BEIRUT NAVAL MUSEUM
BEIRUT HARBOR

AMERICAN UNIVERSTY OF BEIRUT.
DEPARTMENT OF ARCHITECTURE AND DESIGN.
A535 FINAL PROJECT RESEARCH AND DESIGN.
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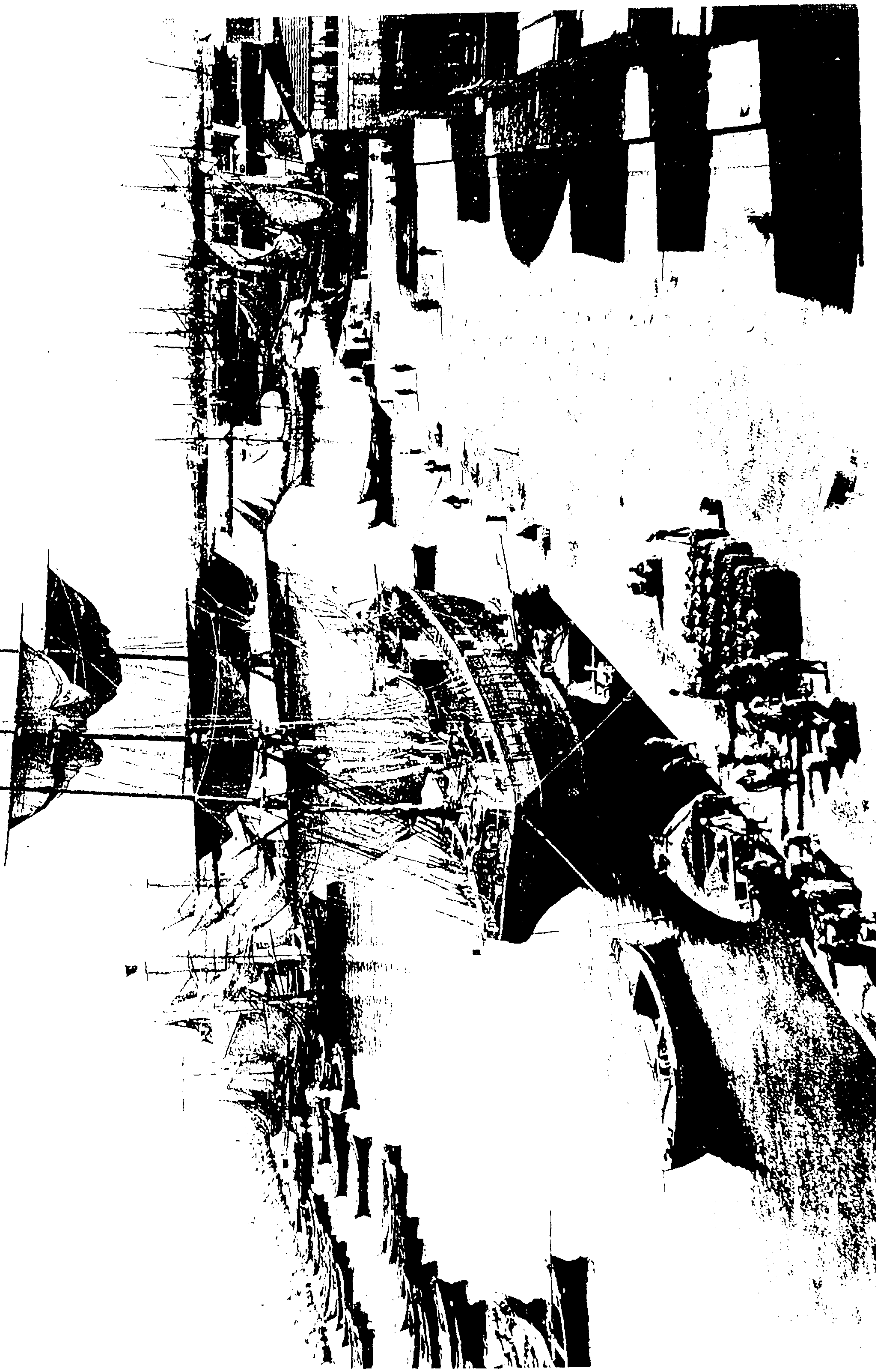
RAJA ABILLAMA ARCH. '97.



Contents

Introduction

OBJECTIVES AND SCOPE.

The eastern coast of the Mediterranean has had a long history of maritime presence and naval dominance and innovation. With the re-gaining of Beirut's touristic role, the project would achieve several goals: the introduction of tourists as well as Lebanese citizens to Beirut's history as a sea port, as well as its role on that coast, and the opening of the current port of Beirut to the public, for a long time excluded from it.

The choice of a naval history museum as a final project sprang from personal interests in the subject of naval and maritime history. The decision over the site was a logical and obvious relation between the subject matter of the project and the port. In this sense, the project is a site specific one. Why the port of Beirut in particular and not other ports along the Lebanese coastline? In the present case, its location in the capital, it scale of activities, as well as the important economic role it plays on the national level make it the major port in Lebanon. Therefore, it seemed logical to locate such a project in such a location. The importance of the site and the way it functions, however, when intersected by external intervention, becomes problematic. In other words, the imposition of a layer of public/entertainment activities over the port -an efficient, heavy duty economic machine- complications abound. This research and the design are intended to deal with some of these complications. The research is directed towards a thorough analysis of the site, its current functioning as well as its history, its users and its organization. It is also an analysis of the problems that would spring due to the intervention and the possible solutions to these problems. The design on the other hand is an implementation of the solutions in architectural terms. The physical form imposed on the port is, at the same time, the problem as well as the solution. Site analysis has been carried over after site visits as well as a rigorous reading of maps and images.

The location of the museum in Beirut in general, and on the port in particular, gives an idea about the way the museum should (and might) be used and by whom. Of course, the Lebanese population is the major target, especially since the project is located on the northern entrance to Beirut and also adjacent to Beirut's downtown. Furthermore, the presence of a passenger terminal in the port and the supposedly "international" character of the BCD's financial district, the museum would naturally attract tourists. On the other hand, it might also have the potential to be used as a research facility for people interested in the subject. Therefore, the museum is both an entertainment facility as well as an educational one.

Although the museum might not seem an indispensable need for the country, it is potentially useful on several levels: economic, educational, political and urbanistic. On the educational level, it seems that a lot of confusion, if not ignorance, exists about the history of Beirut in general and its seaport in particular. The project would give people a chance to know more about it as well as have their own stories to tell. Economically, the museum would include public facilities which would increase the income of the port, as well as the generation of income by its touristic role in the region. In terms of urban planning, the museum would open the seaport to the public and therefore create a link between Beirut and the port, for a long time separated from each other.

The basic intentions behind this choice of project are: Historiographical/intellectual; political; architectural/urban. The project would deal with the question of history and its interpretation. The project would reflect a notion of history as an interpretation of events as well as the conception of history as discontinuous and fragmentary. This is a reaction to the reality of Lebanese society which, divided as it is into several sects, in addition to the socio-economic divisions that exist in any capitalist society. In such cases, the issue of history becomes highly sensitive and ideological. This tension among different histories is highly present in Lebanon.

On the political level, the project would examine the potentials of the port area and its role on the Green Line, compared to the BCD which is considered as the only area which the Lebanese share as common memory, and therefore history. The notion of history is thus extended to examine its role in local politics and politics in general. The political issue in this case is implicit in the historical issue, whereby the questioning of dominant histories itself becomes a political act.

The port is a traditional locus of working-class unions and activists, and indeed, the syndicates and workers' unions are located on the port. On the other hand, the workers themselves form a considerable sample of the working-class. With the introduction of a museum, historically a bourgeois institution with a dominantly bourgeois audience, another stratum of society is introduced. This group might be considered as the antithesis of the port population. How would the new structure accommodate for the contradiction which, paradoxically, it itself has introduced? What could be done architecturally -spatially, programmatically or otherwise- to keep a balance between both, without diluting one within the other. This issue is politically delicate however. How can differences be accommodated and harmonized without at the same time reinforcing the reality of the working classes, and as a consequence, freezing change and halting improvement of their socio-economic conditions?

Although museums in general are usually accessible to everybody, this does not necessarily mean that they are used by everybody. Art galleries for example, according to Pierre Bourdieu, are "the least accessible of all public collecting institutions. This is largely because of their continuing commitment to display principles which entail that the order subtending the art on display remains invisible and unintelligible to those not already equipped with the appropriate cultural skills."[1] Of course, the museum is theoretically different from the art gallery, but the issue of intelligibility and *a priori* knowledge is an important one especially since the museum is dealing with history. An important remark to note, however, is that the intentions behind the project are *not* an attempt at social change through architecture. Nor is there any assumption that architecture alone can have such a role. This assumption is neither affirmed nor denied but is simply beyond the scope of the objectives mentioned above. The project, from the moment of its conception, creates contradictions which it should attempt to solve. In other words, the project should be a synthesis between its presence and its absence, between a bourgeois institution and a working class environment and between an entertainment facility and an economic powerhouse. The project then is about the politics of architecture and not about the architecture of politics.

Those historical/political complexities, however, become even more complex when they enter -and mix with- the sectarian realm. Ever since its conception, the Lebanese society has been divided over and confused with its history and identity. This has created tensions which erupted at certain periods into violent conflicts. The divisions exist therefore not only vertically between classes, but horizontally as well, across sects. How would different, sectarian interpretations of history be represented in such a museum? The nature of the class struggle is intrinsically different from the existing sectarian struggle. That said, how would the combination of two fault lines be accommodated and represented without a confusion between the two, and also without one aggravating the other? Two forms, or layers, of dialectics are at work here: On the one layer there is the dialectics existent between the museum as a bourgeois institution and an ideological apparatus, and the port as the domain of the working-class from which the working-class launches its struggle against bourgeois hegemony. On the other layer, there is the tension inherent between the nature of Lebanese society and its pluralism, and the notion of national identity and social unity. The unification of history as an

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[1] Paraphrased by Bennett, p.10.

attempt at national unification is by nature coercive and ultimately dangerous, while the complete fragmentation of that history puts at risk the unity of the country and ultimately its existence.

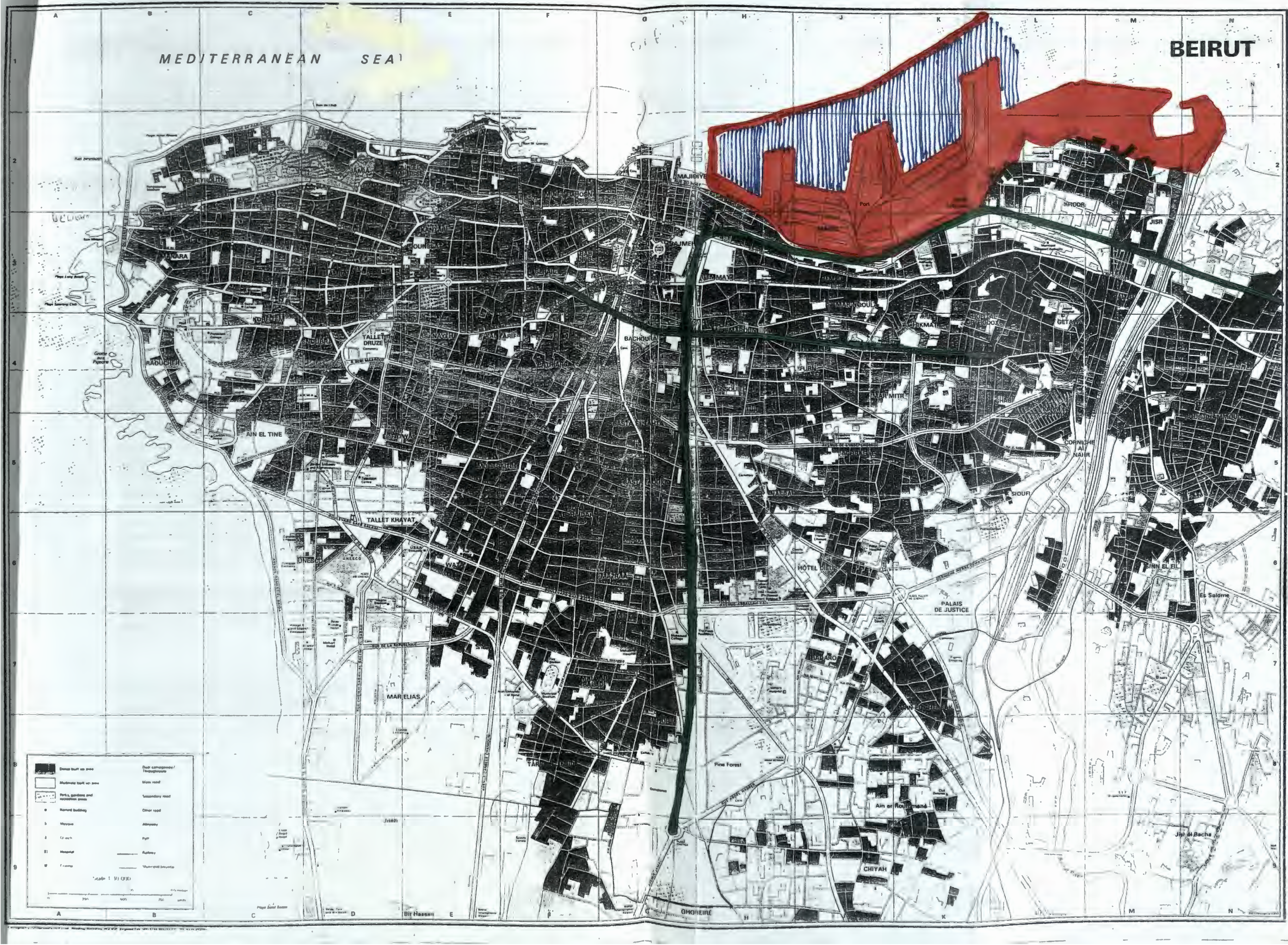
SITE LOCATION.

The port is located on the northern coastline of the Beirut peninsula on the eastern coast of the Mediterranean. It lies parallel to the main artery which links Beirut to the north of Lebanon and is bounded to the south by that artery. It is at the eastern entry point to the capital. (Fig.1)

To the west of the port lies Beirut's central district currently being reconstructed by Solidere. To the west lies the industrial area of Quarantina and Burj Hammoud. The north-south artery separates the port from the residential area of Achrafieh and as consequence isolates the port from that area. The highway acts as a belt which turns the port's back to the city.

The port is made up (from west to east) of three main basins, one projected basin and one small basin to the east. An extension is projected by the year 2000 to add a fifth basin to the east of the port, as well as an additional container terminal. A railway line reaches the port at the first three wharves coming from the railway terminal east of the port in Mar Mikhael quarters. The train terminal used to be a passenger terminal with one railway line passing through and continuing to the port. This terminal is a node on the Lebanese railway network which is planned to reopen and link to other networks in the Middle-East. Hence the prospects of an intensification of tourist presence in and around the port especially after the re-establishment of the passenger terminal on the first basin. Other vehicular activities within the port are cargo trucks and container carriers.

SITE LOCATION



The third basin is 33.8 hectares and is surrounded by quays nine, ten, eleven and twelve. These range in depth from 10.5 to 13 meters and are 370 meters long. Quay number 8 is used by vessels carrying cereals and grains due to the presence of the silos.

In addition to the above mentioned basins there is the fourth basin which has been under construction since 1974. The quays twelve, thirteen and fourteen surround it.(Fig.2)

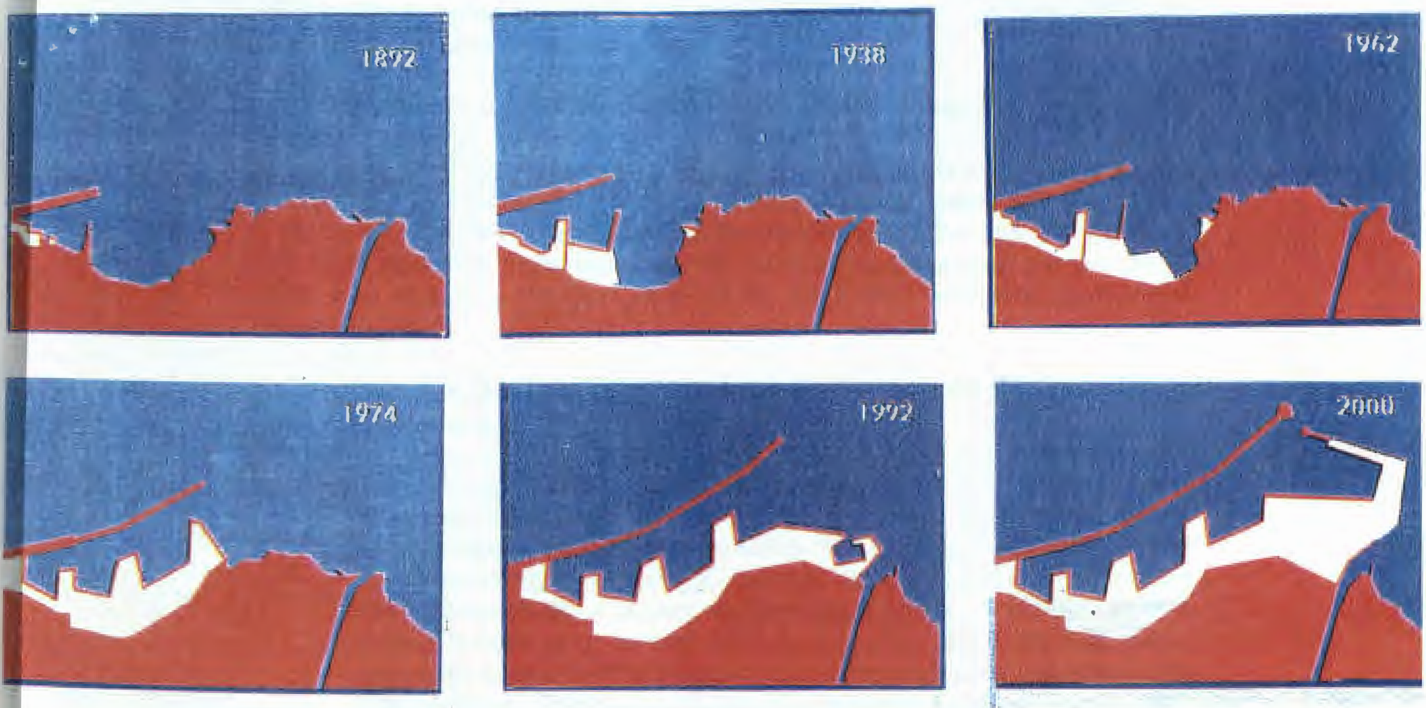


Fig.2

Historical development of the port.

MANAGEMENT AND OPERATION[3]:

The management of the port is shared among a number of companies that are either privately or publicly owned. These companies are:

1. La Capitainerie du Port or the Harbor Master. It works as a mediator between the State and the shipping companies, and gives permits to the ships for entering, berthing, unloading and departing the harbor. It also determines where each entering vessel should berth.

2. The Lebanese Customs. It checks and controls the arrival of goods that are declared by the vessels' manifests. It also supervises storage and withdrawal of goods after payment of relative customs duties. It works in collaboration with the *Compagnie de gestion et d'exploitation du port de Beyrouth* (from now on CGEBP) and the shipping companies.

3. The CGEPB: A Lebanese company that handles everything related to porterage, storage, preservation and delivery of goods. It owns equipment, quays, open storage yards and warehouses. The CGEPB used to operate the port under a governmental franchise where the government paid the CGEPB in the forms of royalties and percentages of the profits. This was still the case until 1990 when the State automatically restored ownership of the company which was exploiting the port since 1960. The CBEPB therefore exploits the following zones:

a) The Customs zone: Goods imported for local consumption are kept in the warehouses belonging to this zone.
b) The Free zone: Goods received for ordinary or international transit are stored in the warehouses belonging to this zone. Another important function of this zone is that it used to encompass private warehouses that traders or industrialists would rent from the CGEPB for establishing their stores or factories. There used to be for instance a carpet bazaar, a factory for grain preservation, a Brazilian coffee manufacturer and several clothes factories. This zone has been inoperative since 1976. A large part of the Free Zone belongs to the Central Beirut District which is now owned by Solidere.
c) Specialized warehouses: Inflammable material or acids are stored in this zone. There are also freezer warehouses which the CGEPB leases to traders.
d) Grain silos: These have the capacity of around 105,000 tons and can upload grains at the average of 600 tons per hour. Completed

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[3] Ibid.

in 1970, they have all the necessary equipment for cleaning and preserving grains.

e) The port's sea station: All passengers departing from or arriving to Beirut port should pass through this station.

4. The piloting station: It is owned by a Lebanese family who was granted exclusive operational power by a governmental decree, and is controlled by the general directorate of transport.

5. The shipping agencies: They are represented by the International Chamber of Navigation.

Site Analysis.

I. GENERAL PHYSICAL FEATURES[4].

A. Topography.

The port lies on the northern shores of Beirut. Beirut is built on an undulating site which falls sharply to the northwest and east and rather gently to the north towards the port and the old city. Therefore, the port was originally built in a topographically advantageous area. The port topography itself is horizontal being a platform inside the sea.(Fig.3)

B. Geology.

The Beirut region has a varied soil structure with several geological faults mainly east of the town. The formations range from Cretaceous, such as the Cenomanian limestone which outcrop in Ras Beirut, to Tertiary such as the marly limestone in Ashrafieh to Quaternary such as the alluvium of the old town. The port seems to be of dolomitic limestone west of the first basin, the oldest part of the port, while the rest is made of deposits of alluvium landslide debris.(Fig.4)

C. Hydrology.

Most of the natural drainage of Beirut runs down the sea or to the Beirut River. According to the map, the port seems to be also located in an area where there is natural drainage away from most of the site, except towards the old part of the port where there is a natural drainage outlet.(Fig.5)

D. Climate.

The port's location to the north of Beirut peninsula protects it from prevailing south-west winds as well as from water currents. Being closer to Ashrafieh area, it has a similar micro-climate, a drier atmosphere and cool breezes even in mid-summer.

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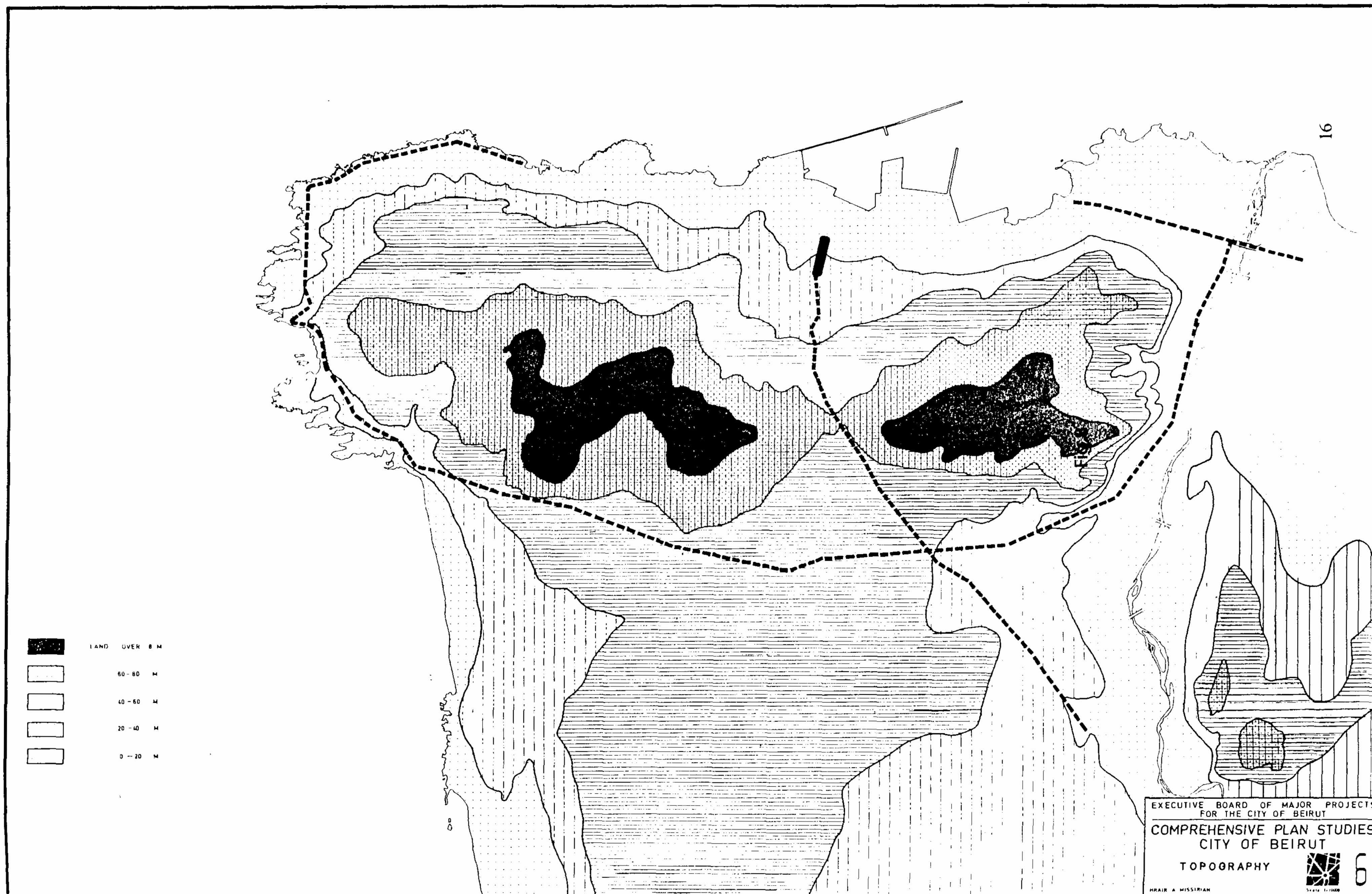
[4] From *The Comprehensive Plan Studies for the City of Beirut*, by the Executive Board of Major Projects for the City of Beirut, March 1968.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City & Regional planning & Design consultant AIP
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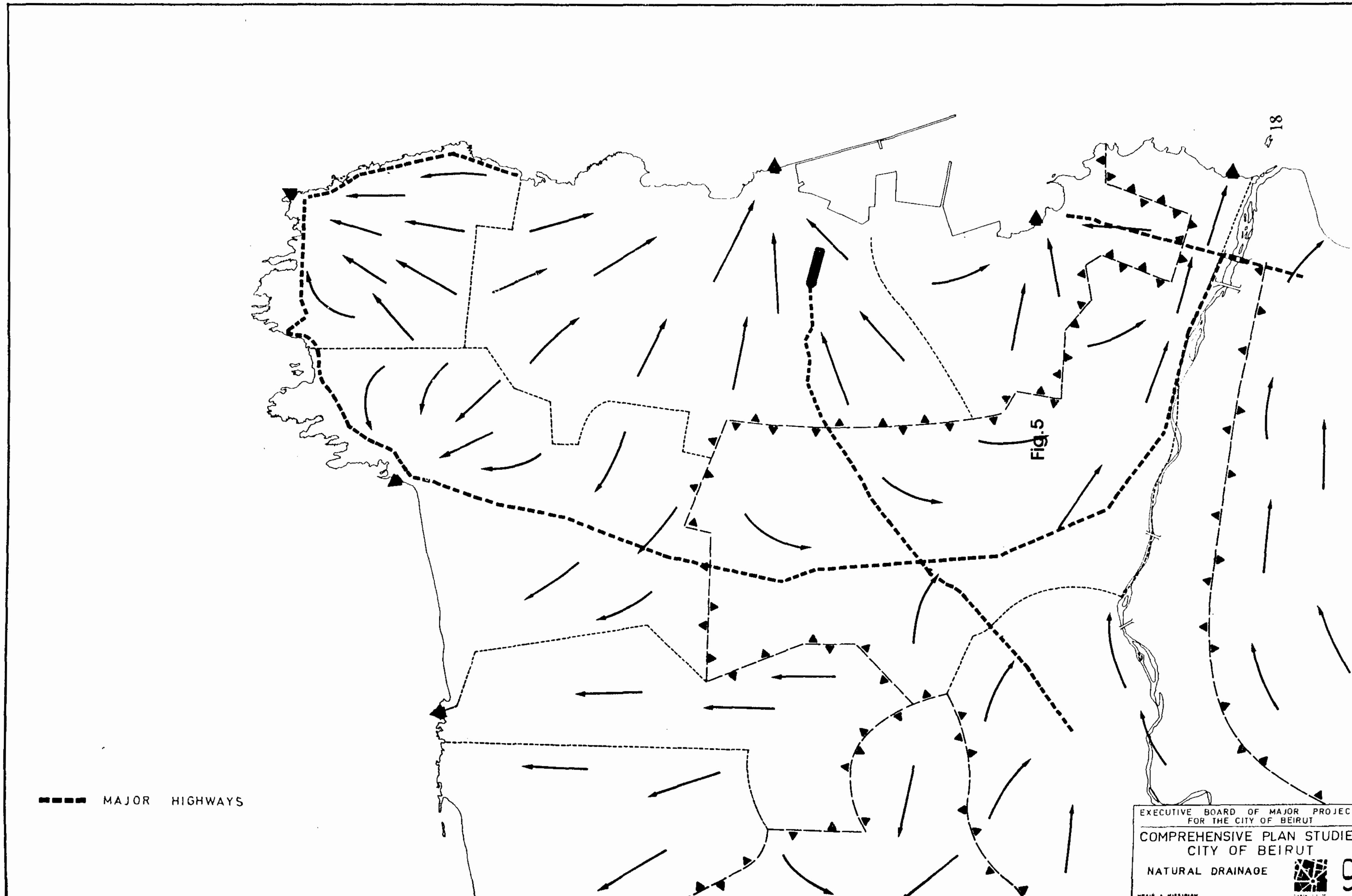
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HRAIR A. HISSIRIAN

Fig.5

II. THE PORT.

The port is located on the edge of a residential area to the south and is separated from it by a main vehicular artery on its southern border. Southwards from this artery begins the hill of Ashrafieh which overlooks the port. This artery forms the southern border of the port and prevents it from expanding southwards. The circulation on this road runs parallel to the port, the road being a link between downtown Beirut and the northern suburbs. Therefore no secondary roads lead directly from this highway to the port. However, it branches at one point at the western edge of "Quarantina" into another parallel road which distributes into the port, and continues as well towards Beirut. There is at the moment only one direct link from Ashrafieh to the port area from the Saifi district. This road runs perpendicularly to the port and crosses the major artery. It leads directly towards the main entrance to the port, and the administrative area. The main road provides visual connections toward most of the port area. Underneath it lies a car park which has the potential to serve the area around the port as well as the BCD.(Fig.6)

The port has three points acting as entrances and exits to it and one functioning as an exit from the Free Zone distributed along its southern edge: two on the western end, the third, right in the middle, is the exit from the Free Zone, and the fourth one on its western end. The first entrance is leads directly into the first basin and the second quay. This entrance is mainly used by trucks carrying goods and containers from and into the port. The trucks pass security checks on the quay #2 before leaving and entering the port. the second entrance is the main entrance for vehicular and pedestrian access and exit. Trucks do not pass through this entrance. It lies in the area where most administrative buildings are found and is directly accessible by the employees of the companies whose locations are in buildings across the street. This area forms a node of activities in which all the procedures of loading and unloading goods take place, from customs to clearing and declaring ships. This is in fact the busiest part of the port area. The Free Zone exit is directly along the road which stems from the highway adjacent to the Free Zone. This exit is not in use right now but is under construction. The last entrance is on the eastern end of the port, in "Quarantina". This entrance is a busy truck access and opens into the huge container yard to the east. Trucks exit from this side and reach directly the main highway.(Fig.7)

The other edge of the port is the northern one which meets the water. This edge is made up of the fourteen quays. The first quay, the easternmost, is currently used by the Lebanese Naval Forces. The second quay is also out of use and is reserved for keeping old and disused machinery like cranes and transportation platforms. The first and second quays, however, are now owned by Solidere, which will turn the first basin into a marina. The third quay is used by fishing vessels and guide vessels. The size of vessels and the activities increase gradually westwards, because of a proportional increase in the depth of the waters as mentioned above. Hence, large tonnage ships berth and unload on quays 10-14. Besides ships, quays are used for fishing by workers and mariners during their free time, which seems to be abundant. Human activity and presence on the other hand decrease gradually towards the western part where containers become dominant. This is due to the fact that almost all administrative buildings are concentrated to the west of the southern edge. To the east, space is taken over by container yards and warehouses. What predominates in this area, are trucks and machinery (cranes, forklifts...) which are required to move the containers. The texture of the port changes from a soft but active human texture to the west into a rough, heavy machine texture to the east.

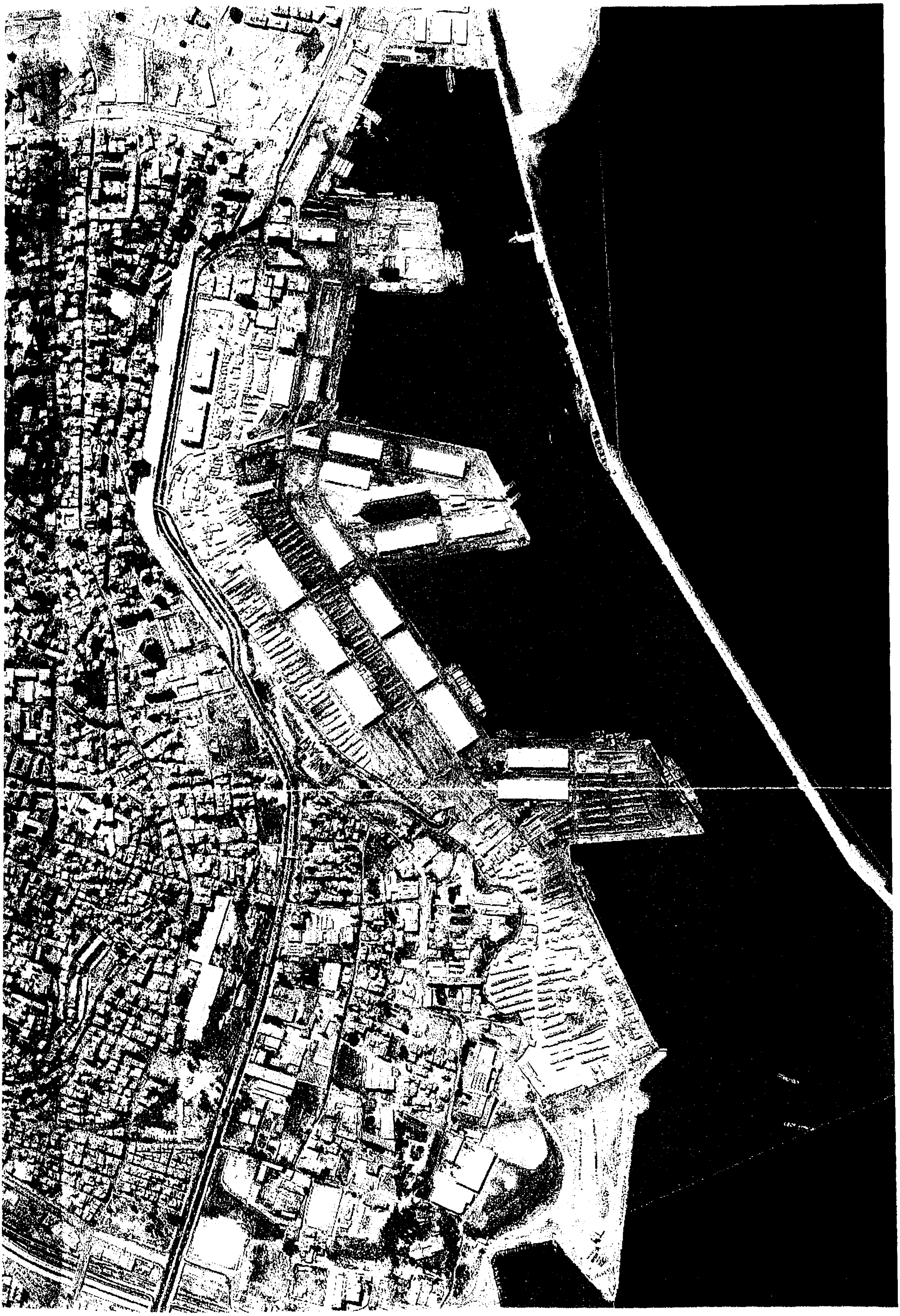
The circulation pattern inside the port, both pedestrian and vehicular - vehicular being divided into two types, ordinary cars and trucks and machinery- follows a defined path along the quays and around warehouses and containers. It follows a clear grid fashion which joins the whole port together. The grid obeys two axes, a north-south axis which links the quays to the containers yards and the warehouse; and an east-west axis which links the two ends of the port and also the warehouses to each other. This is the major circulation grid. Pedestrian and vehicular circulation intermingle, and parking spaces for cars are provided around the first and second basins. The busiest area, in terms of vehicular and pedestrian circulation, is the area around the second entrance. Cars and pedestrians use this entrance, but no trucks or heavy vehicles. These use the other entrances. The presence of the entrance as well in the area where all administrative buildings exist, and where all transactions take place, makes it the mostly used entrance of the port. In addition to vehicular and pedestrian circulation, there exist a railway line that enters the port and distributes within it reaching the water lines. This railway line penetrates the port at two points: one at the main entrance, and the other at the Free Zone. These railway lines come from the terminal at Mar Mikhael. Although nowadays they do not function, they might get back in use later on with the rehabilitation of the whole Lebanese railway network.(Fig.8)

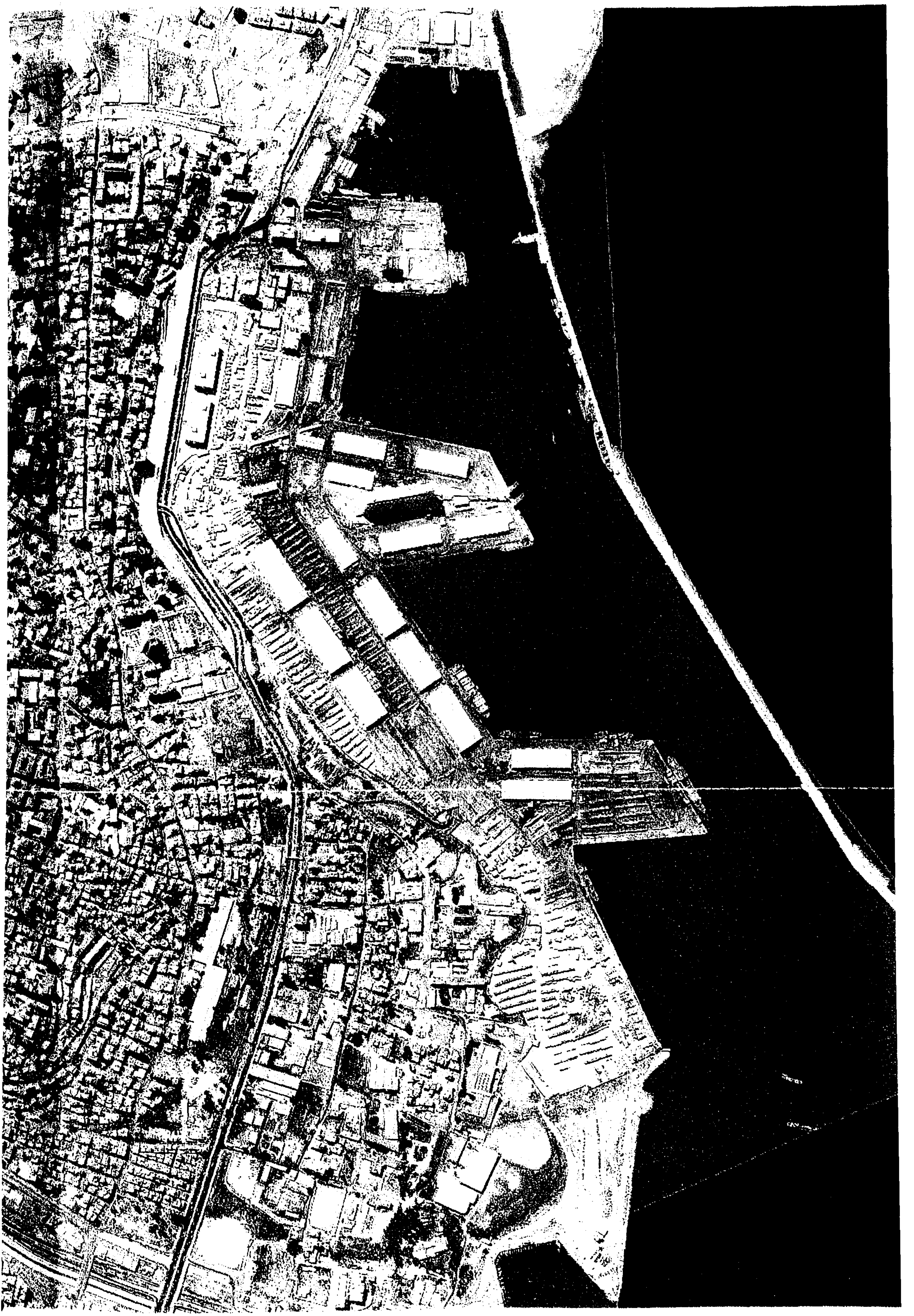
In addition to the containers yards, there exist open-air warehouses which are walled and gated. These exist mainly on the jetty between the first and second basin (first jetty from now on). There are also covered warehouses, called Customs Warehouses, in which goods are stored. These vary in area from about 1900 m^2 to 8100 m^2. These are completely enclosed with entry points distributed along their sides. These points also function as control points where goods are checked and controlled by representatives from the customs, the owners etc. The Customs Warehouses are found all along the second jetty and the third and the area in between them. On the second jetty, there are also the grain silos. These are a large structure used for the storage of grains. Hence, quays #8 and #9 are used by vessels carrying grain. Grain is transferred from the vessels directly to the silos by conveyor belts which bridge the silos and the ships.(Fig.9)

In addition to these major aspects, other functions exist on the port like small restaurants selling sandwiches, soft drinks, water... as well as the locations of workers' unions. These are scattered along the port in small containers each dedicated for a specific group of workers. There are also small offices for the shipping companies and insurance companies. These offices are either large containers or pre-fabricated enclosures (similar to ready-made houses).

