installations) sound of the air moving may be annoying.
6 The stop-start cycling of many hot air systems regularly delivers short periods of "too cold" or "too hot" air that is uncomfortable for people and may be detrimental to plants. This situation leads to an inordinate amount of thermostat adjustment to satisfy comfort conditions when the heating or cooling delivery fails to provide an even temperature.
7 Several more sophisticated systems provide features other than that of merely blowing heated or cooled air through a duct. One is a two-pipe convector unit in which chilled and heated water coils are included. This unit has a thermostat that can be regulated for individual room temperature and heated or cooled air is circulated by a fan. These units are rather large and take up a lot of wall space. Unless carefully specified they may be as noisy as a poorly designed fan and duct system. They do, however, eliminate the loss of interior cubic footage required for duct space.
8 In spite of obvious drawbacks, a hot air system is often chosen because it can be modified so easily to include cooling coils.
9 The first cost of installation may be lower than a hot water system.

On a sunny late spring day in latitude 44° north the welcome sun reaches well into the living room. The sun's intensity is diminished on this day by a low-lying layer of light fog, a condition often prevailing in northwestern and northeastern United States. Heating is introduced into this room by hot water pipes in the plaster ceiling. A curtain of warm air is also provided at the window by finned radiation (see detail, page 105). Room is also left for a curtain to be drawn between the glass and the indoor garden at night. A lower planting would have allowed a better view from a sitting position.

Steam

1 Water is heated above boiling point and, because of pressure piping, condensate handling, and the necessary controls it is recommended only for large installations.
2 Steam heat is "dry" heat.
3 Steam heat can be transferred by conventional radiator or finned convector radiation systems or unit heaters that contain the necessary valves and controls.
4 Cooling systems must be separate.

Electric Resistance Heat

1 Electric resistance heat is installed in floors, ceilings, or walls, thereby heating one of the largest of a room's surfaces.
2 As with hot-water floor or ceiling heat, it produces a more even room heat than a radiator system.
3 It has the lowest first cost.
4 The fuel cost is the highest in most areas. However, there is no need for fuel storage.
5 It is nonconvective and does not circulate dust.

These basic heating systems are used in various combinations for special situations.

It may seem unnecessary to discuss the basics of a heating system in detail, but in making a choice for both people and plants one system may be better adapted to this particular use over all others available in spite of the disadvantages it may have in other situations.

An installation of plant growth lights suitable for a lobby design. Air flow through the duct space will diminish heat buildup from lights.

In large public buildings heating systems are designed by a mechanical engineer who must be informed by the architect of the special conditions essential to the growth of plants.

Residential heating, cooling, and ventilation systems are often designed by architects or "laid out" by the trade. Plant needs must be considered in their design.

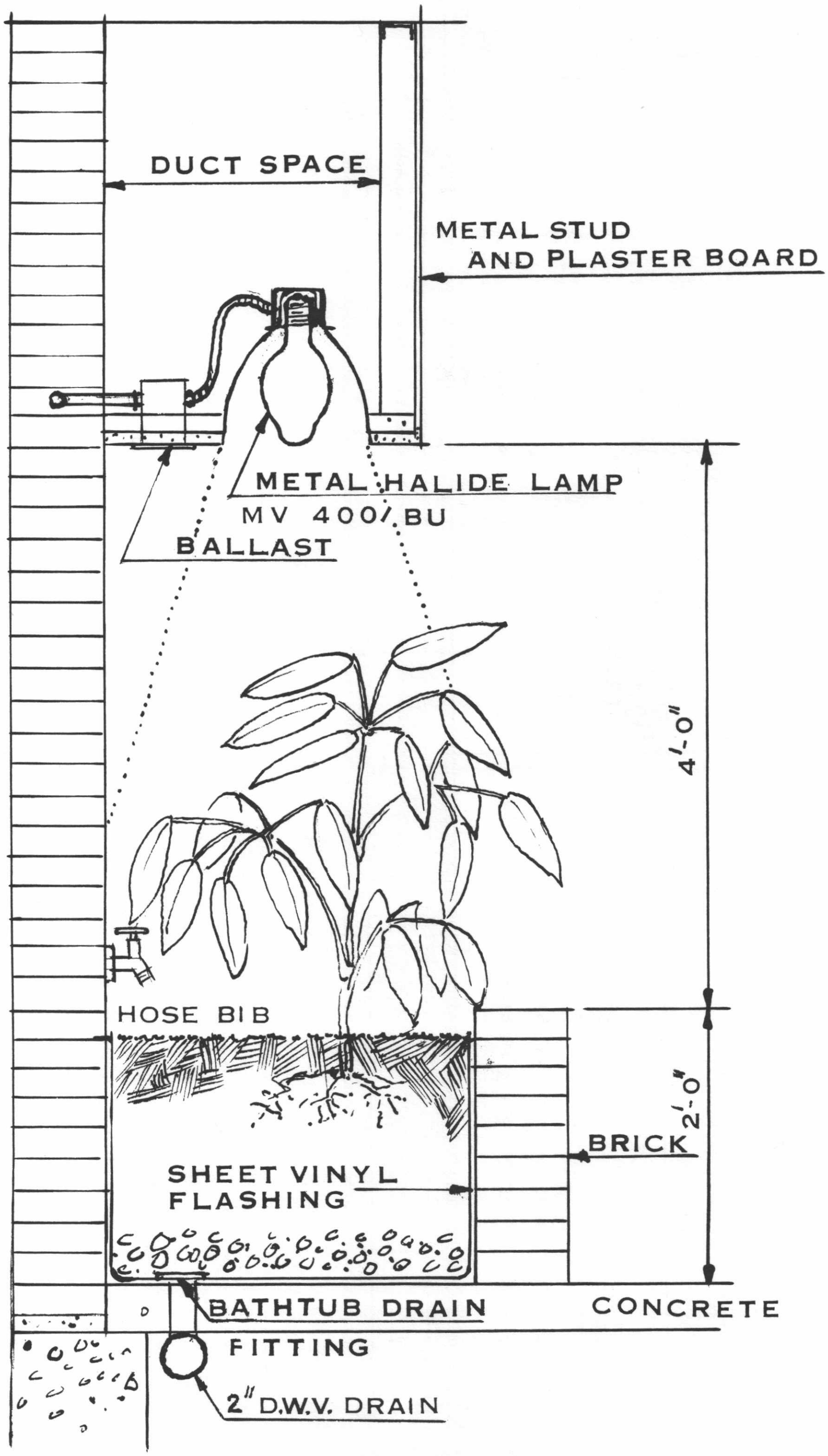
The architect should include passive solar heating for the indoor garden, a substantial portion of which can be obtained cost free when the structure is designed. Solar heat passes through insulated (and solar-oriented) glass in winter. Exterior shading can be provided to prevent overheating in summer. Natural ventilation can also be obtained by means of screened and shaded openings at the bottom of an exterior wall and screened and rain-protected vents at the top of an opposite interior wall or, in a one-story design, through the ceiling.

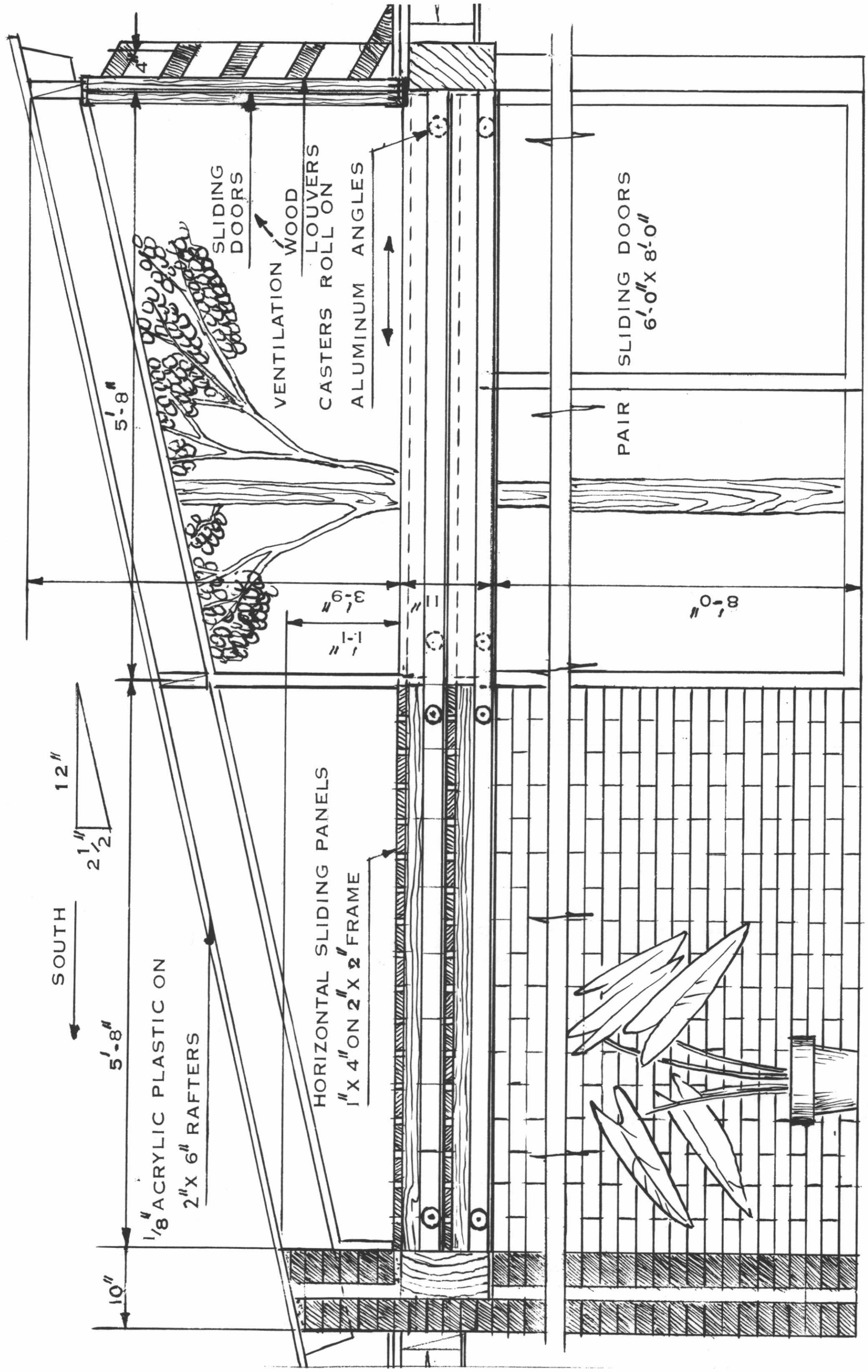
"Active" or mechanical systems require a relatively low amount of man-produced energy to obtain large amounts of free solar heat. Energy from the sun can also be used for cooling by reverse-cycle refrigeration or an "absorption" type of mechanical equipment.

Several packaged solar heating systems are on the market. These hot water systems consist of collectors, a heat exchanger to allow the use of antifreeze in low-temperature climates, and a distribution system. A solar system requires a substantial amount of hot-water storage to collect daytime heat for distribution at night.

RECOMMENDATIONS

For long-winter or extremely cold regions radiant hot-water floor heat in a concrete slab with a slate, quarry tile, brick paver, terrazzo, or other masonry floor finish provides the best conditions for plants and people. In a residential installation the evaporation of water splashed on the floor around an indoor garden will add to humidity in the air. This is especially helpful if hanging plants are part of the design, for they may be allowed to drip freely on the masonry floor.


DUCT SPACE
METAL STUD
AND PLASTER BOARD
METAL HALIDE LAMP
MV 400/BU
BALLAST
4'-0"
HOSE BIB
2'-0"
BRICK
SHEET VINYL
FLASHING
BATHTUB DRAIN
FITTING
CONCRETE
2" D.W.V. DRAIN


SOUTH
12"
2 1/2"
5'-8"
5'-8"
10"
4"
1/8" ACRYLIC PLASTIC ON
2"X 6" RAFTERS
HORIZONTAL SLIDING PANELS
1"X 4" ON 2"X 2" FRAME
VENTILATION
SLIDING DOORS
WOOD LOUVERS
CASTERS ROLL ON
ALUMINUM ANGLES
3'-9"
1'-1"
11"
8'-0"
PAIR SLIDING DOORS
6'-0"X 8'-0"

A curtain of warm convected air at a window wall can be supplied by hot-water finned radiation or electric baseboard heaters. Plants, as well as people, radiate heat to cold surfaces, and a convecting heat source placed next to the glass takes advantage of the fact that heat rises. This system may be used to good effect in addition to radiant floor heat in an extremely cold climate (see page 7).

Hot water may be circulated by means of a large variety of convector designs now on the market. Among them is finned radiation which is installed uncovered as shown on page 159 with grilles at the top and bottom (see page 105). This system uses the space around the garden to circulate air from the bottom grille to the top and up into the room. In this arrangement the soil in the garden is warmed as the air circulates. Standard covers are available for additional radiation in other locations in the room.

When air conditioning is a requirement, heat will probably be introduced by circulating air. Every system should be supplied with a built-in humidifier for human as well as plant health. If the system is forced air, in which cooling is combined with heating, air should be introduced at wall grilles at low velocity to allow air to drift into the garden. A fairly constant temperature should be maintained. Grilles should be located so that they cannot be accidentally watered.

Ventilation is of utmost importance to plants, although they do not tolerate air blowing directly on them. The indoor garden should be protected from prolonged blasts of hot or cold air from opened doors or windows or from heating or cooling systems. Leaf structure indoors is more delicate than on outdoor plants which have been "hardened off." Poor ventilation allows a film of water vapor to form on leaves — an ideal disease-producing condition. Air that is too dry will cause the plant's transpiration system to malfunction. Plants sheltered in a protected indoor environment become even more sensitive to sudden indoor climate changes.

Ceiling diffusers are often used to introduce hot and cooled air. The diffuser should not be located directly above the indoor garden because of the sudden fluctuation of air temperatures which even for people is uncomfortable and for plants provides unhealthful stress. If very low velocity air is used, a long narrow grille may be located along the back wall of the indoor garden to drift the air into the space. Probably the most satisfactory arrangement for plants as well as people is to introduce the hot or cool air low on a wall some distance from the garden and evacuate the air high on the wall above the plants to give good air circulation. The air temperature will be modified when it reaches the plants.

Steam heat can be introduced by methods similar to those of a hot water system. Mechanical modifications can be designed for vapor instead of liquid.

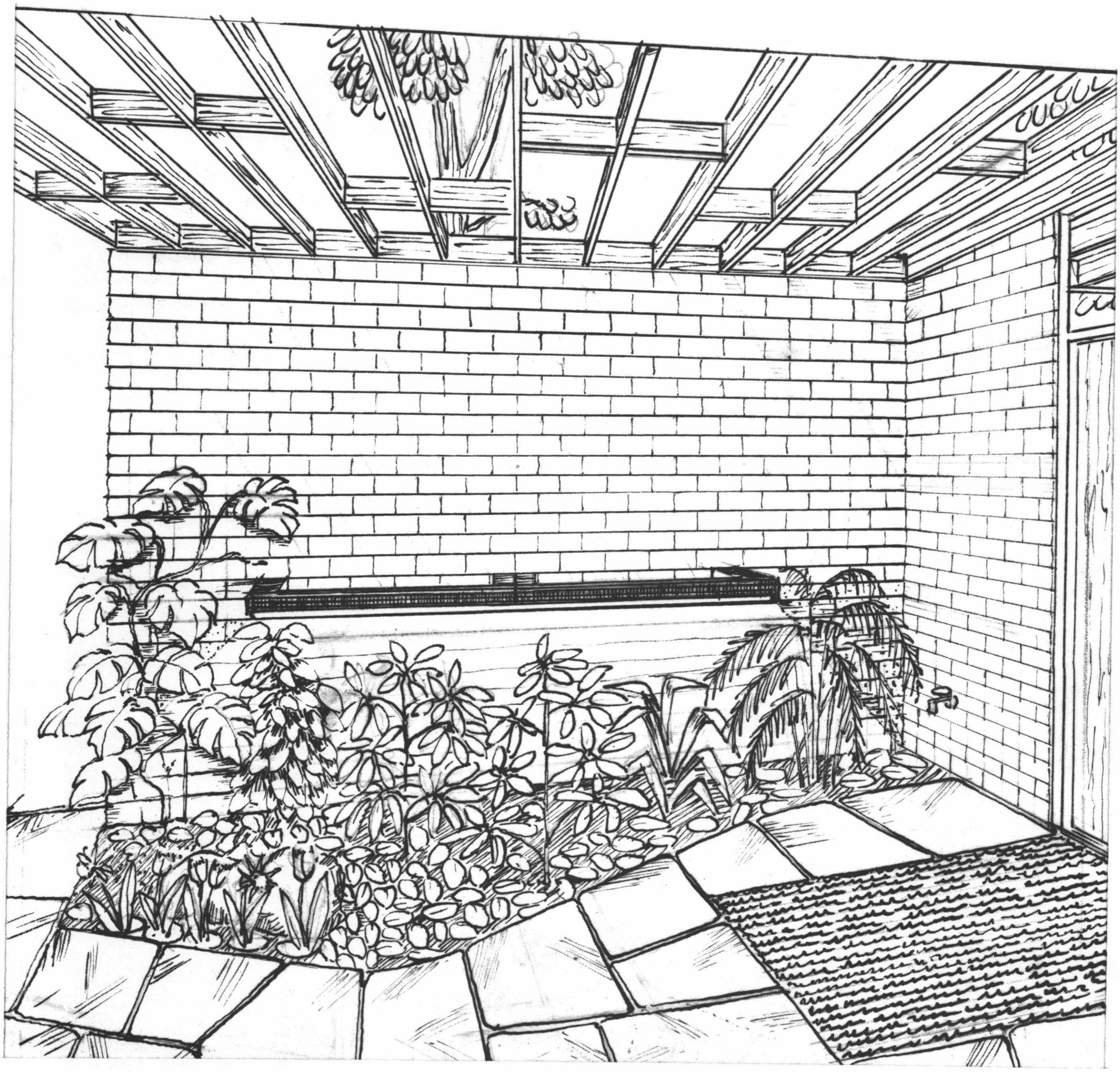
Electric resistance heat may be introduced in heating cables in the floor, ceiling, or walls or in baseboard units. A valance design now on the market can be used to combine light and heat. If located at a window, a curtain track can be installed.

The acrylic plastic sun roof slopes to drain rainwater. Inside, sliding horizontal panels store over the entrance when not needed to shade plants. Ventilation is provided.

As we move into our energy-short era, new and better systems for the delivery of heated and cooled air must be designed. As in most good design, awareness of the requirements and sensitive forethought are more important than system complexity or expense.

A well-trained Ficus elastica, Philodendrons dubia, and pertusum, (the juvenile form of the huge Monstera deliciosa), with dracaena accent the lines of this formal, south-facing entrance. A tiny pool contains a water poppy and a miniature waterfall. To give additional light to the water plants, a plant growth lamp can be used in the adjustable focal light on the adjacent wall. The rectangularity of the entrance and the patterns of sunlight coming in through the windows of this two-story space are accented by the curve of the stairs and the leaf shapes of the plants.

Photograph by Jack Roche



This sun-roof garden at an entrance adds an element of pleasant surprise as guests find themselves "outside" again after entering the house. Auxiliary plant lights feature the plants and augment the light on cloudy days.

Growing Media, Water, and Fertilizer

GROWING MEDIA

The growing medium into which a plant sends down its roots is the anchoring agent for its top growth and the holding medium for food, water, and root air. The components of a growing medium will determine the variety of plant that will fluorish in it.

Soil Characteristics

There are four primary soil-particle types: gravels (2 mm and up), sands (0.05 to 2 mm), silt (0.05 to 0.002 mm), and clays (0.002 mm and under). Gravels and sands contain slow-to-release minerals that are negligible in amount available to plants. Out of doors, the action of sun, wind, rain, and bacteria effect this release. Indoors, all but the wind keep the soil a living, creating medium for plant growth.

Silts and clays, because of more extensive weathering, retain high levels of nutrients. Clays, however, do not allow free passage of air or water. Loam is composed of equal amounts of sand, silt, and clay. (Thus a sandy loam is one that predominates in sand and a clayey loam in clay). The astonishing vitality of soil is shown in this quotation from *Organic Gardening and Farming,* October 1969.

> Soil possesses the highest concentration of "life power" on earth. At a depth of six inches, one acre of typical farmland contains several tons of bacteria, a ton of fungi, 200 pounds of protozoa (one-celled animals), and 100 pounds each of algae and yeasts.

These living soil components work in the soil to release nutrients to plants.

