GARDEN ENCLOSURES

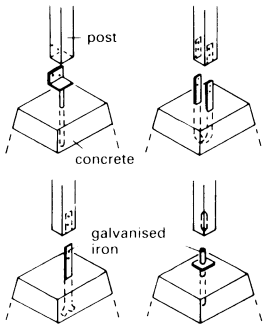
In most countries, neighbours have legal rights in relation to fencing. Within an area built as an integrated development, the owner of a building used for domestic or business purposes is obliged at the request of the owner of the neighbouring plot to enclose his plot along the common boundary. Local (or national) regulations may, if both plots are built on or used commercially, require both owners to erect a boundary fence/wall jointly and share the cost. Under English law, ownership of, and responsibility for, fences etc. is spelt out in the property owner's deeds.

A 'common fence' is located in the centre of the boundary whereas with an 'own fence' the foundation wall should be flush with the boundary.

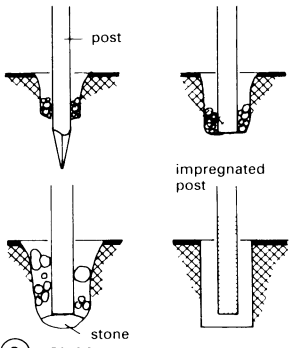
The style of fence chosen should always suit the locality as far as possible → ⑤ - ⑳. Fencing that is intended to protect against wild animals should be sunk 10–20cm into the ground, particularly between hedges → ㉑.

Wooden fencing, posts, frames and palisades can last more than 30 years if they are first chemically impregnated in a tank.

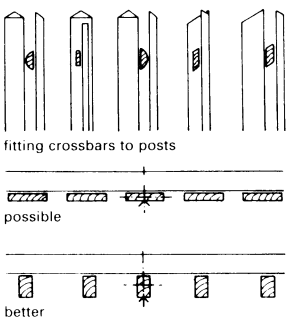
Wooden louvre fences are best for privacy → ⑦ + ⑧ and can also provide some measure of sound insulation. Scissor or rustic fencing is also popular for plot enclosure → ⑨.



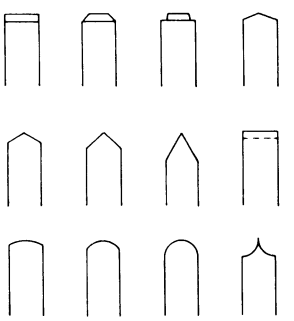
① **Fixings for posts, fencing, pergolas**



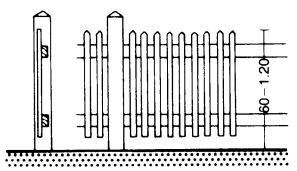
② **Sinking posts**



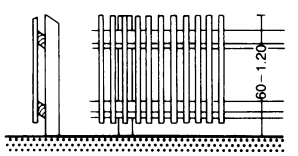
③ **Battens on crossbar**



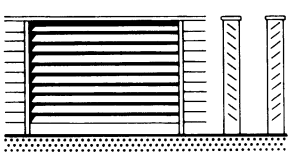
④ **Batten head shapes**



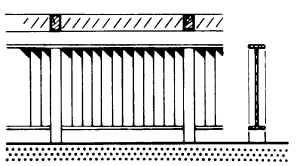
⑤ **Fence with projecting posts**



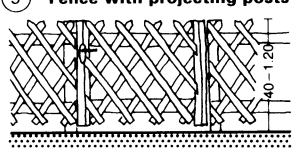
⑥ **...with continuous crossbars**



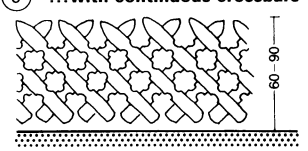
⑦ **Horizontal louvres**



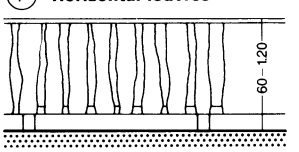
⑧ **Vertical wooden louvres**



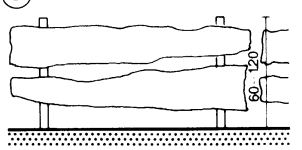
⑨ **Rustic fence**



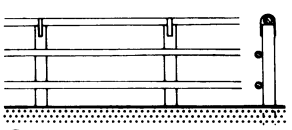
⑩ **Ornamental fence**



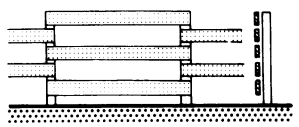
⑪ **Rustic fence with frame**



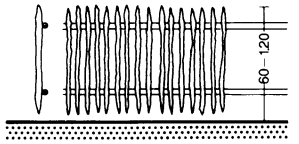
⑫ **...with rough-cut boarding**



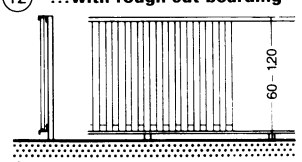
⑬ **Meadow fence with round wood cap**



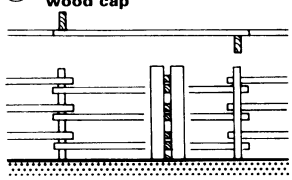
⑭ **Alternating glued planks**



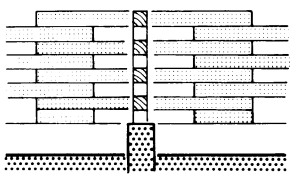
⑮ **Simple wooden fence**



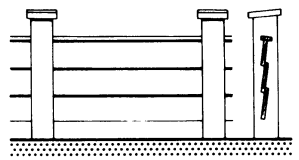
⑯ **Wooden fence with aluminium plate fixings**



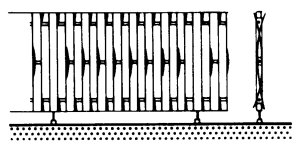
⑰ **Meadow fence with offset posts and spars**



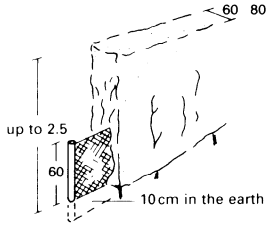
⑱ **Square cross-section wood beam fence**



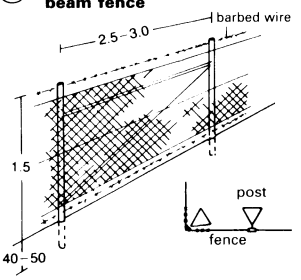
⑲ **Rough-sawn boards nailed to posts**



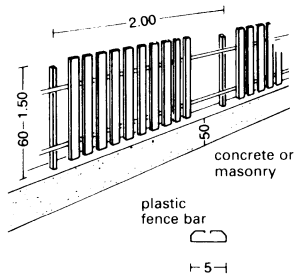
⑳ **Bent wooden slats on tubular steel frame**



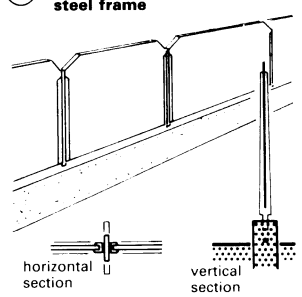
㉑ **Hedge with wire netting**



㉒ **Wire netting: the bottom either has a small gap (with barbed wire) or is buried**



㉓ **Steel profile fence (galvanised) with plastic fencing bars**



㉔ **Partition fence of ornamental wired glass on concrete base**

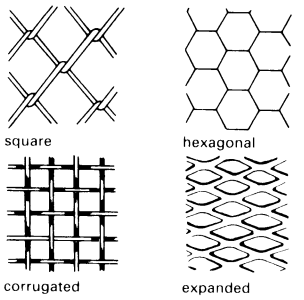
GARDEN ENCLOSURES

The owner of a plot usually erects fencing only on one long side since the neighbour on the other side puts up the fence on that long boundary.

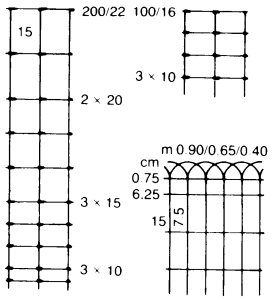
Wire mesh fencing → ① can be obtained in many mesh sizes to cover a wide range of usage conditions and if the mesh is plastic coated and supported by galvanised posts the fence will require close to no maintenance. Mesh fences can be braced with wooden, concrete or steel posts which are anchored in the ground → ⑦ + ⑩. Ornamental wire or lattice fencing is usually spot-welded and galvanised → ③ + ④.

Wrought-iron fencing can be elaborate or simple in design and almost any shape is possible → ⑥.

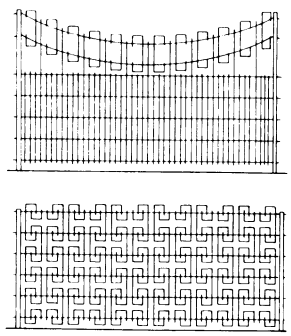
Natural stone such as granite or quartz quarry stone can be used without any processing → ⑨ or cut to shape by a stonemason → ⑧. If possible, only one sort of stone should be used.



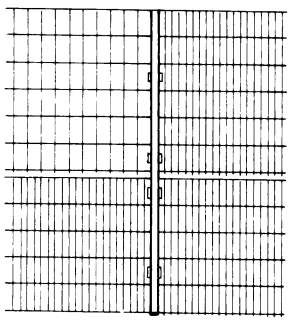
① **Wire mesh: standard mesh width 4–5.5 cm**



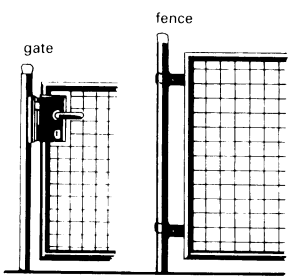
② **Twisted link and decorative lattice**



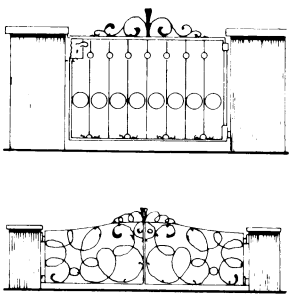
③ **Ornamental wire lattice**



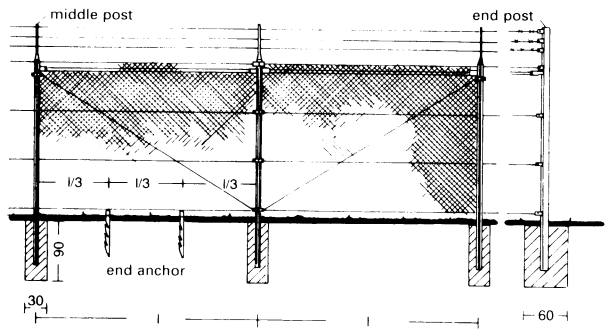
④ **Welded mesh fencing**



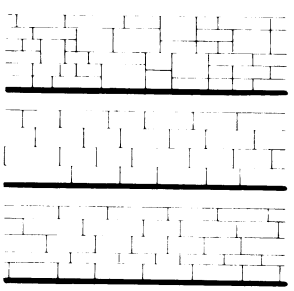
⑤ **Woven wire mesh gate and fence panel**



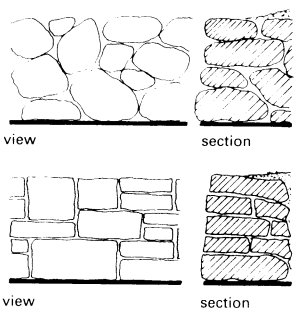
⑥ **Garden gates made from wrought iron**



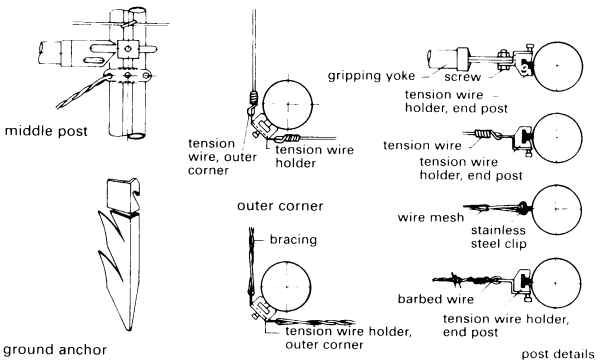
⑦ **Tensioning of intersecting wire netting**



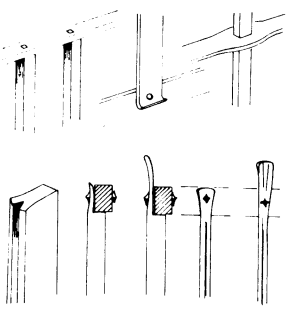
⑧ **Layered walling with stone layers of different heights**



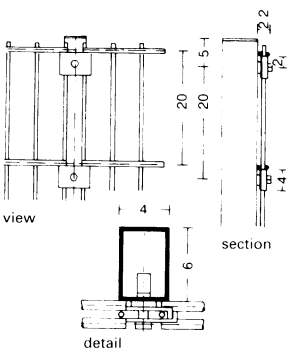
⑨ **Quarry and cast stone walls**



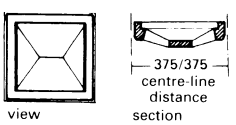
⑩ **Tensioning details for a twisted link wire netting fence → ⑦**



⑪ **Connection methods for iron fence/gate elements → ⑥**



⑫ **Steel railings**



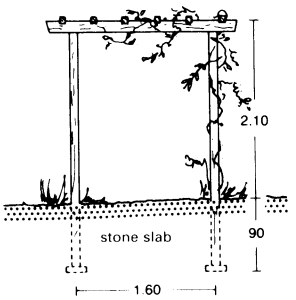
⑬ **Common shapes for commercially available cast concrete blocks**

the table shows the dimensions according to the dimensional regulations for building construction: all centre-line distances are a multiple of 125 mm with 10 mm joints

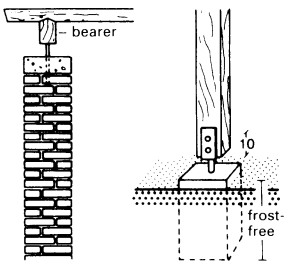
	250	500	625	750	875	1000	1125	1250	1500
1500						8/12			
1250		5/9	6/10						
1125		5/9							
1000		4/8	5/8	6/8		8/8			12/8
875		4/7							
750		4/6	5/6	6/6		8/6		10/6	
625		4/5	5/5	6/5		8/5	9/5	10/5	
500		4/4	5/4	6/4	7/4	8/4			
375		4/3							
250									
187.5									

187.5 375

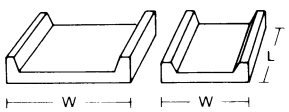
PERGOLAS, PATHS, STEPS, RETAINING WALLS



① **Climber supporting frame**



② **Pergola on brick pier** ③ **Raised timber frame (avoids rot)**

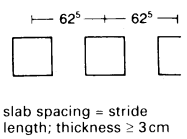


length (cm)	width (cm)	edge height (cm)
50	50	12
50	70	14

④ **Garden path blocks**

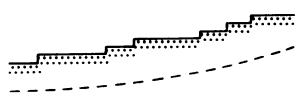
easier to keep clean

no impediment to lawn mowers

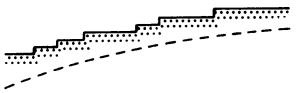


slab spacing = stride length; thickness ≥ 3 cm

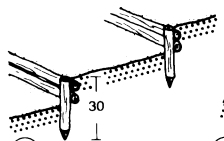
⑤ **Path raised above borders** ⑥ **Flush with lawn surface** ⑦ **Stepping stones**



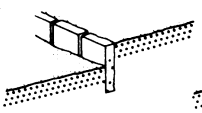
⑧ **Good: concave slope (easiest to walk down)**



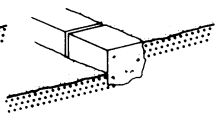
⑨ **Bad: convex slope**



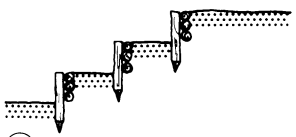
⑬ **Wooden posts**



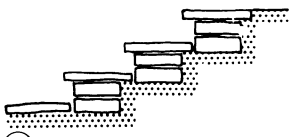
⑭ **Vertical stone slabs**



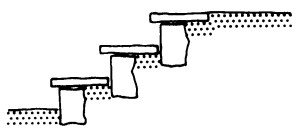
⑮ **Stones smoothed on two edges**



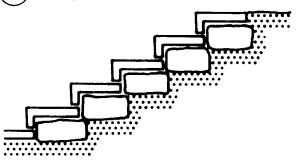
⑲ **Steps made with wooden posts**



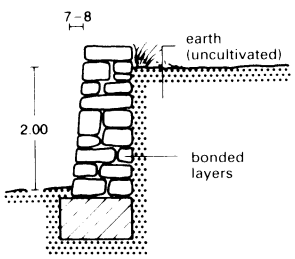
⑳ **Steps made with stone slabs**



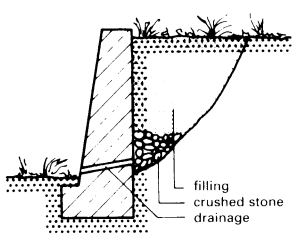
㉒ **Steps made with stone slabs on supporting blocks**



㉓ **Concrete steps on supporting blocks**



㉖ **Dry wall, special drainage unnecessary**



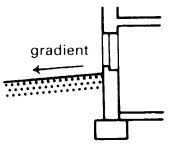
㉗ **Concrete retaining wall (also available in ready-made sections)** → ㉘

Prefabricated paving slabs are ideal for creating solid and easily maintained garden paths between beds → ④. Paving stones can be laid in the borders or the lawn, either raised or flush with the surface → ⑤ – ⑦. Allow for a gradient when laying paths → ⑩ – ⑫. (See also page 217.)