There are no high buildings on the port except the silos which jut out of the second jetty. The rest is quite low, and with the horizontal extent of the port, makes it more of a horizontal surface without depth, over which activities take place. It is not much different to the sea beside it which, although deep, functions in this case as a surface over which the ships move. In this sense the port and the sea are one continuous surface on which a whole range of activities takes place. The sea activities are separated from land activities by a thin line which the line of the quays, which forms the threshold between the land and the sea. The port itself seems more as belonging to the sea, as extending from the sea inland towards the urban area, than the other way round, although functionally it is a mediator between the sea and the urban mesh. The port and the city function differently but symbiotically, in that each requires the other for its survival.

The circulation pattern as mentioned above, also involves pedestrian circulation which overlaps with vehicular circulation. The major pedestrian or human node is, again, the main entrance and the area around it, which also includes an area outside the port itself. Workers of all sorts concentrate at this point and distribute later on towards the different port facilities and functions. Entry to the port is restricted to people working there who usually have a pass which allows them to enter the port quarters. Hence, visitors can not enter the port. Workers range from security officers to employees at the customs, as well as workers, porters and representatives of shipping companies and clearing offices. Employees and workers carry passes provided by their companies from the port authorities for a fee which varies according to the validity date of the pass given.





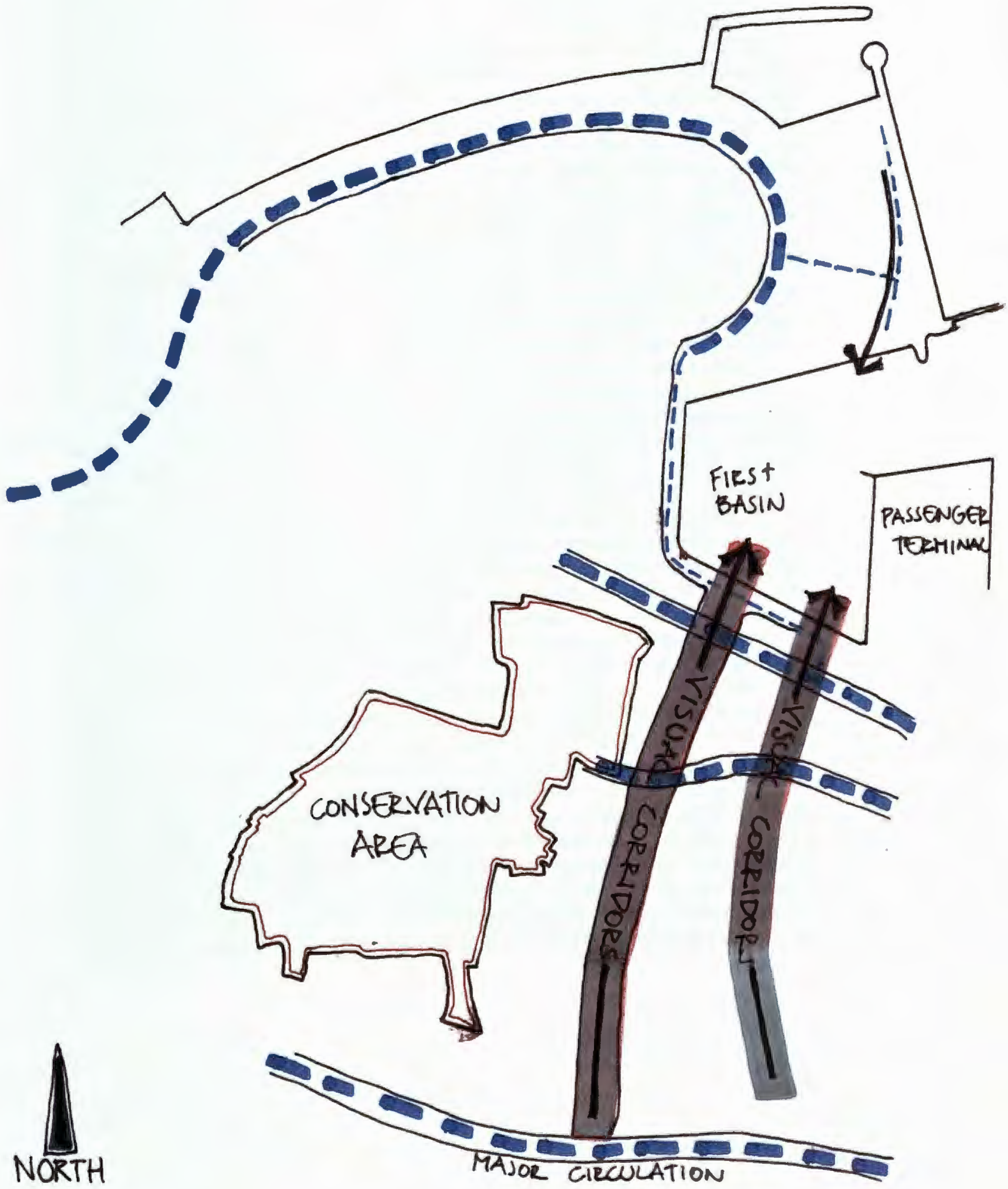
Human concentration and presence decrease gradually towards the eastern and northern parts of the port along the quays and in container yards and warehouses, as well as the western part on quays #2 and #3. In addition to these, there are the mariners and workers on board the ships that berth in the port, who are not allowed to leave the port area and remain either on their ships or on the quays.

Another type of people which used to exist on the port were passenger leaving or arriving to Beirut. The passenger terminal used to exist on jetty #2 facing quay #5 which was reserved for passenger ships. A car park was provided for the terminal which served passengers leaving or arriving at the port. The passenger terminal was directly facing the main entrance also, and was served directly by it. Nowadays, the passenger terminal is partly destroyed and no longer functions.

The port will undergo a process of rehabilitation and renovation. As a first step, it will be divided into three specialized zones, each having a particular function. It is going to be extended towards the east, having Beirut river as eastern limit. This zone, from the river westward until the third jetty will become a container yard with its own administration, circulation, and access/exit points. The second zone, extending from the western limit of the container yard until the first jetty will become the free zone with its own warehouses and administration as well. The western part, from the first jetty westward, will be reserved for the passenger terminal and the general administration of the whole harbor.

The westernmost basin, due to Solidere's interventions, will become dysfunctional as it is right now. In order to make use of it again, the port administration is going to increase the width of the quays towards the sea, hence making the basin smaller, but at the same time gaining more space on its edges for ships to berth, load and unload. Solidere's intervention around the first basin however, makes that part of the port a strategic point of intervention. By closing in on the first basin, and by opening up roads on its edges, it opened a space for another intervention which would exist outside its territory, but at the same time using that territory to its advantage. The museum and the BCD work symbiotically.

The first basin is surrounded on three sides by the BCD, its quays forming the limits. To the north there is the marina that Solidere will be developing as well as low to medium development and public open spaces. To the south, a secondary road stemming from the main artery towards the BCD forms the edge of the basin and continues along the western edge. Perpendicularly to this road, and opening towards the first basin lie two corridors one extending from Martyrs' Square, the other from Fouad Chehab avenue. These provide direct visual and circulation links to the first basin. Beyond the secondary road lie medium density development to the south and west. The center's archaeological sites are at walking distance from the basin.(Fig.10and 11)


FIRST BASIN
PASSENGER TERMINAL
VISUAL CORRIDORS
VISUAL CORRIDORS
CONSERVATION AREA
NORTH
MAJOR CIRCULATION

The analysis mentioned above shows a correspondence among the different layers forming the port. The historical development of the port - geographically and programmatically- as well as the human presence, the mechanical presence, the depth of the basins, the warehouses and the container yards, in addition to the entrances and their locations and the administrative buildings all work in relationship with each other and affect each other's morphology. Hence, the geographic point from which the port was established historically is the point where most administrative buildings are found, and at the same time the main entrance, which is supposed to be close to them. This point is also at the edge of the circulation artery just outside the port area, at walking distance from the buildings which house the shipping and clearing companies, and all trading companies. Adjacent to this area lies the passenger terminal which is linked directly to the main gate and the streets hence providing instantaneous exit and entrance to the passengers without these having to interfere in the other functions of the port. In this way, the flow of non-workers could be easily controlled and contained. This area is also near the first and second basins which are the shallowest, and therefore used by smaller vessels. With the increase in the size of ships, the basins developed in the eastern direction further away from the node, and an increase in storage spaces, in the form of warehouses and container yards developed in the same fashion. This spatial development is reflected on the human presence which is also inversely proportional to the presence of heavy-duty trucks and transportation machinery. The more the storage spaces, the greater the number of vehicles and machines, and the less the number of people. Another node in this network of elements and effects are the secondary entrances which are mostly used for vehicular access and exit. One thing should be clarified though. These different elements making up the structure of the port are not necessarily hierarchical, meaning that it is not necessary that one element affect another lower-level element down a hierarchy of causes and effects. The whole structure had developed -and is still developing- in way which made it what it is right now. Hence, the projected development of the port now includes another jetty and basin and further extension of the container yard to the east. One further element in this network is the nature of the surrounding areas around the port and the roads. These have affected the location of the point of origin of the port. Of course, one factor affecting the location of the first basin was the historical presence of the port at that point in the first place. But why would the administrative buildings be located there too? In addition to the requirement that they be close, another reason was the nature of the area around. The administrative buildings are close to what is now known as the BCD, which had always been a busy part of Beirut. The other areas however were either undeveloped or industrial, especially to the east. The areas to the south, were separated from it by the railroad which linked the train terminal in Mar Mikhael to Beirut. Instead of the present day highway, there existed the railroad. The port being an infill in the sea, the areas south of the present highway became detached from the port by default. Hence, the area around what is now the main entrance of the port was at a tactical point between the BCD, and Achrafieh through the Saifi sector. What does that mean? How is this analysis in any way relevant prior to any intervention on the port?

As mentioned above, the present organization of the port was a result of several factors working together and upon each other. In this context, three factors may be identified which should be taken into consideration prior to any intervention on the site. These are: program, location and spatial relationships. These factors although seemingly clearly demarcated from each other, affect each other and determine, to a certain extent, the situation of each other. In addition to this, they also determine other phenomena such as movement and flows of people, machinery and goods... They exist therefore in a network which forms the underlying structure of the port. At first hand, these factors should be defined.

1. Program: The general program of the port which is needed for the port to function. It is made up of subprograms which are autonomous but are all needed for the proper functioning of the port. These are the administration, customs, warehouses, silos, transportation...
2. Location: This includes the geographic location of the different buildings inside the port itself and the relationships that exist among them, as well as their location relative to the urban context.
3. Spatial relationships: Each activity on the port requires a space, or else defines its space. This space is not necessarily only physical space as buildings and such, but also a more abstract space of activities which exist in relationship to each other. For instance, the space of vehicular circulation and the space of pedestrian circulation. These might appear at first glance to be overlapping, but a closer look shows a distinction between the two spaces along the same path -the same physical space- and different requirements for both. Hence, pedestrians not familiar with the port require an effort to create their own space. Another example of this is the relationship between the circulation pattern of transportation trucks and the warehouses, whose points of access are on their longer sides parallel and adjacent to the path of the trucks. While their shorter sides are closed and provide a better environment for pedestrian circulation.

The intervention on the port therefore should involve the integration of these three elements and the analysis of their relationships as a starting point. In this manner, the project would fit in a complex context which is the port, without either one disrupting the proper functioning of the other.

Program.[5]

[5] General reference Coleman, Laurence Vail, *Museum Buildings.*

Contemporary museums require a diversified program. They have become a place for work, learning, study, exhibition and entertainment. They require also new media for learning and exhibiting, like computers, videos, audio-visual... The museum is transformed into a cultural center which is open even during the night. It should become a whole environment providing for a variety of functions and audience.

The program is made up of several sub-programs which work in relation to each other without one taking priority over the other. The museum, being more a public space of social interaction in addition to its serving as a museum proper, is, after all, an urban intervention having a relation with the city as well as with the port. In this case, the program and the relationship between its several parts determines to a great extent the way this space is going to be used.

The museum proper, with its galleries and exhibition spaces, opens up a space inside the port. With the addition of other sub-programs, the museum no longer functions as one integrated building with a specific program, but becomes an agglomeration of different buildings existing together in an urban space. This urban space includes enclosed as well as open spaces. What reinforces the presence of this space and its connection with the urban fabric as well as the port is programmatic variety.

Program outline:

A. Museum.
- I. General spaces.
- II. Administration.
- III. Exhibition spaces and galleries.
- IV. Conservation.
- V. Education.

B. Entertainment and Recreation.
- I. Shops.
- II. Restaurants.
- III. Cafes.
- IV. Pubs.
- V. Walkways.
- VI. Bicycle tracks.
- VII. Sea trips.

I. SPATIAL DESCRIPTIONS.

A. Museum.

General Spaces.

1- The vestibule: Or anteroom of the lobby or foyer, is a kind of weather trap. The vestibule should afford protection from wet and cold when people are waiting for the museum to open.

2- Foyer or lobby: This is the control room of the museum. A large museum should have its lobby arranged for effective supervision of public parts of the building by the minimum number of museum people. Public phones should also be provided in the lobby. Also, a sales counter, at which publications, postcards, and sometimes prints and other reproductions may be purchased by visitors, should be part of the lobby. The sales counter requires a display top for books and prints, and there should be wall space nearby for further display. The necessary storage closet for stock is best placed behind the sales desk.

3- Cloak room and Information desk: These are two features of the lobby. The latter often serves also as a sales place for publications and postcards. The several tasks may be divided between one or more doormen, a checking attendant, and information clerk, and a sales person, with helpers as required. The cloakroom is usually at the right of the entrance, fairly close to the doors but not so near that a waiting line might block the way. The checking counter should be long enough for several people at once if use is active. For a certain building, the required checking capacity naturally varies according to climate as well as by season and the weather of the moment. For museums in most places the ordinary capacity (including hats, packages, umbrellas...) might be for one fifth of the daily attendance; this could take care of one-third to one-half of the people in the building at any time. The cloakroom should have an annex which is used in cases of overflow, which happens during special occasions for example. The information desk is usually placed at the left of the main entrance. Near the information desk should be found the stairway and elevators and the starting point for exhibits. The information desk should provide a bulletin board and a floor plan for visitors' orientation nearby.

4- Guides and journalists room.

6- Press conference room: -Storage room
-Coat room
-Main room.

7- VIP reception lounge.

8- First aid room.

9- Multipurpose room.

10- Night watching areas: -Sleeping rooms
-Lockers
-Bathrooms
-Kitchen
-Control room.

11- Post office: -General work space with letter drop and counter
-Public lobby with counter
-Directory
-Covered loading platform
-Unit mail clerks with counter
-Storage space
-Toilet (if public toilets not accessible)

Administration and Curatorial Departments.

1- Administration, under the president and the governing board with its committees, is the job of the director. The director presides, first, over curatorial and library functions, these being carried out by staff members with their subordinates and technicians. The director also sees to the performance of certain well defined, primarily educational, public services that should have separate staffs to make them effective. In addition, she/he exercises several kinds of operating functions that may have their own heads for financial business, membership, public relations, publication, and registration, besides the sphere of the superintendent. Operating staff members, together with their helpers as well as the mechanical force, the watch, and labor, sometimes number several hundred. The director's office, with its business extensions, should be oriented to the main entrance. Location of offices in the building is a matter of practical convenience since business visitors should not be privately conducted, nor should they be sent exploring through the building in order to reach a member of the staff. Administration should also be placed not very far from the basement or service entrances because it is responsible for receiving, shipping, registration, shop work, superintendance...

Rooms required for administrative work begin, logically, with a board room for meetings of trustees which should communicate with the director's office, and should be planned as a room involving lunch meetings. The director's office needs a separate outer office for secretarial work and reception. A small toilet room connected with the office and the board room is advantageous. Other offices are required in museums for the assistant director, finance officer, membership secretary, editor, and public relations head, each with his helpers. There may be a general office for part or all of the secretaries.

2- *The curatorial departments*, or staff divisions headed by curators, are organized following chronological and topical divisions. Several curators, each specialized in a particular subject, work together in collaboration. Three curatorial departments in this case are enough for the general organization of displayed material. One is specialized in the chronological arrangement of exhibits, another one responsible of the topics of the exhibitions (fishing, military, commercial...) and still another specialized in the material displayed (ship models, nets, manuscripts...). Live storages, often called study storages because they make collections available for reference work and research, form the largest part of curatorial
space. Curatorial suites are made up of study rooms, curatorial workrooms, and live storages. Exhibition space is of course also part of the curator's job. The place in the building that is best for curatorial space follows necessarily from the general organization scheme. Curatorial space should be accessible to the public requiring access to study storages. Curators should have contact with each other and with the director.

3- Photocopying/telex area (communication)

4- Drafting studio

5- Specialist staff offices: the specialist staff includes specialist in naval history, in naval architecture, graphic designers taking care of all graphical work needed by the museum as well as publishing, marketing specialists and public relations department.

6- Archive: the archive room needs a person specialized in archiving.

Exhibition Spaces.

1- Adaptation to uses: a) Temporary exhibitions.
b) Permanent exhibitions (two types)

Temporary exhibitions: although rarely do history museums put on temporary shows, when they do though they suffer from inadequate spatial requirements and end up with bad performances. Temporary exhibitions are usually small compared to the permanent collections, and the displayed objects are also smaller in scale. Nevertheless, space should be provided for temporary exhibitions flexible enough though not to turn into disused space for the rest of the time. In general, the best place for temporary exhibition space is on the main exhibition floor, at ground level and giving off the lobby.

Permanent, or relatively fixed, exhibitions: a) For the general visiting public
b) For students and researchers

The main public exhibition space might be nearer the lobby and more prominent, so as to draw the public in. For instance, it could be on the ground floor and forward, toward the lobby. The study displays can be placed in other less prominent places keeping a link between both nevertheless. As a consequence of this, the scale of public exhibition spaces is larger than that of study exhibitions since the objects displayed are different in scale, and the type of activity varies.

2- *Scale and Proportions:* Since the scale of the exhibits vary in scale and proportions also, the volumes of exhibition spaces should vary accordingly. The relationship between exhibits and the visitors, as much as the exhibit and its enclosing space, is also an important factor in determining the scale and proportions of exhibition spaces.

3- *Types of Exhibition Rooms:* These vary in accordance with the type of exhibits as well as with methods of lighting. In a naval museum, the objects displayed vary in scale, nature and light requirements reflecting also a variety in the type of rooms in which these objects will be displayed.

4- *Groupings of Rooms:* In exhibition areas, grouping of rooms has to do with the general organization of space in the building; but within this framework, there are some familiar patterns that relate to different methods of lighting and different routings of visitors. Some patterns of arrangements are:

a) The room-to-room arrangement: spaces in this lay-out are arranged in a continuous array of chambers. The advantages of this grouping are its possible simplicity and economy of space. The main disadvantage though is that when a room is closed the circulation of visitors is disturbed and even blocked off altogether.

b) The corridor-to-rooms arrangement: in this arrangement, each room is accessible from a passageway. The principle advantages of this system of grouping are that any room can be reached directly, and therefore can be closed without affecting other rooms, and that the scheme of circulation is clearly indicated to the visitor.
c) The nave-to-rooms arrangement: this is centered on a large chamber with doorways along the sides giving onto smaller rooms arranged in single or double file and variously connected among themselves.

These groupings are just general instances of possible arrangements and should not be regarded as the only ways for exhibition space organization. Other, newer possibilities may arise as well as variations of these.

5- *Supervision:* Another factor affecting the planning of exhibition spaces and the museum as a whole is the problem of supervision. Room should be laid out in a way such that they be supervised by the smallest possible number of people. In large museum, the watch problem is solved by hiring special guards who watch the place.

6- *Circulation:* The movement of the visitor in the exhibition space takes its pattern from the layout of the building; but how the visitor responds to the space may be affected by the exhibits and is influenced by a complex of human behavior called visitor behavior. One instance of visitor behavior is the tendency for visitors to start their circuit from the right going anti-clockwise around a room. Routing, or pre-control of circulation seeks to take account of these factors. It should be noted though that a building may have excellent circulation without having good routing. Good routing promotes full and orderly coverage of exhibits by the visitor. One of the difficulties with routing schemes is that it has to make a compromise between arranging for a majority of casual sightseers and for a minority of interested people. With the main crowd the objective is to promote exposure to the principle exhibits while with minority of specialized visitors the objective is to assist selection and concentration. As mentioned above, the division of exhibits into public displays and study displays is one response to that objective. Another way of dealing with that is through planning, by providing an outer circuit of rooms for everyone and an area for those whose visit takes more time. The latter area could include orientation space, for reading and contemplation, and perhaps communicating with study rooms in curatorial quarters.

Types of circulation have their roots in the lobby, in general. In most museums the lobby gives a view of the general layout, offering a natural path or an obvious choice between several parts of the plan. Routing within one room is usually planned as a loop, but is often carried out by the public as a direct transit through the room. A room with one opening for both entrance and exit imposes a circuit which most of the time is carried over only mentally while standing at the doorway. A room with two doorways has exit attraction to pull the visitor in, but the benefit it gets from this depends upon where the exit is placed in relation to the entrance. The placement of doors on walls should also take into consideration the usability of the wall as an exhibiting surface. The circulation path in an exhibition space also depends strongly on the disposition of the displayed object. Some exhibits need to be viewed in a certain sequence, which determines the way the visitors should move. Another type of routing is that found in a suite of rooms, where common doorways between two rooms become problematic. For example, two many doorways in line is disturbing to the visitor who would prefer to see an exhibit through a door opening than another door.

Therefore, in the planning of exhibition spaces, several factors have to be taken into consideration as spatial determinants. These factors work all together and sometimes against each other in a network of factors affecting design. Some of the most prominent factors are lighting, circulation patterns, spatial flexibility, scale, visitor behavior... Nevertheless, these are not always given. Other factors are introduced which transform these determinants and shape them in other directions to serve other purposes. But the issues mentioned above are a point of departure from which a clearer idea of the general functioning of those spaces is perceived. In this way, the introduction of further constraints becomes more effective in reaching the objectives behind the design.

Conservation.

1- *Preparation and restoration rooms:* Those are the special shops and studios for preparators of exhibits and for restorers, and are not functionally related to the mechanical workshops. Preparators and restorers collaborate with curators. Museums often attach these technicians, artists, and craftsmen to the departments they serve, and tend to locate their workrooms in curatorial suites. Studio arrangements should be suited to the particular work. All shops and studios should have large sinks with running water and drain traps. Storage closets and shelves are also useful. One possibility of the disposition of the workshops would be to have an overlooking space for the visiting public.

2- Boat sheds: Storage spaces for small boats which are usually part of the museums collection but are exhibited periodically. They are usually run by two people: A director and an assistant.

3- Wet rooms

4- Textiles: Where the restoration and storage of sails, nets and other textiles relevant material take place. Requires two workers, an office and a toilet.

5- Conservation laboratories

6- Staff rooms, toilets and lockers.

7- Kitchens.

Education.

1- *Library:* The library is an important museum arm for both public service and the work of the curatorial staff. It is a reference department, its books being used in the building; but also the library usually does extramural reference work by correspondence. In addition, the library may administer lending collections of slides and photographs. The library's place in the building is best determined by considering the two principal forces that pull upon it -the demands of the public and those of the staff. Therefore the position of the library should take both demands into consideration. Relationship between parts of the library should be highly functional. The reading room, the librarian's desk and work place, and the bookstacks, should form all together a well knit system. Any collection of slides or pictures with which the library is charged might share space with the stacks. The museum library in this case is not intended to act as a public library in the sense of serving the town or the city. It is a library specialized and limited in its collection of books to history in general and naval history in particular, subjects which form the theme of the museum. The library will mostly serve a specialized group of people interested in the subject and researches. Since the museum library is not inside a town or neighborhood where the population served is defined, a general assumption of a population of 3000 served will be considered.

-Book stacks (open and closed): These may be placed in part of the reading room or they may be in a separate space and arranged on two or more levels; or the may be divided over both. Stacks are also divided into closed and open stacks. Open stack are stacks that have access to the public whereby the visitor looks

for his book by himself. Closed stacks are not accessible to the public. Stacks height is of an average 2.25m high. They are spaced at around 1m 40cm apart from center to center. Stacks are necessarily lighted artificially throughout, although windows or panels of glass may be introduced to give some natural lighting in some parts. Books per shelf is 21 books per 900 mm run of shelf. The layout of shelving depends largely on the type of structural system used.
Open stacks 2.3m high, with 3m ceiling: 140 books/m^2; 14 books/m^3.
Books per single-sided 900mm tier (6 shelves high): 140 to 150.
Closed stacks 2.3m high, shelved close to ceiling, 2.5m ceiling: 180 books/m^2; 22.5books/m^3.
Compact book storage: 330 to 440 books/m^2; 40 to 55 books/m^3.
For a total population of 3000 served, 4000-5000 volumes are provided, occupying 100m^2 of floor area.

-Reading area: The reading room, in its arrangements, can follow general library experience. Public libraries try to give the reader at least 2.25m^2 of floor space. There is also the possibility of having an extension of the reading room to a patio, roof setback, or other outdoor space. Includes a browsing area where readers can read in a casual atmosphere.
For a population of up to 10000, a total floor area of 45m^2 per 1000 persons should be allocated. Therefore, a total floor area of 135m^2 should be provided.

-Carrels: These individual study rooms are usually used by researchers who require a 'private' study space in the library. They are provided with a cupboard in which books can be kept. Average dimensions: 2.1m by 1.7m. Area: 3.6m^2. Table dimensions =1.2m by 0.6m. Total area for five carrels: 18m^2.

-Periodicals: Bound volumes of periodicals per single-sided 900mm wide, 1.8m high: 75.

-Reference: Absolute minimum space taken up by one reader: 0.93 to 1.2m^2.
Seating space allowance for one reader: 2.3m^2.
One seat per 500 population served, 7m^2 per 1000 population served.
Therefore, for 3000 population: 6 seats and 21m^2.

Librarian
Deputy librarian
Secretary/reception
Issue/circulation desk (two employees)
Accessioning (two employees)
Binding preparation (two employees)
Room for visually impaired (one assistant)
Computer room (one assistant)
Microfilm (one assistant)
Maps and special collections (two assistants)
Audio-visual room (one assistant)

Work space per head of staff: $11m^2$. Fifteen persons $=165m^2$.

Cataloguing (two employees)
Catalogues
Computers

Work space per head of cataloguing staff: $13.5m^2$. Two persons $=27m^2$.

Lobby
Photocopy
Toilets

2- Publication: publishing pamphlets, newsletter, educational material, as well as graphic materials for the museum itself (signs, labels...).

3- Lecture and projection room

4- Conference room

Services.

1- Service quarters (Land and sea): Service functions of the museums involve a lot activities having to do with supply, maintenance and shop work, and with the arrival, movement, and departure of museum objects and exhibitions. The worker engaged in these functions are under supervision of the superintendent, who is responsible for the passing of people and of things through the service entrance, and for the conduct of services through the building. The superintendent's office should be at the service entrance to facilitate supervision. The service entrance, which leads to workrooms and other parts of the service quarters, should be placed to facilitate truck deliveries and pick-ups. The rooms of the registrar and photographer should be grouped with service quarters since recording and photographing of museum objects that come and go can best be carried out near the service entrance. The service entrance leads directly to the receiving room with a packing and unpacking area. This is the distributing point for the entire building. It should be placed so as to minimize hauling distances from the freight elevator on floors above. The service entrance should have a doorway for the use of service employees, delivery men, and other persons entering on foot; it also requires a freight portal for the use of trucks and a loading deck. Outside space should allow for any necessary turning of large trucks. The loading platform should be designed to take account all sorts of material and the sizes of trucks which are to load and unload upon it. It should be of an average height of 1 meter. It should have a narrow flight of steps leading to it from the ground. The receiving room is the place where incoming shipments come for unpacking and distribution inside the building, and outgoing shipments go to be packed and sent away. Other room having to do directly with these functions, that should connect with the shipping room, are the superintendent's office, the temporary storage room for crates, and the registrar's and photographer's quarters in which museum objects coming and going are recorded. The freight elevator should be here. The receiving room should be in this case around 180m^2. The superintendent's office, adjacent to the service entrance, is the control room for all that happens here. The registrar's quarters where records of museums accessions and of borrowings and lendings are kept, form a place of pause for museum materials on their way to or from the exhibition rooms or curatorial quarters. There must be space for examining objects and assembling large groups of things coming and going, a place for the registrar's office work, and a safe temporary storage place. The registrar's temporary storeroom should not be confused with the temporary storage in which empty crates are kept while awaiting reuse. It not to be confused either with the curatorial storages. The registrar's room is strictly a place for momentary safekeeping of museum pieces passing in or out. The floor area required for photography is, on average, a 25m^2 camera room or studio, and two darkrooms that can be entered independently from the studio, each of about 5m^2.

2- Workshops: Shops need adequate space in a suitable location and should be planned for the required operations by someone with experience in such work. The principle kinds of shops are : carpentry, including both mill and cabinet work; painting and finishing; machine and sheet metal work; and also shops that go with plumbing upkeep, electrical maintenance, plastering roofing, glazing and the care of other plant and structural installations in the building. There are also the crafts of the preparators, workers who are charged with the creation of exhibits and the care of museum collections. Shop area in this case is around $500m^2$. One possible location of the shops area is on one flank of the receiving room. The equipment of shops, in general, involves a long bench for each carpenter, three in this case, a table circular saw, a band saw, a joiner and a planer; for metal working: a bench, a machine lathe, a small drill press, a power grinder, a bar folder and a squaring shear.

3- *Public toilets.*

4- *Electro-mechanical rooms or floors*

5- *Shuttle services and station (Land and sea)*

6- *Parking*

7- *Circulation including staircases, elevators, escalators and handicapped facilities:* The number of elevators required will depend on the occupancy conditions. Most large museums have two passenger elevators operated by attendants. Also, a freight elevator should be provided, which is sometimes used to transport large groups of visitors like school groups. Staff elevators are also needed in certain places in the museum. The principal stairway takes off from the lobby within view of the desk. Stairs should be arranged in grouped flights of steps; they should not be divided into scattered parts, as where there are two or three steps from the vestibule to the lobby, a few mire from the lobby to adjacent exhibition rooms, and perhaps others to slightly higher levels in other rooms. This scattering of steps creates serious museum problems. Scattered steps block the paths of handicapped people for example. Also, scattered steps may interfere with moving cases and heavy objects from place to place.

8- *Quarters for the force* of artisans and laborers are necessary part of the *service layout*. There should be dressing and locker space and a connected toilet room and lavatory with one or more showers.

B. Entertainment and Recreation Spaces.

Entertainment activities are an integral part of the museum's functioning as an urban public space as a way of refamiliarizing the port with the city, and are

necessary to the activation of that space at different times of the day. These functions, however, are not secondary or ancillary to exhibition spaces which usually form the core of the museum, but are as important to the functioning of the space in its context.
Shops, restaurants, cafes, pubs, pedestrian walkways, sea trips, bicycle tracks... (Public activities of entertainment, indoor and outdoor, day and night)

II. LIGHTING[6].

Ambient vs. Task Lighting.
The obvious function of light within the museum is the illumination of the objects displayed, referred to as "task lighting". An equally important function of light is its general use within the physical space of an exhibition space, referred to as "ambient lighting". These two functions, while related, are quite different and need to be discussed separately.

Ambient lighting defines the general experience of light within the exhibition, independent of how it affects the specific experience of viewing works of art. Many of the advantages attributed to natural light actually deal with the psychological mood that it conveys within an interior space. The two most frequently cited advantages of natural light are: the experience of not being confined within an enclosed space and the changing quality of natural light over time.

Task lighting deals with illuminating displays without regard for its effect on the overall physical space. Task lighting can be divided into three critical components in terms of hoe it affects the visual experience: spatial distribution of the illumination, the intensity of the light source, and the spectral distribution of the light.

Spatial Distribution. Shadows and gloss on a surface are caused by directional sources such as incandescent lamps. Shadows are eliminated under non-directional diffuse light; this makes surfaces appear flat and matte. In addition, there is a loss in colorfulness as a result of veiling reflections caused by nondirectional sources such as natural or fluorescent light through a diffusing daylight. From a practical standpoint, many naturally lighted exhibitions use some diffusion to reduce the high intensity of direct sunlight and to distribute light uniformly around a room. Diffuse laylights also hide duct work, light louvers, and other distracting elements hidden in the ceiling. But too often, such diffusion also destroys much of the quality that we associate with natural light. As an alternative, properly designed reflected light can provide general control and still maintain directionality, although it is difficult to provide acceptable light distribution in all directions at the same time.

Intensity. The human tendency to prefer high light levels must be weighed against conservation concerns favoring lower light levels. In general, intensity

[6] Progressive Architecture, p.49

values are based on a compromise between long-term preservation needs and the ability to view objects comfortably with good color perception.

Light Intensity Adaptation. Although the eye is capable of adapting to different intensities of illumination, adaptation requires time, and this must be considered in the design. The most successful museum spaces allow for a transition from brightly lighted entrances and atriums into more controlled exhibition space. The East Wing of the National Gallery in Washington D.C., for example, uses a series of galleries with gradually decreasing light levels to achieve a transition from the brightly lighted core. In other museums such as the Degas Room in the Metropolitan Museum of Art's Andre Meyer Galleries, the visitor proceeds directly from a bright zone into a darker, controlled exhibition zone. Here, the change in light levels is abrupt and discomforting. The visitor initially perceives these galleries as being dark. Within a few minutes, however, after the eye has fully adapted, there is sufficient light to view the collection on display.

Even within a room, light adaptation must be considered. The eye uses the brightest surface as a reference point. If a luminous ceiling is many times brighter than the surrounding walls, the walls may seem dark even if they are illuminated at a "high" value. Highly reflective white walls make it difficult for the eye to adjust to the less reflective surface of dark objects. Reduction in contrast between wall surface and objects reduce the need or time for brightness adaptation; maximum visual resolution is achieved when all surfaces have similar reflectance.

One of the ironies of naturally lighted exhibitions is that many objects look brighter at night under artificial light than during the day when illuminated by a combination of natural and artificial sources.

Conservation Considerations.
Light is a form of radiant energy. When an object is exposed to light, it absorbs energy that can induce chemical change. For example, pigments and dyes can fade, and paper can discolor and lose physical strength. Changes brought about by light exposure are called photochemical damage. Studies show that natural light passing through UV filtering glass is far more harmful than an equivalent amount of incandescent light. Although ultraviolet radiation is particularly hazardous for works of art, visible light also will cause damage. For this reason, the total amount of visible light must be controlled. The real problem, however, is the cumulative amount of destructive light exposure over a long period of time. Most naturally lit exhibitions are not designed to exclude natural light during non-public hours.

