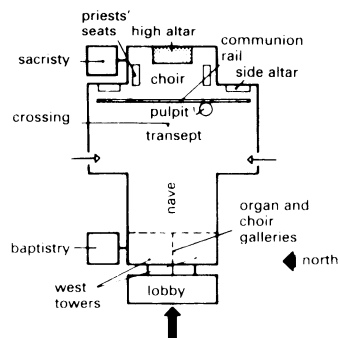
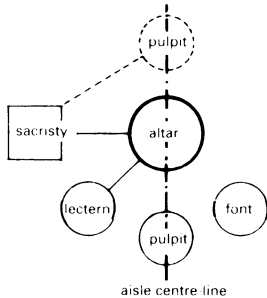


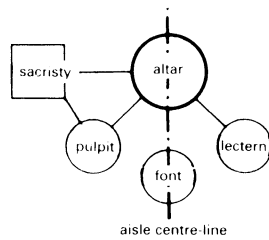
① **Layout of the Berlin Dom (Protestant cathedral) designed by Schinkel**



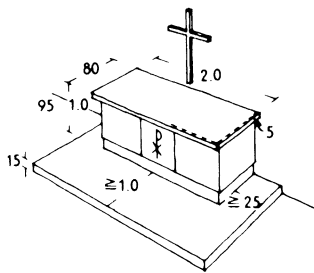
② **Layout of typical Roman Catholic church**



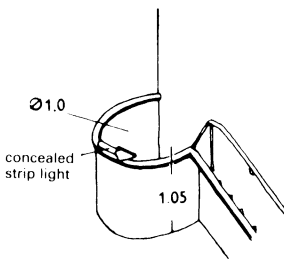
③ **Pulpit and altar on same axis**



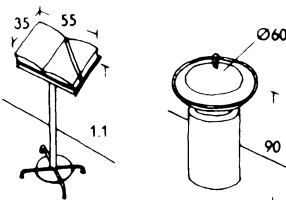
④ **Pulpit off the altar axis**



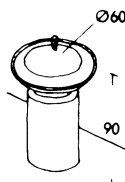
⑤ **Protestant altar table. Similar dimensions for side altars in Roman Catholic churches; main altars 3.00 length · 1.00 depth including tabernacle**



⑥ **Pulpit without sounding board (microphones have made sounding boards unnecessary)**

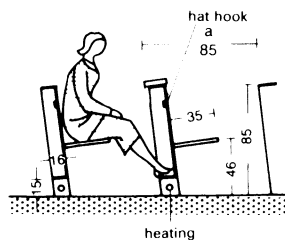


⑦ **Lectern (typical dimensions)**

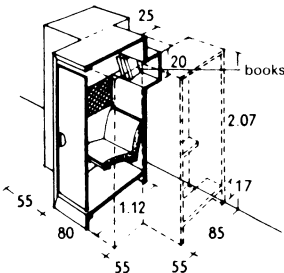


⑧ **Font (typical dimensions)**

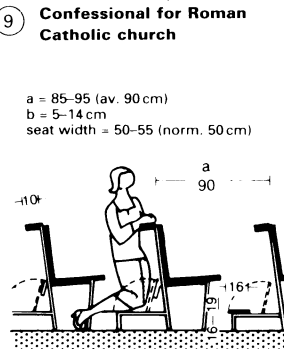
a = 80–90 (av. 85 cm)  
seat width = 50–55 (norm. 50 cm)



⑨ **Confessional for Roman Catholic church**



⑩ **Seating in Protestant church (without kneeler)**



⑪ **Seating in Roman Catholic church (with kneeler)**

Since churches are places of worship, the form of the building should be derived from the worship and the liturgy. Each individual diocese or sect has guidelines for its own churches, but local regulations on places of assembly should also be observed.

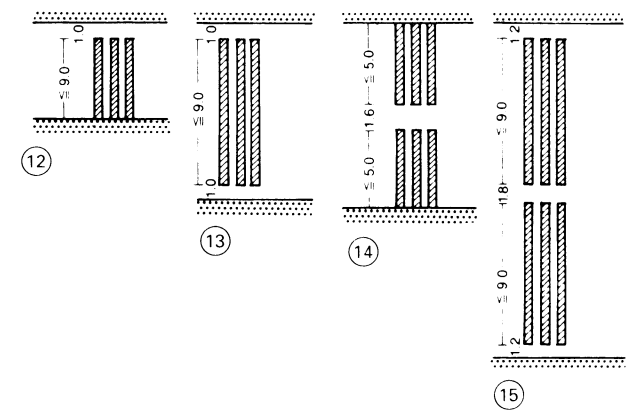
Once, all Christian churches were Catholic. They were places for the 'servants of God' to worship. The common people often had to remain outside in the courtyard, in 'paradise'. The church was a sacred building, profoundly symbolic in its plan (cruciform), direction (choir in the east) and dimensions, and in all liturgical details. Later the whole congregation was admitted into the nave. The choir, with the high altar (a tomb with relics of saints), was separated by a grille, and in larger churches the central area, the 'heart of the church', was reserved for the clergy.

The space requirements are 0.4–0.5 m<sup>2</sup> per seat without a kneeler bench (Protestant) · 10, and 0.43–0.52 m<sup>2</sup> per seat with a kneeler bench (Catholic) · 11, not including aisles. The arrangement and form of seating is of great importance for the spatial effect, audibility and visibility. For smaller churches (or chapels), one side aisle, 1 m wide, with benches for six to ten people, is sufficient · 12, or one central aisle, 1.50 m wide, with seating on either side · 14. However, external walls can feel very cold, so two side aisles with benches between for 12–18 people are better · 13. Wider churches will need correspondingly more aisles · 15.

