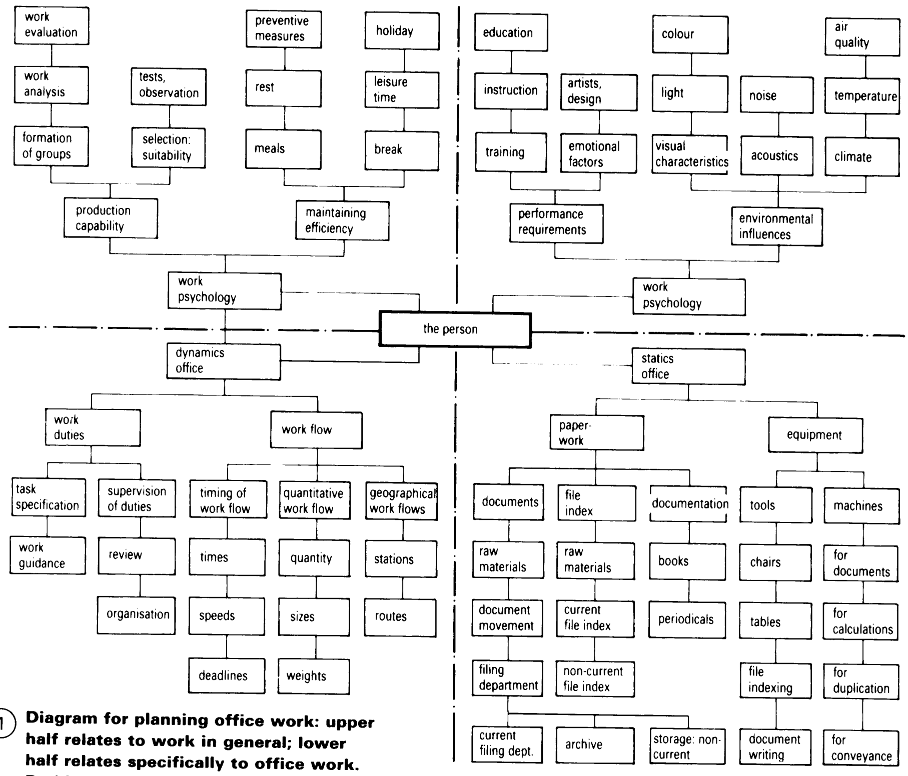
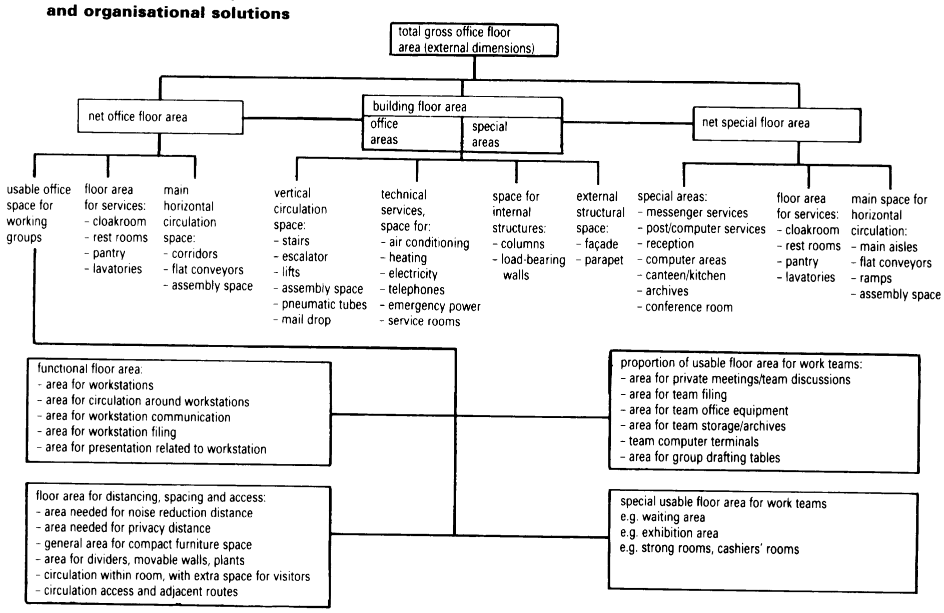
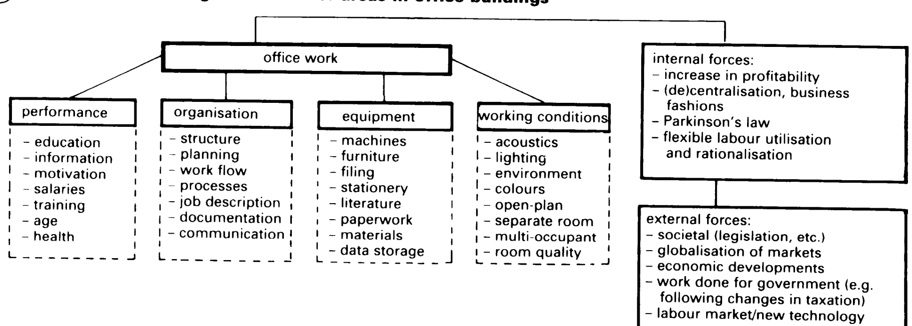


1 **Diagram for planning office work: upper half relates to work in general; lower half relates specifically to office work. Problems in the left half can be solved by preventive measures and training; those on the right require technical and organisational solutions**



2 **Organisational arrangement of floor areas in office buildings**



3 **Factors affecting office work**

PRINCIPLES

Office Work

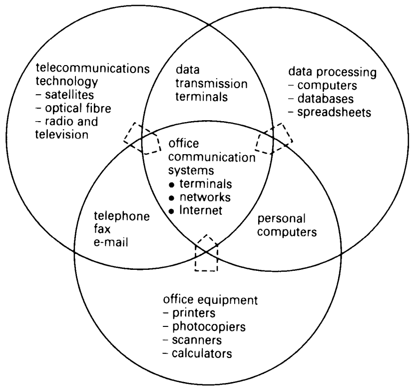
The way in which office work is organised and roles are defined (office structure, customer management, office technology) affects the requirements for office space.

Building types develop and change over time. In addition to innovative prototypes, there are types of buildings which are representative of the forces and influences around when they were built → ③. The organisation of office work increasingly focuses on human relationships and communications → ①. As office work continues to change (from the introduction of new technologies), a clear understanding of the task required becomes a significant motivating force. Designers can influence all aspects of the working environment. Good design is extremely important, and has a strong influence on job satisfaction.

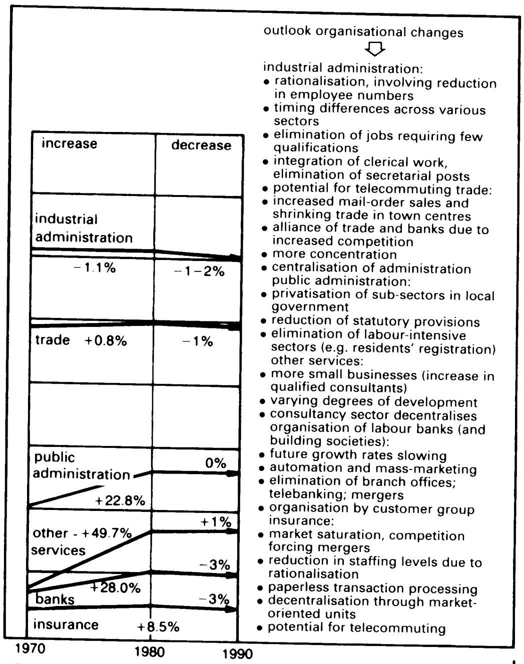
The space allocated to a person to execute a task is referred to as a workstation. This can be a private office with full-height partitions and a door, an open-plan 'cubicle' configured from systems furniture or low-height partitions, or an individual desk in an undivided space.

A large office building will consist of several different types of space → ②. (1) Office areas will have separate offices for one to three people with workstations for trainees, group offices for up to 20 people, also with workstations for trainees, and open-plan offices for up to 200 people on a single level. Some offices may combine individual workstations with areas used by groups. In an open-plan office, all spaces are multipurpose for individual or team work, except for a separate secretarial department. (2) Records areas are for the storage of files, drawings, microfilm and electronic media, filing and recording equipment, document reproduction, play-back and shredding. (3) Central clerical services areas contain dictating, duplicating, printing and photocopying equipment, and personal computers. (4) The post room handles all incoming and outgoing post. (5) Corporate display areas contain board rooms with moveable walls, exhibition areas, conference rooms and meeting rooms. (6) Social facilities should include cloakrooms, a kitchen for each floor or area, toilets, a rest area for employees, refreshment rooms, sports facilities and a dining room with a kitchen. (7) Additional spaces and extensions may be needed for training on audio-visual equipment. (8) It may also be necessary to have an entrance drive, parking spaces (possibly underground) and delivery bays. (9) Circulation spaces include corridors, stairways, lifts, and internal and external emergency exits. (10) Central services are responsible for technical equipment, air conditioning, ventilation, heating, electric power, the water supply, data processing, the computer centre, telecommunications, and cleaning and maintenance.

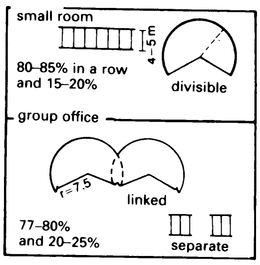
A detailed description of the company and its organisational structure, including company-specific functions and relationships, will help produce a suitable analysis of its requirements.



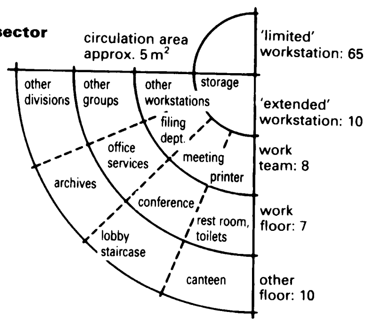
(1) **Linking telecommunications technology, data processing, and office equipment**



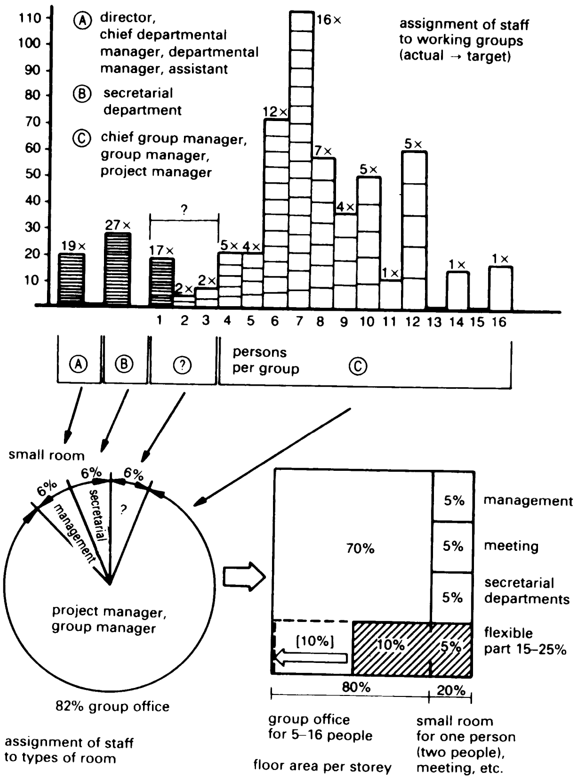
(2) **Evolution in the service sector**



(3) **Room sizes**



(4) **Daily office floor area usage (%)**



(5) **Principles of use for distribution of space**

Effects of information technology and office automation

Developments in information and communication technologies have contributed greatly to the changing working conditions in offices. Multipurpose terminals are replacing individual data-, word- and image-processing equipment, and individual systems are being networked to form integrated office communication systems → (1). Video display stations, which also require computer terminals and additional equipment, have increased the floor area needed in offices by approx. 2–3 m² to approx. 15–18 m². The effects of office automation on workstations and layout have created needs which existing office buildings can no longer fulfil. These include the greater importance given to the quality of the individual workstation, which improves flexibility, minimises operating costs, and results in working environments that are ecologically acceptable. Reorganisation of space and the modernisation of furniture and fittings are just as important as new buildings → (2).

Streamlining working procedures can potentially reduce the time spent on administrative activities (filing, sorting, copying, searching, acquisition of material etc.) and communication (conferences and meetings) by approx. 25%. Good design can minimise interruptions to the workflow. More telecommuting (work at home) compensates for the increased floor area requirement described above, but some activities (meetings, etc.) must still take place in the office building. There are also limits to the usefulness of telecommuting.

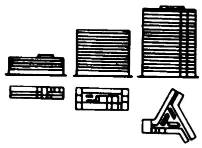
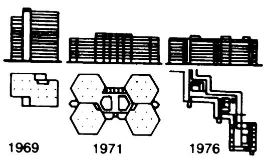
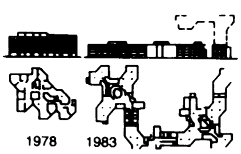
There are other forces which tend to work against potential decentralisation, and which may be very important. A centralised location may have a prestige advantage, a company's presence in a city is a symbol of continuity, and employees often prefer a communal working atmosphere and shared leisure activities. Video-conferencing, however, could reduce job-related travel by approx. 50%.

Changes in the workplace

Increased efficiency due to information technology and changes in work requirements (processes and organisational patterns) are changing office structures. Staffing levels are dropping, and working groups are getting smaller. The former hierarchical division of labour amongst staff, such as manager, secretary, senior clerk etc., often develops into an integrated working group. This in turn may change floor space allocations. A greater awareness of the immediate working environment is closely linked to current societal values. These are reflected in attitudes toward workplace quality (daylight, use of environmentally friendly products, energy conservation) and daily activities (ecological aspects, consumption of materials, waste disposal). From the employee's viewpoint, the workplace is a vital forum for social interaction. This is increasingly important because of the stress caused by new technology and formalised work structures. Rising levels of physical and psychological stress have resulted in greater attention being paid to the work environment. Office workers need sufficient space, the freedom to arrange their own furniture, good ventilation and lighting, and protection against external or unnecessary disruptions. Approximately 65% of the working day is spent in limited work areas and 10% in extended work areas → (4). Work contacts and shared equipment are becoming more important, resulting in the need for individual and shared offices and workstations → (3) + (5).

In addition to reorganisation of existing buildings, new concepts for individual and group offices are taking shape, e.g. the interconnecting group office partially divided into zones, the combined office, or the multiple or multivalent workstation, although the latter does not appear to be popular.

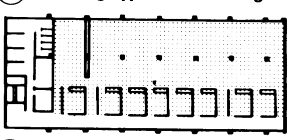
Typology

influence of function and ...	equipment	preferred locations
 1958 1961 1963 typical layout	mechanical typewriters and calculators telephone files pneumatic tube system 1950–1965	city centre and adjacent area
 1969 1971 1976 organisational flexibility	electric typewriters filing central data processing 1965–1975	business parks city edge
 1978 1983 differentiated working environment	data display terminals communications technology 1975–	city edge country

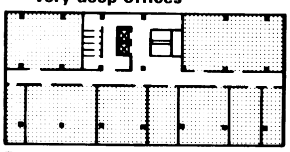
① Floor plans since 1950

time	type	equipment	process diagram
from 1950	small room: in rows, stacked	mechanical office machines telephone files	linear
from 1965	open-plan office: transparent, flexible	electric typewriters photocopier central data processing	networked
from 1980	group office: connected, articulated	decentralised data processing word processing data display terminals computers	sequential

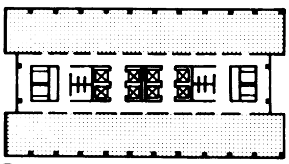
② Building type and working arrangement



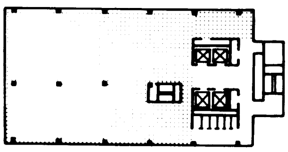
③ Economical one-row layout; very deep offices



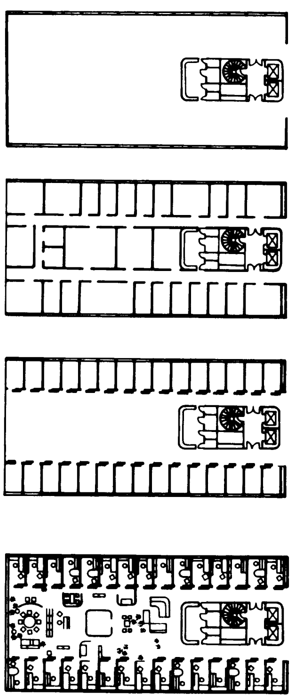
④ Double row layout



⑤ Three-row layout



⑥ Layout without corridor



⑦ First design, combined office: ESAB HQ, Tenbom Architekter AB, Stockholm. Various internal arrangements: open-plan, group, separate and combined offices

Types of office space

The layout of office space has changed dramatically since the 1950s → ①. Working methods are always closely linked to available technology → ②, and the working structure of earlier years is being expanded by modern information technology and office automation. As a result, new forms of floor plan are being generated.

After changing from separate offices in the 1950s, to open-plan concepts after the mid-1960s, and group office principles in the 1970s and 1980s, it seems that a combined office design is becoming established in the 1990s. The first examples appeared in Denmark in 1976, where new space dividers and combinations of all known basic forms were being used.

The orientation of a new office building will depend on location. Where possible, the building should be orientated to admit useful daylight while avoiding glare and solar heat gain. In the USA, the principal axis of 90% of office buildings runs east–west, since deep penetration by morning and evening sun is unpleasant. It is easy to use canopies to block the sun from the south. However, if the primary axis runs north–south, the sunlight can reach every room. In the northern hemisphere, north-facing rooms are justifiable only when the building does not have a corridor.

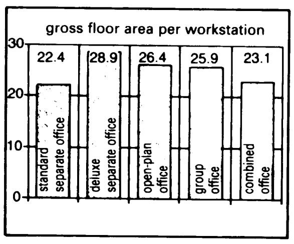
Systems

A single row of rooms is generally uneconomical, and is only justified for deep office spaces where daylight is a problem → ③. A double row of individual small rooms, all with daylight, was previously used in most office buildings → ④. A three-part arrangement is typical of high-rise office buildings → ⑤. In city centres in the USA, designs without corridors evolved. In some, all rooms (with either natural or artificial lighting) were grouped around a circulation core containing elevators, staircases, ventilation ducts etc.; in others, services were located on the periphery → ⑥.

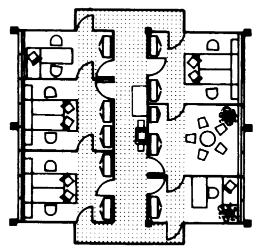
Outside the city centre, another US system had a large work space in the centre, with sound insulation, ventilation and lighting in the ceiling; small offices with daylight were placed around the edge. These combined offices were used in Scandinavia after the mid-1970s. As in the US system, the floor plan was normally 16–18 m deep. They were also built as a large open-plan office or as separate offices divided into three rows → ⑦.

Daylight can usually be used up to a distance of 7.00 m from the window. New daylight technology systems (see section on daylight) which convey and change the direction of the light (prisms and reflectors) can make more efficient use of daylight.

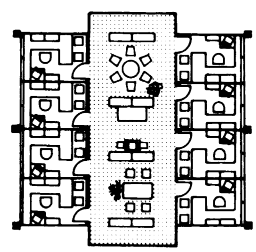
A schedule of accommodation is shown → ⑧ which compares five alternatives in order to obtain quantifiable information about floor area requirements. (1) A standard separate office, 1.25 m grid module, three module spaces only. (2) Deluxe separate office, grid module 1.50 m, various widths. (3) Open-plan office, room depth 20–30 m, floor area up to 1000 m^2. (4) Group offices for 15–20 employees, workstations no more than 7.50 m from the façade. (5) Combined office, all single rooms approx. 10 m^2 with a common area 6–8 m deep.



⑧ Types of offices and comparison of floor area requirements



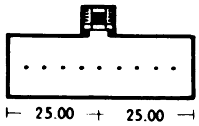
⑨ Separate office



⑩ Combined office

PRINCIPLES

Typology



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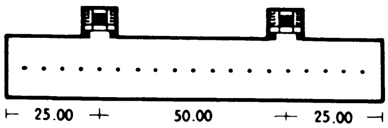

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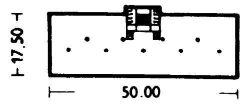

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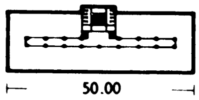

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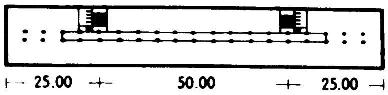

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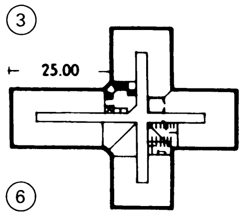

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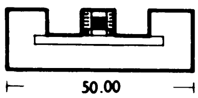

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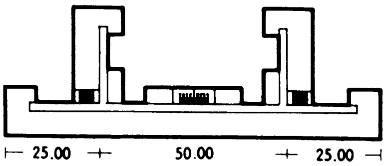

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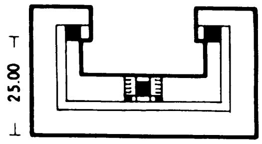

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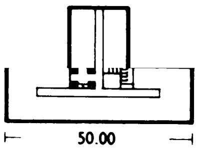

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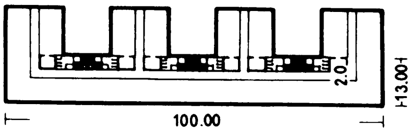

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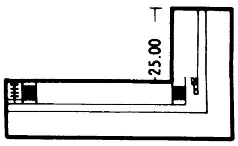

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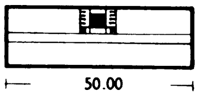

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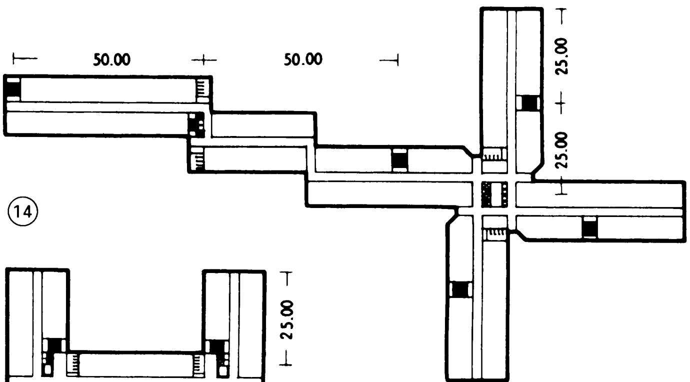

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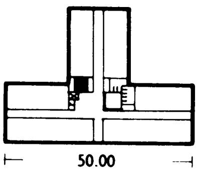

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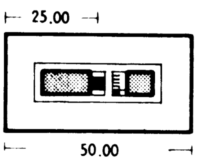

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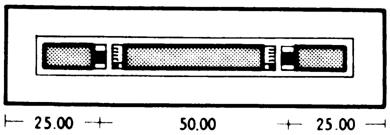

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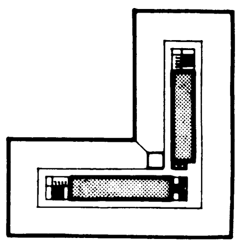

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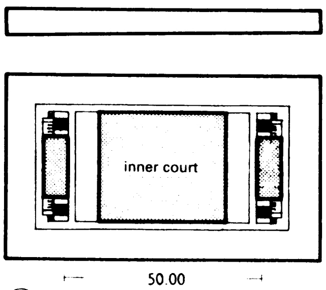

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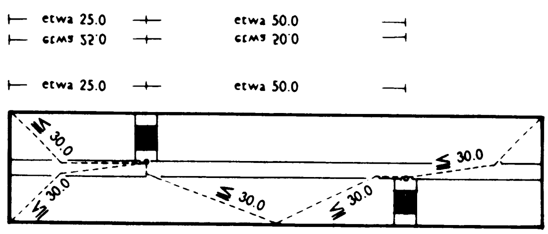


㉑ According to building codes, there must be escape stairs no more than 30m from any point in a non-work room. It is best to calculate the distance of the staircases as 25m from the site boundary and the distance between staircases as 50m → ① – ㉑

Large office buildings are usually multistorey structures with moveable internal walls → (p. 92). Service cores, containing plumbing, staircases, elevators etc., are generally located at the maximum distances specified by the building regulations. Service cores can be placed at the front of the building → ① + ②, to one side within the building → ③ – ⑤, at interior corners → ⑥ + ⑩ – ⑫ + ⑮ + ⑯, at the end of a passage → ⑧,⑨,⑪,⑫,⑭ or between corridors next to a light shaft →⑰ – ㉑, in order to maintain the greatest possible length and continuity in working spaces. A simple central rows of columns → ① + ② allows for a corridor on one side or the other according to space requirements. A double row of columns → ③ – ⑤. In such cases the corridors may be lit directly by high-level windows and/or by glass doors in the corridor wall. Daylight in the corridor may be provided economically by overhead skylights in buildings with wings → ⑩ + ⑪, and those that are short → ⑬, angled → ⑫, T-shaped → ⑮ or U-shaped → ⑯.