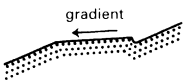
Examples ⑬ – ㉔ show various arrangements for garden steps. They should be safe and easy to use (note that a concave gradient is more comfortable to walk on → ⑧ + ⑨) but should also fit harmoniously into the surroundings. The steps should slope gently forwards to permit rainwater to run off. In gardens that are designed to be as close as possible to a natural state, log steps are a worthy solution → ⑬ + ⑲. Whatever type of garden steps are chosen, the same rules as apply to indoor stairs should be taken into account → pp. 191–4.

It is possible to incorporate ramps in the garden steps to facilitate movement of bicycles, prams and roller waste bins → ㉕. Wheelchairs being pushed by carers can also make use of such ramps.

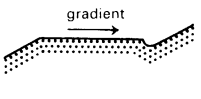
Layered dry stone construction can be used for retaining walls up to 2 m high in front of uncultivated earth, with an inclination to the slope of 5–20% → ㉖. However, concrete retaining walls → ㉗ are simpler and cheaper, and can be bought as ready-made sections → ㉘ in various sizes and shapes such as corner profiles, quarter segment profiles and round sections, making it possible to form bends with standard parts.



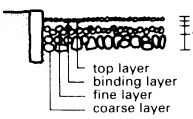
⑩ **Paths beside house**



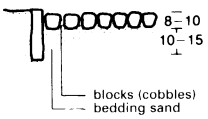
⑪ **Footpath on slope**



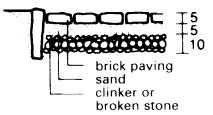
⑫ **Road on slope**



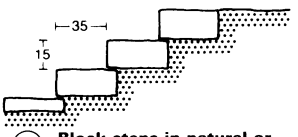
⑯ **Gravel path**



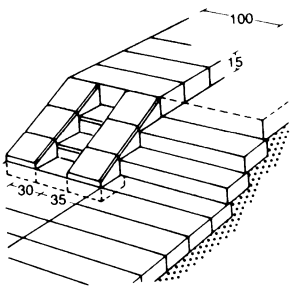
⑰ **Small paving blocks, expensive but durable**



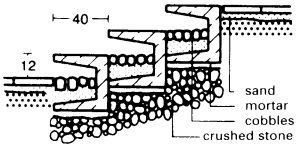
⑱ **Brick paving**



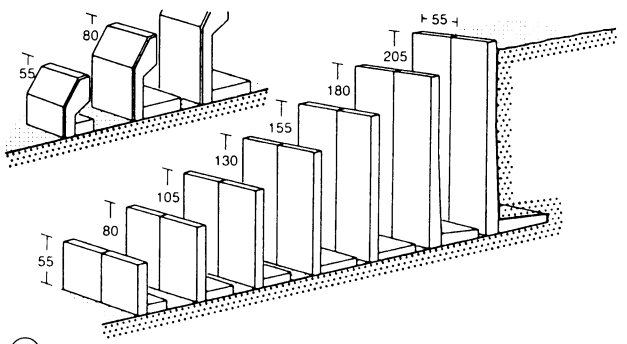
㉑ **Block steps in natural or cast stone**



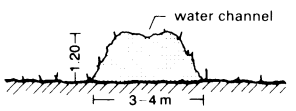
㉕ **Concrete block steps with ramp**



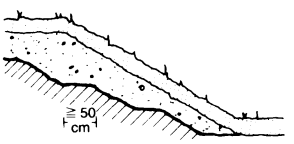
㉔ **Karlsruhe garden stones arranged as concrete steps**



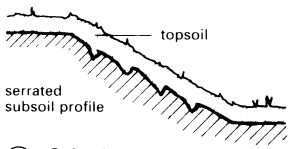
㉘ **Ready-made concrete sections for retaining walls**



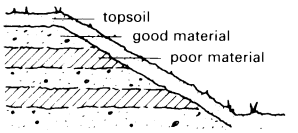
① **Topsoil mound**



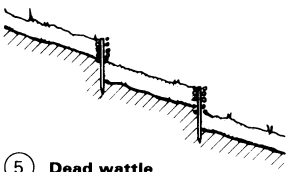
② **Topsoil fill on sloping surface**



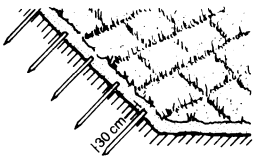
③ **Cohesive material in core with shallow stepping**



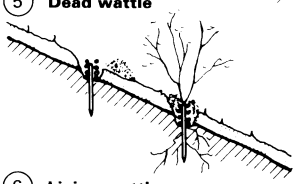
④ **Layered fill**



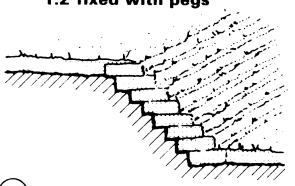
⑤ **Dead wattle**



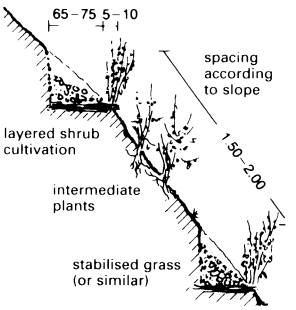
⑦ **Turf on slopes of more than 1:2 fixed with pegs**



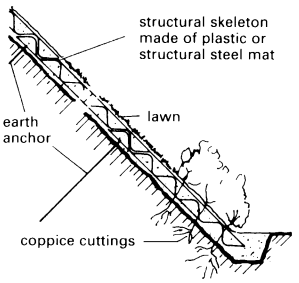
⑥ **Living wattle**



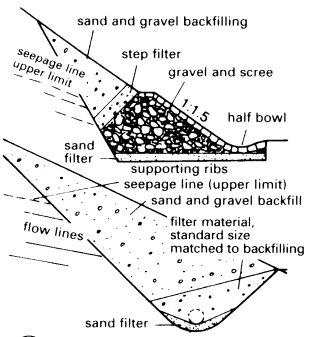
⑧ **Binding with stepped turf**



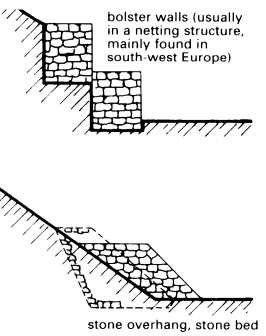
⑨ **Preserving bank surface with shrubs and stabilised grass**



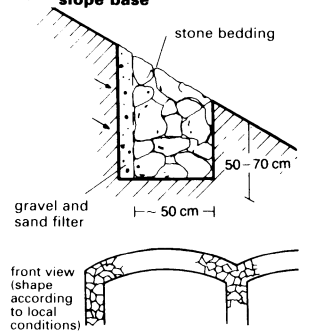
⑩ **Preserving bank surface with structural skeleton**



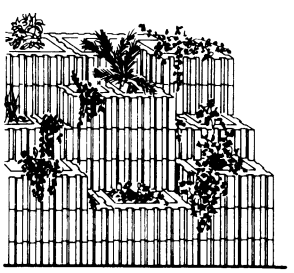
⑪ **Drainage and support of slope base**



⑫ **Slope support using stone**



⑬ **Stone ribs for drainage and support**



⑭ **Open topped, stepped composite grid arrangement**

Topsoil can be stored on site by temporarily removing it and building soil mounds → ①. If it is not in the shade, the top of the mound should be protected (with turf, straw etc.) to prevent excessive drying out. Topsoil mounds should be turned over at least once per year, and 0.5kg of quicklime added per cubic metre. If the topsoil needs to be stored for very lengthy periods, consider sowing plants on the mound.

When making up the ground again after the earthworks are completed, compaction measures are necessary if landscaping, lawn laying or planting work is to be carried out immediately, and especially if the work involves laying paths and paved areas. The following techniques can be considered.

- Rolling using a tracked vehicle (e.g. bulldozer) usually provides sufficient compaction for each layer of fill.
- Soaking can be used, but only if the filling material is good (sand and gravel).
- Rolling with a drum roller to compact stable soil in layers (fill height 30–40cm per layer) is another option. Note that it is important always to roll from outside towards the centre (i.e. from the slope towards the centre of the built-up surface). Use rolling for broken stone hardcore when building roads and paths.
- Tamping or ramming is possible on all stable soils.
- Vibration can be used in the case of loose, non-binding materials.

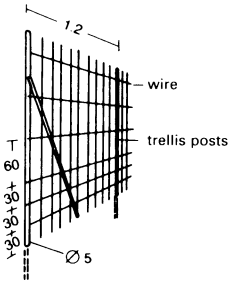
All compaction should take account of subsequent work. For paths and paved areas compaction is needed up to and including the top layer while lawns require 10cm of loose topsoil, and planted areas 40cm.

Slope protection

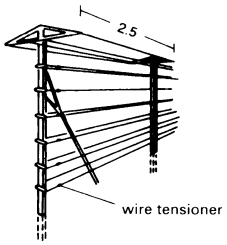
To avoid slippage and erosion by wind, water run-off etc. the filling on slopes should be laid in layers. Serrated subsoil profiles → ② prevent the loose infill mass from forming a slip plane on the base material. In the case of higher banks with steeper slopes → ③, stepping provides an effective means of preventing slippage (step width ≥50cm). If steps are inclined into the slope a longitudinal gradient must be created to allow any build up of water to run away.

soil type		density (kg/m³)	angle of repose (degrees)
earth	loose, dry	1400	35–40
	loose, naturally moist	1600	45
	loose, saturated with water	1800	27–30
	compacted, dry	1700	42
	compacted, naturally moist	1900	37
loam	loose, dry (average for light soil)	1500	40–45
	loose, naturally moist	1550	45
	loose, saturated with water (average for medium soil)	2000	20–25
	compacted, dry	1800	40
	compacted, naturally moist	1850	70
gravel	medium coarseness, dry	1800	30–45
	medium coarseness, moist	2000	25–30
	dry	1800	35–40
sand	fine, dry	1600	30–35
	fine, naturally moist	1800	40
	fine, saturated with water	2000	25
	coarse, dry	1900–2000	35
crushed stone, wet		2000–2200	30–40
clay	loose, dry	1600	40–50
	loose, very wet	2000	20–25
	solid, naturally moist (heavy soil)	2500	70
dry sand and rubble		1400	35

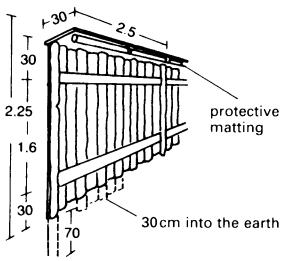
⑮ **Densities and angles of repose for different soil types**



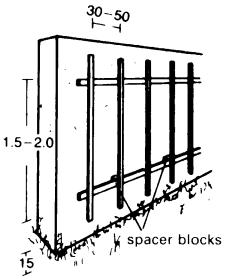
(1) **Trellis frame made of boiler pipes**



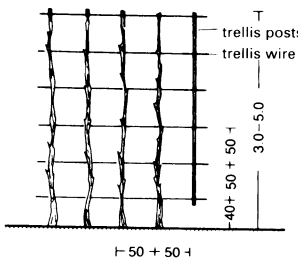
(2) **Frame for double trellis**



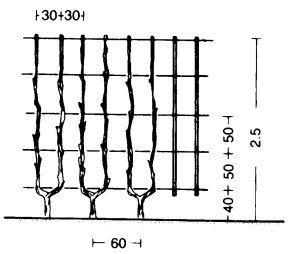
(3) **Trellis wall made of wood**



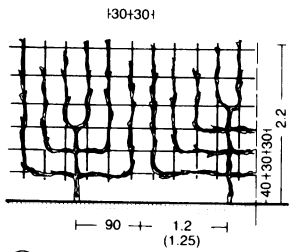
(4) **Trellis attached to wall**



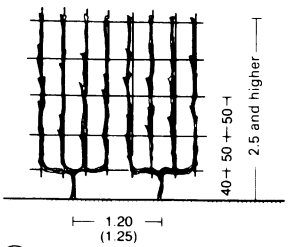
(5) **Vertical training**



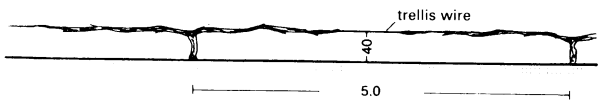
(6) **U-shaped training**



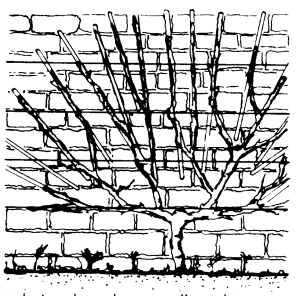
(7) **'Verrier' training (six and eight branches)**



(8) **'Chandelier' training**

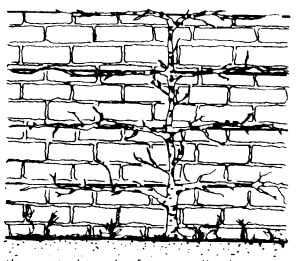


(9) **Two-armed horizontal training**



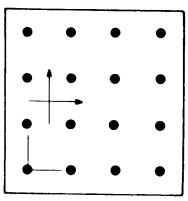
only two branches are allowed to grow at an angle to the ground; the shoots from these form the fan in early spring