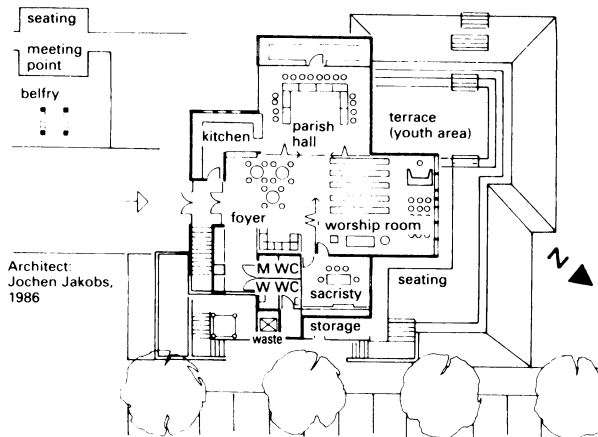
The total area required for standing room varies between 0.63 and 1 m<sup>2</sup>. A large area of the aisle space, particularly along the back wall, is commonly used for standing. The width of the exit doors and stairs must comply with the same regulations as for other places of assembly (e.g. theatres and cinemas). The central aisle on the axis of the altar is useful for funerals, processions etc. · 3, but is a disadvantage to the preacher if the lectern is on the same axis, as is often required in Protestant churches.

Churches should always have a clergy house attached to them. Where appropriate, the advice of the Diocesan Commission should be sought for new buildings, conversions and refurbishments. In certain cases, approval must be given by the Bishop's representative. Vatican II has brought in a new orientation in Catholic church building.

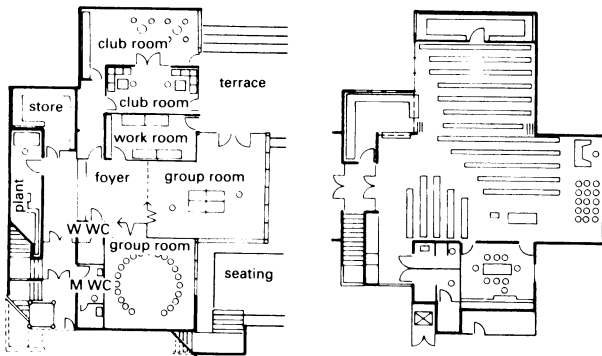
The altar is the Lord's table (the communion table), the centre of the celebration of the Eucharist and often the focal point of the building. In churches, altars must have a top (mensa) of natural stone, but the support (stipes) can be of any material provided it is durable and worthy. In other places of worship, portable altars of a worthy material may be used. The altar should be 95 cm high, and free standing so that it is possible to walk around it easily · 5. The priest celebrates behind the altar facing the congregation. Relics of martyrs or saints may be set into the altar or sunk into the ground beneath it.



⑫ – ⑮ **Minimum width of churches depending on aisle arrangements**

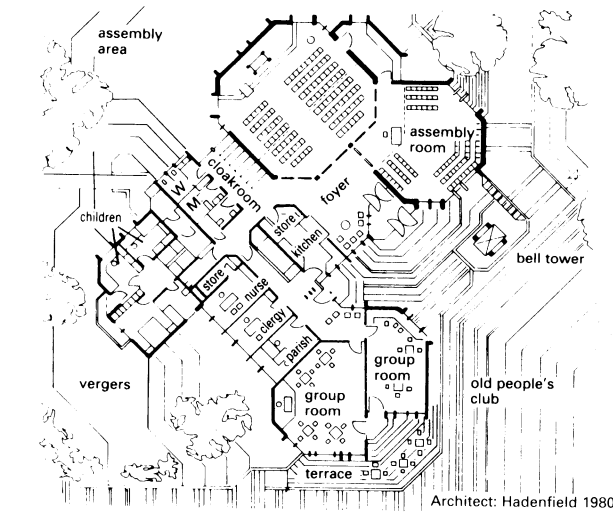


① Ground floor of parish centre in Widdersdorf, Cologne → ②-③

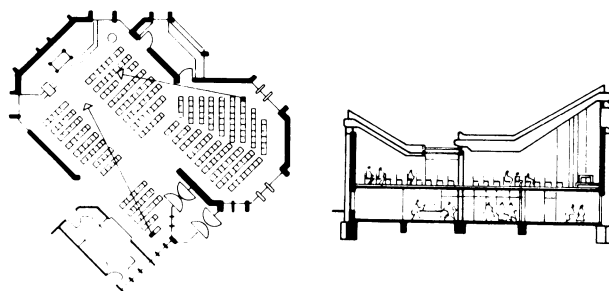


② First floor → ①

③ Ground floor: multi-use, 180 seats → ①



④ Ground floor of the Hoffnungskirche in Porz, Cologne



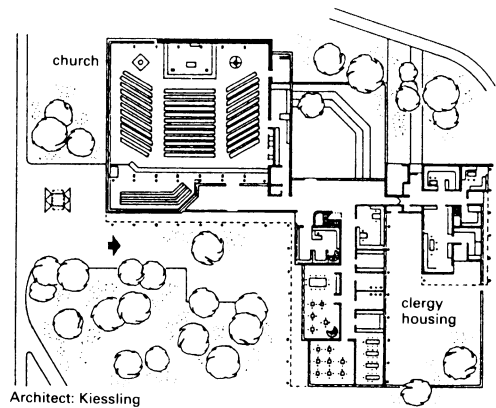
⑤ Service seating 254 → ⑥

⑥ Section → ⑤

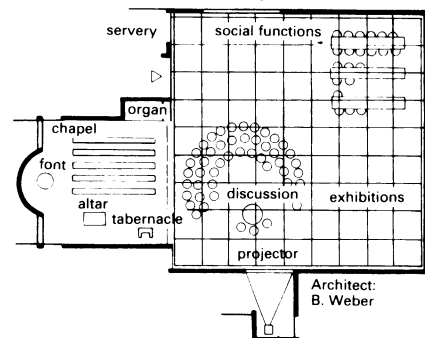
In larger churches or cathedrals (the seat of the bishop), side chapels with ancillary altars may be built. The chancel should be slightly raised for good visibility, and suitably set off from other areas. As well as the altar, a table is required for the missal (Gospels) and the vessels, and also a seat for the priest and servers (not a throne), usually at the vertex of the altar facing the congregation. A fixed lectern (ambo) is also necessary. The sermon (homily) and intercessions should be given from the right as seen by the congregation. Communion benches are no longer obligatory. Side altars in Roman Catholic churches are movable or in lockable recesses  $\geq 2.00\text{m}$  wide and  $3\text{m}$  deep.