Lateral illumination of corridors by recesses is less economical → ⑦ + ⑧. On deep, expensive sites it is best to locate corridors, service rooms, archives, toilets and cloakrooms on interior courts or atria → ⑰ – ⑳. Elevators and toilets can be located at the interior corners of stairwells. Dark rooms, strong rooms and storage rooms should be in dark areas → ⑩ + ⑪ + ⑲.

The area required to connect functional spaces in office buildings is the circulation area. In a closed plan, this is the corridors between rooms; in an open plan, it is the paths through the workstations. Path widths need careful consideration, especially when they are part of an escape route. Disability access considerations include the width of doors and circulation routes, wheelchair turnaround clearances, and the slope and length of ramps, etc.

slope and length of ramps, etc.

Fire safety is a primary consideration in the planning of circulation routes, and should be considered at an early stage. The main considerations are the width of escape routes, the distance to be travelled, provision of alternative escape routes and the avoidance of dead-end corridors. The plan must comply with local statutory safety requirements → ㉑.

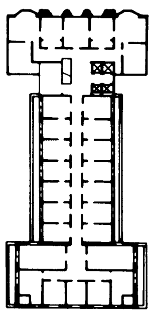
Building concepts I

The relationships between office organisation and spatial design have been classified in a field study in the USA which provided a benchmark for changes in office structures as a result of office automation.

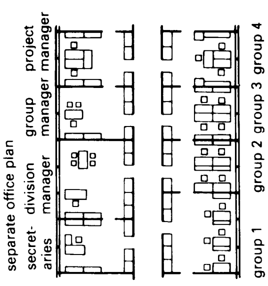
Open-plan offices are suitable for large groups of employees with a high degree of division of labour, performing routine activities with a low level of concentration. Nowadays, open plan is more the exception than the rule. The concept was developed in the 1960s to provide efficiently organised, multipurpose areas, based on arguments such as transparency and clarity of working processes, and the development of a group spirit. Data processing equipment was kept in separate rooms and was not available at each workstation. Extremely deep offices (from 20 to 30 m) resulted in the use of expensive services technology that became unsuitable when the building use changed. Modern requirements, such as windows which open, lighting and environmental control, and electric power suitable for partitioned spaces all limit potential flexibility.

Sociologists have attested to the implicit coercive nature of open-plan offices, which is caused by social control, reliance on technical equipment, and visual and acoustic disruptions. This has led to a rejection of this type of office by employees.

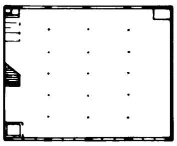
Separate offices are suitable for independent work requiring concentration, and also for multi-occupant offices for very small groups constantly exchanging information. They are still used for certain workstation requirements, and in multistorey office buildings where the structural form of the building is so dominant that it determines the spatial and organisational features of the workstations.


Architects: Dankmar Adler and Louis H. Sullivan, 1892

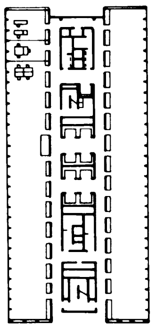
(1) **Separate office, Garrick Building, Chicago**



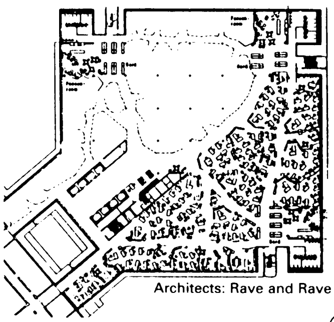
(2) **Separate office variants (Henkel)**


Architect: William LeBaron Jenney, 1879

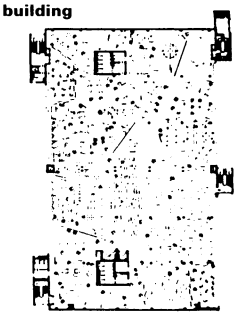
(3) **Open-plan office, Leiter Building I, Chicago**


Architects: Hentrich and Petschnigg, 1954–57

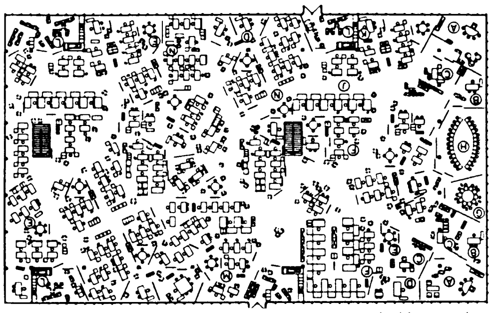
(4) **Three-row division layout: BASF AG administration building**



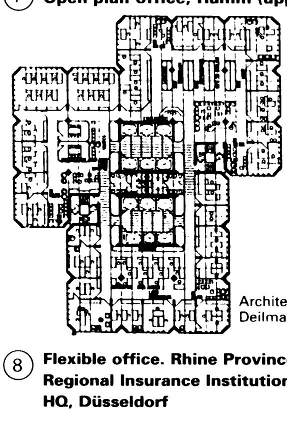
(5) **German Federal Employment Office HQ, Berlin**


Architect: Walter Henn, 1962

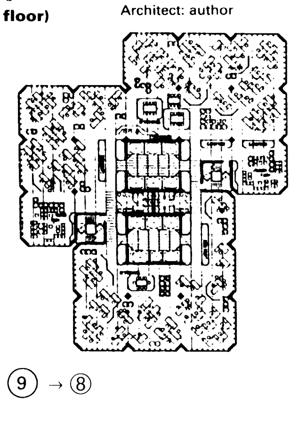
(6) **First open-plan office with 270 workstations in Germany (5th floor, former warehouse)**


Architect: author

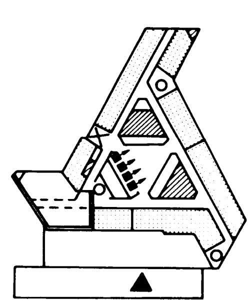
(7) **Open-plan office, Hamm (upper floor)**


Architect: Deilmann

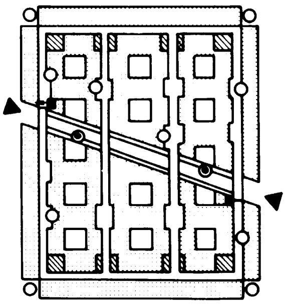
(8) **Flexible office. Rhine Province Regional Insurance Institution HQ, Düsseldorf**



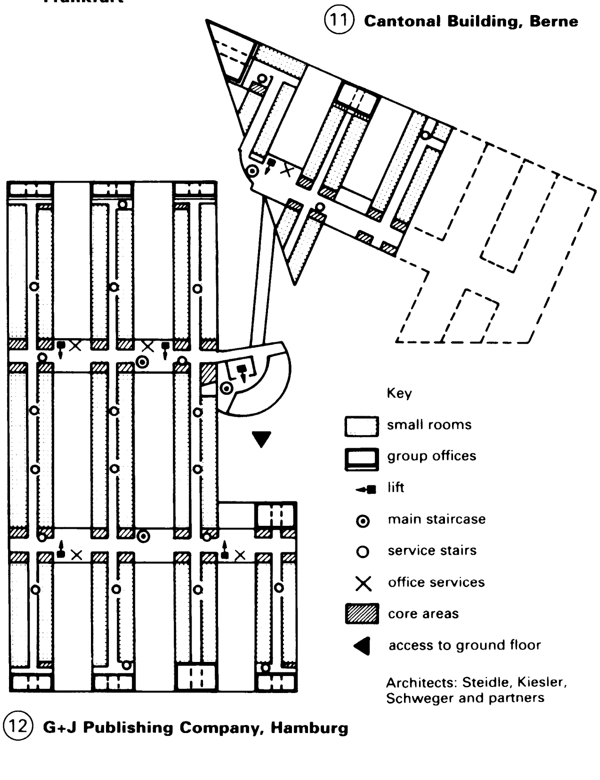
(9) → (8)


Architects: Nowotny-Mähner, HPP, Speer and partners

(10) **Bank für Gemeinwirtschaft, Frankfurt**

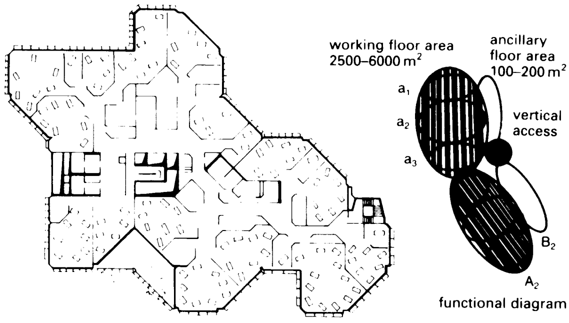

Architects: Matti, Bürgi, Ragaz, Liebefeld

(11) **Cantonal Building, Berne**



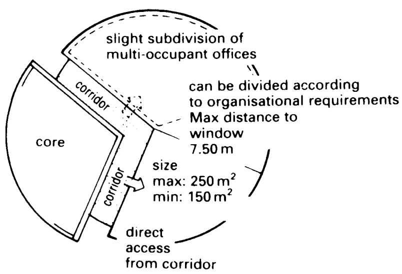
Architects: Steidle, Kiesler, Schweger and partners

(12) **G+J Publishing Company, Hamburg**

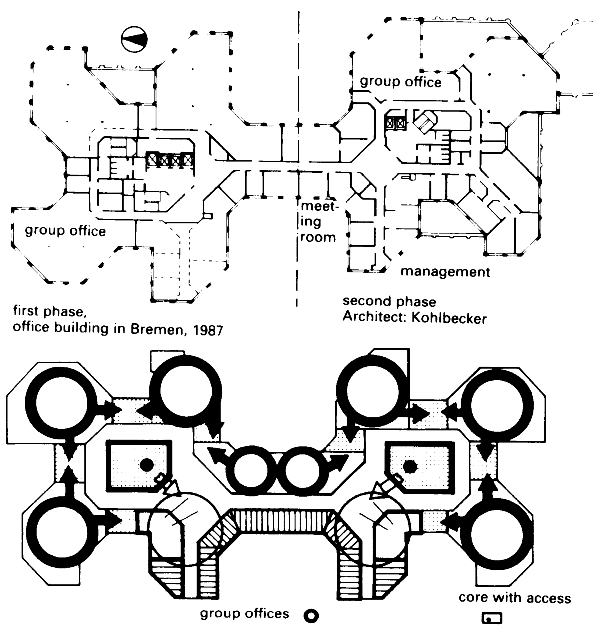


Architect: Striffler, 1977

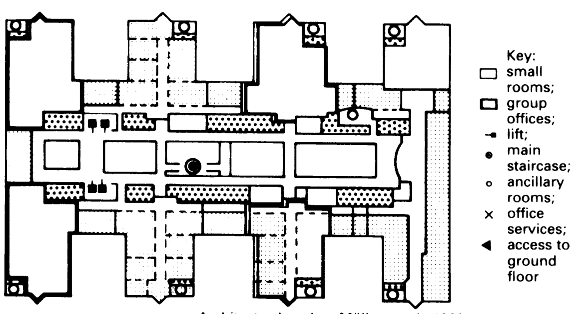
(13) **Group office, ÖVA insurance, Mannheim**



(14) **Requirements for group office**



(15) **Group offices connected via small flexible zones and partially zoned for group offices when required**



Architects: Jourdan, Müller, et al., 1988

(16) **Provincial State Central Bank of Hesse, Frankfurt am Main**

Building concepts II

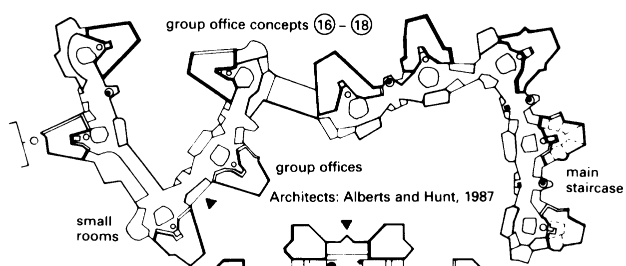
The reversible office was an attempt to improve the open-plan office system, which was felt to have many drawbacks for users. These included no individual environmental or daylight control, and visual and acoustic disturbances. Larger areas were subdivided into separate offices, which are better for work requiring great concentration, and this began a move toward greater flexibility. In addition, skyrocketing energy prices also cast doubt on the desirability of open-plan offices.

Changes in working structures as a result of new technologies (such as personal computers) made it possible to organise work in small groups. Group offices (small open-plan offices) are suitable for teams of clerical workers who constantly exchange information. They also allow greater flexibility for individual decisions about the working environment because of their smaller size (max. 7.50 m to window) (see earlier notes on changes in the workplace). Fully localised environmental control is not necessary; back-up control methods can be used, in addition to ventilation fins on façades and heating surfaces.

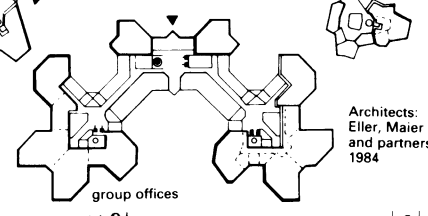
Methods of reorganisation include remodelling the building, providing daylight through courtyards, clear subdivisions in the floor plan to create workstations with uniform standards of light, ventilation and noise protection, or the use of office equipment that can quickly be adapted to fulfil new technical functions that entail more electrical cables and complex connections, as well as dividing the space. Raised floors and movable partitions often provide an easy way to adapt a building in terms of services, communication and space division. An example of space reorganisation after employee dissatisfaction is provided on the next page (→ (26) – (28)). Although it is still a popular trend, the open-plan office appears to be useful for very few organisational forms or types of work. The prime objectives at Bertelsmann were to improve the quality of the workplace while retaining the flexibility to adapt to new office technologies and group reorganisation, and to use the working space economically and reduce operating costs.

Building concepts III

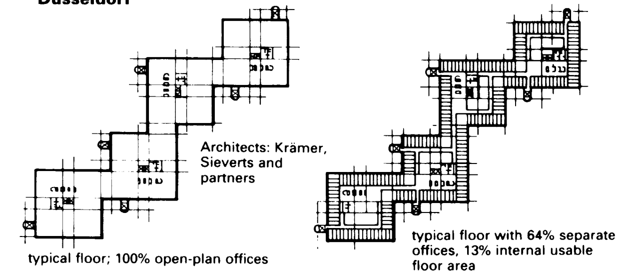
Recent trends aim to provide a spatial design that is appropriate for all the individual office requirements of an organisation. That means providing a space that is flexible when required, allows for group work, and includes individual rooms for work requiring concentration. It should also provide equipment that can be used both separately and collectively by groups, and which is particularly well-suited for high-quality independent work while allowing workstations to change according to daily requirements.



(17) **NMB Bank, Amsterdam**



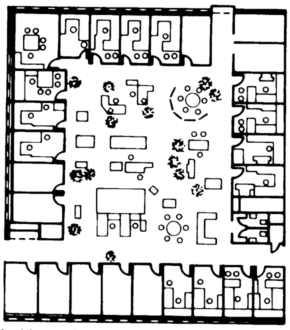
(18) **SMS building, Düsseldorf**



(19) **Flexible office, Dortmund City Administration**

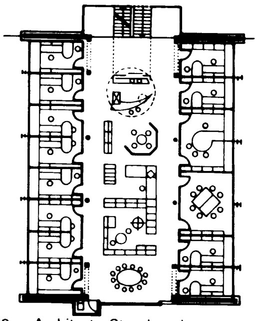
PRINCIPLES OF TYPOLOGY

1980s–1990s



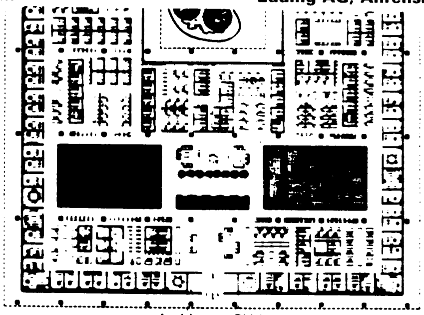
Architects: Lennart Bergström AB, Stockholm, 1978

(20) **Combined office, Zander & Ingström**



Architects: Strunk and partners

(21) **Combined office unit, Edding AG, Ahrensburg**



Architects: Skidmore, Owings & Merrill

(22) **American Can Company HQ, Greenwich, Connecticut**

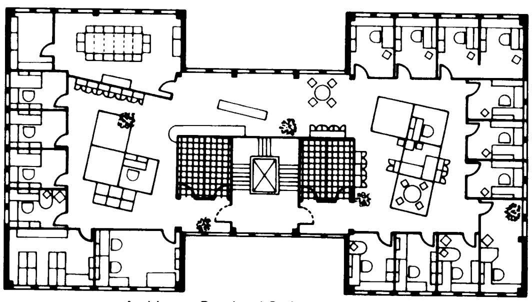
In general, modern office buildings tend to fall into three categories: closed plan, open plan, and modified open plan. Selection criteria include:

- the amount of planning flexibility required;
- the amount of visual and acoustic privacy required;
- initial and life-cycle costs.

Closed-plan offices have full-height walls or partitions dividing the space into offices with doors. Private offices are typically located along the window wall. Administrative support is housed in workstations along corridors or in shared rooms. The advantages include a controlled environment, security, visual privacy, physical separation, external views, and traditional and systems furniture applications. Disadvantages include lower efficiency than in an open-plan office, lack of flexibility, especially in responding to changes in office technology, the high cost of relocation, restricted individual and group interaction, and the fact that more extensive mechanical systems are required.

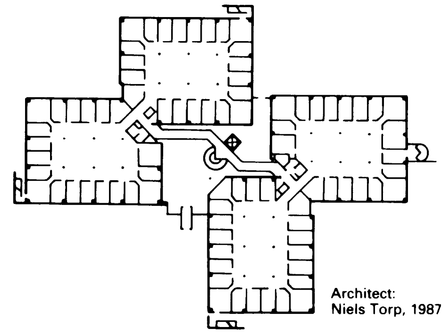
In open-plan offices, all workstations are located in an open space with no ceiling-height divisions or doors. Administrative support is located in rooms with floor-to-ceiling partitions and doors. The advantages include efficient space utilisation, greater planning flexibility, ease of communication and lower life-cycle costs. Disadvantages include higher initial costs, no visual privacy, no external views and less environmental control.

Modified open-plan offices combine elements of both the others by positioning certain workstations in an open plan with systems furniture, and others in private offices. Administrative support is also located in enclosed rooms.