(19) **Fan array**



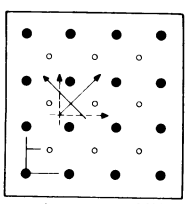
the central trunk of an espalier is grown vertically and the side branches are trained to each side at right angles

(20) **Espalier**



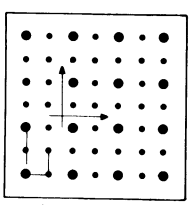
spacing	trees per 0.25 ha
4 × 4 m	156
6 × 6 m	69
10 × 10 m	25

(10) **Square planting system**



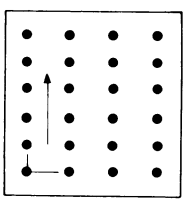
spacing	trees per 0.25 ha main	filler
4 × 4 × (2) m	156	156
6 × 6 × (3) m	69	69
10 × 10 × (5) m	25	25

(11) **Square planting with infill**



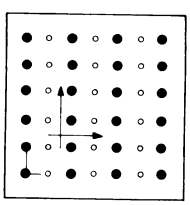
spacing	trees per 0.25 ha main	1st fill	2nd fill
6 × 3 × 3 m	69	69	103
8 × 4 × 4 m	39	39	58
10 × 5 × 5 m	25	25	37

(12) **Square planting, double infill**



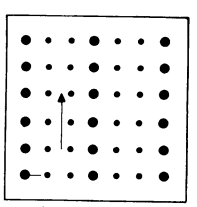
spacing	trees per 0.25 ha
2 × 4 m	312
6 × 6 m	69
4 × 10 m	42

(13) **Rectangular planting system**



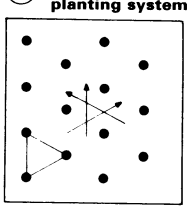
spacing	trees per 0.25 ha main	filler
3 × 5 × 2.5 m	167	167
4 × 6 × 3 m	104	104
6 × 10 × 5 m	42	42

(14) **Rectangular planting with infill**



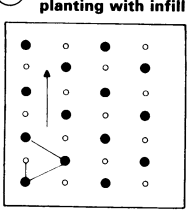
spacing	trees per 0.25 ha main	1st fill	2nd fill
3 × 3 m	46	46	184
4 × 4 m	26	26	104

(15) **Rectangular planting, double infill**



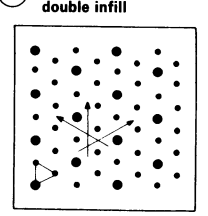
spacing	trees per 0.25 ha
3 × 3 × 3 m	320
4 × 4 × 4 m	178
6 × 6 × 6 m	80

(16) **Triangular planting system (equilateral)**



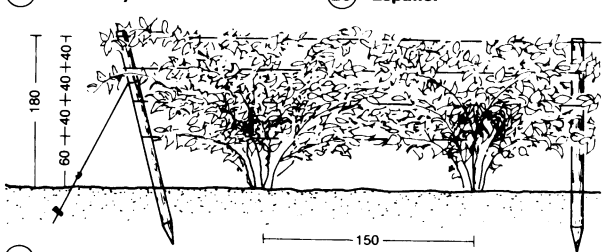
spacing	trees per 0.25 ha main	filler
1.5 × 3 × 3 m	320	320
2 × 4 × 4 m	178	178
3 × 6 × 6 m	80	80

(17) **Triangular planting with infill**

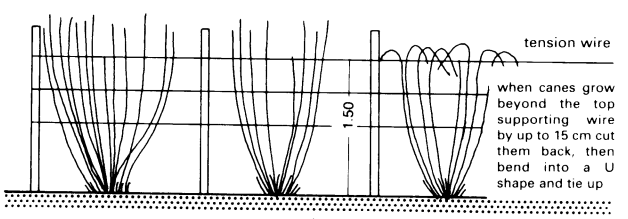


spacing	trees per 0.25 ha main	1st fill	2nd fill
3 × 3 × 3 m	80	80	160
4 × 4 × 4 m	44	44	88

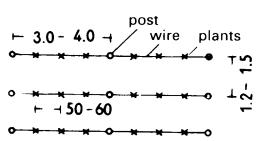
(18) **Triangular planting, double infill**



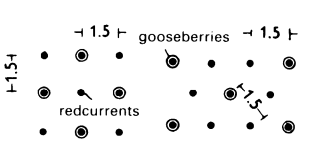
(21) **Wire framework for blackberry branches**



(22) **Raspberries**

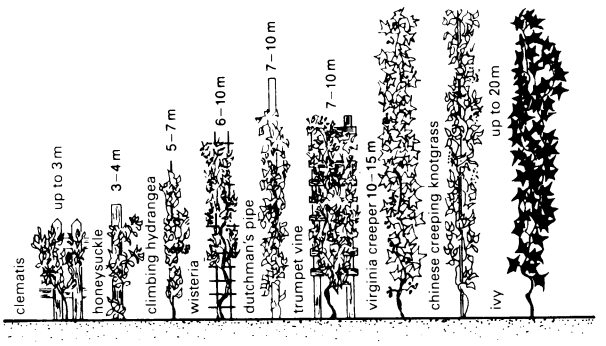


(23) **Spacing for raspberry plants**

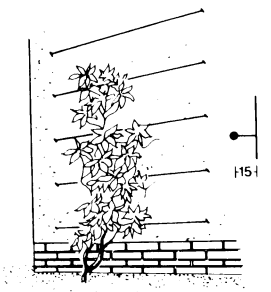


(24) **Gooseberries in square formation in combination with redcurrents**

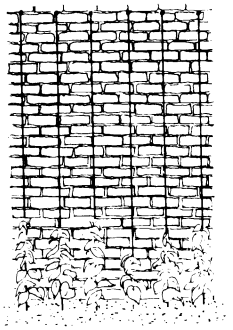
GARDENS: PLANTING METHODS



(1) **Climbing plants and their growth heights**



(2) **Horizontal climbing aids**



(3) **Beans growing up a wall**

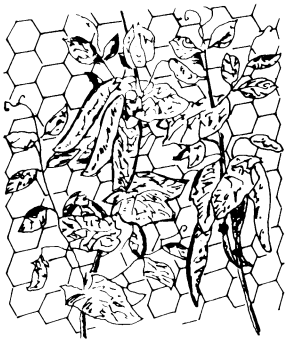
Two important factors for the successful cultivation of climbing plants are the soil quality and the direction they face. In addition, the height to which they will grow must be taken into account → (1). Climbing aids are required for plants that are to grown up house walls → (2) + (3).

In the case of beans each plant requires a climbing cane. The tent method is best used for two rows of plants → (7).

The wigwam method is ideal for growing plants in troughs and tubs → (6) and twigs gathered during coppicing can be used as a climbing aid for peas → (9), as can taut wire netting → (4) or a double wire mesh. Wire mesh is also useful to protect seeds and shoots from birds → (10) + (11).

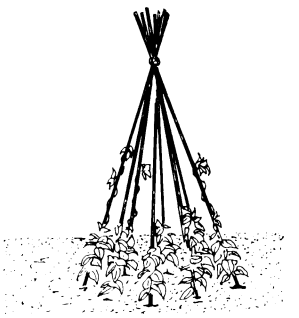
Guidelines for the choosing the best conditions for perennial climbing and creeping plants are given in (12).

annuals	height (m)	growth	leaves
bell vine	4–6	fast	summer, green
ornamental gourd	2–5	fast	summer, green
Japanese hop	3–4	fast	summer, green
trumpet convulvulous	3–4	fast	summer, green
sweet pea	1–2	fast	summer, green
scarlet runner bean	2–4	fast	summer, green
nasturtium	2–3	fast	summer, green

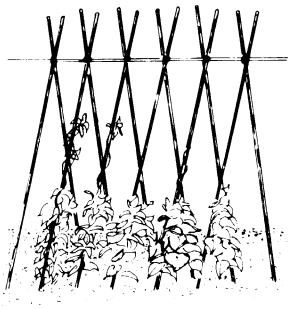


(4) **Hexagonal wire mesh**

(5) **Wooden fencing trellis**



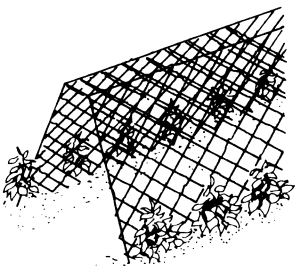
(6) **Wigwam method for 8–11 plants**



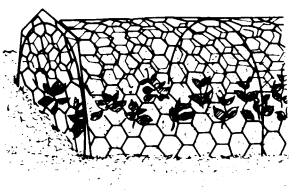
(7) **Tent method**

distance apart: 70 × 60, maximum 50 × 100

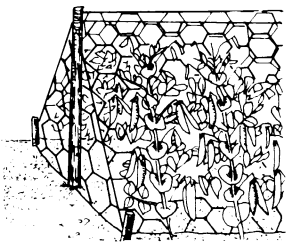
(8) **Twig frame**



(9) **Double wire mesh frame**



(10) **Wire mesh to protect plants from birds**



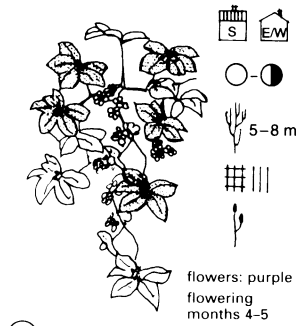
(11) **Climbing mesh for peas made of wire netting**

perennials	height	growth	climbing aid	leaves	watering	flowers/month	location
ivy (*Hedera helix*)	up to 25 m	slow		winter	–	9–10 greenish	●
knotgrass (*Polygonum aubertii*)	up to 15 m	fast	x necessary	summer	+	7–9 white	●
virginia creeper (*P. tricuspidata 'Veitchii'*)	up to 15 m	fast		summer	(+)	5–6 greenish	◢
anemone (*Clematis montana*)	up to 8 m	fast	x	summer	+	5–6 white	◢
wisteria (*Wisteria sinensis*)	up to 10 m	medium	x	summer	(+)	5–6 blue	◢
common traveller's joy (*Clematis vitalba*)	up to 10 m	fast	x	summer	+	7–9 white	◢
climbing hydrangea (*Hydrangea petiolaris*)	5 to 8 m	medium	(x) sensible	summer	–	6–7 white	◢
dutchman's pipe (*Aristolochia macrophylla*)	up to 10 m	medium	x	summer	(+)	5–6 brown	◢●
trumpet vine (*Campsis radicans*)	up to 8 m	slow	(x) sensible	summer	+	7–8 orange	
grapevine (*Vitis coignetiae*)	up to 10 m	medium	x	summer	(+)	5–6 greenish	◢
grape (*Vitis vinifera*)	up to 10 m	medium	x	summer	+	5–6 greenish	◢
red honeysuckle (*Lonicera heckrottii*)	3 to 4 m	medium	x	summer	(+)	6–9 yellow-red	◢
hop (*Humulus lupulus*)	4 to 6 m	fast	x	summer	–	5–6 greenish	◢
honeysuckle (*Lonicera caprifolium*)	up to 5 m	medium	x	summer	+	5–6 yellow-red	◢
climbing rose	up to 5 m	medium	x	summer	–	6–8 various	◢
spindle shrub (*Euonymus fortunei*)	2 to 4 m	slow	(x) sensible	winter	(+)	6–8 greenish	◢●
traveller's joy (*Clematis hybriden*)	2 to 4 m	medium	x	summer	+	6–9 various	◢
winter jasmine (*Jasminum nudiflorum*)	up to 3 m	slow	x	winter	+	1–4 yellow	◢

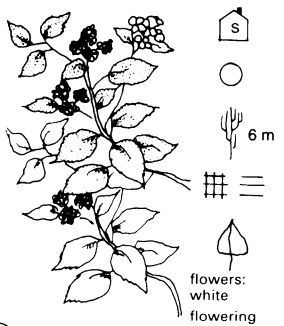
○ = sunny location ◢ = half shade, e.g. north wall ● = shade

(12) **Summary of some climbing and creeping plants** → (1)