All the radiation striking the object during such periods is inefficient light that causes damage. Artificial sources or naturally lighted galleries with cut-off louver controls are safer in this context, since it allows the light to be shut out during non-exhibition hours.(Fig.12)

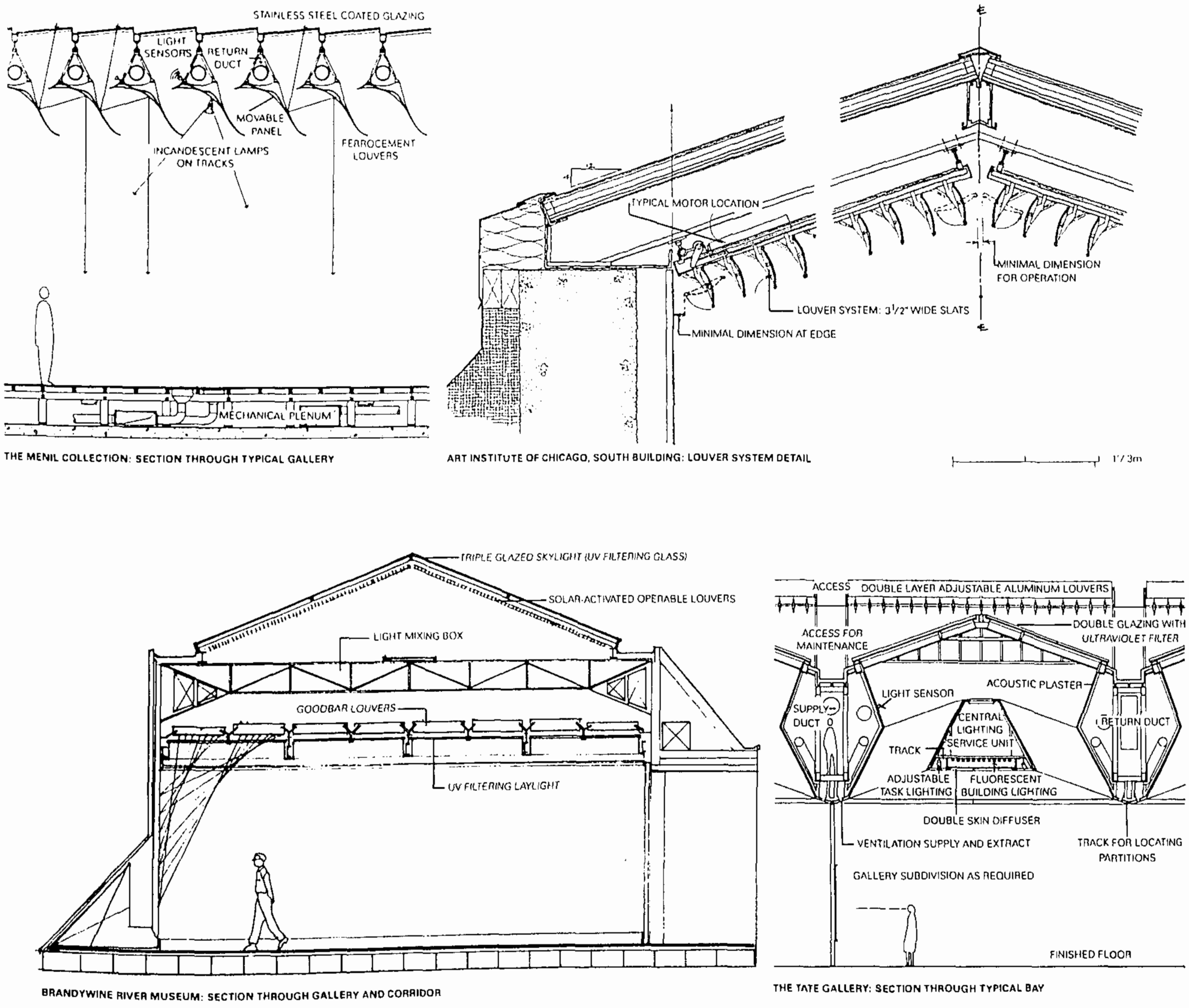


Fig.12

III. SPATIAL REQUIREMENTS.

ACTIVITY:	NUMBER OF OCCUPANTS:	NET AREA: (in m^2)
A. General Spaces.		
1. The vestibule		
2. Foyer/lobby		700
3. Cloak room and information desk	2 each	100
4. Guides and journalists	4 guides, 7 journalists	70 each room
5. Press conference room	75	500
6. VIP reception lounge	30	350
7. First aid room	2	25
8. Multipurpose room		195
9. Night watching areas	3	100
10. Post office	3	120
B. Administration and Curatorial Departments.		
1. Director	1	25
2. Director's Secretary	1	
3. Assistant director	1	15
4. Ass. Director's secretary	1	
5 Finance officer	1	10
6. Membership secretary	1	10
7. Editor	1	10
8. Public relations head	1	10
9. Reception		35
10. Secretaries	6	50
11. Curators	3, one in each office	10 each office
12. Study storage		100
13. Study room	15	55
14. Workroom	3	25
15. Specialist staff	2, one in each office	10 each office
C. Exhibition.		
D. Conservation.		
E. Education.		
1. Library:		
Book stacks.		100

Reading area		135
Carrels		18
Periodicals		30
Reference		25
Librarian	1	12
Assistant librarian	1	12
Secretary	1	12
Reception	5	
Circulation desk	2	22
Accessioning	2	22
Binding preparation	2	
Room for visually impaired	1 assistant and 2 other persons	
Computer room	1 assistant and 5 users	
Microfilm	1 assistant and 3 users	
Maps and special collections	2 assistants and 15 users	
Audio-visual room	1 assistant and 5 users	
Cataloguing	2	
Catalogues and computers		
Lobby		
Photocopy		
Toilets		
Services and storage space		
2. Publication		
3. Lecture and projection room		
4. Conference room		
F. Services.		
1. Service quarters		
Superintendent's office	1	
Registrar's room	1	
Registrar's temporary store room		
Photographer's room	1	35
Receiving room		180
Temporary storage room		
2. Workshops	5	500
3. Public toilets		
4. Electro-mechanical rooms or		

floors

5. Shuttle services

6. Parking

7. Quarters for the workers

G. Entertainment and Recreation.

3708m^2

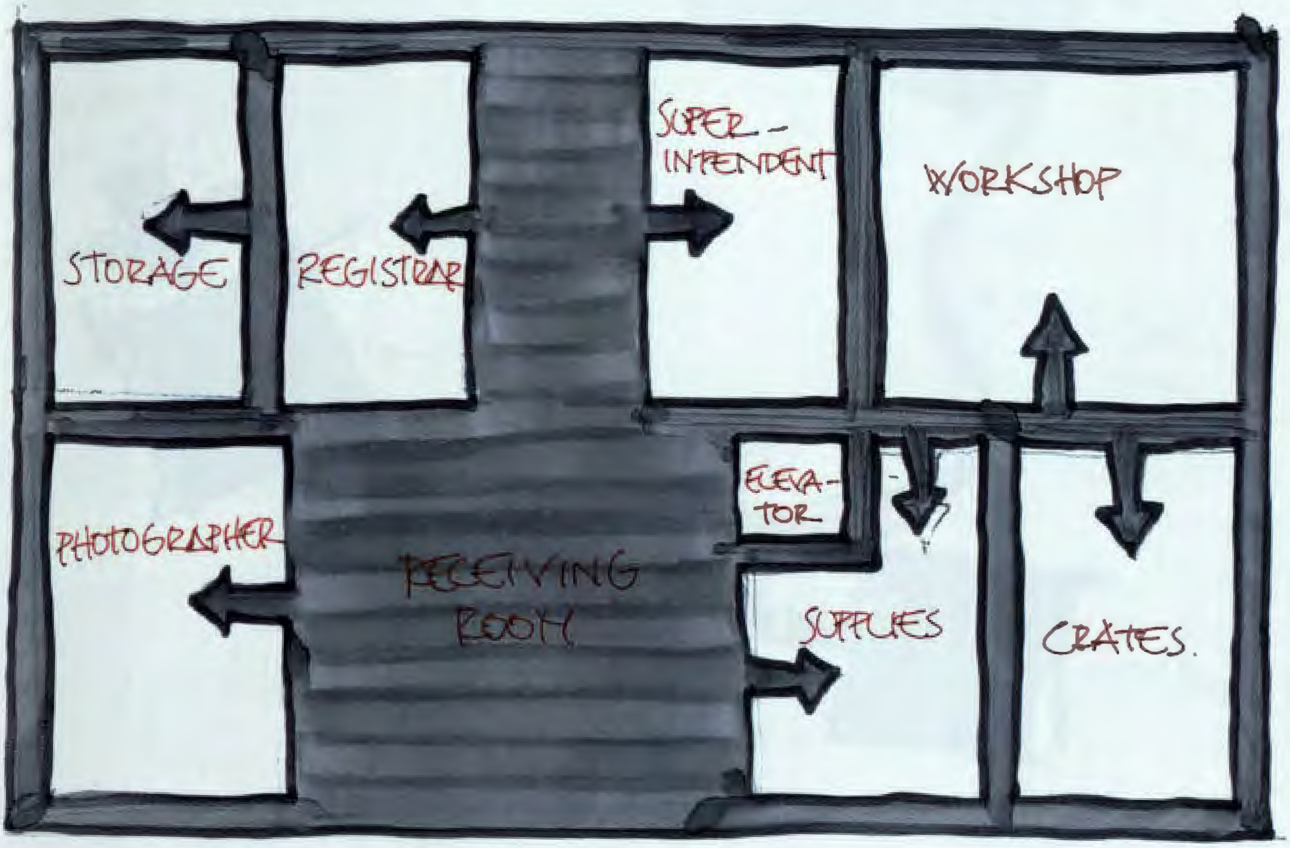


Fig.13 Diagram showing the relationships between the main parts of the museum.

The museum proper consists of five parts. General spaces, education, administration, conservation and exhibition spaces. In general, the exhibition spaces, administration and education should be accessible from the lobby, usually part of the general spaces. Although the museum in this case is dispersed on the port, this relationship does not change since only one

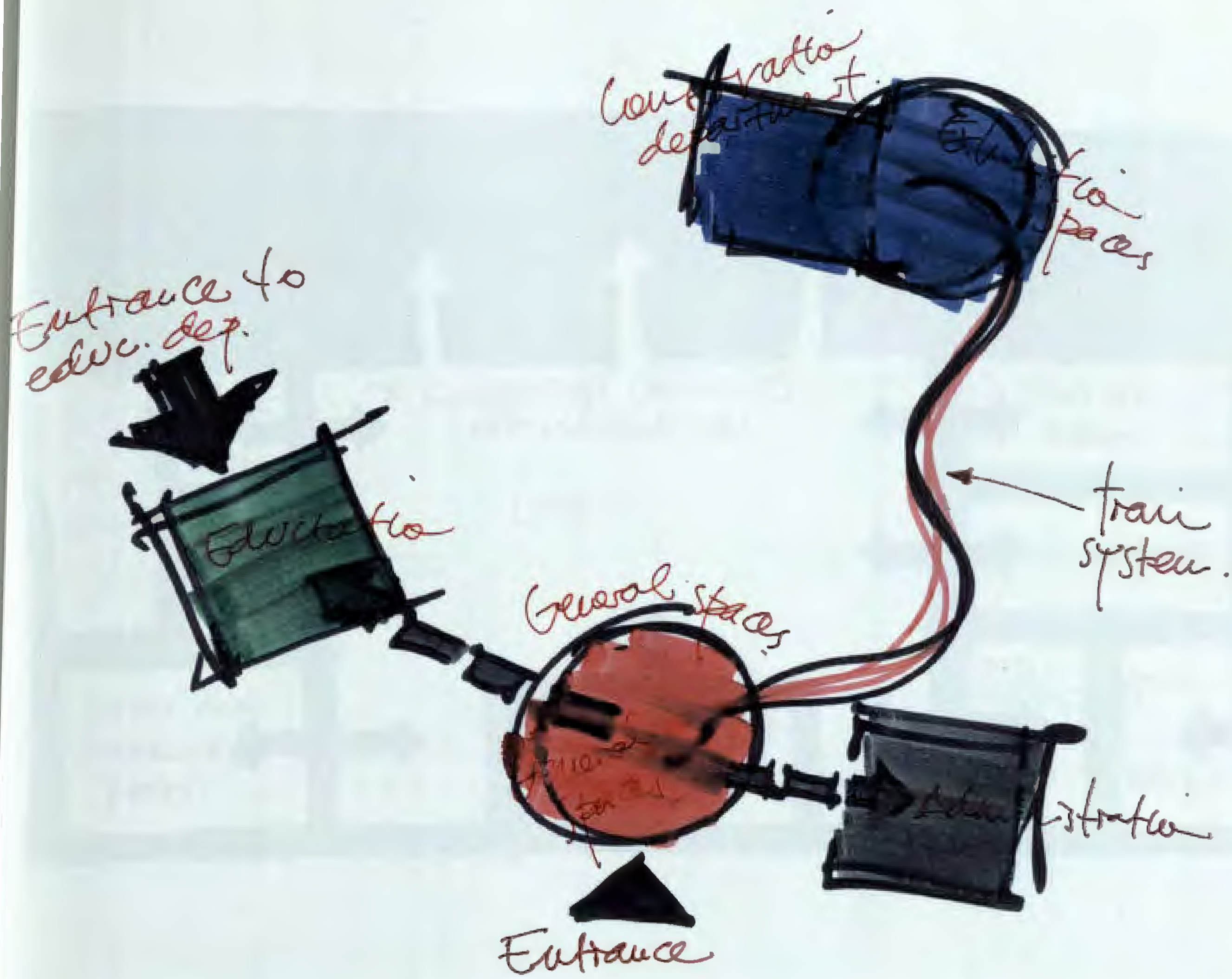


Fig.14

access/exit is provided, and the whole is linked by the circulation system. However, the education department can be accessed separately due to the presence of the library. The conservation department usually lies next to the exhibition spaces, with a direct link between the two. The conservation department, however, although not accessible to the public, can be visually accessed from the general spaces, education department and exhibition spaces (see The Acropolis Museum, below).

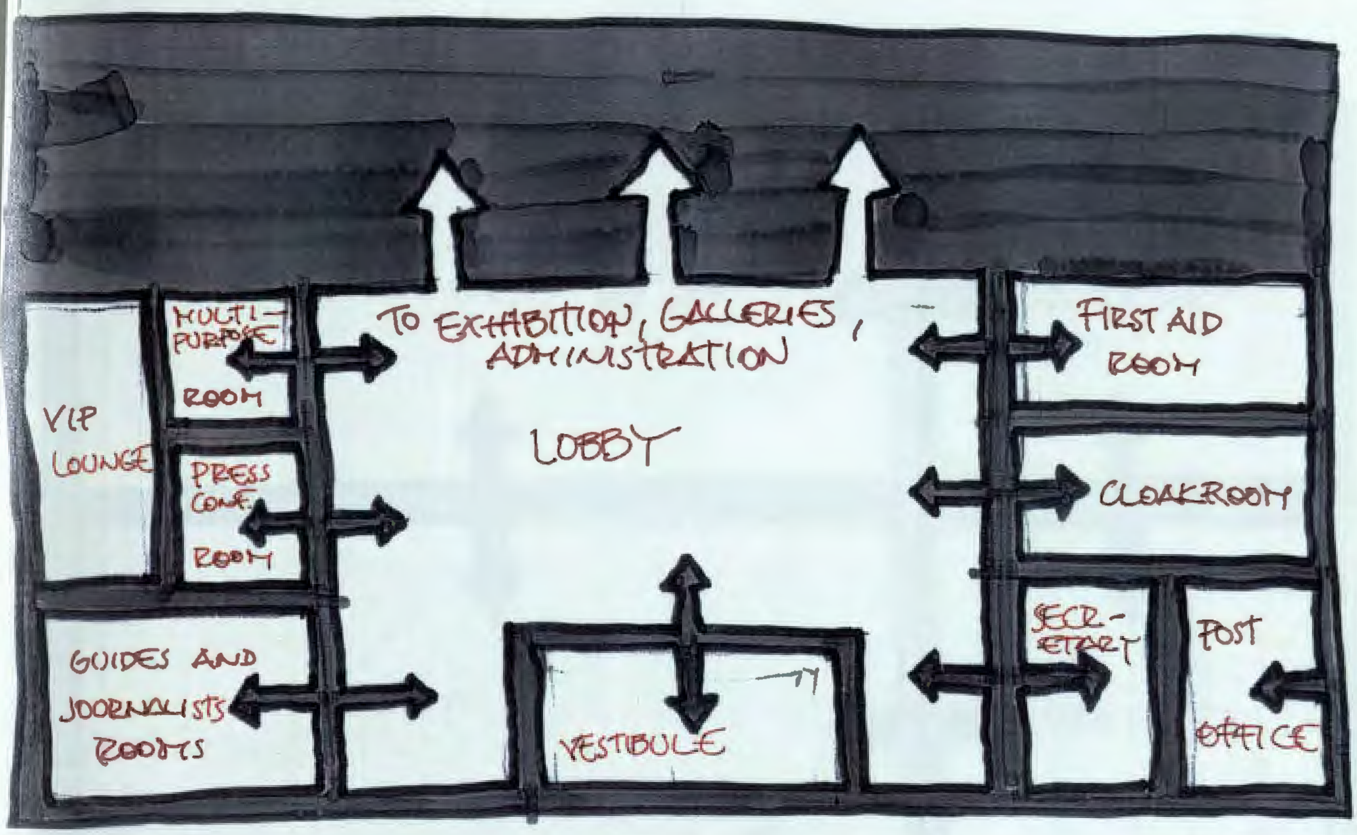


Fig.15 Diagram showing organization of the general spaces.

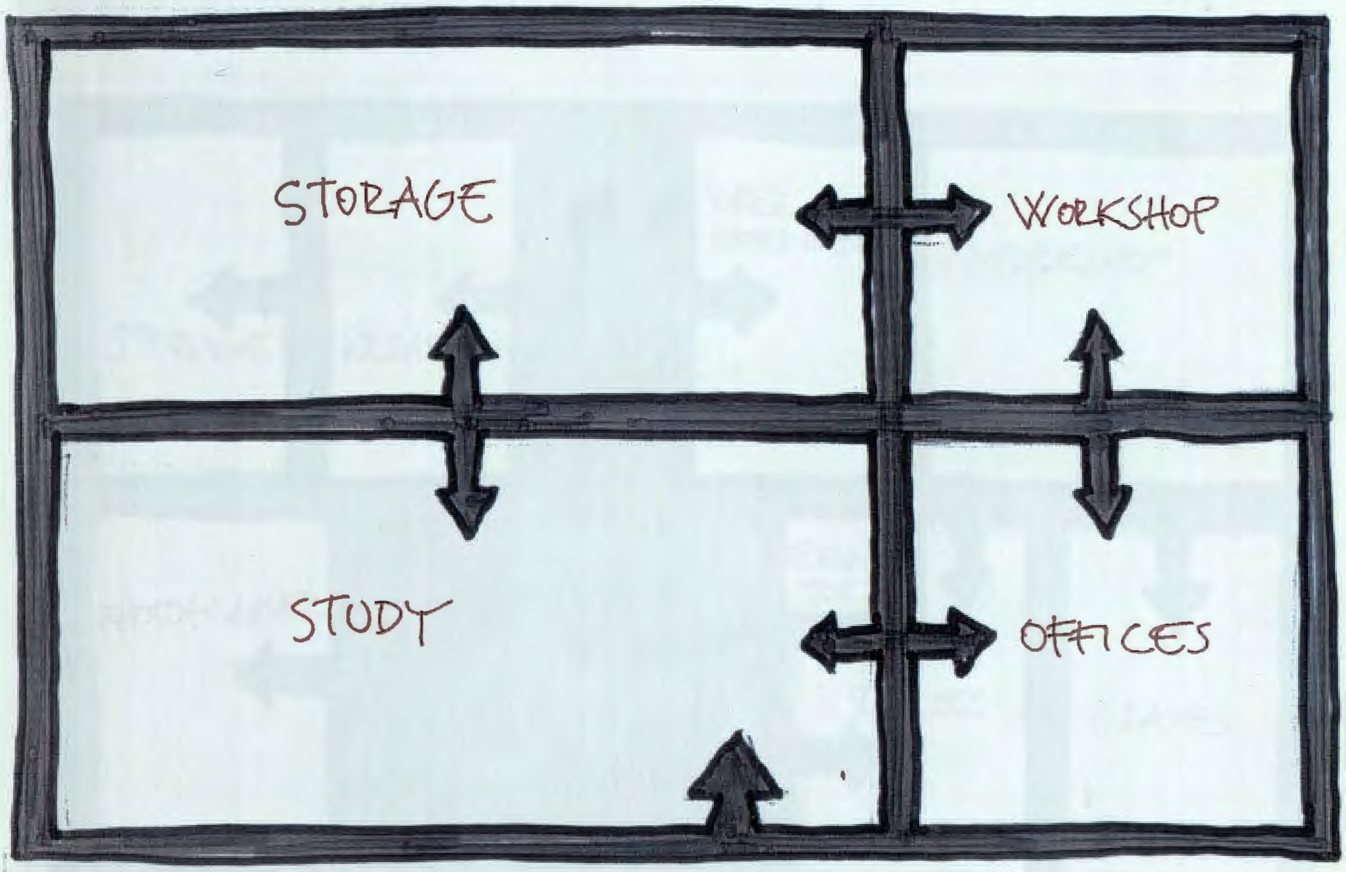


Fig. 16 Diagram showing organization of curatorial spaces.

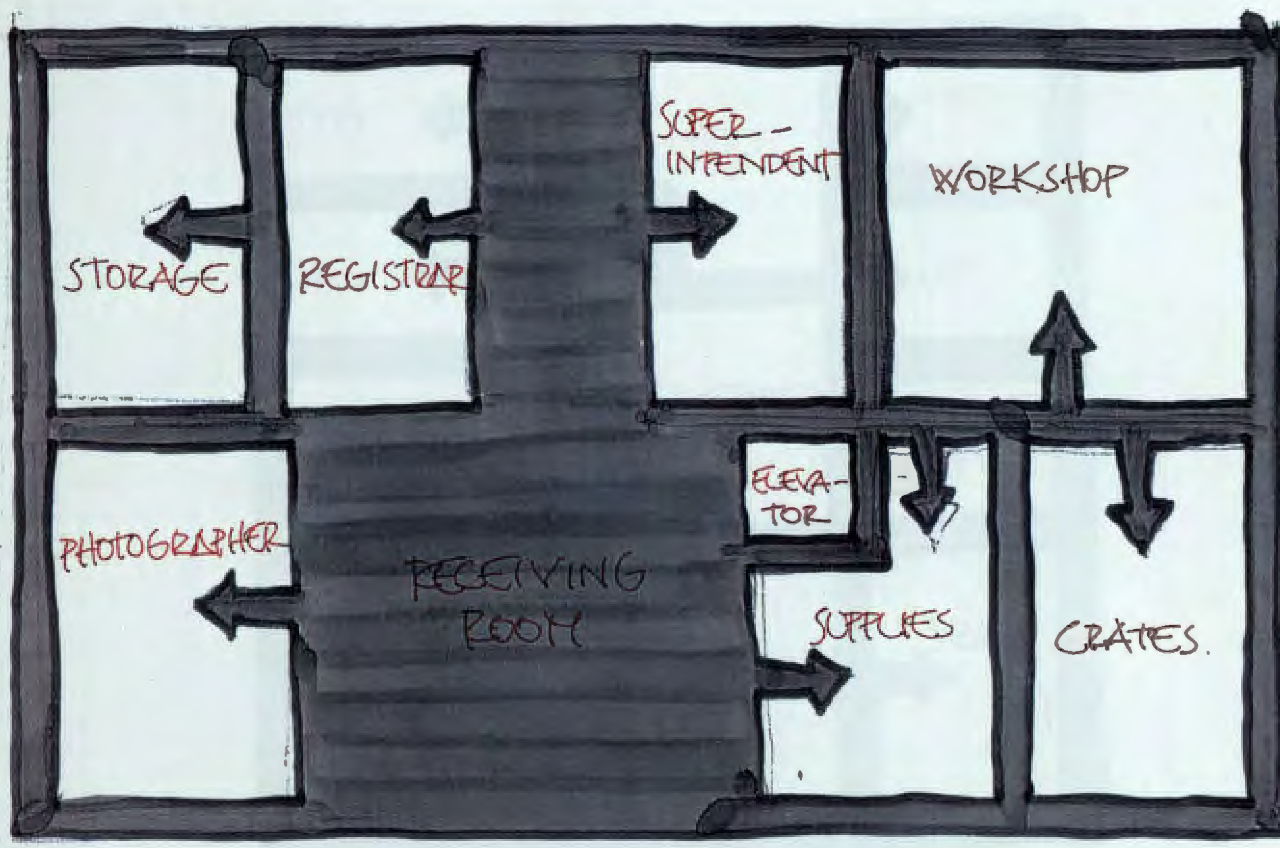


Fig.17 Diagram showing organization of service area.

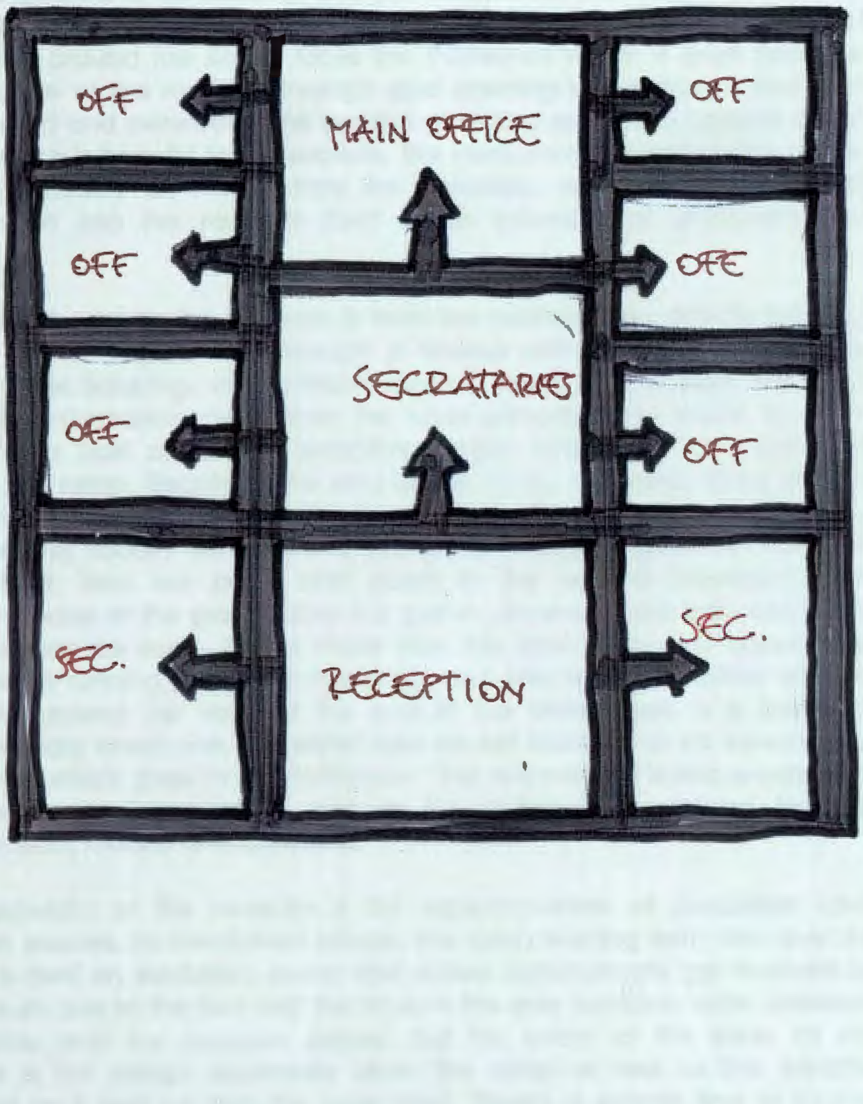


Fig.18 Diagram showing organization of administration.

IV. RELEVANT EXAMPLES.

A. The Acropolis Museum.
Architects: Manfredi Nicoletti, Studio Passarelli.

The site is located to the south of and just underneath the Acropolis hill which overlooks it. The museum is dedicated to the exhibition and preservation of relics found around the site. It faces the Parthenon which is seen from the interior space of the museum through and opening in the sloped roof. The roof is sloped and penetrates the ground providing protection against direct sunlight which is harmful to the exhibits. The museum is a continuation of the Acropolis whereby on moves from the Acropolis, visits the premises and continues on into the museum itself as an extension of archaeological ground.

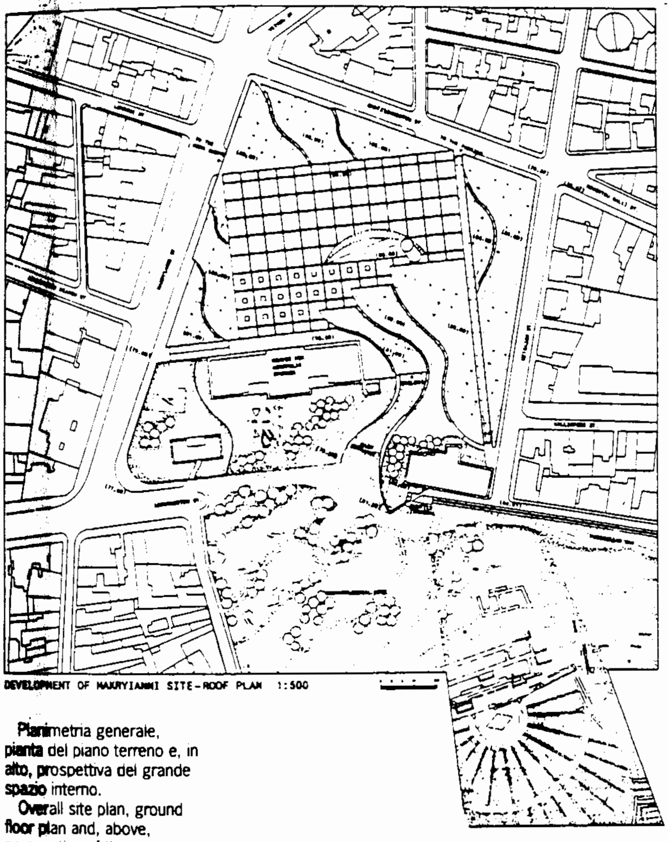
The main entrance to the museum is from the northern side directly leading from an archaeological site, through a sinuous path into the foyer of the building. After ticketing, visitors move down a ramp directly from the foyer behind the information desk. From the foyer extends some shops, a cloak room, and a post office. The exhibition begins directly at this point and includes the ramp. Reaching the end of the ramp, the visitor lands on the lower level of the ground floor. The two basement floors are the workshops, which are only visually accessible to the visitors through a glass roof from the ground floor, and car parks and plants in the second basement. The exhibition space of the ground floor is a gallery around a void from which the workshops can be seen. Visitors move from this floor to the first upper floor through stairs running parallel to the ramp, and also reach exhibition spaces distributed around the void. At the end of the stairs, there is a bar and belvedere from which one can either take an exit staircase or an elevator up to the "eye" which gives to the Parthenon . The second floor is also reached in the same way. The western part of the building is reserved for the administration, theater and cafeteria.

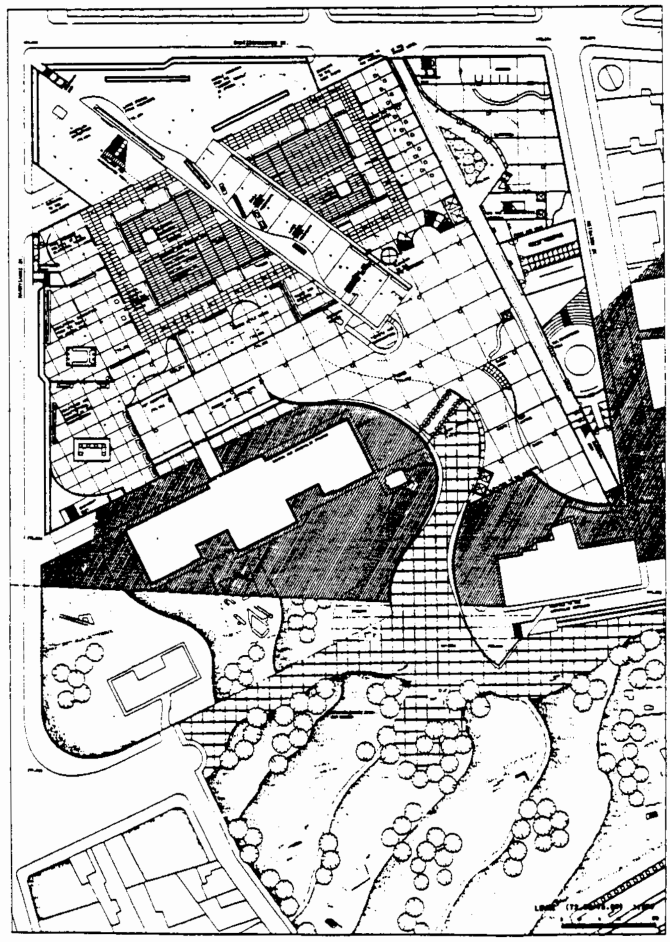
A characteristic of this museum is the superimposition of circulation and exhibition spaces. As mentioned above, the ramp leading from one level to another is itself an exhibition space and visitors automatically get involved in the museum due to the fact that the foyer is the only transition zone between the outside and the museum proper. But the effect of the foyer as an mediator is not abrupt especially since the ramp as well as the exhibits displayed on it start off from the foyer itself. There's a smooth flow of space from the moment of entry until the exit. The museum, being organized around a large void in the middle which unifies visually and conceptually the whole museum, reinforces the sense of a unified space inside it. With the exhibits and the view of the Parthenon from any point in the museum, a further sense of unity is felt, within the museum and between the museum and its surrounding.

Being partly tucked into the ground, and having its main entrance towards the Acropolis, the museum seems to turn its back to the urban area around it though. The streets around it are faced with non-accessible walls, except for an access to the workshops from the eastern side, and a parking access from the south.

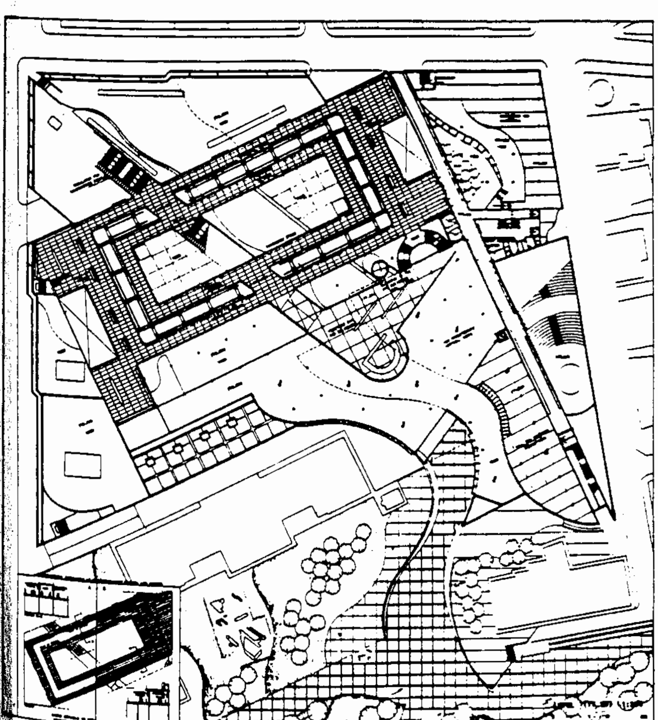
The program of the museum includes main exhibition spaces for the display of a range of archaeological relics such as metopes, pediment remains, columns etc. Also, guides and journalists rooms and VIP lounge, shops, post office, foyer, ticket and information desk, security quarters, administration, cafeteria, lecture room, first aid room, public toilets...

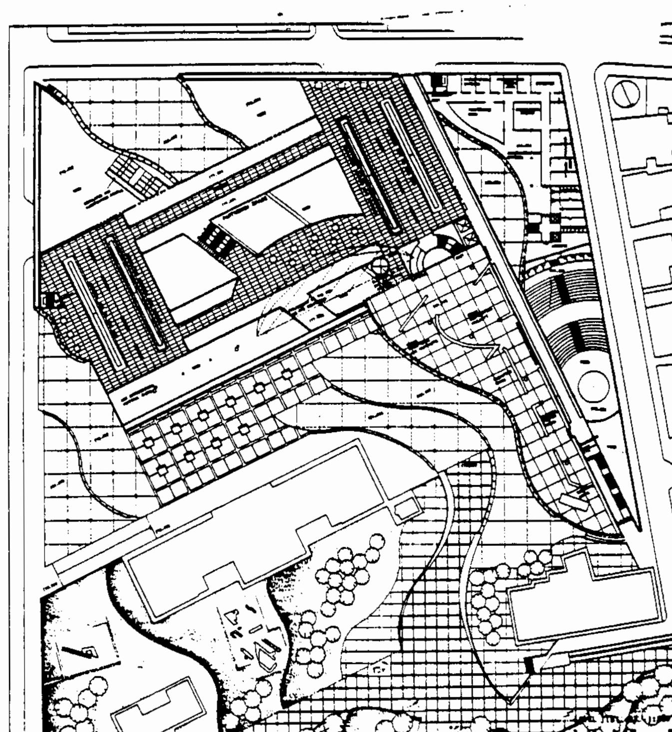
The museum and the open space in front of it open toward the acropolis ignoring the urban fabric behind, turning their back to it. In section, the relationship between the street and the museum is more repulsive, due to the height of the wall, which does not provide any access from the neighboring street into the museum accept for the parking and the services.