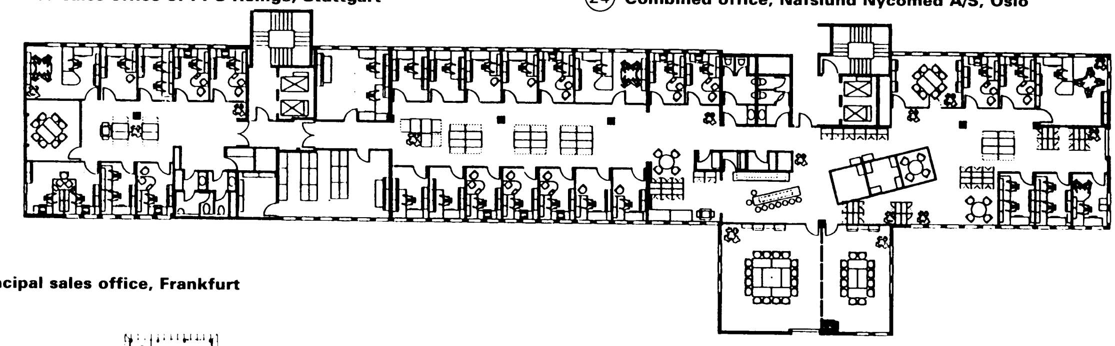
Architects: Bernhard Steiner and Bernhard von Wallis, 1991

(23) **Combined sales office of PPC Hellige, Stuttgart**

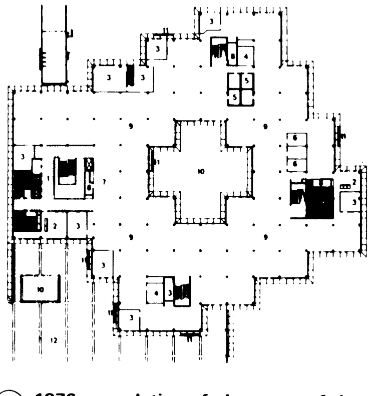


Architect: Niels Torp, 1987

(24) **Combined office, Nafslund Nycomed A/S, Oslo**

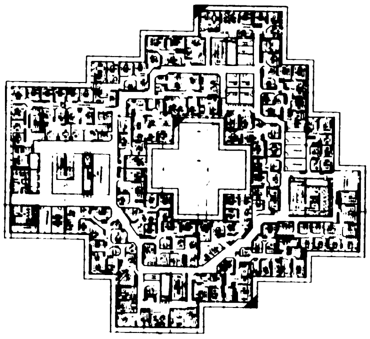


(25) **Principal sales office, Frankfurt**

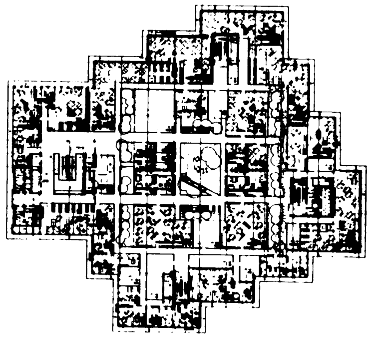


1 lobby
2 lounge
3 office
4 meeting room
5 recording studio
6 storage
7 document conveyor
8 air conditioning shaft
9 open-plan office
10 central courtyard
11 escape ladder
12 roof terrace

(26) **1976: completion of phase one of the administration building (V1) for Bertelsmann** → (27) – (28)

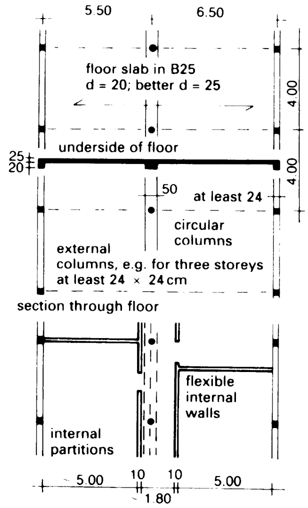


(27) **Complete re-arrangement of workstations, 1985**



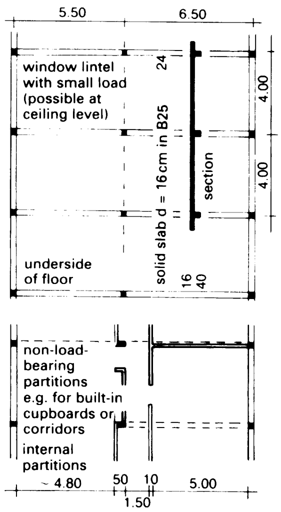
(28) **Reorganisation: mixture of individual and group offices**

CALCULATIONS: CONSTRUCTION



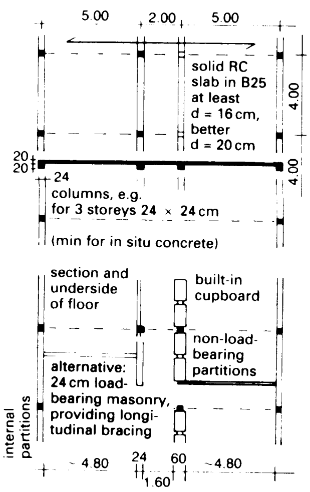
① **Structural system: asymmetrical double-span beams**

Floor spans building. Main beams run longitudinally in centre, with columns at side within corridor area, separated from corridor wall.
- Unlimited flexibility; reversibility.
- Sufficient corridor width required for clear passage between columns and wall.
- Suitable for structures without suspended ceilings or on top of car-parks with access lanes running the length of building.



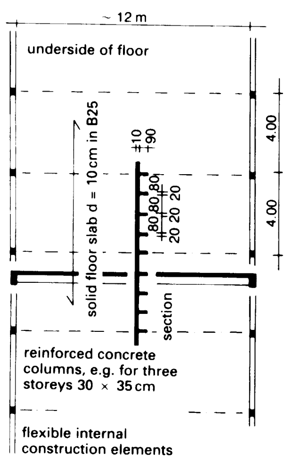
② **Structural system: multi-span beams**

Floor stressed the length of building. Main beams run across building from external columns over centre columns to external columns.
- Unlimited flexibility; reversibility.
- Additional sound insulation required due to low floor density (suspended ceiling, floating composite floor).
- Suitable for structures above car-parking with access lanes running the length of building.



③ **Structural system: triple-span beams**

Floor spans building. Main beams run length of building in centre span on both sides of the corridor. Corridor wall can also act as bearing/stiffening panel to increase longitudinal rigidity.
- Masonry corridor wall cannot be changed; limited flexibility of depth of space.
- Min floor thickness 20cm (impact noise insulation) if suspended ceiling or floating composite floor not used.
- Not suitable above car parking.
- Economical to use corridor wall as bearing panel.
- Increasingly economical for greater building depths and distances between columns in the length of the building.



④ **Structural system: T-beam ceiling**

Main beams: uninterrupted span, without central columns, between external columns.
- Unlimited flexibility; reversibility.
- Suspended ceiling required.
- Services run across building between webs. Longitudinal installation through holes in beams almost impossible.
- Uneconomical overall structure, high main beams (also in steel structure), large building volumes, only for superstructures without columns. Reduced main beam height of 60cm, structure sensitive to vibration with high degree of deflection.

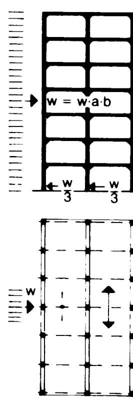
The structural members of the building have a strong influence on the possible ways in which an office area can be divided → ①-④. A clear floor-to-ceiling height of 2.75m permits the later installation of raised floors or suspended ceilings. Ceilings can be 25cm lower if most activities are carried out while seated, but the clear height should not be less than 2.50m. Corridors and toilets can be 2.30m high, but must have space for ducts and pipes. The economic efficiency of load-bearing members depends far less on the optimisation of individual components than on their integration into a functionally efficient building

Beam systems may be longitudinal or transverse → ①-④. This example of the range of design approaches is based on a reinforced concrete floor with a span of 6.50m. The cost and weight of the span affects the choice of supporting structure and foundation. A greater floor thickness has advantages because the optimum rigidity of the structure will be maintained if the loadings vary.

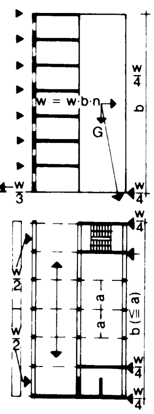
A ribbed floor is economical only for larger spans. Although it is light weight, it costs more for sound insulation. It is not possible to cut through ribs, and openings cannot be introduced owing to the limited space between ribs. Double-T or Pi-shaped slabs or beans are structurally better for large spans. Transverse service ducts should be located in the floor in corridor areas → ①-⑤. The facade plane may be located either behind, between or in front of the structural plane. The maximum flexibility of space is achieved if the external skin is independent of the structure of the building.

With interior columns, cantilever floors (with curtain walls) can even up the loads on the columns. Rigidity is provided by the use of wall plates, multistage bracing, and solid access cores with secondary zones on the ends.

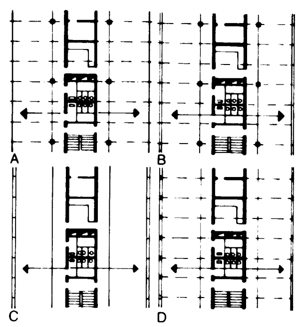
Solid dividing walls can replace columns and main beams in some parts of the structure, and the inclusion of panels helps to improve rigidity → ⑥-⑧. Fixed openings should be specified in advance to prevent later problems. Lightweight partitions have the advantage of being movable and also permit later decisions concerning the division of space.



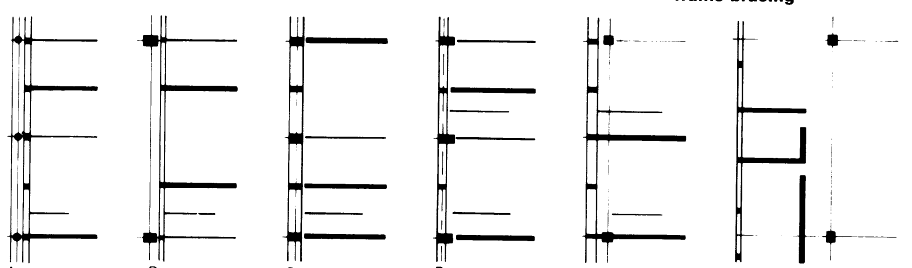
⑥ **Wind loads transmitted to foundations by frame bracing**

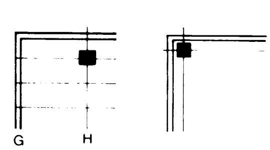


⑦ **Bracing by wall panels**



⑧ **Four ways to distribute the floor load to columns and the core zone for three-part structures**

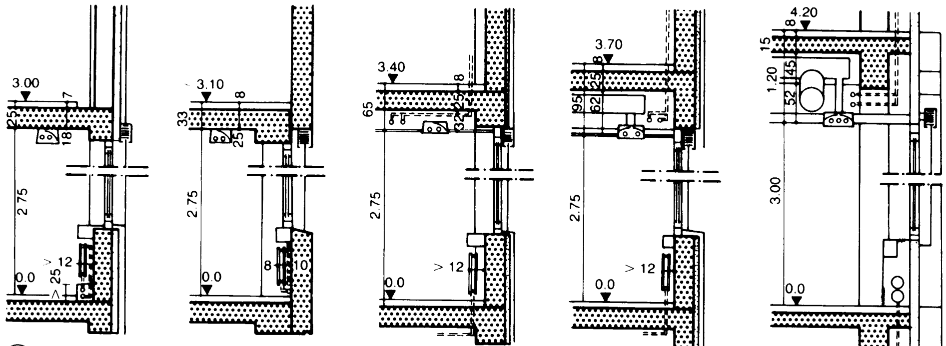




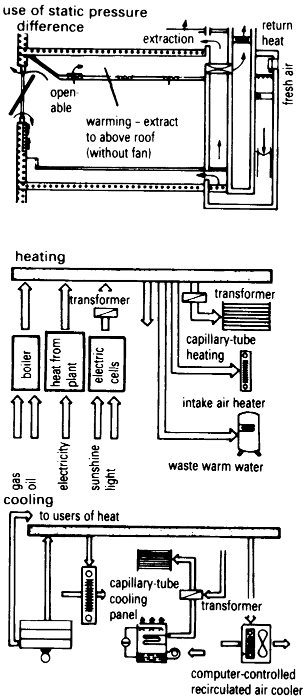
A–H: influence of design on ability to subdivide office space with movable partitions. A–B: external columns; C–E: columns within or immediately behind façade; E–F: internal columns (possibility to create corners G–H)

⑤ **Structural connections and division of office floor space**

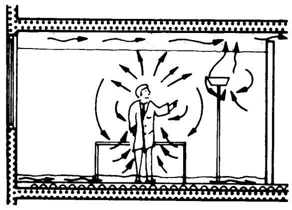
CALCULATIONS: BUILDING TECHNOLOGY



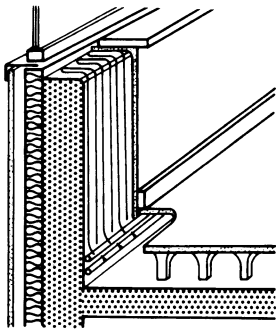
(1) **Floor-to-ceiling height, depending on services equipment**



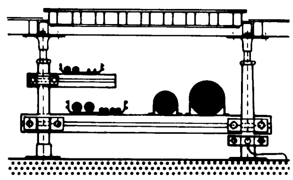
(2) **Air conditioning technology, heating and cooling**



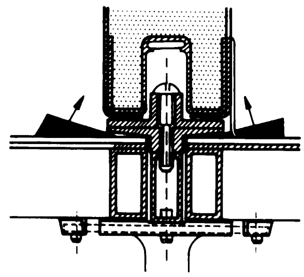
(5) **Air movement due to temperature gradient**



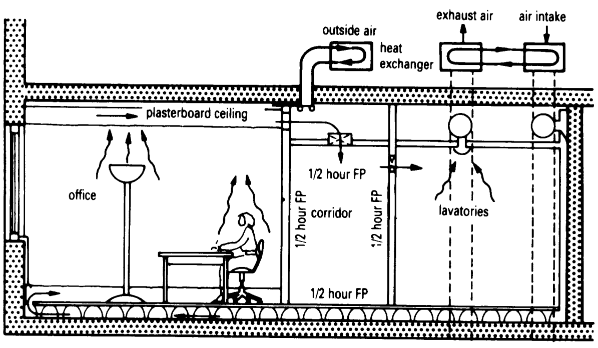
(6) **Heating panel; capillary mat**



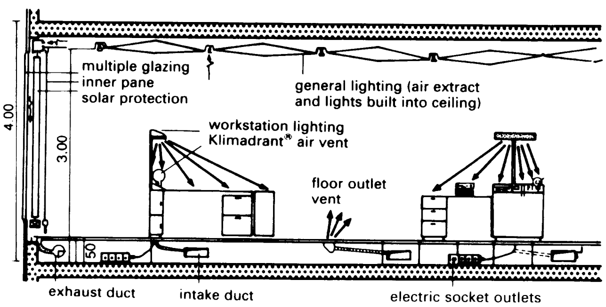
(7) **False floor with cable runs**



(8) **Floor/wall section: dividing wall**



(3) **Air conditioning with localised element cooling**



(4) **System section for Klimadrant® Control of air to individual desks**

	average (%)	range (%)
lighting	40	± 10
elevator and conveyors	6	± 2
low voltage equipment	1	± 0.5
heating, cooling and ventilation systems	47	± 15
lavatories	2	± 1
kitchen facilities (electric)	2	± 1
cleaning and waste disposal	2	± 1
total	100	

(9) **Energy costs of service plant in an office building**

The gross volume of space needed and the total construction cost mean that fully air-conditioned buildings are 1.3–1.5 times more expensive than non-air-conditioned buildings, i.e. those which are naturally ventilated → (1).

A ceiling height of 3.0–3.10m is suitable for buildings with little service equipment, no suspended ceilings and heating pipes on an exterior wall. Electric power should be supplied through ducts in window sills or floors, and the power supply for ceiling lights through conduits or partitions. Corridor areas should also be used for ducts and pipes.

A ceiling height of 3.4m is suitable for a building with some service equipment, but without ventilation equipment. Ducts under the floor in corridor areas (h = 32cm) should be used for heat, electricity and water.

A ceiling height of 3.70m is suitable for office buildings using ventilation equipment. A duct height of at least 50cm is needed for air-conditioned offices, with long ducts in the corridor area.

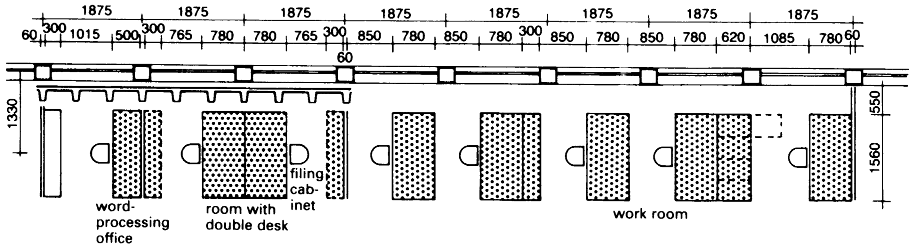
Open-plan offices need a clear ceiling height of only 3.00 m. However, the ceiling height should be 4.20m if ventilation ducts are to be installed. All height-related building components affect the cost of the building in relation to its usable office floor area.

Air-conditioning systems with capillary tube mats use water and the principle of localised cooling → (2) + (3). The air intake is equivalent to the minimum air-change rate. Comfortable cooling is achieved by radiant protection and displacement ventilation without turbulence (expanding-air ventilation). This creates a flow of fresh air (with outlets near the floor and at the base of furniture), a cushion of warm air at the ceiling, and an air-flow through the room → (5) caused by the temperature gradient (main surfaces 32°C at the ceiling, 20°C at each wall).

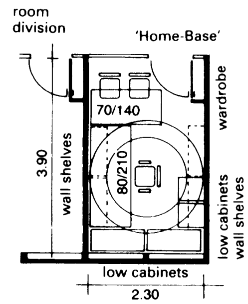
Radiant heating from panels in combination with an air intake system may be sufficient for heating → (6). Such a system uses less equipment and thus increases the usable floor area. The cost of air conditioning with localised cooling compares favourably with the cost of conventional air conditioning. The advantages include no draughts, quiet, lower investment and operating costs (the volume of water that has to be conveyed is 1000 times less than the volume of air for a closed system with the same output and heat recovery), a reduction of the space required for services (water instead of air) and a smaller energy plant. Raised floors are required to achieve the necessary room ventilation and for installing services to areas with a large amount of equipment. There is an increased demand for space for services (cables, office automation), and a need to guarantee flexibility when functional processes change → (7) + (8).

The selection of a heating, ventilation and air conditioning (HVAC) system is usually based on performance characteristics, system capacity and the availability of space to accommodate the equipment.

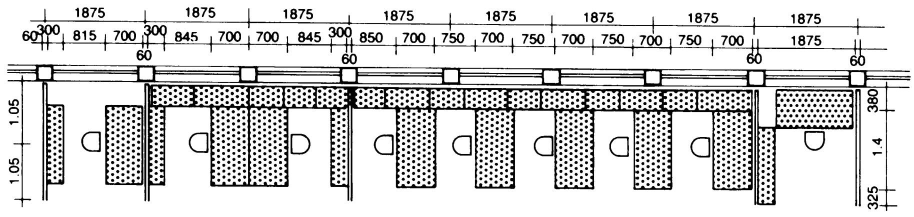
CALCULATIONS: DIVISION OF SPACE



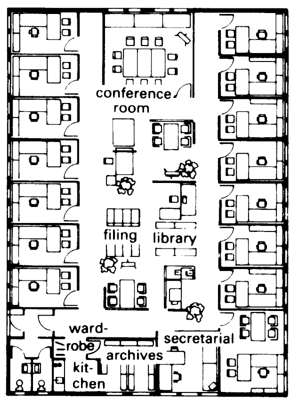
① With standard desks (size 0.78 × 1.56 m), a division of 187.5 is suitable for a ribbed/slab-and-beam floor having a 62.5 grid module (Koenen floor) with normal formwork. Better for movable partitions



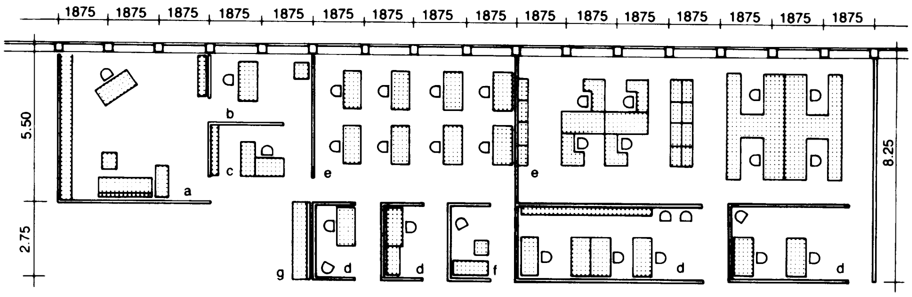
⑥ Individual office within a combined office



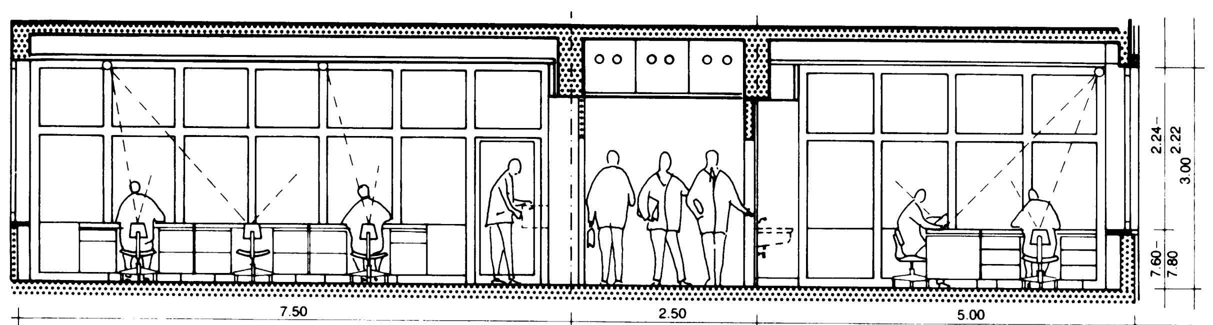
② Modular desks (size 0.70 × 1.40 m, Velox system). By combining modular desks with Velox continuous table with filing units below windows instead of filing cabinets (→①), one grid module in every five was saved. Desk clearance of 75 cm is possible only when swivel chairs on casters are used.