The nave should have benches for worshippers to sit and kneel (and in France, also low chairs with high backs). If absolutely necessary, install an amplifier system with microphones at the altar, the priest's chair and the lectern. Locate seats for the choir and musicians near the organist; galleries are not usually suitable. The organ loft needs expert acoustic and spatial planning in advance, as does the bell tower (see following pages). The Blessed Sacrament is kept in a secure tabernacle at a place marked by the sanctuary lamp. In front of the tabernacle place a table for the vessels and kneelers for private prayer. The 14 stations of the Way of the Cross, with symbolic, artistic depictions and the crosses of the 12 apostles, are distributed evenly for people to walk around. A baptistery with the font can be in the nave or in a side chapel. Confessionals in Roman Catholic churches are next to the choir or in the side aisles, and if possible can be entered from two sides.

The sacristy is used to keep robes and vessels and to prepare the services, and should be situated near the altar. Ventilation, heating, toilets, disabled access and seats for people with impaired hearing, as well as sufficient parking space, complete the brief.



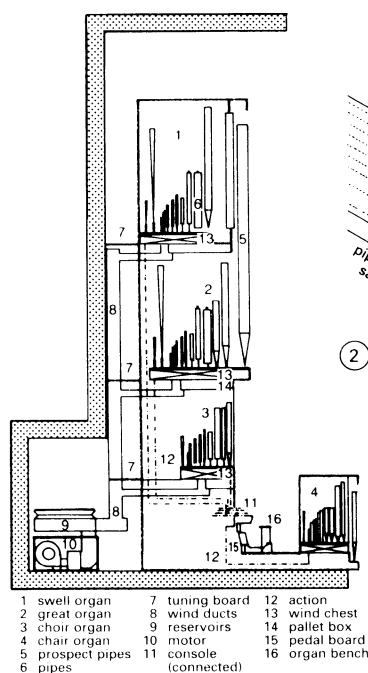
⑦ Catholic parish centre in Burglengfeld



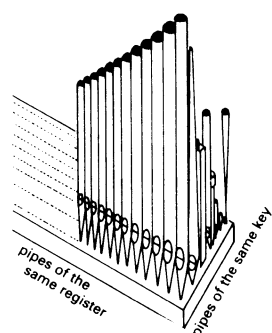
⑧ Possible different usage of space

## CHURCH ORGANS

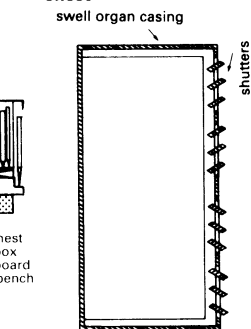
The organ in a church or concert hall is a work of art incorporating musical, architectural and technical aspects. There is no fixed form. The design is based on the technical requirements of the organ, and each organ is unique. The organ is an integral part of a space and of the architecture. The space and the organ must be planned together. At the beginning of the planning process, the architect and the organ builder should work together. The problems are complex and cannot be solved by the architect alone. The external appearance of the organ should match its inner structure. The factors affecting this are the volume of the space, the acoustics of the space, the position within the space, the number of seats and the musical requirements (solo instrument, accompaniment). The better the acoustics and the better the positioning of the organ, the smaller the organ needs to be. The optimum reverberation time is 3–4 seconds in a full space with high diffusion and good reflection from the rear wall, the side walls and the ceiling. The frequency range of an organ is between 16Hz and over 10000Hz. The sound is better in front of, rather than behind, the organ. The sound in any space is best on the main/longitudinal axis. The units for determining musical capacity are register and number of stops → 12. In small spaces, one register requires 60m<sup>3</sup>, medium-sized spaces require 100m<sup>3</sup> per register and larger spaces 150m<sup>3</sup>. If the acoustics for the organ are not good (reverberation time under 3.5 seconds), 10% must be added to these figures. Organs actually consist of a number of different organs which are normally contained in a wooden frame or filled structure. Rough guidelines for the proportions are shallow rather than deep, and high rather than wide. Ensure that the space is sufficiently high. The casing is open at the front near the prospect pipes. These may only begin at head height (approx. 2m). The rear wall has many doors to allow the organ to be tuned and maintained → 1. Tuning boards are 50–80cm wide. The face of the organ is known as the prospect and holds the prospect pipes, which are made of a tin/lead alloy and are visible from the front. The prospect should preferably match the structure of the organ(s). The pipes produce the sound. Their shape (cylindrical, conical, open, covered), dimensions (narrow/wide) and material (tin/lead alloy, wood) determine the tone colour. For technical reasons, wind chests are always rectangular in plan. Organs with a round plan form should be large enough to house a rectangular wind chest.