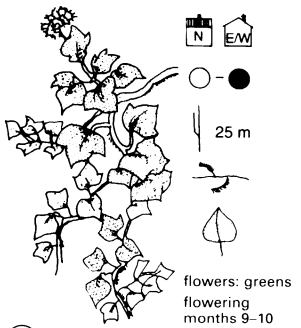
TENDRIL AND CLIMBING PLANTS



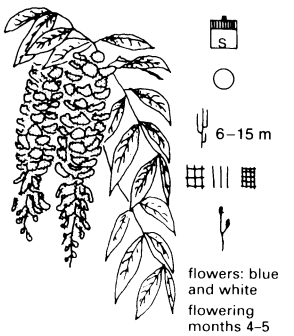
1 ***Akebia***



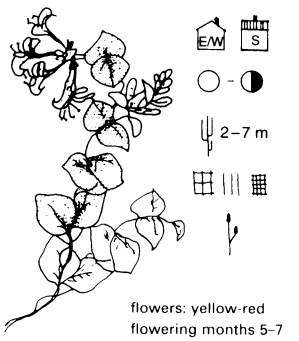
2 **Blackberry**



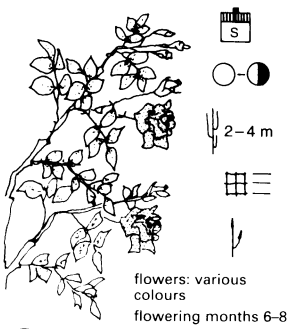
3 **Ivy**



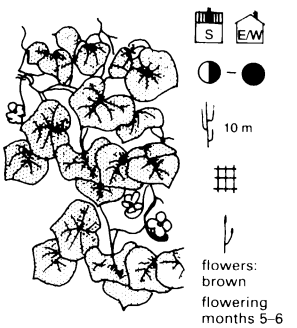
4 **Wisteria**



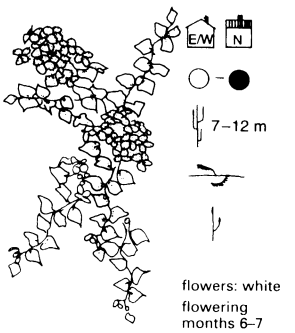
5 **Honeysuckle**



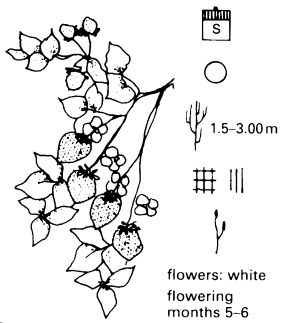
6 **Climbing rose**



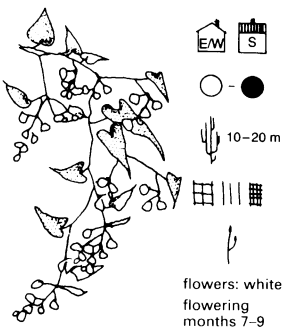
7 **Dutchman's pipe**



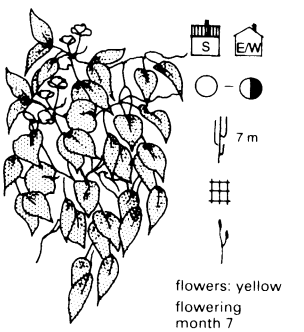
8 **Climbing hydrangea**



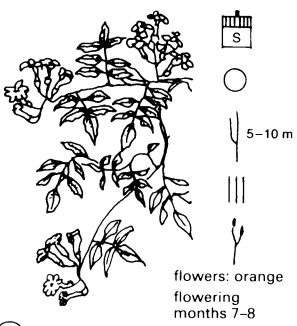
9 **Climbing strawberries**



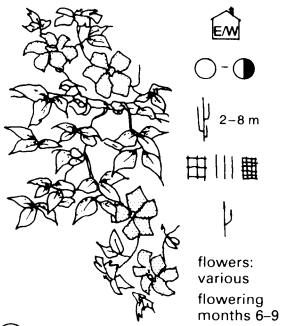
10 **Russian vine**



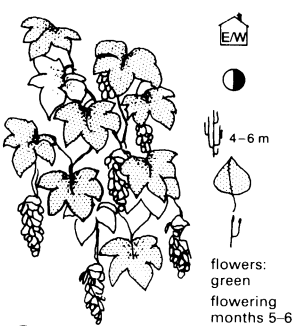
11 ***Actinidia chinensis***



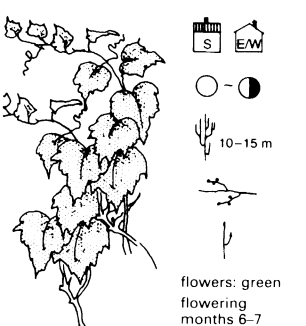
12 ***Campsis radicans***



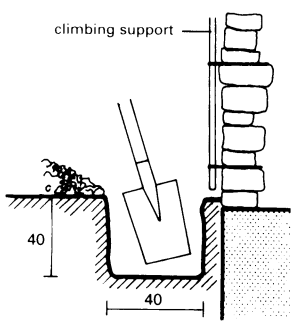
13 **Clematis**



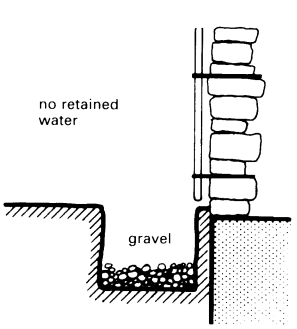
14 **Common hop**



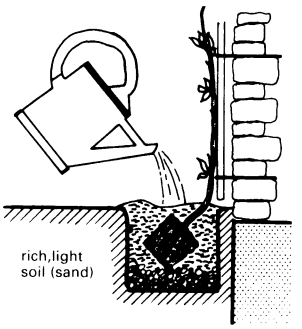
15 **Virginia creeper**



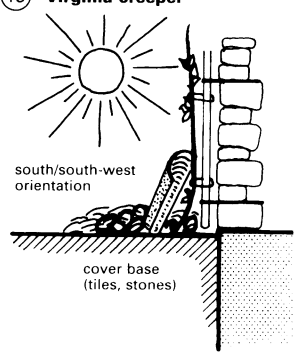
16 **Planting a clematis**



17 **Ground must be well drained**

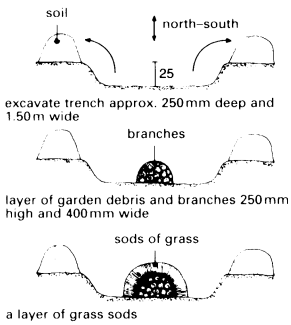


18 **Watering**

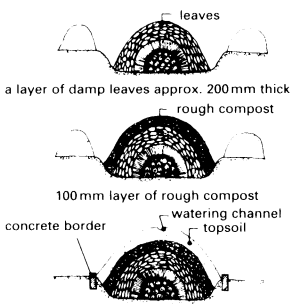


19 **Clematis likes cold foot and hot head**

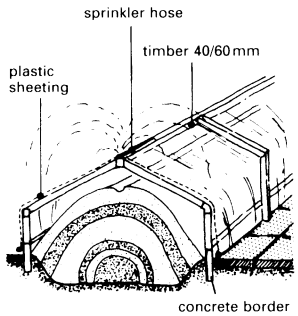
BANKED AND RAISED BEDS



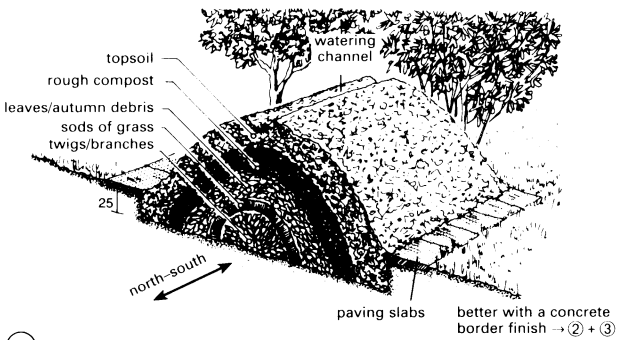
① **Construction of a banked bed** → ② + ③



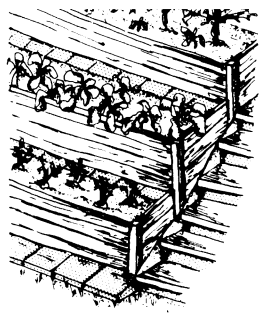
② **Finish with 100 mm thick layer of topsoil**



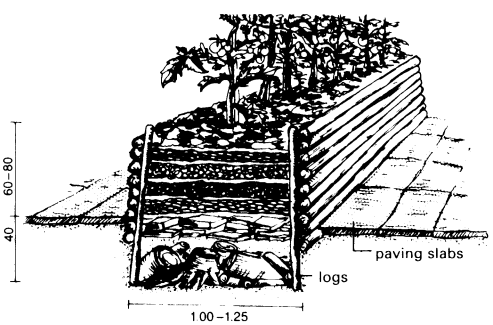
③ **Bed covered with plastic sheeting**



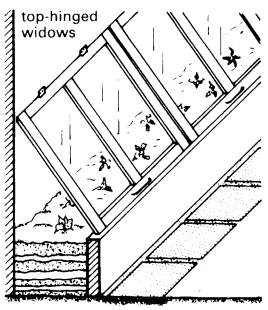
④ **Cross-section through a banked bed**



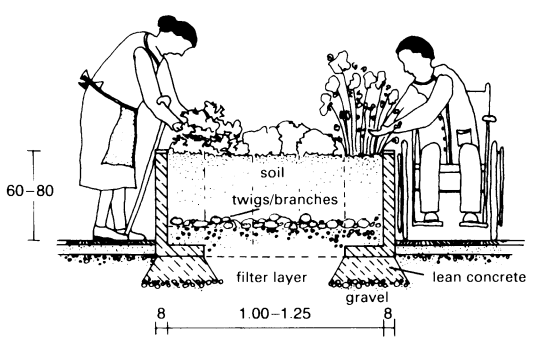
⑤ **Raised bed, ideal for terracing slopes**



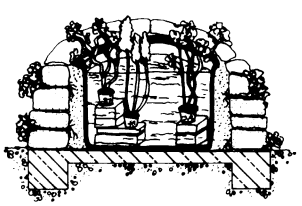
⑥ **Raised bed: same layers as banked beds**



⑦ **Raised bed built against a south wall; covered with glass like small green house**



⑧ **Raised bed made from prefabricated concrete units**

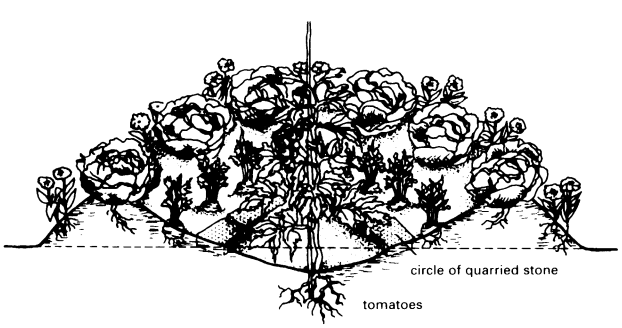


⑨ **Small pond in a raised bed made with stones**

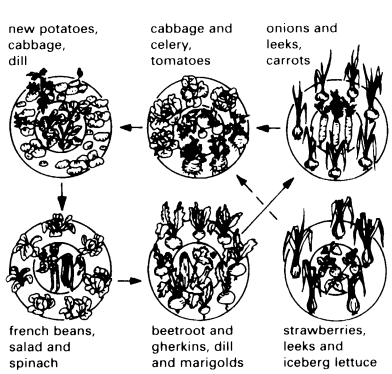
Banked beds are ideal for growing vegetables in the garden. They offer the possibility of quick harvests and very high yields. The most important factors in constructing a banked bed are the correct build-up and a north–south orientation → ① – ③. Although they require some effort to build, banked beds can be used for several years. In general, a banked bed is approximately 1.50 m wide and 4 m long and watered with a sprinkler hose → ③ or trickle irrigation. It is best to carry out the construction process in the autumn when the most garden debris is available. Mixed planting has proved to be particularly effective in banked and raised beds.

The raised bed is a variation of the banked bed in that it has the same composition and is, in principle, a compost heap contained by a boarded frame → ⑥. Any rot-resistant material is suitable and can be used instead of wooden boards (e.g. impregnated logs, wood blocks, or stone walls). In addition to the advantages of the rich bedding material, the plants also benefit from the sunshine which impinges on the side walls.

If the beds are 600–800 mm high, it is no longer necessary to bend when planting seeds, bedding plants or harvesting → ⑥ + ⑧, which makes raised beds ideal for the elderly and wheelchair users. Raised beds give increased yields when they are filled with layers of organic materials, tree stumps at the bottom, then branches, then chopped twigs up to well rotted compost.



⑩ **Crater bed 2 m diameter** → ⑪

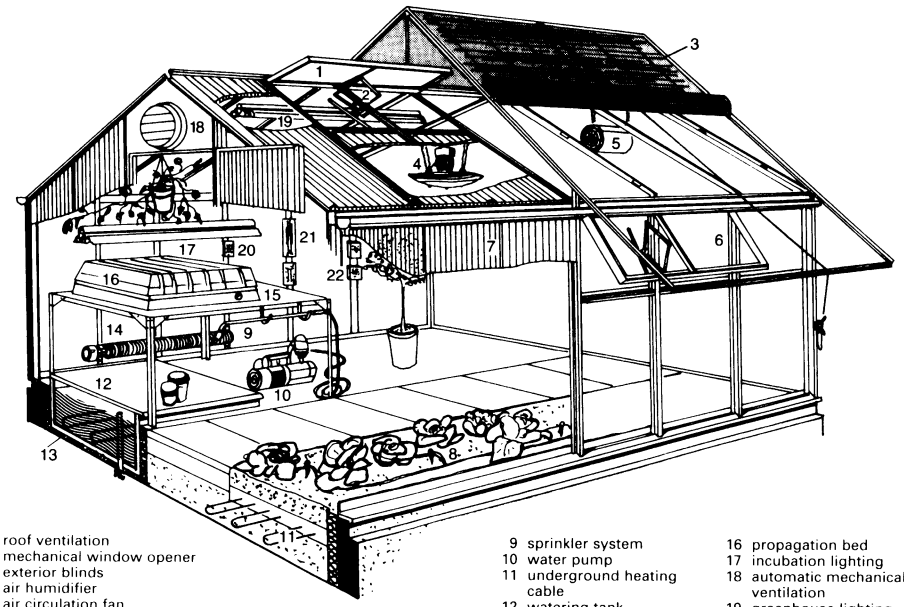


⑪ **Mixed planting in six crater beds** → ⑩

GREENHOUSES

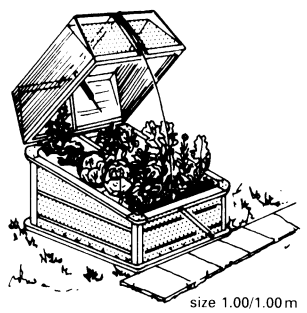
The ventilation of greenhouses should be calculated such that, when fully ventilated, the inside temperature can be held close to that outside. For this it is necessary that about 20% of the roof area consists of a ventilation strip or windows that can be opened individually. An adequate supply of fresh air must also be ensured.

Where there is insufficient natural shading from outside it may be necessary to install sun blinds in order to maintain temperate conditions during bright sunshine. Blinds can be installed on the inside or outside of the greenhouse. Although those inside are more economical, exterior blinds are more effective, particularly when there is a sufficient gap between the blinds and the glass → ⑩ + ⑪.

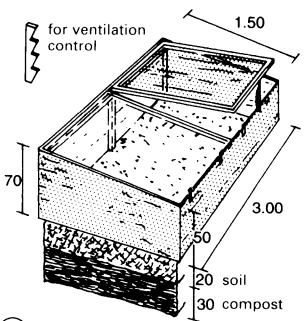


1 roof ventilation
2 mechanical window opener
3 exterior blinds
4 air humidifier
5 air circulation fan
6 side ventilation widow
7 double layer plexiglass
8 trickle irrigation
9 sprinkler system
10 water pump
11 underground heating cable
12 watering tank
13 insulation
14 heating
15 plant table
16 propagation bed
17 incubation lighting
18 automatic mechanical ventilation
19 greenhouse lighting
20 humidity controller
21 air humidity sensor
22 thermostat

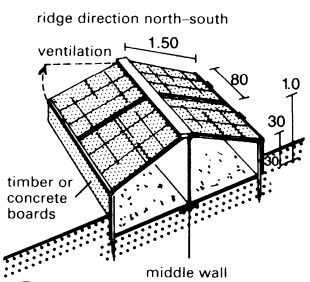
① **Greenhouse with practical climate control**



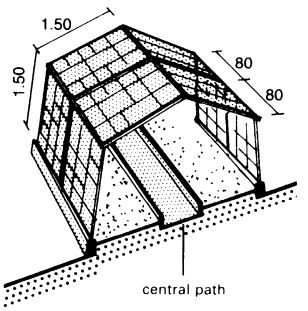
② **Banked bed with solar hood**



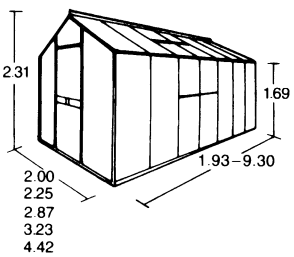
③ **Cold frame**



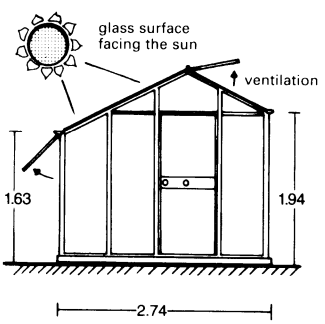
④ **Small greenhouse**



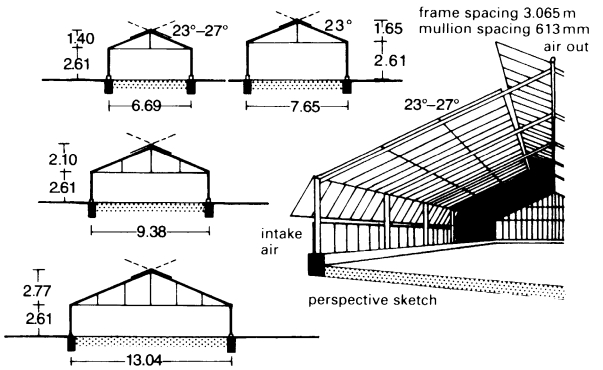
⑤ **Dutch greenhouse**



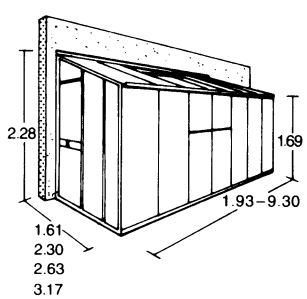
⑥ **Standard greenhouse**



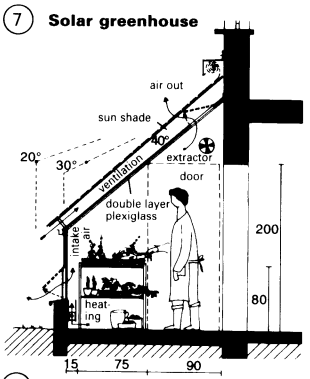
⑦ **Solar greenhouse**



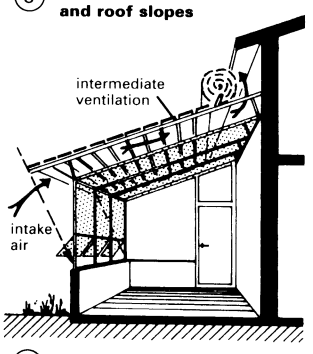
⑧ **Greenhouse dimensions and roof slopes**