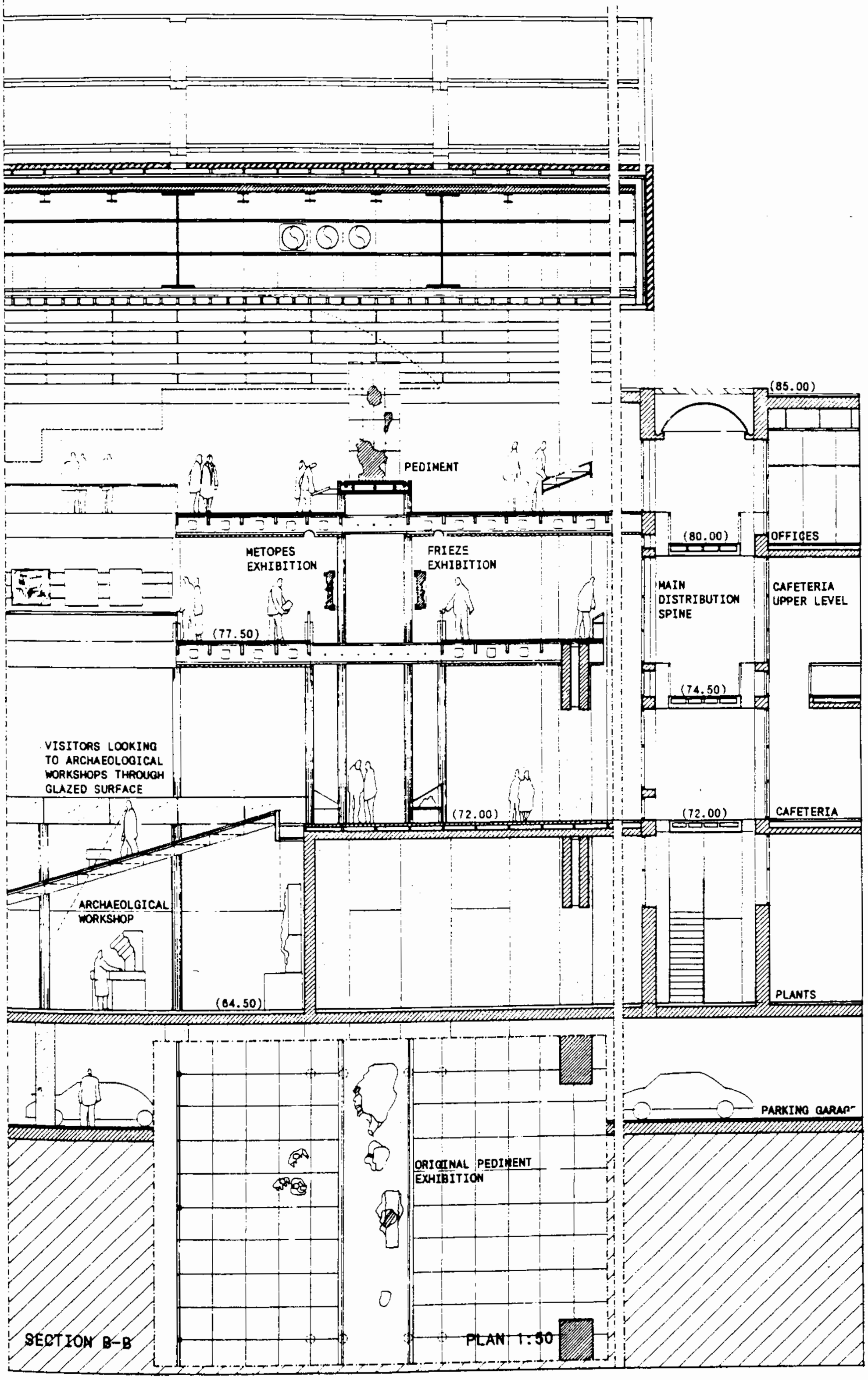
Planimetria generale, pianta del piano terreno e, in alto, prospettiva del grande spazio interno.
Overall site plan, ground floor plan and, above, perspective of the vast interior space.



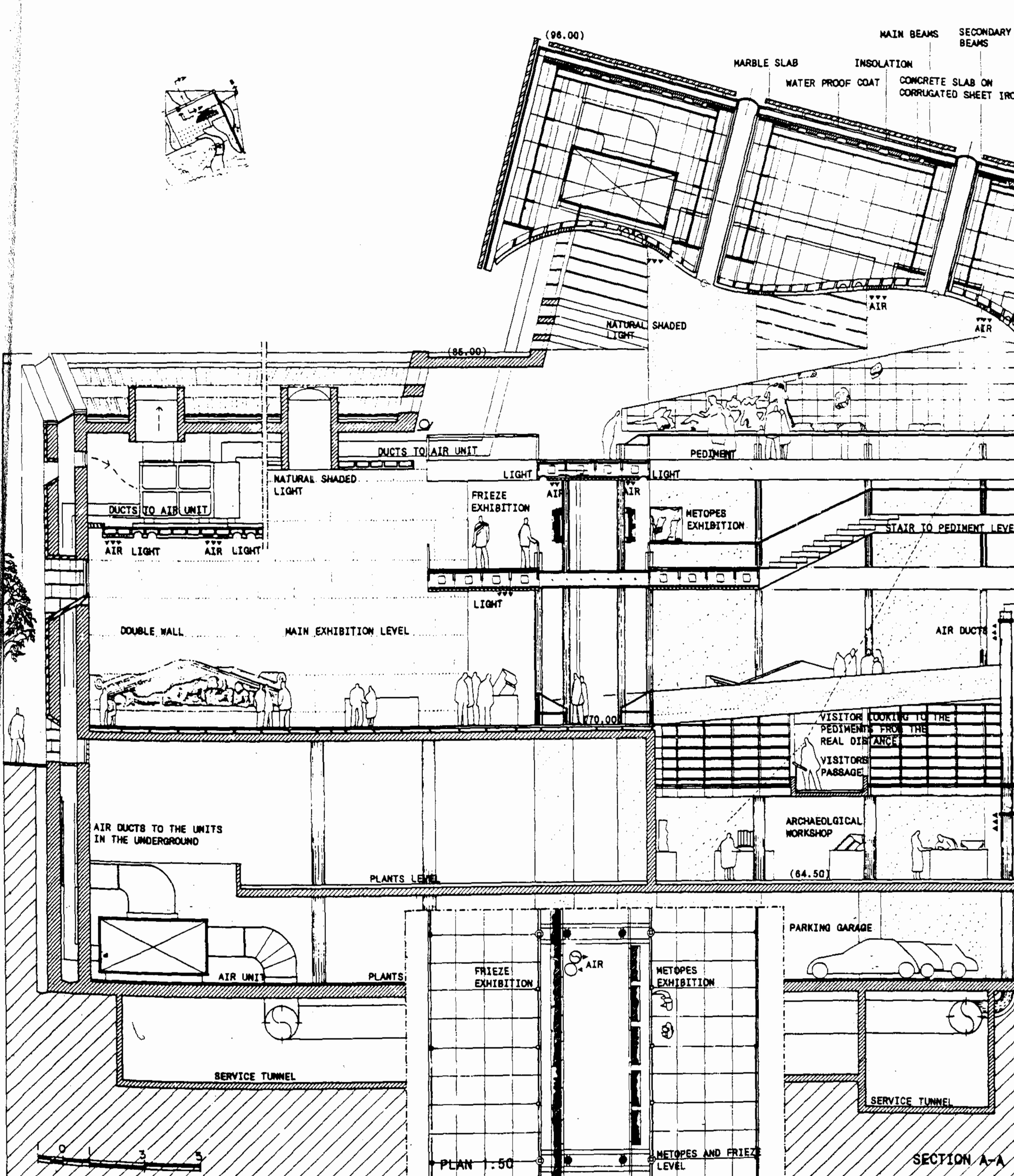


Piante del primo e del secondo livello.
First and second floor plans.

Credits
Project:
Manfredi Nicoletti
Studio Passarelli
Team Representative:
Lucio Passarelli
Collaborators:
Piera Bisignani
Piero Gandolfi
Museography:
Carlo Pietrangeli
Archeology:
Demetrius V. Schilardi
Structures:
Arrigo Carè
Antonio Michetti
Plants:
Enetec:
Gino Moncada Lo Giudice



Particolari di sezione dei margini nord ed est.
Sectional details of the north and east margins.

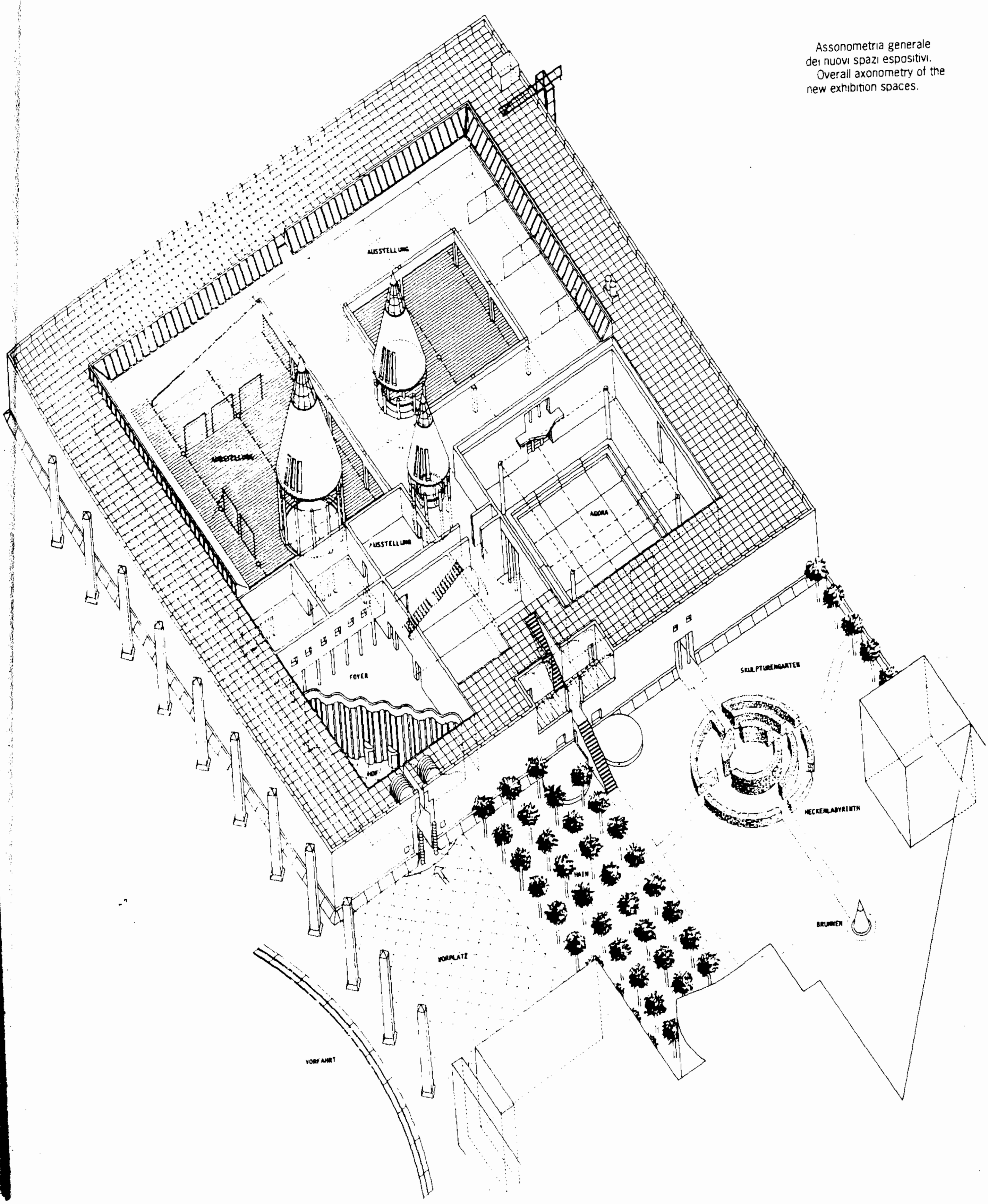

(96.00)
MAIN BEAMS
SECONDARY BEAMS
MARBLE SLAB
INSOLATION
WATER PROOF COAT
CONCRETE SLAB ON CORRUGATED SHEET IRON
AIR
AIR
NATURAL SHADED LIGHT
(85.00)
PEDIMENT
DUCTS TO AIR UNIT
LIGHT
LIGHT
NATURAL SHADED LIGHT
FRIEZE EXHIBITION
AIR
AIR
METOPES EXHIBITION
DUCTS TO AIR UNIT
STAIR TO PEDIMENT LEVEL
AIR LIGHT
AIR LIGHT
LIGHT
DOUBLE WALL
MAIN EXHIBITION LEVEL
AIR DUCTS
70.00
VISITOR LOOKING TO THE PEDIMENTS FROM THE REAL DISTANCE
VISITORS PASSAGE
AIR DUCTS TO THE UNITS IN THE UNDERGROUND
ARCHAEOLGICAL WORKSHOP
(64.50)
PLANTS LEVEL
PARKING GARAGE
AIR
FRIEZE EXHIBITION
METOPES EXHIBITION
AIR UNIT
PLANTS
SERVICE TUNNEL
SERVICE TUNNEL
PLAN 1:50
METOPES AND FRIEZE LEVEL
SECTION A-A

B. The Republic of Germany Art Gallery.
Architect: Gustav Peichl.

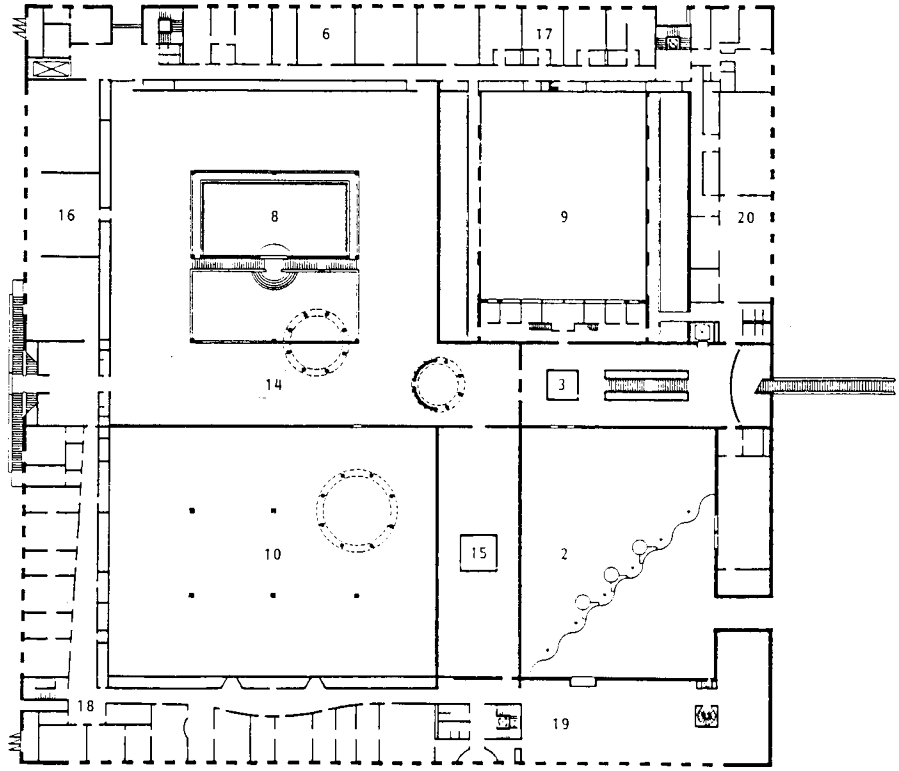
It is the main functions that have determined the building's spatial layout. The Forum is a flexible space conceived for the promotion of debate within exhibition programs featuring various media, including cinema, theater and musical performances.

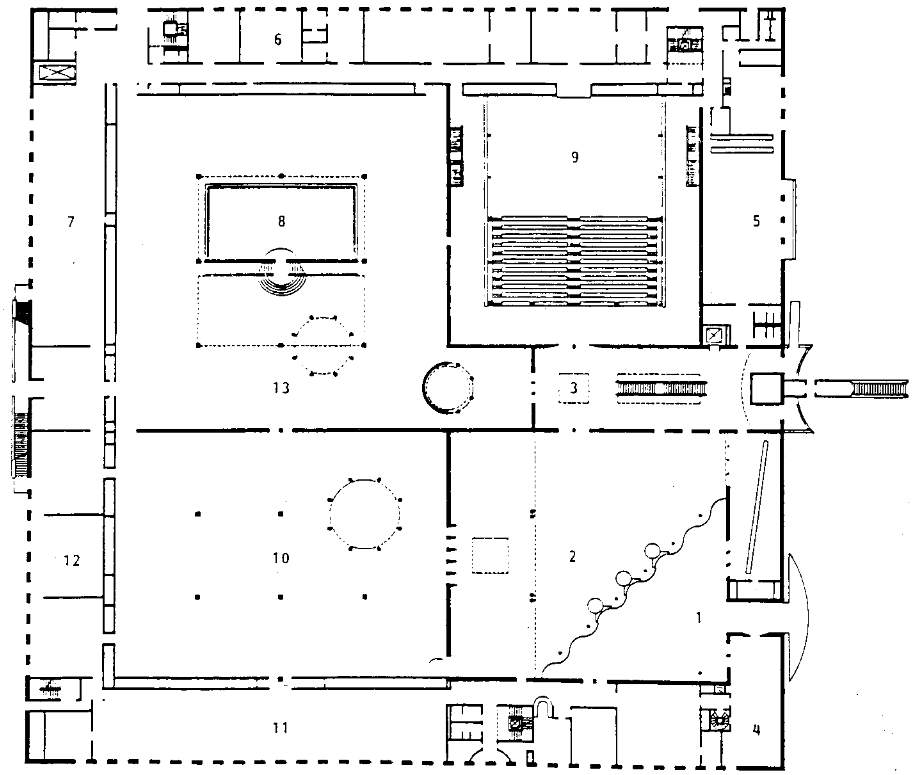
In this building, there are no paths of horizontal circulation. The circulation takes place within the exhibition spaces depending on the pattern of exhibits. Since this is not a permanent exhibition nor a museum, maximum flexibility should be provided. Hence, the absence of a clear, predetermined circulation path. The exhibition spaces are in the middle of the building and are surrounded by a thin shell of services, workshops and galleries. The entry to the building is from one of the corners and into an entrance courtyard. From this courtyard visitors enter the foyer through an undulating glass wall. The main exhibition halls can be accessed directly from the foyer which lies adjacent to them. Visitors can go to the auditorium facing the foyer by passing through a small lobby separating the foyer from the auditorium itself. This lobby is also accessible from the exhibition halls. On the periphery of the building, and on the ground floor, there are services, galleries and laboratories or workshops which are linked directly to the main exhibition halls. From the foyer also, a staircase leads to the upper floor which has a similar organization as the ground floor, in addition to a library, administration, studios and another laboratory, also arranged on the periphery of the main exhibition halls.

The ancillary activities around the main exhibition spaces act as a barrier and prevent direct light from entering the main exhibition from the sides. An indeed, the facades of the museum are opaque, whereby light is allowed in from the top through skylights.



Assonometria generale dei nuovi spazi espositivi.
Overall axonometry of the new exhibition spaces.





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C. Le Bourget Museum of Air and Space.
Architect: Area-Alain Sarfati.

The project was submitted for an architectural and museological ideas competition in 1992, for the new *Musee de l'air et de l'espace*, the fourth important airport in France regarding air traffic and the number of scheduled business flights. The competition required the refurbishment and extension of a museum of aviation dating back to 1919, housing a prestigious collection of old equipment, aircraft, objects, work of art and photographic documentation. Now, the museum occupies the space taken up by the old airdrome dating back to the thirties, and five concrete hangars built in the twenties.

The projects were guided by three objectives: the conservation and renewal of an existing architectural, artistic, technical and documentary patrimony; the creation of new spaces in order to up the intrinsic value of the permanent collections and to complete them, and also to hold temporary exhibits, give renewed impetus to educational activity, study, and documentation.

Sarfati's project is developed around the idea of a single platform geared to functionally link up the various components and unifying the whole. A kind of technical and scenographic instrument able to structurally improve the existent airdrome and other architectural components. This project theme aspiring to the aeronautical world is represented by the sixth facade of the museum, where the buildings rest on the ground like completely autonomous objects with respect to the terrain. This principle has meant developing all activities below the airdrome's main exterior plaza, while the new platform, which is to be paved in black polished concrete, becomes the support for the installation of all the technical equipment. This technological "carpet" that branched out and folds (permitting access to the handicapped), recounts a story, guides the visitor along a continuous itinerary between exterior and interior, between various pavilions and the different levels. The location of activities has been organized according to the museographic requirements stipulated in the competition brief, which envisages the complete revitalization of the airport complex. Thus a complete re-opening of all the original entrances was proposed so as to underline the public character of the building. The central hall will contain the main entrance, spaces for temporary exhibits, a café, conference rooms, and study and research spaces. The museum proper starts on the third underground level where a mezzanine floor permits a global vision of the exhibition space. A simple and linear route facilitates passage from one building to another, crossing the exterior plaza where several vehicles of the collection are on display. The continuity between the various elements, which is the constant factor ordering the entire project, is rendered concrete in the idea of the platform where technical and metaphoric dimensions find their equilibrium.

CONCEPT AND SCHEMATICS.

The problems that the intervention on the harbor poses can be outlined by the following questions:

- **Site**: How and where in the port might the project be located in order that it attains its objectives without any hindrance to the proper functioning of the port activities?
- **Urban**: What relationship with the BCD would the museum assume? To what extent would it function as a public space?
- **Theoretical**: What is the relationship between the objects displayed and the container which houses it? What is the relationship between the container, i.e. the museum, and the 'larger container' which is the port itself? How can the project accommodate the port as an object to be displayed? To what extent is the museum itself an object on display?
- **Political**: How can the museum accommodate the overlap of two different strata of the society? How can the organization of the museum affect the interpretation of historical material?

These problems present themselves on two levels: first on a general level involving the distribution of the museum on the port, in other words, on the level of the master plan and zoning. Second, on the level of spatial relationships and internal organizations of the different spaces.

The general strategy used will be, first of all, the identification of spaces within the overall space which have the potential to be intersections of both spaces, that of the museum and that of the port. These spaces allow an overlap of programs and functions without any hindrance to the overall functioning of neither the port nor the museum. They are spaces of intersection. They can dilute the tension which might occur due to the meeting of oppositions. These might be located all over the port and in several different places. This identification would organize the master plan of the project as well as the zoning. As an answer to the questions raised above, the extension of the program to the interior of the port would include the port in the general experience of the museum, making it an object on display as well as the container. In this case nevertheless, the circulation system becomes crucial in linking these different spaces together and unifying the experience of the port as an exhibit. This extension inside the port would become an extension of the public space of the city, inside the port, hence modifying the relationship between the city and the port. Then, after locating those spaces, the next step would be to program, or "cross-program" them. "Cross-programming" those allows, or should allow, as well, an intersection of two types of people existing on the port: the workers and the visitors of the museum. By being able to accommodate such intersections, these spaces, along with their programs, facilitate the exchange that might take place between these two groups of people. The design approach then works on two levels. One is strategic, consisting of the identification and location of those 'spaces of intersection', the other is tactical, and consists of programming them.

"Architecture has always been as much about the event that takes place in a space as about the space itself. The Rotunda at Columbia University has been a library, it has been used as banquet hall, it is often the site for university lectures, someday it could fulfill the needs for an athletic facility at the university. What a wonderful swimming pool the rotunda would be! ... If 'shock' can no longer be produced by the succession and juxtaposition of facades and lobbies, maybe it can be produced by the juxtaposition of events that take place behind these facades in these spaces..."[7]

This is how Bernard Tschumi introduces his concept of "cross-programming". In the intervention on the port, this concept would not only substitute a program for another within a space, but would be used as an attempt at juxtaposing the port activities with the museum in certain places. The museum becomes a series of events distributed on the port linked together by a 'promenade'. The port itself also becomes a series of events on this 'promenade' as much as the museum. This would integrate both the museum and the port together making the port a container of itself as an object on display, and part of the museum collection. The museum on the other hand, becomes the condition of possibility for the port to open up to the public.

Some 'spaces of intersection' on the port: the warehouses, the first basin, the passenger terminal (first jetty), and the old railway that circulates in the port. The railway is a major tactical tool in the design. It opens up the possibility of distributing the museum inside the port and linking the different parts, without the need for another circulation system. The introduction of another layer of circulation would add another long and winding path which would get in the way of the proper functioning of the port, which already has a complex circulation system. It would also be inefficient. The rehabilitation of the old track would avoid these problems. It had been a part of the general circulation system of the port, it goes through all the port area, and it can be controlled. It is also an 'enclosed' circulation system, in the sense that visitors are not free in moving around, but would be limited to this linear path, and would be enclosed, making it easier to provide for guided tours. The railway

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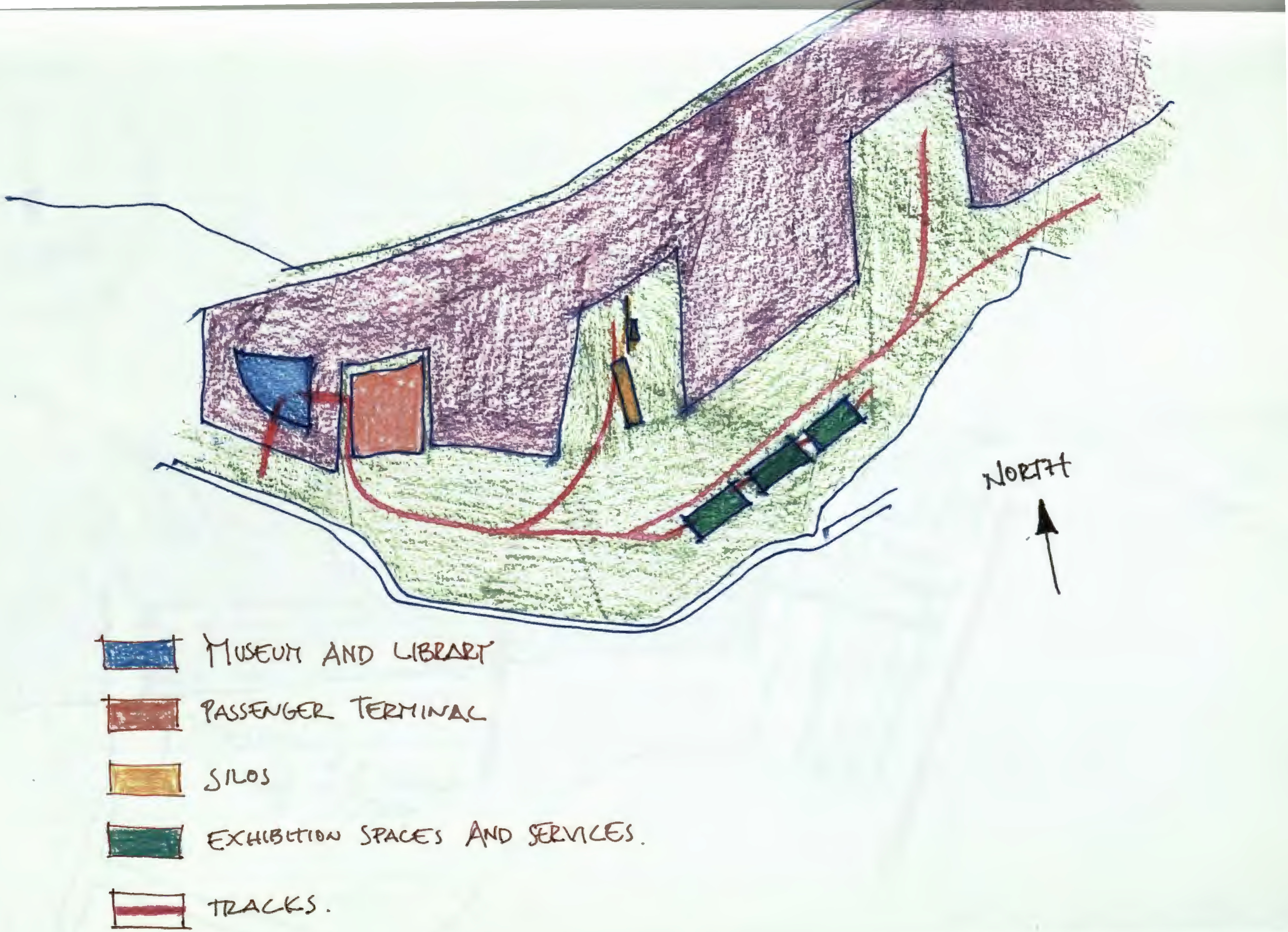
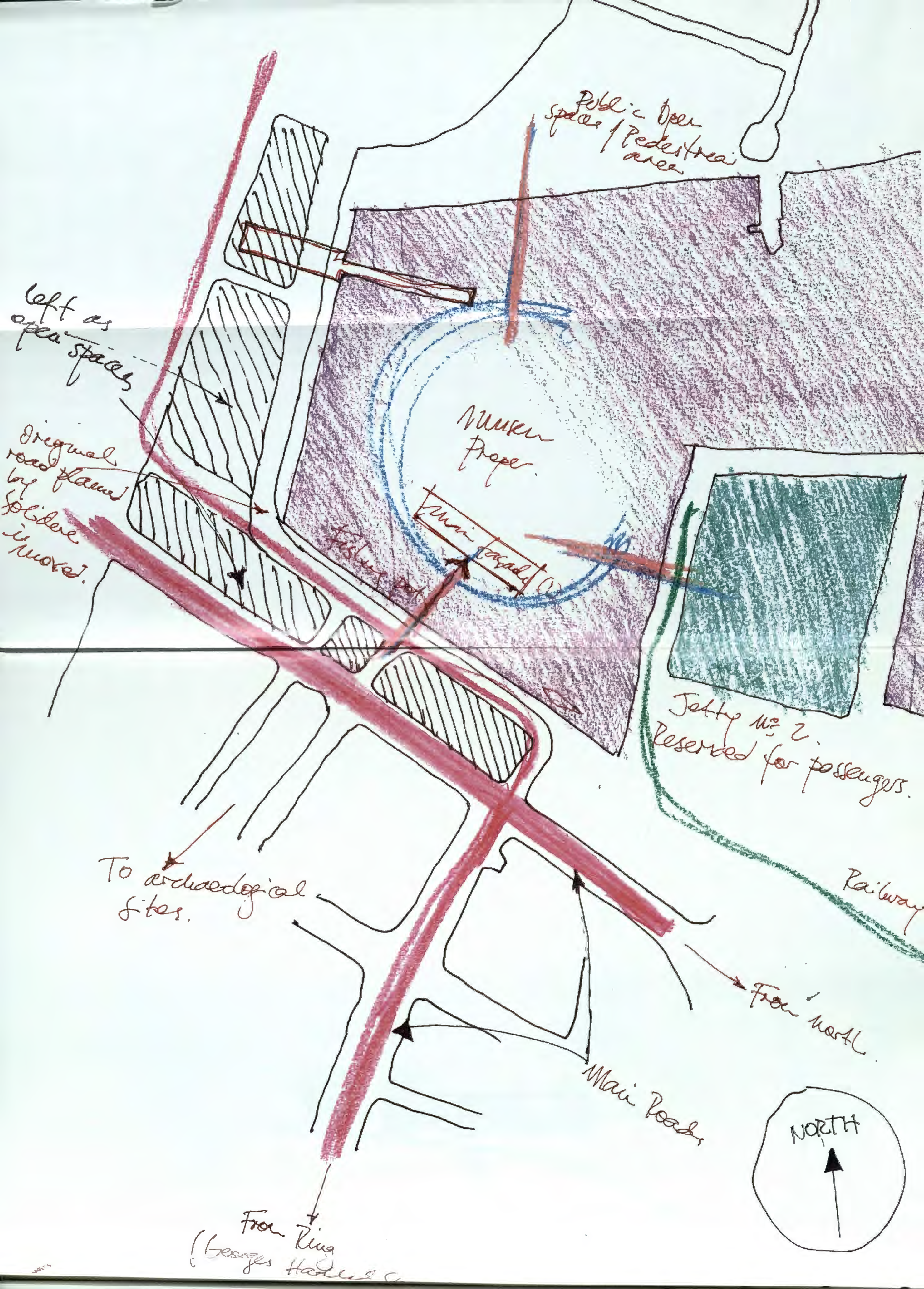
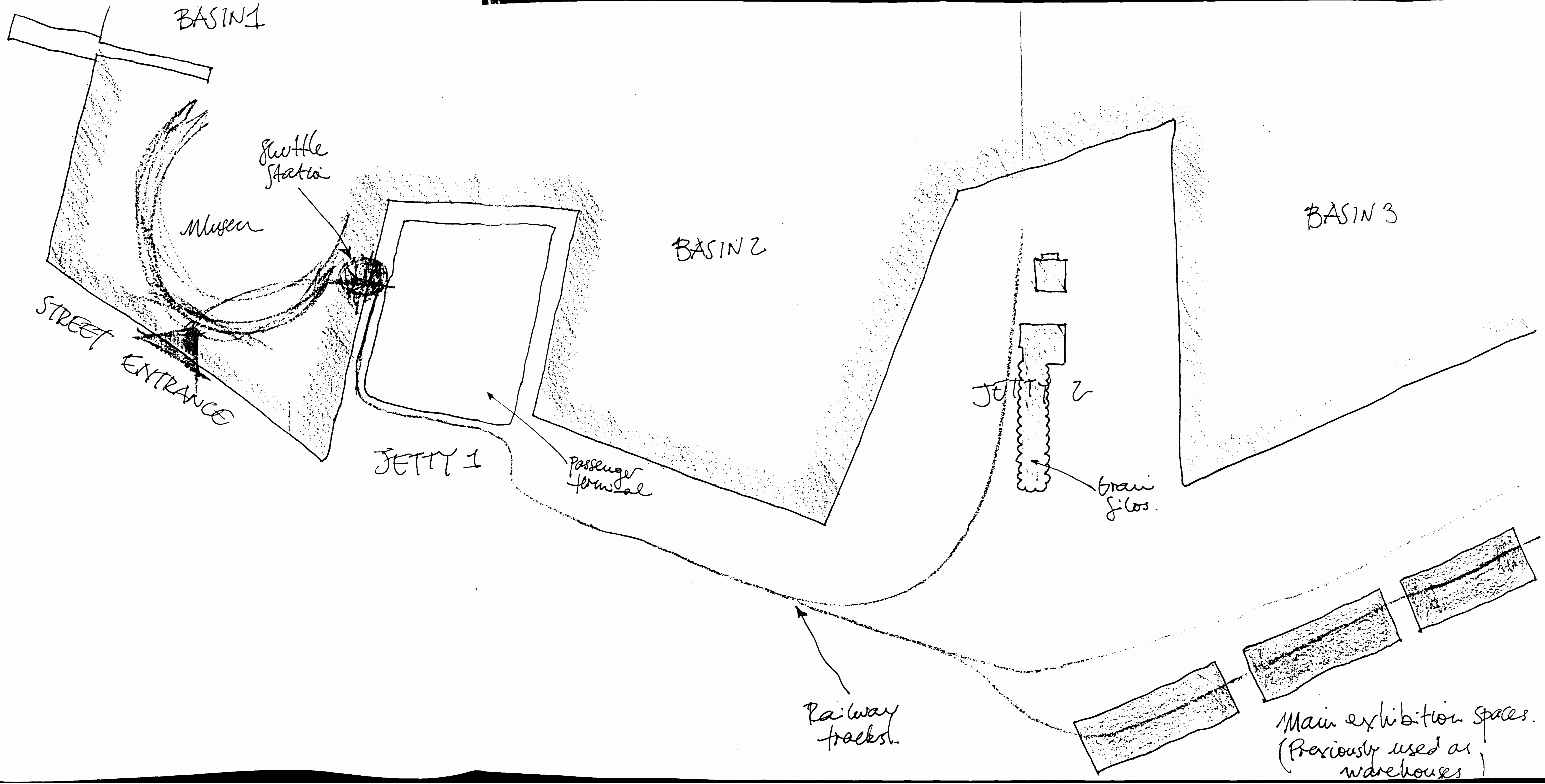
[7] Tschumi in *Theory and Experimentation: An Intellectual Extravaganza,* edited by Andreas Papadakis, p.16.

system would work with the warehouses since it passes through or beside some of the warehouses. Including exhibition spaces within these warehouses would be made easier because of this fact. The exhibition spaces would be on the same major circulation path and would not require the addition of a secondary one. These warehouses are well inside the port also, further integrating the museum with the port.

The starting point of the museum would be located near, around, or within the first basin. This would include some of the general spaces and other public spaces. This location has the advantages provided by the area around it as mentioned in the site analysis above. It also restricts access to and exit from the port, for the public, to one point, away from the other port entrances. From this area, the visitors would be constrained in their circulation to the railway.


NORTH
MUSEUM AND LIBRARY
PASSENGER TERMINAL
SILOS
EXHIBITION SPACES AND SERVICES.
TRACKS.


Public Open Space / Pedestrian area
left as open spaces
Original road planned by Solidere is moved.
Museum Proper
Main facade (1)
Existing port
Jetty No 2 Reserved for passengers.
Railway
To archaeological sites.
From north.
Main Roads
NORTH
From Ring (Georges Haddad


BASIN 1
Shuttle Station
Musem
STREET ENTRANCE
BASIN 2
JETTY 1
passenger terminal
BASIN 3
JETTY 2
Grain Silos.
Railway tracks.
Main exhibition spaces.
(Previously used as warehouses)

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APPENDIX A

By BRUNO MOLAJOLI

GENERAL OBSERVATIONS

Whenever it is proposed to build a museum—whether large or small—there is usually one preliminary matter to be settled: the choice of a site. Where several possibilities are available, the drawbacks and advantages of each must be carefully weighed.

Should the site be central, or on the outskirts of the town? This appears to be the most usual dilemma. Until 20 or 30 years ago there was a preference for the center of a town, with its better transport facilities. But as the use and speed of public and private transport have gradually increased and it has become easier to get from one point to another, it has been realized that the convenience of a central situation for a museum is outweighed by the many and substantial advantages of a less central position. These include a greater choice and easier acquisition of land (at lower cost), less fatigue from the noise of traffic—a growing and already very real problem—and an atmosphere less laden with dust and with gases which when not poisonous are, to say the least, unpleasant.

A museum should always be readily accessible from all parts of the town by public transport and, if possible, be within walking distance as well, and must be within easy reach of schools, colleges, university, and libraries. As a matter of fact, all these institutions have similar problems and stand equally in need of topographical coordination; it would be advisable to take this into account at the town-planning stage, rather than deal with each case separately, as it arises, a method which may involve the sacrifice or neglect of many desiderata.

Museums tend nowadays to be regarded more and more as "cultural centers." It must therefore be remembered that as such they are visited not only by students but by people with different backgrounds who, if a museum is near enough and easy to reach, may come to it, even with little time to spare, in search of instructive recreation.

Though there is still a prejudice against the building of museums in parks or gardens—on the plea that this makes them more difficult to reach and disturbs the tranquillity of such places—these are becoming very popular as the sites of new museums. They offer considerable advantages—a wider choice of detached positions, thus reducing the risk of fire; a relative degree of protection from dust, noise, vibrations, exhaust gases from motor engines or factories, smoke from the chimneys of houses and from municipal heating plants, the sulphur content of which is always harmful to works of art.

A belt of trees surrounding the museum building serves as an effective natural filter for dust and for the chemical discharges that pollute the air of a modern industrial town; it also helps to stabilize the humidity of the atmosphere, to which paintings and period furniture are often sensitive. It is said that large trees, if unduly close to the building, cut off or deflect the light and thus diminish or alter its effect on color; but this disadvantage would appear to be unimportant, or in any case easy to overcome.