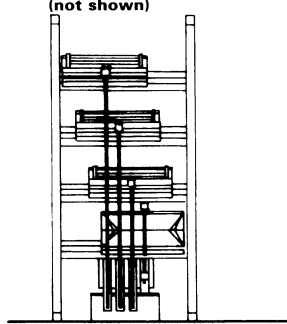
1 Section through organ, four manuals; pedal to the side (not shown)



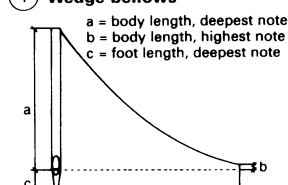
2 Pipe arrangement on wind chest



3 Swell organ



4 Wedge bellows



5 Dimensions of blower and reservoirs

blower (incl. motor casing)					
registers (no.):	10	20	30	40	
length (cm)	85	85	120	150	
width (cm)	65	75	110	120	
height (cm)	60	60	110	135	
reservoirs: no. of organs					
	1	2	3	4	5
length (cm)	70	110	160	200	300
width (cm)	50	60	80	100	130
height (cm)	20	30	30	35	40
varying blown pressure may necessitate wedge bellows (to side/behind organ), in housing to following dimensions:					
length	300–400 cm				
width	110–150 cm				
height	130–390 cm				

6 Rank of pipes of an open B flat register

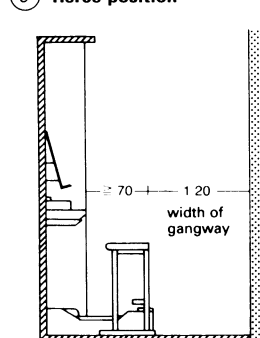
		32'	16'	8'	4'
manual	a	1000	488	240	119
56 notes	b	38	19	9.5	4.8
C-9"	c	90	50	30	18
pedal	a	1000	488	240	min
30 notes	b	159	78	38.6	dimen-
C-9"	c	90	500	30	sions

7 Table with pipe bodies



8 Diatonic pipe arrangement (C and C sharp side)

9 Tierce position

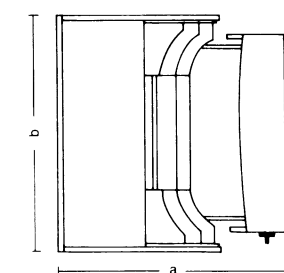


10 Plan of manual console

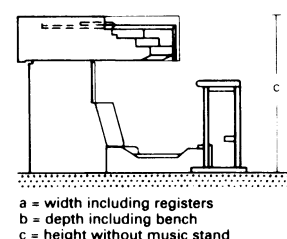
11 Section → 10

seats	registers	no. of organs incl. pedal boards	lowest main register great organ	pedal board	type of organ
100	3–7	1	2'	none	A chest/positive
200	8–12	2	4'	8'	B positive
300	12–20	2	4'–8'	8'	C small
400	20–30	3	8'	8'	D
500	25–35	3–4	8'	16'	E
600	30–40	4	8'	16'	F
700	35–45	4	8'	16'	
800	40–50	4	8'–16'	16'	
900	45–55	4	16'	16'	G
1000	50–60	4–5	16'	16'	
1250	60–70	4–5	16'	16'–32'	H
1500	70–80	5	16'	16'–32'	
1750	75–85	6	16'	32'	I
2000	80–90	6	16'	32'	
2500	90–100	6	16'	32'	

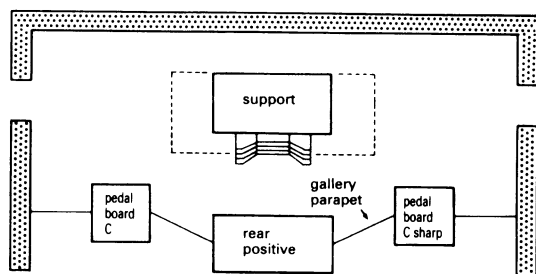
12 Formula for determining number of registers (according to H.G. Klais)



13 Plan of free-standing console



14 Section → 13

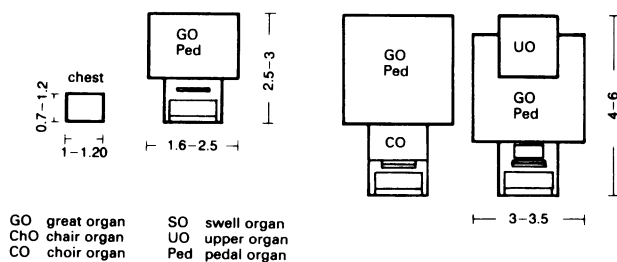


① Plan of pedal towers on the parapet

type	height (m)	width (m)	depth (flat prospect) (without tuning board)	
③ - ④	0.6 - 0.8	1 - 1.2	0.7 - 1.2	chest h = 0.6-0.8m
⑤	2.5 - 3	1.6 - 2.5	0.8 - 1.6	positive
⑥	4 - 6	3 - 3.5	1.2 - 1.8	small organ
⑦	6 - 7	5.5 - 6.5	1.2 - 2	II manuals/GO 8'/Ped 8'
⑧	6.5 - 9	4.5 - 7	1.5 - 2.5	II manuals/GO 8'/Ped 16'
⑨ - ⑩	7.5 - 10	7 - 9	2 - 3	III man./GO 8'-16'/Ped 16'
⑪ - ⑫	9 - 13	8 - 12	2 - 4	IV-V man./GO 16'/Ped 16'-32'

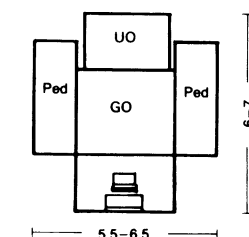
dimensions given for the depth of the organ casing are meant solely as a guideline; if the organs are arranged one behind the other with a projecting prospect the organ will require more space

② Summary of casing sizes → ③ - ⑫

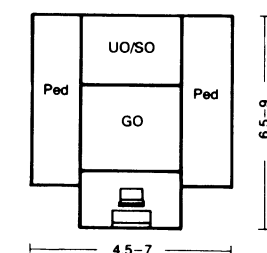


③ - ④ → ②

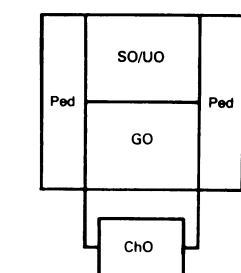
⑤ - ⑥ → ②



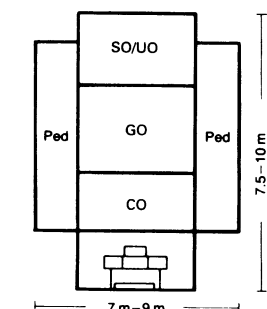
⑦ → ②



⑧ → ②



⑨ → ②



⑩ → ②

The console should be firmly connected to the organ when using a mechanical action. This is the only way to ensure short actions and an optimum touch. Electric actions (direct electric and electro-pneumatic) allow the console to be placed as far from the pipes as required, but normally the console is built into the front of the organ. In the case of a prospect organ, the console can be positioned to the side, but only rarely behind the organ.