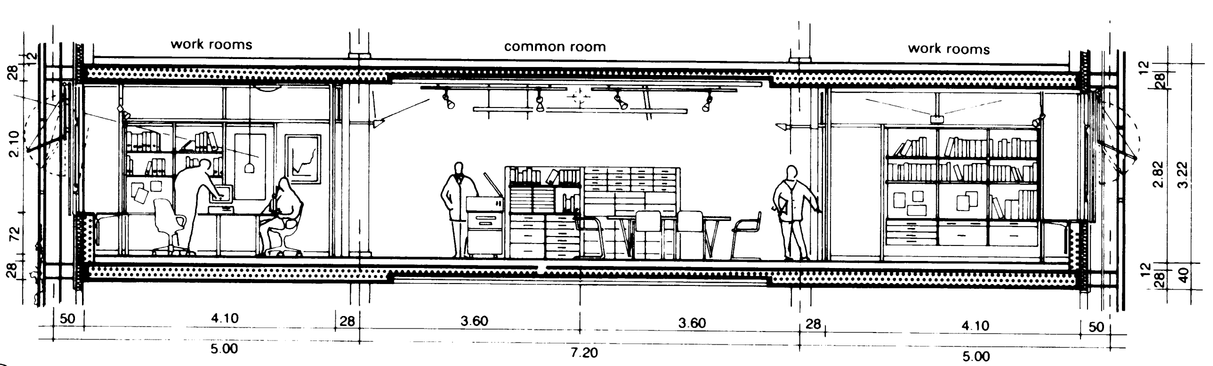
⑦ Division of combined office, with outer individual offices and related common areas



③ Division of space using modular desks. Various office spaces in open-plan office system: a) manager, with small meeting or conference room; b) assistant or departmental head; c) secretary, receptionist; d) senior clerk dealing with public; e) work rooms (working groups)



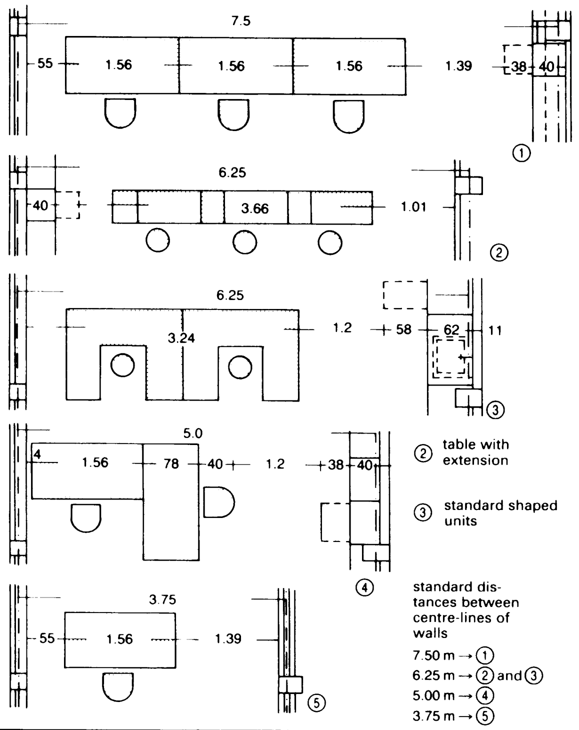
④ Section through office space



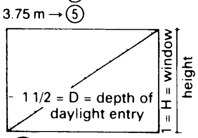
⑤ Section through individual and shared rooms in a combined office

Architects: Struhk and partners

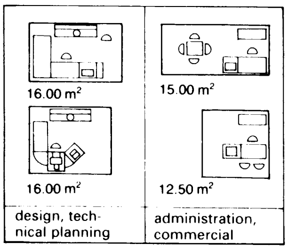
CALCULATIONS: FLOOR AREA REQUIREMENTS



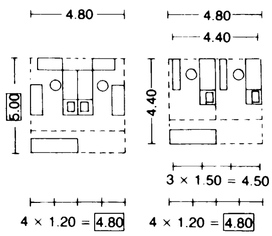
single/group office	normal	maximum
depth of office	3.75 7.50 m	9.25 m
dist. between windows	1.00–3.25 m	6.00 m
dist. between columns	1.75 7.50 m	11.00 m
main corridor width	1.75 2.50 m	3.25 m
side corridor width	1.50–2.00 m	2.50 m
height of office	2.50–4.00 m	5.00 m



⑥ **Rule of thumb: $D = 1.5H_w$ → text**



⑦ **Examples of ideal workstations**



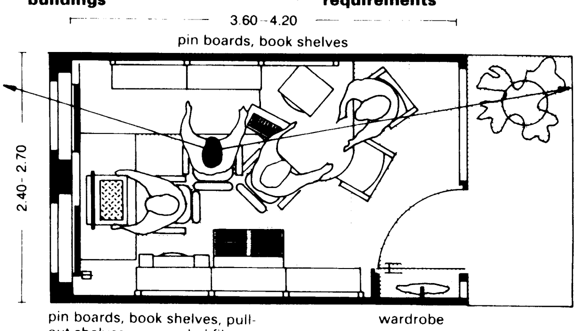
⑧ **Minimum dimensions for two-person office**

general lighting only	average level (lux)	at work-station
corridors, toilets, ancillary rooms	30	–
stairs	60	–
archives	120	250
clerical work, post room, kitchen	250	500
tech. drawing	600	1.000
laboratory	–	4.000

⑨ **Light levels in office buildings**

fresh air m³/h/person	to VDI requirements	to ASHRAE guideline
10	non-smoking; heated air when < 0°C outside	
10–27		office space
20 30	non-smoking	
26–34		
30 40	smoking	
34–51		smoking
51–68		exec. office

⑩ **Typical ventilation requirements**



⑪ **Possible layout of a small room in a combined office (perhaps, home-based)**

Office area requirements are calculated in two parts.

(1) People space is calculated as (standard individual space × number of people) + allowances for immediate ancillary needs + a factor (usually 15%) for primary circulation.

(2) Non-people space (e.g. machine rooms, and libraries and the like for which fittings and equipment sizes are more important than staff numbers in setting the area requirement) should be calculated by informed estimates based on existing good practice or comparable examples + an additional factor for primary circulation.

Figures for the average floor area requirement for each workstation and employee in an organisation (including office equipment and space to operate it), not including management, have roughly the following distribution:

30%	3.60–4.60 m²
55% (average 8.5 m²)	7.00–9.00 m²
15%	>9.00–15.00 m²

The space requirement per employee clearly depends on a number of factors, e.g. type of work, use of equipment and machinery, degree of privacy, level of visits made by outsiders and storage needs. The average workstation floor area requirement until 1985 was 8–10 m²; in future it will be 12–15 m². Although a minimum floor area requirement for office workstations has not been defined, the following guidelines should be followed: separate offices, minimum 8–10 m² (according to the grid module); open-plan offices, minimum 12–15 m².

A representative calculation of the space requirement for a workstation is as follows:

work room, min. 8.00 m² floor area;

free circulation space, min. 1.5 m² per employee, but min. 1 m wide;

surrounding volume of air, min. 12 m³ when most work is done while seated, min 15 m³ when most work is done while not seated.

The following floor-to-ceiling heights are recommended for floor areas of:

up to 50 m²	2.50 m
over 50 m²	2.75 m
over 100 m²	3.00 m
over 250 and up to 2000 m²	3.25 m

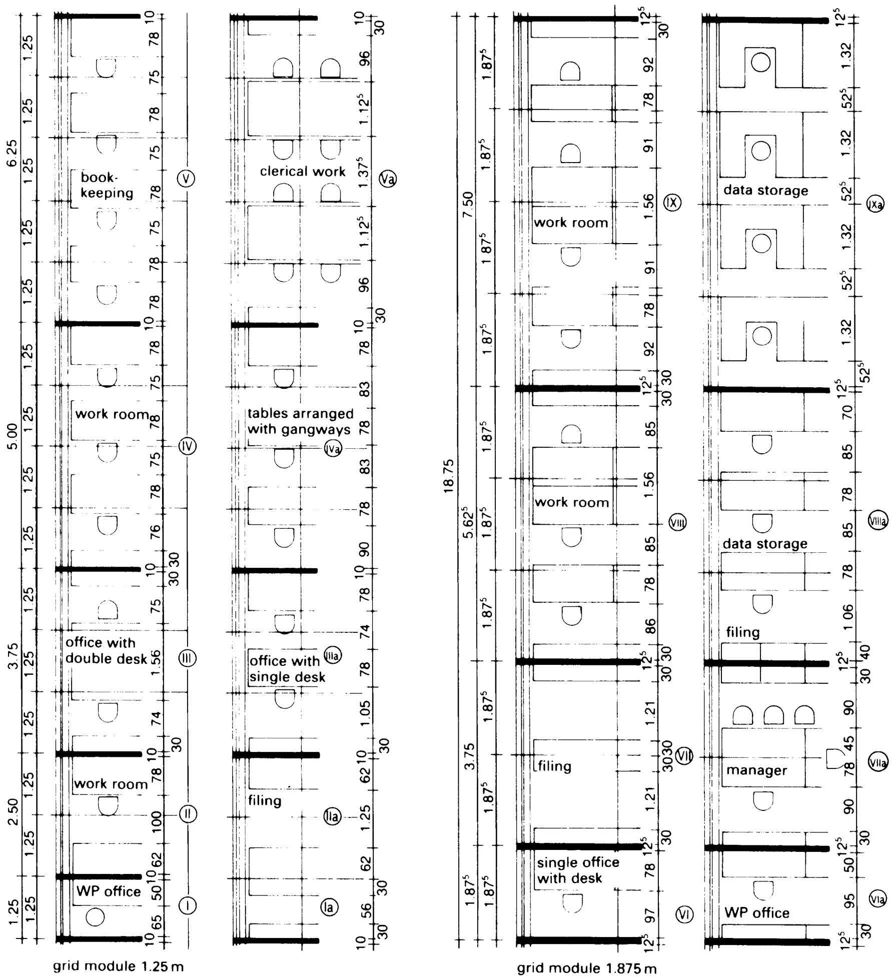
An American study (Connecticut Life Insurance) indicates the following requirements for floor area and space to operate office equipment (personal floor area + an additional 50 cm on all sides):

office employee	4.50 m²
secretary	6.70 m²
departmental manager	9.30 m²
director	13.40 m²
assistant vice president	18.50 m²
vice president	28.00 m²

The depth of a room depends on the space required for an individual in a multi-occupant, open-plan, group or office room. The average depth of office space is 4.50–6.00 m. Daylight illumination reaches work workstations to a depth of approx. 4.50 m from the window (depending on the location of the office building, e.g. in a narrow street or in an open area). Rule of thumb: $D = 1.5H_w$, where D is the depth of light penetration and H_w is the height of the window head (e.g. $H_w = 3.00$ m, $D = 4.50$ m). Workstations located in the deepest third of the room require artificial light. Working groups often have to do without daylight penetration, since they may be allocated to deeper rooms if that is required by the building layout.

The width of corridors depends on the occupation of the space and the area required to move equipment. Generally speaking, it should be possible for two people to pass each other.

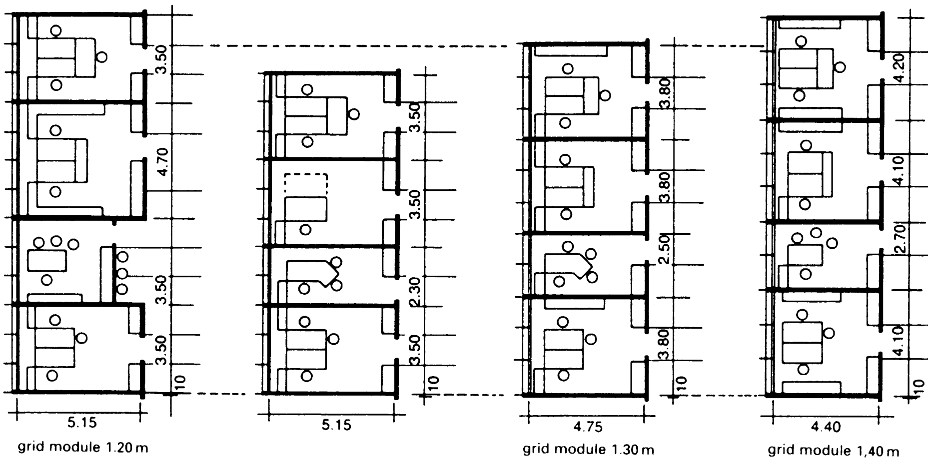
CALCULATIONS: FLOOR AREA REQUIREMENTS



(1) **Minimum room width according to window grid modules**

According to standard dimensions relating to the varied space requirements in office buildings, the minimum distance between the centre lines of windows or window columns is 1.25m. The resulting distances between the centre lines of partitions are 2.50m, 3.75m, 5.00m etc. → (I) - (V). These offer considerable choice in positioning furniture, and are flexible enough to fulfil almost every requirement. If a larger module is needed, the spacing shown in (II) should be selected.

The largest grid module for office buildings is 1.875m; the figure → (VI) - (IXa) shows some examples of the many efficient ways to position furniture. Beam spacing according to the standard dimensions of 625mm or 1.25m is also suitable for this centre distance, and every third beam will coincide with a façade column.



(2) **Possible arrangement for different window grid modules**

Usable floor area is based on the principle of office units arranged in a row along the façade or some variant thereof, with office size determined by rank or function.

user	usable floor area in office
One senior staff member with a need for discretion regarding personnel or social services, or needing to be able to concentrate	approx. 12 m^2
Two senior staff members (perhaps with seating provided for a trainee) or one employee with a conference table for about four people	approx. 18 m^2
Manager with a conference table for about six people, or three senior staff members or secretaries, or two senior staff members with additional equipment or a workstation, or a room in front of the Director's office with a waiting area	24–30 m^2
Section leader's office or functional room containing a great deal of equipment	larger than 30 m^2

(3) **Number of occupants for various office sizes**

1.20 m grid module

The standard room size of 18 m^2 (3 × 1.20m less 0.10m for the partition) corresponds to a 3.50m room width, which is too narrow for standard furnishings for two employees (2 × 1.00m clearance plus 2 × 0.80m depth of desk = 3.60m). The two-grid-module room, 2.30m wide, is too narrow for one senior staff member with seating for a visitor. Deeper workstations with video display units and other special equipment require the next largest room (4.70m).

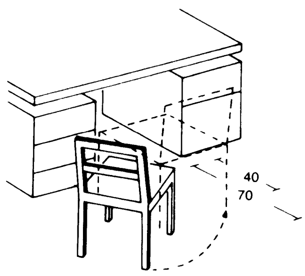
1.30m grid module

A room 3.80m wide, corresponding to 18 m^2 usable floor area, allows for an additional filing cabinet, two video display stations 0.90m deep, one drawing table or drawing machine and one desk, and one desk and conference table for four people. Such an office is very flexible, and will accommodate workstations of all standard office sizes without any need to move the walls.

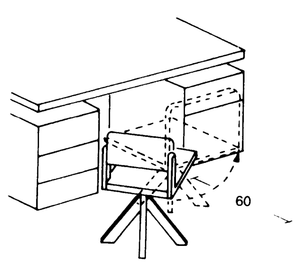
1.40 grid module

A room 4.10m wide, i.e. 3 × 1.40m less 0.10m for a partition, provides excellent possibilities for furnishing and more flexible use. A room depth of 4.40m, providing 18 m^2 floor area (i.e. 4.10m × 4.40m), is normally sufficient for special uses or greater demands on space. Increasing the room depth to 4.75m increases the usable floor area of a three-grid-module standard room to 19.5 m^2 (i.e. 4.10m × 4.75m).

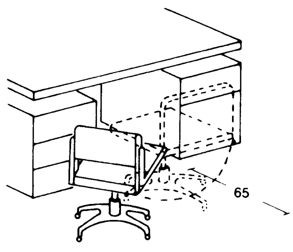
CALCULATIONS: SPACE FOR FURNITURE



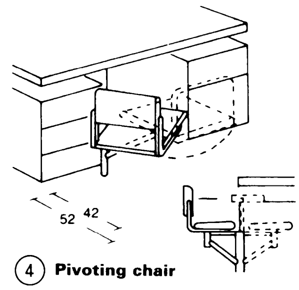
(1) **Traditional chair**



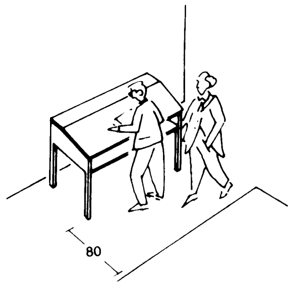
(2) **Swivel chair**



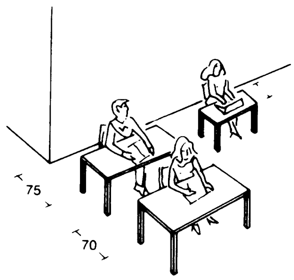
(3) **Swivel chair on casters**



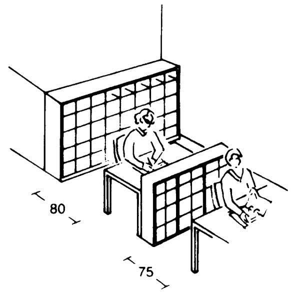
(4) **Pivoting chair**



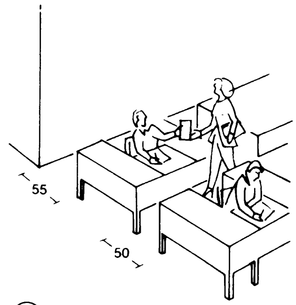
(5) **High desk**



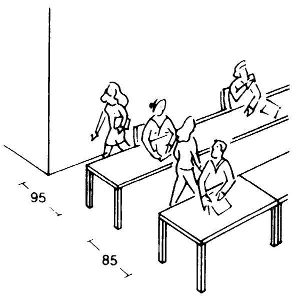
(6) **Individual tables**



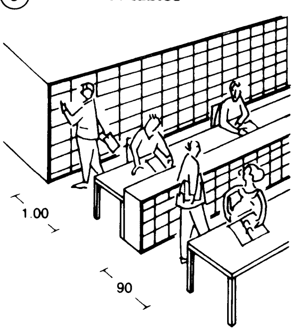
(7) **Individual tables with filing racks to rear**



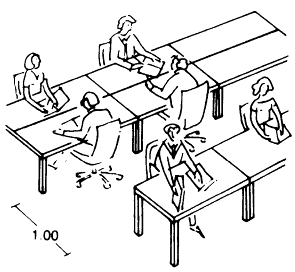
(8) **U-shaped desk**



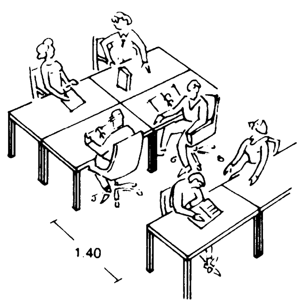
(9) **Rows of tables with circulation behind**



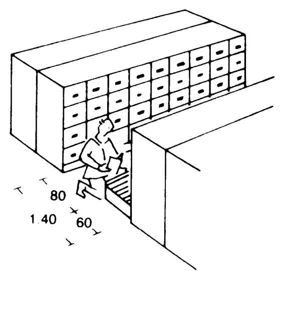
(10) **Rows of tables with filing racks to rear**



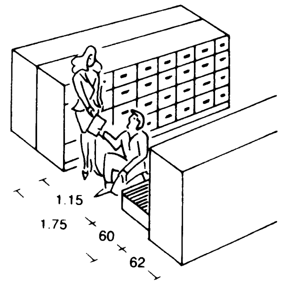
(11) **Rows of tables in blocks with staggered seating**



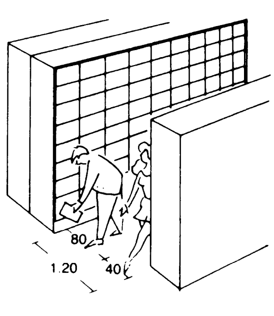
(12) **Blocks with in-line seating**



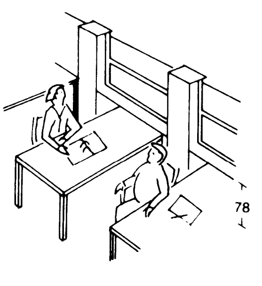
(13) **Filing cabinets**



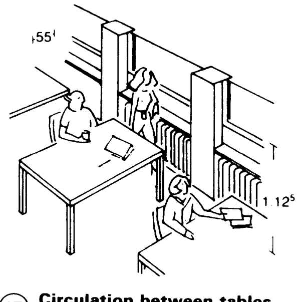
(14) **Filing cabinets with passageway**



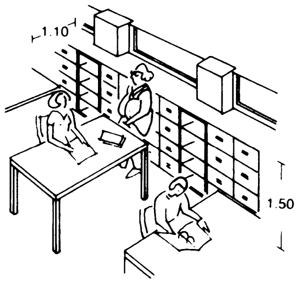
(15) **Pigeon-holes**



(16) **Tables connected directly to window sills**



(17) **Circulation between tables and windows**



(18) **Filing cabinets beneath window sills**

A wide range of office furniture is available. The suitability of furniture for any office is influenced by its flexibility, adjustability, durability, IT compatibility, storage space, ergonomics, aesthetics and cable handling.

The space required while seated and standing is used to calculate the minimum clearance between individual desks or tables (preferably a minimum of 1 m), depending on whether they are placed against walls or other tables, or in front of filing cabinets.

Windows placed high in the wall provide satisfactory illumination deep into the room, which allows efficient use of space and access to the window ledge → (18).

CALCULATIONS: SPACE FOR FURNITURE

Many furniture systems in contemporary offices are still designed according to standards in use since 1980. In addition, furniture units such as simple work tables and desks that incorporate filing systems are still used. Because of the increasing use of VDUs and keyboards, European standards for workstations specify a surface height of 72cm high. A new desk measuring 140cm x 70cm x 74cm → (2) has been introduced, together with the standard desk whose dimensions are 156cm x 78cm x 78cm. The requirements include adjustable workstation height, protection against vibrations, a sound-absorbent surface and foot rests with ergonomically correct height, preferably adjustable.

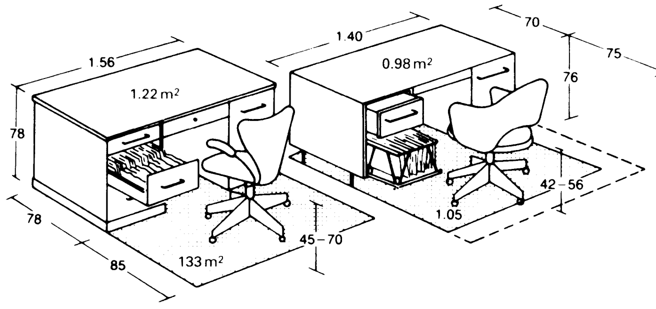
Chairs should be adjustable, with castors and upholstered seats and backs. Properly contoured back support for the lumbar curve is essential in an office chair. It should also provide firm support for the lower part of the back and the upper thighs. Many combinations of typewriter stand and desk are available, ranging from space-saving units to built-in systems.

Filing archives and card systems.

Filing, archives and card indexes may use cabinets without sides, usually in steel units of standard dimensions.

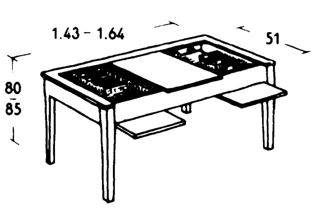
Counters for transactions with a person standing on the other side are generally long, and should be 62cm wide and approx. 90cm high → (6). If a counter is only 30cm wide, its height should be approx. 100cm → (7). In public areas of a building where high security is required, this makes it difficult for any person in front of the counter to reach anything behind it → (7). Clearance to stand and deal with members of the public should be provided behind the counter → p. 362 (2)–(6). Individual counters are easier to reorganise since the floor space is more flexible → (8).

Some counters and switchboards, e.g. in reception areas, hold VDU terminals and probably keyboards. Their design should take account of this.