Soil Types

Several types of soil are candidates for the growing medium of the indoor garden. Soil mixes are often designed to imitate the soil of a particular plant habitat, such as the desert, the rainforest underfloor, a temperate woodland, or a lake or pond bottom. Unless the garden is to be limited to growing a specific habitat plant, however, either one of the two basic formulas given will promote good plant growth and health.

Cactus

Two layers of soil of differing composition will be needed for the cactus garden.

The bottom layer: a mixture of

¼ clay to ½ coarse sand and ¼ woods loam

Top layer: a mixture of

½ coarse sand and ½ gravel in ¼-inch to 1-inch size

This layer should be about 2 inches deep. Fertilizer should be slightly alkaline. A cupful of ground limestone may be added to a bushel of the bottom layer of soil mix.

An entrance rock garden located where large boulders occur naturally. Clerodendron climbs the rift-sawn fir siding which matches the exterior. A pergola provides summer shading.

Woodland

For the woodland garden:

½ finely ground leaf mold, ½ good garden loam

This soil should test with a pH of 4.0 to 5.0. A mixture of ½ leaf compost, ¼ dried cow manure, and ¼ coarse sand or a top layer of chopped bark, rich in tannic acid, may be used.

Lilies and Bog Plants

For water lilies and bog plants:

add to 1 bushel of clay loam 4 quarts of dried cow manure, a cupful of bonemeal, and a cupful of greensand

Do not include peat moss, sand, or rotted wood. See page 61 for other water-plant mixes.

Tropical Rain Forest

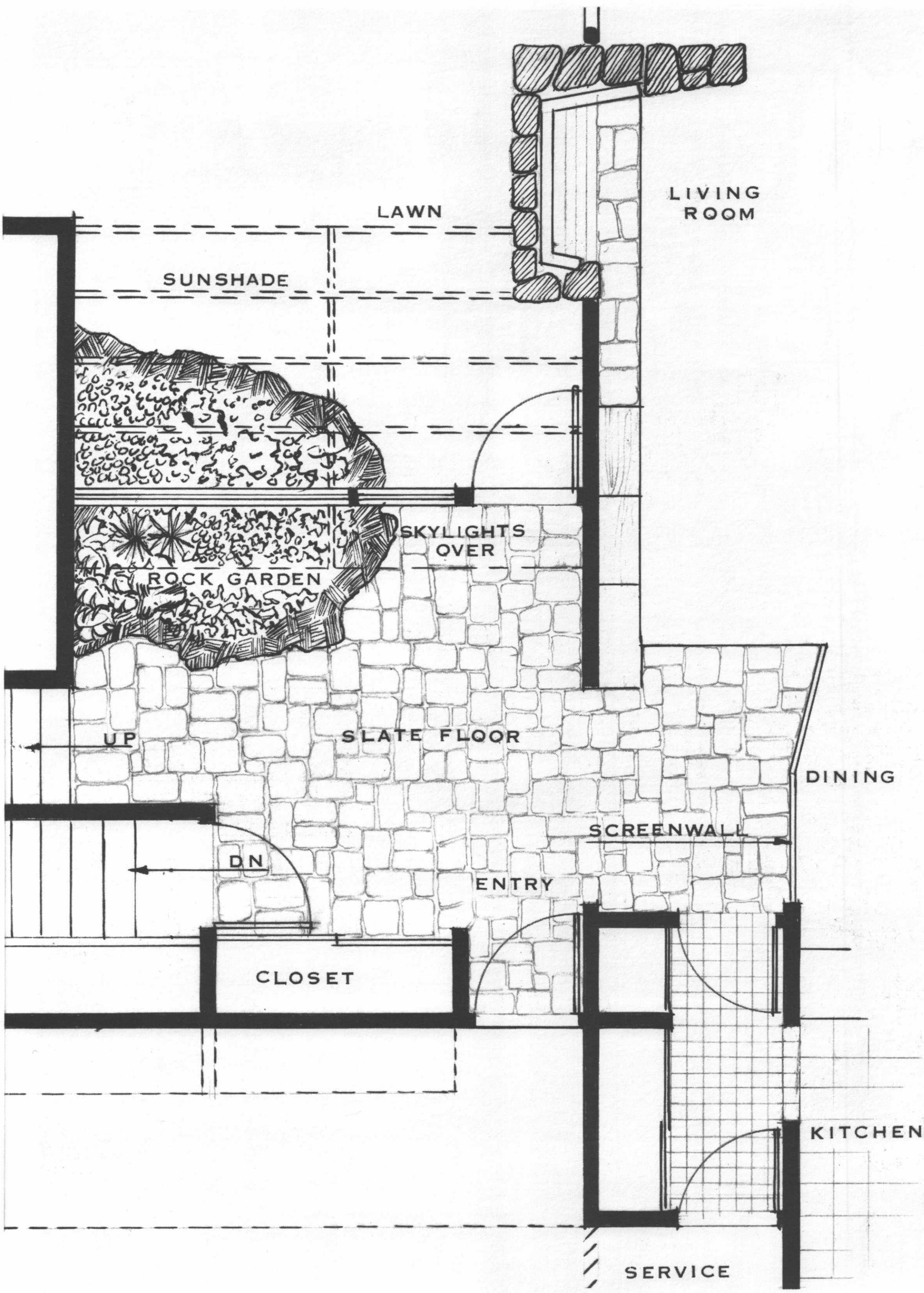
For the tropical rain forest the epiphytes such as some orchids, bromelaids, and the staghorn fern require only a material like Osmunda or tree fern bark to anchor their roots to their host.

The terrestrial tropicals need a mixture of good loam mixed with ¼ part vermiculite for even moisture retention.

Orchid specialists sell a chopped bark mixture for terrestrial orchids, and a piece of charcoal is often added to the soil. Specially formulated liquid orchid fertilizers are recommended.

AVERAGE PLANTS

Most plants grown in indoor gardens require a soil rich in nutrients into which their roots can penetrate with ease, one that drains well but will hold some moisture, and one that will allow air to reach the roots. The following are two basic formulas designed for the average plant:


LIVING ROOM
LAWN
SUNSHADE
SKYLIGHTS OVER
ROCK GARDEN
UP
SLATE FLOOR
DINING
SCREENWALL
DN
ENTRY
CLOSET
KITCHEN
SERVICE

Photograph by Joseph W. Molitor

Basic Formula No. 1

1 part sand
1 part well-rotted compost
2 parts good garden soil
Additions (1 cup each to a bushel of soil) of bonemeal, ground phosphate rock, and granite dust.

Basic Formula No. 2

For one cubic yard of indoor garden:

Rich woods soil (with leaf mold or Michigan peat)	3/4 cubic yard
Sand	1/8 cubic yard
Clay soil	1/8 cubic yard
Ground rock phosphate	1/2 pound
Rock potash or greensand	1/2 pound
Ground limestone	2 pounds
Dried manure	8 pounds

As in any healthy soil the indoor garden should have active bacteria. The working of the bacteria should not, however, produce unpleasant odors. Earthworms should be introduced into the plant space for their nitrogen and trace-element-rich castings and to aerate the soil by their travels through it.

The entrance garden in this home is soil-filled down to natural grade. Granite boulders and outcroppings of granite in this location were incorporated into the garden design. Ivy covers the shallower soil areas and a Birds Nest fern nestles in a pocket in the boulder in the shaded part of the garden. A palm reaches for the sun under the plexiglass skylight at the window edge. Monstera deliciosa lends the interest of its big leaves and Clerodendron reaches up toward the skylight, designed as a trompe-l'oeil just inside the glass wall. On entering the garden, it is difficult to determine the extent of indoor shelter and outdoor exposure provided by the combination of skylight and exterior pergola. The plants obviously do well with this arrangement and observant people enjoy it.

Alternate "holding" media are suggested under Summer Care in Managing the Garden (see page 181). Potted plants may be set into a medium of stones and sand and individually fed and watered, but they will not thrive as they will in soil. These materials cannot be considered true growing media.

Soil may contain weed seeds, insect eggs, and some diseases that can magnify in the indoor environment to the detriment of the plants. The chosen soil mix can be heated to 160°F with steam and held at this temperature for 30 minutes before adding the fertilizers. Commercial greenhouses use wagons lined and covered with polyethylene or vinyl into which pipes with 1/8-inch holes are introduced to pass the steam through the soil. Chemical (methyl bromide) fumigation is sometimes used but is not recommended for the indoor garden because some of the chemicals may be released when brought into a building. It is important that the beneficial bacteria in the soil be preserved. Cleaned earthworms and fertilizers should be added after the soil is steamed.

The architect for the large indoor garden should specify that the recommended soil mix be steamed at the correct temperature and time (160°F for 30 minutes). Steaming to higher temperatures or for a longer time will kill helpful bacteria.

The home indoor gardener may be able to have his soil mix steam-treated at a local greenhouse. Although it is rather expensive in quantity, bags of prepared mix can be purchased to fill the smaller garden.

If garden or collected soil is to be used untreated, it is advisable to have a sample tested for nematodes by the state agricultural department.

PREPARING TO FILL THE PLANT SPACE

Construction jobs are usually untidy and it is important to clean all loose mortar and other debris from the planting pocket. If the garden is formed of concrete or has exposed concrete edges down to grade, the concrete should be washed with a scrub brush and water to dislodge any loose particles and washed again with a strong solution of vinegar and water. Do not use a chemical masonry cleaner.

If the garden goes to natural grade, it should be filled rapidly with water until one-quarter full. If there is good drainage, all water will be gone in half an hour. If subsoil was compacted during the building process, the soil should be loosened before filling the space with the growing medium. When poor drainage is a problem, drain tile should be installed (see page 130).

Little or no preparation is needed for copper, stainless steel, plastic, or fiberglass gardens except to wash them with soap and water and rinse them thoroughly.

WATER

One of the advantages of the indoor garden, as opposed to free-standing pots, is the even supply of water to the plants. As explained in Why Indoor Gardens (see page 6), an uneven supply of water produces a stop-start growth pattern. The proximity of plants will reduce water requirements, and water in the larger body of the growing medium will distribute more evenly, leveling off highs and lows of moisture availability to the plants. An indoor garden can be thoroughly watered and left for two weeks, if necessary, without additional moisture.

Water Quality

City water may contain chlorine and fluoride as well as other pollutants; certain areas of the United States have highly acid or alkaline water, and water treated with a softener is toxic to plants. To a certain extent aeration will dispose of chlorine in the water but most other pollutants remain.

Unlike the outdoor garden, the indoor garden tends to collect some of these undesirable elements from water, which would indicate a change of growing medium when plant growth declines. The need for soil reinforcement is generally due to (a) breakdown of structure, (b) loss of micro or secondary elements, or (c) build up of salts. All conditions can be avoided or corrected by careful management. For the small home indoor gardens it is practical to collect rainwater and water by hand. A charcoal filtering system in the supply line may help to remove pollutants from treated water. For large installations information on the characteristics of the local water supply should be sought from the area greenhouse association, local water supply department, or state agricultural department. Private water-testing companies will analyze samples of water to be used for plants.

The use of masonry materials in the immediate area around the garden which can be saturated at the same time the plants are watered will increase general humidity and reduce frequency of watering.

The stairs leading from the dining room on the lower level to the high-ceilinged living room and library are bordered by gardens. To the left a narrow garden is equipped with a drain and water source. The spiky Sansevieria and the graceful lines of philodendron cordatum are seen against a background of native white birch plywood paneling. Pockets of soil held by lacquered copper boxes step up alongside the stairs. A variety of small cacti grow in this location which receives full south sun when the curtain is open.

Photograph by Joseph W. Molitor

Photograph by Jack Roche

Methods of Delivery

Methods of watering the indoor garden can range from hand watering to totally automated water delivery systems.

For most indoor plants water temperature should be room temperature or 5°F above. A small instant heater, set for the correct temperature, can be installed in the cold-water line and is less expensive and more energy conserving than adding hot water plumbing and mixing valves to the system.

Watering should be done early in the day when light levels are high and the air is warming. Late day or night-time watering encourages the development of fungus disease.

Plants that are potted and set into the indoor garden soil should be placed in porous clay pots to make moisture freely available to them.

It is most important to determine the water needs of each plant and to group together those of similar requirements.

Hand Delivery by Hose

The simplest, least expensive, and possibly the best method is hand watering by hose. This method requires more attention than automatic systems, but it also provides plants that may have slightly varying water needs with more individual care.

The following are some of the advantages of watering by hand-held hose:

1 The installation is the least expensive. One cold-water pipe is run to the plant space, and an easily reached hose bib is installed: a lightweight hose is attached and a hanger is fastened to a nearby wall for coiled storage.
2 A variety of water forces can be used.
3 A mister, bubbler, or heavy sprayer can be attached to the hose for different purposes.
4 The bubbler can be left for extended periods at the roots of a plant more demanding of water than its companions in the plant space.
5 Misting can be done by changing the fixture at the end of the hose.
6 A strong force of water may be used to dislodge insects and wash plant leaves.
7 A trigger release lance can be attached to the hose for reaching through thick foliage.
8 The masonry materials next to the indoor garden can be wetted down.
9 Nutrients and pest-control liquids can be applied in the correct strength by attaching a small plastic bottle suction sprayer to the end of the hose.
10 The users end of the hose can be equipped with a shut-off valve for quick control.
11 The owner may enjoy watering his own plants.

Cypress paneling, glass, painted concrete brick, an adjacent stone wall, which is one end of the fireplace, and a slate floor, which is an extension of the fireplace hearth, are all materials that will take water and soil spills. Careful planning of the materials for the indoor garden and the area immediately adjacent to it will reduce the work involved in its care and thus increase the pleasure in its use. The delicate tracery of the philodendron and ivy leaves is in good contrast to the gray-brown of the cypress paneling and the rough textures of the stone fireplace.

Desirable additions to the hose system would be the installation of an electric resistance cable on the water line. A preset tempering valve will regulate the water temperature.

Several good moisture meters which can be plunged into the soil are available and can serve as a warning of the water needs of the plants.

Automated Systems

The architect will have a choice of several automatic watering systems for large private or public indoor gardens.

Water can be delivered on the surface of the soil. This arrangement will be unsightly unless it is worked into the design of the plant space (see page 134) as shown for hydroponic gardening.

Another surface delivery system, which can be made less conspicuous by covering it lightly with soil, is the watermatic kit which consists of tubes 5 feet long (these can be custom made to any length). When attached to a rubber water distributor and then to a hose or hose bib, these tubes deliver water to individual plants. For automating this system there is inexpensive equipment that includes a timer clock that will turn water on or off. If this system is used in conjunction with a water sensor and a thermostatically controlled warm-water source, it could provide a moderate cost solution to surface watering.

A sprinkler system fed by underground piping and using low velocity control and fountainheads is another installation. The radius of the effect of the water must be regulated to avoid wetting floor surfaces adjacent to the plant space and the consequent hazard to pedestrians. Buried piping may restrict the placement of plants, and the system should be designed to minimize this problem.

A subirrigation system (see page 133) for hydroponics will deliver water by the process of capillary action. There are several drawbacks to this approach, however. Capillary action in soil is slower than in the hydroponic growing medium for the water must stand at the bottom of the garden for a period of time before it will take place. Roots of plants may reach down for the water so deeply that the plant may be injured if it has to be moved.

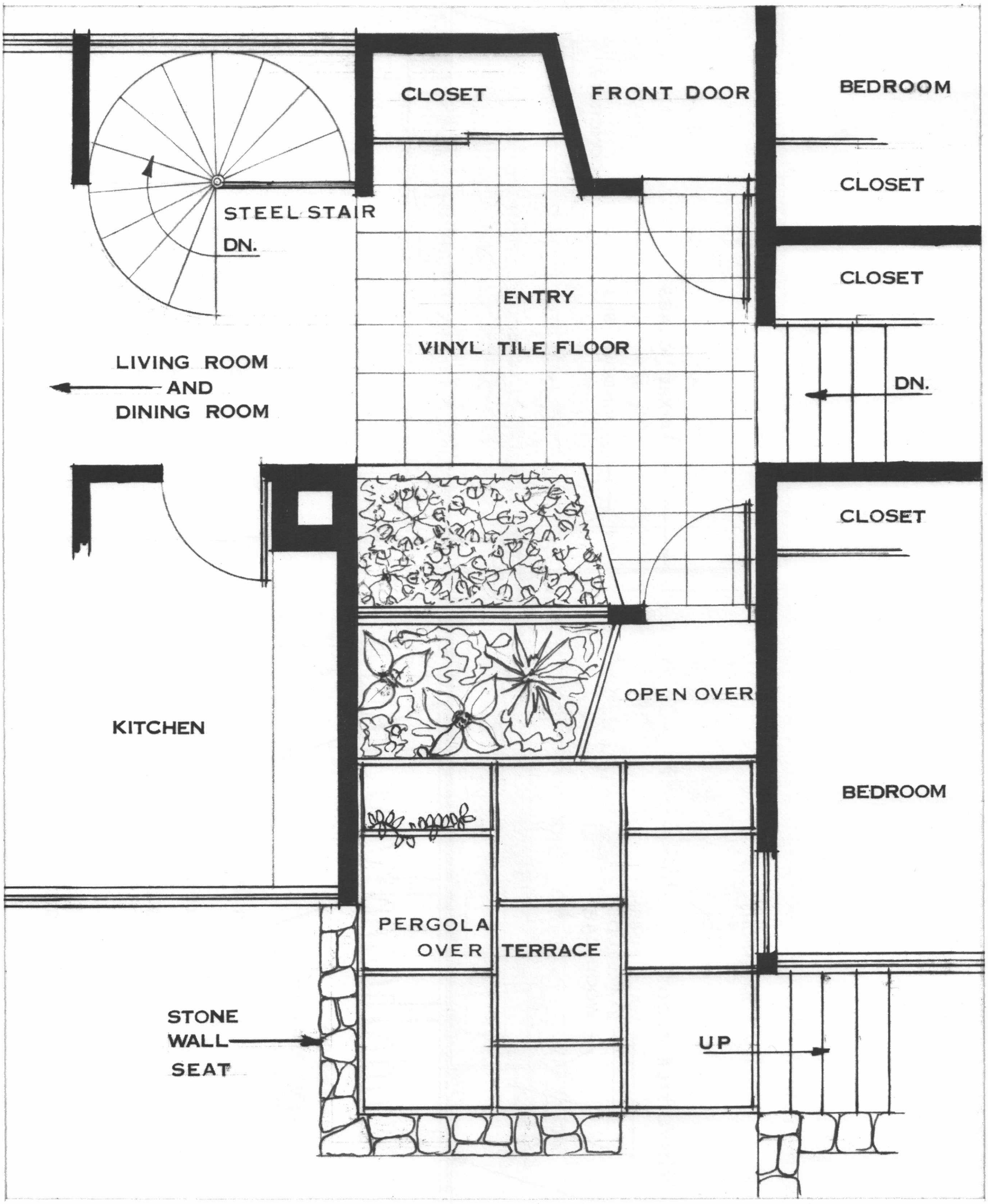
A "submatic" drip irrigation system can be installed on the surface of the indoor garden or imbedded among the plants. This system, which is also adaptable to hydroponic gardening, provides "drip" irrigation by a constant supply of water through ordinary garden hose and fittings that can be adjusted to a desired layout. Several other forms of the drip system are on the market. Drip system delivery is economical in water use.