The surrounding land may offer space for an annex, built at a suitable distance from the museum itself, to house various types of equipment and services (heating and electricity, repair shop, garage, etc.), or the stores required for them (wood, textile materials, fuel oils, etc.), which it would be unsafe or, for some reason, inconvenient to stock in the main building.

Moreover, space will always be available—at least in theory—for future expansion, either by enlargement of the original building or by the construction of connected annexes; this is particularly important if the first project has to be restricted in scale for reasons which, though unavoidable, are likely to be transitory.

The beauty of a museum is considerably enhanced if it is surrounded by a garden which, if the local climate is propitious, can be used to advantage for the display of certain types of exhibit, such as ancient or modern sculpture, archaeological or architectural fragments, etc.

Part of the surrounding grounds may also provide space for a car park.

The planning of a museum is an outstanding example of the need not only for preliminary and specific agreements but for close and uninterrupted collaboration between the architect and his employer.

There is no such thing as a museum planned in the abstract, suitable for all cases and circumstances. On the contrary, every case has its own conditions, requirements, characteristics, purposes, and problems, the assessment of which is primarily the task of the museum director. It is for him to provide the architect with an exact description of the result to be aimed at and of the preliminary steps to be taken, and he must be prepared to share in every successive phase of the work—failing which the finished building may fall short in some respects of the many and complex technical and functional demands which a modern museum must satisfy.

Another point to be considered is whether the new building is to house an entirely new museum (whose contents have yet to be assembled) or to afford a permanent home for an existing collection. In the first case we have the advantage of a free approach to the problem and can decide on an ideal form for the museum, but with the attendant drawback of beginning our work in the abstract, on the basis of entirely vague and theoretical assumptions which future developments will probably not confirm. In the second case we must take care not to go to the opposite extreme by designing a building too precisely adapted to the quality and quantity of the works or collections which form the nucleus of the museum, future needs and possibilities of development should always be foreseen and provision made for them.

All this is part of the director's responsibility.

Due regard should also be given to the special character of the new museum—the quality it already possesses and by which it is in future to be distinguished—in relation to its collections. This may, of course, be of several kinds (artistic, archaeological, technical, scientific, etc.) and respond to various needs (cultural, general or local permanence or interchangeability, uniformity of the exhibits or group display, etc.).

Naturally, every type of collection, every kind of material, every situation has its own general and individual requirements which will considerably influence the structure of the building and the form and size of the exhibition rooms and related services. It is no use attempting to present a series of archaeological or ethnographical exhibits, whose interest is chiefly documentary, in the space and surroundings that would be appropriate to a collection of works of art, paintings, or sculpture of great aesthetic importance, or to apply the same standards to a museum arranged chronologically and one whose exhibits are classified in artistic or scientific categories; nor is it possible to display a collection of small works of art, such as jewelry, small bronzes, medallions, miniatures, etc., in rooms of the size needed for large objects of less meticulous workmanship, which require to be seen as a whole and from a certain distance.

Even a picture gallery cannot be designed in such a way as to serve equally well for the exhibition of old pictures and modern ones: for, apart from the fact that aesthetic considerations recommend different settings for the two groups, it is obvious that a gallery of old paintings is comparatively "stabilized," whereas the appearance of a modern gallery is to some extent "transitory," owing to the greater ease and frequency with which additions, changes, and rearrangements can be made. In the latter case, therefore, not only the architectural features of the building but also its actual construction must be planned with a view to facilitating the rapid displacement and changeover of exhibits. The transport of heavy statues, the adaptation of space and the use of the sources of light in the way and on the scale most appropriate for particular works of art, should be taken into account as well as the possibility either of grouping or of displaying them singly, according to the importance and emphasis to be attributed to them.

A museum must be planned not only in relation to its purpose and to the quality and type of its exhibits, but also with regard to certain economic and social considerations. For instance, if it is to be the only institution in the town which is suitable for a number of cultural purposes (theatrical performances, lectures, concerts, exhibitions, meetings, courses of instruction, etc.) it may be desirable to take account in the initial calculations of the financial resources on which it will be able to rely, the nature of the local population, the trend of development of that population as revealed by statistics, and the proportion of the population which is interested in each of the museum's activities.

In fact, the word "museum" covers a wide range of possibilities, and the architect commissioned to design one must make clear—to himself first of all—not only the specific character of the museum he is to build but the potential subsidiary developments and related purposes which can be sensed and foreseen in addition to the dominant theme.

The future may see substantial changes in

Museums, The Organization of Museums, UNESCO, Place de Fontenoy, Paris, 1967.

our present conception of museums. If the architect who designs one allows in his plan for easy adaptation to new fashions, new developments, new practical and aesthetic possibilities, his work will be all the sounder and more enduring. A museum is not like an exhibition, to be broken up after a short time and brought together later in an entirely different form. There should be nothing "ephemeral" in its character or appearance, even where the possibility of changes or temporary arrangements is to be contemplated.

These considerations should be borne in mind when the architectural plans for the building are drawn up.

According to a prejudice which, though gradually dying, is still fairly common, a museum building should be imposing in appearance, solemn, and monumental. The worst of it is that this effect is often sought through the adoption of an archaic style of architecture. We are all acquainted with deplorable instances of new buildings constructed in imitation of the antique; they produce a markedly antihistorical impression, just because they were inspired by a false view of history. Another outmoded prejudice is that which demands a "classical" setting for ancient works of art, as though their venerable dignity would suffer and their aesthetic value be diminished if they were placed in modern surroundings.

But though the style of the building should be frankly contemporary and governed by the creative imagination of its designer, architectural interest must not be an end in itself but should be subordinated to the purpose in view. In other words we must not devote our entire effort to designing rooms which will be architecturally pleasing; it is at least equally important that attention be concentrated on the works exhibited, that their *mise en valeur* be ensured and their predominance established. A museum in which the works of art were relegated to the background and used to "complete" a pretentious architectural scheme, could not be regarded as successful; but neither could a museum which went to the other extreme, where the construction was subordinated to cold, mechanically functional considerations so that no spatial relationship could be created between the works of art and other exhibits—a museum with a completely impersonal atmosphere.

The ideal would seem to lie somewhere between these two extremes—the aim being to allow for that sense of proportion which should always be in evidence when a museum is planned, to ensure that the visitor will find there the friendly, welcoming atmosphere, the attractive and convenient features that he enjoys in his own house.

It is the difficult but essential task of the architect, no less than of the director of a museum, to bring the place into conformity with the mentality and customs of every citizen of whatever rank and standard of education. Much will depend on the level of taste of both men, on their human qualities of sympathy and sensibility, which must go hand in hand with their professional abilities and which cannot be prompted or taught.

PLANS FOR SMALL MUSEUMS

The foregoing remarks apply to every new museum, whatever its size. We shall now consider more particularly the principles and characteristics on which the planning and construction of small museums should be based.

By "small museum" we understand any institution whose program and finances are restricted so that, at least at its inception, the premises built for it will be of limited size, in most cases only one story high.

It is not so easy to determine precisely within what limits the idea of the "little museum" is to be confined; for while it may, at its smallest, consist of one room, it may on the other hand be of an appreciable extent, though still too small to be properly described as a medium-sized or large museum.

For the present purpose it may be assumed that the "small museum" will not consist of more than 10 to 12 medium-sized exhibition rooms (16 × 24 sq ft) in addition to its other services.

A new museum, even on this small scale, cannot function efficiently unless it respects the general principles of museography and the special possibilities for applying them which are provided by the particular circumstances governing its construction.

There are certain museographical considerations which must have a decisive influence on the structure of the building, for instance, on the arrangement of the rooms or the type of roof chosen, and which are therefore of technical importance in the construction.

Consequently, the successful planning of a museum entails the well-considered choice and unerring application of these deciding principles, whose chief theoretical and practical aspects I shall now briefly describe.

Natural Lighting This is one of the subjects most keenly discussed by museum authorities, and is, indeed, of outstanding importance. It was believed at one time that electric light, being easy to switch on, adaptable and unvarying in its effects and able to give full value to architectural features, might provide not merely an alternative to the use of daylight in museums, but a substitute for it. But experience has forced us to recognize that—especially where running expenses have to be considered—daylight is still the best means of lighting a museum, despite the variations and difficulties which characterize it at different seasons and in different places. The building should therefore be so planned as to make the best use of this source of light, even if certain other structural features have to be sacrificed as a result.

Daylight may come from above or from the side. In the former case suitable skylights will be provided in the ceilings of the exhibition rooms. In the latter case, one or more walls will be pierced by windows, the height and width of which must be decided according to individual requirements (see Fig. 1*a-j*.).

Lighting from Above This type of lighting, sometimes called overhead lighting (I dislike this term, which seems too restrictive, ignoring the possibility of directing the light from above at any desirable angle), has long been favored by the designers of museums, for it presents certain obvious advantages.

1. A freer and steadier supply of light, less liable to be affected by the different aspects of the various rooms in the building and by any lateral obstacles (other buildings, trees, etc.) which might tend, by causing refraction or by casting shadows, to alter the quantity or quality of the light itself.
2. The possibility of regulating the amount of light cast on the pictures or other exhibits and of securing full and uniform lighting, giving good visibility with a minimum of reflection or distortion.
3. The saving of wallspace, which thus remains available for exhibits.
4. The maximum latitude in planning space inside the building, which can be divided without requiring courtyards or light shafts.
5. The facilitation of security measures, owing to fewer openings in the outside walls.

Compared with these advantages, the drawbacks seem trifling and can in any case be reduced or overcome by suitable technical and structural measures. They are:

1. The excess of radiating light, or of diffused light interspersed with irregular rays.
2. The disadvantages inseparable from any system of skylights (increased weight of the roof or ceiling supports; liability to become coated with dirt; risk of panes being broken; danger of rainwater infiltration; condensation of moisture; admission of sun rays; irradiation and dispersion of heat, etc.).
3. The monotony of the lighting, and oppressive claustrophobic effect produced on visitors called upon to walk through a long succession of rooms lit from above.
4. The greater complexity of the architectural and technical problems to be solved in providing a roof which, while adapted to this form of lighting, will effectively serve its various purposes (problems relating to weatherproof qualities, heating, maintenance, cleaning, security, etc.).

Lateral Lighting This is provided either by ordinary windows of various shapes and sizes, placed at suitable intervals in the walls, or by continuous openings; both windows and openings may be placed either at a level at which people can see out of them or in the upper part of the wall.

The solution adopted will be determined by the type of museum and the nature of its exhibits, as the advantages and disadvantages vary from one to another.

Windows at the usual level, whether separate or continuous, have one serious drawback, in that the wall in which they are placed is rendered useless and the opposite wall practically useless, because showcases, paintings, and any other object with a smooth reflecting surface, if placed against the wall facing the source of light, will inevitably cause an interplay of reflections which impedes visibility. These windows will, however, shed full and agreeable light on exhibits placed against the other walls and in the center of the room at a correct angle to the source of light.

Advocates of lateral lighting point out that this is particularly successful in bringing out the plastic and luminous qualities of paintings and sculpture created in past centuries, when artists usually worked by such light.

All this must be considered in conjunction with the proper use of the floor space, the shape, arrangement, and sequence of the different rooms, their size and depth in relation to the outer walls—the aim being to make the most of the sources of light and to obtain the greatest possible uniformity of lighting throughout each room.

A definite practical advantage is, however, that of rendering possible the utmost simplicity and economy in the style of building, permitting the adoption of the ordinary, nontransparent roofing (flat or sloped) customary in the district, and providing, thanks to the side windows, a convenient and simple method of regulating ventilation and temperature in museums which cannot afford expensive air-conditioning apparatus.

Another advantage of windows placed at the ordinary level is that some of them can be fitted with transparent glass, allowing pleasant views of the countryside, gardens, or architecturally interesting courtyards. This provides a

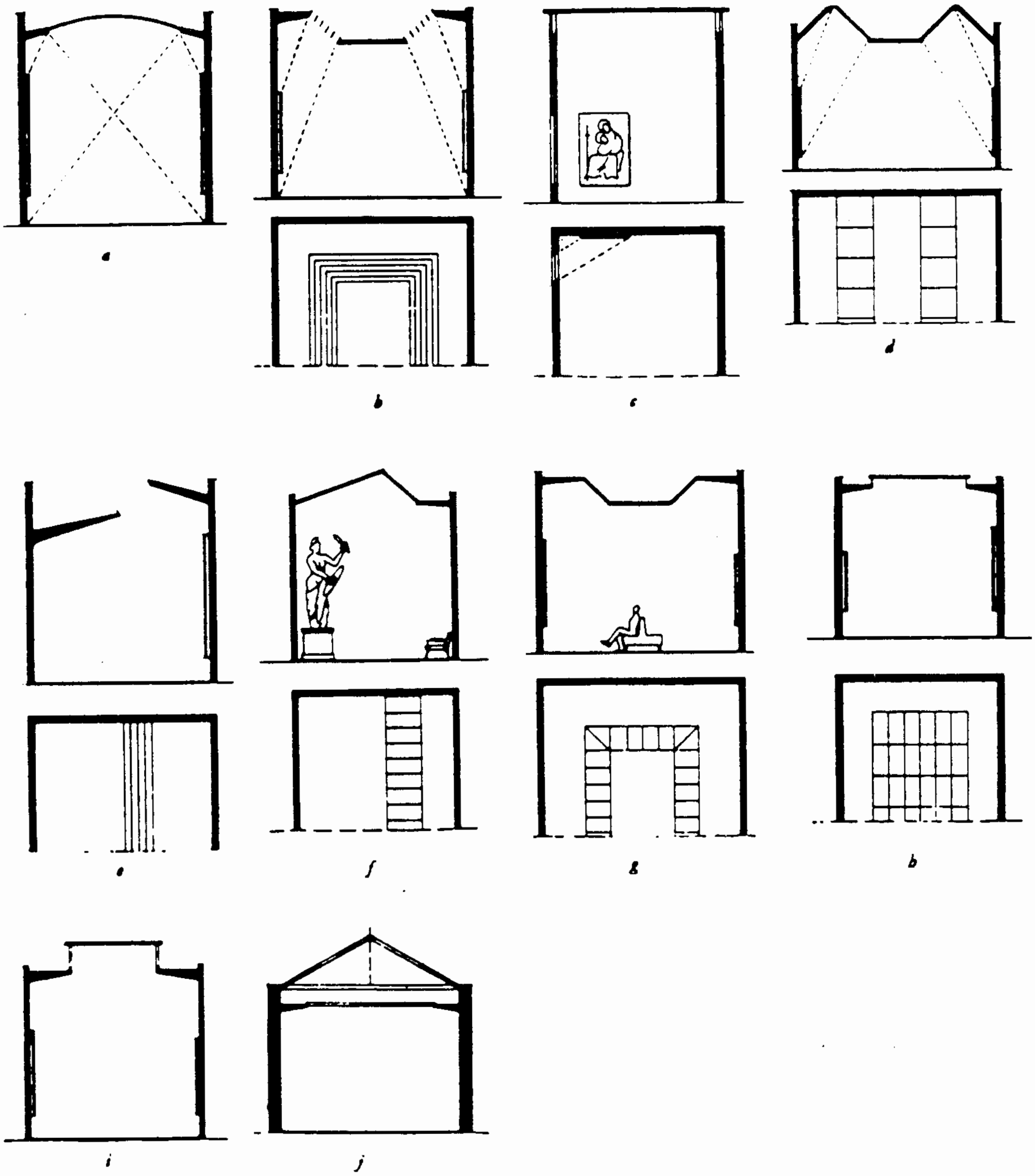


Fig. 1 Different methods of admitting natural light from above. (a) Cross section. (b) to (h) Cross section and view from above. (i) and (j) Cross section.

diversion, resting the visitor's eyes and refreshing his mind.

For this purpose it may be wise, even where overhead lighting is adopted, to arrange a few lateral openings for the passing visitor.

High-placed windows, especially if they occupy more than one wall, provide more light, more closely resembling that supplied by skylights, and leave all four walls free for exhibits: but as they must be placed at a considerable height, if visitors are not to be dazzled, the rooms must be comparatively large and the ceilings lofty. This means that considerable stretches of wall will be left blank, and building expenses will increase owing to the larger size of the rooms.

The tendency nowadays is to abandon uniform lighting in favor of light concentrated on the walls and on individual exhibits or groups of exhibits, which are thus rendered more conspicuous and more likely to attract the visitor's attention. Consequently, instead of lighting the whole room, it is found preferable to light the showcases from within, either by artificial lighting or by backing them with frosted glass which admits daylight from outside.

This is a possibility which the architect of a small museum can bear in mind, making use of it in special cases and for objects (glass, ceramics, enamels, etc.) whose effect can be heightened by such lighting. But it entails special structural features which may complicate the general budget.

Moreover, if the lighting system is too rigid, too definitely planned to suit a particular setting and to establish certain relationships between that setting and the exhibits, it will form an impediment by imposing a certain stability, tending to reduce the museum to the static condition from which modern institutions are striving to emerge—the present-day being that a museum should make a lively, dynamic impression.

It therefore seems preferable, especially in small museums, to choose an intermediate system which can be adapted to varying needs and necessary changes, even if it thus becomes more difficult to achieve ideal results.

Utilization and Division of Space In designing a museum the architect will also be decisively in-

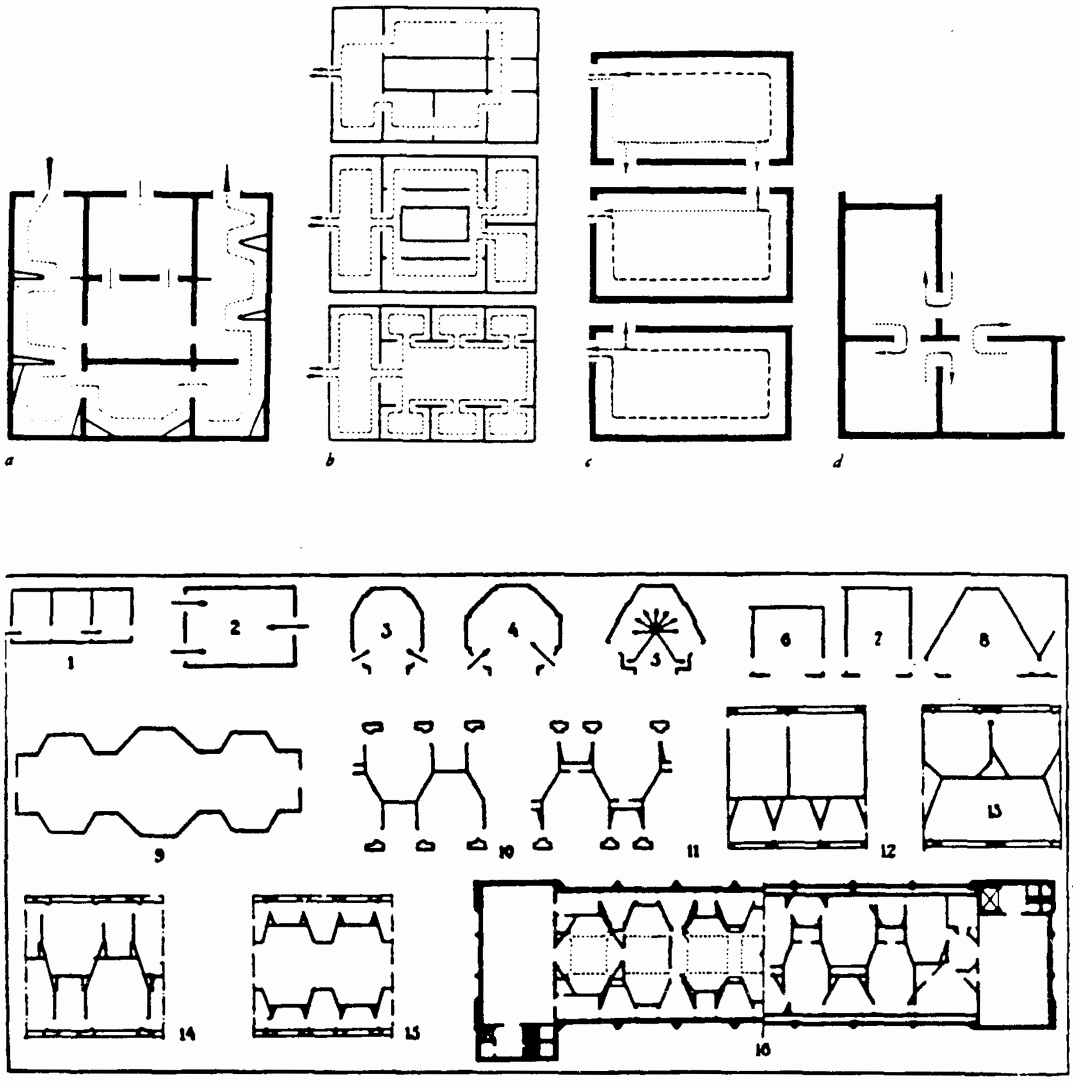


Fig. 2 (a) to (d) Floor plans for the location of doors in relation to the use of space. (e) 1 – Traditional location of doors. 2 to 8 – Secondary doors. 9 to 15 – Polygonal enclosures.

fluenced by the way in which it is intended to utilize and divide the space to be devoted to the displays. This, too, is of course closely connected with the question of lighting, which we have already discussed.

The modern tendency is to create large unbroken spaces, which can then be divided up by movable partitions or lightweight structures, to be grouped or displaced as required.

The traditional system is the contrary one of dividing the space, by means of permanent walls, into rooms of various sizes, which may be either communicating or independent (connected, in the latter case, by passages or side galleries) (see Fig. 2a-e).

A small museum may do well to adopt an intermediate system with a succession of average-sized rooms (for the display of permanent collections whose contents *will not* change, such as those received through bequests, donations, etc.) and one or more large rooms which can be variously divided up when *required* by *movable partitions or light structures*.

The structure of the building and, with it, the interior and exterior technical features, will vary according to the purpose for which it is intended. Requirements and costs will be different in each separate case, for it is evident that the larger the surface to be roofed in one span without intermediate supports, the greater the technical problem and the cost of the roof. Furthermore, the architect's calculations for the various features of a coordinated project (plan, circulation, lighting, etc.) will not be the same if the project relates to rigid construction subdivided by permanent *walls*, or to flexible construction, adjusted to the changes periodically effected in the museum.

Museum Services *Before considering the planning* of the museum it is essential to determine the size and location of the various services. In other words, we must decide how much *space can and* should be allocated for subsidiary activities, or for those necessary to the functioning of the museum in its relationship with the public (offices, rooms for meetings *and* lectures, library, documentation service) on the same floor as the exhibition rooms, and which services and technical plant (heating and electrical apparatus, storerooms, workshops, garage, etc.) can be housed in the basement or, if possible, in special outlying buildings to be *built as* annexes, *at a convenient* distance from the main building.

It should be remembered that the usual custom is to set aside for these purposes an *area which may be as much as* 50 percent of the total space available. In small museums this proportion may be reduced. But the fact remains that two conflicting needs have to be *reconciled*: on the one hand there *must* be easy communication between the public rooms and the museum services, since this makes for smooth relations between visitors and staff; on the other hand it must be possible to separate these two sections, so that they can function independently at any time. This is necessary chiefly to safeguard the collections at times when the building is closed to the public while the curators or office staff are still at work and the library and lecture hall in use.

Planning

It is *hardly* necessary to explain, before embarking upon a discussion of the different questions that may arise when a small museum is being planned and built, that my aim is merely to put forward certain suggestions to serve as practical pointers, based on experience of the subject, with no intention of trespassing upon the domains of the various technical authorities who must inevitably be consulted.

The Exterior *A museum* which is to be built in an isolated spot or reserved space (park, garden, etc.) needs to be surrounded by an enclosure, especially if the site forms part *of an extensive area.* For the visitor, this enclosure will provide a foretaste of the museum's architecture, and thus must not constitute a "psychological barrier," though *the fundamental* aim of security, which it has to serve, must not be sacrificed.

If, on the contrary, the museum is to overlook a public street, it will always be advisable: (a) to separate it from the stream of traffic by a belt of trees or even by flowerbeds; (b) to set back the entrance in a quiet corner: (c) to allow space for a public car park.

The architect should think of the building he has been asked to design as an organism capable of growing, and therefore provide from the outset for suitable possibilities of expansion, so that when the time comes for this it will not require far-reaching and costly alterations. He should regard the portion to be built as the nucleus of a cell, capable of multiplying itself or at least of joining up, according to plan, with future enlargements.

Where space permits, it is best to allow for horizontal expansion, as this, though more expensive, has the twofold advantage of enabling all the display rooms to be kept on one level and of leaving the roof free for overhead lighting.

Renouncing all pretensions to a monumental style, the outward appearance of the building—especially if overhead lighting is adopted, so that there are no windows to break the surface—should be distinguished by a simple balance of line and proportion and by its functional character.

Arrangement Any general plan of construction which entails an apportionment of *premises* is closely bound up with the purpose of the museum and the nature, quality, and principal components of its collections. Each type of museum has *different requirements,* which may be met by various architectural methods.

It is difficult to give any exact classification of the different types of collections, but we can *offer a very brief one, if* only to indicate the wide range of demands the designer of a museum may be called upon to meet:

1. *Museums of art and archaeology.* The *size of the rooms* and height of the ceilings will be determined by the nature and dimensions of the works to be exhibited. It is not difficult to calculate a practical minimum capable either of accommodating old paintings, which are usually large, or medium-sized modern canvases; a suitable room might measure about 16 by 23 ft, with wall accommodation to a height of about 14 ft. In the case of furniture, or of examples of decorative art (metal, glass, ceramics, textiles, etc.) to be displayed in showcases, the ceiling need not be as high. If pictures and sculpture are to be shown separately, their settings must be different from the point of view of space and lighting. For silver, jewelry, or precious objects, it may be better to use showcases set in the walls—which can thus be equipped with locking devices and antiburglar safeguards—lit from within, the rooms being left in semidarkness. Rooms lit by artificial means rather than by sunlight are best for drawings, engravings, watercolors, and textiles. Such rooms may be *long and narrow rather than square*—rather like corridors or galleries—as the visitor has no need to stand back in order to look at the exhibits, which will be arranged *in showcases against* the longest walls.

2. *Historical or archival museums.* These need less space for the showcases in which their exhibits are placed, and comparatively large and numerous storerooms for the documents kept in reserve. Relics and papers are best shown in rooms equipped with suitable protective devices and artificially lighted, though some use may also be made of indirect natural light.

3. *Ethnographic and folk museums.* The exhibits are usually displayed in showcases. They are often large and cumbersome, requiring a good deal of space. Considerable space is also needed for reproducing typical surroundings, if this is done with genuine pieces and properties or full-sized replicas. Strong artificial lighting is generally used as being more effective than daylight.

4. *Museums of physical and natural sciences, technological or educational museums.* Owing to the great variety of collections involved, their division into sections and the necessary scientific cataloging, these museums differ in size and in architectural and functional characteristics. Where the exhibits are arranged in series (minerals, insects; fossils, dried plants, etc.), medium-sized rooms may suffice, whereas reconstructions and built-up displays of animals or plants demand considerable space and special technical features (for instance, means of keeping the special materials and preparations in good condition, unaffected by the atmosphere, or equipment for maintaining aquaria, permanent film displays, etc.). This type of museum needs laboratories for the preparation and upkeep of certain exhibits (*stuffing, drying,* disinfecting, etc.).

It thus rests with the architect to decide, for each of these types of museum, what arrangement *will best satisfy the particular* conditions, purposes, and requirements involved.

There can never be any objection to adopting *the modern* principle of a building so constructed that its interior can be adapted, divided, and altered to meet the varying demands of successive exhibitions. If this is done, the most important thing is that the construction shall be "flexible," that is, capable of adaptation to the different features it must simultaneously or successively contain, while preserving unchanged its general framework—entrances and exits, lighting system, general services and technical installation. This principle is particularly valuable in small museums and in any others which must allow for enlargements not always foreseeable at the outset.

The internal arrangement of the available space, the distribution and style of the galleries can then be either temporary or comparatively permanent. In the former case, use will be made of movable partitions, panels of lightweight material (plywood or thin metal frames covered with cloth, etc.) fitted into special supports or into holes or grooves suitably placed in the floor; these can either be separate or arranged in groups held together by bolts or hinges.

This system is very practical for small museums which intend to follow a definite cultural program including successive loan exhibitions of works of art, and are therefore obliged to make frequent changes, dictated by circumstances, in the size and appearance of their galleries. It has, however, the drawbacks that all the interior structure is independent of the outer walls of the building and made of comparatively fragile materials which are expensive to keep in repair; moreover the place never looks settled, but rather mechanical and disjointed—an effect which is displeasing to the eye unless the architect designs the component parts with great taste.

Other objections to this method include the difficulty of preparing new catalogs and guides to keep pace with the changes, and of overcoming the conservatism of a great proportion of the public; and, above all, the consequent impossibility of arranging circulation within the building, and other matters affecting the division of space on a permanent basis. These things have to be left to the organizers of each successive exhibition, and therefore cannot be included in the architect's original plan.

If, on the other hand, the interior space is to be divided up in a more or less permanent manner, the question of "flexibility" being set aside until the comparatively distant time when the original plan of the museum comes to be radically altered, then the dividing walls can be really "built" to last, even if lightweight materials are employed. For their role will be reduced to providing a background for works of art, for showcases, or for any exhibits hung on them, and to supporting their share of whatever type of roof or ceiling is chosen.

In this case the interior arrangement *will* be very similar to, if not identical with, that of a museum of the traditional type, planned as a complete building with all its sections permanently fixed *and the size and shape of* its rooms settled once and for all.

In this kind of structure it is more than ever necessary to plan with a view to enabling *the public to circulate and to arranging the collections* and services in the most rational and functional manner possible.

The question of circulation must be studied *attentively,* so that the arrangement and the itinerary will be clear not only to anyone looking at the ground plan of the museum but also to anyone walking through the rooms. It should be planned to fit the logical order of the exhibition, whether that order is governed by chronology, by the nature of the material displayed, or as in a scientific museum, aims at providing a connected sequence of practical information.

Though a compulsory, one-way route may not be entirely desirable in a large museum, it is satisfactory and one might say logical in a small one, as it saves space and facilitates supervision. Visitors should not have to turn back and return through rooms they have already seen, in order to reach the exit. They should, however, be able to turn off on their way round if they wish to cut short their visit or confine it to certain things that particularly interest them.

So, even if a museum is to show a series of selected works of the first quality, we should consider the possibility of arranging them in proximity to one another in such a way that they can be seen without the necessity of traversing the entire building. For example, in a succession of rooms surrounding an inner courtyard (see Fig. 3).

Care should always be taken, however, to avoid the confusion of too many adjacent doors, or of rooms running parallel to one another; visitors must not be made to feel that they are in a maze where they can *easily* lose their way.

If the designer's preference or the demands of space result in a series of rooms all set *along the same axis, it may be desirable to* connect them by a corridor. But this should not be the only means of access to the rooms, for if the visitor is forced to return to it each

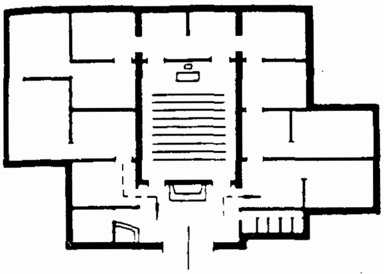


Fig. 3 Suggested floor plan for a small museum.

time, fatigue and bewilderment will be much increased.

Entrance However many outside doors may be found necessary for the various museum services (but these should be as few as possible, to facilitate supervision and security measures), there must be only one public entrance, placed quite separately from the others. This should lead into a vestibule where certain essential services will be located—sale of tickets, information service, and sale of catalogs and postcards. In a small museum one person will of course be responsible for all this, and the necessary installation must be carefully planned to ensure the most practical form and arrangement. The official in charge should not be confined to a booth behind a window, but should be able to move about freely and leave his (her) position when circumstances require.

In a little museum it would be particularly unsuitable to design the entrance hall on a massive or pompous scale, as was customary in the past, making it unnecessarily lofty, and to decorate it in would-be monumental style, like the atrium of a classical temple, with arches and pillars. Modern architects tend increasingly to reduce overhead space and give the greatest possible width and depth, producing a balanced effect of greater intimacy and attraction. It is important for the entrance hall to seem attractive even to the casual passerby—who is always a potential visitor to the museum. It should provide an easy introduction to the building, a point from which the individual visitor can find his way without difficulty and where large parties can be greeted and assembled. It must therefore be fairly spacious, and provided with the strict minimum of sturdily built furniture (one or two tables for the sale of tickets, catalogs, etc., a cloakroom, a few benches or chairs, a notice board, a general plan of the museum to guide visitors, a clock, and perhaps a public telephone booth and a letterbox). It is not advisable to have only one door from here into the exhibition rooms; there should be two, an entrance and an exit, far enough apart to prevent delay should there be a crowd but placed in such a way that both can be easily watched at the same time.

In museums where arriving and departing visitors are to be mechanically counted, an automatic turnstile should be installed, serving both doors but placed at a sufficient distance from the main entrance and the ticket office. Another possible method is that of the photoelectric cell, but the objection to this is that when visitors are crowding through the turnstile the record may not be accurate. In museums where admission is free, attendance can be computed for statistical purposes more simply by the custodian with a manual counter—which will avoid adding an unnecessary complication to the fittings of the entrance hall.

Exhibition Rooms—Shape and Requirements A museum in which all the rooms are the same size becomes very monotonous. By varying their dimensions and the relation between height and width—and also by using different colors for the walls and different kinds of flooring—we provide a spontaneous and unconscious stimulus to attention (see Fig. 4a–f).

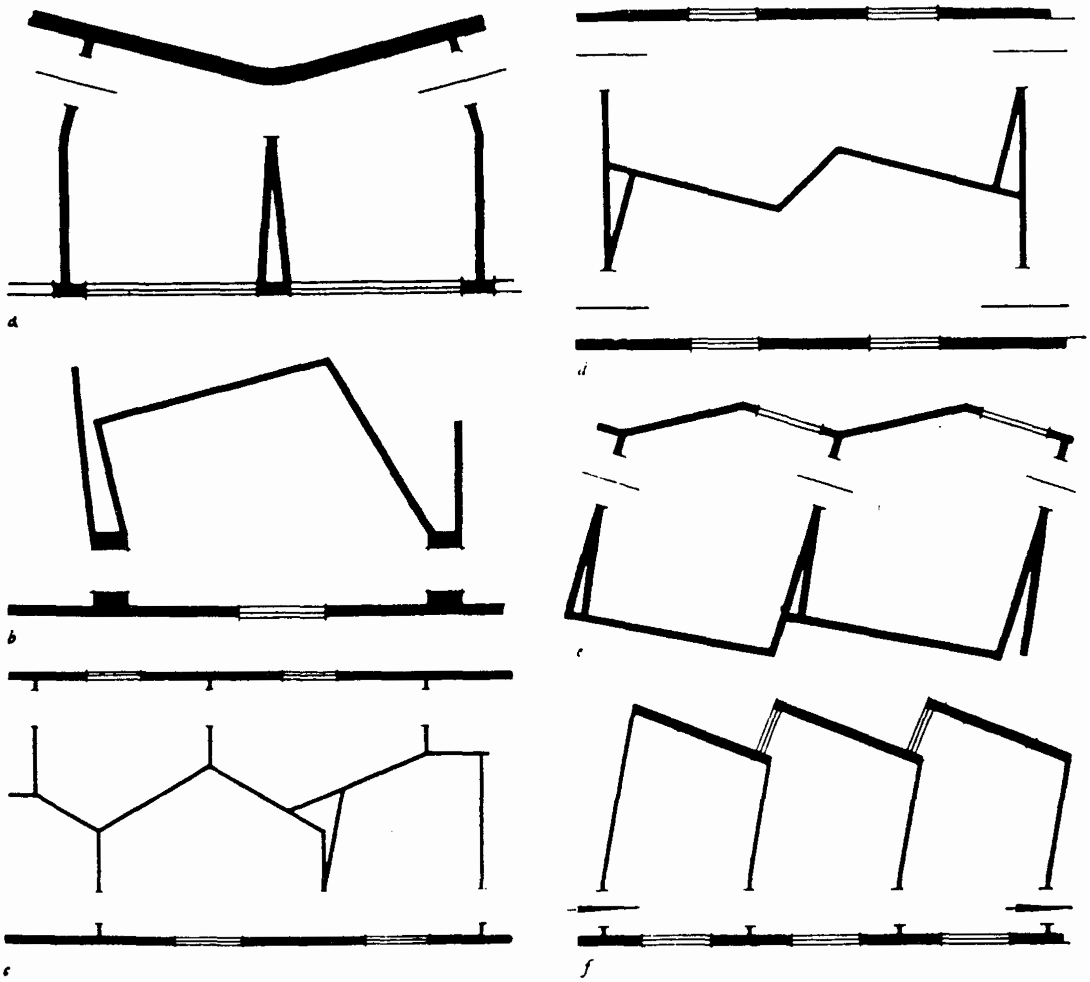


Fig. 4 Different ways of dividing up exhibition space.

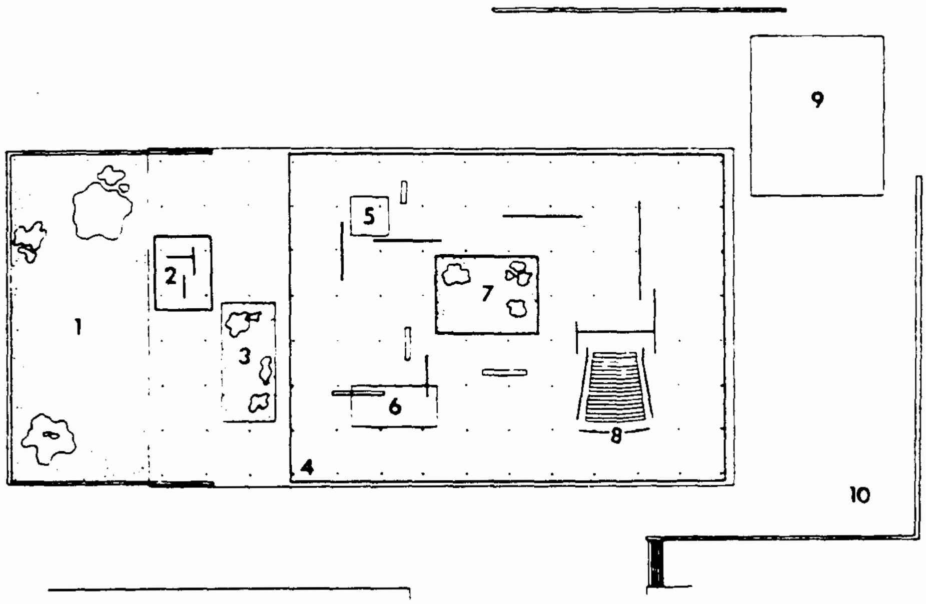


Fig. 5 In 1942, Mies van der Rohe devoted a great deal of attention to the theoretical design of a museum for a small city to provide a setting for Picasso's painting *Guernica*. The building is designed to be as flexible as possible, consisting simply of a floor slab, columns, roof plate, free-standing partitions and exterior walls of glass.