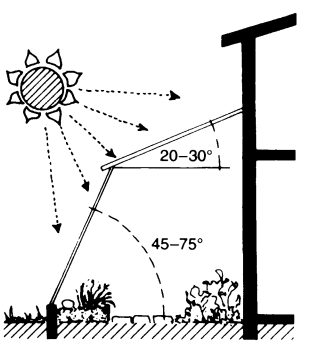
⑨ **Lean-to greenhouse**



⑩ **Lean-to greenhouse**

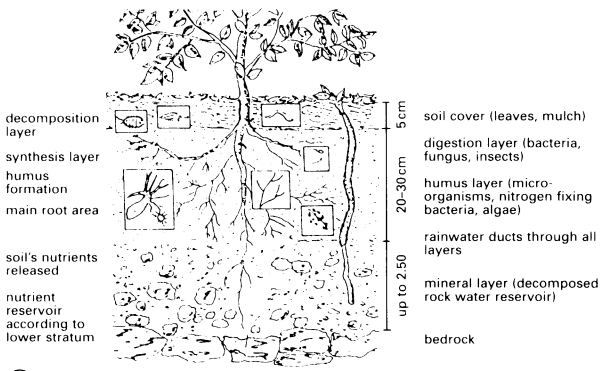


⑪ **Exterior blinds with full intermediate ventilation**

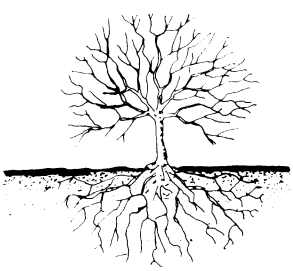


⑫ **Optimal angles for glass surfaces**

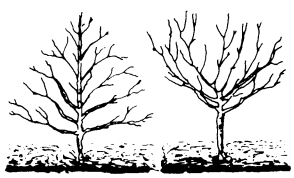
GARDENS: TREES AND HEDGES



① **Soil and humus layers are filled with life**



② **The root network mirrors the natural top of the tree**



preferred to the 'Christmas tree', or pyramid, shape, is the cup shape: with branches grown outwards the tree has an open centre like a cup or goblet, which allows light into the fresh growth at the top; side branches are kept short so that they can withstand the weight of fruit or snow

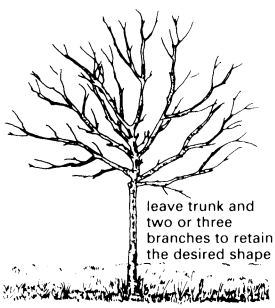
③ **Tree shapes**

Fertile soil contains an abundance of life, with the different layers being inhabited by different groups of species → ①. Tree roots can penetrate the soil down to rocky layers and the shape of the underground root network is usually a mirror image of the shape of the tree's crown → ②.

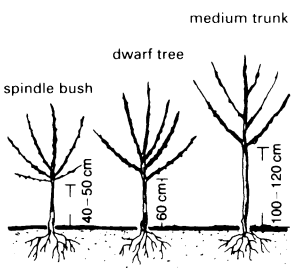
For cultivated trees the cup shape is preferred. These have open centres from which the branches are drawn outwards so that light can penetrate the treetops. Side branches are kept short so they will not break under the weight of fruit or snow.

The best time for planting fruit trees is late autumn (October in areas with early frost, November and in milder areas). Grafting points, which can be clearly recognised as a swelling on the end of the stem, must always be above the soil surface. Supporting posts must be a handbreadth away from the trunk and should be to the south to prevent sunburn. → ⑦

When planting hedges the correct distance from the neighbouring plot must be maintained: 0.25 m for hedges up to 1.2 m high, 0.5 m for hedges up to 2 m high and 0.75 m for hedges over 2 m. Hedges are ideal for providing privacy in one's own garden as well as protection from noise and dust. They also reduce wind speed, increase dew formation, regulate heat and prevent soil erosion. Banked hedges (so-called 'quick-set hedges' → ⑩) are used as windbreaks in coastal areas.



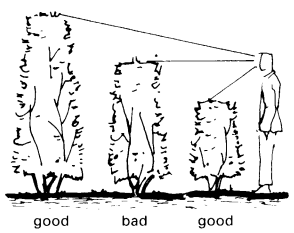
④ **High trunk on a sapling**



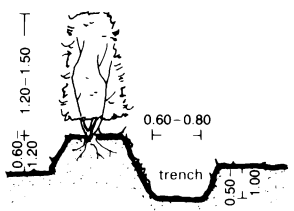
⑤ **Tree shapes for small gardens**

⑧ **Trim a hornbeam hedge in the 1st, 3rd and 5th year after planting (left summer, right winter)**

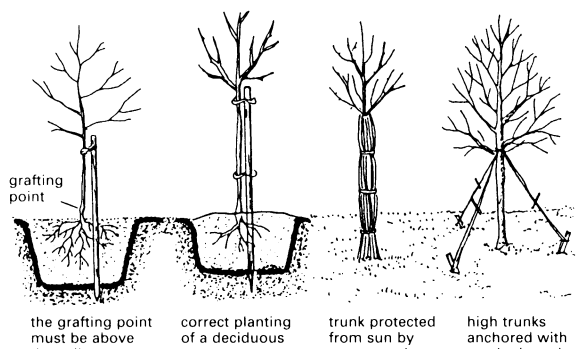
⑥ **When planting a conifer the root ball must be loosened**



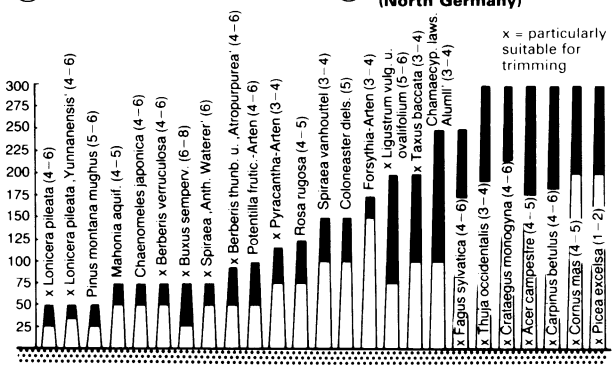
⑨ **Hedge heights**



⑩ **'Quick-set hedge' (North Germany)**



⑦ **Planting garden trees**



⑪ **Heights for trimmed and free-growing hedges (number of plants required per metre run in parentheses)**

GARDEN PONDS

Careful consideration needs to be given as to how best to integrate a pond into the garden. To begin with, selecting the correct position is extremely important for the well-being of the plants and animals in and around the pond. For instance, the majority of bog and water plants require plenty of sunlight (about 4–6 hours per day). The pond also needs to be easy to view so the best position is in the proximity of a terrace or a seating area, where it can be observed at leisure.

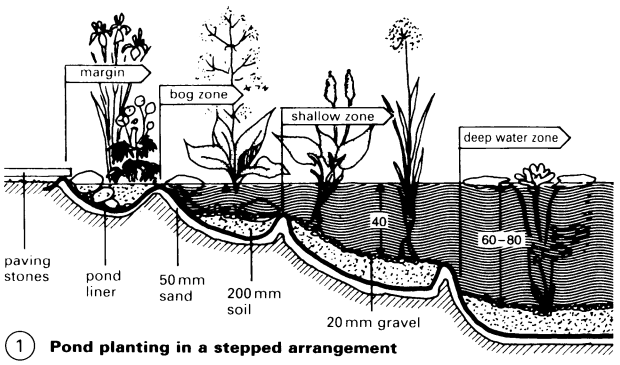
In addition, the constituent elements of the pond need to be carefully planned. If the correct proportions of plants, water and sand are used, a biological balance can be achieved within 6–8 weeks, at which time the water becomes clear. One of the most important factors in this is to have the correct ratio of water surface to water volume (a pond average of around 400 l per m^2 of water surface is recommended). The garden pond will then become a habitat for both insects and plants.

The planting of the pond is done before the water is carefully topped up to its final level. The pond edge and surrounds need to be specially designed: bog and flood water zones, as well as moist beds, → ① + ② help to expand the pond area and create a more natural balance. The pond should be sized according to the area of the garden: a water area of 20–25 m^2 is ideal, although even 3–5 m^2 gives enough room for many types of plants. Generous shallow water zones of 50–200 mm depth and a deep area of at least 600 mm in depth are necessary for the survival of aquatic insects and larvae during the winter months. The deep areas also provide a place of hiding for all of the pond inhabitants.

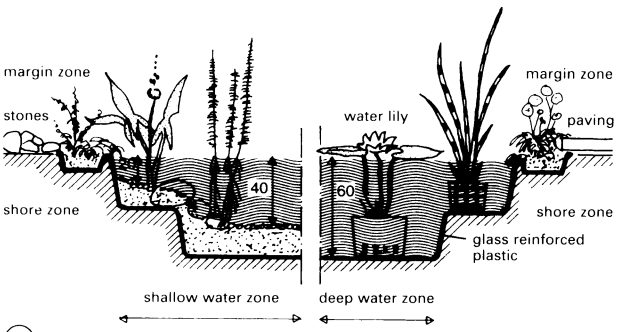
The pond should be kept full throughout the winter to reduce the possibility of it being forced out of the ground or tilted by the action of ground frost.

Fish, frogs and other amphibians will only survive the winter if the pond is protected from freezing over completely for extended periods so an ice preventer or a heating stone should be used.

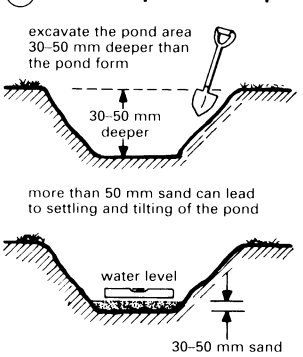
Prefabricated ponds provide planting shelves at appropriate depths and these prevent gravel and planting soil from slumping or sliding away completely → ②.



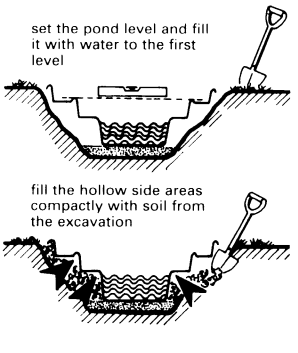
① **Pond planting in a stepped arrangement**



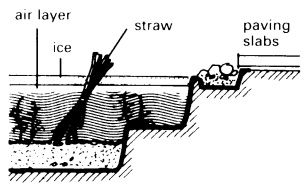
② **A suitable prefabricated pond**



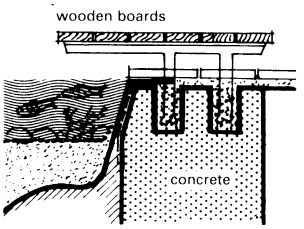
③ **Garden pond installation: excavating**



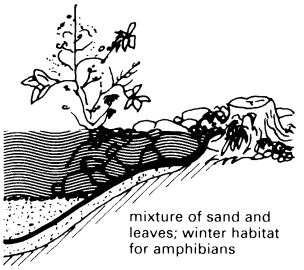
④ **Garden pond installation: compacting**



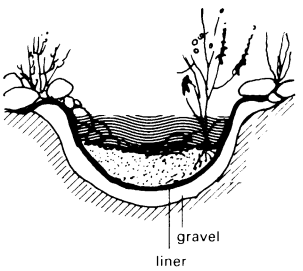
⑤ **Put in a bundle of straw or heating stone during frost**



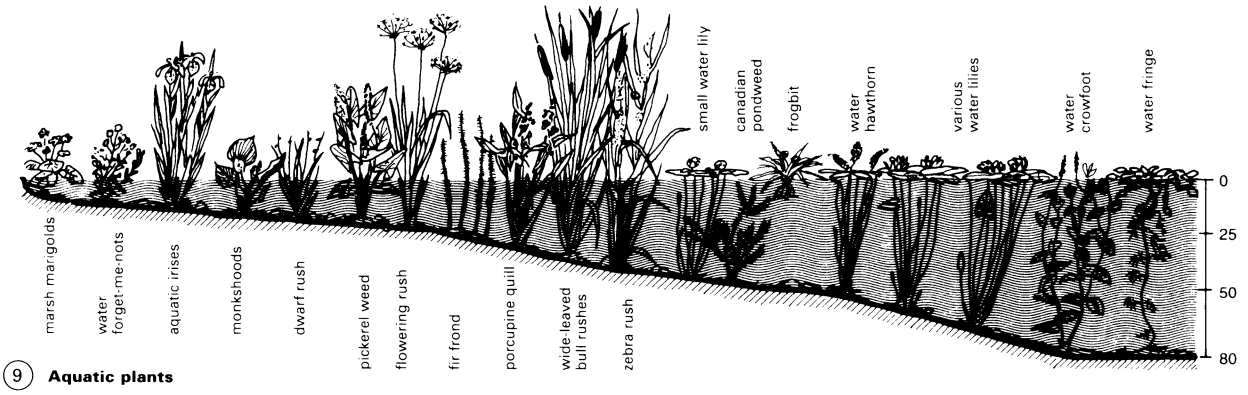
⑥ **A cantilevered jetty**



⑦ **Edge zone**

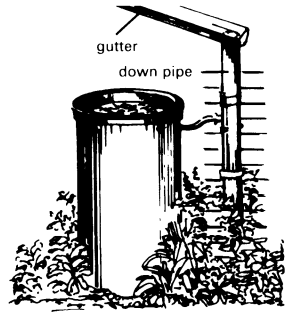


⑧ **Cross-section of a stream**

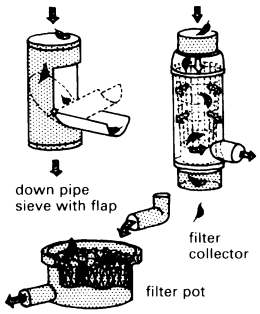


⑨ **Aquatic plants**

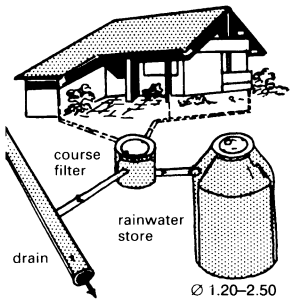
GARDENS: USE OF RAINWATER



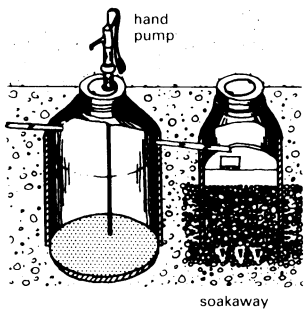
① **Constant storage for watering (rainwater butt)**