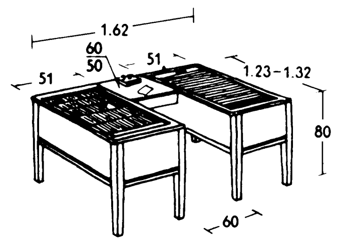


(1) **Standard writing desk with drawers**

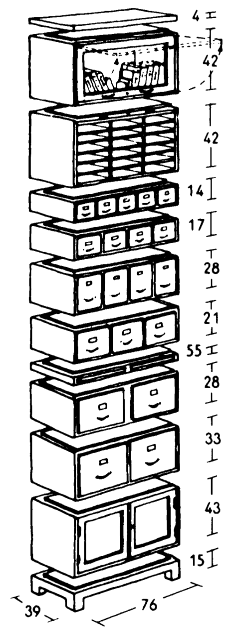
(2) **Office desk; 0.5 m² less floor space than (1)**



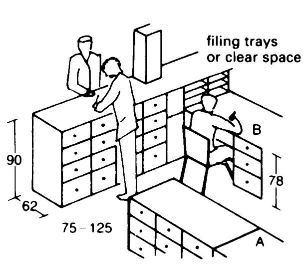
(3) **High desk for card index; 1500 cards in each box**



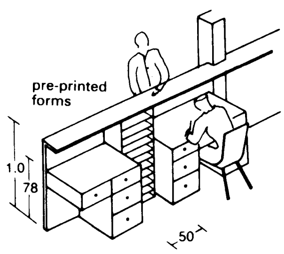
(4) **Double unit → (3)**



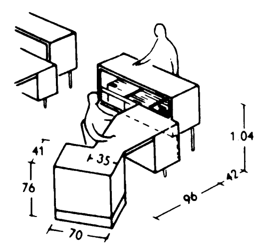
(5) **Cabinet for storage of various standard size cards and diskettes**



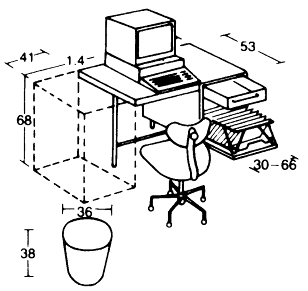
(6) **Service counter**
A: with passage behind it
B: with adjoining desk



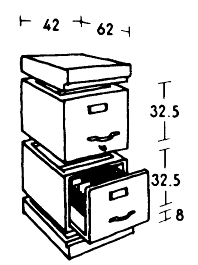
(7) **Service counter with desk facing clients (Swedish style)**



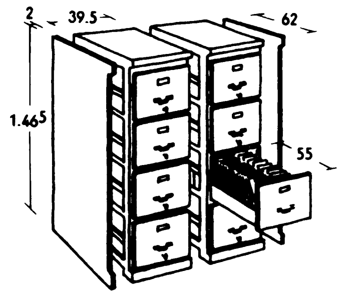
(8) **Individual counter units; can be separated**



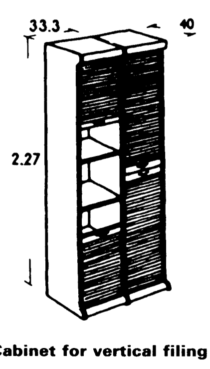
(9) **Computer desk with double retractable trays (Velox)**



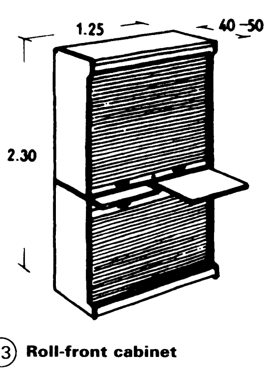
(10) **Stackable filing cabinets**



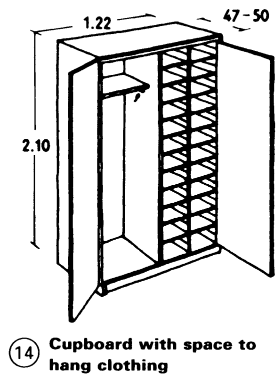
(11) **Filing cabinets that can be combined in rows**



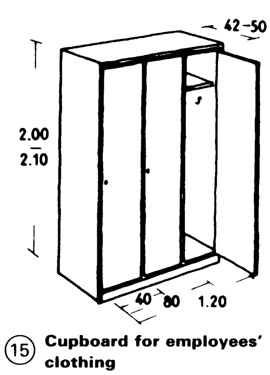
(12) **Cabinet for vertical filing**



(13) **Roll-front cabinet**

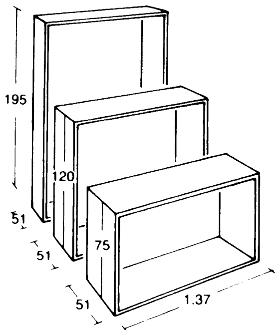


(14) **Cupboard with space to hang clothing**

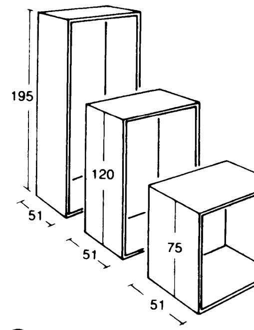


(15) **Cupboard for employees' clothing**

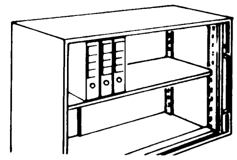
CALCULATIONS: ARCHIVE SPACE



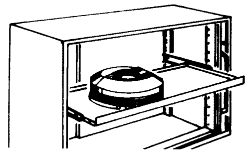
① **Cabinet system, series A**



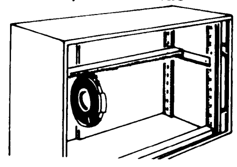
② **Series B → ③ – ⑩**



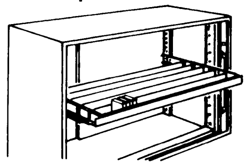
③ **Shelves: usable depth 42 cm; 1.37 m wide**



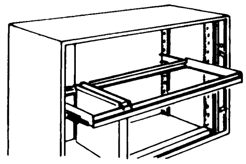
④ **Pull-out shelf with telescopic runners**



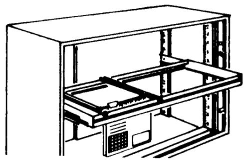
⑤ **Rack for magnetic tapes or film (49 separate holders)**



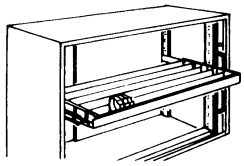
⑥ **Pull-out shelf for microfilm cassettes (164 capacity)**



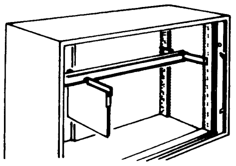
⑦ **Pull-out rack for suspended files**



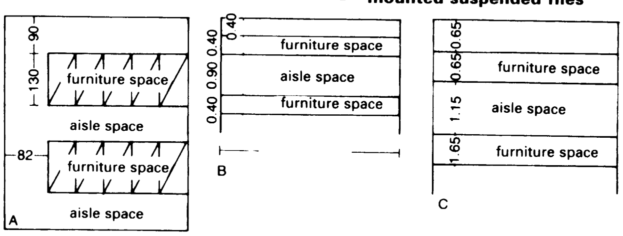
⑧ **Rack to hold suspended files parallel to front**



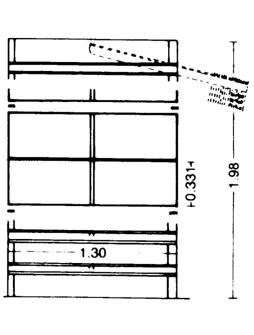
⑨ **Pull-out shelf for diskettes**



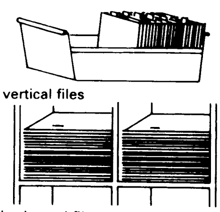
⑩ **Supporting rail for centre-mounted suspended files**



⑪ **Circulation/furniture areas for various filing systems**



⑫ **Large Velox archival shelf (section and plan)**



Handling times:
Comparison of flat and vertical files

	flat	vertical
remove file	29%	14%
sort files	41%	66%
replace files	30%	20%
	100%	100%

⑬ **Filing systems**

In spite of new office technologies, the use of paper as the main storage medium for information has increased. Paper consumption doubled every 4 years until 1980. Computer memory has now become a more common way of storing information in office communication systems, but the need for what is known as uncoded information (printed letters, texts, periodicals etc.) means that paper will continue to be used.

It is necessary to arrange stored documents in a clearly labelled system, with short circulation routes and efficient use of space. Space should also be available for archives → ①. As cabinet widths increase, the aisle between cabinets should also get wider.

L × W (filing equipment)	= space for furniture
+ 1/2L x W + 0.5	= aisle space
Total requirement = space for furniture + aisle space	

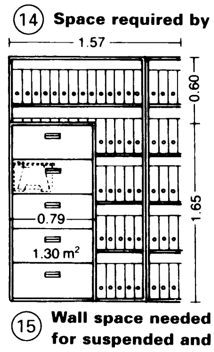
Deep filing cabinets are more economical. The diagram in → ⑪ shows the relationship between furniture floor area and aisle space required for a vertical filing system using large archival shelves (Velox system) or a flat filing system. The floor area needed for a vertical filing system is 5.2 m², and the aisle space should be 4.6 m² (100:90). For flat filing systems, the floor area is 3.2 m² and the aisle space 3.6 m² (90:100, ratio reversed). Flat filing systems cannot hold as much as vertical ones, and high shelf units are hard to organise. Vertical files may reduce staffing levels in the filing section by 40%. Hanging files use wall space 87% better than box files → ⑮. An efficient way to move files is by paternoster elevator. Workstations should include shelves for sorting, a small table and a chair on castors.

The filing room should be centrally located, and the best window grid module is between 2.25 m and 2.50 m. Since a clear height of only 2.10 m is required, three storeys of filing could be fitted into a space which would only take two storeys in normal offices. Dry storage rooms are essential, and therefore attics and basements are unsuitable.

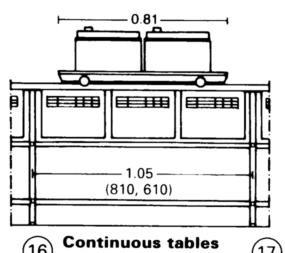
Narrow shelves → ⑯ and ⑰ with hanging files and a writing surface can provide a functional connection between workstations. Trolleys can be used either as writing surfaces or for card-index boxes. Movable filing systems give substantial space saving (100–120%) by eliminating intermediate passages → ⑱B. There are no fixed standards for filing systems. They are usually adapted to suit individual requirements, such as registries, archives, libraries and storage areas. The increase in load for each square metre of floor space must be taken into account. File shelving may be moved by hand or by mechanical means. In some designs, the entire filing system, or only parts of it, can be locked by one handle.

		flat filing in loose-leaf binder on open shelves 35 × 200	library: storage in letter organiser in roll-front cupboard 40 × 125 × 220	combined vertical and suspended filing in folders, units 65 × 78 × 200
10 000 files approx. 2 mm thick (without holders); approx. 25 sheets each	1) continuous cabinet or wall length 2) floor area (m²) including operation but excluding side passages	7.25 m 5.92 m²	11.00 m 8.25 m²	2.4 m 3.6 m²

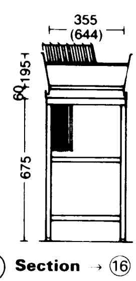
⑭ **Space required by different filing systems**



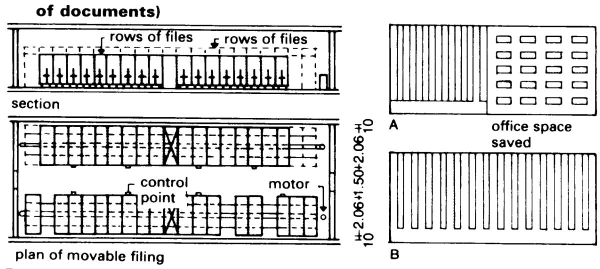
⑮ **Wall space needed for suspended and box files (equal nos of documents)**



⑯ **Continuous tables with trolley**

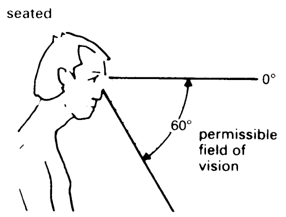


⑰ **Section → ⑯**

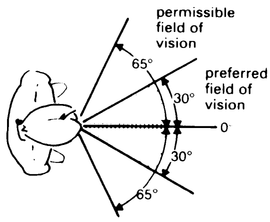


⑱ **A = movable filing; B = comparison with space for normal filing**

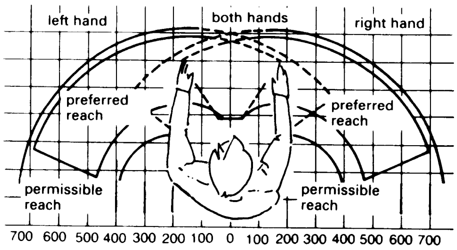
CALCULATIONS: WORKSTATIONS WITH COMPUTERS



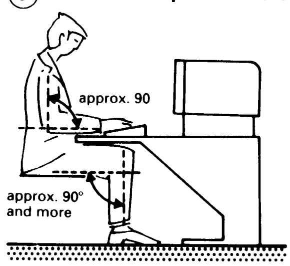
(1) **Vertical field of vision**



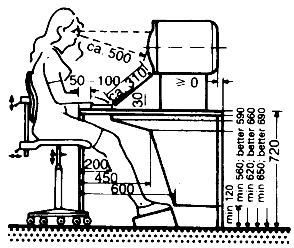
(2) **Horizontal field of vision**



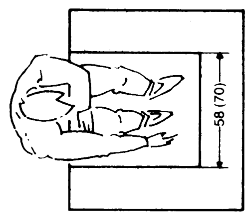
(3) **Preferred and permitted area of reach**



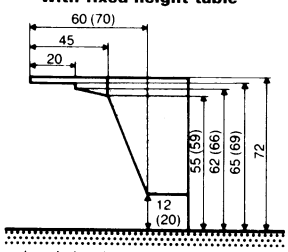
(4) **Correct ergonomic position**



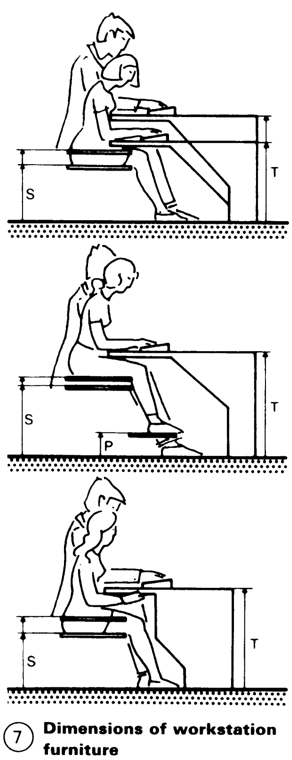
(5) **Ergonomic VDU workstation with fixed-height table**



(6) **Leg space**



values in brackets are target values



(7) **Dimensions of workstation furniture**

Type 1 workstation
adjustable-height table
adjustable-height seat

	women	men and women
T	(630 – kb) – (730 – kb)	(630 – kb) – (780 – kb)
S	420 – 460	420 – 500

Type 2 workstation
fixed-height table
adjustable-height seat
adjustable-height footrest

	women	men and women
T	(700 – kb) – (730 – kb)	(750 – kb) – (780 – kb)
S	460 – 500	500 – 550
P	0 – 100	0 – 150

Type 3 workstation
fixed-height table
adjustable-height seat

	women	men and women
T	(640 – kb) – (800 – kb)	(680 – kb) – (800 – kb)
S	420 – 460	420 – 500

T = table height
S = seat height
P = footrest height
kb = height of keyboard above table top

Workstations equipped with a computer must accommodate at least a visual display unit (VDU) and an alphanumeric keyboard. There is no standard for such workstations because the requirements vary widely depending on individual work processes (e.g. from a simple networked terminal for enquiries to stand-alone systems for data entry and manipulation, which in addition to the VDU and keyboard may also have disk drives, scanners, printers and other peripherals). These workstations should be designed according to national safety requirements and generally accepted technical standards for good practice based on an understanding of ergonomics.

Workstation design

Items that are used frequently should be placed within the preferred field of vision and reach area → (1) - (3).

The best working position is when the person is seated with the upper arm perpendicular to the floor and the forearm at a 90° angle. The thighs should be parallel to the floor with the lower leg at a 90° angle → (4). The table and chair must be adjustable to allow proper positioning for users of different heights. Two ergonomic systems are equally acceptable.

A: Type 1 workstation

Adjustable-height table	60–78 cm
Adjustable-height chair	42–54 cm

B: Types 2 and 3 workstations

Fixed-height table	72 cm
Adjustable-height chair	42–50 cm
Adjustable foot rest	0–15 cm

Sufficient leg clearance should be provided → (6).

In work areas, all items of equipment close to the user (on the desk top, etc.) should have a 20–25% reflection factor. Illumination should be between 300 and 500 Lx, and glare from lights must be limited (e.g. by providing specular louvred ceilings above VDU stations). Arrange lighting strips parallel to the window. Matt surfaces in the room should have the recommended reflection factors (ceiling approx. 70%, walls approx. 50%, movable partitions approx. 20–50%).

The worker's line of sight to the monitor should be parallel to the windows and to any lighting tubes; the monitor should be between these if possible. It is necessary to install blinds to control daylight at visual display workstations.

Follow local recommendations for environmental control and noise protection. The increased use of heat-generating electronic equipment in offices tends to result in the need for additional cooling to maintain a comfortable temperature.

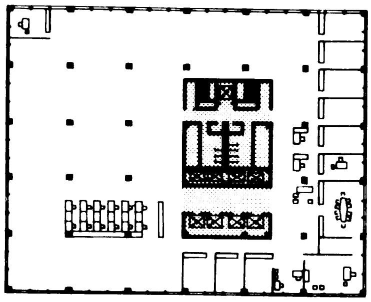
The impact of information technology

Employment usually required attendance at a place of work because the materials and tools were there, and the work needed to be supervised. However, advances in information technology mean that the 'material' for most office work (information) can be transmitted electronically. The tools of office work are increasingly a telephone and a workstation, both of which can be installed at home. Innovations in communication technology are gradually having a major impact on how the work environment is defined. It is also freeing many workers from geographical constraints. The free-address workstation is becoming a technical reality, with portable voice and data links to anywhere in the world. However, the free-address workstation has implications for both people and organisations, such as the need for increased social interaction and new management techniques which are able to cope with a widespread workforce.

OFFICE BUILDINGS

Examples

Organisation of plan

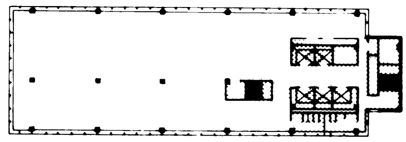


Architects: I.M. Pei & Associates

① **Rental offices; 93% rentable floor area. Public circulation vertically. Asymmetrical design allows small rooms and large open offices**

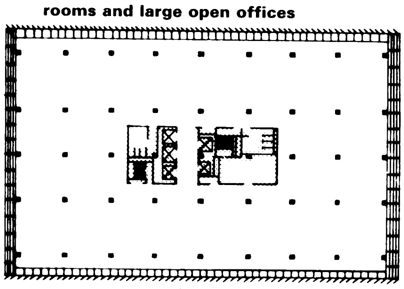
Architects: Skidmore, Owings & Merrill

③ **Typical floor-plan for open offices; lavatories separated. External columns allow furniture to be positioned anywhere. 17.50 m free span**



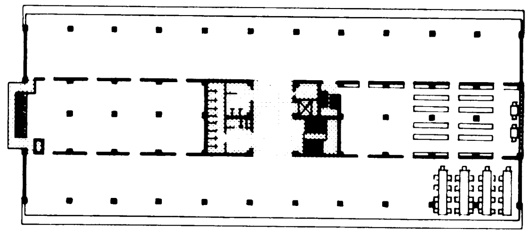
Architects: Skidmore, Owings & Merrill

④ **Design without corridor, service core at one end. Manager's office accessible from open office**



Architects: V. Gruen & Associates

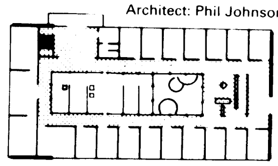
② **Steel skeleton acts as rigid load-bearing structure; no need for bracing with wall panels. Vertical fins, east and west; horizontal sun shades, south**



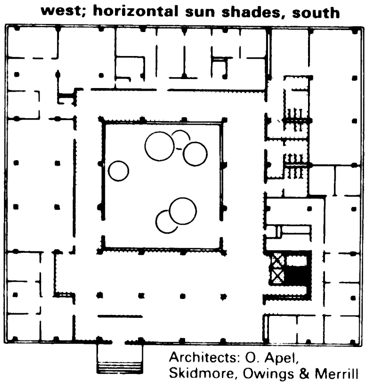
Architect: H. Kosaka

⑤ **Open offices with closest possible direct access to fireproof strong rooms. Service core in centre minimises circulation space**

Architect: Phil Johnson



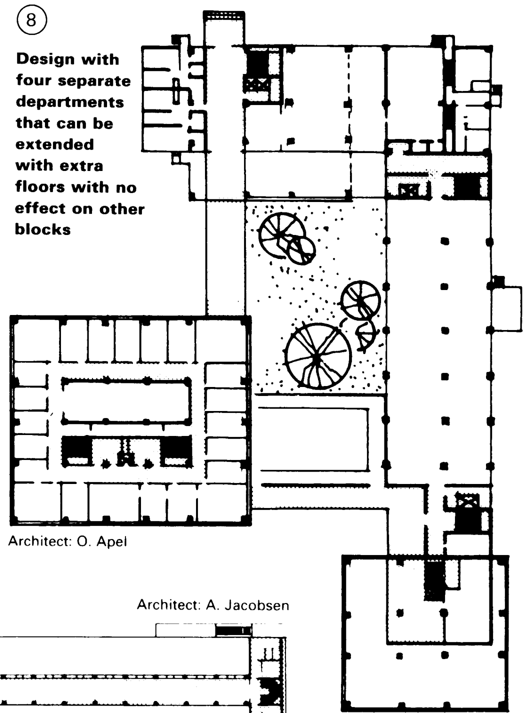
⑥ **Single-storey building with offices on periphery. Conference room and secretarial open onto garden court**



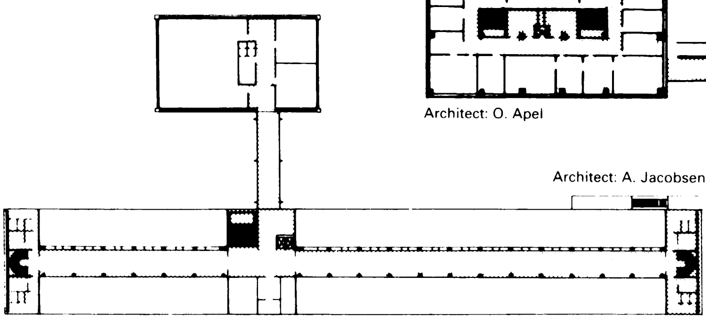
Architects: O. Apel, Skidmore, Owings & Merrill

⑦ **Ground floor public space; three-storey north wing for offices**

⑧ **Design with four separate departments that can be extended with extra floors with no effect on other blocks**



Architect: O. Apel



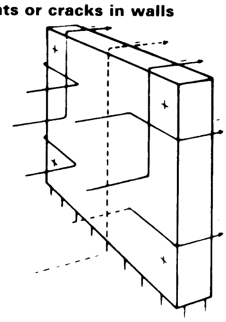
Architect: A. Jacobsen

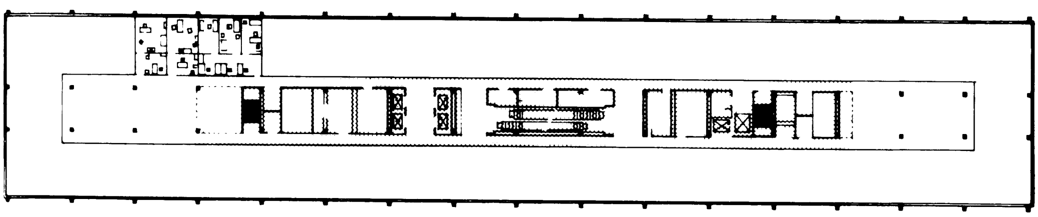
⑨ **Parts separated according to main functions → ⑦, ⑧. Public circulation on ground floor; meeting rooms separate from main building**

The placement of general expansion joints depends on the type of structure, foundations, ground conditions, etc. They are usually between 30 and 60 m apart. Joints are generally required to accommodate movement safely. e.g. structural movement, or thermal expansion and contraction.