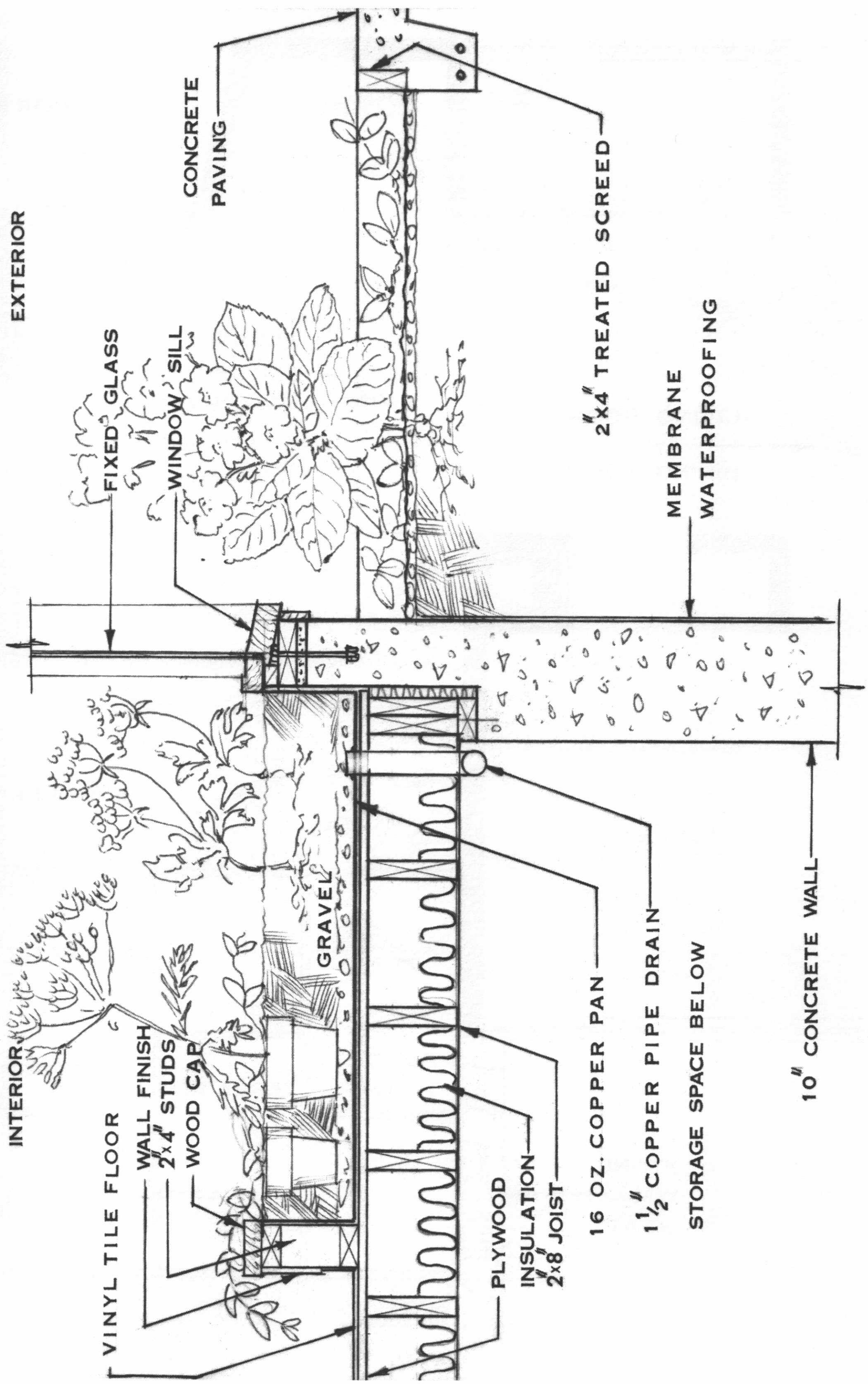
A system of inward focused jet heads installed around the periphery of the garden will supply water and add to the aesthetics of the space at watering time.

Overhead watering of the indoor garden in a public space can follow that designed for the rain forest garden (see page 148). If the plant space is not enclosed, accidental watering of the occupants of the building and of nearby floor surfaces must be prevented.

When water is supplied only to the roots of the plants, some provision must be made for washing their leaves. Frequency of treatment will depend on the quantity of dust particles in the air.

An entrance garden joins with one outside on the terrace to extend visually the size of the hall.


CLOSET
FRONT DOOR
BEDROOM
CLOSET
STEEL STAIR
DN.
CLOSET
ENTRY
VINYL TILE FLOOR
LIVING ROOM
AND
DINING ROOM
DN.
CLOSET
OPEN OVER
KITCHEN
BEDROOM
PERGOLA
OVER TERRACE
STONE
WALL
SEAT
UP



EXTERIOR
CONCRETE PAVING
2"x4" TREATED SCREED
MEMBRANE WATERPROOFING
FIXED GLASS
WINDOW SILL
10" CONCRETE WALL
STORAGE SPACE BELOW
1 1/2" COPPER PIPE DRAIN
16 OZ. COPPER PAN
GRAVEL
INTERIOR
WALL FINISH
2"x4" STUDS
WOOD CAP
VINYL TILE FLOOR
PLYWOOD
INSULATION
2"x8" JOIST

FERTILIZERS

A healthy plant is the result of good light, water access, air humidity, CO_2 content, and food. Though a plant must have carbon dioxide to convert food into tissue, it must also have access to a steady supply of nutrients which it takes up through its roots and occasionally through its leaves.

Thus a fertilizer which provides the plant with a sudden jolt of food and then allows it to starve is not an ideal plant food. Chemically based fertilizer, unless compounded to be slow-release, will give the plant an on-and-off nutrition pattern that makes it more vulnerable to disease and less productive of leaves and flowers.

The food content of fertilizers is generally stated in a proportional formula such as 10-10-10, meaning equal parts of nitrogen, phosphorous, and potassium. Ignored by this formula are the important trace elements boron, cobalt, copper, iron, manganese, molybdenum, and zinc. It is assumed that the impurities in chemicals supply some of these nutrients.

Good natural sources for these nutrients, which are suitable for indoor gardens and will release food to the plant in an even pattern, are the following:

Nitrogen. Bloodmeal, dried blood, coffee grounds, dried cow manure, greensand, and fish emulsion

Phosphorous. Bone meal, dried cow manure, dried blood, fish emulsion, and ground phosphate rock

Potassium. Wood ashes, greensand, dried seaweed, and dried cow manure

As you will note, dried cow manure has some of each of these elements. It also introduces needed bacteria.

Fish emulsion is an odorless liquid fertilizer with a 10-5-0 nutrient component. This formula needs the addition of some bone meal or phosphate rock for phosphorus and wood ashes or greensand for potash.

These elements in their natural form do not leach away from the roots and are available by bacterial action as required.

Nitrogen is a major element in plant, stem, and leaf growth. Phosphorus produces a strong root system and affects flowering, fruiting, and disease resistance. Potassium is necessary for cell division and growth, facilitates the utilization of nitrogen, and decreases water needs. Trace elements more frequently take a form in which plants can utilize them in natural materials. Boron is found in granite dust, copper, in manure, iron, in composted leafy weeds, manganese, in forest leaf mold, molybdenum, in ground rock phosphate, and zinc, in leaf mold. Manure is a good source for all micronutrients.

Different varieties of plant have differing needs and the proportions of the major elements must be adjusted accordingly.

The inside-outside entrance garden.

Intimately connected with the plant's use of fertilizer is its need for acid, neutral, or alkaline soil. On the pH scale which runs from 0 to 14

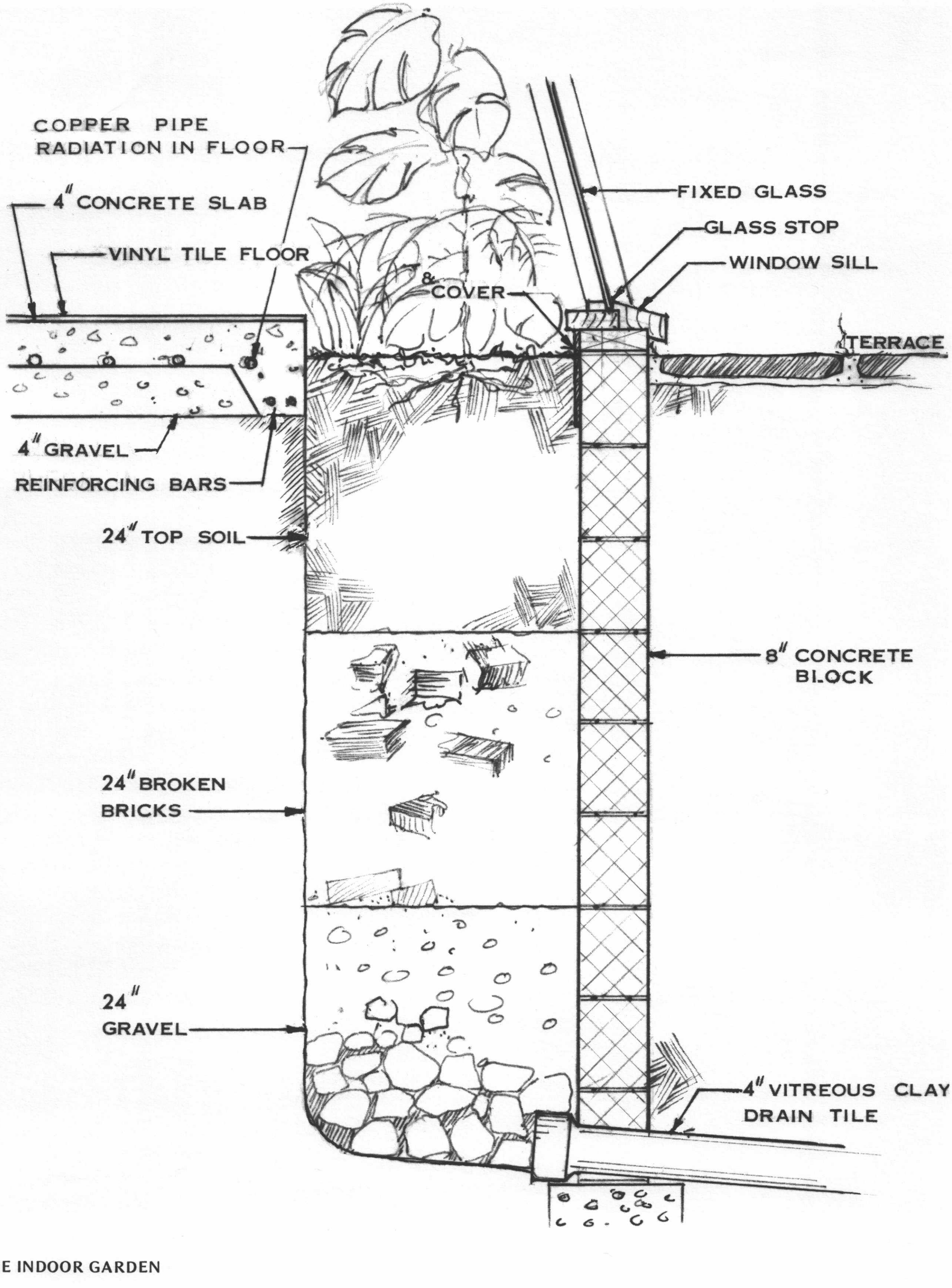
0 is most acid, 7 is neutral, and 14 is most alkaline. Most vegetables and fruits do best at 6.5 to 7.0 pH, but there are plants at each end of the scale. The pH needs of a particular type of plant can be obtained from the supplier, and a soil test kit will give a soil reading on pH value.

In the indoor garden in which light levels are high feeding of plants should be more frequent. Never fertilize plants when the soil is dry. If the soil is dry, water thoroughly and apply the fertilizer by stirring it into the soil.

Natural fertilizers should be incorporated in the growing medium when it is placed in the plant space. Regular additions should be based on whether a plant is in active growth or resting (at which time it should not be fertilized) and according to high or low light levels.

Late October sunshine enters this dining room through the slanted glass window. The tracery of the leaves of a cucumber plant beginning to bear at the central mullion, a geranium trained to climb on the plant-space wall at the left, and a dubia on the right-hand wall shows a variety of foliage, flowers, and food for the table. Flowering herbs and other sun lovers fill this plant space. The sun helps to heat the room. See detail, page 130, and photographs, pages 70 and 179.

Photograph by Fred Rola


COPPER PIPE
RADIATION IN FLOOR
4" CONCRETE SLAB
VINYL TILE FLOOR
& COVER
FIXED GLASS
GLASS STOP
WINDOW SILL
TERRACE
4" GRAVEL
REINFORCING BARS
24" TOP SOIL
8" CONCRETE
BLOCK
24" BROKEN
BRICKS
24"
GRAVEL
4" VITREOUS CLAY
DRAIN TILE

Hydroponic Indoor Gardens

Hydroponics, nutriculture, hydroculture, aqua gardening, and chemical gardening are a few of the names given to soilless plant growing. The techniques of this approach to gardening have been developing sporadically since the early eighteenth century. Each food crisis (e.g., the "dust bowl" years) and each war has renewed interest in this artificial method of raising crops. Today hydroculture is practiced in nutrition experiments on cash crops at many universities and agricultural experiment stations because it is a strictly controlled system that can be measured.

Experiments are conducted at these institutions to study the development of nutritional deficiencies demonstrated by plant symptoms, to determine fertilizer requirements of various crops, to demonstrate the effect of various nutrients on plant size, strength, disease, and pest resistance, and leaf, flower, and fruit development. Hydroculture is also used to grow Florida tomatoes on gravel soil which could not otherwise support plant life. Some desert areas with access to piped-in water use aquaculture because the soils are low in plant nutrients or are too alkaline in composition to be adjusted to good plant nutrition. In some cases the weight of soil is a limiting factor in growing plants in certain locations. Some of the substrates recommended for hydroponics (such as sawdust, perlite, or vermiculite) are light in weight in comparison with soil. The Montreal experiment described later (see page 139) found that the mix of perlite, vermiculite, and sand was 2% of the weight of soil. Aquaculture is also economical in water consumption because the amount used is measured and recirculated. It is for weight reasons that the indoor garden may have to be constructed for hydroponics instead of soil culture; for example, large indoor gardens in remodeled buildings, locations in public buildings in which a cantilever or other structureal consideration may make it impracticable to add soil weight to other structural loads, and structural systems that respond harmonically to movement (i.e., open-web steel joists) might be adversely affected by the soil weight of a large indoor plant space.

Some enthusiasts claim that hydroponic gardening requires less labor that soil gardening, but a look at the schedule of necessary activities connected with hydroponics given later in this section puts this in doubt.

SYSTEMIZED GARDENING

The designer of an hydroponic indoor garden in a public space must provide his client with an almost foolproof system. Pumps, piping, water-temperature regulators, nutrient mixes, and holding media must all be correct to ensure the success of the garden. Fortunately a hydroponic system can be designed to be as fully automatic as heating and cooling systems. Lighting and humidity levels will resemble those in soil culture. Experts in current systems are usually to be found in state agricultural departments and at local branches of the U.S. Department of Agriculture. The architect should consult these experts to determine the best system to suit local conditions and to fulfill his client's needs.

Hydroponics or aquaculture for residential indoor gardens should be installed only if the owner is willing to manage the water culture of plants. He should fully understand that he must tend them regularly and be willing to suffer some losses while he is learning how to handle the system if it is not automated. Details on page 133 are guidelines for hydroponic and aquaculture gardening. These gardens can be attractive in appearance and functional in the nutrition supplied to the plants.

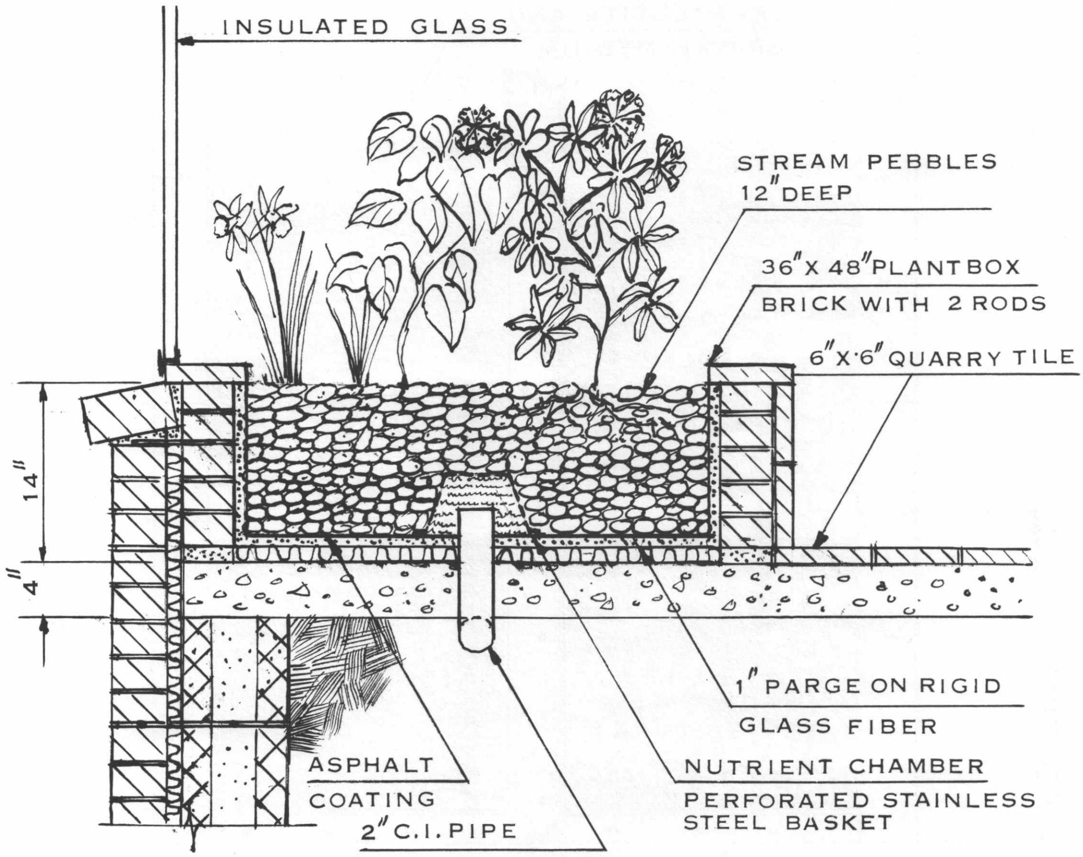
SCHEDULE OF CARE IN HYDROPONICS AND AQUACULTURE

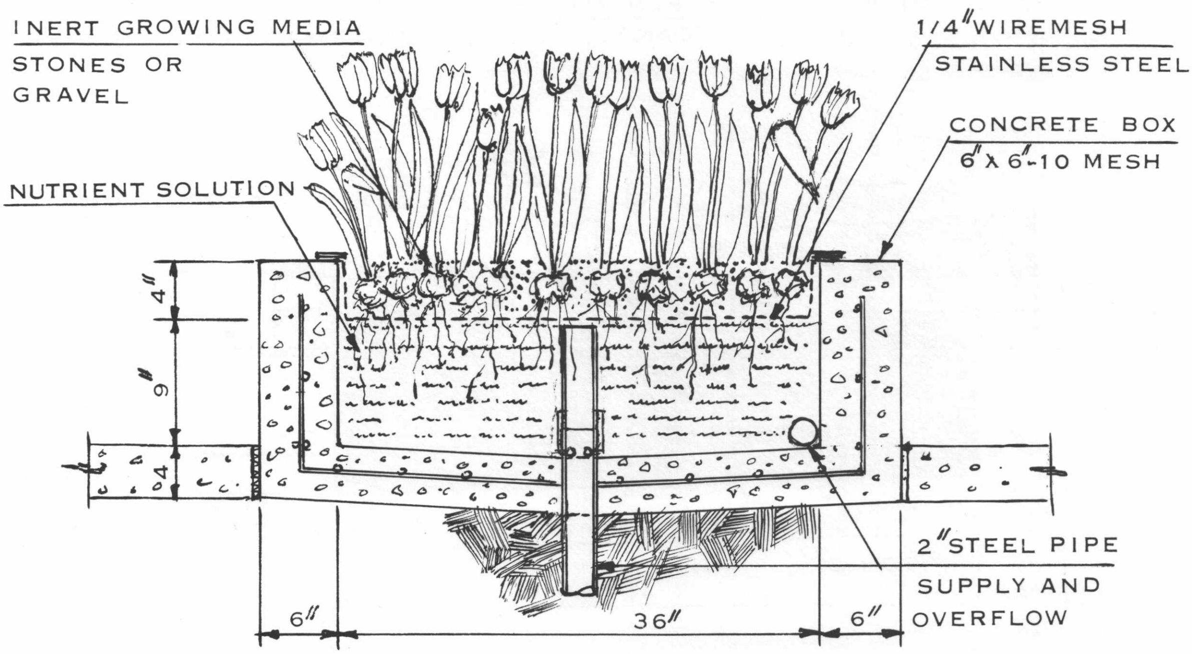
1 Check pH at planting and then once a week.
2 Check nitrate level every week.
3 Check conductivity of growing medium once a month.
4 Replace nutrient solution once a month.
5 Drench growing medium to remove toxic salts every two weeks.
6 In sand or perlite bed culture water should be allowed to drain out every third day.
7 Sterilize the garden once a year if there are not permanent plantings.