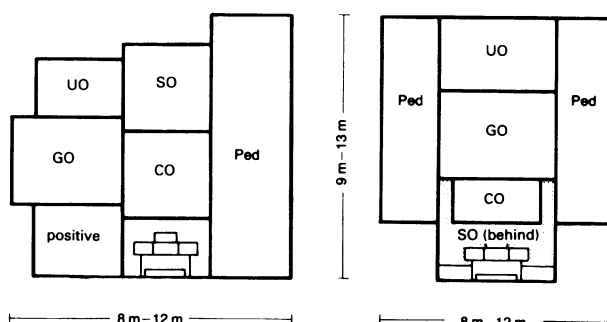
A free-standing console must be in a central position in front of the organ, at a maximum distance of 2.00m. The organist should be facing the instrument (→ 570 ⑬ - ⑭). The mechanical devices connecting the console to the wind chest of the organ are called actions. They should be short and simple. The bellows consist of a blower, reservoirs and wind ducts leading from the bellows to the wind chests. Bellows are normally in the base of the organ, but can also be behind or to the side. Large bellows systems are in separate bellows chambers, particularly in concert halls.

Organs need not necessarily be housed in a gallery. They can also be located in the sanctuary or in a 'swallow's nest'. Avoid fitting them in towers, in deep recesses or in front of large windows (cooling surfaces). Do not impede the sound reflection with timbers or arches. In a concert hall, the organ should be positioned close to the stage.

In any building housing an organ, the humidity should be even throughout the year (optimum 60%) if possible. The limits are between 45% and 80% air humidity, with no draughts or rapid variations in temperature. Allow the organ 10 hours to warm up and to cool down. There should be no windows near the organ, and none behind it. If possible, install heat-insulated walls behind and to the sides of the organ, with hard, reflective surfaces. Do not place the display pipes in direct sunlight, and avoid floodlights.

Organs need regular maintenance. Leave tuning gangways behind the organ 50-80cm wide. Projecting organs should be accessible from below. Rostra for the choir and orchestra should be in front of organ.

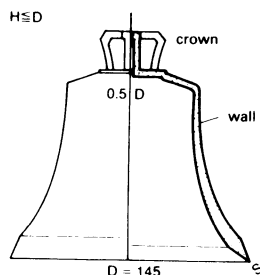
The weight of an organ can range from 100kg per register for choir organs to 600kg per register for pedal organ bases, including frames and casework. Free-standing consoles with two keyboards weigh up to 250kg, and those with three manuals up to 300kg. The preponderance of point loads means that it may be necessary to fit load distributors.



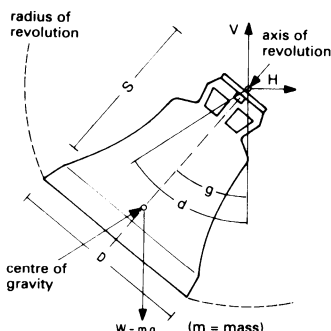
⑪ → ②

⑫ → ②

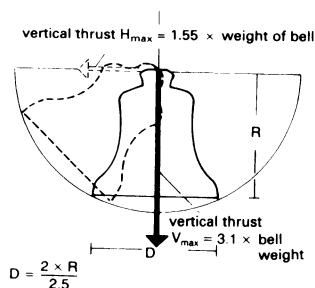
## CHURCHES: BELLS, TOWERS



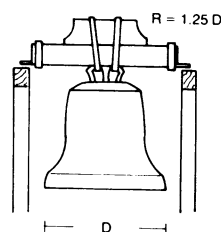
① Bell proportions



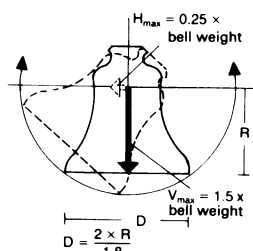
② Specifications



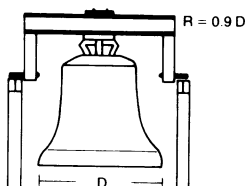
③ Horizontal thrust



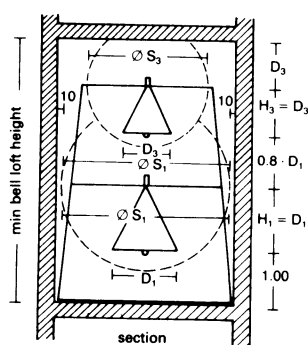
④ Straight yoke



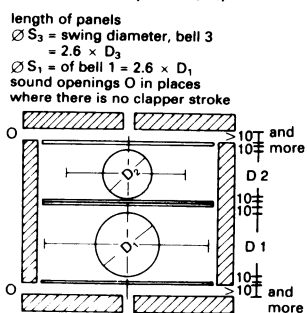
⑤ Suspension near the centre of gravity



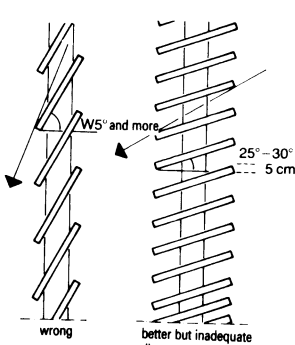
⑥ Returned steel yoke



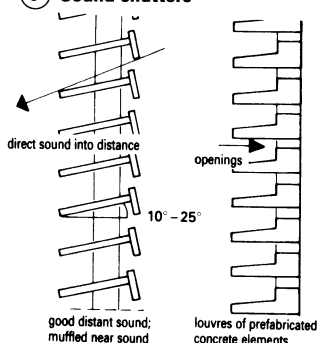
⑦ Dimensions of bell chamber (minimum)



⑧ Plan → ⑦



⑨ Sound shutters



⑩ Sound shutters

Before planning, consult a bell specialist about the size and pitch of the bells, and their acoustics and weights. The foundryman designs the bell frame as the basis for the dimensions of the bell chamber and sound openings. He also provides the expected loads for the structural engineer. The structural engineer must take both static and dynamic loads into consideration. The inherent frequency of the tower must not resonate with the frequency of the bells.