- The simplest design uses reinforced concrete to erect paired columns that are covered to protect against weather.
- Cantilevered floors and expansion joints between the two cantilevers are subject to the greatest stress.
- Complex designs, e.g. with connected buildings and parapets, usually create enormous stresses.

⑪ **Wind force on high-rise buildings causes areas of high or low pressure that can force rainwater in through window joints or cracks in walls**

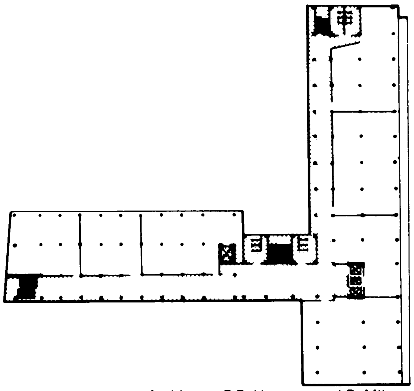




Architects: Skidmore, Owings & Merrill

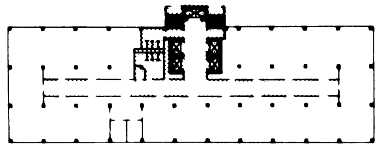
⑩ **Very deep, subdivided offices. Secretary or receptionist and senior clerks have open or enclosed workstations with access to corridor. Artificial ventilation and lighting**

Examples



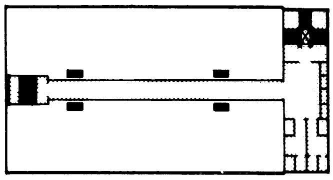
Architects: P.R. Vazquex and R. Mijares

(1) **Single-range building that is economical because of 10.0m deep rooms; central vertical circulation connects the two parts of the building**



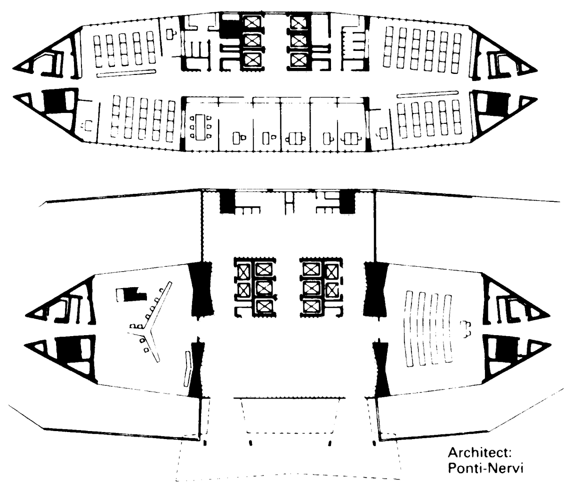
Architect: P. Beluschi

(2) **Normal double-range of rooms, economical design; disadvantage: structural grid dictates office modules**



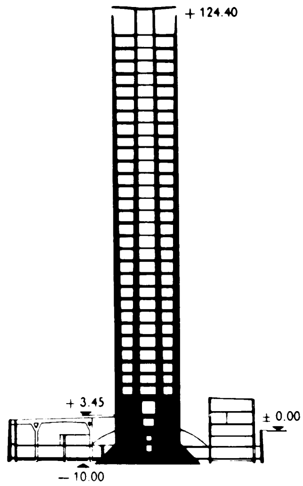
Architect: A. Jacobsen

(3) **Pair of piers on ground floor allows through access. Floor supported by two longitudinal main beams projecting 5.50m**

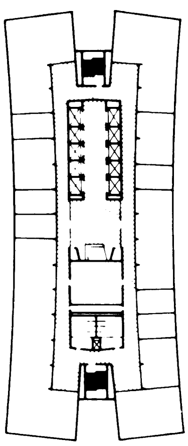


Architect: Ponti-Nervi

(4) **Load-bearing structural towers → (5) with pre-stressed floors with spans up to 24m but only 0.75m in depth in between**

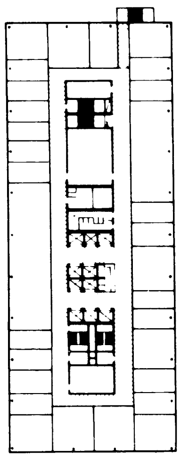


(5) **Section → (4)**



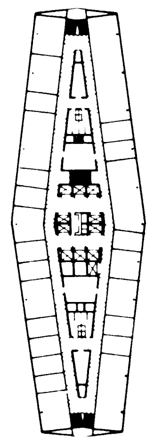
Architect: Scheller

(6) **Curved rows of rooms give better lighting and ventilation**



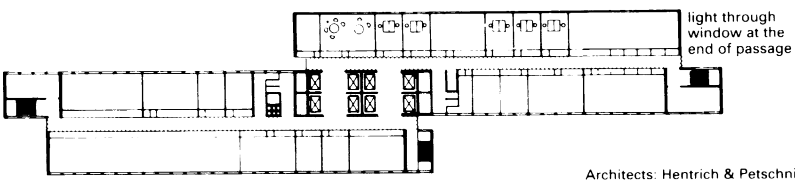
Architect: Rosskotten

(7) **Interior circulation areas and rooms have only artificial light and ventilation**



Architects: Hentrich & Petschnigg

(8) **Lift arrangement makes structure widest in the circulation core**



Architects: Hentrich & Petschnigg

(9) **Two double-range buildings connecting at a single vertical circulation core → p. 339 (14)**

High-rise buildings

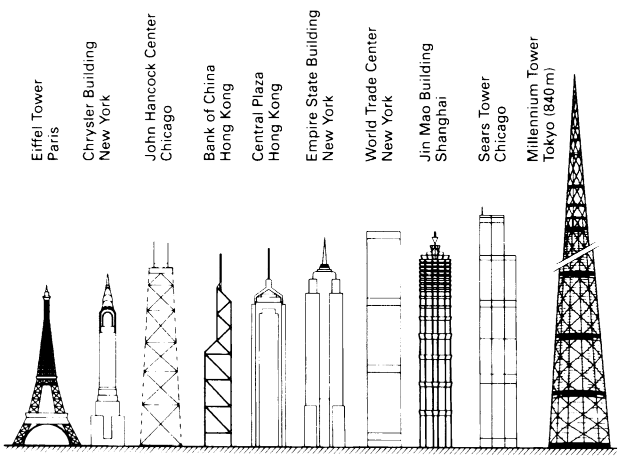
The first high-rise buildings were office blocks. Lower floors usually contained shops and stores with sales areas throughout and no atria. Office areas were located above, and were often set off by a different scale and choice of materials. Vertical circulation components, lifts, stairs and service rooms in a central location had only artificial ventilation and lighting. New possibilities were provided by stepped buildings with stairway and lift towers situated immediately to one side.

High-rise buildings are intended for continuous human occupation, and have a floor on the top storey on at least one side of the building that is more than 22m above ground level. Window sills must be at a height of at least 0.90m above floor level and be fire resistant. Window surfaces that cannot safely be cleaned from inside the building must be cleaned by experts, using exterior equipment. High-rise buildings should be divided into fire compartments that are 30m long and enclosed by fire-resistant walls. Escape routes from each room on each storey must be provided via at least two independent staircases. Alternative escape routes within limited travel distance must be accessible from the fire to a protected zone. One stairway must have external windows on each floor. In high-rise buildings, some staircases should be constructed as fire-fighting staircases with smoke outlets, vents and fire-resistant, self-closing doors. The effective width of stairways and landings depends on the function of the building, but must be at least 1.25m. Emergency stairs must have an effective width of at least 0.80m.

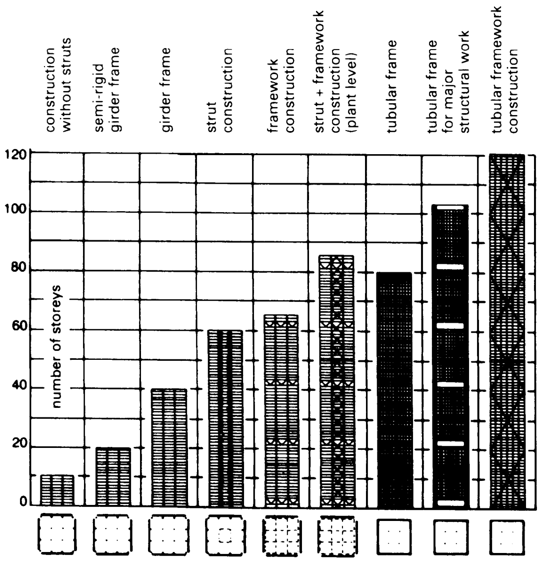
A frame construction of steel or reinforced concrete is the standard structure for high-rise buildings. The need for flexible spaces with large spans is making masonry construction obsolete. However, the size of span depends on material and design. A solid reinforced concrete floor can have a span of 2.5–5.5m, and a ribbed floor 5.0–7.5m, both with a maximum 12.5m between main beams. The effective span of pre-stressed concrete is 25.0m, but only with 0.75m structural depth. The exterior wall should be a curtain wall in front of set-back external columns. In both steel construction and assembly units, steel main and secondary beam systems make assembly easier but shorten the possible spans. A mixed design with a steel frame and concrete floors is often used.

OFFICE BUILDINGS

Examples



① **Some of the world's tallest structures**



② **Economic efficiency range of structural systems**

Skyscrapers

New York City passed a new planning law in 1982 to regulate skyscraper construction. Its provisions represented an attempt to come to grips with dense traffic, 3 million commuters daily, and town-planning aspects such as maintenance of street spaces, expansion of public sidewalks and subway entrances, pedestrian traffic, availability of daylight and micro-climates → ③.

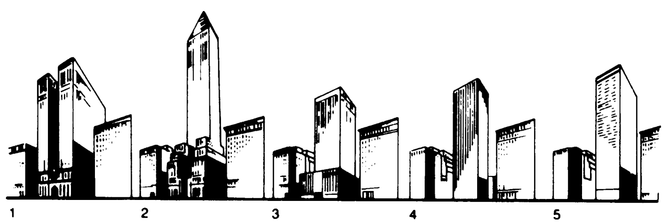
Structural engineering for skyscrapers

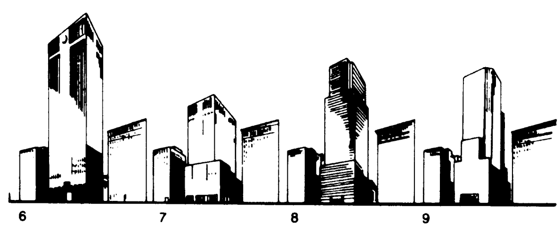
Structural systems and vertical-access elements are of decisive importance when designing skyscrapers. The ratio of usable floor area to construction costs worsens as building height increases. Structural areas and circulation spaces occupy more of the building. Dividing skyscrapers into sections with 'sky lobbies', served by express elevators where passengers can change to local elevators, minimises the space required for shafts and reduces travel time.

Economic efficiency depends on the 'sway factor', i.e. the ratio of the maximum allowable horizontal deformation at the top to the total height of the building (max. 1:600). Horizontal forces (wind) are much more important than vertical loads when making calculations for very tall buildings. Ninety percent of horizontal deformations result from shifting of the frame ('shear sway'), while 10% come from the leaning of the building as a whole. Frame construction with special wind bracing is impracticable beyond ten storeys. Conventional framework systems result in uneconomical dimensions above the 20th storey. Reinforced concrete framework structures are limited to ten storeys without bracing walls and 20–30 storeys with them. Higher buildings require concrete pipe or double-pipe construction.

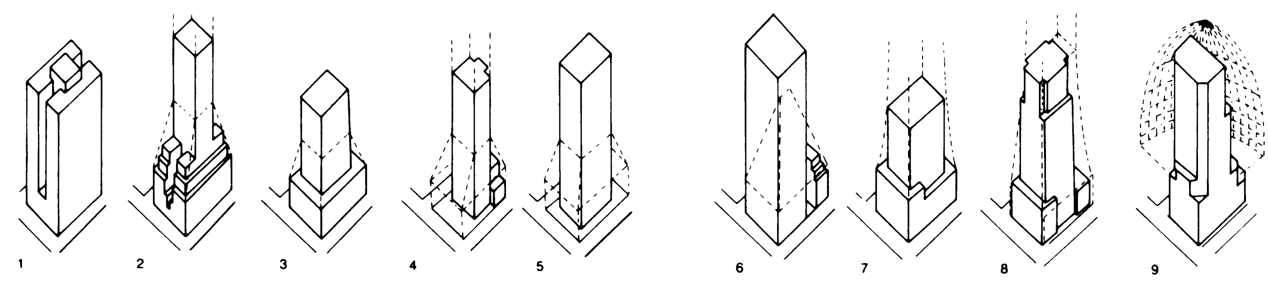
Factors determining whether a building is economic include use of materials, appropriate design and efficient structural engineering methods → ②. The John Hancock Center, Chicago, 1965 → ①, was the result of an economical structural approach by Skidmore, Owings & Merrill. The visible structural components were part of the design concept. Use of the pipe principle significantly reduced the use of steel. Its efficiency of operation is due to its multiple uses: floors 1–5 have shops, floors 6–12 are parking spaces, floors 13–41 are flexible-use offices, floors 42–45 have technical facilities and a sky lobby, floors 46–93 are residences, floors 94–96 are for visitors and restaurants, and floors 97 and 98 house television transmission equipment.

New York's Department of City Planning has issued a brochure that contains examples of how statutory requirements attempt to guarantee sufficient daylight and circulation space in spite of the increasing volume of construction.





1 Equitable Building, 120 Broadway, built in 1916 before the first zoning regulation
2 The 1916 regulation required a specific ratio of street width to building height. That led to the typical 'wedding cake' skyscraper
3 The plot ratio as a regulatory instrument was introduced in 1961. The initial limit was 15
4 At the same time more street space was required, resulting in the tower over a plaza. The Seagram Building is shown here
5 Plazas received a bonus that increased the plot ratio to 18
6 The use of plazas would have meant the destruction of avenues in some cases, so the system of running public roads through buildings was developed. The plot ratio was increased to 21.6
7 More recent regulations once again deal with daylight, with one alternative involving a daylight curve for a plot ratio of 15
8 Another alternative depends on the dimensions of the unobstructed skyline (plot ratio of 18)
9 The most recent daylight chart may also be used (plot ratio of 18)

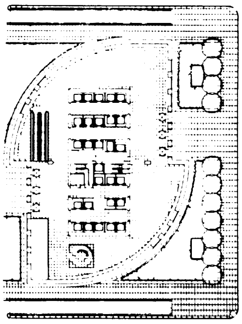


③ ①–⑨ **Zoning laws indicate permissible building volumes**

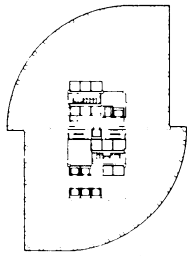
OFFICE BUILDINGS

Examples

① and ② Curved surfaces reduced wind load by up to 25%, and also saved 10% in structural steel.
③ and ④ Office tower taking the geometry of its plan from the triangular shape of the site on which it is built.
⑤ and ⑥ Part of site transferred to public use in return for a planning gain increasing the number of storeys.
⑦ and ⑧ Recessed façade in the arc of a circle creating a new plaza. The rotunda is an enclosed atrium.

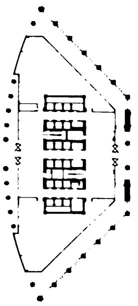


(1) **Ground floor, Allied Bank Plaza, Houston (71 storeys)**

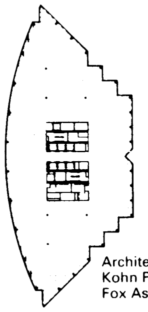


Architects: Skidmore, Owings & Merrill

(2) **Typical floor**

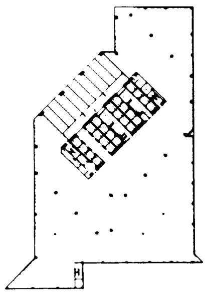


(3) **Ground floor, 333 Wacker Drive, Chicago (37 storeys)**

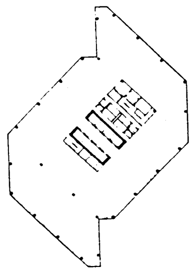


Architects: Kohn Pedersen, Fox Associates

(4) **Typical floor**

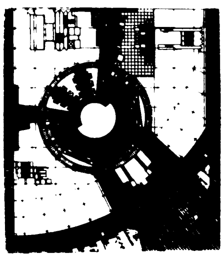


(5) **Typical floor, plinth area, 101 Park Avenue, New York City (48 storeys)**

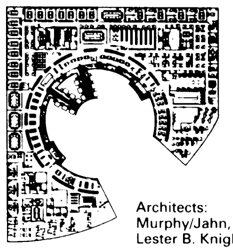


Architects: Eli Attia Associates

(6) **Typical floor, tower portion**

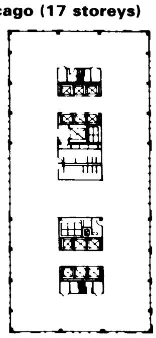


(7) **Ground floor, 1985. State of Illinois Center, Chicago (17 storeys)**



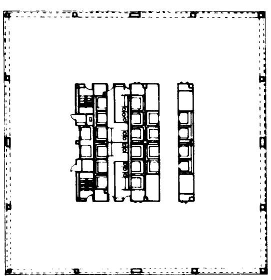
Architects: Murphy/Jahn, Lester B. Knight and Associates

(8) **Office floor**



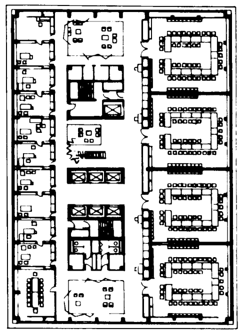
Architects: Philip Johnson and John Burgee, Harry Simmons, New York

(9) **AT&T headquarters, New York. Typical floor, 1984**

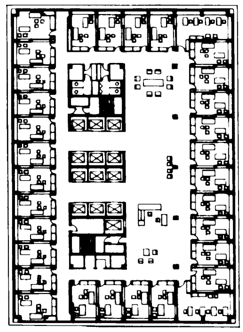


Architects: Hugh Stubbins & Associates, Cambridge, Massachusetts

(10) **Typical floor, Citycorp Center, New York**

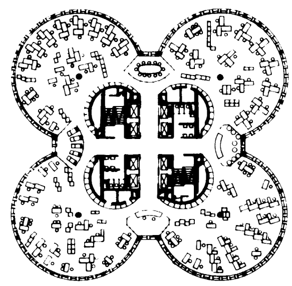


(11) **Floors 2–17 of 'Abgeordnetenhaus' in Bonn contain offices for German MPs, 1969**

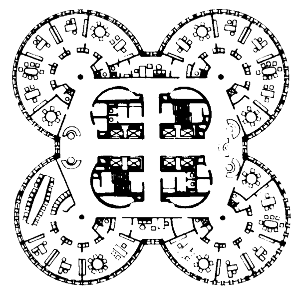


Architects: E. Eiermann in conjunction with the BBD (Federal Department of Building)

(12) **Floors 19–28 contain meeting rooms**

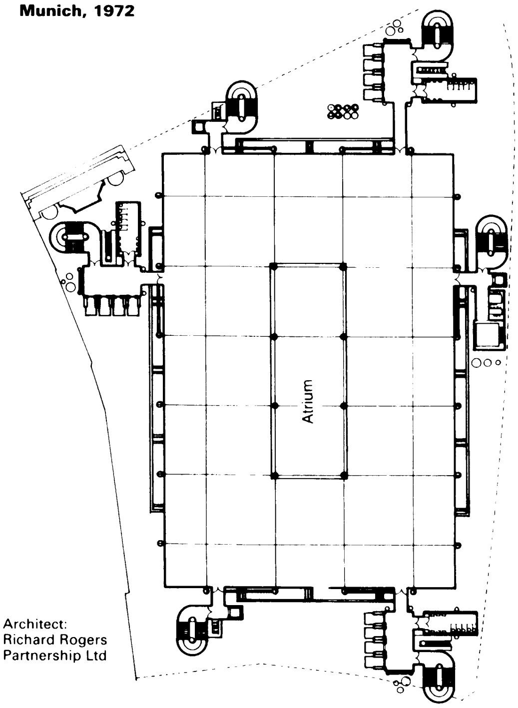


(13) **Typical floor used for open-plan office, BMW headquarters, Munich, 1972**



Architect: Karl Schwanzer

(14) **Floor plan showing individual offices**



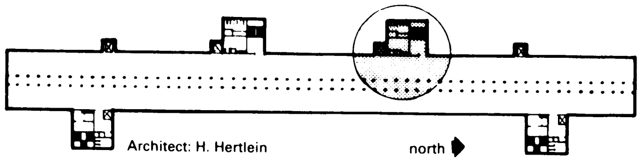
Architect: Richard Rogers Partnership Ltd