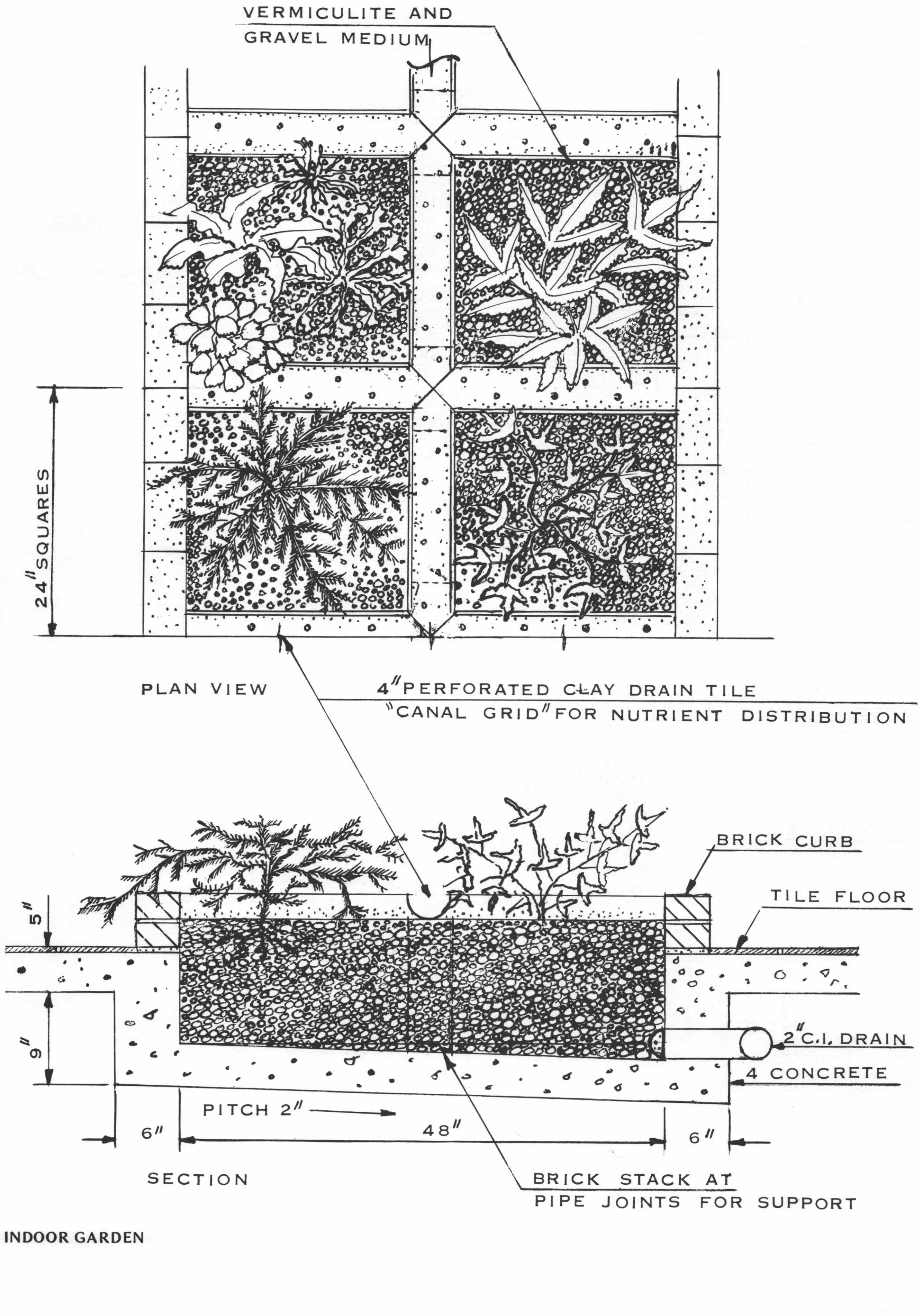
General

1 Growing medium should never dry out.
2 Air must be mechanically supplied to the root system when water is used as the soil replacement.
3 No water should be visible at the top of the solid growing medium.
4 Fifteen fluid ounces of nutrient solution per plant per day or one gallon per square yard of medium once a week is a guide to the quantity of liquid needed.
5 Solution should be 70 to 80°F (21 to 27° celsius).
6 Nutrients are dissolved separately if the chemical method is used.
7 Concrete gardens should be painted with pure asphalt to prevent lime from leaching into the solution and to prevent other chemical reactions that might form toxic materials.

Sections through a hydroponic and an aquaculture garden demonstrate the two major methods of the soilless culture of plants.


INSULATED GLASS
STREAM PEBBLES
12" DEEP
36" X 48" PLANT BOX
BRICK WITH 2 RODS
6" X 6" QUARRY TILE
14"
4"
1" PARGE ON RIGID
GLASS FIBER
ASPHALT
COATING
NUTRIENT CHAMBER
PERFORATED STAINLESS
STEEL BASKET
2" C.I. PIPE


INERT GROWING MEDIA
STONES OR
GRAVEL
1/4" WIREMESH
STAINLESS STEEL
CONCRETE BOX
6" X 6"-10 MESH
NUTRIENT SOLUTION
4"
9"
4"
2" STEEL PIPE
SUPPLY AND
OVERFLOW
6"
36"
6"



VERMICULITE AND
GRAVEL MEDIUM
24" SQUARES
PLAN VIEW
4" PERFORATED CLAY DRAIN TILE
"CANAL GRID" FOR NUTRIENT DISTRIBUTION
BRICK CURB
TILE FLOOR
5"
9"
2" C.I. DRAIN
4 CONCRETE
PITCH 2"
6"
48"
6"
SECTION
BRICK STACK AT
PIPE JOINTS FOR SUPPORT

8 Do not use galvanized metal for tray culture mesh. Again toxic salts may be formed by the chemicals. Iron or stainless steel wire mesh should be used.
9 Add micronutrients after pH has been adjusted.
10 To adjust pH:

Chemically. Add small amounts of phosphoric acid to lower pH and small amounts of caustic potash to raise pH.
Organically. Add small amounts of vinegar to lower pH and small amounts of baking soda to raise pH.

11 A soil test kit such as Sudbury's or laboratory litmus paper can determine pH. A soil test kit can also be used to determine the nutrients present in the solution.

HOLDING MEDIA

Soil is a growing medium that not only holds the nutrients for the plants' use but in which nutrients are made readily available to plants by the action of living microorganisms contained in the soil. Water is held in soil and gas exchange is made possible because of the many tiny air spaces contained in it. Soil also permits the establishment of a root system that holds the plant upright.

The solid media used in hydroponic culture provide for gas exchange and some support for the plants, and although they do not contribute to the plants' nutrition they distribute the nutrients to them. In aquaculture (see page 133) water provides the nutrient reservoir. Aeration for gas exchange must be mechanically introduced, and the shallow holding medium is merely to hold the plant upright and to protect the roots from light. All but the shortest plants will require more support than the loose holding medium can provide.

Some of the holding media discussed here are not truly inert but do not provide enough nutrients for plant growth by themselves; the best of them will not interfere with the nutrient formulations that may be used with them. Several of these growing media must be specially cleaned before use.

Cinders. The old literature on hydroponics frequently recommended the use of cinders for water growing. This was in a time when cinders were a freely available waste product. Cinders are now difficult to find, although with the proposed increase in the use of coal they may become available again. Cinders have a disadvantage over gravel because some may contain boron in an undesirable quantity. Cinders are often alkaline and give off iron and phosphorus when attacked by other chemicals. Iron and phosphorus are desirable additions to the plant diet, but a growing medium that adds these elements naturally does not fit the formula method of hydroponics. We do not recommend cinders as a growing medium because

A canal garden can be an attractive method for surface distribution of nutrient solutions.

the treatment necessary to make them useful far outweighs in cost their current supposedly low-cost availability.

Gravel. Crushed gravel is in most cases preferred over stream bed gravel. If the manager of the indoor garden will check the point of origin of the gravel he uses, he can then consult his state's soil maps or ask the state agricultural department to determine whether the quarry from which the gravel came is in a limestone area. If it is a limestone-based gravel, a pH test can quickly determine the acid-alkaline balance necessary for the plants he wants to grow.

Granite chips. These chips are usually white and most attractive to use. Nutrient formulations must take into account the necessary adjustments because of the slow release of alkalinity from some granite chips. Chips should be washed thoroughly before use.

Sand. Washed mason's sand can be used for artificial gardening in the nutrient bed approach. In this design a bed of sand is laid down and moistened; plants are then set into the bed. Overhead, or on top of the sand, perforated plastic pipes deliver the nutrients necessary for plant growth (see page 134).

Perlite. This material, much used in horticulture, is vitreous rock in the form of globules. It is lightweight in comparison with sand and may be used instead of it when weight is a factor. Finer particles fill up some of the pores, thus reducing aeration.

Vermiculite. This mineral originating in mica rock is used for insulation as well as horticulture. It is a lightweight material and can be handled like sand and perlite. Vermiculite collapses with time, thus losing aeration.

Ground fir bark. Redwood, cypress, or cedar bark give off toxic matter and should not be used. Fir bark has special application in the decorative planting of an indoor garden.

Sawdust. A freely obtained material, preferably the product of hemlock, pine, or fir trees. Never use cedar, redwood, or cypress sawdust. Aged sawdust is free of toxic compounds. As fresh sawdust breaks down, it ties up nitrogen which may have to be compensated. The volume will shrink and require subsequent application. Sawdust is light in weight, but its lateral moisture distribution is slow. It has good compaction for holding plants. Air does not freely enter sawdust. Sawdust is not recommended because of the expertise needed in its management.

Sawdust and sharp sand. The addition of sharp sand to sawdust improves the lateral movement of moisture and permits more air entrainment. Use for bed culture.

Peat moss. This material has several dis-advantages. It will break down rather quickly and does not support the plants well. When fresh, it entrains air readily. Most suitable for tray culture.

Osmunda or tree fern bark. Both materials are used in the culture of epiphytes. Their breakdown is slow, and coarse roots can penetrate well. Finer roots will have more difficulty. Its high cost is a deterent. Lightweight.

Wood shavings. Holding characteristics are not quite so good as sawdust; air spaces good and water can move freely; same management needed as for sawdust.

METHODS OF PRESENTING NUTRIENTS IN SOILLESS CULTURE

1 Plants may be set into coarse material such as ground fir bark, cinders, gravel, or excelsior and suspended in nongalvanized wire mesh trays over a container holding nutrient solution (see page 133). The "growing medium" for aquaculture merely holds plants upright. The roots seek out the nutrient solution through the wire mesh. It is necessary to give additional support to any but the shortest plants because the roots have no hold on anything stable but are merely immersed in an aqueous solution through the wire mesh. The tank should be kept dark to avoid algae growth. It is also necessary to introduce air for the roots into this solution. In large installations constant circulation of the solution can be maintained by a pump, thus introducing some air. Smaller installations can adapt an aquarium bubbler for air introduction or the solution can be agitated frequently by hand. A waterfall in which the nutrient solution is recirculated will aerate the water. The temperature of the solution should be 70 to 80°F (21 to 27° celsius). A thermostatically regulated immersion heater will serve this purpose.
2 *Growing plants in an "inert" medium.* A wider choice of holding materials is available in hydroponics. The plant space should be designed so that the bottom is sloped to the drain end, making it slightly lower than the inlet end, to ensure that no standing liquid will remain at the bottom. The detail on page 133 shows a section through this garden in which the perforated plastic pipe that delivers the nutrients is protected from possible obstruction by particles of the holding medium using an inverted trough.

The nutrient solution in commercial installations is often delivered by a pipe on the surface of the holding medium. This system could be changed to provide a better aesthetic by a system of canals made of 4-inch perforated clay pipe cut in half and recessed into the surface of the holding medium. As shown on page 134, the canal system can be designed as an attractive addition to the appearance of the plant space. In this system each branch of the canal should be fed by a pipe delivering the nutrient solution. Excess liquid will drain out at the sloped bottom as in other systems.

Overhead delivery of nutrients is a method seldom practiced. It is feasible, however, to deliver food to foliage. In nature the epiphytes take much of their nutrition in this manner. The natural holding media for epiphytes, growing wild, will catch the nutrients. In the rain forest (see page 148)

overhead delivery of nutrients is practicable. This is a closed system; in other words the water is recirculated by pumps and would not require redesigning if nutrient solutions were used. The nutrient solution should be one quarter the strength of that in the other two systems of hydroponic food delivery to avoid damaging delicate flower petals and because the nutrients are so frequently delivered to the plants' leaves. We recommend the fish emulsion and liquid seaweed solution adjusted with vinegar or soda for pH and without the bloodmeal component in the organic formula. Good, constant ventilation is important in this system to prevent disease organisms from developing. When the nutrient is replaced, the rain forest should be flushed for two days with plain "rain" water to avoid a buildup of the nutrients in the holding medium and to wash the leaves of the plants thoroughly.

NUTRIENT REQUIREMENTS

There are almost as many chemical formulas as there are experimenters with hydroponics. We give just one of the more common chemical formulas and a newly developed organic formula. These cautions.

First. As organic gardeners we do not recommend chemical nutrients in soil *or* water for plants that produce food.

Second. The chemicals themselves may be dangerous to store in the home or even in a public building (i.e., some formulas include sulfuric acid as a component).

These elements are those *known* to be required by plants. The place of micronutrients found in soil as well as the dynamics of microbacterial elements in soil are not fully known and thus cannot be included in a chemical formulation.

Primary Elements Required By Plants

Macronutrients (used in large quantities)

Nitrogen
Phosphorus
Potassium

Secondary Elements

Calcium
Magnesium
Sulfur

Trace Elements

These are used in small quantities

Boron
Copper
Iron
Manganese
Molybdenum
Zinc

A CHEMICAL FORMULA

This formula, developed by Dr. D. R. Hoagland, University of California at Davis, is standard today.

Macronutrients

Nutrient Source	Stock Solution (grams per liter)	Culture Solution (milliliters of stock solution per liter)
Monobasic potassium phosphate (KH_2PO_4)	136	1
Potassium nitrate (KNO_3)	101	5
Calcium nitrate ($Ca(NO_3)_2 \cdot 4H_2O$)	236	5
Magnesium sulphate ($MgSO_4 \cdot 7H_2O$)	247	2
Trace Elements		
Iron chelates (10% Fe)	20	4
Boric Acid H_3BO_3	2.86	1
Manganese $MnCl_2 \cdot 4H_20$	1.81	1
Zinc sulfate $ZnSO_4 \cdot 7H_2O$	0.22	1
Copper sulfate $CuSO_4 \cdot 5H_2O$	0.08	1
Sodium molybdate $Na_2MoO_4 \cdot 2H_2O$	0.027	1

AN ORGANIC FORMULA

The real breakthrough in hydroponics came in 1975 as an offshoot of a project funded in Montreal by the Canadian government. An experiment was underway to utilize the "desert" areas of the inner city (the rooftops) for gardening. The deciding factor in the switch to hydroponics was the weight of the soil which had to be carried up flights of stairs and which also endangered some of the buildings structurally. The gardeners on the project were organic gardeners. During the second year of the project an organic formula was developed by Miranda Smith which is still being used in Montreal and at the Institute for Local Self-Reliance in Washington, D. C., where Ms. Smith is now Director of Urban Agriculture. The details of the nutrient first appeared in the November issue of "Self-Reliance," published by the Institute.

The holding medium for an area 5'-0" X 7'-0" X 1'-6" is half perlite, half vermiculite, plus 50 pounds of sand. The perlite and vermiculite should be thoroughly mixed and the sand added and mixed before wetting the medium.

3 tablespoons fish emulsion
3 tablespoons liquid seaweed

1 tabelspoon bloodmeal
5 gallons water

Bloodmeal is high in nitrogen and is excellent for foliage plants. Less bloodmeal should be used for flowering and fruiting plants.

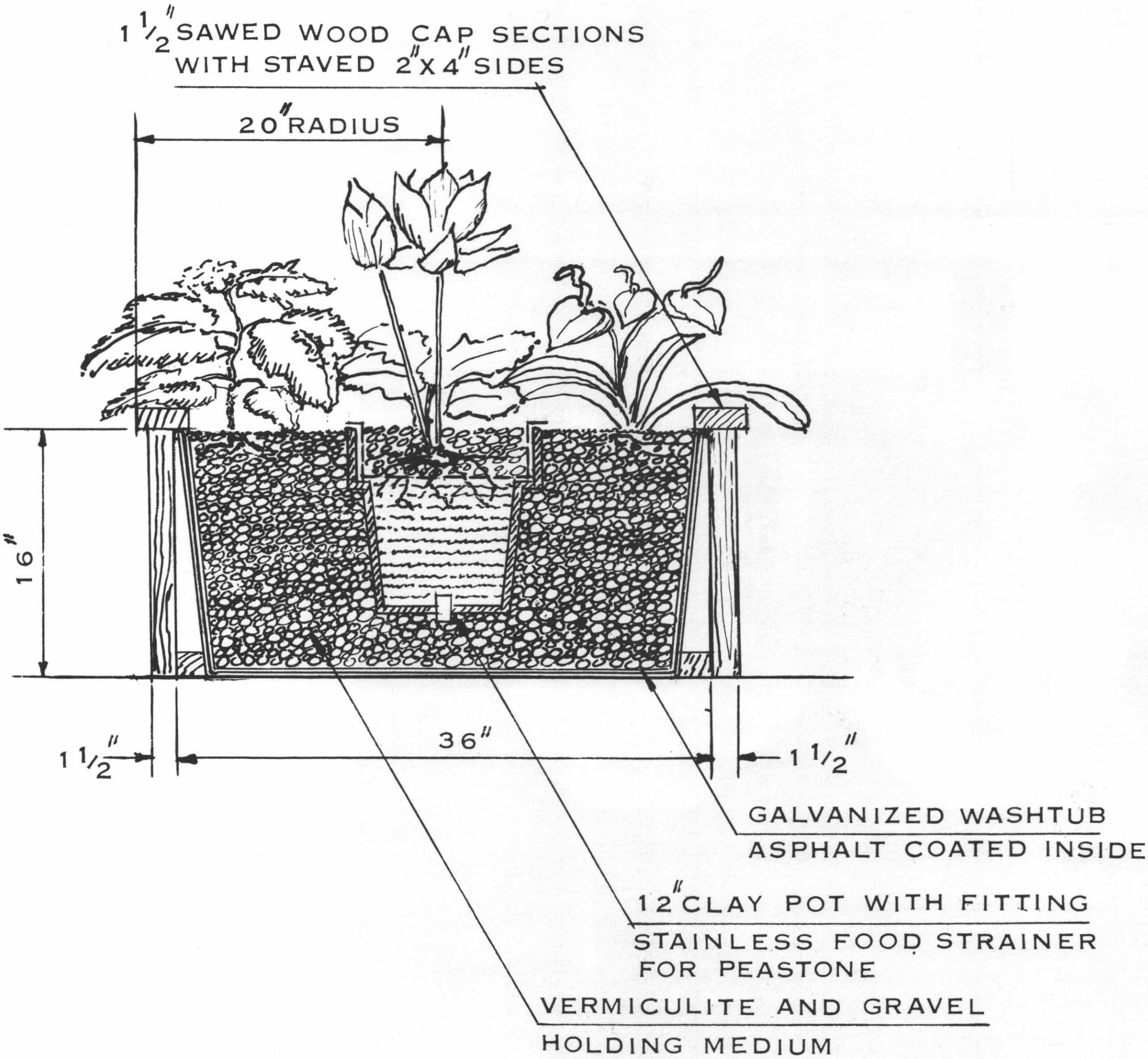
pH can be adjusted by adding finely ground limestone or baking soda for greater alkalinity or vinegar for a more acid solution. A soil test kit will help to adjust nutrients and pH balance.

The same rules used in chemical gardening apply as to aeration, changing solution, and general construction of the plant space with one exception. This formula has never been used in a holding tank hydroponics operation; rather it is mixed as it is used. Flushing of the medium can be done less frequently because there will be no build-up of toxic salts. Flushing should be carried out every three or four months to ensure that no salt residues are introduced by the water used and no pocket concentrations of the nutrients exist.

COMMENTS

Extra care must be taken in hydroculture to grow plants with compatible nutrient and pH needs, for they all feed from the same fluid. In soil gardening it is possible to develop areas of soil that will have different nutrient components and pH by separating them from other nearby plants by potting or by installing a recessed metal barrier, mentioned earlier for use in restraining root growth of plants bedded directly in the garden to separate different soil types.

Soilless culture with nutrient solutions is force feeding. It is better used for plants with short productive lives than for long-life plants which are a larger original investment. Structural weaknesses may develop that are not important in a short-lived plant, such as a crop plant, but in plants that may live for many years will eventually show up as lack of resistance to disease or as structural failure. It is apparent also that if the sustained feeding in water culture breaks down because of mechanical failure or neglect the plants will have nothing to fall back on. Plants in organically fed soil receive a slow release of nutrients as required because of the minute organisms at work in the soil, and a neglected plant will be sustained by this system for extended periods of neglect in the properly constructed soil-filled indoor garden.



This is a simple, easily constructed way to experiment with hydroponics and aquaculture. The lotus in the center sends its roots into the nutrient solution, and the anthurium and kohleria use the holding medium for roots to search out nutrients in solution.

Photograph by Herrington Olsen. Courtesy Prescolite.

Lighting for hydroponic or aquaculture gardens should be planned as carefully as for soil-based gardens. These elegant ceiling-mounted eyeball fixtures are for spotlight, floodlight, or plant light, adjustable to the exact angle desired. Source: Prescolite.