The relative "absence of architecture" intensifies the individuality of each work of art and at the same time incorporates it into the entire design.

One of the museum's original features is the auditorium which consists of free-standing partitions and an acoustical dropped ceiling.

"Two openings in the roof plate (3 and 7) admit light into an inner court (7) and into an open passage (3). Outer walls (4) and those of the inner court are of glass. On the exterior, free-standing walls of stone would define outer courts (1) and terraces (10). Offices (2) and wardrobes would be free-standing. A shallow recessed area (5) is provided, around the edge of which small groups could sit for informal discussions. The auditorium (8) is defined by free-standing walls providing facilities for lectures, concerts and intimate formal discussions. The form of these walls and the shell hung above the stage would be dictated by the acoustics. The floor of the auditorium is recessed in steps of seat height, using each step as a continuous bench. Number (6) is the print department and a space for special exhibits. Number (9) is a pool." (From P. C. Johnson, "Mies van der Rohe," Museum of Modern Art, New York, 1947.)

Monotony also results when a number of rooms follow one another in a straight line. Even where this cannot be entirely avoided, the rooms should be so constructed that the doors are not opposite one another, providing a "telescopic" view through the building. An uninterrupted prospect of the long route ahead is usually found to have a depressing effect on visitors.

There are, however, undoubted advantages in being able to see into several rooms at the same time; it is a help, for instance, in directing visitors, and for security purposes.

On the other hand, by varying the positions of the doors we are also able to place the visitor, from the moment of his entrance, at the point chosen by the organizer of the display as the best for conveying an immediate and striking impression of its general contents, or for giving a view of the most important piece in that particular room. In principle, the door should be placed in such a way that a visitor coming through it will see the full length of the opposite wall. It is therefore not advisable for it to face a window, since the visitor will then be dazzled just as he comes in.

With regard to the shape and size of the rooms, I have already pointed out that dimensions should be varied so as to stimulate the attention of the public and should also be adapted to the size of the exhibits.

I ought perhaps to repeat here, for the sake of clarity, that the form and size of the rooms will also depend to some extent on the lighting system chosen. Overhead lighting allows greater diversity of shape (rectangular, polygonal, circular, etc.) because the lighting can always be arranged on a scale to suit the room. Oblong rooms, divided by partitions to a certain height, but with one ceiling and skylight, should however be avoided; this system has proved unsatisfactory both from the aesthetic and from the functional points of view.

The practice of rounding off the corners of rectangular rooms is also going out of fashion, as it has been found that the advantage of unbroken walls and the impression of better use of light in a more compact space are offset by the resultant monotony, and that the general effect is not pleasing to the eye.

Lateral lighting requires shallow rooms, their walls set at an oblique angle to the source of light. But the larger the windows, the more difficult it becomes to prevent light from being reflected in the works placed against the opposite wall. It is undeniably difficult to give a pleasing appearance to these asymmetrical rooms; the taste of a fine architect is needed to give them character and harmony, either by careful attention to spatial proportion or by the use of different colors for the walls and ceiling.

Theoretically, the door between two laterally lit rooms should be placed near the wall next to the windows, because otherwise the two walls meet in a dark corner where nothing can be exhibited. But if the daylight is admitted not through a vertical or comparatively narrow window, but through a "ribbon" of glass running the whole length of the wall, the problem is not the same. In this case the two end walls, meeting the outside wall from the normal direction, or at a slight angle, will be well lit throughout their length; the doorways can therefore be placed at the furthest extremities, thus adding to the effective depth of the room.

One important fact should be remembered when the shape of the rooms is being decided. A square room, when it exceeds a certain size (about 23 sq ft), has no advantage over an oblong one, either from the point of view of cost (roof span) or from that of the use of space in the satisfactory display of the exhibits, especially if they are paintings.

It is sometimes found advisable to place a work of art of outstanding interest and exceptional value in a room by itself, to attract and concentrate the greatest possible attention. Such a room need be only large enough to accommodate a single work; but there must always be enough space for the public to circulate freely. Galleries intended for permanent exhibitions may, on the contrary, be of considerable size, though it is never advisable for them to be more than about 22 ft wide, 12 to 18 ft high, and 65 to 80 ft long.

PLANNING THE SMALL MUSEUM

The objective of the proposed museum should be clearly defined, as well as the geographic region, the subject (history, natural history, or art) and extent of display and other services.

The following is an example of a suitable basic statement for a small museum:

> The basic objective of the Museum is to collect, preserve, study and exhibit significant objects of the community, and provide related educational services in order to increase public knowledge and stimulate creative activity.

This statement should have further definition by incorporating a reference to the type of collections, whether human history, natural history or art.

A good museum includes these basic functions: (1) curatorial, (2) display, (3) display preparation, (4) education. In order to realize both objectives and functions, certain facilities and spaces are essential.

There must be sufficient diversification of spaces to allow each function to be undertaken separately while at the same time combining certain activities in a single area as required for economy in a small museum. Because of the many and varied kinds of tasks which a museum has to perform, it is absolutely impossible to maintain good housekeeping and curatorial procedures without separation of functions into separate rooms. This relation between functions and physical facilities is summarized in the following.

Functions	Space required
1. Curatorial Functions	
a. Collection, preservation, identification, documentation, study, restoration.	a. Office-workroom, Workshop
b. Storage of collections.	b. Reserve Collection Room
2. Display Function	
Thematic and changing displays of selected objects and documents from the collections arranged to tell a story.	Display Gallery
3. Display Preparation Function	
The preparation of exhibits.	Workshop, Office-workroom
4. Educational and Public Functions	
This term has been expanded to include all public functions.	
a. Lectures, school tours, society meetings, films, and social functions.	a. Lecture room, Chair storage closet, Kitchenette
b. Reception, information, sales, supervision of display gallery.	b. Lobby Sales and Information Counter
c. Public requirements.	c. Cloak room, Washrooms
5 Other Services	
a. Mechanical.	a. Heating-ventilation plant
b. Janitorial.	b. Janitor's closet

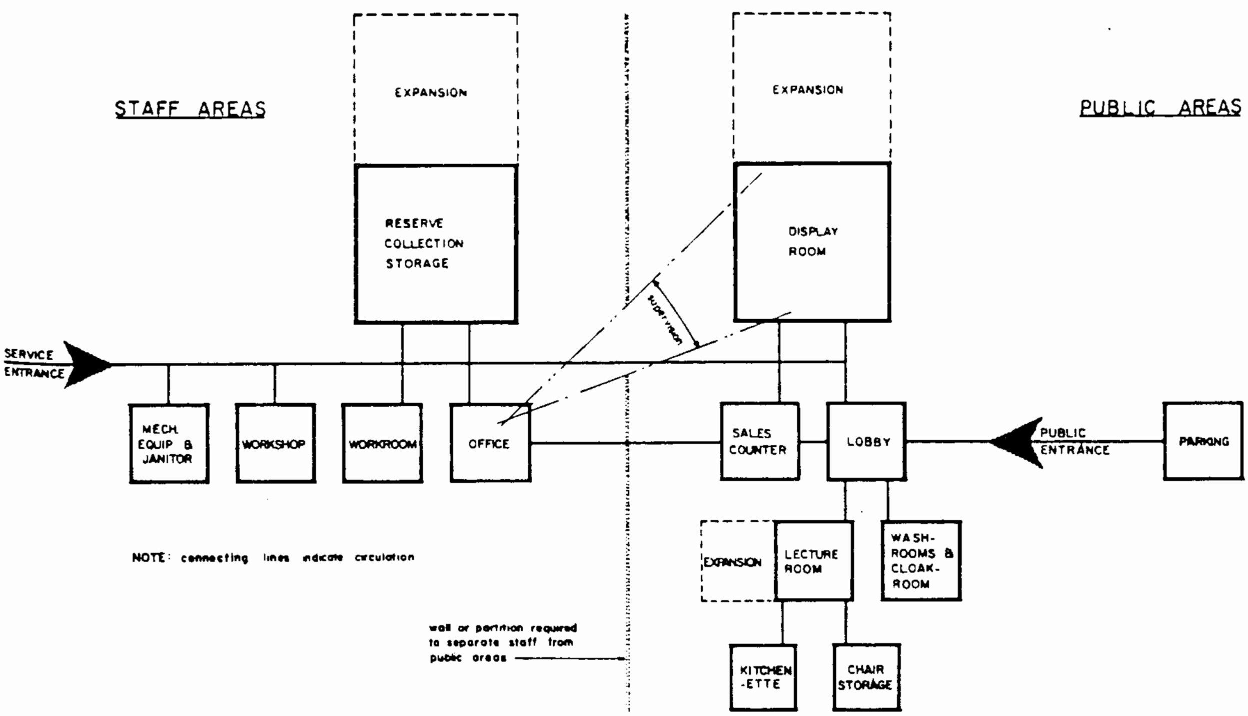


Fig. 1 Space organization diagram.

The Technical Requirements of Small Museums, Raymond O. Harrison, M.R.A.I.C. Technical Paper No. 1, Canadian Museums Association, Ottawa, Ontario, 1966.

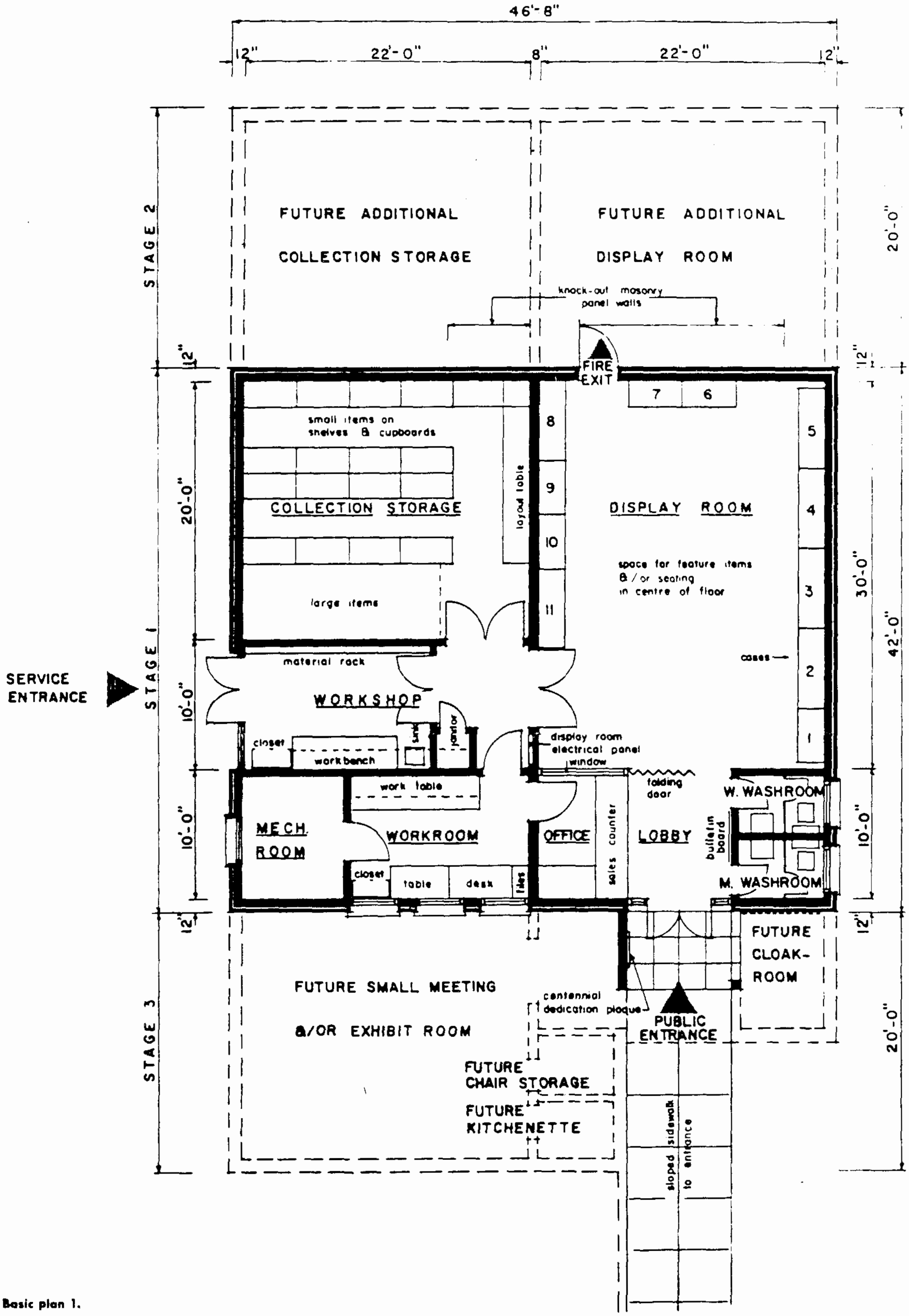


Fig. 2 Basic plan 1.

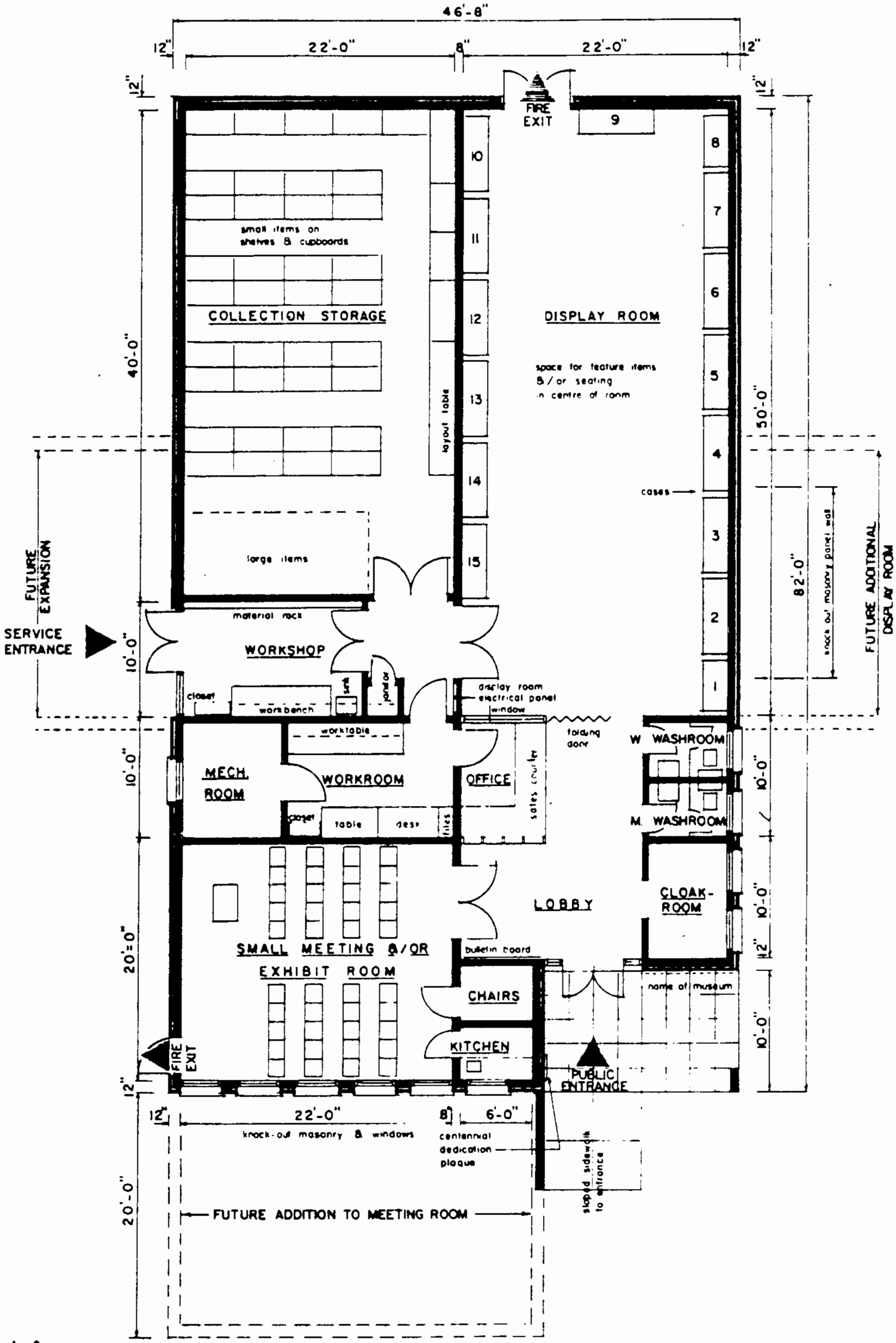


Fig. 3 Basic plan 2.

ORGANIZATION OF SPACE

The next step in the planning of a museum is the working relationship between these various functions. The planning of a good museum must reflect the most efficient manner in which the various tasks are carried out individually and in relationship to each other, without one adversely affecting the other. A major consideration in this planning is the matter of future expansion and construction in several stages.

The diagram (Fig. 1) illustrates the most efficient working arrangement.

To illustrate the manner in which a good small museum may be planned on the basis of the organizational diagram, three basic plans are presented as examples, ranging from the smallest possible at 1960 sq ft, up to 3823 sq ft, and therefore representing three different capital expenditures and operating costs. All plans incorporate provisions for future expansion and construction in several stages as a basic principle.

It should be further noted that the museum plans shown are based upon collections comprising smaller types of specimens and artifacts. Large equipment, vehicles, and farm machinery would require considerably more space although the basic functions outlined earlier would still apply. The following is a summary of some main features.

Basic Plan 1

This plan (Fig. 2) shows the absolutely minimum sizes of spaces required for an effective minimum museum. It will be noted that the display area is only about 40 percent of the area of the building.

Future expansion of the existing collection storage room can take place as the collections grow, while the existing display room also can be increased in size as required. Future addition of a lecture room off the lobby can also be achieved so that the educational functions of the museum can be expanded. Note that these additions can be made without complication to the roof structure of the original plan. The number of perimeter display cases shown would be ample to maintain and ensure changing displays.

Basic Plan 2

This (Fig. 3) is an expansion of Plan 1, with allowance for further expansion of the display, collection, and educational functions in the future. The number of perimeter cases shown would be ample for the story theme and changing exhibits while the center of the room may have larger items, photographic panels or special feature displays. The display room is 33 percent of gross.

GALLERY DESIGN*

The average American museum visitor (Fig. 4), if a man, is about 5 ft 9¼ in tall, and his eye level is 5 ft 4¾ in; the average woman is about 5 ft 3¼ in tall, and her eye level is 4 ft 11¾ in. Thus, the mean adult eye-level height is about 5 ft 2¼ in. With little eye movement, people usually see and recognize with ease things that are within an approximately elliptical cone of vision, with the apex of the cone at the eye-level height. Studies have shown that, in general, the adult museum visitor observes an area only a little over 1 ft above his own eye level to 3 ft below it at an average viewing distance of 24–48 in (Fig. 5). Arranging objects and labels above and below these limits places a strain on seldom-used muscles and produces aching backs, tired feet, burning eyes, and stiff necks. Some quite large objects, such as totem poles or dinosaurs, will inevitably soar above these viewing limits, and, in this event, the visitor must be permitted space to back far enough away from the object to comprehend it without becoming a case for an orthopedic specialist (Fig. 6).

The flow of visitors is like the flow of water in a stream. If the cases are arranged with gently curving lines to take advantage of this pattern of movement (Fig. 7*b*), visitors will find the room more attractive and can progress easily with the line of the case. Often the arrangements can be staggered (Fig. 7*c*) which produces a certain mystery and a desire on the part of the visitor to peek around corners to see what is next. It is not always necessary to have a wide opening into a hall. Cases that are arranged to narrow the entrance a bit (Fig. 7*d*), so that the hall inside then opens out, provide a certain amount of interest.

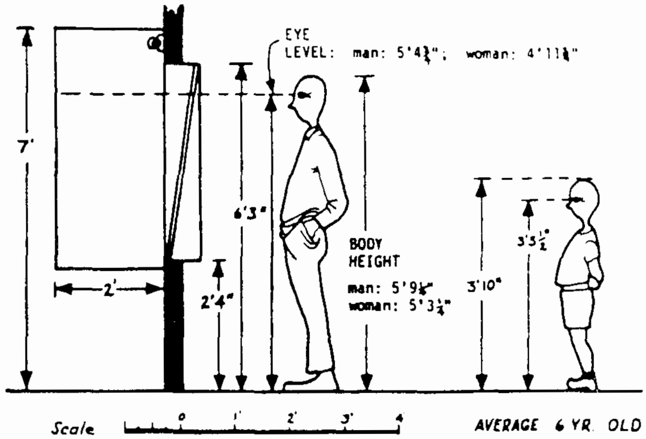


Fig. 4 Measurements of adult and six-year-old visitors in relation to cases.

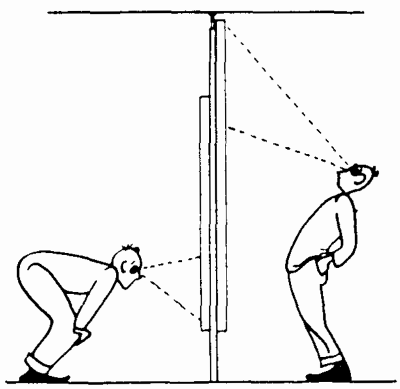


Fig. 5 Difficulties encountered in viewing details more than 3 ft below or 1 ft above one's eye level.

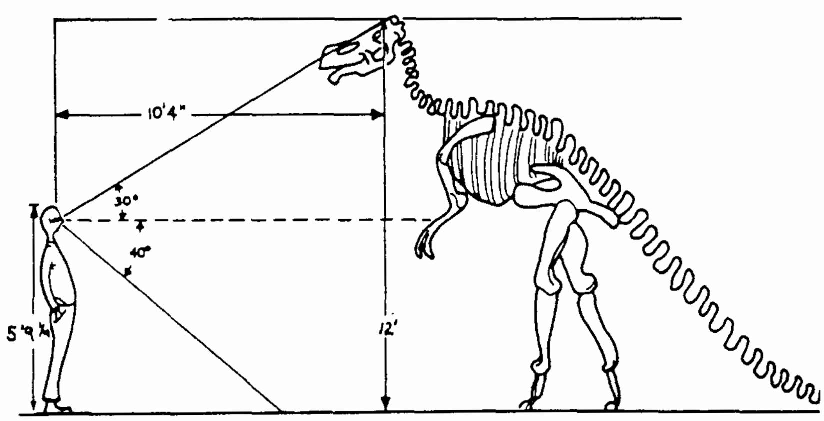


Fig. 6 Viewing distance should increase with greater size of object.

* Reprinted with permission from Technical Leaflet # 52, *Gallery and Case Exhibit Design*, by Arminta Neal, Copyright 1969 by the American Association for State and Local History, 1400 8th Avenue South, Nashville, TN 37203.

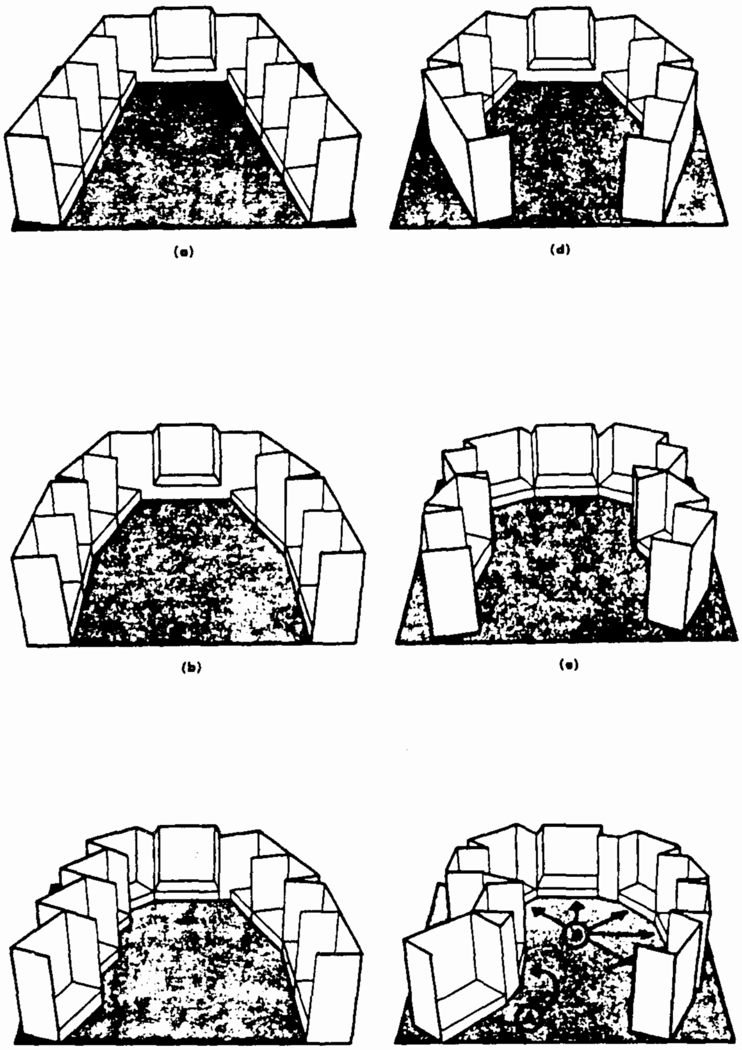


Fig. 7 Possible gallery arrangements.

EXHIBITION SPACES

The first step in designing exhibition spaces is to have a clear idea of what you will be showing. How many exhibits are planned per year, and how often will they change? What kinds of traveling exhibitions do you hope to schedule? If you have a permanent collection, how many pieces will remain on view? Will you be showing some very large-scale art? Mostly small pieces? Three-dimensional objects to be displayed in cases or on pedestals? Fragile prints and drawings?

With firm program plans in hand, you can determine the degree of flexibility you need, the layout of your galleries, and the size and environmental qualities of the spaces. There are few fixed rules, so the guidelines in this section are necessarily general.

The guidelines here reflect the belief that exhibitions of paintings, prints, drawings, photography, and sculpture will continue to be the "bread and butter" of any visual arts facility's annual programming. Providing for such newer developments as video and performance art is not that difficult, even for the small or medium-sized museum or art center. The key is flexibility: Can you turn gallery space into a performance art site for an evening with a minimum of fuss? Do you have sufficient, conveniently located outlets to accommodate video monitors? If you plan to emphasize nontraditional art forms, be sure to talk with artists who work in these media about their specific needs.

Orient the Visitor

Unlike the performing arts, in which the audience stays in one place to watch the action on stage, the visual arts require movement and choice on the part of the spectator. Your galleries and other public spaces must be designed to help the viewer organize the experience of looking at and considering a sequence of objects.

The entry and lobby areas should direct visitors to the galleries, where they should be able to survey what there is to see, select a starting point, and move to it as directly as possible. From that point, you want the arrangement of spaces to yield a continuously unfolding experience, allowing the visitor's attention to be drawn easily from object to object, gallery to gallery.

Some factors to keep in mind when designing your exhibition spaces:

- Viewers should be able to move through the exhibit without being forced to walk past objects they have already seen.
- There must be adequate space for visitors to move at different speeds. Some will move continuously, while others will stop to examine particular objects in greater detail.
- A viewer tends to turn to the right upon entering a gallery. Circulation patterns should be designed with this in mind.
- The ability to survey the gallery area in one sweep will help viewers understand what is on display and decide what they want to see.

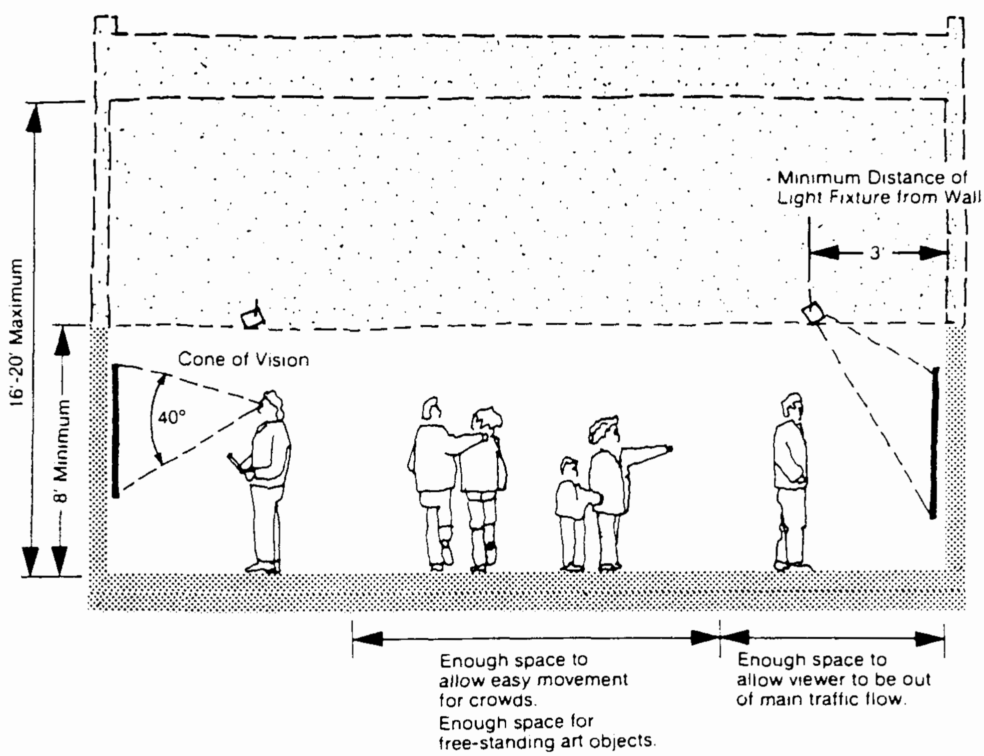
Provide a Pleasant, Varied Environment

A crowded, warm, or noisy environment can make the most ardent art lover irritable. Be sure the facility has sufficiently roomy corridors and aisles as well as other "transitional" areas such as courtyards or skylit spaces. Viewers need places to sit down and rest, reflect on the art, take a break from the visual richness of the galleries, or simply get their bearings. Frequently, these spaces are illuminated by daylight, in contrast to the gallery areas, which are lit primarily with electric light. Seats at appropriate distances from large, important works of art give visitors a chance to pause and examine the art without standing for long periods of time.

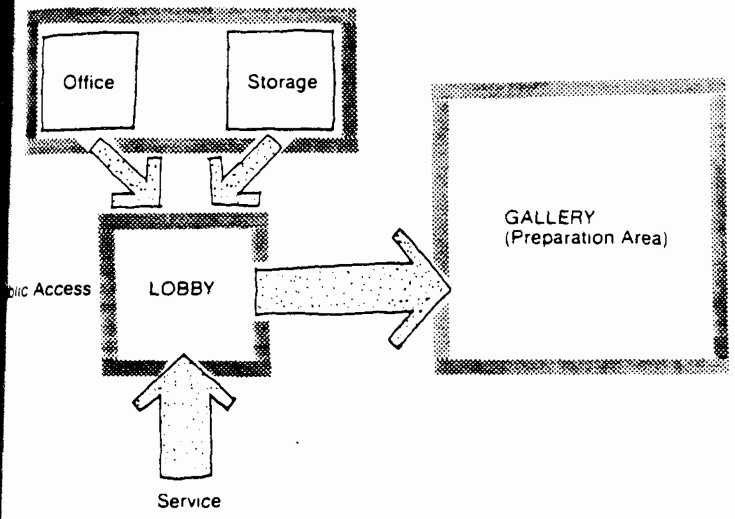
These amenities also vary the "pace" of the visit—an important element in the design of a visual arts facility. When viewers become tired, satiated with the sheer quantity of the art, or discomfited by noise, their gallery experience ceases to be rewarding. Visual diversity helps keep the viewer interested. A low level of ambient lighting in the gallery area can be contrasted with dramatic highlighting. Variations in ceiling heights and different wall colors throughout a sequence of galleries help ward off visitor fatigue. Of course, none of these features should ever upstage the art.

It is essential to control noise and vibration *in* the exhibit space; air conditioning and other equipment should be selected and located accordingly. The mechanical engineers on your project *should* be aware of the *need* to mask distracting sounds.

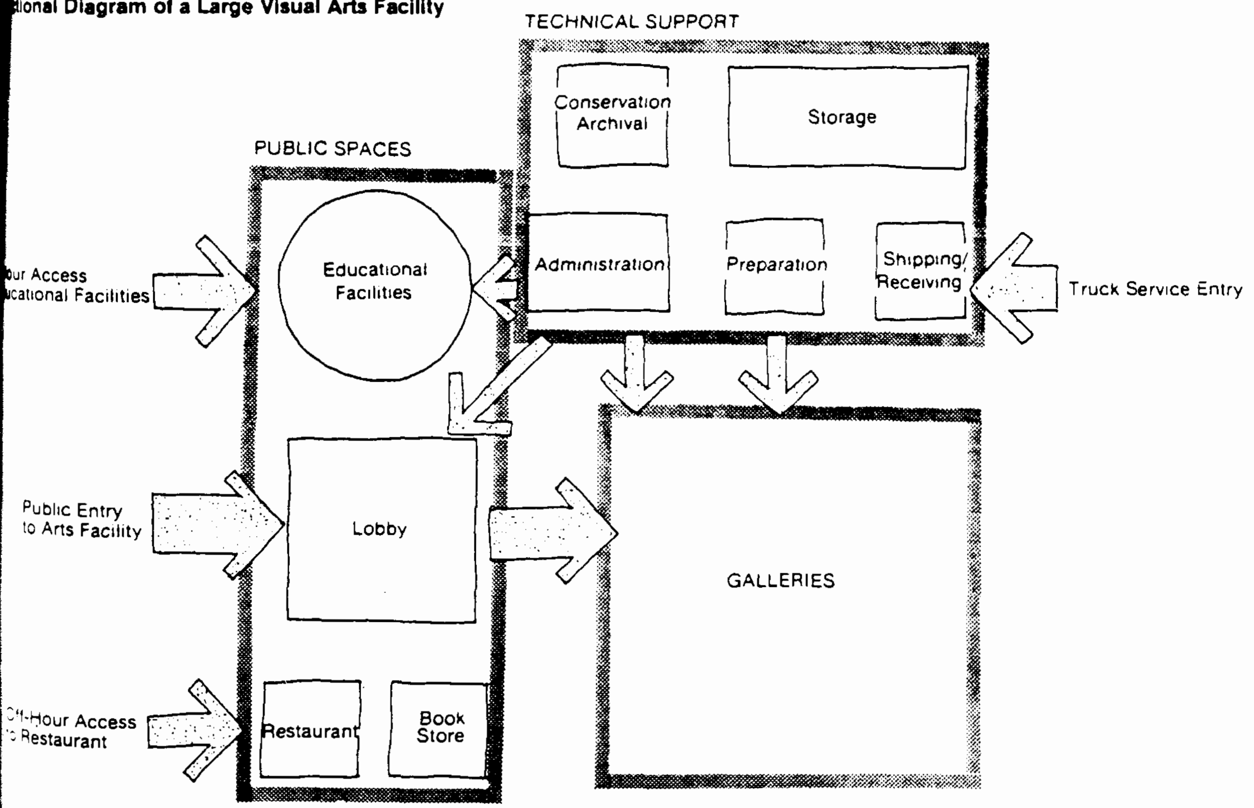
Critical Dimensions for a Visual Arts Facility

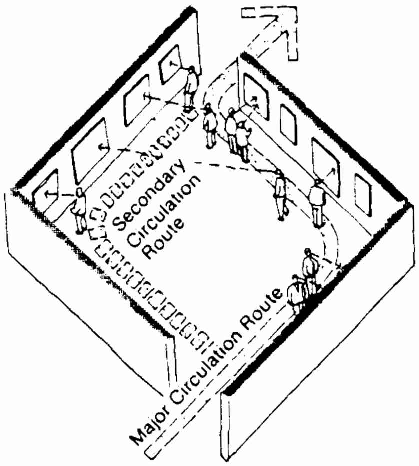


onal Diagram of a Small Visual Arts Facility

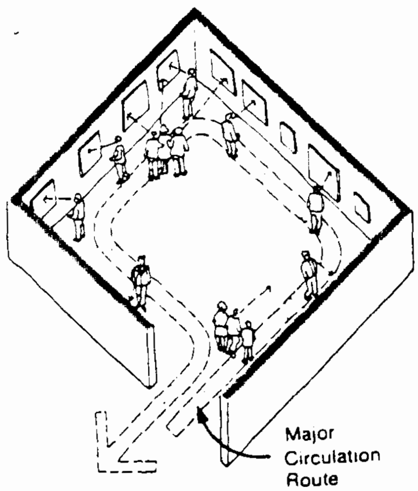


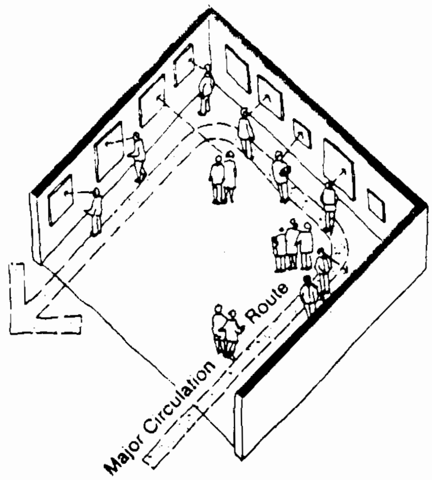
ional Diagram of a Large Visual Arts Facility





Right Hand Preference Circulation Patterns





APPENDIX B

ral

RIES

ms of Essential Library Elements

AMS OF ESSENTIAL LIBRARY NTS

diagrams have been prepared as an aid ualizing the functional relationships of the al areas in typical small libraries. These ms are for libraries for towns of 5,000, 0 and 25,000 persons respectively.

y are meant to clarify relationships and cir- n patterns. They definitely are *not* building nor do they constitute the only possible nships between the program elements. It nded that they assist in understanding the ationships between the major program ele-

y are intended to suggest a starting point e planning of the library and represent *um standards.* They are derived from "In- Standards for Small Public Libraries: Guide- *Toward* Achieving the Goals of Public Library e." ALA—Public Library Association, Chi- 1962. (See Table 2 on p. 345.)

Library for the Town of 5,000 tion

asic principles when planning for the library 1) are:

Location to insure maximum accessibility
Simplicity of design concept
Ease of supervision by library staff
Provision for future expansion

e basic statistics of the library are:

One and one-half persons, including a professional rian and a part-time assistant.