The weight, alloy and thickness of the bell walls determine the volume of sound. Today, electric ringing machines are often used. Steel bells are about 15% larger in diameter and about 25% lighter than bronze bells, but are rarely manufactured nowadays → ①.

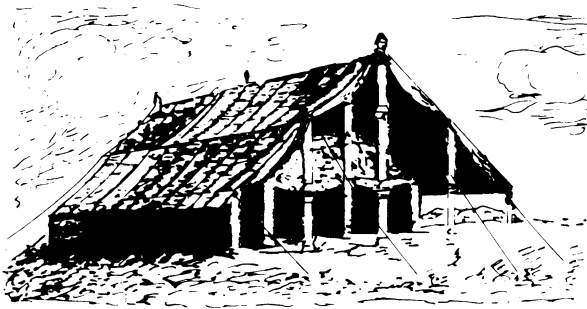
The bell tower is, by definition, a solo musical instrument and forms an orchestra with neighbouring bell towers. The desired hearing distance determines the height of the bell loft in the tower, which should be above surrounding buildings. The quality of the bell tone depends on the material and acoustic design of the building. The tower is insulated against structure-borne sound. In this respect, free-standing towers have advantages such as access hatches for installing and changing bells, and accident-proof access to the bell loft for maintenance (stairs instead of a ladder).

The bell loft is a resonance and mixing chamber and determines the musical quality of the radiated sound. The loft is completely closed apart from the sound openings → ⑦ + ⑧.

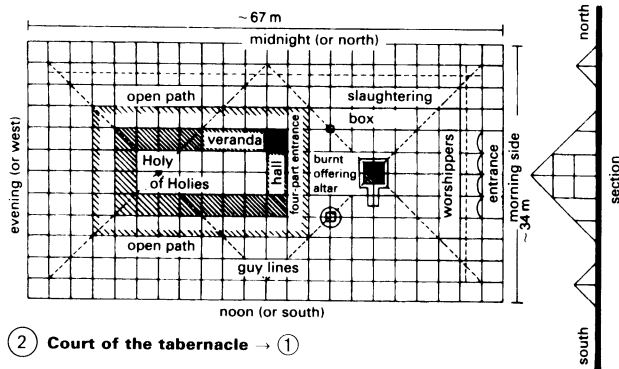
The sound openings are at right angles to the direction of the bell swing. A lot of small openings are better than a few large ones. The sound radiation angle should not be more than 30° from the horizontal to protect the neighbourhood. The striking of the clapper should not radiate. This should be taken into account when positioning the sound shutters. The total openings should be a maximum of 5% of the interior walls of the bell loft if the walls have a smooth surface, and a maximum of 10% if they have a rough surface. Concrete floors and ceilings can be covered with wood → ⑨ + ⑩.

	bell diameter d (mm)	bell weight W (kN)	bell diameter d (mm)	bell weight W (kN)	bell diameter d (mm)	bell weight W (kN)
	walls					
pitch	light		medium		heavy	
F°	2250	58	2320	71		
F° sh.	2120	48	2220	59		
G°	2000	40	2100	50		
G° sh. A° fl.	1880	34	2000	41		
A°	1780	28	1880	35		
A° sh. B°	1680	24	1760	29		
B°	1580	20	1660	24		
c°	1480	16	1570	20	1680	31
c° sh. d° fl.	1400	14	1475	17	1580	25
d°	1325	11	1390	14	1500	21
d° sh. e° fl.	1240	10	1310	12	1410	17
e°	1170	8.0	1240	10	1330	15
f°	1110	7.0	1170	8.0	1250	13
f° sh. g° fl.	1035	5.5	1100	7.2	1175	11
g°	980	4.6	1040	6.0	1110	9.0
g° sh. a° fl.	930	4.0	980	5.0	1040	7.2
a°	875	3.2	925	4.3	985	6.2
a° sh. b°	830	2.8	870	3.5	930	5.3
b°	780	2.3	820	3.0	880	4.3
c°	740	2.0	775	2.5	830	3.7
c° sh. d° fl.	690	1.6	730	2.1	780	3.2
d°	650	1.4	690	1.7	735	2.6
d° sh. e° fl.	600	1.1	645	1.5	690	2.1
e°	575	0.90	610	1.2	650	1.7
f°	550	0.80	580	1.0	620	1.5
f° sh. g° fl.	510	0.65	545	0.80	595	1.2
g°	480	0.55	510	0.70	550	1.0
g° sh. a° fl.	450	0.45	480	0.59	525	0.90
a°	425	0.38	455	0.50	495	0.75
a° sh. b°	390	0.32	430	0.40	465	0.65
b°	370	0.25	405	0.35	440	0.50
c°	350	0.20	380	0.30	415	0.43

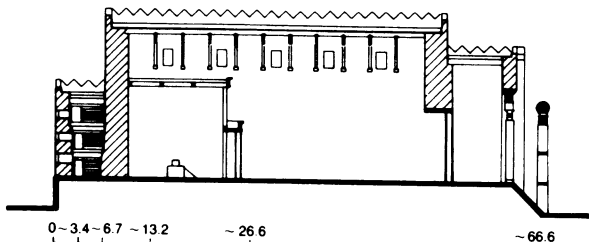
⑪ Characteristic values of bells



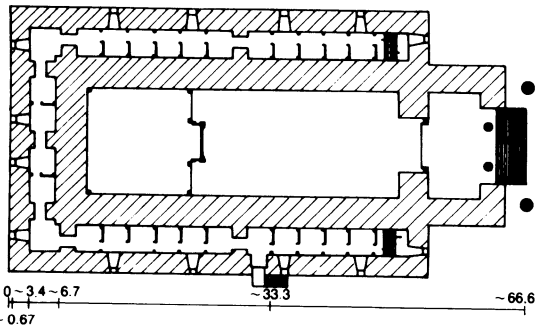
① Meeting tent (tabernacle): Jews' first place of worship