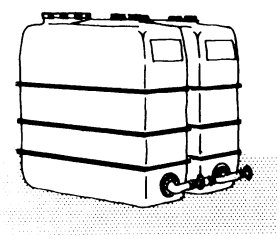
② **Filter before the rainwater store**



③ **Eco rainwater storage up to 12500 l**

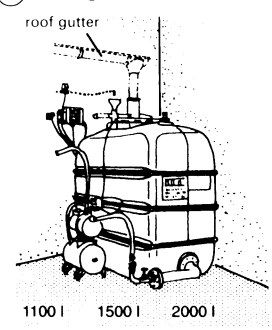


④ **Rainwater storage with eco soakaway**

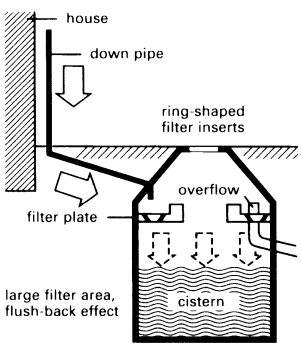


capacity	length	width	height	weight
1100 l	1.45	72	1.33[5]	53 kg
1500 l	1.52	72	1.60[5]	81 kg
2000 l	2.05	72	1.64	130 kg

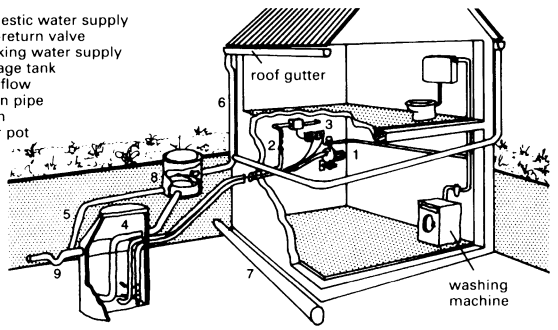
⑤ **Storage containers**



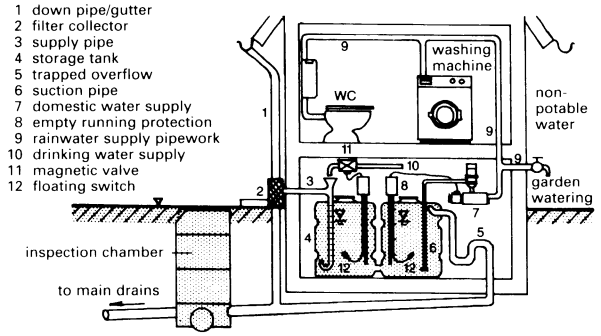
⑥ **Distribution system**



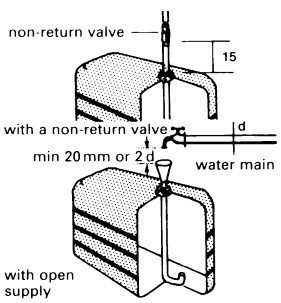
⑦ **In-flow filter**



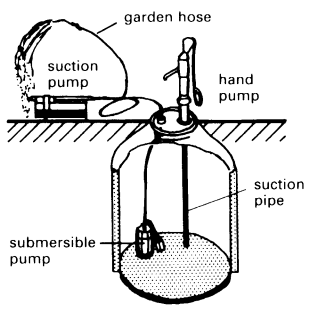
⑧ **Rainwater collection system with filter pot and external storage tank**



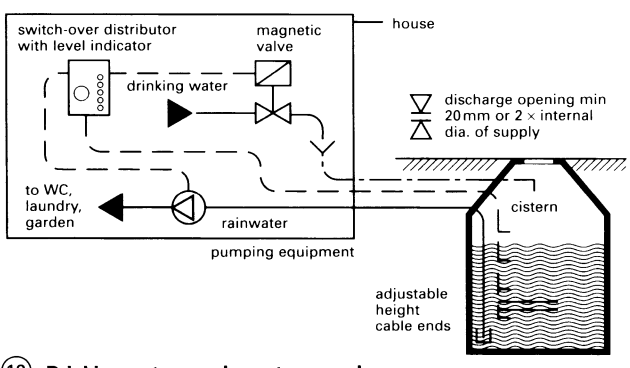
⑨ **Rainwater system**



⑩ **Drinking water supply**



⑪ **Rainwater storage for garden watering**



⑫ **Drinking water supplementary supply**

In the design of new buildings it is desirable to include means for collecting and storing rainwater. Rainwater systems can also be installed in existing houses or gardens. The storage volume should be generous because the greater the volume, the more the potential economies. The average storage required for garden watering (given 40–60 l/m² as a typical annual usage) for a single family house is about 5000 l (it depends on the area of garden, annual rainfall, roof area and run-off value). To calculate domestic water needs, use the following figures for average water consumption per person per day: 15 l drinking/cooking, 10 l washing, 40 l bathing/showering (total: 65 l potable water); 18 l clothes washing, 4 l cleaning, 45 l WC flushing (18 l with economy flush), 8 l sundries (total: 75 l rainwater or 48 l with economy flushing).

Example

Annual rainfall 800 mm = 800 l/m²
Pitched roof run-off value f = 0.75
Net roof area = 120 m²
Rainwater production = net roof area (m²) × annual rainfall (l/m²) × run-off value (f)
= 800 × 120 × 0.75
= 72000 l/year

Number of persons = 4
Usage per day = 45 l per person (WC with economy flush)
Garden area = 200 m²
Annual garden watering = 50 l/m²
Rainwater requirement = persons × usage per day (l) × 365 days) + (garden area (m²) × usage per year (l/m²))
(4 × 45 × 365) + (200 × 50)
= 75700 l/year

Factor g = (1 – [rainwater production ÷ rainwater requirement]) x 100%
= (1 – [72000/75700]) × 100 = 4.9%
(this is less than 20% so use g = 0.05)
Storage requirement = rainwater production (l) × g
= 72[t]000 × 0.05
= 3600 l
Recommendation: 4500 l rainwater storage tank

Explanations

Net area: the plan area of the roof connected to the gutters (equivalent to the plan area of the house).

Annual rainfall: mean annual rainfall (e.g. typical values are 740–900 mm = 740–900 l/m²) as read from appropriate rainfall maps or information from a local weather station.

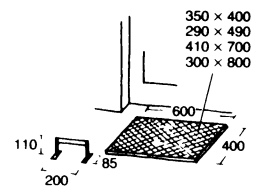
Run-off value (f): f = 0.75 for pitched and flat roofs.

Factor g: when the difference between rainwater production and rainwater requirement is less than 20%, use g = 0.05.

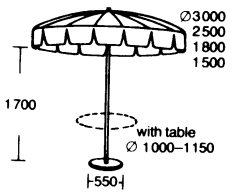
g = 0.03 when the difference between rainwater production and rainwater requirement is more than 20%.

g = 0.20–0.40 when the water is used mainly for garden watering and when there are large seasonal rainfall variations.

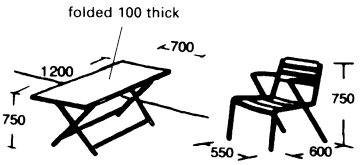
GARDEN EQUIPMENT



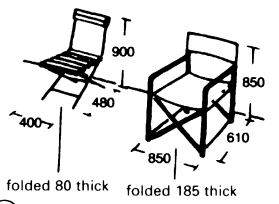
① **Metal foot scraper**



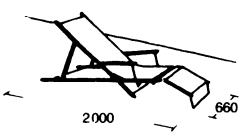
② **Sunshade**



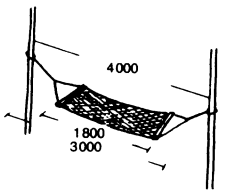
③ **Garden chair and table**



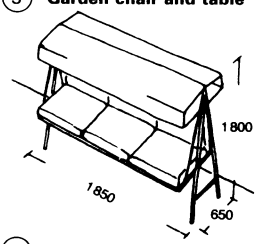
④ **Garden chairs**



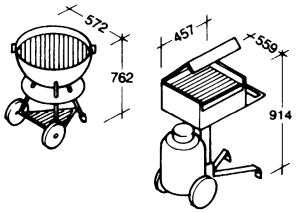
⑤ **Deckchair**



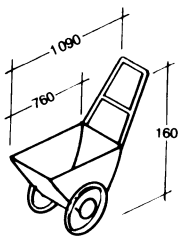
⑥ **Hammock**



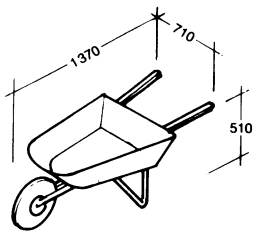
⑦ **Garden swing**

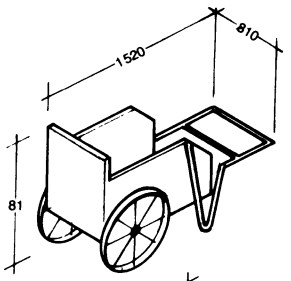


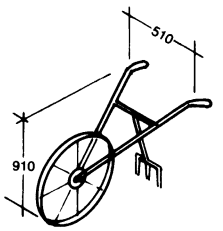
⑧ **Portable barbecue (gas or charcoal)**



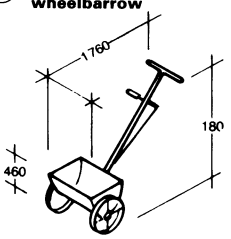
⑨ **Garden carts and wheelbarrow**



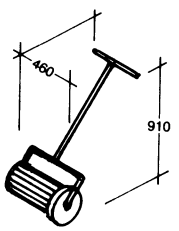


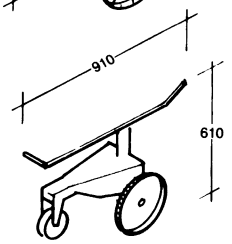


⑩ **Wheel cultivator**

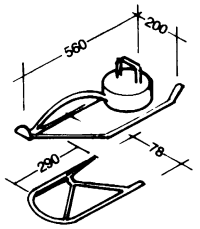


⑪ **Seed spreader**

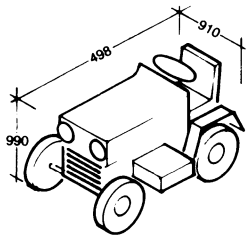




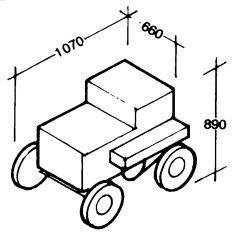
⑬ **Walking sprinkler**



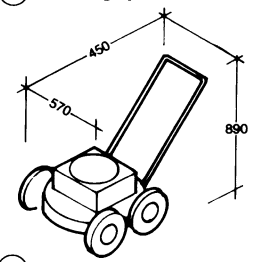
⑭ **Lawn sprinklers**



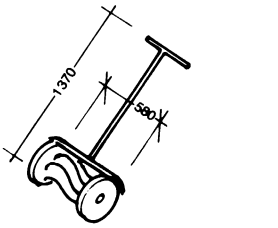
⑮ **Tractor mower**



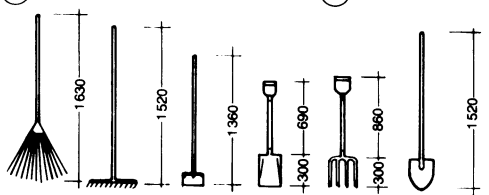
⑯ **Leaf collector**



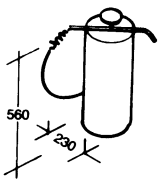
⑰ **Rotary mower**



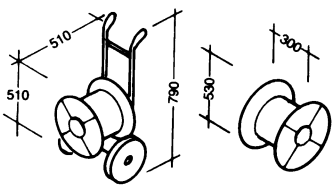
⑱ **Reel mower**



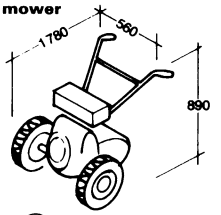
⑲ **Garden tools**



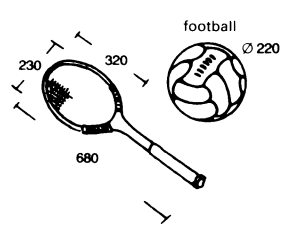
⑳ **Sprayer**



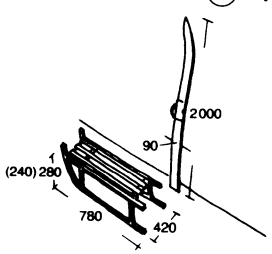
㉑ **Hose reels**



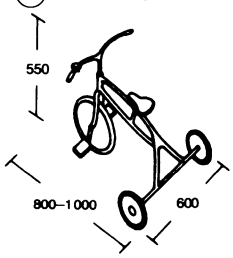
㉒ **Tiller**



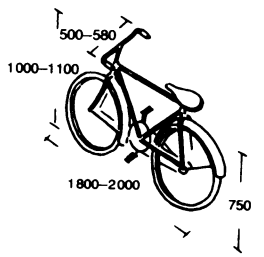
㉓ **Sports equipment**



㉔ **Toboggan, skis**

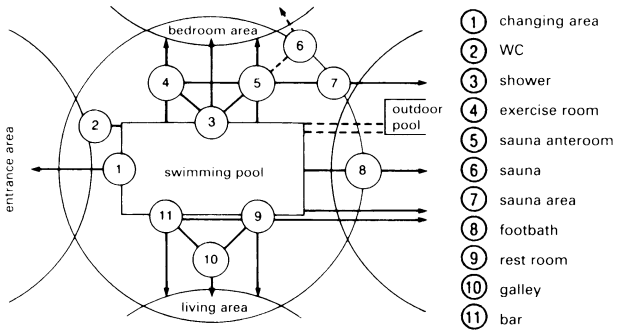


㉕ **Tricycle**

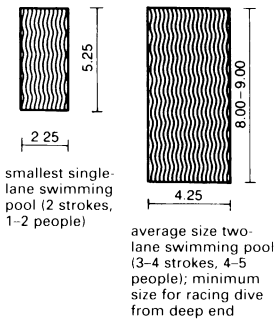


㉖ **Bicycle**

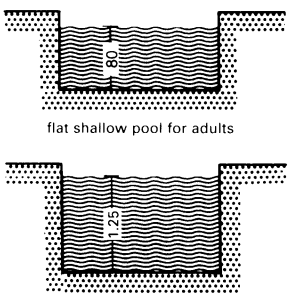
GARDEN SWIMMING POOLS



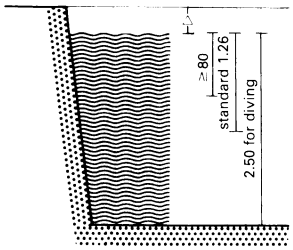
① **Layout of an integrated swimming pool in a single family house**



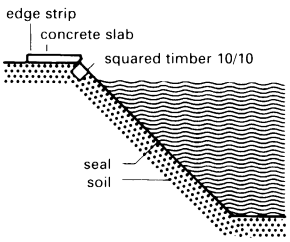
② **Pool sizes**



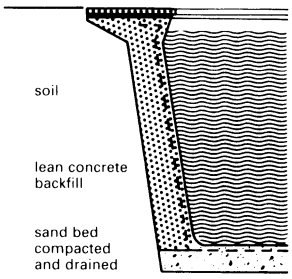
③ **Normal depths of garden swimming pools**



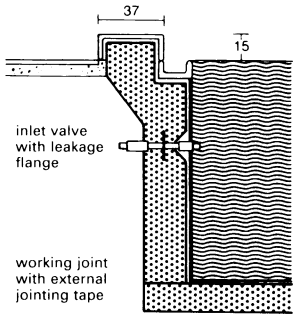
④ **Pool depths**



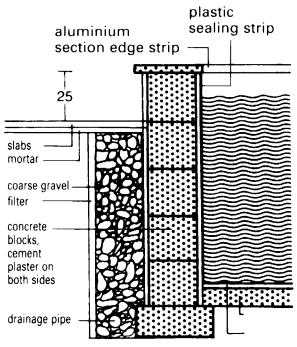
⑤ **Pool with sloping sides, liner and squared timber edge surround**



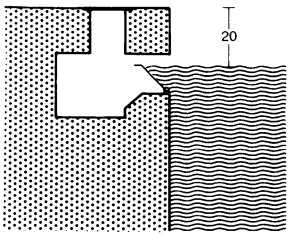
⑥ **Single-shell precast polyester pool**



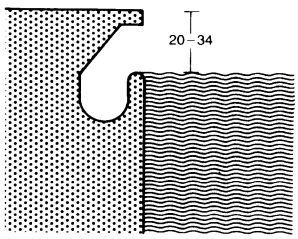
⑦ **Reinforced concrete pool of simple design**



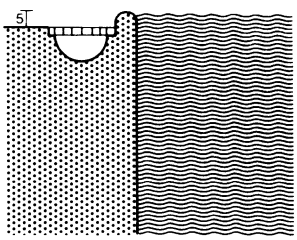
⑧ **Masonry pool with drainage**



⑨ **Skimmer**



⑩ **Pool with 'Wiesbaden' overflow channel**



⑪ **'Zürich' channel in surrounding walkway**

The ideal position for a garden pool is sheltered from the wind and visible from the kitchen and living room (to allow supervision of children). There should be no deciduous trees or shrubs immediately next to the pool and a surrounding walkway ought to be provided to prevent grass etc. from falling into the water.