Book Collection:	15,000 volumes
Space for book collection:	1,000 sq ft
Space for readers:	700 sq ft
Staff work space:	500 sq ft
Estimated additional span for utilities, circulation, and miscellaneous:	800 sq ft
Total estimated floor space:	3,500 sq ft

These are approximates only and will, of course, vary with each community.

II. The Library for the Town of 10,000 Population

This library (Fig. 2) in many respects is an expanded version of the first one. The basic principles and relationships are the same. The staff and space requirements are approximately twice those of the first.

The larger size permits the development of special areas that add to the usefulness of the library and enable it to provide better services. Some of these may be: a special area in the children's section for storytelling and related activities, expanded reference, and separate periodical areas. A small meeting room may be a useful addition to the program.

The basic requirements for this library are:

Staff: Three persons: a professional librarian, an assistant, and part-time clerical and page help equivalent to one full-time person.

Size of book collection:	20,000 volumes
Space for the book collection:	2,000 sq ft
Space for readers (40 seats min.):	1,200 sq ft
Staff work space:	1,000 sq ft
Estimated additional space for utilities, circulation, and miscellaneous:	2,800 sq ft
Total estimated floor space	7,000 sq ft

III. The Library for the Town of 25,000 Population

This library (Fig. 3) in function is more complex than the previous libraries. To the three basic functional areas of the library, which are expanded and elaborated on, there usually is added a fourth, a community function, often in the form of a meeting room or small auditorium. There may also be (Fig. 4):

- Special exhibition space
- Special exhibition rooms
- Study area with carrels near the stacks
- Small meeting rooms
- Audiovisual rooms or booths

The circulation pattern is more complex. A separate entrance for children is highly desirable. Access to the community facility by the public after normal library hours is required. A library of this size may be a two-level structure. On the diagram (Fig. 3) we have indicated these circulation requirements. Note the separate staff and public circulation between levels. The basic requirements for the library for the town of 25,000 persons are:

Staff: Ten—this might be broken down to include two professional librarians, a college graduate, three assistants, and four other persons, divided between clerical and pages.

Space for book collection:	5,000 sq ft
Reader space (minimum of 75 seats):	2,250 sq ft
Staff work space:	1,500 sq ft
Estimated additional space required for special uses, utilities, and miscellaneous:	6,250 sq ft
Total estimated floor space:	15,000 sq ft

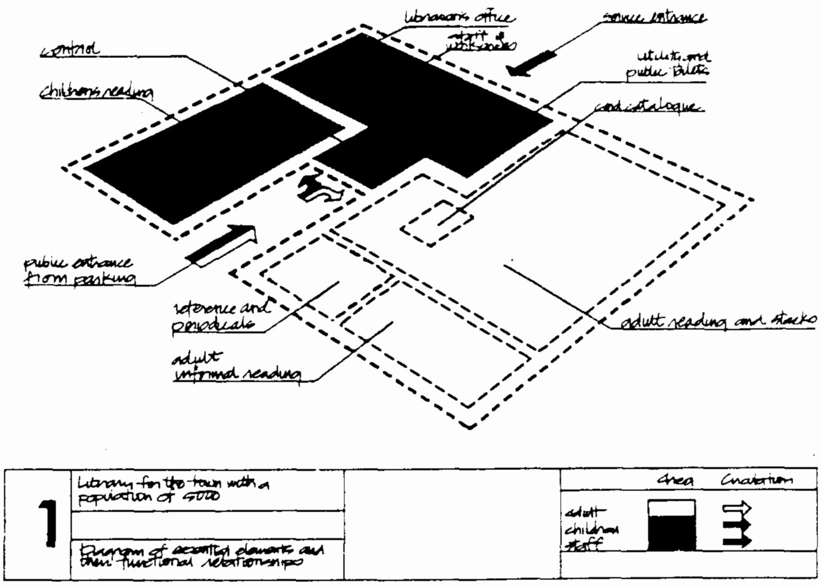


Fig. 1

Anthony Tappé, ALA., *Guide to Planning a Library* g, Huggens and Tappé, Inc., Boston, 1968.

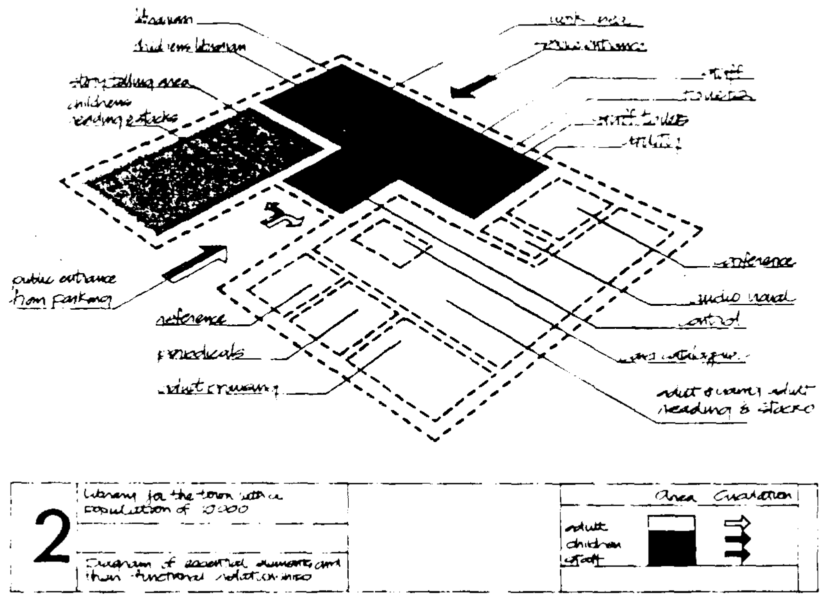

reference
periodicals
adult circulation
adult reading & stacks
2
Area Circulation
adult
children
staff

Fig. 2

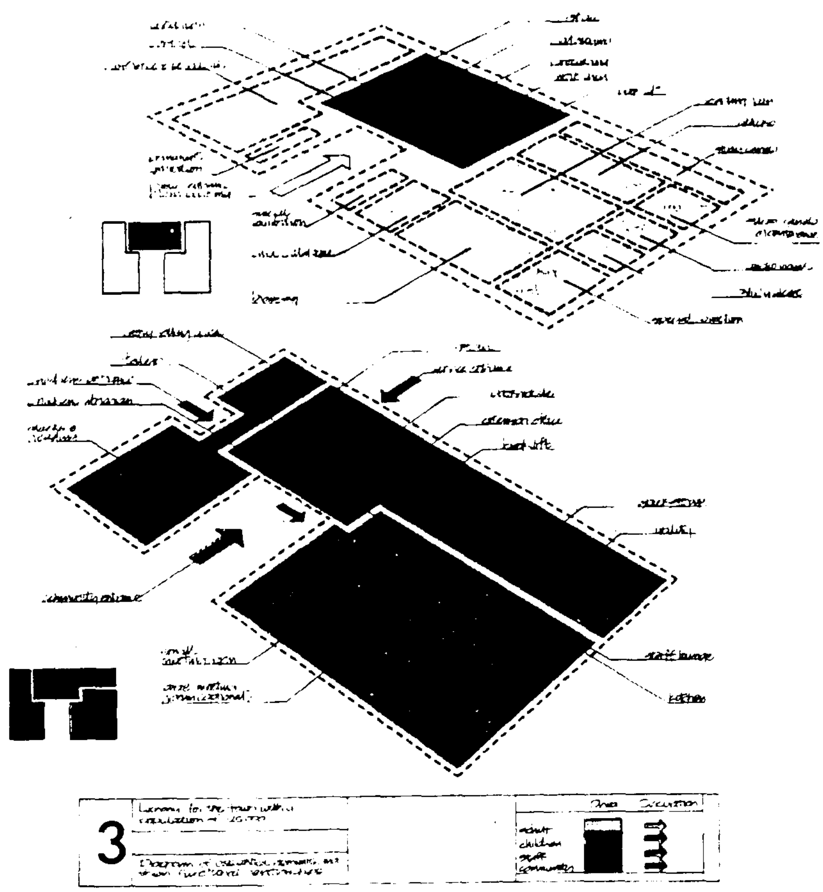

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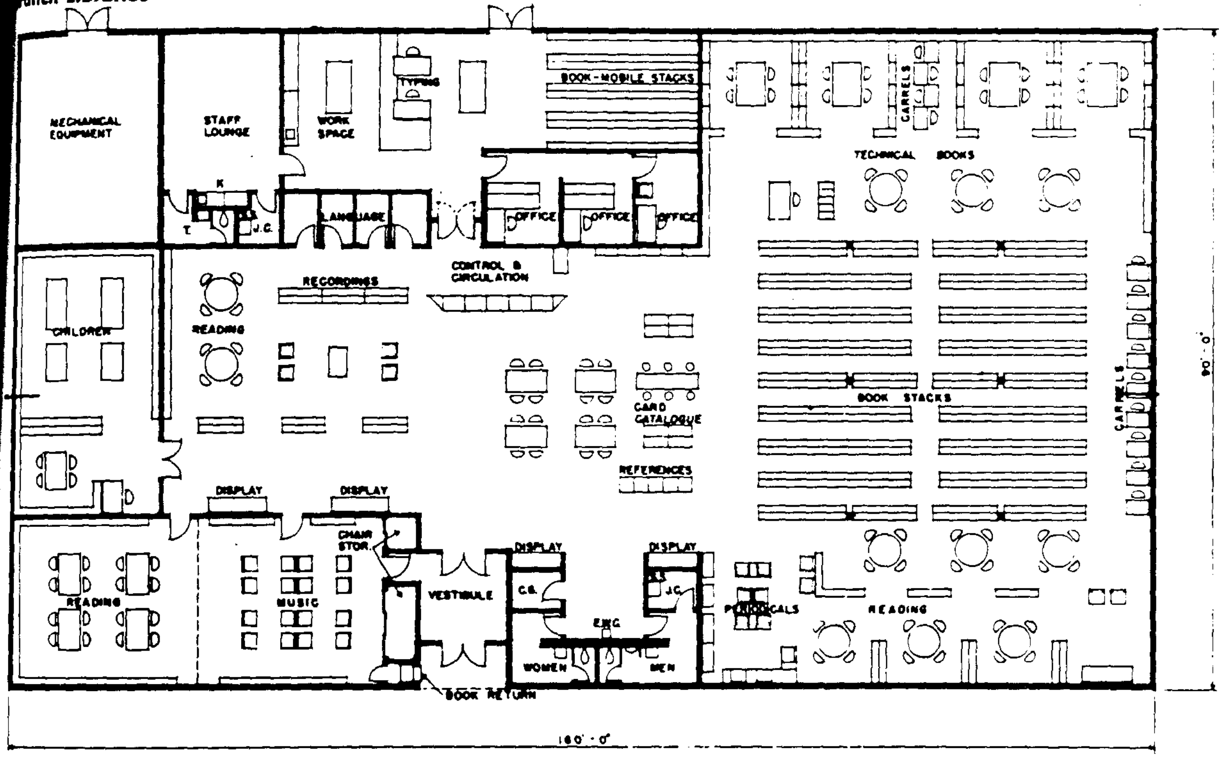
Fig. 3



FLOOR PLAN AREA SHOWN: 14,364 SQ FT

Fig. 4 Floor plan of a library. *Source:* U.S. Naval Facilities Engineering Command, Department of the Navy, Washington, D.C.

BRANCH LIBRARIES

A branch library can play an important role as a cultural center. In addition to providing books, it can provide record and tape lending, music-listening facilities, visual-aid facilities, and lecture series as well as act as a general information center. With such an expanded role, the library or cultural center will be an important element in the neighborhood. Figs. 1 and 2 are possible floor plans.

Regardless of the size of the community, its library should provide access to enough books to cover the interests of the whole population.

1. Libraries serving populations from 5,000 to 50,000 require a minimum of 2 books per capita.
2. Communities up to 5,000 persons need access to a minimum of 10,000 volumes, or 3 books per capita, whichever is greater.

The library building should provide space for the full range of library services. All libraries should have designated areas for children's, young adult, and adult materials.

Multipurpose rooms should be provided for meeting, viewing, and listening by cultural, educational, and civic groups unless such facilities are readily available elsewhere in the community. They should be located for easy supervision so that they may be used for quiet reading and study when not needed by groups.

No single type of building is satisfactory for all public libraries. Each building is likely to be different, and its differences should be directly related to its service program.

The library building should be located in or near the community shopping center and at street level if possible. Adequate parking should be available nearby.

Manual of Housing/Planning and Design Criteria, De Chiara and Koppelman, Prentice-Hall, Inc., Englewood Cliffs, N.J., 1975.

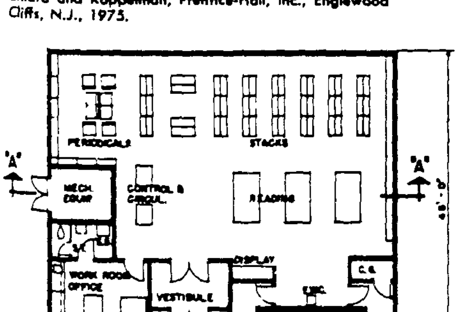


Fig. 1

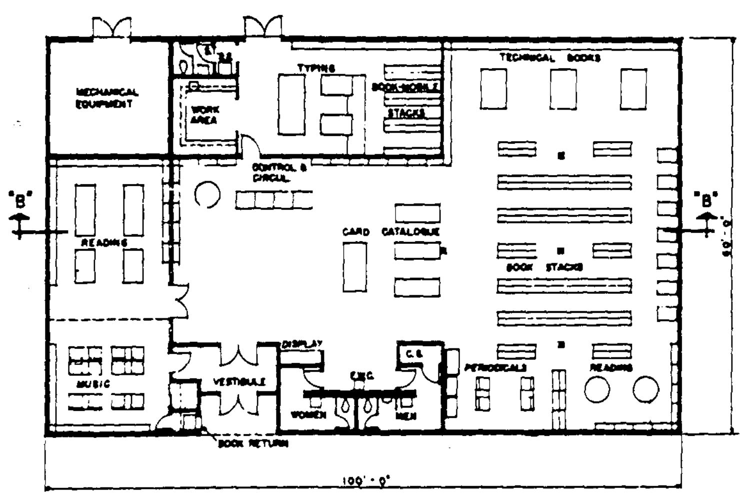


Fig. 2

SPACE REQUIREMENTS

The program statement, which includes objectives, activities, and requirements, will spell out total needs in terms of square feet of floor space. Generally speaking, the total need may be divided into five categories: space for (1) books, (2) readers, (3) staff, (4) group meetings, and (5) mechanical operations and all other (stairways, elevators, toilets, etc.). Actual space allocations will tend to vary in accordance with the library service program in relationship to community needs.[1] Table 1 provides general guidelines for programming the total building, and Table 2 provides guidelines for interior space in relation to population and size of the book collection.

Space for Books

To a large extent the amount of book shelving required will depend on the size of the library service area and whether the library is a member of a library system. Most library planners, when estimating the size of the book collection, apply a standard which ranges from three books per capita (smallest communities) to one and one-half books per capita (largest cities). In any event enough book shelving should be provided to plan for 20 years' anticipated growth.

The program statement should also include a detailed analysis of the amount of shelving needed. *It should be presented in terms of category, location, and linear feet.* Categories *found in nearly all public libraries include* adult fiction and nonfiction; children's books; books *for young adults; reference* books; bound, unbound, and microfilmed newspapers; bound, unbound, and microfilmed periodicals; local history books; less used books for the bookstacks; and special subject collections. Allowances should be made also for nonbook materials (i.e., phonograph records) which are often accommodated on library shelving.

Despite the fact that there is considerable variation in the size of books, there are several reliable formulas which may be used to estimate the amount of space required for books. These are: open reading rooms, 7 volumes per lineal foot, or 50 books per foot of standard height wall shelving, or 100 books per foot of double-faced shelving; bookstack areas, 15 books per square foot (includes aisles), or 2 books *per cubic foot. Approximately 50 long-play phonograph records may be shelved in one lineal foot of wall shelving. It is important* to note that these formulas are given for full capacity. Under normal conditions, one-third of each shelf should be left for future expansion. (See Figs. 1 to 3.)

Local Public Library Administration, International City Managers Association, Chicago, Ill., 1964. With illustrations from Harold L. Roth, Ed., *Planning Library Buildings for Service,* American Library Association, Chicago, 1964.

[1] Much of the discussion on space standards is based on Joseph L. Wheeler, *The Effective Location of Public Library Buildings* (Urbana: University of Illinois Library School), Occasional Papers, No. 52, 1958), 50pp.; Joseph L. Wheeler and Herbert Goldhor, *Practical Administration of Public Libraries* (New York: Harper and Row, 1962), pp. 553-60; American Library Association, Subcommittee on Standards In Small Libraries, Public Library Association; *Interim Standards for Small Public Libraries: Guidelines Toward Achieving the Goals of Public Library Service* (Chicago: The Association, 1962), 16pp.; and Russell J. Schunk, *Pointers for Public Library Building Planners* (Chicago: American Library Association, 1945), 67pp.

Figures 1 to 9 by Francis Joseph McCarthy, FAIA.

Space for Readers

Reader seating requirements should be determined for at least 20 years ahead. Two principal sources of information which library building planners will find equally useful for this purpose are first, a careful analysis of

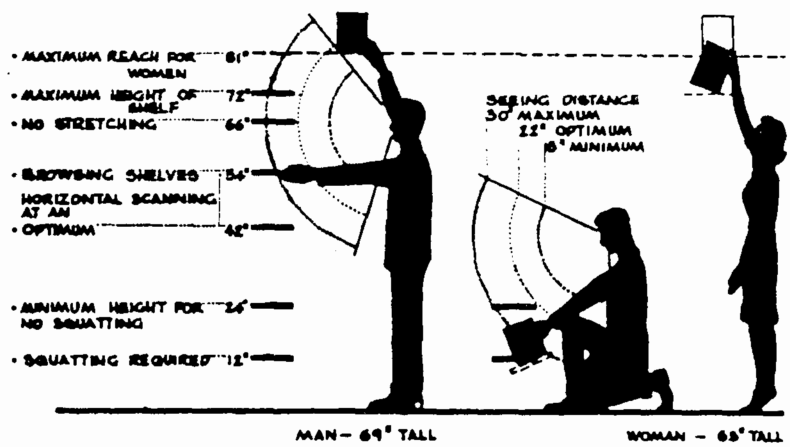


Fig. 1 Optimum shelving conditions for adults.

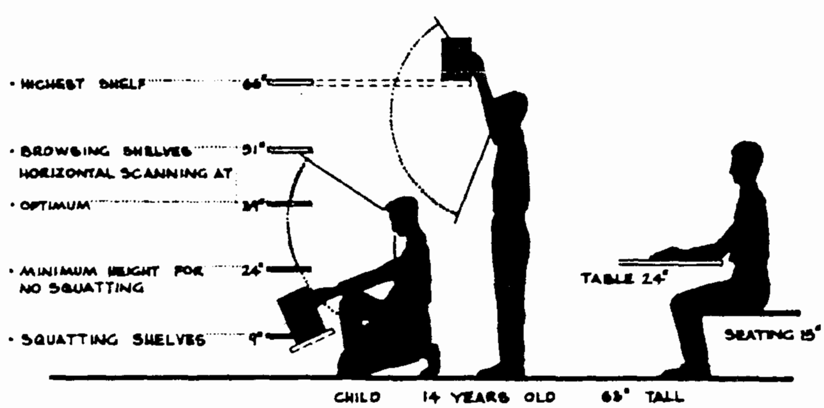


Fig. 2 Optimum shelving conditions for teen-agers.

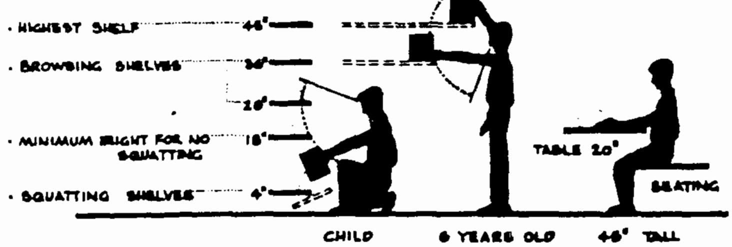


Fig. 3 Optimum shelving conditions for children.

purely local needs, and second, existing, time-proven formulas applied as a basic guide.

The most important factor in determining reader space needs is of course the reading potential of the people who will use the library. A conveniently located, attractive library will stimulate dramatically increased library use. Serious errors can result when estimates are based on use of the old, existing library.

As noted earlier an additional problem that must be carefully evaluated is providing an adequate number of seats for use by readers during peak periods. This problem has been intensified in recent years due to the increase in school attendance and the newer methods of instruction which involve extensive use of reference and supplementary materials by students of all ages. Since these periods of peak use occur irregularly, it is not economical to provide reading rooms which will be large enough to accommodate abnormally large crowds. Therefore, some libraries have attempted to solve this problem by locating multipurpose rooms adjacent to adult reference

TABLE 1 Experience Formulas for Library Size and Costs

Population size	Book stock – volumes per capita	No. of seats per 1,000 population	Circulation – volumes per capita	Total sq ft per capita	Desirable, first floor, sq ft per capita
Under 10,000	3½-5	10	10	0.7-0.8	0.5-0.7
10,000-35,000	2¾-3	5	9.5	0.6-0.65	0.4-0.45
35,000-100,000	2½-2¾	3	9	0.5-0.6	0.25-0.3
100,000-200,000	1¾-2	2	8	0.4-0.5	0.15-0.2
200,000-500,000	1¼-1½	1¼	7	0.35-0.4	0.1-0.125
500,000 and up	1-1¼	1	6.5	0.3	0.06-0.08

SOURCE: Joseph L. Wheeler and Herbert Goldhor, *Practical Administration of Public Libraries* (New York: Harper and Row, 1962) p. 554.

TABLE 2 Guidelines for Determining Minimum Space Requirements

	Shelving Space*						
Population served	Size of book collection, volumes	Linear feet of shelving†	Amount of floor space, sq ft	Reader space, sq ft	Staff work space, sq ft	Estimated additional space needed, sq ft‡	Total floor space, sq ft
Under 2,499	10,000	1,300	1,000	Min. 400 for 13 seats, at 30 sq ft per reader space	300	300	2,000
2,500-4,999	10,000, plus 3 per capita for pop. over 3,500	1,300. Add 1 ft of shelving for every 8 vols. over 10,000	1,000. Add 1 sq ft for every 10 vols. over 10,000	Min. 500 for 16 seats. Add 5 seats per 1,000 over 3,500 pop. served, at 30 sq ft per reader space	300	700	2,500, or 0.7 sq ft per capita, whichever is greater
5,000-9,999	15,000, plus 2 per capita for pop. over 5,000	1,875. Add 1 ft of shelving for every 8 vols. over 15,000	1,500. Add 1 sq ft for every 10 vols. over 15,000	Min. 700 for 23 seats. Add 4 seats per 1,000 over 5,000 pop. served, at 30 sq ft per reader space	500. Add 150 sq ft for each full-time staff member over 3	1,000	3,500, or 0.7 sq ft per capita, whichever is greater
10,000-24,999	20,000, plus 2 per capita for pop. over 10,000	2,500. Add 1 ft of shelving for every 8 vols. over 20,000	2,000. Add 1 sq ft for every 10 vols. over 20,000	Min. 1,200 for 40 seats. Add 4 seats per 1,000 over 10,000 pop. served, at 30 sq ft per reader space	1,000. Add 150 sq ft for each full-time staff member over 7	1,800	7,000, or 0.7 sq ft per capita, whichever is greater
25,000-49,999	50,000 plus 2, per capita for pop. over 25,000	6,300 Add 1 ft of shelving for every 8 vols. over 50,000	5,000. Add 1 sq ft for every 10 vols. over 50,000	Min. 2,250 for 75 seats. Add 3 seats per 1,000 over 25,000 pop. served, at 30 sq ft per reader space	1,500. Add 150 sq ft for each full-time staff member over 13	5,250	15,000, or 0.6 sq ft per capita, whichever is greater

SOURCE: American Library Association, Subcommittee on Standards for Small Libraries, Public Library Association, *Interim Standards for Small Public Libraries: Guidelines Toward Achieving the Goals of Public Library Service* (Chicago: The Association, 1962), p. 15. This brief 16-page report is based on standards set forth in ALA's, *Public Library Service; A Guide to Evaluation with Minimum Standards*. It is intended to provide interim standards for libraries serving populations of less than 50,000 until these libraries can meet the standards of ALA's *Public Library Service*.

*Libraries in systems need only to provide shelving for basic collection plus number of books on loan from resource center at any one time.

†A standard library shelf equals 3 lin ft.

‡Space for circulation desk, heating and cooling equipment, multipurpose room, stairways, supplies, toilets, etc., as required by community needs and the program of library services.

and study areas. Arrangements of this type have proved to be most effective in smaller libraries and in branch library buildings.

The following formulas, developed by Joseph L. Wheeler, are based on building analyses made over a period of more than 30 years. If the estimated future population is less than 10,000, allow 10 seats per thousand; if more than 10,000 but less than 35,000, allow 5 seats per thousand; between 35,000 and 100,000, 3 seats per thousand; between 100,000 and 200,000, 2 seats per thousand; between 200,000 and 500,000, allow 1¼ seats per thousand; and 500,000 and up, 1 seat per thousand.[2]

As an established rule of thumb, minimum allowances are made of 30 sq ft per adult reader and 20 sq ft per child. These allocations for reader seating are in terms of net space for readers, chairs, tables, aisles, and service desk. Seating requirements should be listed according to the several areas of the building. In addition, the program statement should estimate the proportion of table seating to informal seating (See Figs. 4 to 6.)

Space for Staff

Space requirements for the staff must also be stated in the program. These estimates will be conditioned by (1) anticipated growth for a 20-year period and (2) the nature and extent of the library's service program. The American Library Association recommends that space for staff be calculated on the basis of "one staff member (full-time or equivalent) . . . for each 2,500 people in the service area."[3] It is a minimum standard that includes pages but not maintenance personnel. Although suitable for application to most situations, it must not be regarded as inflexible. As an example, a library that is not affiliated with a system will probably require a somewhat larger staff than libraries that have joined together in cooperative arrangements, such as centralized technical processing centers. Moreover, something as fundamental as the number of hours per week the library is open will affect the size of the staff and, consequently, space requirements. There are striking differences in staff requirements between libraries open 20, 38, or 72 hours per week.

Staff space requirements should be calculated on the basis of 100 sq ft per staff member. It is important that this standard be met for there is ample evidence that space for staff has been outgrown more rapidly than any other type of space in most library buildings. Only too often is it easy to forget that an expanding service program will require the support of an enlarged staff. The unit of measurement of 100 sq ft per staff member includes space for desk, chair, books, and equipment.

A checklist of staff work areas should include (1) administrative offices, (2) work rooms, and (3) staff lunch and lounge rooms.

Administrative offices should include a combination librarian's office-trustee room; spaces for the assistant librarian and a secretary-receptionist; business office; and other related offices. Work room areas should be provided for technical processing; reference, circulation, extension, and other departments; subject specialists; and supply storage. Comfort facilities for the staff should include cooking and lunchroom areas as well as appropriate locker, lounge, and toilet facilities for both men and women. Comfortable working conditions contribute to effective personnel administration as well as to efficient library service.

[2] Wheeler, *op. cit.*, p. 18; Wheeler and Goldhor, *op. cit.*
[3] *Public Library Service, op. cit.*, p. 43.

Meeting Rooms

With the exception of the very smallest libraries, most public libraries should provide some group meeting space, at least one multipurpose meeting room. At the other extreme, a small auditorium and a series of conference rooms may be required. The services proposed by the library together with community needs for facilities of this type will be the final determinants.

Multipurpose rooms meet two general classes of need. First, they can be utilized for children's story hours, discussion groups, staff meetings, and other library-sponsored activities. Second, various community, educational, cultural, and local government groups will make frequent and varied use of a multipurpose room. To be of maximum value, however, the room should be arranged for easy and effective use of audiovisual equipment. In addition, there should be adjacent closet space for storage of blackboards, folding tables, chairs, and related equipment.

Many libraries provide a small "pullman" type kitchen in an area adjoining group meeting rooms. Serious consideration should be given to including this facility since there are many occasions when it is highly appropriate to serve simple refreshments. A kitchen featuring a compact combination stove-sink-refrigerator unit will not cause administrative or maintenance problems provided regulations governing its use are stated clearly. Separate provisions should be made for staff kitchen and lounge facilities.

Small auditoriums may feature sloping floors along with elaborate lighting, stage, and projection equipment, or they may be austere with major emphasis placed on flexibility. It is recommended that no auditorium ever be included in a library building program statement without first consulting community leaders. Such facilities are expensive to maintain and, as a result, can place an invisible but dangerous strain on the library's budget unless fully justified. Whenever group meeting spaces are provided, it is important that they be located where there can be access for community use without opening the rest of the building. It is customary to allow from 7 to 10 sq ft per seat for meeting room and auditorium seating.

Space for Mechanical Operations

Included within this category are halls, stairways, toilets, elevators and lifts, air ducts, heating and air conditioning equipment, closets, and shops.

Because it is exceedingly easy to underestimate the amount of space required for mechanical operations, it is recommended that the best available technical advice be secured to assure inclusion of an accurate estimate within the program statement. Fortunately, with the development of new construction materials and techniques combined with new concepts in planning, much less space is needed for these

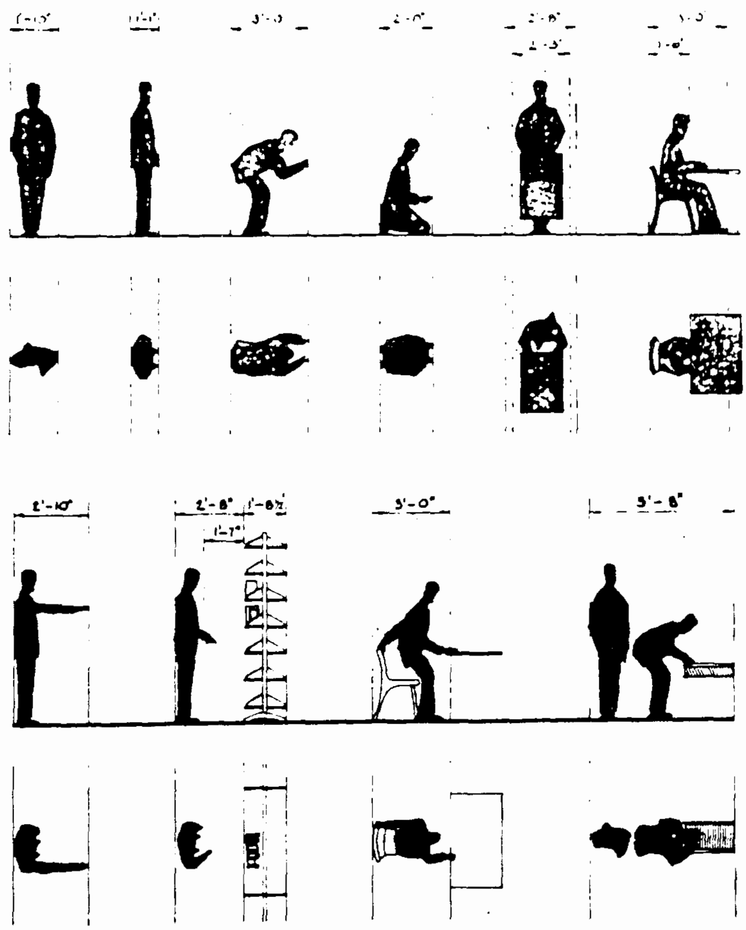


Fig. 4 Minimum clearances for various body positions in library stack areas.

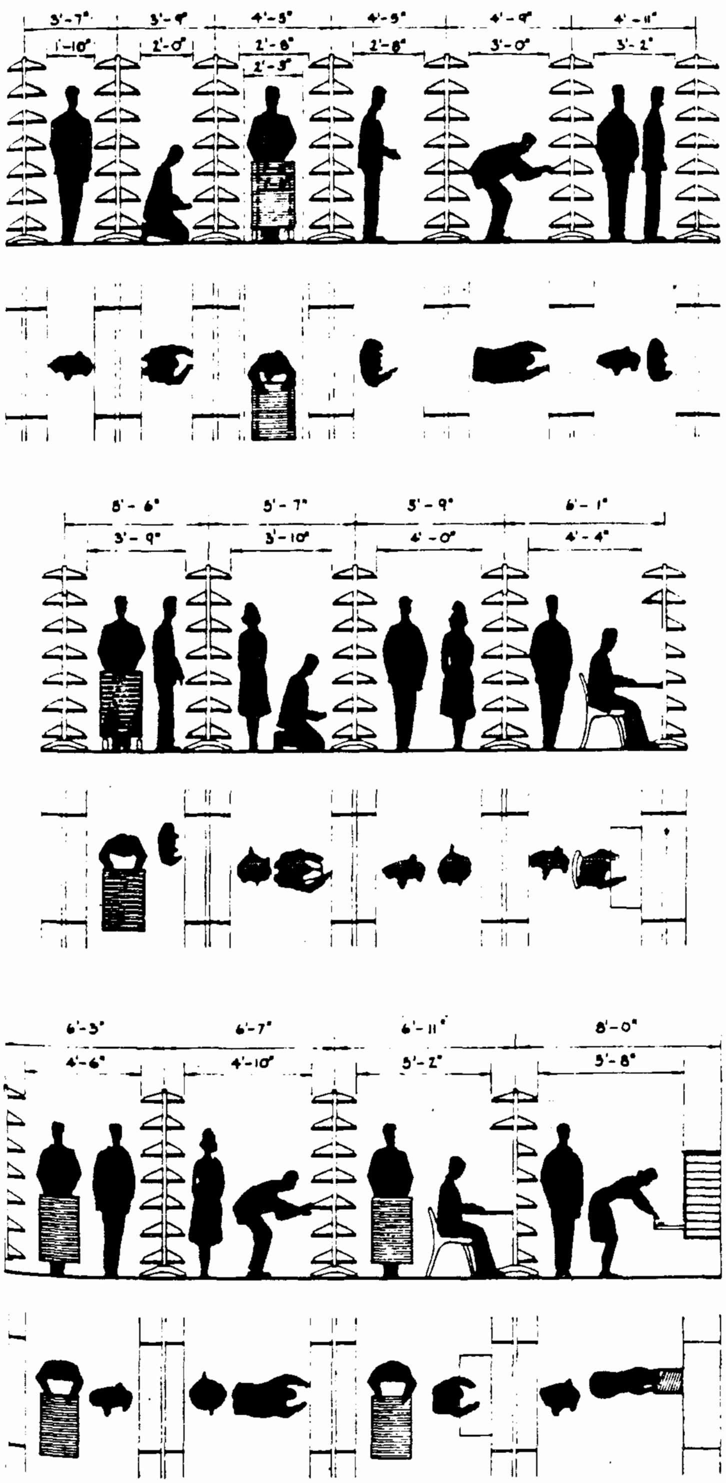


Fig. 4 (cont.) Minimum clearances for various body positions in library stack areas.

purposes than was formerly the case. It is suggested that an allowance of 20 percent be made for mechanical operations. In comparison, some planners allowed twice as much space not too many years ago. It is of utmost importance that this space requirement not be overlooked. After the amount of space needed has been estimated, it should be added to the total required for the other activities to be provided in the building.

SERVICE AND SPACE RELATIONSHIPS

As a logical extension of the program statement, it is important that the members of the planning team, especially the architect, acquire an understanding of the interrelationships between areas within the library. It is not enough to simply know how much space is needed; it is equally important to determine which element is to be placed where—and why. Toward this end, service and space relationships can be most readily clarified by *analyzing all of the* activities that take place in the library. This analysis of both public and staff use can be facilitated through preparation of work flow studies.

The central objective for the library planner is to arrange the several elements in a manner which will assure maximum flexibility. Reduced expenses for supervision, personnel, and construction are among the benefits derived from an "open," flexible building.

More specifically, flexibility implies successful, long-time use of the building. The same area may be used for one or more purposes at different times. The amount of space allocated for a certain use may be shrunk or expanded without structural changes. Furniture and equipment are not fixed and may be relocated.

Ideally, all public services should be located on the main floor of a library in the interests of user convenience, economy, and simplification of operation. Where this is impossible, as in the case of libraries in large cities, every effort should be made to visualize the vertical movement of persons and materials. Under any circumstances, a careful study of the flow of traffic and material is basic to the development of successful service and space relationships. Members of the planning team will find it useful to visualize the traffic flow of library users according to age and purpose of their visit to the library from the point of entrance into the building to the time of departure. Another test that will help to clarify *space relationships is to* trace a book from the placement of its order to the time it is placed on the public shelves and the cards are filed in the card catalog. (See Figs. 7 to 9.)

In addition to locating a maximum number of public services on the main floor, the following points should be kept in mind:

1. *Only* one complete card catalog should be maintained. It should be located conveniently as near as possible to the reading and reference areas, circulation desk, and the processing department. Department catalogs, a children's catalog, and shelflist and other processing records should be placed in their respective areas as needed.

2. Except for large libraries, there should not be more than one circulation desk. It should be near the main entrance where there will be direct visual control of the movement of both children and adults.

3. There should be a single public entrance within short distance of the circulation desk. Auditoriums and meeting rooms need not be directly accessible from the main entrance.

4. Public toilets, telephones, and display cases should be located where they can be supervised by circulation desk personnel.