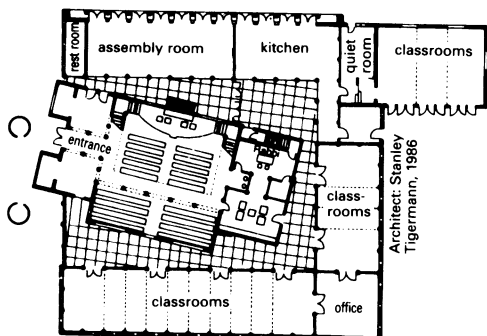
② Court of the tabernacle → ①



③ Temple of Solomon, Jerusalem: longitudinal section → ④



④ Plan of the Temple



⑤ Or Shalom Synagogue, Chicago: plan

God's first commission for a sacred building, with exact technical and design specifications, can be found in the passage in the Bible describing the construction of the Tabernacle (Exodus 25-27).

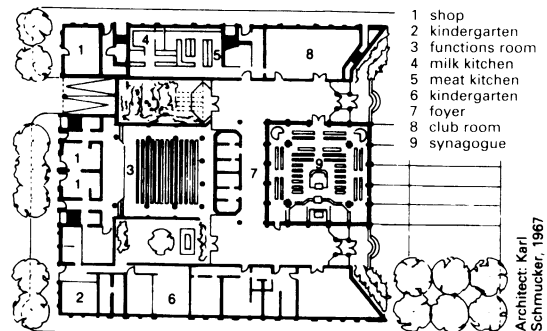
The focal point in a synagogue is not an altar but a raised preaching rostrum (almemor) with seats for the rabbi and the cantor. Extracts from the Torah are read from here. The synagogue is sited to face Jerusalem. On the front wall is an ark in which the Torah scrolls are kept (Aron Hakodesh). The ark and its contents are the holiest features in the synagogue. It is in one single section in the 'Askenasi' part of the world (European Jews), and in three sections in Sephardic areas (oriental Jews). Between the almemor and the Aron Hakodesh is an aisle used for the ceremonial procession preceding the reading from the scrolls.

The plan of every new synagogue is an attempt to solve anew the problems of the locations of the spiritual focal point, which is the almemor (i.e. a more orthodox, centralised building), and the spatial focal point, which is the Aron Hakodesh (i.e. a more modern long hall). The symbolic elements of the star of David, the seven-branched candelabrum and the Decalogue given to Moses are also essential.

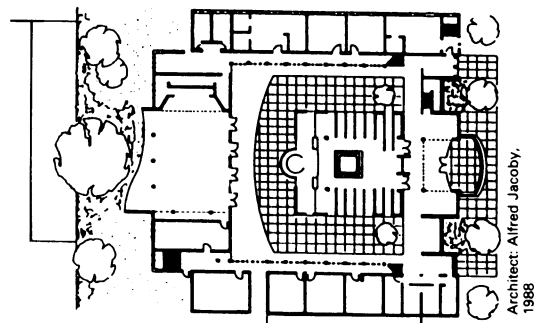
A pulpit has been included in some synagogue interiors since at least the fifth or sixth century, but they were not commonplace until the eighth century. It is used for reading texts less holy than those read at the bimah table, and for offering prayers. It is likely to be a modest piece of furniture with only occasional ornamentation.

A synagogue may be surrounded by other annexes and buildings. It may even be part of a multi-synagogue complex, as at the Great Synagogue courtyard in Vilnius. The synagogue is often part of a community centre, thus combining spaces for assembly and prayer. There is usually (at least symbolically) a separate space for women out of view of the men, often in a gallery. At the entrance there is a fountain or washstand for hand washing. The ritual bath (mikva), with immersion for women, is usually in the cellar. It should have natural running water which has not passed through metal pipes. Some liberal synagogues and Reform temples have organs, but they are never show-pieces.

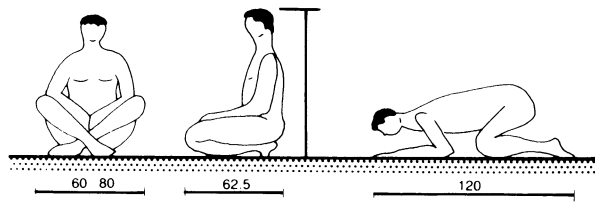
The decorations in a synagogue may not contain depictions of human beings; only plants or geometrical or calligraphic ornamentation is allowed.



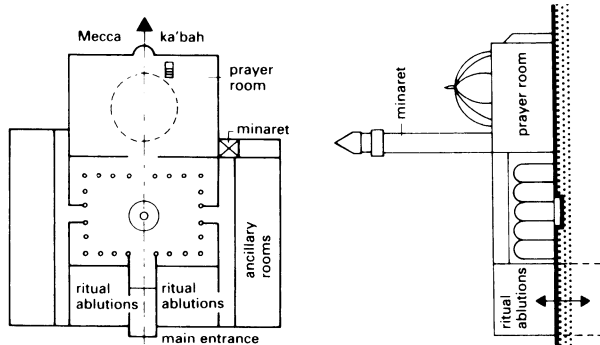
⑥ Mannheim, synagogue and community centre: plan