Furnishing the Indoor Garden

The architect may have a broad or limited knowledge of plant furnishing suited to the indoor garden he has designed. Furnishing and maintaining plants indoors have equal importance with outdoor landscaping. In the public or commercial building furnishing plant spaces and providing for their maintenance should, like exterior landscaping, be a part of the construction contract. The subcontractors bidding for this work must be chosen even more carefully than the plumbers and electricians. The latter must be licensed but the seller of indoor plants who is often not concerned with long-term results is not. Exotic plants are sold by grocery chains as well as specialty shops, sources that are of little use to the architect in search of bidders for this section of the contract. The architect should first determine whether the bidders on the exterior landscaping also specialize in indoor plantings, although this is not often the case. Another possible source of bids is the retail exotic plant store that has its own greenhouses. Growing and managing plants over the long term makes this source a good one. Finally, if there is difficulty in locating a proper number of bidders for the job, the architect should write to a wholesaler of exotic plants for information on indoor planting subcontractors. Some major wholesalers may have a subcontracting service, whereas others will be able to offer advice. It is in the interest of the wholesaler to be able to recommend competent suppliers, installers, and maintenance staffs. A list of some major exotic plant wholesalers is contained in the appendix.

The homeowner with an indoor garden is interested in the choice and maintenance of his plants. Often the search for suitable plants and the adjustment of the habitat to their individual needs of water, humidity, light, and heat are the pleasure he obtains from his garden. Although wholesalers do not sell retail, they can often provide a list of good retail sources. Those who sell at retail as well as wholesale are identified in the appendix.

Books and magazines that specialize in indoor plants and their culture have proliferated in recent years. It would be redundant to include material here that is so competently covered in other books and periodicals on the subject.

The basic text for descriptions and native conditions of tropicals is Alfred B. Graf's *Exotica,* published by Roehrs Company, Inc., East Rutherford, New Jersy, or *The Exotic Plant Manual* by the same author and publisher. There are also several fine books on specialities for indoor gardening. The serious student of indoor garden flora will find it interesting to obtain from the library books on the flora of other countries such as South Africa, Egypt, Australia, New Zealand, and countries of South America. These books, used in combination with Graf's *Exotica,* will suggest many plants of interest for use in the indoor garden, although many of them will probably not be easily found. However, the use of a plant hunter service may locate them. Plant-hunter services advertise in garden magazines. Information on foreign plants and regulations regarding their import may be obtained from the embassies of the countries of origin.

An especially fine, well-illustrated example of this type of book is *South African Flowers for Gardens* by Sima Eliovson, published in 1955 by Howard Timmins, Cape Town, South Africa. There is a companion volume, *Flowering Shrubs and Trees for South African Gardens,* by the same author and publisher.

This section suggests some approaches to furnishing the indoor garden that cannot usually be found in other literature or by consulting a local grower of exotics.

Much attention is focused on foliage plants in the literature, whereas some of the other potential indoor garden inhabitants are only slightly treated, possibly because they are considered too difficult for pot culture in the average situation.

A wide range of plants is adaptable to the designed indoor garden with its controlled environment. Because the following are listed in groups, it is not implied that the plants cannot be combined if cultural conditions are similar.

THE EDIBLE INDOOR GARDEN

The Citrus

One of the most satisfying plant families to cultivate indoors is the citrus. Aesthetically and functionally citrus can be raised most successfully in the indoor garden. Dark green, evergreen leaves, sprays of fragrant flowers and delicious fruits make them the perfect indoor inhabitant. Limited in outdoor culture to only a few areas of the United States, the citrus family can be enjoyed everywhere indoors.

The mature dwarf trees can be grown in 12-to16-inch pots in loose, quickly draining soil. They bear when they are young and small. The potted plants will benefit from being sunk into the indoor garden soil because of the improved evenness of the moisture level. They can also be planted directly in the plant space. To bear better crops of fruit indoor plants must be hand-pollinated. Using a cotton-tipped swab, gently touch the stamens and the stigma of each flower. This is an easy and pleasurable task. A 4-foot dwarf Meyer lemon can bear as many as 24 juicy lemons at Christmas time.

Cultural requirements for citrus include regular weekly watering and soil that will drain quickly. If these trees are to be potted, soil should be equal parts good garden soil and peat moss. Feed with fertilizer intended for acid lovers and supplement occasionally with iron chelates, manganese, and zinc. High light levels are needed for flowering and fruiting.

Dwarf citrus will grow to 8 feet unless pruned but take well to shaping and can be maintained at 4 feet. They can also be espaliered. If the back wall of the plant space is masonry or treated wood paneling and receives direct sun, this is an effective way to use a citrus tree. in which case the tree is permanently planted in the indoor garden. It would be well to use a grow ring (see Equipment) to define the root area so that the roots will not be disturbed when other plants are moved about. A ground cover of miniature Wandering Jew or ivy can be used over the root area.

A California specialist (see Appendix) has developed a group of fine dwarf citrus that includes varieties of orange, grapefruit, lemon, lime, tangelo, kumquat, and tangerine. There are more than 30 kinds to choose from. We do not recommend buying citrus plants from mail-order houses that do not specialize in plants.

Citrus culture. Will accept 12 hours of special plant fluorescent lighting per day during winter. Prefer cool, draft-free, medium-humid environment; benefit from but do not require summer out of doors; cover with plastic for a few days after bringing indoors. Citrus can be grown in equal parts perlite and peat moss. This mix has no nutrients and must be kept constantly fertilized while the plant is growing. A food-producing mix would be ½ light, rich, garden soil, ¼ crumbled leaf mold, and ¼ peat moss. Mix a handful of raw bone meal, dried cow manure, a dusting of ground potash rock, and a cupful of ground phosphate rock with each bushel of soil.

Feed about every two weeks with fish emulsion, and make bimonthly additions of iron chelates and ground phosphate rock while plants are growing. Withhold fertilizer if plants seem to be resting. Top and root pruning should be done in the resting period.

Common Fruits for Indoors

Although these plants will bloom and bear in the well-lighted indoor garden, they are deciduous. They will rest well in a cool place under lights. Self-pollinating varieties should be helped along by using cotton swabs. These cool climate plants are particularly attractive when planted indoors in a desert climate.

Bonanza peach. Four to 5 feet tall; beautiful in bloom; bears fine freestone peaches sometimes in the first year. Double pink blossoms are self-pollinating.

Nectarina. A genetic dwarf variety like the Bonanza. Will fruit when 3 feet high. Fruits ripen about 4 weeks after Bonanza. Fruit round and fuzzless; red flush outside; yellow flesh.

North Star cherry. Genetic dwarf sweet cherry. About 7 feet tall. Early ripening.

Stark jumbo dwarf apple. Five-inch fruits; maximum height is 8 feet but may be kept pruned. Requires a pollinator, or artificial pollination may be accomplished by gathering pollen from outdoor varieties and storing in airtight container in the refrigerator.

Culture of Common Fruits
Soil mixture

Two parts of good garden soil, 1 part sand, 1 part peat moss. A fertilizer such as 10-10-10 should be applied at the start of the blooming season and again as fruiting is finished.

Flowering and fruiting in midwinter can be accomplished by resting the plants in the dark at 35 to 40°F for 3 months. When moving them back to the indoor garden for winter flowering, water well and cover with light plastic for a week to reduce shock. Give plants 12 hours of light.

Exotic Fruit Bearers

Banana, Chinese or dwarf Cavendish (*Musa acuminata*). About 6 feet tall; compact plant. May have branches of as many as 75, 5-inch chubby fruit. Must have constant warmth, water, and heavy feeding.

Barbados cherry or acerola (*Malpighia glabra*). The famous "cherry", so high in vitamin C. Shiny, green, leathery 3-inch leaves, carmine-rose flowers. Fruit has applelike flavor. Three teaspoons of acerola "cherry" jelly will provide minimum daily vitamin C requirement.

Fig (everbearing). Delicious fruits on a handsome shrub. Bears almost year round. Self-pollinating. Likes cool, moist atmosphere in winter.

Jaboticabo or Surinam cherry (*Eugenia uniflora*). A small tree that can be kept pruned to 8 feet; glossy leaves; crimson, edible fruit following fluffy, white flowers. Other edible Eugenias are *E. jambos, E. jamboland, E. myrtifolia,* and *E. malaccensis.*

Kiwi. Exotic New Zealand fruit for fresh eating or in salads. Vine that may be pruned and trained as are grape. Must purchase "matched pair" for pollination and do the cross pollination in the absence of bees.

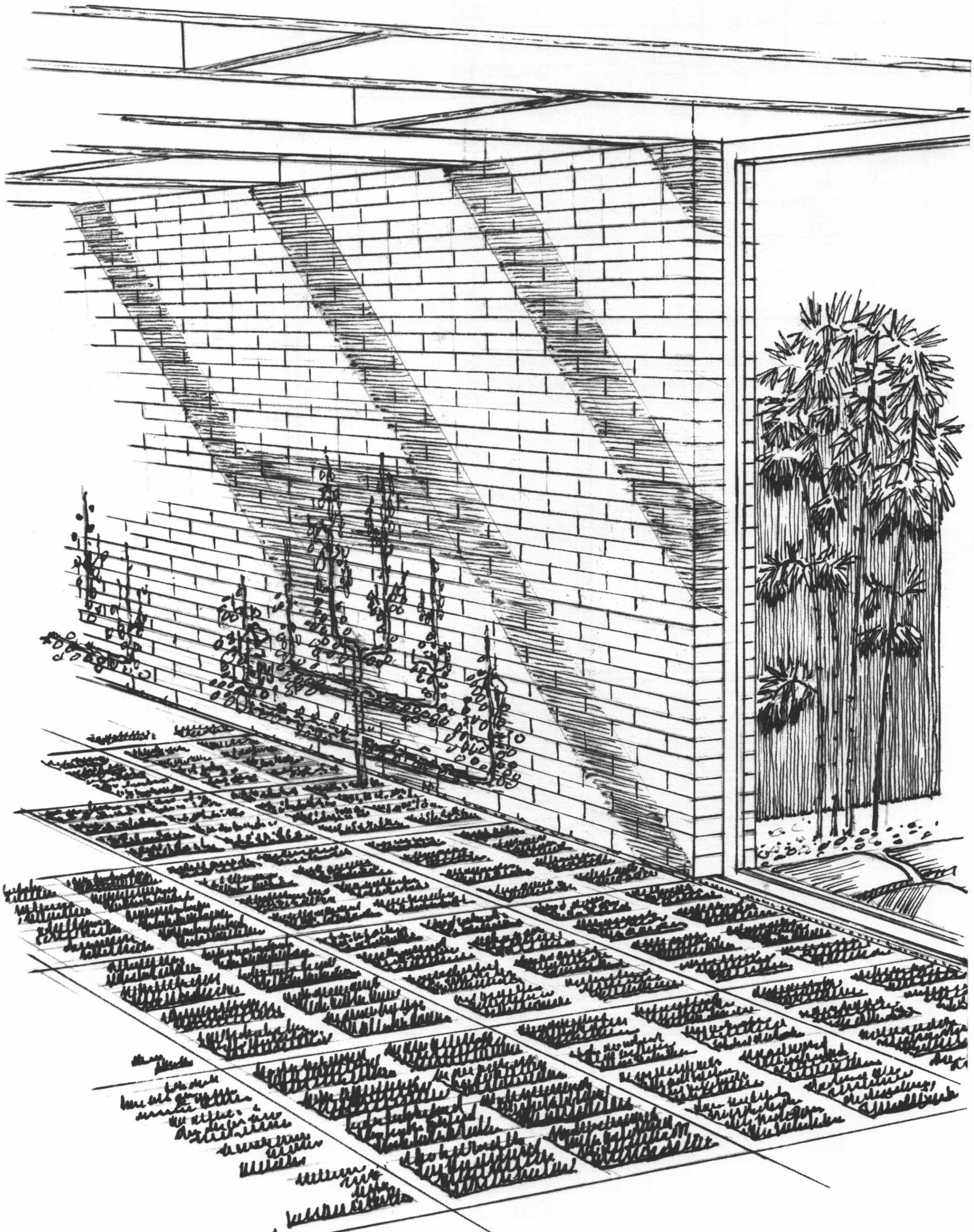
Loquat (*Eriobotrya japonica*). Shrub or small tree. Can be kept pruned. Ribbed and toothed evergreen leaves; fragrant flowers in clusters and delicious pearshaped fruit up to 3 inches.

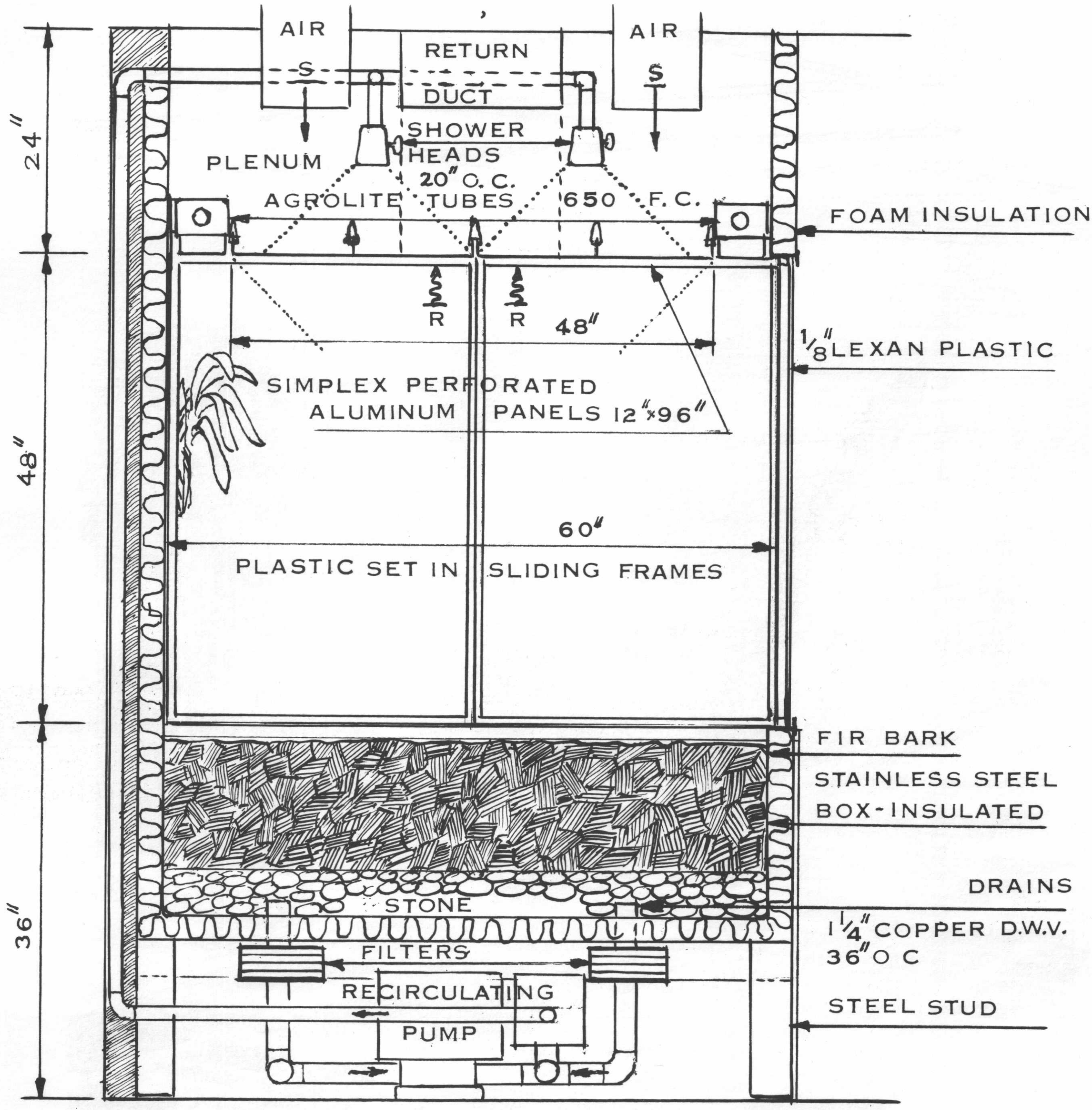
Monstera Deliciosa (*Philodendron pertusum*). Well-known foliage plant. Flowers have rank odor but fruits have flavor of banana and pineapple combined.

Nutmeg (*Myristica fragrans*). Seed is nutmeg and web is mace. A tree that may be kept pruned and dwarfed by root restriction. Evergreen. Aromatic leaves. Both male and female plants are necessary for fruiting.

Papaya (*Carica papaya*). A small tree of 12 feet. Plant may have male, female, or bisexual flower. Try to buy the latter or plant three and discard the unisex plant. Should bear 8-to-10-inch melonlike fruits within 12 months.

A walk-over herb garden is lighted by a sun roof. Citrus trees are espaliered against the brick wall. The herbs are all dwarf varieties. Chamomile, woolly thyme, and other varieties of creeping thymes are used for texture and color contrast. Dittany kept sheared will add its distinctive fragrance to the garden. If a program of twice-a-year shearing were carried out, dome of the taller varieties of herbs could be used to provide a greater variety of fragrance and texture. Creeping rosemary, sweet woodruff and marjoram, would be amenable to this treatment. Construction is on quickly draining subsoil. On this level surface are laid hollow concrete pavers intended for use in grassing parking lots to allow gradual water run off. The hollow center of each paver should be filled with good garden soil, then planted. Here is an excellent location for a buried automatic water system.





AIR
RETURN
AIR
S
DUCT
S
SHOWER
HEADS
20" O.C.
PLENUM
AGROLITE TUBES 650 F.C.
FOAM INSULATION
24"
R
R
48"
1/8" LEXAN PLASTIC
SIMPLEX PERFORATED
ALUMINUM PANELS 12"x96"
48"
60"
PLASTIC SET IN SLIDING FRAMES
FIR BARK
STAINLESS STEEL
BOX-INSULATED
DRAINS
STONE
36"
1 1/4" COPPER D.W.V.
36" O C
FILTERS
RECIRCULATING
STEEL STUD
PUMP

The detail of this tropical garden shows shower heads for the rainstorm and method of recirculating the water for even temperature. Growing lights and ventilation ducts are also located in the ceiling.

Passion flower or purple Granadilla (*Passiflora edulis*). White flowers, 2½ inch, with a blue violet ring at center. Handsome three-lobed foliage. This vine bears edible fruit.

Pineapple (*Ananas comosus*). A bromeliad with spiky leaves up to 3 feet long. Fruits mature in 18 to 20 months. Plant dies after fruiting but produces suckers that can be started. Place plant where sharp leaves cannot damage eyes.

Pomegranate (*P. granatum nana*). This dwarf form will bear miniature pomegranates. They are bright orange to red when ripe. Single-flowered; glossy leaves, sometimes tinted pink. Orange-scarlet blossoms. The regular pomegranate can be raised to bearing in about a year. It will need pruning to keep its attractive shape.

Sapote. Normally a tall tree, this plant may be kept to 8 to 10 feet high by pinching out the terminal bud when the tree is 3 feet tall. Fruit ripens September to November and has a soft cream-colored pulp with a yellow-green skin, tastes like a ripe peach. Flowers are inconspicous but trunk and branches are rough, gray, and covered with lenticels that give the bark an interesting texture. Culture as for oranges. Good varieties: Coleman, Pike, and Wilson.

Vanilla (*Vanilla fragrans planifolia*). A tall, climbing orchid with fleshy leaves up to 9 inches; 2-inch "orchid" flowers, greenish-yellow and white. Seed pod is commercial vanilla. Blooms December to June.

Vegetables in Indoor Gardens

The pleasure of having fresh, unsprayed vegetables out of season and the urbanization of the countryside with consequent shrinking of lot size will tempt many gardeners to use an indoor plant space for a vegetable garden. This is entirely practical if lighting is arranged to give a minimum of 4 hours of sun plus 8 hours of artificial light for the long-day plants and 3 hours of sun plus 6 hours of artificial light for short-day plants. Watering should be distributed evenly (see Equipment); a misting spray should be used on hot, dry days and regular fertilizing must be done. A productive vegetable plant indoors cannot suffer setbacks brought on by water deprivation and hunger.

Because of lack of pollination in the indoor garden, vegetables like beans and peas should be eliminated from consideration. Although they will grow and bloom, they will not bear unless pollinated. Tomatoes self-pollinate, but the plant should be shaken to accomplish the spread of pollen. A hormone spray called Blossom Set may be used to induce fruiting. Do not breathe this vapor and plan to use it on a cool, cloudy day.

Avocado Littlecado, Armstrong. Dwarf avocado with shiny, green delicious fruit of normal size. May be pruned to a very small tree or allowed to grow to 10 to 12 feet. Excellent for indoor culture. (Avocados raised from seed will not bear, though they make attractive plants).