Realistically, the pool should no less than 2.25m wide and the length worked out on the basis of a swimming stroke length of approximately 1.50m plus body length (e.g. four swimming strokes equates to 8m). The standard water depth is usually based on the average height to the chin of an adult. The difference between the overall pool depth and the water depth depends on the type of water extraction system → ⑨ – ⑪.

For reasons of cost and the water circulation system (see below), the shape of the pool should be kept as simple as possible.

The standard type of pool design uses a sealed surface on a supporting structure made of masonry → ⑧, concrete, steel (particularly for above ground pools) or dug out of the earth → ⑤. Polyester pools (which are rarely made on site, being mostly made up from prefabricated parts) are generally not self-supporting so lean concrete backfill necessary → ⑥. Cast or sprayed concrete pools → ⑦ must be watertight. The surface is usually ceramic tiles or glass mosaic, although they are sometimes painted (chlorine rubber, cement paints).

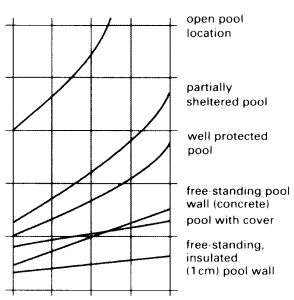
The water needs to be kept clean and this is normally done by water circulation systems and filters. The process is improved with a good surface cleaning system using a skimmer → ⑧ or channel → ⑩ + ⑪. Adding a regulated countercurrent plant or through-flow heater can extend the swimming season considerably without prohibitive costs.

Other factors to consider are child-proofing measures and frost protection.

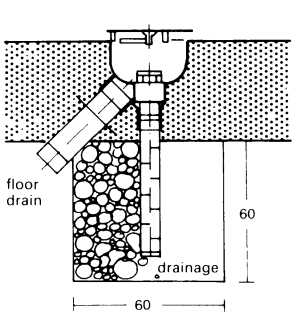
water	season			additional months	
t_W	4 months	5 months	6 months	5th month	6th month
22°C	1.25/6.5	1.33/7.2	1.55/7.8	1.65/7.2	2.65/7.8
23°C	1.50/7.2	1.70/7.9	2.00/8.5	2.50/7.9	3.50/8.5
24°C	2.08/7.9	2.26/8.6	2.66/9.2	2.98/8.6	4.66/9.2
25°C	2.60/8.5	2.80/9.3	3.20/9.8	3.60/9.5	5.25/9.8
26°C	3.50/9.2	3.75/10.0	4.00/10.5	4.75/10.0	5.25/10.5

figures are in kWh/m²/d; special influences are not included, such as the considerable heat losses in public or hotel pools through the use of heated pool water for filter backflushing (up to 1.5kWh/m²/d or 1300kcal/m²/d)

⑫ **Heat losses in open-air pools (average/maximum)**



⑬ **Relative heat losses in a 5 month season (averages)**

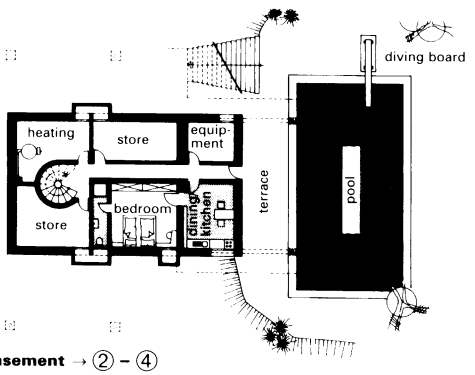


⑭ **Floor drain with groundwater pressure balance**

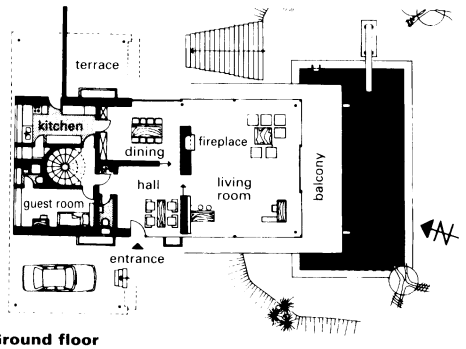
GARDEN SWIMMING POOLS

Example → ① - ④: house on a slope with an outdoor swimming pool reached from the lower floor or exterior steps.

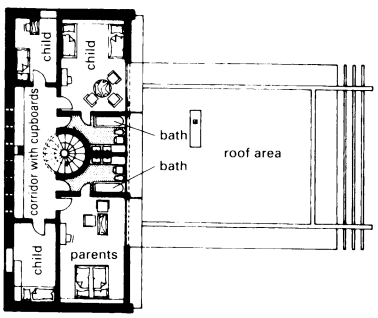
Example → ⑥ - ⑧: the pool is a short distance from the sauna and bedrooms and on the same level in front of the living room.



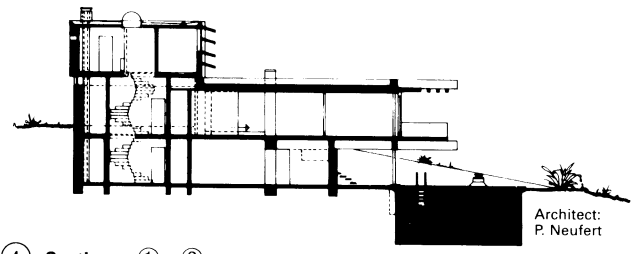
① **Basement** → ② - ④



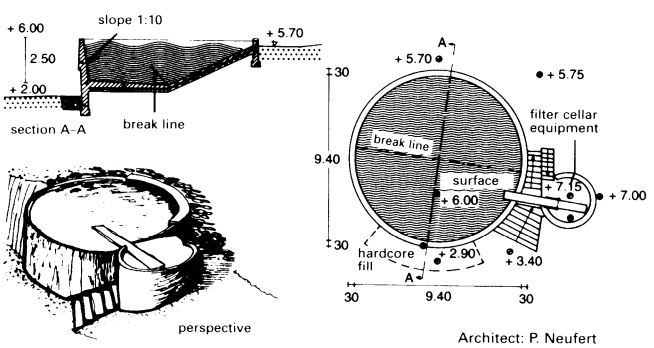
② **Ground floor**



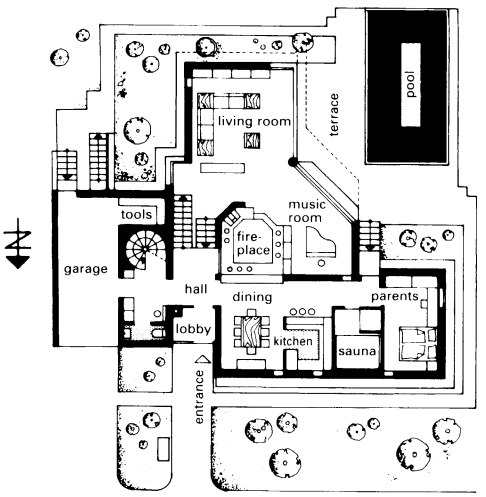
③ **Upper floor**



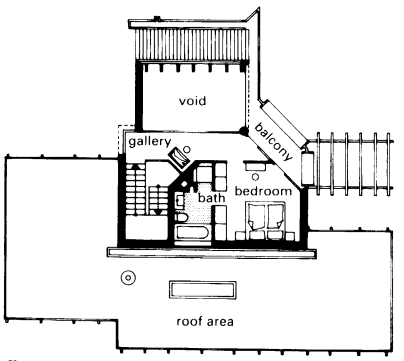
④ **Section** → ① - ③



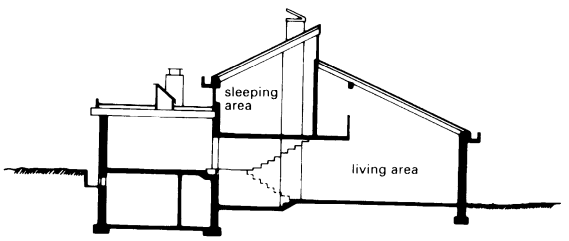
⑤ **Circular swimming pool on a slope**



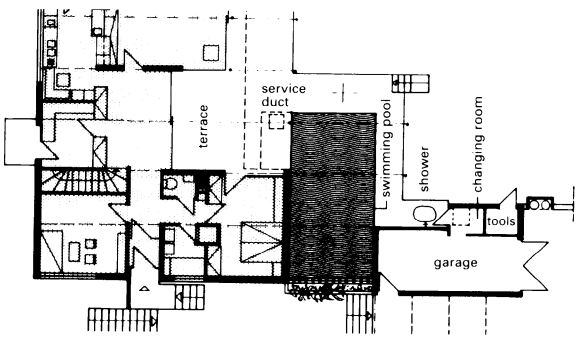
⑥ **Ground floor** → ⑦ - ⑧



⑦ **Upper floor**

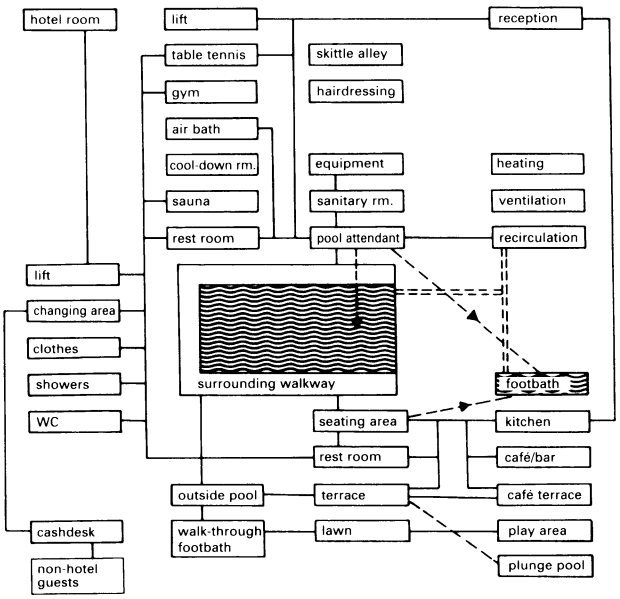


⑧ **Section** → ⑥ - ⑦ Architect: K. Richter

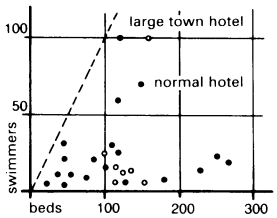


⑨ **Swimming pool between house and garage** Architect: Kappler

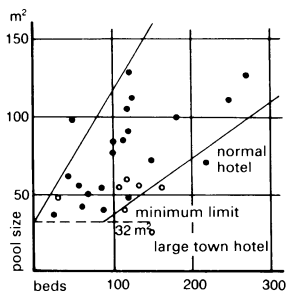
PRIVATE SWIMMING POOLS



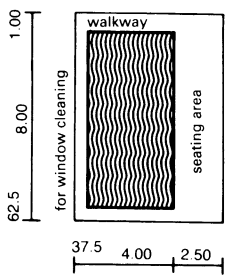
① **Arrangements relating to indoor pools**



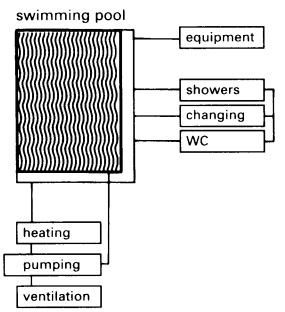
② **Maximum number of swimmers present at one time**



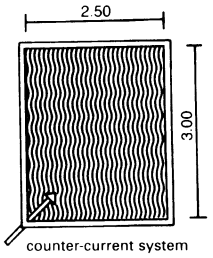
③ **Rough guide to hotel pool sizes**



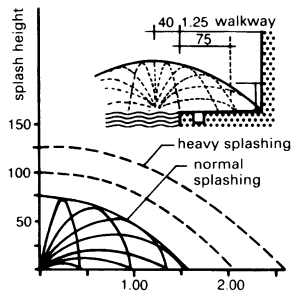
④ **Common size of private indoor pool**



⑤ **Indoor pool in a single-family house**



⑥ **Smallest pool**



⑦ **Splash distance from point of origin**

Atmosphere is a very important factor in the enjoyment of indoor pools so they should be well lit with natural daylight. An ideal location for the pool is at the rear of the house, overlooking the garden. With removable or sliding wall and ceiling panels it is possible to give the feel of being in an outdoor pool when the weather permits. Although this is the ideal it does introduce problems with heat bridges. Access to the pool can be through the living room or the master bedroom (allowing an en suite bathroom to be used for showering and changing) and should include a walk-through footbath to combat infections.

The standard conditions for indoor pools are: water 26–27°C, air 30–31°C and 60–70% relative humidity; maximum air circulation speed 0.25 m/s.

Construction considerations

The main problem with indoor pools is controlling the air humidity. Water evaporates from the pool at rates from 16 g/m²/h (when still) up to a maximum of 204 g/m²/h (when in use) and the process continues until the saturation point is reached → p. 243 ⑪ + ⑮. Evaporation loss approaches zero when the pool is still if a vapour-saturated 'boundary layer' develops just above the pool surface. Therefore, the water should not be disturbed by strong air currents from the ventilation system.

Removing moisture from the pool area is very expensive using ventilation systems but it is indispensable. If the air humidity is above 70% every small heat bridge can lead to structural damage within a short time. Ventilation equipment may be fresh air or a mixed air system → p. 243, with ducts in the ceiling and floor, or ventilation box and extractor (with the air flow kept low to avoid draughts).

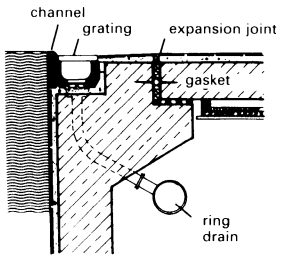
The most common structural design is a fully insulated all-weather pool with glazed panel roof and walls. Less common are non-insulated 'summer' pools (which can also be of a kind that can be dismantled). The materials used should be corrosion-proof (galvanised steel, aluminium, plastics and varnished woods): avoid plasterboard.