(15) **Lloyd's of London, floors 4–7/ complete floors, 1986**

OFFICE BUILDINGS

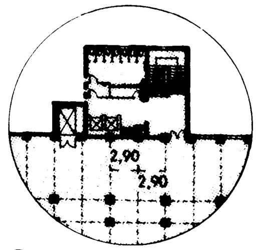
Examples

Vertical components

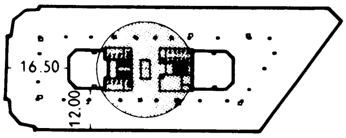


Architect: H. Hertlein

(1) **High-rise in Siemensstadt, Berlin**

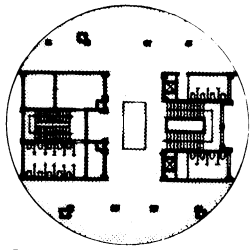


(1) a service core in Siemens high-rise

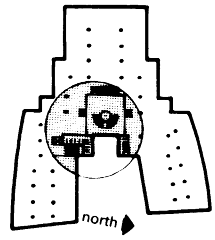


Architects: Rambatz & Jolasse

(2) **Bieberhaus, Hamburg**

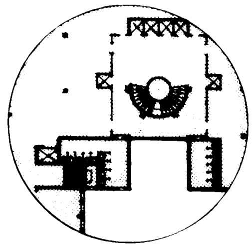


(2) a service core in Bieberhaus

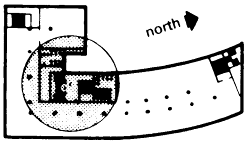


Architects: H. and O. Gerson

(3) **Ballinhaus, Hamburg**

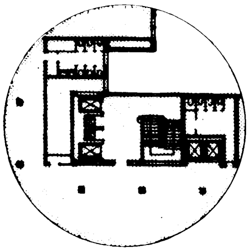


(3) a service core in Ballinhaus

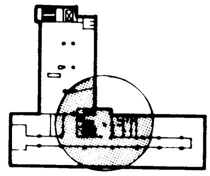


Architect: E. Mendelsohn

(4) **Columbushaus, Berlin**

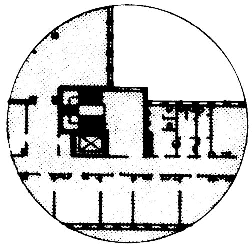


(4) a service core in Columbushaus

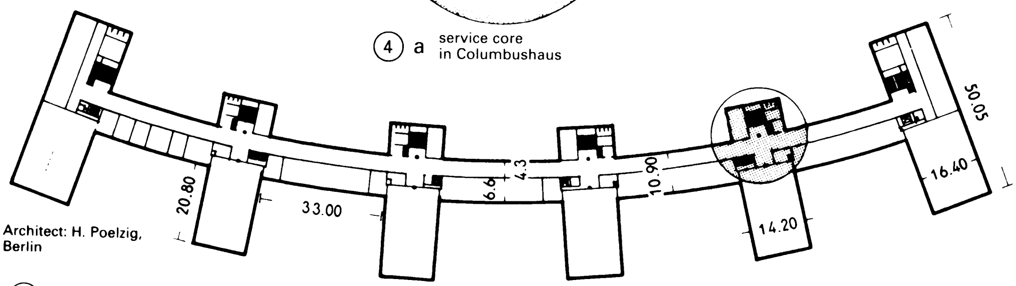


Architect: H. Hertlein

(5) **Siemenshaus, Essen**

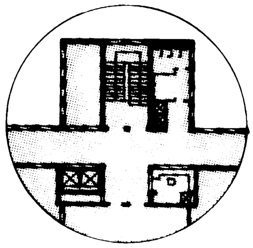


(5) a service core in Siemenshaus

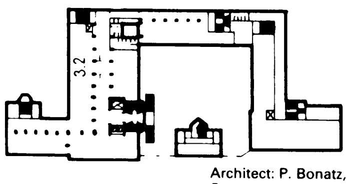


Architect: H. Poelzig, Berlin

(6) **I.G. Farben headquarters, Frankfurt am Main**

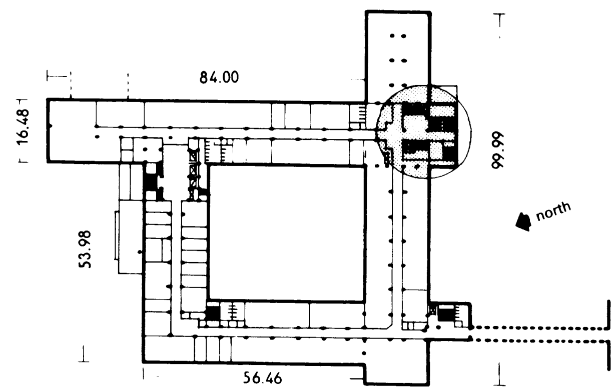


(6) a service core in I.G. Farben headquarters



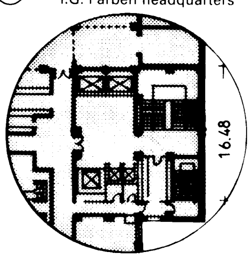
Architect: P. Bonatz, Stuttgart

(7) **Stummhaus, Dusseldorf**

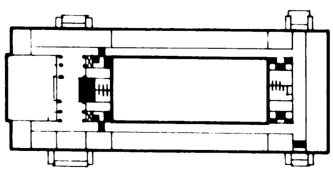


Architect: H. Hertlein

(8) **Wernerwerke HQ in Siemensstadt, Berlin**

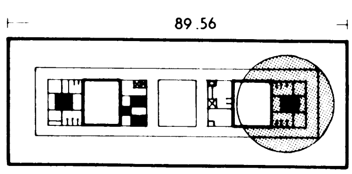


(8) a service core in Wernerwerke headquarters



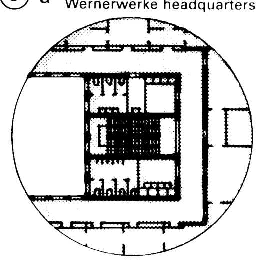
Architect: G. Epitanse

(9) **International Labour Organisation, Geneva**

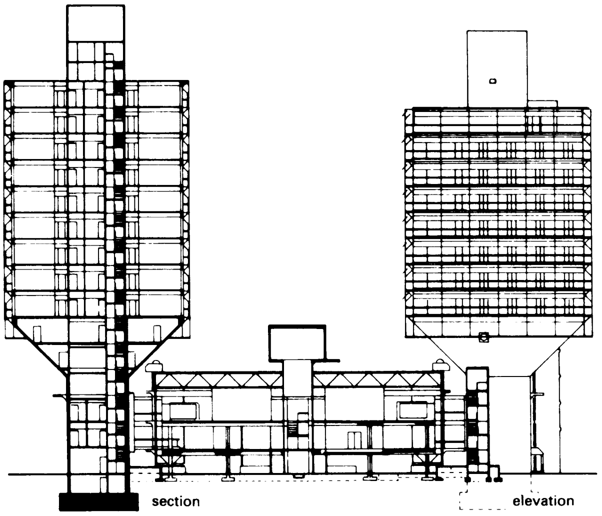


Architect: Blecken

(10) **Headquarters of Vereinigten Stahlwerke, Duisburg-Ruhrort**



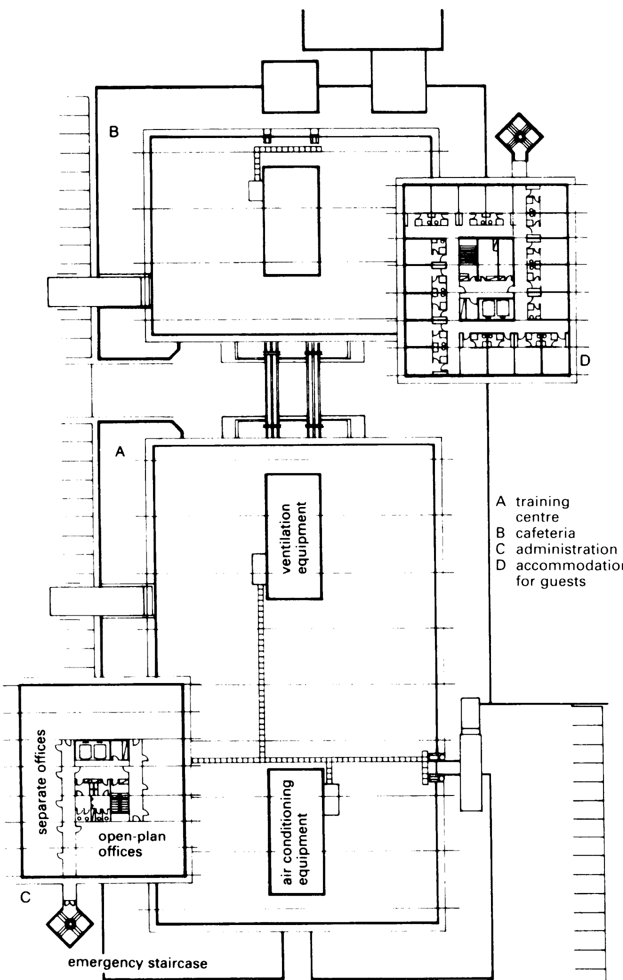
(10) a service core in Vereinigten Stahlwerke



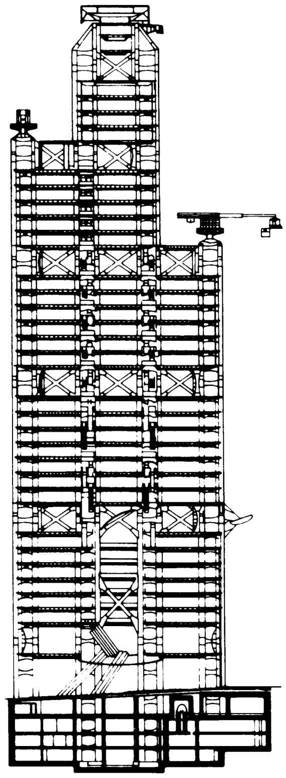
Architects: E. Eiermann

Section of high-rise office building and training centre, including high-rise accommodation for trainees. Centre includes secretarial department, classrooms, computer suite, sales offices, service areas, and underground level with outdoor parking places for cars. Administration high-rise has office space, technical facilities and access to archives and environmental control (cooling and re-cooling plant) → ②

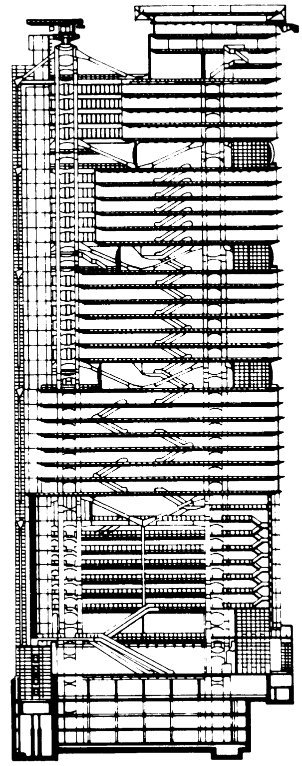
① **Deutsche Olivetti, Frankfurt am Main, 1972**



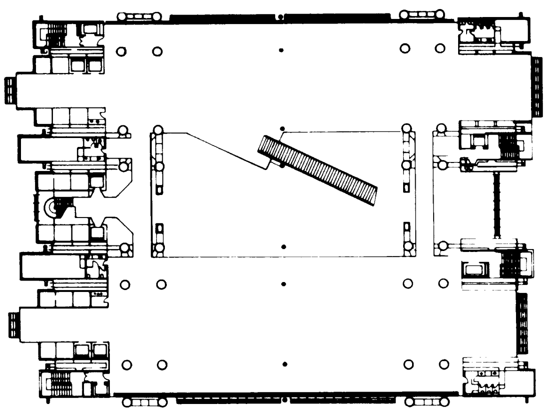
② **Typical floors in towers. Space is suitable for both separate and open-plan offices** → ①



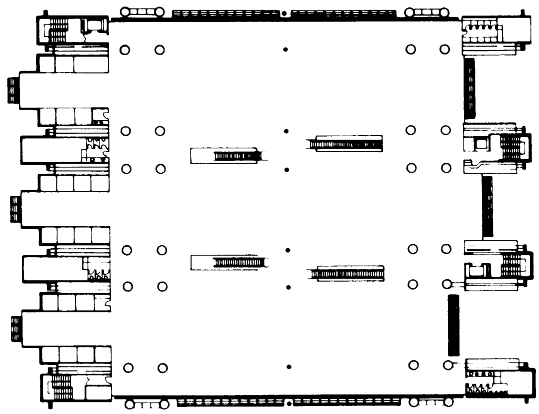
③ **Reflectors throughout the low levels reflect daylight into the atrium hall** → ④ – ⑥



④ **Storeys are staggered within the office spaces**



⑤ **Upper floor, upper banking hall**



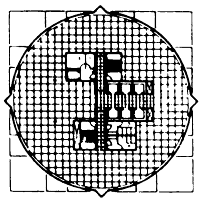
Architects: Foster Associates

⑥ **Typical three-bay floor, Hong Kong & Shanghai Bank, 1986**

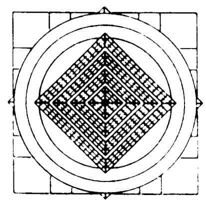
OFFICE BUILDINGS

Examples

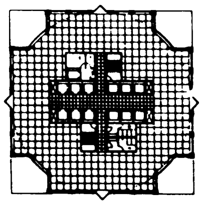
A high-rise office block project in Frankfurt am Main, 1990, was the outcome of a competition. The offices were to be let. Most of the ground floor area was kept open, and the plinth floors recall the requirements of New York City's zoning laws. A striking effect in the urban space was an important criterion in appraising the entries to the competition. The building has 51 storeys, including 45 floors of offices, and is over 200m high. Gross usable floor area is 66081 m² → ①–⑩.



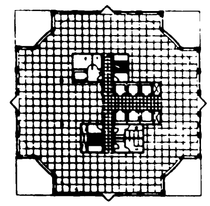
① **Offices on floors 41–47 (core 231 m²)**



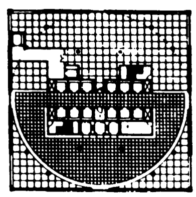
② **Roof plan**



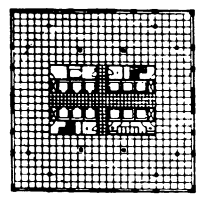
③ **Offices on floors 5–25 (core 309 m²)**



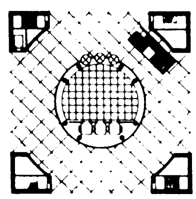
④ **Offices on floors 26–40 (core 231 m²)**



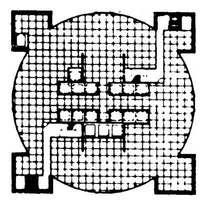
⑤ **Sky lobby, second floor**



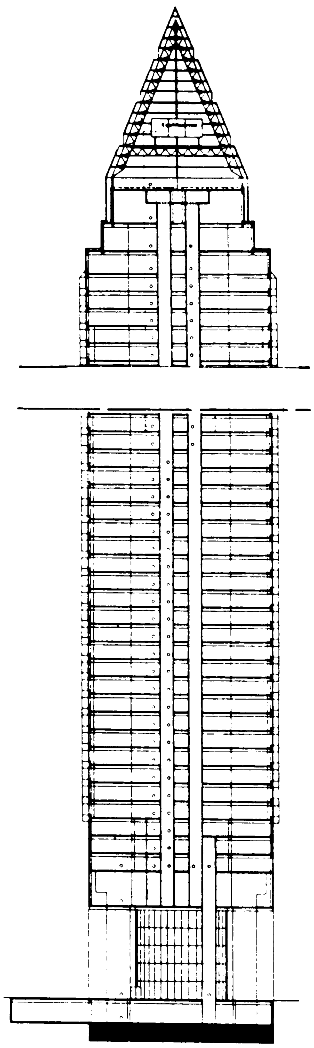
⑥ **Offices on third and fourth floors (core 307 m²)**



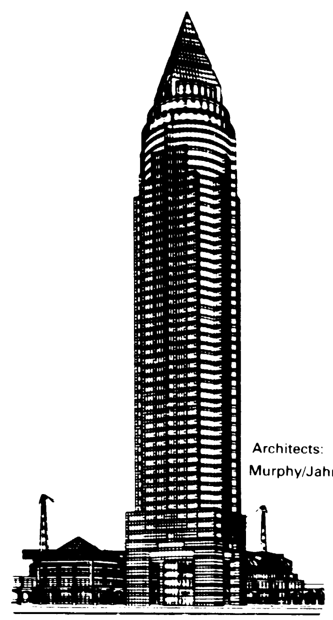
⑦ **Lobby on ground floor**



⑧ **Technical plant, first floor**

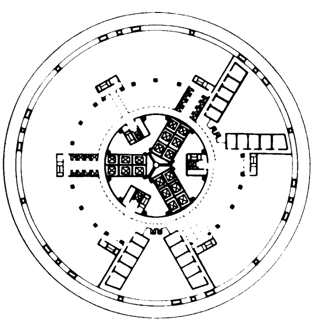


⑨ **Section → ① - ⑧**

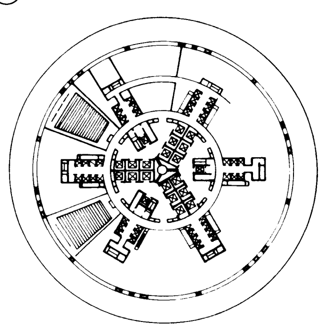


⑩ **Perspective view**

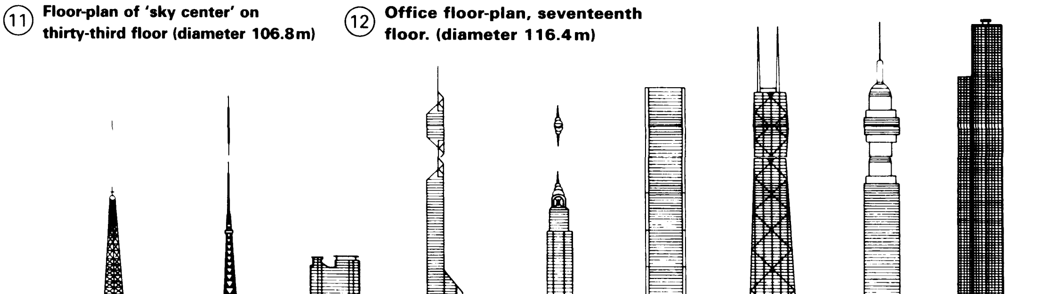
Millennium Tower, Tokyo: study commissioned by Ohbayashi company. Anchored in the sea, 2 km outside Tokyo, on an artificial atoll 400 m in diameter. Usable floor area designed to accommodate 50000 people. Office space is included in part of the tower at a height of 600 m. Building diameter at ground level is 130 m. Lifts for 160 passengers provide express transport to the five 'sky centres' where passengers can change lifts to gain access to 30 other storeys. The pipe-like construction, involving multiple concentric rings, has foundations 80 m deep in the sea. A dynamic balance regulation system that uses weights and water tanks, automatically controlled according to wind measurements, has been designed to counterbalance movements of the building caused by wind pressure. The result is a slimmer structure using less material → ⑪, ⑫ and ⑭.



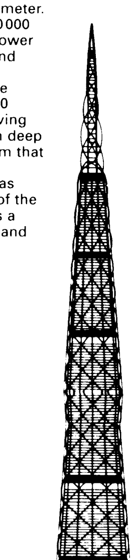
⑪ **Floor-plan of 'sky center' on thirty-third floor (diameter 106.8 m)**



⑫ **Office floor-plan, seventeenth floor. (diameter 116.4 m)**



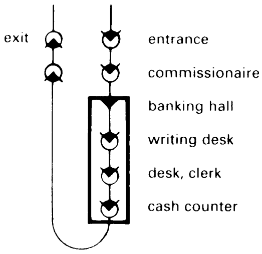
⑬ **Comparative heights of well-known buildings**



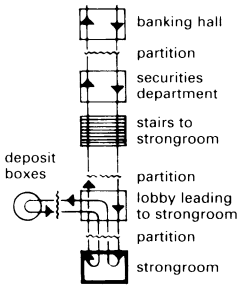
⑭ **Millennium Tower, Tokyo**

BANKS AND BUILDING SOCIETIES

General Requirements



(1) **Customer circulation in large banks**



(2) **Routes to strongroom**

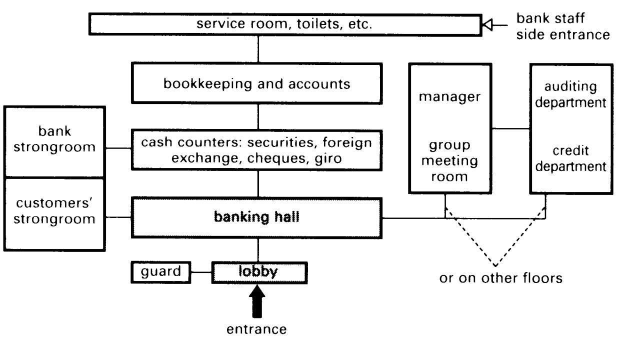
The requirements for the construction of a bank vary and depend on the nature of the bank's business (e.g. a high street bank with a large number of customers or an institution that handles large-scale investments and corporate work). In general the function of a high street bank is to allow money, whether in cash or some other form, to be paid in and withdrawn. Procedures must be transacted as quickly, securely and simply as possible.

Customers enter from the street outside, and then pass through a lobby, if appropriate, into the banking hall. The latter is often fitted with bench seats or chairs for waiting customers and small writing desks for customers, and has various positions for conducting transactions.