⑦ Darmstadt, synagogue and community centre: ground floor plan

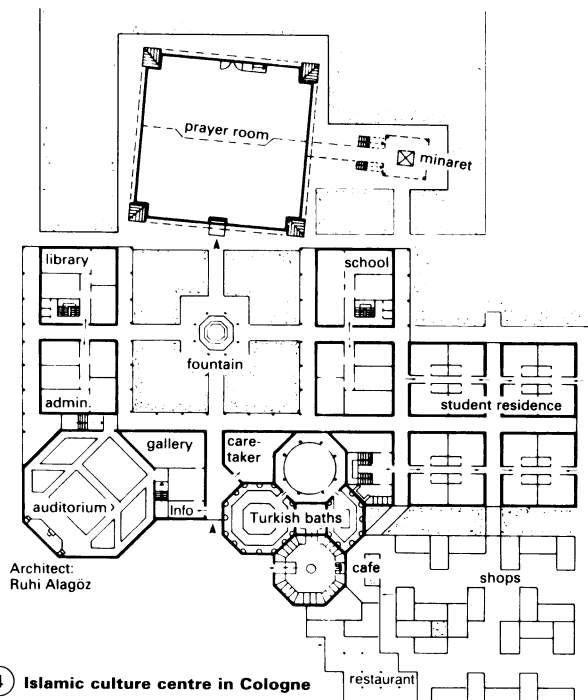


① People at prayer

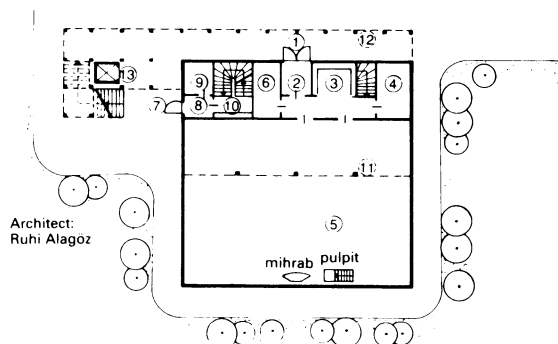


② Historical arrangement

③ Section → ②



④ Islamic culture centre in Cologne



⑤ Islamic culture centre in Frankfurt

The five basic categories of mosque design occur in seven distinctive regional styles. In the Arabian heartland, Spain and North Africa there is a hypostyle hall and an open courtyard. In sub-Saharan West Africa the hypostyle hall is of mud-brick or rammed-earth construction. Iran and Central Asia have a bi-axial four-iwan style. On the Indian subcontinent there are triple domes and an extensive courtyard. In Anatolia there is always a massive central dome. The Chinese style has detached pavilions within a walled garden enclosure, and South-East Asia has a central pyramidal roof construction.

The mosque (masjid or jamih) is a house of prayer, a cultural centre, a place for social gatherings, a courthouse, a school and a university. (In Islam, the Quran is the central source of all rules for living and teaching, and for the pronouncements of law, religion etc.)

In Islamic countries the mosque is in the bazaar (souk), and thus in the centre of public life. In countries where the amenities of the bazaar (hairdressers, shops selling permitted foods, cafés etc.) do not exist, they should be included in the planning of the mosque.

Smaller mosques (masjid) rarely have a minaret (minare), whereas larger mosques (jamih) always do. There are neither bells nor organs in Islam. The muezzin's call to prayer can be heard five times a day resounding from the minaret, which has stairs or a lift leading to the upper ambulatory, which is usually covered. Nowadays the call to prayer is virtually always relayed by loudspeakers, although this is not permitted in some countries.

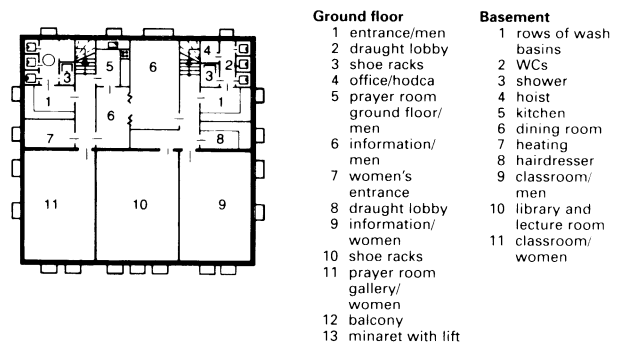
The size of the prayer hall is based on 0.85m<sup>2</sup> praying space per person. It is usually rectangular or square, often with a central dome, and faces Mecca, the direction in which people pray (qibla). The prayer niche (mihrab) is set in the front wall (qibla) and next to it is the minbar (pulpit), which must always have an odd number of stairs. This is used by the prayer leader of the mosque (the Imam) in the Friday prayers. Men and women are segregated, sometimes purely symbolically, sometimes with the women in a gallery.

The entrance area has shelves for the school, and rooms for ritual ablutions and showers which must always have a flowing water supply. The WCs are usually squatting closets at right angles to the direction of Mecca. All these facilities often have separate entrances for men and women, including the stairs to the women's gallery.

Many mosques have a central courtyard the same size as the prayer hall, which can be used on holy days as an extension. It has a decorative fountain (tscheschme) for ritual ablutions. In hot countries, trees are planted in the courtyard in a geometrical pattern to provide shade.

Offices, a library, a lecture hall and classrooms, storerooms and apartments, at least for the imam and the muezzin, complete the accommodation.

Representational depictions of humans and animals is not allowed. Plants and geometrical ornamentation (arabesque), and verses from the Quran in Arabic calligraphy, are very popular and have been developed into a form of high culture.



⑥ Basement → ⑤

Ground floor	Basement
1 entrance/men	1 rows of wash basins
2 draught lobby	2 WCs
3 shoe racks	3 shower
4 office/hodca	4 hoist
5 prayer room	5 kitchen
6 information/ men	6 dining room
7 women's entrance	7 heating
8 draught lobby	8 hairdresser
9 information/ women	9 classroom/ men
10 shoe racks	10 library and lecture room
11 prayer room gallery/ women	11 classroom/ women
12 balcony	
13 minaret with lift	

⑦ Key → ⑤⑥