Beet. Lutz green leaf, Burpee. For baby beets and tops.

Cabbage. Dwarf Morden, Park. 4-inch heads; 55 days. Likes to start in cool temperature.

Cantaloupe. Short 'n Sweet, Park. Bush cantaloupe. Pollinate by hand. Heavy feeder.

Carrot. Tiny Sweet, Park. 62 days; 3-inch golden orange roots, crisp tender.

Carrot. Little Finger, Burpee. 63 days; 3½-inch carrots.

Chives. Buy plants. Use for seasoning.

Cress. Curly cress, Burpee. Tangy salad green.

Globe artichoke. Silver leaves will take much space. Heavy feeding. Heat needed. Eat the flower buds.

Cucumber. Cherokee, Park. 3-foot vines; 7-inch cucumbers. Water and fertilize heavily. Disease-resistant.

Eggplant. Modern midget, Park. 65 days, a medium-sized purple fruit. The plant itself is handsome with furry leaves and purple flowers.

Lettuce. Tom Thumb, Park. 65 days. Butterhead type. Size of tennis ball; individual serving.

Lettuce. Buttercrunch, Burpee. 75 days. Fine, large, compact head.

Lettuce. Green Ice, Burpee. 45 days. A quick, leaf lettuce. Wavy leaves.

Lettuce. Ruby, Burpee. 47 days. Loose leaf, red-tinged leaves.

Onions. Green. Started onion plants or sets will produce fine green salad onions. Interplant.

Parsely. Banquet, Harris. A good indoor producer.

Radish. Champion, Burpee. Interplant with leaf crops.

Spinach. New Zealand, Burpee. Cut and come again greens for salad and cooking. Will make a good ground cover. Feed heavily.

Sweet Bay Tree. Normally a full-sized tree from which bay leaves for cooking are obtained. Can be kept pruned to small size.

Swiss Chard. "Rhubarb," Burpee. A decorative red variety; grows year round; cut and come again vegetable. Good in salads and for cooking. Feed heavily.

Turnip. Tokyo Cross, Burpee. This tiny turnip produces delicate white roots and fine greens.

Herbs. Sage, mints, chives, rosemary, and oregano will stay green and produce year round indoors.

SOME SPECIAL FLOWERING VINES

Allamanda cathartica hendersonii (Gold cup). Leathery leaves; funnel-shaped yellow, waxy, flowers. Very striking. Needs moist, humus-rich soil.

Allamanda (Thunbergia grandiflora). Restrain roots by potting; 3-inch blue flowers. Well-drained, rich soil.

Aloe ciliaris (Climbing Aloe). Flower spike like a small, red, 8-inch Christmas tree tipped in green; always upright. Roughly toothed leaves. Sun loving; needs rich porous sandy loam with leaf mold and bone meal.

Bauhinia galpinii. Brick red to orange flowers. Petals narrow at the base in clusters. Kidney-shaped light green leaves. Sun or part shade. Warmth, moisture, and well-drained soil.

Beaumontia grandiflora. Woody twiner. Young shoots tinted rose and hairy; 5-inch flower, white with dark throat, trumpet-shaped, fragrant. Borne in terminal racemes.

Bougainvillea (*buttiana*). "Temple"; fire-brick red flower bracts turning cerise. "Praetoria" flowers golden bronze with overtones of pink and yellow. "Barbara Karst" brilliant red floral bracts. Bougainvilleas have been a greenhouse favorite for centuries.

Clematis (*armandii*), hybrid "Apple Blossom." Leathery, shining leaves, rose flowers, very fragrant. Many other varieties of clematis are suited to indoor growing. Alkaline soil. Flowers need sun; roots, cool shade.

Clerodendrum (variety splendens). Corrugated leathery leaves to 6 inches and brilliant scarlet 1-inch flowers. Variety Thomsonae called glory bower with papery green leaves and many small white and crimson flowers. These are easy vines to grow. Variety Ugandense has bright blue flowers in panicles. Tends to be more shrubby.

Doxantha (*unguis-cati*). Clings by clawlike tendrils. Canary yellow flowers 3 inches long flare to 4 inches. Sun or partial shade. Water well. Infertile soil needed to produce blooms. Small plants will bloom.

Hibbertia scandens (Guinea gold). Waxy, evergreen leaves; bright lemon yellow; funnelshaped flowers. Cut back after flowering. Needs moist, well-drained, sandy loam and leaf mold. Part shade; hose off leaves occasionally.

Hoya (*carnosa* and varieties). Flat branches of pale pink flowers, thick glossy leaves. Mature plant blooms if pot bound. *H. carnosa* Exotica has variegated leaves.

Mandevilla. "Alice Dupont." A splendens hybrid. Dark green, rough leaves, flowers funnelshaped; clear pink with darker throat. Suaveolens, a fragrant variety, has thin, leathery leaves. Pure white flowers in racemes of six to eight.

Passiflora caerulea (Passion flower). Fine white and purple flower of distinctive parts. Will bloom all winter. Heavy feeder. Fragrant (see edibles).

Stephanotis (*floribunda*). White, waxy flowers; thick, evergreen leaves. Needs warmth, moisture, rich soil, and sun.

Tecoma (*Tecomaria capensis*). Can be grown as a climber or pruned to a shrub. Leathery, oval, evergreen leaves. Orange trumpets with yellow throat.

Thunbergia (*laurifolia*). Large, light blue flowers with white throat. Woody climber; fluted trumpetshaped yellow flowers.

Vanilla (see Edibles). A climbing orchid.

SOME STRIKING FLOWERING PLANTS FOR INDOORS

Acacia. Some dwarf varieties have needleshaped foliage and puffs of yellow flowers. The outstanding small tree has gray-green "needles" and the same puffs of yellow with a gentle fragrance.

Agapanthus africanus. "Blue Lily." Straplike leaves; stiff stalk carrying large umbels of tubular blue flowers; *A. orientalis,* albus-white.

Anthurium scherzerianum **Flamingo flower.** Leathery, green leaves; brilliant scarlet spathe with spirally twisted yellow spadix. Hundreds of varieties of *Anthurium* are currently for sale. Prefers filtered sun and will do well in artificial light with 50% humidity; also *A. andreanum* rubrum.

Callistemon coccineus. Bottle brush. Bright scarlet red bottle-brushlike flowers tipped by yellow anthers. A woody shrub that may be trained to formal tree shape.

Carissa spectabilis. Evergreen shrub with oval, glossy, leaves and clusters of fragrant white flowers.

Clivia miniata. Long, straplike evergreen leaves. Stalks of many trumpet-shaped orange or red flowers (variety grandiflora).

Ervatamia coronaria. "Crape Jasmine." Shrub with glossy leaves; white, waxy, fragrant flowers. *E. coronaria* plena has waxy leaves, pure white, lacy, double flowers.

Erythrina acanthocarpa. A fine shrub with leathery leaves; large, showy, orange-red flowers. Can be pruned to a small tree shape. Variety crista-galli, "Coral Tree," is a small tree.

Gardenia jasminoides. "Belmont." Large, glossy leaves; 4- to 6-inch flowers; heavy substance; white, fragrant. *G. radicans* florapleno. Dwarf, narrow-leaved gardenia; small, fragrant white flowers.

Hibiscus rosa-sinensis. Shrub or tree to 10 feet. Fine, large red, yellow, or pink double or single flowers.

Hylocereus undatus. "Queen of the Night." A night-blooming cereus. A

4-foot plant can have 30 blossoms of the most beautiful form and fragrance. Blossoms up to 1 foot long. Each blossom opens only one night. Epiphyte, but will grow in soil.

Ixora javanica. Smooth, thick leaves; large clusters of waxy, salmon-red flowers.

Jacaranda acutifolia. Shrub or small tree. Lacy bright foliage, 1½ inches long, blue-violet flowers of silky texture borne in lang pannicles.

Jasminum officinale grandiflora. Small bush with showy, white fragrant flowers. Glossy green leaves.

Jatropha integerrima. An evergreen shrub that grows to 3 feet; glossy, green leaves and clusters of red flowers.

Lonicera hildebrandtiana (Burmese honeysuckle). May be pruned and espaliered. Fragrant yellow, 7-inch flowers change to orange.

Raphiolepis indica. "Pink Lady" or "Springtime." Large, pink clusters of flowers from fall to spring. Evergreen shrub with dense, glossy leaves.

Scutellaria mociniana. "Scarlet Skullcap." Twenty-inch, shrubby plant; quilted leaves and a head of scarlet-red flowers. Blooms January to July.

Solandra longiflora. Evergreen shrub to 6 feet; woody branches, small oval leaves on purple petioles. Large, upright, trumpetshaped greenish-white flowers. Frilled edges.

Strelitzia reginae. "Bird-of-Paradise." Stiff plant with large leaves; flower heads with striking conformation; orange, with blue tongue.

A WOODLAND ENVIRONMENT

It is possible to create a woodland setting at home or in a public place. Little or no true sunlight is required. An artificial light source will suffice. Because woodland inhabitants range from short-day, early-spring bloomers through hot-summer, long-day flowers and back to short-day fall bloomers, the gardener will want to give attention to creating his own season by length of light exposure. Temperatures should not rise above 75°F for the woodland garden and should be 55 to 60°F at night. A woodland setting should have a small stream of water flowing over lava rock. Mosses and ferns can be established in its porous surface. Mosses can be collected, shredded by hand, shaken in a quart of buttermilk, and poured over portions of the rock. Fern spores of maiden hair and polypody can be gathered and kept moist in its tiny holes. Woods soil, constant 50% humidity, and cool 55 to 75°F temperatures must be maintained.

A small tree or bush should be included in the plans. A bonsaied red bud, a miniature-leaved holly, or the indoor oak *Nicodemia diversifolia* will stand in for real woodland trees. Dwarf rhodendron species such as *R. glaucophyllum* or *R. charitopes* are small flowering bushes with handsome evergreen foliage. Ferns in variety as well as ground covers such as partridge berry and wintergreen or small foliage plants such as jack-in-the pulpit or Pyrola are a good basis for a garden. Marsh marigold will bloom along the stream. Flowering plants could include arbutus, hepatica, blood root, Dutchmans' britches, trillium, ladyslippers, habeneria, and showy orchis. The woodland plant space should be filled with rich woods' soil, mixed with good garden loam with a moderately acid pH. It is desirable to grind oak or maple leaves to add to this mixture. In the absence of leaves peat moss may be used. Several wildflower nurseries will send out mail order catalogues (see appendix). Plants should be obtained from them and not gathered in the wild except on construction sites.

A DESERT ENVIRONMENT

Hot sun low humidity, warm days, and suddenly cool nights are the climate for the plant that is a desert dweller. A south- or southwest-facing indoor garden plus 12 hours of artificial lighting a day during the growing season can approximate this environment. An indoor garden in a northern climate can provide a dramatic element by imitating desert conditions. To achieve this environment some compromise must be made between the living conditions natural to the plants and human comfort. Fortunately the plants seem more adaptable than people, who would find the 100°F+ heat of the desert noonday intolerable for daily living.

Low humidity is seldom difficult to achieve in heated northern buildings. True desert plants receive 3 to 12 inches of rain a year and are subjected to high drying winds. High and constant levels of bright light are a requirement.

Many small cacti with a great variety of form and blossom are on the market. Major elements of this garden should be at least one large rock (lava rock for light weight) and one or two major plants such as an *Agave attenuata,* one of the smaller century plants. The flower spikes of this Agave grow to 10 feet. The variety celsii, a dwarf century plant, has short, broad, fleshy, toothed, gray-green leaves. Many varieties of *Agave,* large and small, will fit into the desert garden. The desert supports forms of plant life other than cacti. Native desert shrubs which can be adapted to indoor culture are

Algerita (*Berberis haematocarpa*). Hollylike leaves, bark brown. Wood is bright yellow. Light yellow flowers followed by edible red berries.

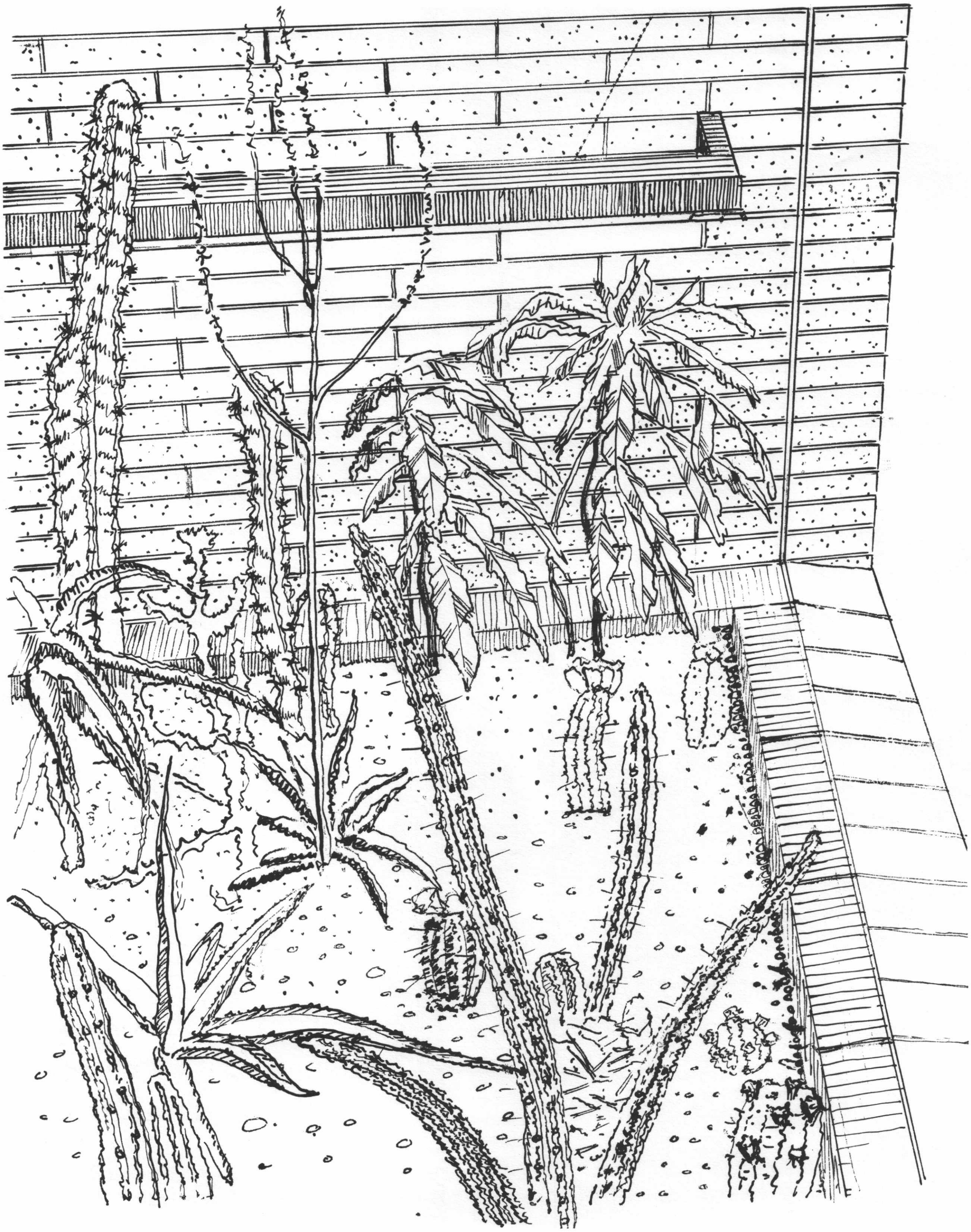
Coffee berry or deernut (*Simmondsia chinensis*). A low, gray-green bush.

Honey mesquite (*Prosoris juliflora*). A small, thorny tree with yellow flowers.

Four-winged salt bush (*Atriplex caneses*). Evergreen, woody plant; irregular shape.

Some of the Euphorias, stapelias, aloes, lithops, opuntia (prickly pear), and many other plants of contrasting form are useful in the indoor mini-desert.

A cactus garden with a south or southwest exposure will grow well. Cacti are colonists and a colony will set the boundaries of the territory that other cacti will not violate. Because of this habit they should not be planted close together in the garden but should be allowed room to form a colony. Cacti will not live with a constant supply of water, for they are adapted to areas that have a maximum of only 3 to 12 inches of rain a year. The spines of cacti control heat loss from the plant. Their green skin carries on photosynthesis. They have one-tenth of the surface area of the average plant through which to lose water and gain sun. In this cactus garden supplemental light is provided by a Prescolite fixture.



Photograph by Jack Roche

Soil for this garden should consist of a layer of sandy loam of neutral to slightly alkaline pH with a 2-inch top layer of sandy gravel in which the plants should be placed. Desert growth is sparse and plants should be arranged in small groups with ample space between them for aesthetic and functional reasons.

ORCHIDS

The wonderful variety in the family Orchidaceae includes orchids that can be hung in baskets or 12-inch pots, grown in pots set in the soil of the plant space, fastened to a wall in a basket with one flat side, or trained up in a trellis. There are orchids with blooming periods for each season of the year and for various temperature and humidity ranges. Only a few of each type can be covered here, but any orchid catalogue will cover many more.

Cymbidium orchids stand highest in estimation of the growers for many reasons. First, the blooms are many, forming an arching stem, and beautiful; second, the straplike, evergreen leaves make the plant attractive even when not in bloom. Cymbidium is a terrestrial species and may be set into the soil of an indoor garden. Flower colors range from ivory-white through yellow, green, salmon, pink, to deep maroon. Many hybrids display these colors in combination.

Coelogyne cristata is one of the most desirable of the epiphytic orchids for the indoor garden. The fleshy pseudo bulbs sprout twin leaves. Sprays of fragrant pure white flowers with a yellow lip keel are freely produced. Flowers measure 3 to 4 inches and are long lasting unless pollinated. This lovely orchid comes to us from Nepal in the Himalayas and enjoys a cool temperature with 50% or more humidity. A. B. Graf's Exotica includes a map of the climates of the world and a chart of the temperatures, rainfall, latitude, and elevations of the tropic and subtropic zones as well as the native habitats of some tropicals. Exotica can be used by the designer or gardener as an aid to choosing plants that will be successful in a given situation or as a guide to the design of the indoor garden to accommodate the desired tropicals.

The flowers will last 4 to 8 weeks unless pollinated. If pollination occurs, a light-colored cymbidium will blush a fine, rosy hue before shriveling. Few insects bother them. Culture is simple: feed and repot seldom, provide a moderate temperature and sunlight, and keep moderately watered all year round.

Another "easy" orchid is Phalaenopsis, an epiphyte that can be fastened to bark or a branch of driftwood with a handful of sphagnum for the roots to penetrate. Phalaenopsis likes room temperature and sun that is not too strong. Blooming through winter into spring, its flowers last for weeks.

Orchids can be grouped according to culture.

Dendrobium, Phalaenopsis, and Vandas like warm temperature, (62 to 80°F). Vandas need a high light level.

Cattleya, Paphiopedilum, Oncidium, and Cycnoches need intermediate temperatures (55 to 70°F) and a high level of light. Cattleyas require 2000 to 3000 footcandles of natural light or 650 footcandles for 16 hours of artificial light.

Cymbidium and Odontoglossom will grow in cool temperatures, (48 to 58°F) in a lower level of light.

Odontoglossoms do well with high humidity and air conditioning.

Short-day bloomers may refuse to set buds if nearby room lighting extends their day.

The high-light-level orchids will do well in a south- or west-facing window if there is good air circulation and high humidity to prevent sun scorch. The air stream should not be focused on the plants.

Cattleya, Epidendrum, Oncydium, and Odontoglossum are epiphytes with air roots by which they attach themselves to trees. They need to dry between waterings but must have at least 50% air humidity. Epiphytes can be fastened to a slab of cork bark to which a piece of Osmunda is attached for the roots to penetrate and to hold nutrients. They may also be attached in the plant space to a large woody plant, a rock, or a piece of driftwood. Hanging wire baskets or wall baskets filled with Osmunda will also accommodate these aerial plants.

Different potting mixes have been developed for the terrestrials Cymbidium, Cypripedium, and Odontoglossum and can be obtained from orchid breeders.

Applications of fertilizer are required infrequently, and fish emulsion or a special orchid formulation are recommended.