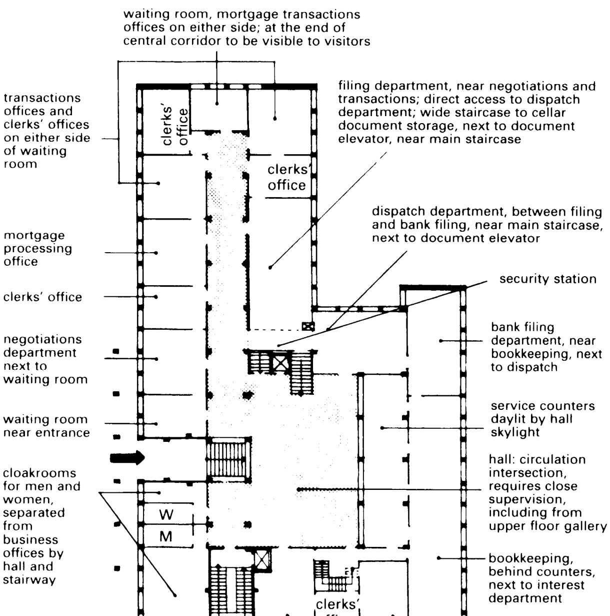
Desks for accounts and bookkeeping staff are usually behind the service counters, where transactions are verified and related operations are dealt with → (1). Cashiers nowadays have individual terminals that display the the customers' account details. Other areas serving customers, such as managers' offices, credit and auditing departments, are usually in the rooms leading off the main banking hall, often with separate anterooms, or on an upper floor → (3).

If the bank has safety deposit boxes, access from the banking hall should be via a partition, usually past the securities department and safe custody department, often one flight down, to a protective grille in front of the lobby leading to the strongroom containing the boxes. In smaller banks the strongroom may be divided behind the door into two, one part for bank use the other for customers → p. 361 (9). Larger banks normally have a separate bank strongroom next to that for customers. Offices of safe custody departments are in front of the entrance to the bank strongroom and have a separate staircase to the banking hall or secure lifts. → (3) Other basement areas must be accessed by a separate staircase. They can provide space for cloakrooms, storage, heating and ventilation plant, communications equipment and so on.

Building societies have existed in the UK since the end of the 18th century. They are societies of investors that accept investments, paying interest on the deposits, and lend to people building or buying properties. The investors are either member-shareholders or simply depositors. They supply the funds from which the house purchase loans are made. The operating basis of an incorporated and permanent Building Society resembles that of a bank so both have similar requirements in terms of building design.

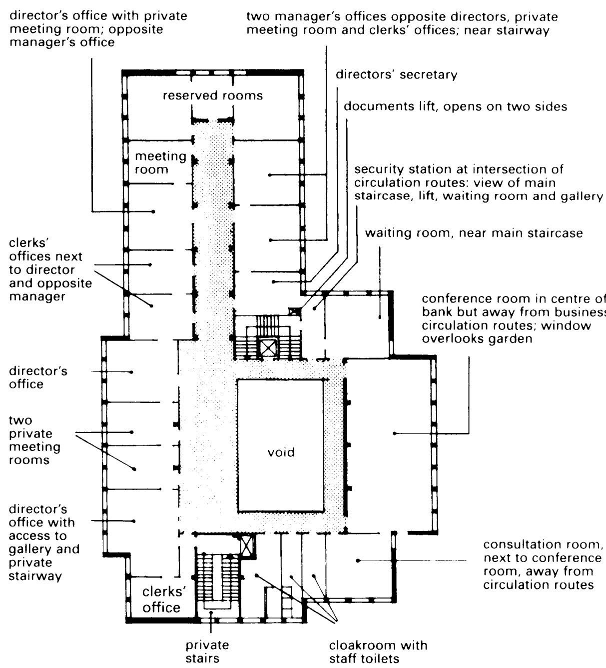


(3) **Relationships of rooms in large banks**



(designed by author for the Mitteldeutsche Hypothekenbank in Weimar)

(4) **Practical relationships of rooms in a large building society/mortgage bank, ground floor**



(5) **Upper floor** → (4)

BANKS AND BUILDING SOCIETIES

Open-plan Layout

There is a trend towards open-plan layouts in modern banks and building societies. This is intended to provide more room for the customers, making them feel comfortable and welcome. Since bulky protective screens are now almost unnecessary, large additional areas can be opened up for customer use.

Over recent years bank design has evolved to accommodate the following ideals:

- A 'shop-like' retail environment.
- Fully glazed or open frontages to create a more inviting image.
- Services that are dealt with as products to be 'sold' by staff trained to deal with customers in a friendly, attractive environment.
- More space given over to the customer and designs with better use of light and colour, prominent merchandising and designated sales, comfortable waiting areas and private interview rooms.

Open-plan principles

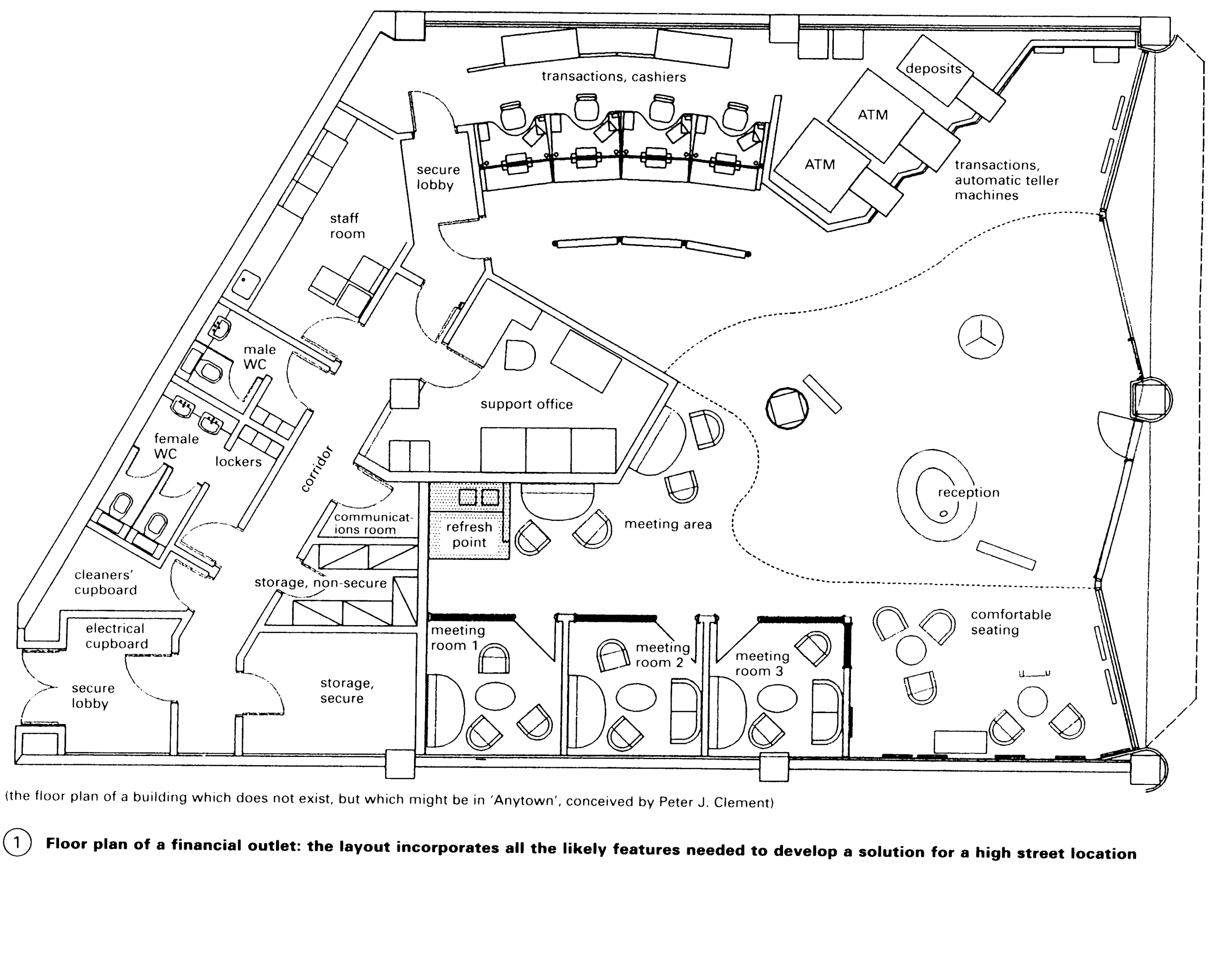
The idea of open planning is to bring staff and customers much closer together and build up customer loyalty. The aim is to generate an environment for improved service and with it enhanced business for the bank. Pugh Martin, an architect working with Barclays Bank, listed the following guiding principles relating to a high street open-plan bank.

- Maximise space given over to customer: move service counters as close to perimeter walls as possible; reduce space for support staff and equipment.
- Minimise space for processes and secure areas ('back office' functions are increasingly being moved from branches and centralised).
- Maximise potential for 'selling' financial products: by re-locating counters and non-sales functions, wall and floor space is released for displaying product literature and advertising material. This makes it possible to deliver coordinated marketing campaigns easily seen by the customers.
- Create personal contact space for dealing with financial products: allow for specialised, sometimes purpose-built, self-contained desks at which trained staff can deal face-to-face with customers.
- Achieve an open, inviting and customer-friendly environment that brings the customer in easily, makes each service easy to find and enables the customer to circulate throughout the bank comfortably.

Cash dispensers

Cash dispensers (or automatic teller machines, ATMs) are now a universal feature of modern high street banks and building societies. They can sit inside the bank or face into the street, the latter allowing customers access to their account details and funds 24 hours per day.

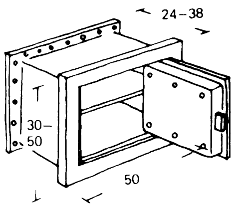
Cash dispensers are usually built into the bank façade and they need to: (1) be at or near ground level to allow for easy public access, (2) allow access from the rear to bank staff, (3) not disrupt window frames, sills or horizontal banding, and (4) correspond to the rhythm and scale of the fenestration above. Sometimes, cash dispensers are placed at the side of the building, which helps to solve the problems of disabled access and of obstruction of the pavement if queues form at busy times when the bank is closed. In larger banks, a number of cash dispensers can be set in an adjoining lobby that is open to customers at all times.

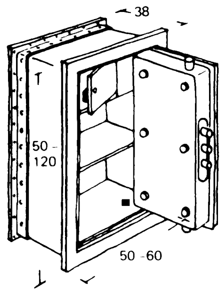


(the floor plan of a building which does not exist, but which might be in 'Anytown', conceived by Peter J. Clement)

(1) **Floor plan of a financial outlet: the layout incorporates all the likely features needed to develop a solution for a high street location**

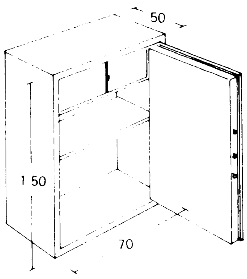
Safes and Strongrooms





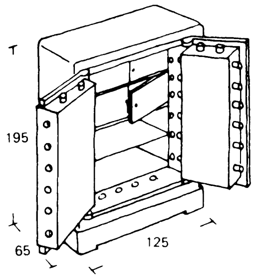
exterior	height	30	30	40	40	50–120
	width	50	50	50	50	50–60
	depth	24	38	24	38	38
interior	height	17	17	27	27	37–107
	width	37	37	37	37	37–47
	depth	16	30	16	30	30

(1) + (2) **Sizes of typical wall safes**



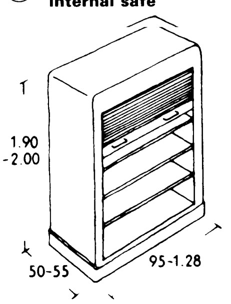
size	exterior H	exterior W	exterior D	interior H	interior W	interior D
1 door	150	70	50	137	57	41
2 doors	195	95	50	182	82	41

(3) **Document cabinet with internal safe**

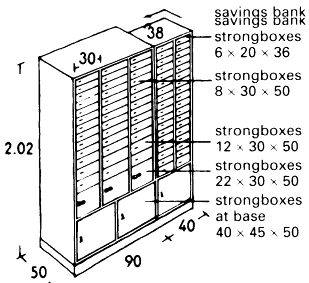


size	exterior H	exterior W	exterior D	interior H	interior W	interior D
1 door	80	60	60	50	37	36
	100	60	60	70	37	36
	125	80	60	95	57	36
	150	80	60	120	57	36
	175	80	65	145	57	41
2 doors	195	125	65	165	102	41

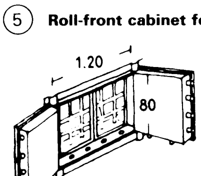
(4) **Floor safe for bookkeeping documents and cash**



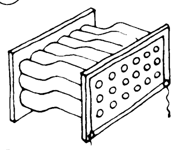
(5) **Roll-front cabinet for valuables**



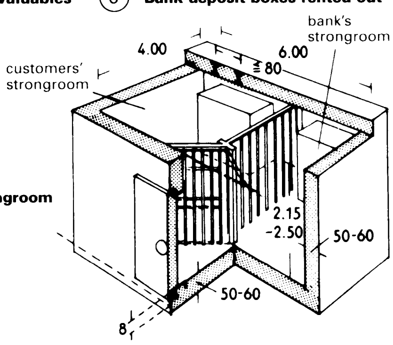
(6) **Bank deposit boxes rented out**



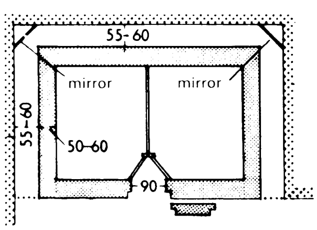
(7) **Steel window for strongroom**

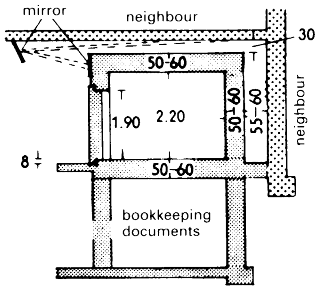


(8) **Ventilation ducts in strongroom wall**



(9) **Strongroom for smaller bank branch**





(example shown is for documents)

(10) + (11) **Strongroom surrounded by neighbouring walls**

external dimensions			internal dimensions			number of shelves
height	width	depth	height	width	depth	
50	50	45	35	35	33	1
60	50	45	45	35	33	1
80	60	45	65	45	33	2
100	60	45	85	45	33	2
120	60	45	105	45	33	2

(12) **Small money cabinets: typical sizes**

external dimensions			internal dimensions			number of shelves
height	width	depth	height	width	depth	
120	70	60	97	55	39	2
155	70	55	125	50	34	3
195	95	60	172	80	39	4

(13) **Fireproof document cabinets: typical sizes**

In general, wall safes are metal boxes built into the walls and hidden behind wallpaper or a painting. They are used to protect valuables in both domestic properties and business premises. → (1) + (2)

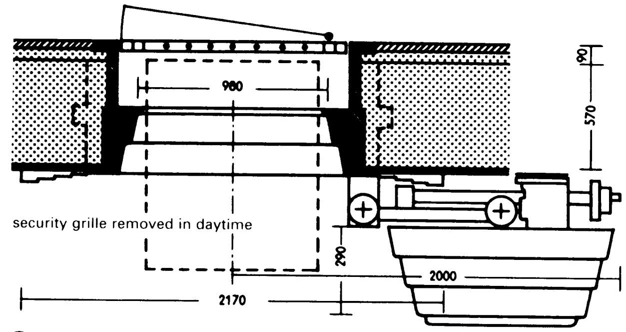
To store valuable and confidential paperwork securely, businesses make use of steel document cabinets → (3), many of which also contain a safe and are fireproof. Floor safes are used for secure storage of petty cash and documents → (4). Valuables that are rarely used are best kept in a rented safety deposit box in the strongroom of a bank → (6).

Bank strongrooms should be designed to prevent criminals from breaking in forceably. The enclosing structure and door must be able to resist penetration for sufficient time to thwart potential intruders. Structures enclosing strongrooms should, therefore, neither adjoin neighbouring spaces (i.e. no party walls) nor be built in seldom-used areas of the bank, and must not have earth below. Experience has shown that intruders otherwise have ample time to work in the unsupervised location and reduce the wall to a thin layer that can then be quickly broken through. Therefore, if a strongroom is not surrounded on all sides, including above and below, by parts of the bank that are in constant use, it must be an independent structure that is surrounded by a free space allowing full supervision.

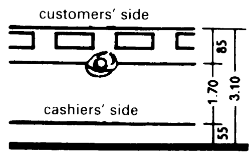
Tests have shown that a 1:3 mix concrete with specific mineral additives offers better protection than masonry. A proficient mason equipped with sharp chisels would need over 12 hours to break through a 40cm thick wall of that type, compared with only 9 hours for a hard-fired brick wall with 1:3 mortar. Iron reinforcement barely slows down a thief (hardened rods can be broken with a hammer and normal rods can be cut out) so the added cost is not justified.

The most economical way to enclose a strongroom is by 50cm of 1:4 concrete, which would require 20 hours to break through. Assuming an 8 hour working day, a thief would have only 16 hours available. However, in the worst case, with a Sunday and two holidays, thieves could have 88 hours and since modern electric and pneumatic drills are increasingly powerful, strongrooms are always vulnerable. Therefore, they should be inspected frequently outside of official business hours and this can be done using electronic listening devices that can notify the watchman's station at the bank, or the closest police station, of the slightest noise occurring outside of business hours.

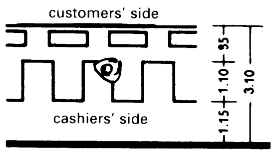
BANKS AND BUILDING SOCIETIES



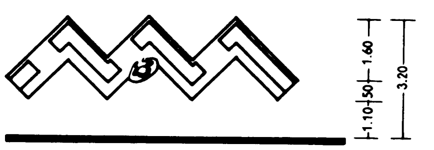
① Strongroom with inner daytime door



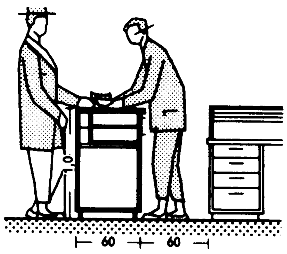
② Straight counter arrangement



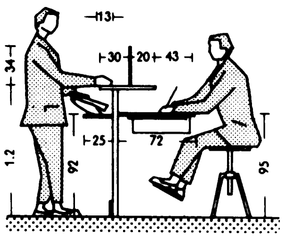
③ As → ② with desks



④ Sawtooth counter arrangement with desks at sides



⑤ German cash desks



⑥ Swedish type cash desk

cashier positions are usually completely protected with bulletproof reinforced glass (≥ 25mm thick) to prevent criminals jumping over the counter; similar protection over sunken drawers → ⑧

Strongroom doors

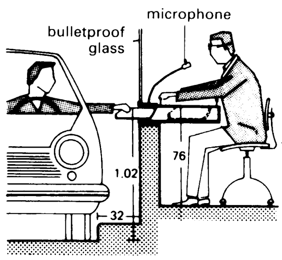
To withstand any attack, strongroom doors are made from toughened steel plate with fireproof and non-melting reinforcement, and are typically 27–30cm thick. The armoured doors pivot smoothly on steel hinges and the edges are machined to fit exactly into the reinforced door surround. They do not have keyholes, instead using elaborate remote-controlled locking devices, and are usually protected by electrically operated alarm systems that are triggered by the slightest vibration of door.

Cashier positions

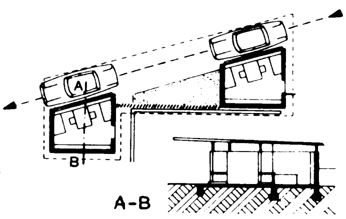
The cashiers' counter is provided with an electric alarm system operated by foot or knee to guard against potential attack. Money is held securely in standard steel cabinets, usually underneath the counter.

Drive-in banks

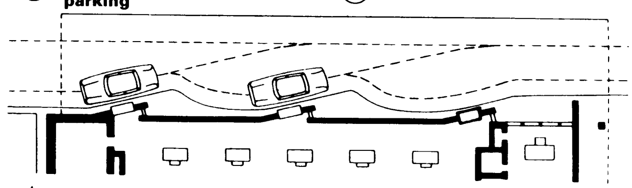
To save time, customers do not go into bank but drive up to an external cash point that may either be manned or automated. This avoids parking problems. The cash points can be integrated in bank building or built separately on islands. Each cash point can serve up to 250 customers per day; transactions can take as little as 60 seconds. However, a normal banking hall is also needed for lengthier business transactions.



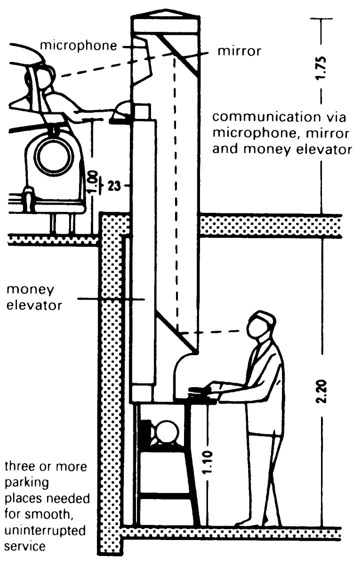
⑧ Drive-up cash point, no parking



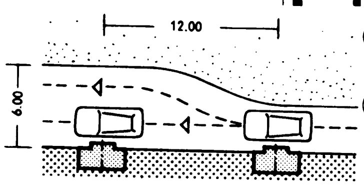
⑨ Drive-up cash point kiosk



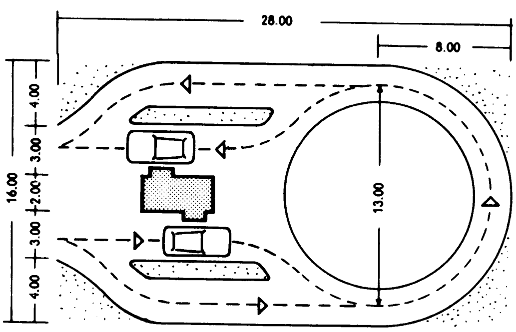
⑩ Drive-up cash points



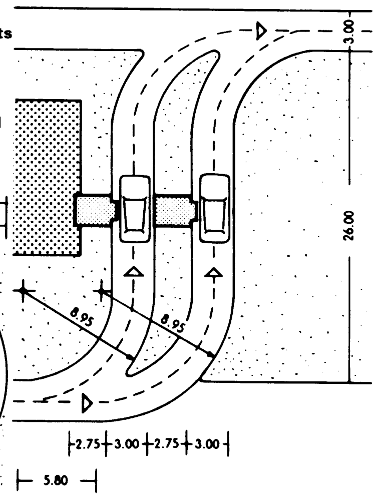
⑦ Cash point below pavement with customer service shaft (snorkel bank)



⑪ Cash points integrated with bank building



⑫ Twin cash points; islands to ease traffic flow



⑬ Cash points as → ⑧ + ⑨ for through traffic