The pool area in most cases should include a WC and shower, and a deck for at least two reclining chairs. The layout must allow 10 m² for a plant/boiler room. When considering the width of the surrounding walkway take into account the wall surface and the likely extent of splashes → ⑦. It is essential to provide an accessible below-ground passage around the pool to contain pipework and ventilation ducts as well as to check for leaks. Space permitting, the design could also include a gym area, a sauna, a hot whirlpool, a solarium and a bar.

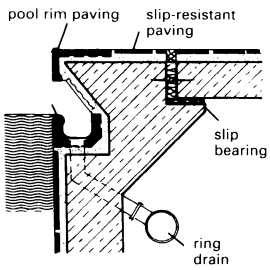
Equipment

The equipment needed for a pool includes: water treatment and filtration plant, steriliser dosing system, overflow water trap (approx. 3 m³), water softener (from water hardness 7°dH) and foot disinfecting unit (particularly if carpeting is laid around the pool). Heating can be with radiators, convectors or air heating, combined with the ventilation system, or possibly a solar energy collection unit. Under-floor heating adds additional comfort but is only worth while with floor insulation k over 0.7 or hall air temperature below 29°C. Energy savings are possible using heat pumps (cost depends on electricity price) and/or recovery heat exchanger in the ventilation system, or covering the pool (roller shutters or covering stage, but only where hall air is below 29°C) or by increasing air temperature (controlled by hygrostat) when the pool is not in use. Savings of up to 30% are possible.

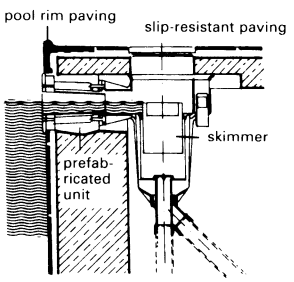
Other considerations are underwater floodlighting (safety element), slide, diving boards (if the pool depth and hall height are sufficient), shade from the sun, counter-current systems (which make small pool sizes practicable → ⑥) and acoustic qualities/noise insulation.



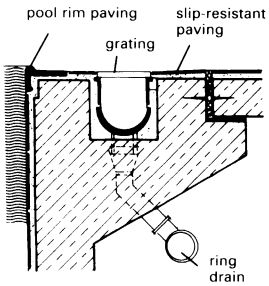
① **'Weisbaden' type pool rim overflow channel**



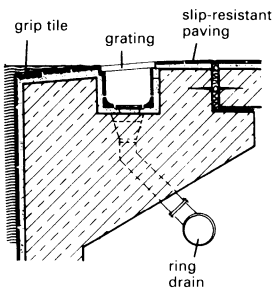
② **'Weisbaden' type poolside overflow channel**



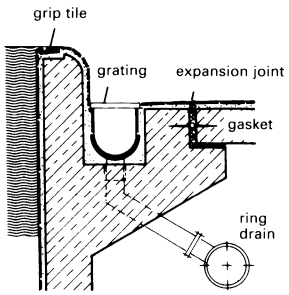
③ **Surface skimmer system**



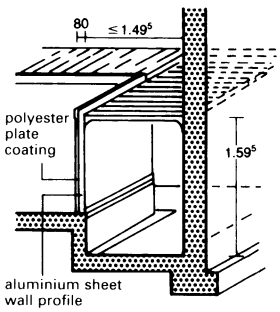
④ **Overflowing pool with rim paving and channel**



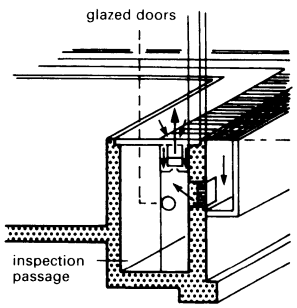
⑤ **Finnish type rim and channel**



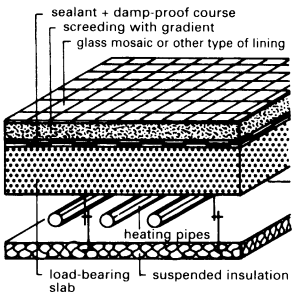
⑥ **'St Moritz' type pool rim overflow channel**



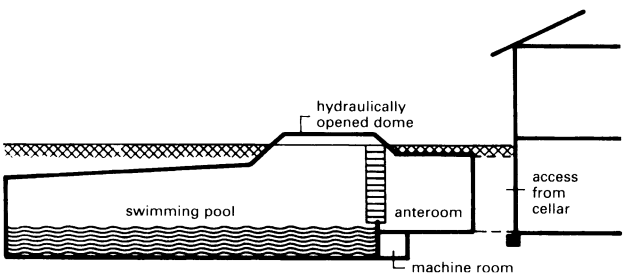
⑦ **Aluminium pool with polyester lining**



⑧ **Ventilation with motor-controlled air supply valve (simple solution)**



⑨ **Suspended underfloor heating: simple, cheap and can be easily inspected**



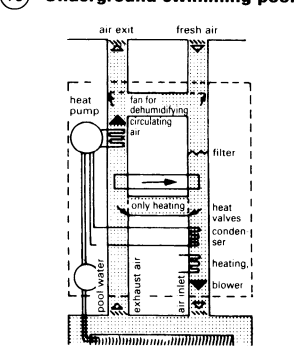
⑩ **Underground swimming pool**

water temp.	relative air humidity 50%	60%			70%
	air temperature 28°C	26°C	28°C	30°C	28°C
24°C R	21	13	0	–	0
24°C M	219	193	143	–	67
26°C R	48	53	21	2	0
26°C M	294	269	218	263	243
28°C R	96	104	66	31	36
28°C M	378	353	302	247	227
30°C R	157	145	123	81	89
30°C M	471	446	395	339	320

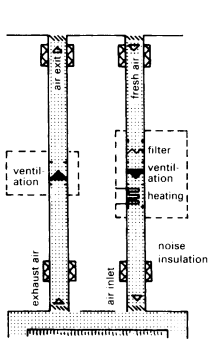
[1] temperature difference 4k water/air cannot be maintained permanently

at rest (R) and during maximum use (M)

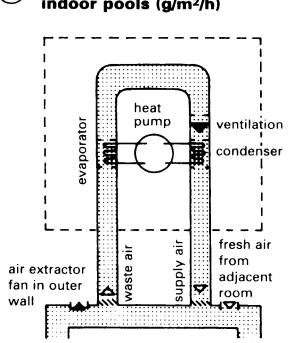
⑪ **Evaporation rates for indoor pools (g/m²/h)**



⑫ **Hybrid heat pump and dehumidification plant**



⑬ **Layout of a fresh-air ventilation plant**



⑭ **Simple plant without fresh air supply (cheaper to operate and install)**

Pools that are within the fabric of residential properties or hotel buildings are generally constructed from reinforced concrete and supported separately. It is essential that they have groundwater compensating valves to avoid damage to the pool although expansion joints are unnecessary for pools under 12 m long. Plastic pools are used only in exceptional cases because of the requirement for a surrounding inspection and services passage → ⑦. Their use is only possible with a special reinforcing support structure.

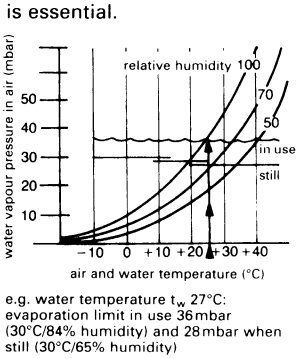
Pool linings can be ceramic tiles, glass mosaic or a simple painted layer (so long as waterproof cement has been used). Another possibility is to use a polyester or PVC film at least 1.5 mm thick to seal the pool.

The edge of the pool requires at least a surface skimmer arrangement or, better still, an overflow channel to feed the filtration and recirculation system. There are several types that can be considered → ① – ⑥.

Plan for a drainage grille at the deepest point and, possibly, a counter-current swimming system and underwater floodlights. All such fittings must be installed with sealed flanges.

The surrounding floor finish is normally slip-resistant ceramic tiles or natural stone and must be inclined towards the pool or overflow channel on all sides. It is also possible to use water-permeable carpet flooring on a damp-proof base. This improves both comfort and the hall acoustics.

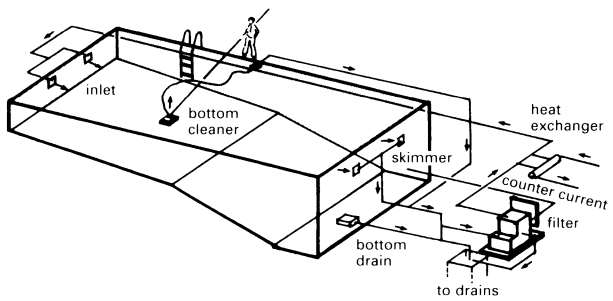
For indoor hotel pools, it is important to have large surrounding lounge areas with chairs and lockers. A separate connection between hotel rooms and the pool area is essential.



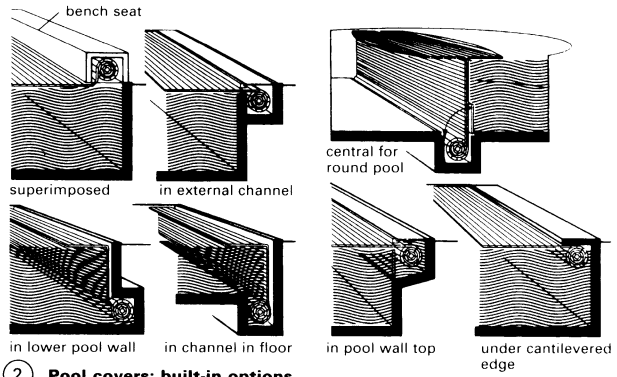
e.g. water temperature t_w 27°C: evaporation limit in use 36 mbar (30°C/84% humidity) and 28 mbar when still (30°C/65% humidity)

⑮ **Evaporation limit for indoor pool**

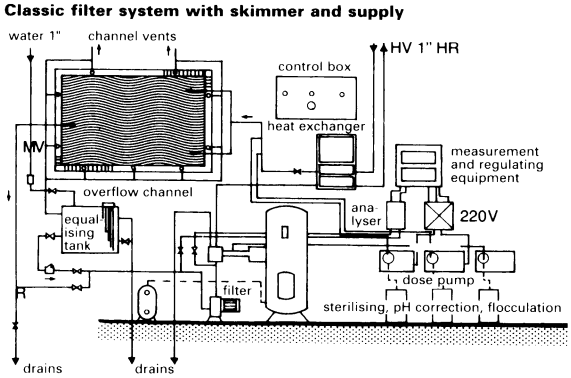
PRIVATE SWIMMING POOLS



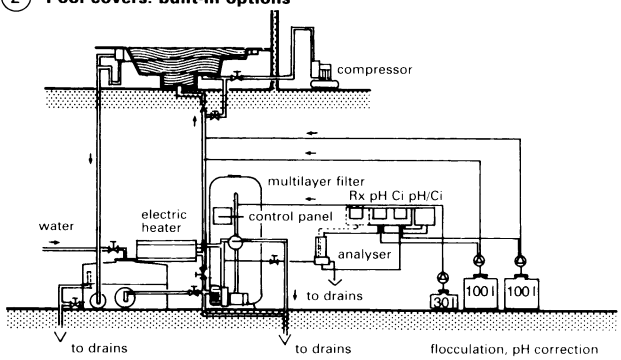
① **Classic filter system with skimmer and supply**



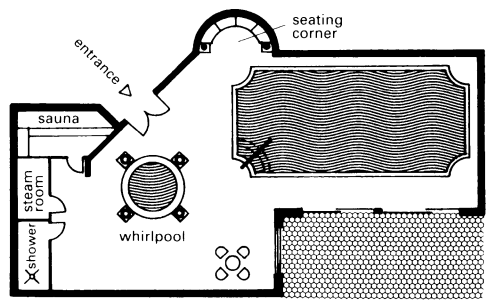
② **Pool covers: built-in options**



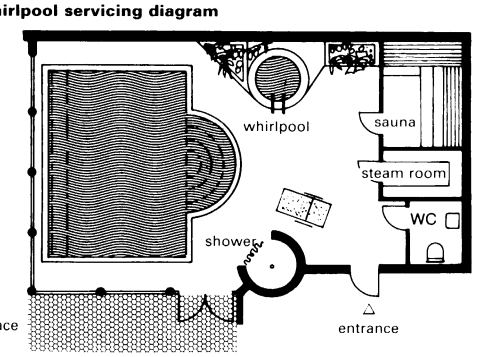
③ **Servicing diagram for pool with overflow channel**



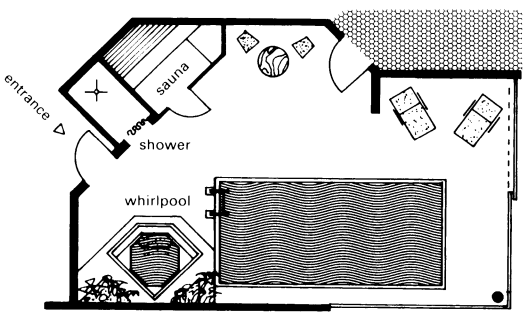
④ **Whirlpool servicing diagram**



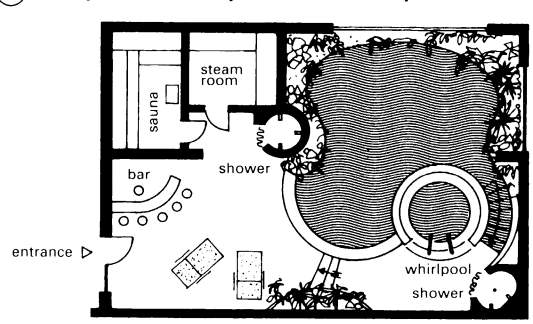
⑤ **Swimming pool, whirlpool and sauna**



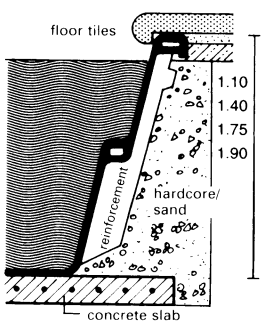
⑥ **Whirlpool, sauna and pool with roman steps**



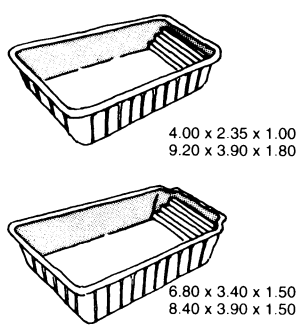
⑦ **Swimming pool, whirlpool and sauna**

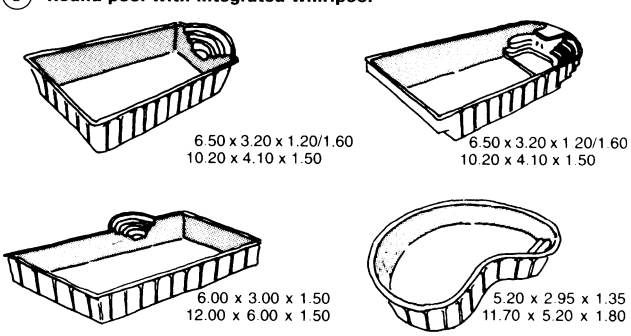


⑧ **Round pool with integrated whirlpool**



⑨ **Polyester prefabricated pool** › ⑩





⑩ **Prefabricated pools**