A RAIN FOREST GARDEN

The details of the "rainstorm" on page 148 suggest a striking display for a restaurant or lobby of a public building. A smaller version can be adapted for the home. In planning this space, the case must be made watertight and the access doors must be weatherstripped to prevent leakage. These plants require 16 hours of light at 650 footcandles, humidity of 70%, a day (when lights are on) temperature of 75 to 80°F, and an after-dark temperature of 68°. Circulating air is absolutely necessary but it should not blow directly on the plants. The rain can be timed automatically at 1- or 2-hour intervals during the period when it will be on view. The rain system should be shut off during hours when the building is closed and the case should be opened, or a dehumidifier used, to simulate the drying-out period required by many tropical epiphytes. Plants should be grown in Osmunda if they are epiphytes and in chopped bark if they are terrestrials to avoid fungus and disease buildup. One or two lava rocks should be supplied for rock-growing epiphytes.

A rough cork bark background for the case permits placement of epiphytes, and a perforated and screened metal tray for the terrestrial mix forms the forest floor. Plants could include

Aerangis (rhodosticta). Small, almost stemless; 5-inch leaves and arching stalks of 1¼-inch starlike flowers; white with orange-red column.

Aerides (crassifolium). Dwarf; thick leaves and racemes of waxlike fragrant flowers of amethyst-purple with upturned greenish spur.

Aerides (japonicum). Miniature orchid; narrow 4-inch leaves and 6-inch arching racemes of greenish white, purple marked flowers.

Anthurium (andraeanum). Coral-red flower and heart-shaped leaves. This variety is epiphytic in the forest.

Bromeliads in variety. Suited to the forest condition.

Cattleya (eldorado var. virginalis). Pure white with frilled lip and orange disk.

Footprints in the snow outside and Cymbidium doris blooming inside make a nice contrast in midwinter. Doris has large, long-lasting flowers, light yellow sepals, petals veined with red, and the lip spotted and veined with red brown. When accidentally pollinated, she will blush a rosy pink and soon shrivel preparatory to producing seed. Doris is easier than most orchids to propagate from seed. Cymbidiums do well with their pots filled with Osmunda or tree bark and sunk into the indoor garden soil to provide them with even moisture. Even when not in bloom their straplike leaves are an attractive addition to the textures of the garden. Note the finned radiation along the window to provide a curtain of warm air on subzero nights. Cybidiums like a cool, moderately humid climate and will benefit from the summer out of doors.

Photograph by Jack Roche

Photograph by Jack Roche

Ten below zero outside and a flower-filled indoor garden! Forced spring bulbs used here against a background of Swedish ivy, Philodendron pinnatifidum with Pep-peromia, and Philodendron dubia in the foreground il-lustrates one of the many ways of furnishing the in-door garden. At all times of the year the garden is filled with the varied green tex-tures of its permanent in-habitants such as philo-dendron and ivy. Seasonally, or on special occasions, pot-ted flowering plants are brought in to give the garden color — chrysanthemums in fall and bulbs in spring. This is a low-care, but satisfying garden for many who may not have time for or interest in growing more demanding tropicals but who enjoy the contrast of the plants inside with the snow outside.

Cattleya (percivaliana). Grows on rocks; 5-inch flowers; deep rose and magenta marked with gold.

Cibotium schiedei. Graceful, light green fronds.

Cymbidium "Flirtation." Miniature floriforous; flowers on arching stems; pale pink shaded to coppery purple, striped with orchid; white lip spotted maroon.

Cymbidium Peter Pan. Miniature flowers green to yellow-green; lip spotted with carmine.

Cypripedium (maudiae magnificum). May bloom twice a year; A small variety; green mottled foliage. Blossom has light green pouch with white striped green top petal. The Cypripediums should be shaded from direct light by a larger plant. (Many colors of Cypripedium are available for this use.)

Philodendron (andreanum). Leaves dark olive, suffused with copper, white veins. This plant could provide shade for the Cypripediums.

Philodendron "Angra dos Reis." Creeping form for forest floor; glossy green leaves and red stalks.

Philodendron cannifolium. Glossy stiff, long, oval leaves; has blossom somewhat like a canna.

Staghorn Fern (Platycerium). Decorative epiphytic fern.

Foliage plants, bromeliads, epiphyllums, palms, ferns, and many other fine plants are available for furnishing the indoor graden. Consult the references for books on these specialities and the Appendix for sources of plants or further information.

The Salvaged or Converted Indoor Garden

When energy was inexpensive and in good supply, Americans threw away quantities of useful objects merely because they weren't "modern" or "fashionable." It is time to consider recycling all possible manufactured objects on which we have already expended our irreplaceable energy. This concept can be made to apply to the indoor garden as well as other aspects of life.

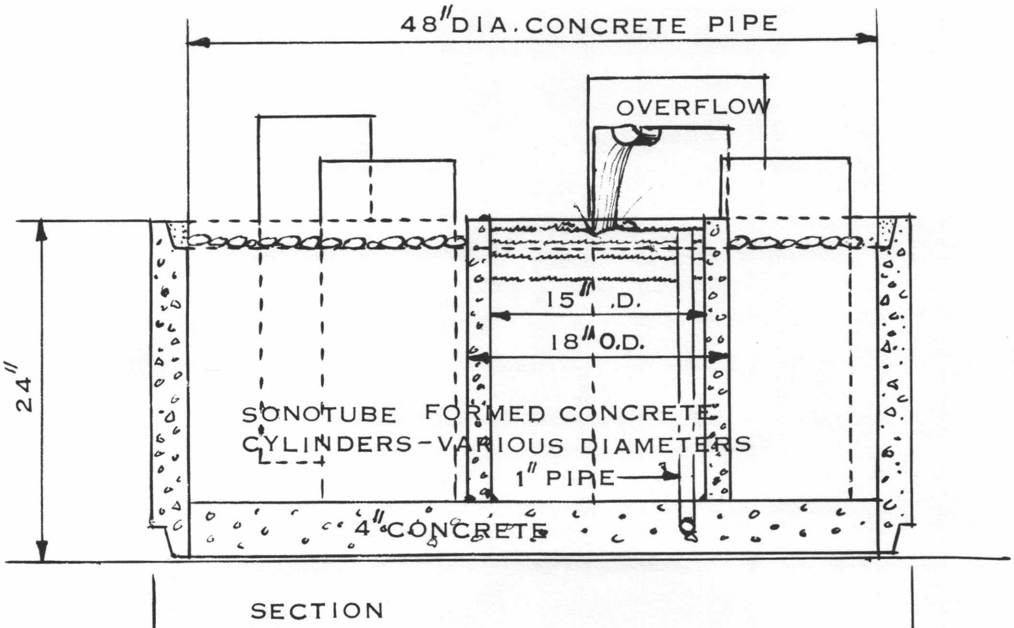
WHAT TO LOOK FOR

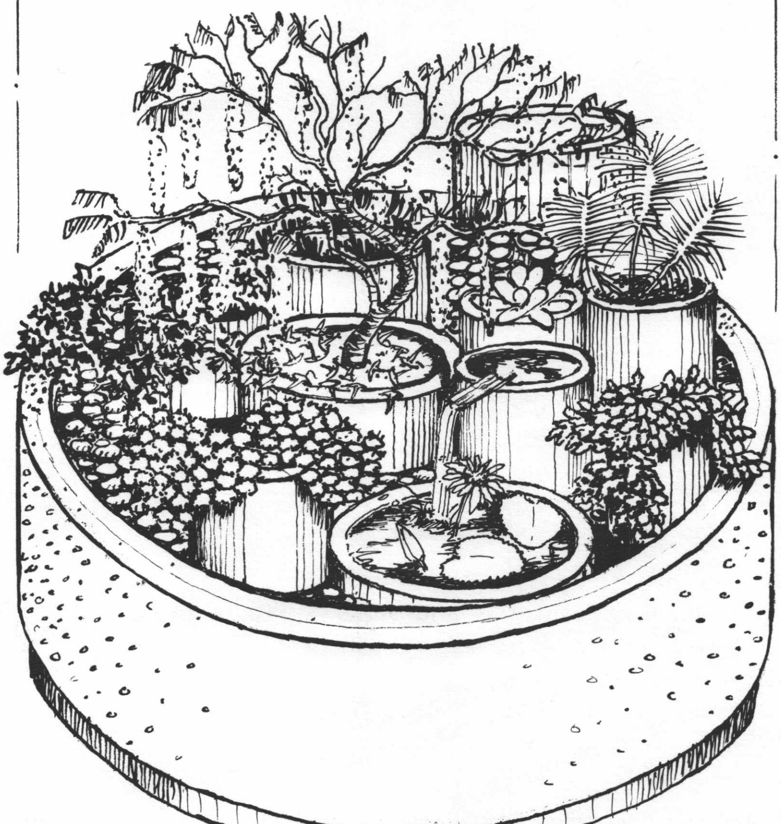
Still to be found in some salvage yards are the fine soapstone sinks of the early 1900s, some of which were shallow—8 to 10 inches deep—and long—up to 5 feet. Drains already installed can be attached to piping to drain the plant space. Some soapstone sinks were intended for laundry and were either single or twinned. These are usually 15 to 18 inches deep and can be converted to indoor pools. However, a threaded vertical pipe must be attached to the outlet as an overflow device in such a way that it can be unscrewed when the pool needs to be emptied. The dark natural look of the soapstone is a good background for plants and bright fish.

A soapstone sink of either type can be sunk into the ground to floor level or placed directly on the floor. Plumbing will drain through the floor, and water supply should be provided nearby. A facing of cypress, redwood, cedar, or teak paneling, capped as shown on page 141 for the tub garden, to blend with the room decoration will hide origin of the garden.

Discarded ceramic-coated cast-iron lavatories and sinks, if 10 or more inches deep, can also be used. A nontoxic pool paint will protect chipped places against further deterioration caused by soil and water. Paint will also help to disguise the original purpose. The major problem will be the top edge of the unit which, unless covered, will always display its sinkly qualities. If the sink is recessed to floor level, the edge can be topped with cut slate, brick, or concrete pavers which will project over the edge. Because the unit will already be formal in shape, this edging will provide

The use of a variety of sizes and heights of individual plant containers in a unifying larger shape provides specialized conditions for separate plant needs and gives a sculptural dynamic to the indoor garden.


48" DIA. CONCRETE PIPE
OVERFLOW
15" I.D.
18" O.D.
24"
SONOTUBE FORMED CONCRETE
CYLINDERS-VARIOUS DIAMETERS
1" PIPE
4" CONCRETE
SECTION



Photograph by Fred Rola

a suitable finish. For the garden raised above floor level the technique suggested for the soapstone sink is a good choice. A drain and water supply should be installed.

Laboratories often discard sinks made of an inert artificial material called compotite. If they are cracked they cannot be filled with water, but they can be mended with epoxy glue for use with soil. They should be washed thoroughly with vinegar and water, then with soda and water, to remove all chemical residue.

New or discarded maple sugar or other steel vats make a good preformed indoor garden. Before nontoxic paint intended for metal is applied both inside and out all serious pitting or holes should be epoxy-filled.

A child's outgrown hard plastic play pool can be adapted to use as a permanent plant space, although drainage will be more difficult if there is no outlet, in which case a hole may be drilled in the bottom to accommodate a plastic drain and piping. Edgings can be selected from among those suggested for a soapstone sink.

Large pieces of fine machinery often arrive at their destinations packed in strong, preformed styrofoam cases which have interior ridges and depressions to match the shape of the contents. This will render them useless. Sometimes, however, these preformed units come in interesting shapes. Styrofoam has little structural strength and must not be stressed or it will crack. It may be used as the liner around which concrete can be poured to form a pool or small garden or painted with waterproof paint suitable for use on styrofoam and recessed in the soil for a garden that does not extend down to natural grade. To construct a concrete garden with a styrofoam container as the inner form lay 6 mil sheet vinyl in a hole in the ground outdoors. The hole should be 4 inches larger in all dimensions than the styrofoam box. The outside of the box should be wrapped in vinyl plastic to allow the form to slip out easily when the concrete has hardened. Pour enough concrete into the plastic-lined hole to form the bottom. Allow to set overnight before inserting the styrofoam box weighted down with rocks. Pour concrete around it. The box may be held in position with 2 x 2's if necessary.

Another "discard" object convertible to garden use is a plasterer's trough (about 4 x 8 feet), which can be cleaned, painted, and patched with a cold plastic (sold in tubes) if the holes are small or by treating them with epoxy paint. Place cheesecloth dipped in paint over the holes, after the trough is cleaned, and paint over them. Allow to dry before doing the entire inside of the trough.

The round wooden tanks used in rural areas for home water storage (if free of insect damage) can be cut down in depth and recessed in or positioned on a concrete floor.

Sonotubes, which are strong, wrapped cardboard tubes designed for forms for concrete columns and piles and sold by building supply outlets, have good design potential for an indoor garden or pool. Cut-off ends are sometimes discarded on large construction jobs, but even if purchased new they pay for themselves in time saved in forming a round shape. Sizes in the regular Sonotube are 8 to 24 inches in diameter. The "A" coated Sonotube (smooth finish) ranges from 6 to 48 inches in diameter. By using the 48-inch tube as an outside form and various other diameters for positioning inside this form, (see page 163) concrete can be poured between the tubes to create plant pockets and pools of different sizes. A variety of heights may be obtained by using one tube inside another and raising them above the top level of the main cylinder.

WHERE TO FIND IT

For the architect or homeowner who is looking for an inexpensive, easily obtainable, and salvagable article to convert to a plant space several sources should be canvassed:

1 The managers of a city dump should be asked to watch for, and to let you know about, any of the rather large items that come their way. Because durable objects of this sort are a major problem in landfill dumps, you will probably benefit from their cooperation.
2 Large firms such as IBM often have their own disposal areas at which they sell obsolete materials at a low price. Call on the companies in your area.
3 Wrecking companies sell salvaged material and are willing to look for and save the kind of item you are looking for.
4 Plastics manufacturers may have slightly damaged or imperfect containers that are still serviceable.
5 A search through the catalogue of a commercial cleaning supply company will reveal heavy-duty plastic containers in many sizes and shapes that may be used in series or alone for pool or garden. Drains and a water supply using plastic pipes, fittings, and mastic may be installed in these containers.
6 Commercial kitchen equipment companies can supply garden or pool shapes in stainless steel. Their catalogues also show adaptable stock items.
7 Fiberglass and plastic pools can be converted to garden use.

All adaptable, salvagable, or convertible items for the indoor garden must have certain essentials; first they must be strong enough to hold soil or water; second, they must be made of a nontoxic material that will not deteriorate.

Equipment

The purpose of plant-space equipment is to measure and increase accuracy in regulating the heat, humidity, watering, and feeding of the plants. To a certain extent equipment saves work, although it is possible to systemize plant care so that little or no pleasure is left for the gardener and there is no interchange between people and plants. Equipment is expensive and requires some care itself. The following are accessories for indoor gardening. None of this equipment is absolutely necessary. Some of it is desirable for the large garden in a public space.

WATERING

Hose coupler. A snap-on attachment from hose to faucet. Saves time in threading hose.

Y connection. Has dual shut-off levers for multihose use or to fill a pail while watering with a hose.

Water breaker. Excellent controlled water-delivery head for especially thirsty plants or general watering. Won't wash away soil; attaches to hose.

Water timer. Meters water; shuts off automatically at preset amount.

Aerator. As on a kitchen faucet, it breaks the force of the water.

Trigger release lance. Long thin 30-inch tube with hand trigger release for reaching through foliage or for watering hanging plants. Nozzle adjusts to mist for humidity or to hard spray for washing foliage.

Solo sprayer and the Gardener. Both are English slide type sprayers. Pump works by telescopic action.

Six shooter. Six small hoses emerge from a brass connection for attachment to a regular hose. Waters the roots of six plants at a time without splashing.

Florist funnel. Spike is pushed into soil near roots of a special plant for extra feeding or watering.

Two-way water tap. Hose connection plus a lever-controlled faucet. Allows hose to remain in place and bucket to be filled simultaneously.

Moisture meter. Electronic meter; dial face on top of metal stake is pushed into the soil to indicate water content of soil.

Tempered water. For watering tropicals. Resistance cable used to thaw pipes or hot bed cable with preset tempering valve.

Bulb and tube. For administering liquids to a small area. Type used for automotive battery filler is suitable.

Soaker. Canvas tube oozes water slowly; fastens to tap or hose.

Sink hose. For hosing down leaves or washing bugs off at the sink. Short length of hose with quick release end.

Watermatic kit. Five-foot tubes attached to rubber water distributor for faucet or hose; will handle individual plants; two tubes for large plants.

Watermatic control panel. Inexpensive equipment to make watering automatic. Timer clock turns system on or off.

Hose shut-off — plant sprayer. Rainlike spray for plant watering. Adjusts to shut off water completely.

English water can. Has 28-inch spout, brass nozzle (or "rose"), and many small holes for gentle distribution of water.

Flashlight battery pump. For automatic plant watering, small fountains, and humidifiers; 7½ gallons per hour.

Water wand. For hanging plants; long wand works by bulb to siphon water from hand-held container.

Moisture meter. A scientific instrument similar in appearance to boxtype thermometer. Electrochemically operated. No batteries needed. Insert probe in to roots; degree of wetness registers on dial.

Bete Mist. Fine dense mist; inexpensive; fastens on hose.

Shut-off valve. Attaches to user's end of hose for quick control. Made of cycolac.

Irrigator wand. Thirty-six-inch wand with a head that produces droplets of water; attaches to hose.

Water miser. This nozzle will shut itself off when laid down. Bend it and water flows.

Little squirt. Tiny vinyl (14 oz.) hose 50 feet long and wand. Attaches to kitchen or bath faucet.

Submatic or Dripigation watering systems. For use on surface of the soil or permanently buried. Provides steady (it can be metered) supply of water or nutrients to plants. Economical in water use.

HUMIDITY CONTROL

Precision hygrometer. Measures relative humidity.

Automatic humidifier. Low-to-high vapor control. Float valve maintains constant water level from garden hose. Attaches to hose and plugs into 110-volt waterproof outlet during dry winter months.

Humidistat control. Can be connected to humidifier and set for 15 to 75% humidity.

Standard bedroom humidifier. A cool type of humidifier to improve humidity in small areas. Can be spray-painted green and hidden behind plants.

Wet- and dry-bulb instrument. Records temperature and humidity.

Dehumidifier. For cactus gardens; many small room units are available.

Central humidifier. For heating systems in public buildings and homes. System and controls can be added to any hot-air system. Improves human as well as plant health.

Automatic humidifier. Excellent, good looking small humidifier. Fastens to water pipe. Comes complete with solenoid valve, humidistat, shut-off fittings, and tubing to connect to water pipe.

Three-gallon cool vapor humidifier. Has dust filter system, humidistat, and wood grain finish.

Humidiplant. Holds 1 gallon of water and produces vapor for 9 to 10 hours. Shuts off automatically.

Fogger-waterer. Fits garden hose. Interchangeable heads provide misting or bubble-stream aeration for watering or pool use.

Mist-a-Matic system. Controls mist spray. Stainless steel screen collects water while mist nozzles are operating. When saturated, the screen actuates a switch and valve to turn water off.

LIGHT FIXTURES AND CONTROLS

Four-bulb unit. In weatherproof console box with 25-foot wire. U.L. approved.

Automatic lighting timer. Turns fluorescent lights on and off at preset times.

Combination light. Four- or two-tube size for fluorescent lights has equal number of sockets for incandescent bulbs; 40- and 25-watt tubes, 48-inches long. This arrangement provides a good growing light balance.

Luna-Gro swag. Handsome 12- or 18-inch fluorescent light fixture; hangs from adjustable black chain. Finish in walnut and black. Several will feature-light a large area.

Thin light fixture. Polished aluminum for two 20-watt or two 40-watt fluorescent tubes.

Four-tube light fixture. Hanging model in polished aluminum for four 40-watt tubes. Three-way switch allows a pair or all four to be lighted; 48 x 14½ inches.

Two-tube light fixture. Has growing tubes spaced 7 inches apart to increase lighted area. Aluminum construction; surface mount with cord and plug.

Luna-Gro bracket light. Walnut and black single-tube fixture 12 inches long. Swivels in bracket to change light focus.

Footcandle light meter. Measures the footcandles of light to which plants are exposed. Has three ranges; 10 to 50, 50 to 250, and 250 to 1000 fc, with x10 multiplying cover.

Low-voltage underwater light. Complete with transformer. Plugs into 115- to 120-volt outlet; transforms house current to 12 volt ac for pools and special lighting effects.

TEMPERATURE

Large Fahrenheit/centigrade thermometer.

Solar cell kit. For supplementary heat direct from sun. Small unit with complete controls.

Thermalarm. Gives warning when temperature goes above or below a preset high or low. Waterproof; works with 6- to 12-volt bell system.

Kool shade. External louvered solar screens. Controls admission of solar heat, yet retains up to 84% outward visibility. Not for roll use. Should be mounted in panels for ease of removal.

Aeroshade. Fine wood-slat horizontal or rolldown screening. Can be motorized for use indoors or out. Many finishes available.

Bamboo slats. Least expensive shading solution. Exterior or interior. Should be held down outdoors to avoid wind damage.

Maximum-minimum thermometer. Gives three readings at once: maximum, minimum, and present temperature. Resets with magnet. Useful for care of special plants or just for fun.

Calibration thermometer. Small well-crafted accurate thermometer.

MISCELLANEOUS

Swivel hook. For ease in rotating hanging plants for more even foliage or flower development.

Plant clip. A ring on a stake snaps over rim of a pot to keep plant from falling or a rangy plant from taking too much room.

Electric pool heater. For indoor-outdoor pool; 12-volt automatic unit turns heater on by snap-action thermostat at 38°. Available in 500-, 1000-, and 1500-watt capacities.

Little giant recirculating pump. For indoor pools. Recirculated water, if filtered once, will contain less chlorine; saves water, evens water temperature, and can be used for waterfalls and fountains.

Long-stick cotton swabs. For artificially pollinating citrus, vanilla beans, and so on, for fruit or to obtain seeds for propagation. Also to dip in rubbing alcohol for plant-pest eradication.

Gibberellin. A natural plant-growth regulator for experiments or serious work on adjusting plant size, bloom period, light response, and breaking dormancy. Not for edibles.

Soil test kit. For testing the acidity/alkalinity and nitrogen, phosphorus, potash content of soil.

Pool pump. For emptying a pool. Pump lifts water 20 feet, 50 feet horizontal. Brass connections fit garden hose. Pumps 350 gallons per hour.

Water pump. Using power drill, will handle 200 gallons per hour; 8 to 10 feet vertical, 25 feet horizontal. Uses drill chuck and garden hose.

Sharp pruning shears. Best to buy is the straight blade type with a hand grip as long as possible.

Grow rings. A 6-inch aluminum band to restrain roots of permanently planted climbers or trees; to restrain roots of greedy plants, or to avoid disturbing roots of one plant when moving another. Set top just below level of top of soil.

Planting mixes. Organic mixes with earthworm castings.

Plant rail. A 3-foot ceiling-mounted track for hanging plants.

Feather or lava rock. Lightweight natural stone for pool and garden effects. Porous aspect of this rock will allow small ferns and epiphytes to take hold.

Plant communicator. Measures soluble salts and moisture in soil. Determines amount of fertilizer present.

Coddington. Illuminates and magnifies for insect or flower examination; 6 inches long; uses two penlight batteries; clips to pocket.

Spoon knife. Razor-sharp stainless-steel spoon on hardwood handle.

Waterfall kits. Available in many sizes and types from dribble to multi-spray.

Fish net. Small net on handle for removing fish from pool.

Soil thermometer. Tests soil temperatures from 20 to 220°F.

CO_2 fogger. For water or insecticide; uses CO_2 cartridge. Empty sprayer with CO_2 cartridge can add CO_2 to air around plants to increase growth. Caution should be exercised in closed spaces.

Handy measure. Marked in ounces, teaspoons, tablespoons, and milliliters.

Soil tester tape. Accurate testing for pH. Tells how to adjust pH for 300 well-known plants. Handy dispenser.

Hanging baskets. Wire half-baskets for use on wall; also regular hanging baskets. Good for some orchids and most epiphytes. Natural fiber mats are available for these baskets.

Snail-bait holder. Use for beer bait for snails and slugs. Commercial bait is too dangerous for children and animals.

Flo filter. To replace the filter in hose sprayers; has washer with filter cone.

Solid plastic hanging pot. Comes in half shape for use on wall or hanging solo. Has drip trap.

Plant support. Diameter of 15 inches; support fits on 1-inch round dowel or stake. Restrains rangy plants. Plant hides support.

Climbing plant support. Disks attached to wall with epoxy glue have a strong bendable double wire for fastening large to small climbing plants.

Hand trowels. Narrow and wide trowels for digging.

Short-handled, small-blade shovel. For ease of work in a confined space.

Hand rake. For loosening top soil and weeding.

Scissors. Should have long handles for reaching to snip off dead leaves and branches.

Managing the Garden

After the indoor garden is built and furnished it will need good management. In a public building this may be arranged on a contract basis with an outside firm or done by in-house staff. Whatever the situation, it is important that plans be made in advance for the maintenance of the space. In the home the owner will, of course, be in charge.

This chapter does not attempt to give complete instructions for the care of plants indoors, but it does cover some of the most important points of indoor garden management. Books for further study are listed in the references.

PEST AND DISEASE CONTROL

The major requirements for pest- or disease-control materials are that they be safe for use in proximity to occupants of the area while being applied, that they leave no harmful residues in this artificial indoor gardening situation, and that applications be done in a manner that will not injure the furnishings in the room or the leaves and flowers of the plants. The plant parts, because of their especially protected environment, are less hardened and more vulnerable to surface stress than plants that have been bombarded by wind, rain, and sun.

Chemical pesticides have come under sharp scrutiny because many of them have proved dangerous to man and his ecosystem. In a restricted indoor area it is wise to limit pest control materials to natural ones, but even in using these caution should be exercised in their application.

Plants should be checked at least once a month for insects. At night, with a flashlight, it is possible to detect many insects that cannot be seen by day. If an identifiable plant enemy appears to be developing, spray or treat only the affected plant. If general spraying is done, it may destroy beneficial as well as detrimental insects.

A small hand-pump sprayer similar to those that dispense glass-cleaning compounds will prevent the spray from reaching other objects in the room.

Many insects can be dislodged with a forceful spray of water. This should be the first remedy to try. If it is practical, a bath under a shower will clean the leaves and remove most insects. Cover the soil with aluminum foil, wrapping it closely around the stem and down over the edge of the pot. Most plants however, should be treated in position in the indoor garden to avoid disturbing the roots. A plant that shows signs of poor health or disease should be removed immediately and taken to another area for treatment to avoid spreading the disease throughout the garden.

PROPAGATION

Several methods of propagation are useful in increasing plant stock.

Use a 10-inch clay bulb pot with a 3-inch small clay pot set in the center. Before placing the small pot, plug the hole in it with a tightly fitted cork. Fill around the small pot with a commercial potting mixture or compost sterilized in the oven for 2 hours at 200°. Place the seeds on the soil and cover with a thin layer of sand. Insert the planted pot in a plastic bag and before closing with a twist-tie fill the water-well with water. Fasten the bag and, following the directions on the seed packet, start the seeds in a warm, sunny window, in partial shade, or in darkness, as stipulated. When the seedlings show, move the pot out of the direct sun and open the bag for a half hour each day to avoid damping off until the seedlings develop a second pair of leaves. Gradually leave the bag open for longer periods to hàrden-off the seedlings and eventually remove it entirely.

The slate floor, mahogany stairs, preservative-treated sheathing on the walls, and the stone wall will take any quantity of water without damage. The plant space itself is soil-filled down to natural grade. The area under the open stairs is used for starting seedlings, for the second stage of bulb forcing, and for storing the hose for which a special hose bib is installed at the far end of the stone wall. The stone wall is an excellent place for climbers such as ivy, and a narrow trough provides soil for growing them. Hooks are sent into the masonry at the top of the stone wall for hanging pots of Cattleya and other Osmunda grown orchids, Staghorn Fern, and other epiphytes. This wall is watered top to bottom twice a week; the other plant areas once a week. The water evaporating from the radiant-heated slate tile floor provides healthy humidity in winter (about 60%).

Many hardstem and softstem house plants will root readily. Hardstem plants such as hibiscus and azaleas as well as the soft stemmed impatiens and begonias can be started like seeds. Make a cutting ½ inch below a leaf node on the stem. Gently remove all leaves except two or three at the top of the cutting, dip the stem in water, and apply a rooting hormone powder. Shake off the excess. Using a pointed stick the diameter of the cutting, punch a hole in the soil (which should have been dampened) and insert the cutting. Be sure that one and preferably two stem leaf nodes are covered by the soil.

When a plant becomes leggy or out of scale for the plant space, there is a way to start over again by air layering. Choose a thick, older stem, make a shallow cut in it, and remove a flap of bark or outer covering so that it cannot heal. With a small brush dust hormone powder into the cut. Dampen a large fistful of sphagnum moss and squeeze it until no water remains. Divide the moss in half and wrap it around the stem to cover the cut, and the stem, at least an inch above and below it. Cut a piece of thick plastic about 6 x 6 inches, wrap it around the moss, and fasten it with electricians tape to prevent water from running down the stem into the moss. Tape should extend around the stem of the plant to seal moisture in and water out. When roots can be seen through the plastic, remove the plastic, and cut the rooted piece from the parent plant. Pot

Photograph by Jack Roche

Photograph by Joseph W. Molitor

up or plant it directly in the indoor garden. Be sure that the soil is kept moist until a good root system is formed.

Leaf Rooting

Many plants such as the epiphitic cacti will root from a leaf. Bend the leaf to break it open slightly and while still attached to the plant fasten the break to the soil with a bent wire. In a month or two roots should be formed and the rooted leaf can be cut from the parent plant to form a new one.

FERTILIZING

The choice of fertilizers for indoor plants will be dictated in the main by their inherent needs, that is, acid, alkaline, or neutral soil. Beyond the pH consideration, however, is the need to avoid chemical residue buildup in the soil. This can be managed in part by not overfeeding, but it is better controlled by the use of organic fertilizers such as deodorized fish emulsions or other organic mixtures. If some chemical fertilizers must be used, they should be alternated with organic supplements. Foliar feeding for indoor plants is successful only if their leaves are sprayed between feedings to remove any residue that might have collected. Do not use cottonseed meal, fish meal, or peanut shells, in the indoor garden, for they support maggots.

Feeding should be limited to the growing seasons of the plants. Fertilizer applied while plants are in a resting stage will merely build up harmful residues. Earthworms should be encouraged in the indoor garden for their castings are high in plant-food value and their presence aerates the soil for better root utilization of food and water.

The health of the plants and the availability of nutrients prevent insect damage. The odor and flavor of the leaves and fruit of a poorly nourished plant attract destructive insects. This is part of nature's scheme of the survival of the fittest which can be demonstrated in plants as well as in man.

WATERING AND HUMIDITY

Water and humidity requirements will, of course, vary according to the flora in the indoor garden; that is, true cactus — sporadic watering and low humidity; fern garden — constant moisture and moderate humidity; tropicals — constant moisture and relatively higher humidity; orchids have various requirements according to variety.

Equipment for the constant measurement of soil moisture as well as air humidity is recommended as an aid to better plant health (see page 168).

Sansevieria is in striking contrast to the horizontals of the stone. It is planted in a small pocket in the top of the low wall that separates the music corner from the fireplace area.

Because city water supplies generally contain large amounts of chlorine and sometimes fluoride, it is recommended that some watering be done with rain water. The designer of the garden should consider the feasibility of an outdoor cistern that would feed into the indoor garden by gravity. Condensate collected by an air conditioning system can also be directed to the indoor garden. This can be done by gravity or with a small pump.

POTTING UP

Prepare a weak manure tea by soaking a small bag of dehydrated manure in 3 gallons of water for a week or two before potting time.

Remove the plant from the old pot by turning it upside down while supporting the plant with spread fingers at soil level and striking the edge of the pot on a table edge to dislodge the plant. Old soil should be removed by using a gentle kneading motion with the knuckles. Mix a thick slurry of water and soil and set it aside. Dip the plant roots in lukewarm water and slosh them around. If marigolds are available, add a cup or two of the leaves that have been whirled in the blender to the water as a precaution against nematodes. Drain the roots and dip them into the manure "tea" for 45 minutes to prevent shock. Small pieces of broken clay are placed in the bottom of the pot to retain moisture. The plant is then placed in the pot and the previously mixed slurry of good garden soil or potting mixture is poured around the roots. Do not pot the plant any deeper than it had been growing before it was transplanted. The slurry is used so that it will spread between the roots and not leave air pockets. The top inch or two should be drier soil.

Not all plants should be repotted every year. Many exotics such as clivia, night blooming cereus, hoya, and philodendron grow and bloom better when slightly pot bound. The pot is then sunk into the soil, stones, or sand of the plant space so that the top of the pot is not visible.

SUMMER CARE

The garden in a public building will of necessity be furnished with plants year round. If soil is used, it will need organic mulching on an annual basis. If stones are the growing medium they should be removed and washed clean once a year to avoid algae buildup and consequent odor and disease.

In summer the home gardener may wish to abandon his indoor garden for the pleasures of the outdoors, but before doing so it would be wise to remember that winter is coming again and that with a minor amount of work next winter's plant enjoyment can be made secure.

Most plants will benefit from a summer out of doors. Many form buds for winter bloom during this period, but they are vulnerable to too much sun and should be located in a not too heavily shaded spot against a northeast or east wall or on a deck or patio where the shade is dappled. Many house plants will dry out and their leaves will burn if they are exposed to full sun.

Place a movable, topless cold frame in partial shade and cover the soil with diatomaceous earth to destroy slugs. Arrange the plants close together and fill around the pots with leaves to retain moisture. In a period of drought these plants must be watered. In any location packed leaves will conserve water.

Before placing the plants for the summer all necessary repotting should be done. Repotting is always a shock and they can recover best from it in summer. If the home gardener has planted any of the legumes — beans, peas, limas — in his vegetable garden, the soil around them will be extra high in nitrogen, and when sterilized to free it of plant pests will make an excellent potting medium.

The fog and chill out of doors seem less gloomy because of the plants indoors in this south-facing garden. Bulbs have been forced and are set into the indoor garden where they will hold their bloom for a long period because of the even moisture in the soil around them. The tracery of the large sun-loving fern brought in from the wild is in good contrast to the solidity of the tulips and daffodils. Kitchen herbs and small foliage plants form a green floor for this indoor garden. At the top of the window is an exterior bamboo slat blind used for summer shading; it stores out of the way at other seasons.

Photograph by Jack Roche

Photograph by Joseph W. Molitor

The Ficus lyrata, often called fiddle leaf fig, has large, stiff, glossy leaves. In its native habitat it grows to a height of 40 feet. It bears yellow-green figs dotted with white. Geraniums and a sun-loving ivy are low enough to leave the view from the window to be enjoyed. It is important to take this condition into account in planning indoor plantings. Indoor gardens that interrupt the view with a line of tall plants will not add to the aesthetics of a room. This plant space is copper-lined inside a wood frame heavily waxed to match the oak parquet floor in which there is radiant heat. The plant space is held back from the window far enough to allow the curtains to be drawn.

Prune plants to desired shapes and pinch the buds of those that you want to hold their blooming period until winter. Fertilize at least once in early summer with weak manure "tea" made by soaking a burlap bag of dried manure in water. In addition, a sprinkling of ground rock phosphate and granite dust will give plants a strong start for the winter.

Bring plants indoors before fall, with its cool nights and lower daytime temperatures, can give them the signal that it is time to rest. Bringing them in early will also give them a chance to adapt to the change in indoor conditions before winter heating dries the air.

Most important of all is to make sure that plants about to move indoors are insect and disease free. If a plant is not thrifty, it should be isolated until it is determined whether there is a cure for its problem. Toward the end of summer a soap and water spray should be used and then used again just before the plants are brought indoors. Hand pick or destroy any bugs that have not been removed by the water.

When some of the plants have moved outside for the summer, the home indoor garden looks forsaken, and because it is part of the decorative scheme it will be necessary to improve its appearance. This may be accomplished in one of the following ways:

For all suggested treatments allow the soil to dry out, smooth its surface, and lay a sheet of 6 mil clear plastic over it except where permanent plant roots may be located.

Sand

Many color tones are found in sand, beige, tan, and reddish brown being the most prevalent. If beach sand is used, it should be washed thoroughly to eliminate the salt. Mason's sand is clean and free of extraneous matter. Sand has one special advantage. It can be mixed with the soil in the plant space at the end of summer. To improve the appearance of the sand garden designs may be made with a small rake, and a piece of sculpture or an interesting rock can be featured against the sandy background. A collection of sea shells or a piece of driftwood makes a good summer display.

Pebbles

Again, as with sand, a variety of tones is available in pebbles. Their size also varies for pea to egg. Potted summer blooming plants may be set in the gravel for special occasions.

Broken Shells

Some beaches on the east coast are composed of broken shells that vary in size from ½ to 1 inch. When washed free of their salt, they make a handsome background for a collection of large shells.

Tree Bark

The rich brown and red-brown tones of commercially available tree bark make this material desirable in many decorative schemes. At the end of the summer remove the bark. Do not attempt to incorporate it into the soil of the plant space because it will disturb the soil balance. Do not used collected bark; it may harbor unwanted insects.

Material such as pine needles is another choice but it must be insect free. Do not use cottonseed meal, buckwheat, or rice hulls or other organic materials of this type for they will develop insect pests during the summer months.

The pleasure of working with plants in the indoor garden is not diminished by the relatively small amount of care they need, and whenever possible the contribution made to the quality of life recommends the installation of a permanent indoor garden. Maintenance of the public or private indoor garden will be minimized by the architect's attention to proper design of the space in relation to light, temperature, and humidity as well as to the careful choice of plants, soil, watering systems, fertilizers, and pest controls. The long-term ease of maintenance of the space can be ensured only by good design.

Appendix

Some Sources of Dwarf Fruit Trees

Four Winds Growers (citrus only)
42186 Palm Avenue
Fremont, California 94538

Wholesale and retail

Armstrong Nurseries
PO Box 473
Ontario, California 91761

Wholesale and retail

Stark Bros. Nurseries
Louisiana, Missouri 63353

Wholesale and retail

Some Sources of Water Lilies and Water Plants

Slocum Water Gardens
1101 Cypress Gardens Road
Winter Haven, Florida 33880

Three Springs Nurseries
Lilypons, Maryland 21717

William Tricker Inc.
74 Allendale Avenue
Saddle River, New Jersey 07458

or

7125 Tanglewood Drive
Independence, Ohio 44131

Some Sources of Cactus, Epiphyllum, and Succulents

Henrietta's Nursery
1345 N. Brawley
Fresno, California 93711

Retail

Johnson's Cactus Sales Co.
24635 Over Lake Drive
El Toro, California 92630

Retail

Beahm Epiphyllum Gardens
2686 Paloma Street
Pasadena, California 91107

Retail only

Some Sources of Wildflowers

Clyde Robin
P.O. Box 2855
Castro Valley, California 94546

Midwest Wildflowers
P.O. Box 64H
Rockton, Illinois 61072

Putney Nursery
Putney, Vermont

Griffey's Nursery
Route 3, Box 17A
Marshall, North Carolina 28753

Conley's Garden Center
Boothbay Harbor, Maine 04538

Some Sources of Foliage Plants

Johns Inc.
P.O. Drawer AC
Apopka, Florida 32703

Wholesale only

Alberts and Merkel Bros.
2210 S. Federal Highway
Boynton Beach, Florida 33435

Wholesale and retail

Some Sources of Tropicals and Orchids

Alberts and Merkel Bros.
2210 S. Federal Highway
Boynton Beach, Florida 33435

Wholesale and retail

Julius Roehrs
Rutherford, New Jersey

Wholesale only

Loyce's Flowers
Route 2, Box 11
Granbury, Texas 76048

Mail order only; tropical vines and plants; no orchids

Kensington Orchids, Inc.
3301 Plyers Mill Road
Kensington, Maryland 20795

Rivermont Orchids
Signal Moutain, Tennessee

The Orchid House
9433 East Broadway
Temple City, California

Rod McLellan Co.
4510 El Camino Real
San Francisco, California

Some Light Fixture and Lamp Sources

Durotest
North Bergen, New Jersey 07047

General Electric Lamp Marketing Department
Nela Park
Cleveland, Ohio 44112

Kim Lighting Inc.
P.O. Box 1275
16555 E. Gale Avenue
City of Industry, California 91749

Lam Lighting
Wakefield, Massachusetts

Lightolier
346 Claremont Ave.
Jersey City, New Jersey 07305

Nessen Lamps
3200 Jerome Avenue
Bronx, New York 01468

Prescolite
1251 Doolittle Drive
San Leandro, California 94577

Some Sources of Equipment

Public Service Lamp Co.
410 W. 16th Street
New York, New York 10011

Sylvania Lighting Center
Danvers, Maine 01923

Westinghouse Electric Corp.
Lamp Commercial Division
Bloomfield, New Jersey 07003

Plants Alive Reader Service
PO Box 24683
Seattle, Washington 98124

W. Atlee Burpee Co.
7287 Burpee Building
Warminster, Pennsylvania 18974

Mellingers Inc.
2330 Range Road
North Lima, Ohio 44452

Burgess Seed and Plant Co.
PO Box 339
Galesburg, Michigan 49053

Dorothy Biddle Service
Hawthorne, New York 10532

Walt Nicke
Hudson, New York 12534

Geo. W. Park Seed Co.
281 Cokesbury Road
Greenwood, South Carolina 29647

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