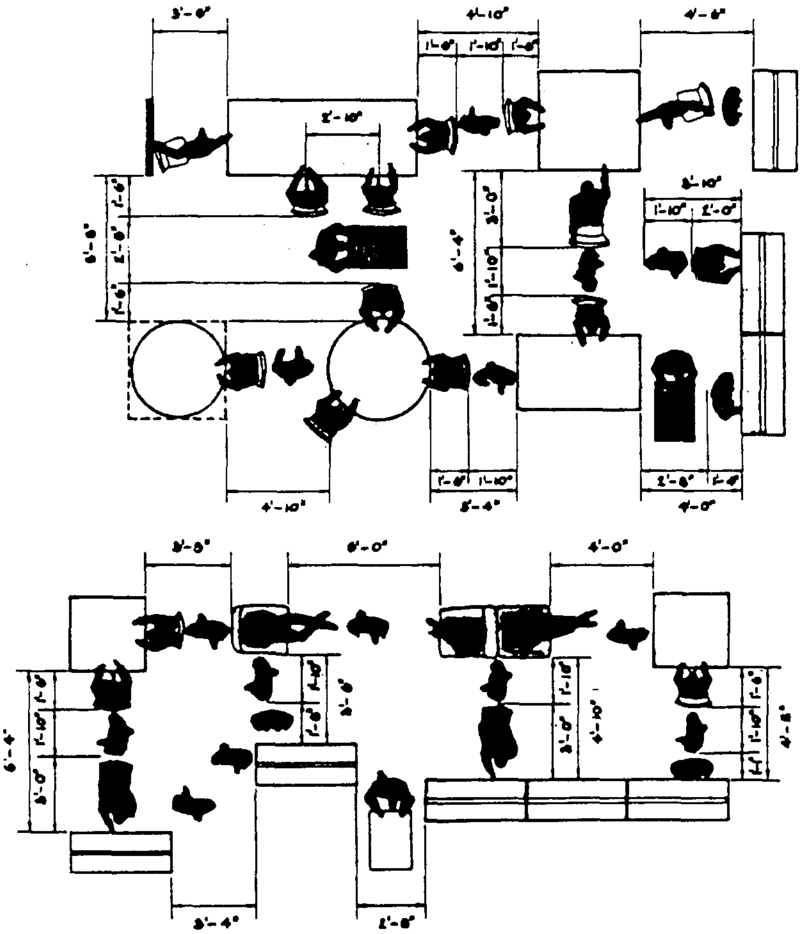


Fig. 5 *Minimum clearances for people and equipment in reading rooms.*

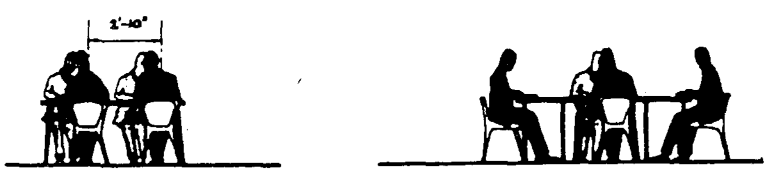


Fig. 6 Table space requirements for readers.

5. Every public service area should be supported by book storage, office, and work areas. Reading rooms should be grouped so that they may be served by common book storage, office, and work area.

6. A librarian or attendant should not be responsible for areas more than 55 ft beyond his desk.

7. Load bearing walls should be kept to a minimum and maximum use of shelving and furniture made to separate different service areas.

Other factors, such as exterior light and noise, also may influence the location of various areas within the building.

Finally it may be said that the success or failure of a building is measured by the degree to which planners succeed in applying the foregoing principles of desirable interrelationships. *Whether it is a simple* village library or a complex large-city library, every effort should be made to facilitate supervisory control, flexibility, and convenience of readers. Careful attention to supervisory control together with a flexible layout of public services will pay off in savings in staff time and ability to handle peak loads with a minimum staff. By the same token, failure to achieve effective service and space relationships can be a financial burden for many years and the source of continuing inconvenience for countless readers.

LIBRARY LOCATION

Central Location

A library is a service organization intended to serve people. Therefore, it should be centrally located where it will be accessible to the largest number of potential readers and information seekers.

This principle is neither new nor revolutionary. It has been advocated by a vast majority of experienced public library administrators for well over a half century. The concept of a centrally located library is just as valid now when there are more than 70 million registered motor vehicles as it was when the first successful American automobile was introduced in 1892.

A central location is usually associated with a heavy concentration of retail stores, office buildings, banks, public transportation points, and parking facilities. "This means that it [the public library] should be near the center of general community activity, i.e., the shopping and business district. Just as dime store operators study the flow of pedestrian traffic before locating one of their units, so should library planners consider carefully the best location to reach John Q. Public. A building located just around the corner from the most advantageous spot can lose a great deal of its potential patronage."[4]

The importance of a central location was reaffirmed in this statement: "A *prominent, easily accessible location is required to attract a large number of persons. Therefore the library should be placed where people naturally converge—in the heart of the shopping and business district, rather than in a remote location such as a park, civic center or quiet side street.*"[5] The American Library Association's *standards for* public library service also emphasize the need of "maximum accessibility."

Unquestionably, a location which affords maximum accessibility to the greatest number of people is fundamental to the success of

[4] Russell J. Schunk, *Pointers for Public Library Building Planners* (Chicago: American Library Association, 1945), p. 6.

[5] Charles M. Mohrhardt and Ralph A. Ulveling, "Public Libraries," *Architectural Record*, December, 1952, p. 152.

very new public library, be it the central library or a branch. It is equally true that a site which is located in the heart of a shopping and business district will usually cost far more than a site which is located in a remote or secondary area. Once confronted with the reality of the high cost usually associated with the acquisition of a prime location, there is a tendency toward "instant" compromise. Fortunately, ever increasing numbers of municipal officials, architects, and citizens recognize that the public library cannot fulfill its functions in a second-rate location and that operating costs are proportionately higher for an off-center library than for one which is centrally located. Maximum use is synonymous with lower service-unit costs, and strategically located sites are synonymous with maximum use.

The Site

In addition to central location, several other important criteria should be considered in library site selection:

1. The site should be prominent. A corner site at a busy intersection where the library can easily be seen is preferred. Maximum use should be made of display windows and views of the interior.
2. The site should permit street level entrance. Although a site that slopes to the rear has certain advantages, a level site should be acquired if possible.
3. The site should be large enough for expansion, accessibility for service vehicles and bookmobiles, and a modest amount of landscaping.
4. The site should permit orientation of the front of the building to the north in order to minimize glare from the sun. When this is not possible, orientation to the east is the second choice. However, an otherwise excellent, centrally located site should not be eliminated for lack of appropriate orientation. Modern year around temperature control devices and artificial light can be used effectively to minimize sun exposure problems.
5. Rectangular service areas within a building lend themselves to easy supervision. As a result, a site which is rectangular in shape and permits construction of a rectangular building should be obtained if possible.
6. Ideally, a site should have uniform foundation conditions, either rock or soil. Test borings should be made, preferably before a site is purchased.

Certain other conditions should be met if the community is to be adequately served. First, the library should be located reasonably near adequate automobile parking. Second, parking provisions should be made for bookmobiles, other official library vehicles, and library staff members. Third, automobile access to drive-in service windows should be provided where this feature has been incorporated into the library building design.

Although emphasis has been placed on acquiring a site which would be large enough to permit easy horizontal expansion, it is important to note that under certain conditions purchase of a strategically located smaller site can be justified provided there is enough space to locate primary adult public service areas at street level. Both Norfolk and Dallas acted accordingly when they acquired their choice downtown sites. In both instances, multistory buildings were erected with provision made for vertical expansion.

Where Not to Locate a Library

Despite the overwhelming evidence that can be offered in support of central locations for cen-

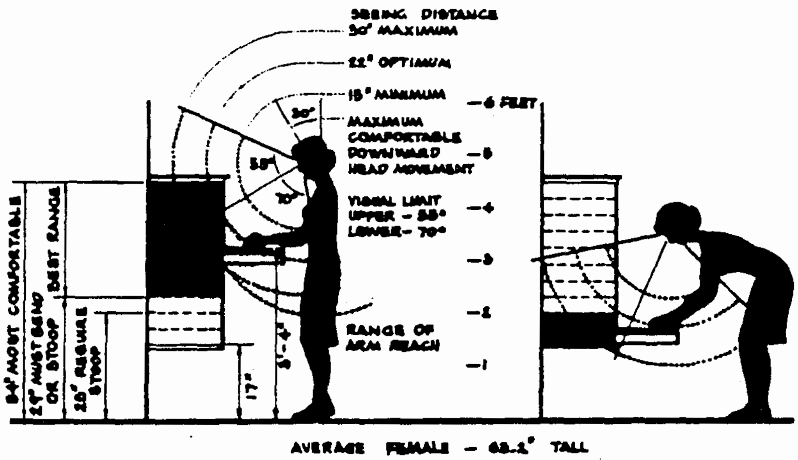


Fig. 7 Desirable heights for catalog tray consultation.

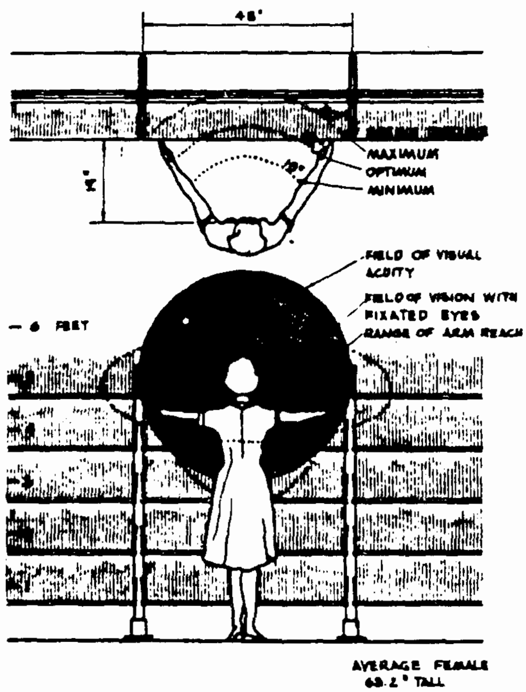


Fig. 8 Study for feasibility of scanning the 48-in. shelf.

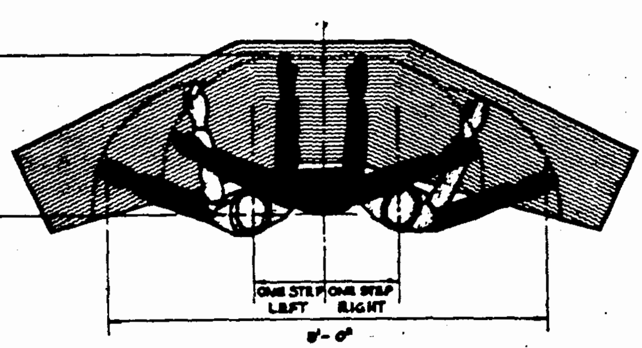


Fig. 9 Study for charge desk—maximum usable space from one position or station.

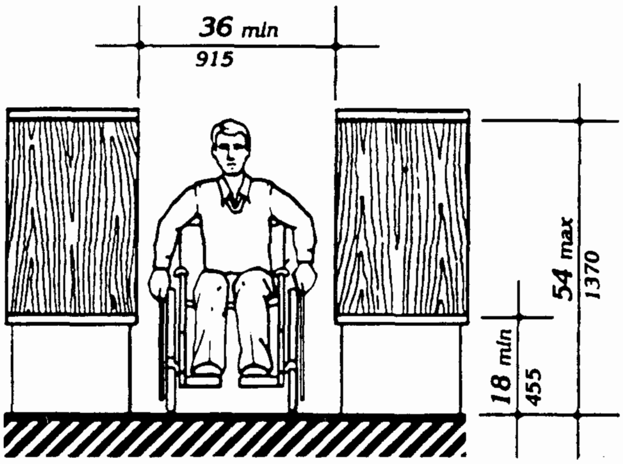


Fig. 10 Card catalog.

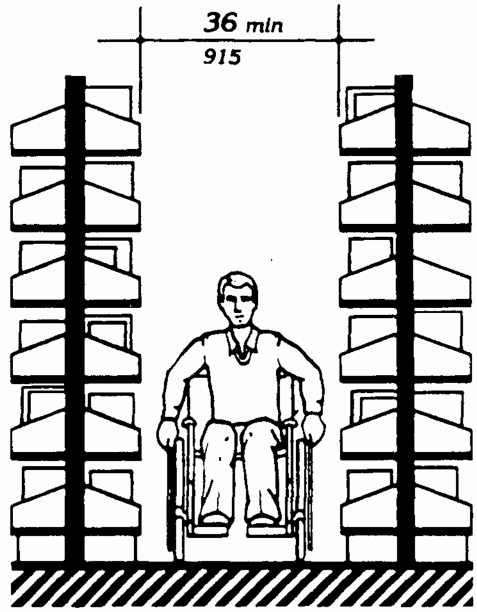


Fig. 11 Stacks.

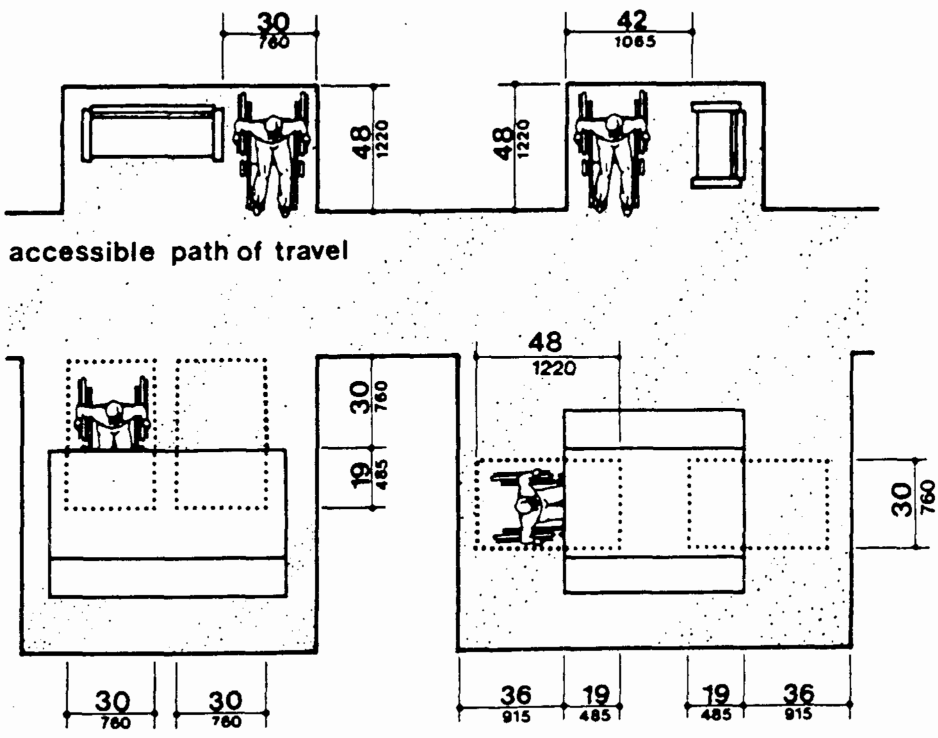


Fig. 12 Minimum clearances for seating and tables.

tral libraries and branches in cities both large and small, library planners continue to encounter seemingly plausible arguments from those who believe that libraries should be located in civic or cultural centers, parks, or on sites where avoidance of noise or provision for parking is the major consideration. Usually these misconceptions are held by those who are not qualified to choose a library site.[4] They do not understand the significance of the library in the daily life of its constituents. Quite to the contrary, they associate the library with a setting of monumental buildings, large landscaped grounds, and quiet, aloof surroundings. Libraries are not mausoleums, they are dynamic educational centers whose services and resources must be easily accessible to the greatest number of potential readers.

Specifically, then, remote locations should be avoided. By definition, "remote" means (either literally or psychologically) to be situated at a distance, out of the way, secluded, separate, not primary. Hence the aloof and inaccessible civic and cultural center fits this definition because it is separated from the daily life of the community and is used principally for attendance at special events. How much more satisfactory it is to be where there are bright lights at night rather than in a civic center where governmental offices close at 5 P.M. and there is little activity at night or on weekends.

The San Francisco Public Library is in a civic center and is a classic example of a poorly located library. Removed from the mainstream of community life, it is flanked by municipal buildings, the civic auditorium, and large landscaped areas. The Carnegie Library of Pittsburgh, which is located in a cultural and educational center, has attempted to overcome its problem of remoteness by establishing lending and business reference branches in the downtown area. Such operations are expensive, unsatisfactory, and would not be necessary if the central library were located downtown.

By the same token, it is almost always a serious mistake to place a library in the geographic or population center of a community. Except in those rare instances where there is coincidence between trade center and geographic or population center, such centers are remote and unrelated to the everyday activities within the life of the community.

Another argument that may be encountered is that the library should be located away from noise. Again, if this point is heeded, it will mean placing the building in a remote location. Fortunately, modern technology has provided acoustical materials, air conditioning, and lighting methods which have completely invalidated this argument.

The argument encountered most often, however, is the one that the library should be placed where there is ample parking space for the library's public. Again, the implication is clear, for if the library is to assume full responsibility for providing enough parking, it will be necessary to locate the building in a secondary location where land is cheap.

Although there are some individuals for whom parking is the main consideration in using the library, numerous surveys have reaffirmed the point of view that a downtown, pedestrian-oriented location in the thick of things is the most important consideration affecting use of the public library. To illustrate, the Knoxville Branch, Carnegie Library of Pittsburgh, is located on the main street of a busy commercial district near banks, post office, liquor and variety stores, and public transportation. Its sister West End Branch, two blocks removed from the neighborhood shopping center, enjoys ample parking facilities in a parklike setting.

[4] Wheeler, *op. cit.*, pp. 3–5.

The centrally located Knoxville Branch, of course, lends more books for considerably less money than does the West End Branch.

As another comparison, a well-stocked bookmobile will lend many more books at a busy suburban shopping center than will secluded nearby community libraries that offer the very same books *plus* parking, peacefulness, and higher service unit costs!

The parking problem cannot be overlooked. On the other hand, it is a communitywide problem that must be solved by the community rather than by the library alone. In fact, choked highways and overtaxed parking facilities are matters of increasing concern to all governments. Perhaps new concepts in mass transit will help to alleviate parking problems throughout the nation. In the meantime, many libraries have attempted to ease the parking problem through provision of curbside book return boxes. Others are experimenting with drive-in return and "will call" windows, similar to those used by banks for drive-in service.

BRANCH BUILDINGS

Branch libraries usually are established as a result of population growth and community expansion. Generally, it is their purpose to provide books and services which will meet the everyday reading needs of children and adult general readers who live within the local neighborhood. The person who requires more advanced information and special materials will use the collection at the headquarters library.

Although there is a definite trend toward the establishment of larger and fewer branch libraries, there are hundreds of branch libraries which vary widely in both size and responsibility. They range from the small subbranch, open but a few hours each week, to large regional centers which provide a full range of library service.

Branch libraries may be found in busy urban shopping centers and quiet rural communities. Many are housed in their own buildings while others occupy rented quarters. In smaller communities, branch libraries sometimes share space in public buildings planned for joint municipal use.

Whether small or large, rural or urban, owned or rented, branch library buildings should be planned with great care. The object of this planning is a building strategically located for the area which it is to serve. It should be attractive, functional, flexible, and economical to operate. Toward this end, it is essential that a written program statement be prepared for the guidance of the architect. This statement should include objectives, services and their interrelationships, physical requirements, and operational procedures. Physical requirements specify the spaces which will be needed for books, readers, staff, meeting and community service rooms, and other auxiliary spaces.

Of equal or even greater importance is the need for adhering to accepted location and site selection standards. The most functional attractive building can never realize its full potential unless it is located where it will be easily accessible to the largest number of people. The following criteria are suggested as a basis for evaluating sites for a new branch building:

1. A branch library usually should serve a minimum of 25,000 to 30,000 people within a 1- to 1½-mi radius of the branch, subject to topographic conditions.
2. A branch library should be located within reasonable proximity of a residential area so that a sizable number of children and adults will be within walking distance.
3. A branch library should be near an important street or highway intersection, especially wherever public transportation is available.
4. A branch library should be either within or on the fringe of a major neighborhood or regional shopping center.
5. A branch library should be located where it can be clearly seen.
6. A branch library should provide parking space equal to its interior area if general parking facilities are not available.

Other factors to be considered by the planning team are parking space for bicycles and space for delivery trucks. In certain communities where bicycles are used heavily, it will be necessary to make appropriate provisions. Where the terrain is rugged, the use of bicycles may be limited. Planners must also make allowances for library system delivery and repair vehicles. The latter may be station-wagon types, full-size trucks, or both.

In addition to a highly accessible location, a branch library building should incorporate the same basic building details found in a headquarters or central library building.

1. A branch library should be at street level entrance with as little setback as possible.
2. When space permits, it should be a one-floor plan with all public service at ground level.
3. It should have a minimum number of fixed partitions.
4. A branch library should be planned to permit easy expansion.
5. It should have enough windows on its street frontage so that the books and people within can serve as a living advertisement and constant invitation to use the library.
6. It should not have more than one single control desk, thereby reducing operating costs.
7. It should be air conditioned and adequately illuminated.
8. It should have one multipurpose meeting room available for both library and community purposes if such use is anticipated.

Branch library buildings, as well as central libraries, should be located in the heart of retail shopping districts in order to serve the greatest numbers at the lowest cost, for the more who are served the less each service performed will cost. In other words, there are certain fixed operating costs which pertain wherever the library may be located. With the maximum exposure gained from a good location, unit costs are reduced accordingly.

It can be safely assumed that the most successful branch library will be the one that is based on a carefully stated written program and is located in the thick of things. It is of great importance that the accepted principles of planning and site selection not be overlooked merely because a "small branch" is being planned. To bypass any of these steps in planning is to invite mistakes which might prove to be costly. This holds true for new branches, rented storerooms, leased branch buildings built according to library specifications, and branch facilities incorporated into other public service buildings.

BOOKMOBILES

Because of obvious space restrictions, a bookmobile is a book distribution service which cannot serve as a substitute for a branch library, since there are neither reference nor study facilities. Known to many as "one-room libraries on wheels," bookmobiles have become a widely and enthusiastically accepted form of library service.

Although they are used principally to serve sparsely populated fringe and pocket areas where a full-scale library cannot be justified, they are used often to serve densely populated areas until branch libraries can be planned, financed, and built. As a natural by-product and added benefit deriving from their mobility, bookmobiles pretest the validity of potential branch library locations.

Wherever the bookmobile goes, it is met and used by crowds of book-hungry men, women, and children, who are entitled to the use of a facility which provides maximum safety and comfort. As a result, it is important that bookmobiles be chosen with great care. Following a thorough study of local service requirements, the bookmobile planner should visit and inspect bookmobiles being used by other libraries which have comparable requirements. Major attention should be given to equipment. Shelving, desks, electric power, heat, light, ventilation, air conditioning, chassis, and convenience accessories are items which relate directly to function as well as reader and staff comfort.

Bookmobile *size will be determined in part* by population to be served, terrain, roads, climate, *number of books to be carried, and the* amount of work space required by the staff. To *illustrate, while a tractor-trailer rig may be* most appropriate to serve the densely populated Youngstown *area, it would not be feasible* for use on the mountain roads of sparsely populated rural New Hampshire.

Another item to be explored is bookmobile storage and service facilities at the headquarters library. When a new library is being planned, adequate provisions should be made for the support of bookmobile service.

Library and other officials responsible for the selection of a bookmobile should be guided by the standards for structural design and equipment as established by the American Library Association.

BOOKSTACK DATA

Unit Stack Weights

Books

25 to 30 lb per cu ft of ranges.

Stack Construction

Quoted as 5, 8, and 8 to 10 lb per cu ft, depending upon the manufacturer.

Deck Framing

2 to 4 lb per sq ft of gross deck area.

Deck Flooring

3-in. reinforced concrete slab, 38 lb per sq ft; 3½-in. reinforced concrete slab, 38 lb per sq ft; gross area, with ⅛-in. *tile or linoleum* covering, 45 lb; flanged steel plate floor, 12 lb per sq ft of gross area; 1¼-in. *marble or slate*, 18 lb per sq ft, aisle area.

Live Loads

Building codes vary, but in general, for column loads, *assume* 40 lb per sq ft of aisle area for live load and reduce this figure 5 percent for each deck below the top deck.

Bookstack Capacities

Among formulas suggested for use in computing the size of stacks necessary to house a given number of books is the "cubook" method, devised by R. W. Henderson of the New York Public Library.[7] The cubook is a measurement of stack capacity, defined as the "volume of space required to shelve the average book in the typical library." According to this formula, a single-faced section of stack 3 ft long and 7 ft 6 in. high has the following capacities:

100 cubooks (85 percent octavos, 13 percent quartos, and 2 percent folios)[8]

117 volumes (87 percent octavos and 13 percent quartos)

132 volumes (octavos only)

67 volumes (quartos only)

12 volumes (folios only)

The cubook method makes provision for 10 percent of each shelf to remain unoccupied, since it often is impractical to load shelves to their full visible capacity.

To determine the number of sections required when the number of volumes to be shelved is known, the following formulas are used:

Let N = number of single-faced sections required (1 section = 100 cubooks)

1. For a *typical library*, when the cubook is considered directly applicable: N = Vols. ÷ *100*

2. For a library made up of octavos and *quartos only*: N = Vols. ÷ 117

3. For a library made up of octavos only: N = Vols. ÷ 132.3

4. For a library made up of quartos only: N = Vols. ÷ 67.5

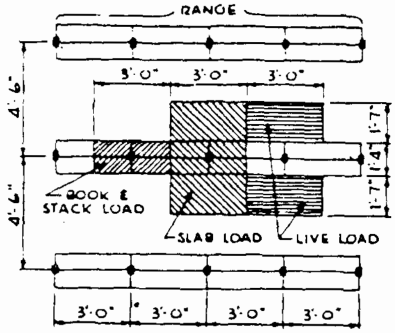
5. For a library made up of folios only: N = Vols. ÷ 11.7

6. For a library made up of various size groups when the ratios are known:

$$N = [\text{Octavos} + (\text{quartos} \times 1.96) + (\text{folios} \times 11.3)] \div 132.3$$

Shelf Size The foregoing formulas indicate the number of sections required but do not cover the number of shelves or the proportion of shelves of each width (8 in., 10 in., or 12 in.). In general, the following shelf data applies:

For folios—thirteen 12-in. shelves per section



TYPICAL STACK LOADING DIAGRAM

For octavos and quartos—usually 7 shelves per section, divided as follows:

85 percent 8-in. shelves

10 percent 10-in. shelves

5 percent 12-in. shelves

Area and Volume Requirements The cubook can be reduced to approximate terms of area and volume requirements for bookstacks, as follows:

11.08 cubooks require 1 sq ft of *stack floor area*

1.48 cubooks require 1 *cu ft of space in a stack*

These *values can be used as follows:*

Required stack floor area = No. cubooks × 0.090

Required space (cu ft) = No. cubooks × 0.676

Stack Loads: General Variation of Stack Loads for from One to Twelve Tiers

Tiers	1	2	3	4	5	6	7	8	9	10	11	12
8-in. shelving												
A	495	2,320	4,120	5,890	7,830	9,340	11,029	12,670	14,290	15,880	17,440	18,970
B	990	3,000	4,880	6,960	8,910	10,840	12,750	14,840	16,510	18,380	20,180	22,000
C	495	1,500	2,800	3,590	4,570	5,540	8,500	7,450	8,380	9,320	10,240	11,150
10-in. shelving												
A	820	2,570	4,490	6,380	8,240	10,070	11,870	13,840	15,380	17,090	18,770	20,420
B	1,240	4,000	6,240	8,460	10,880	12,848	15,000	17,140	19,280	21,380	23,440	25,500
C	820	1,750	2,670	3,980	5,080	6,170	7,250	8,320	9,480	10,530	11,570	12,800

Including stacks, books, live load, and 3½-in. concrete deck floor. (A = typical aisle and support; B = typical intermediate support; C = typical wall end support).

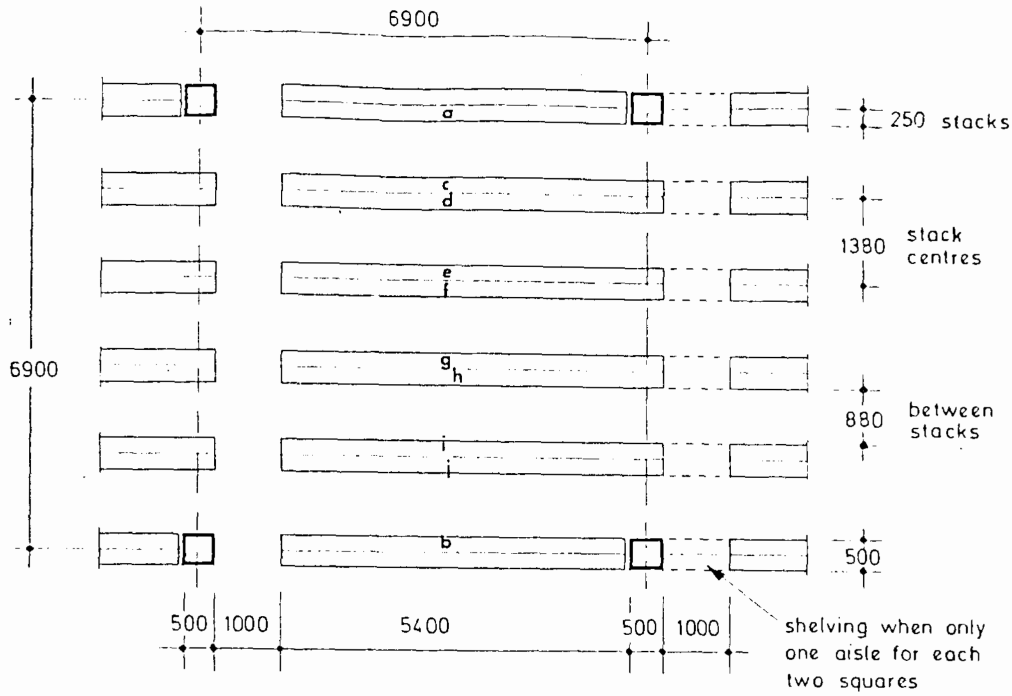
Shelving Data for Special Collections*

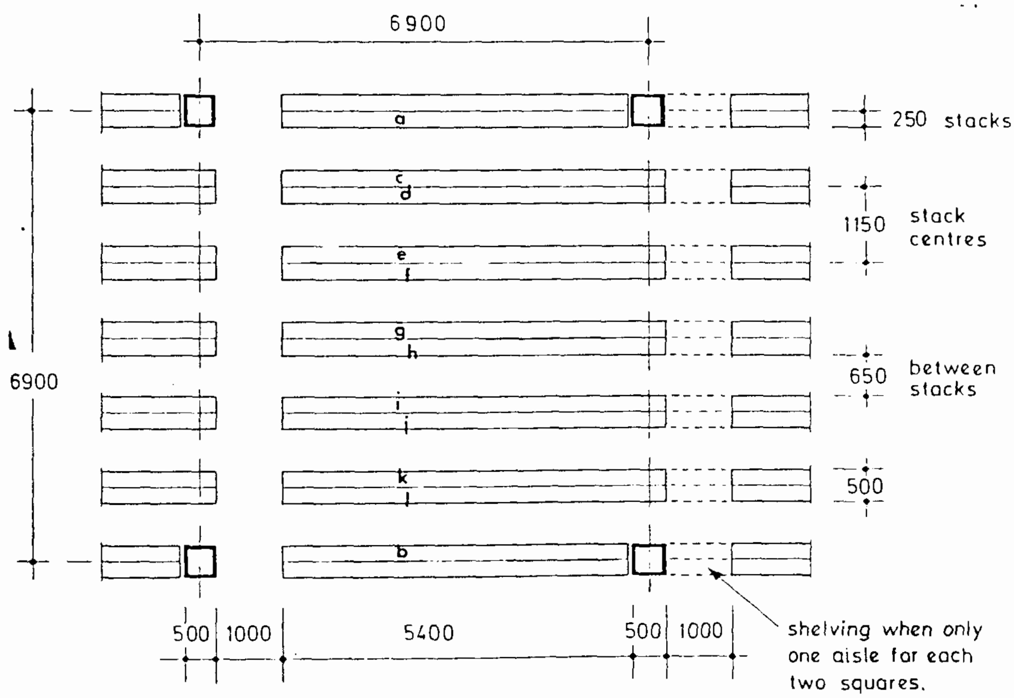
Type of book	Vols. per foot of shelf	Vols. per foot of single-faced range	Vols. per shelf	Maximum vols. per single-faced section	Shelf depth, in.	Shelves per section
Circulating (nonfiction)	8	56	24	168	8	7
Fiction	8	56	24	168	8	7
Economics	8	56	24	168	6	7
General literature	7	49	21	147	8	7
Reference	7	49	21	147	8 & 10	6-7
History	7	49	21	147	8	7
Technical and scientific	6	42	18	126	10 & 12	7
Medical	5	35	15	105	8 & 10	6-7
Law	4	28	12	84	8	7
Public documents	5	35	15	105	8	7
Bound periodicals	5	35	15	105	10 & 12	5-7
U.S. patent specifications . .	2	14	6	42	8	7
Art	7	42	21	126	10 & 12	5-6
Braille	4	24	12	72	15	5-6

* *To be consistent with cubook method, figures shown should be reduced by 10 percent to avoid overcrowding shelves.*

[7] *Library Journal*, Nov. 15, 1934, and Jan. 15, 1936.

[8] According to American Library Association, an octavo is about 8 to 10 in. high; a quarto, 10 to 12 in.; and a folio, over 12 in.


6900
a
c
d
e
f
g
h
i
j
b
6900
250 stacks
1380 stack centres
880 between stacks
500
500 1000 5400 500 1000
shelving when only one aisle for each two squares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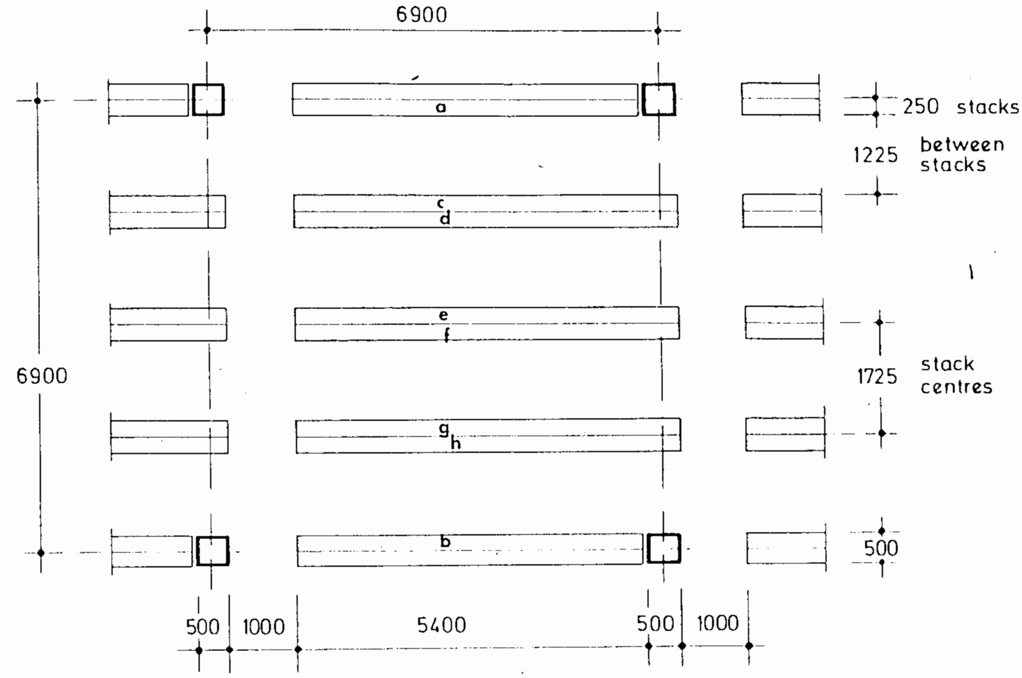
1150 stack centres
650 between stacks
500
500 1000 5400 500 1000
shelving when only one aisle for each two squares.


6900
a
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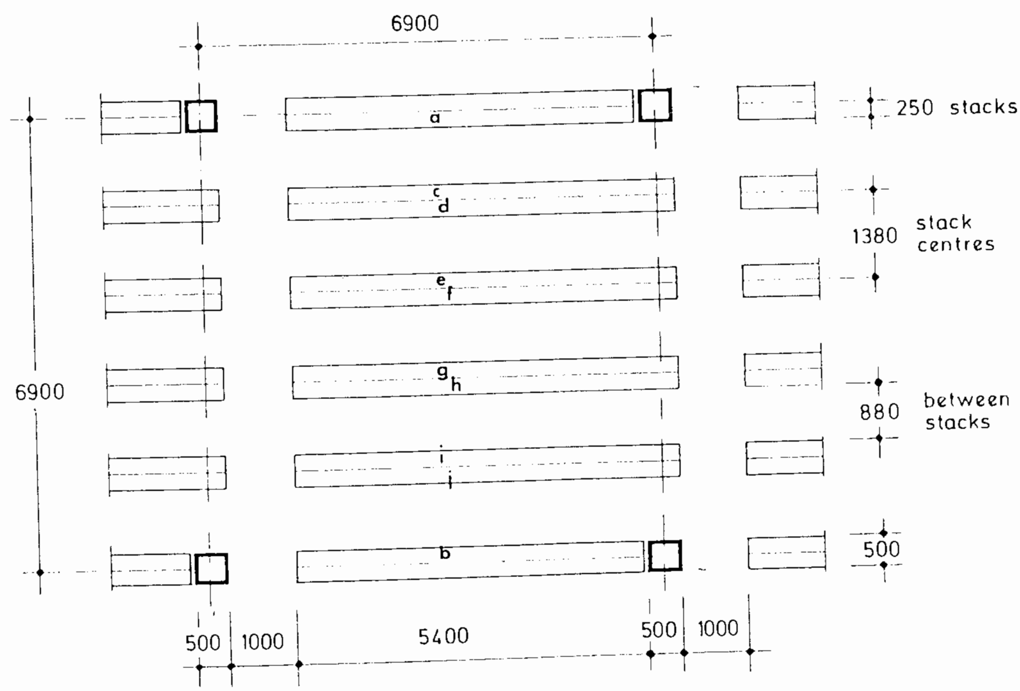
1225 between stacks
c
d
e
f
6900
1725 stack centres
g
h
b
500
500
1000
5400
500
1000


6900
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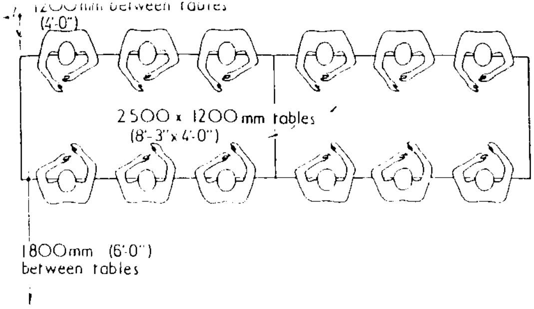
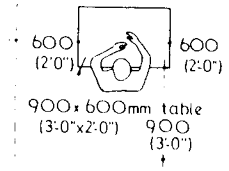
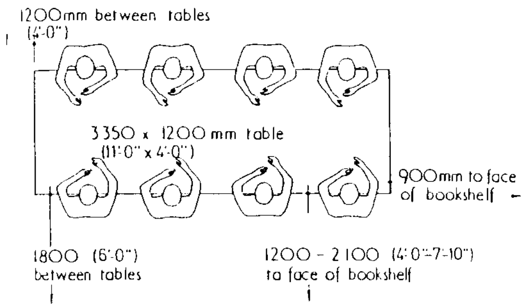


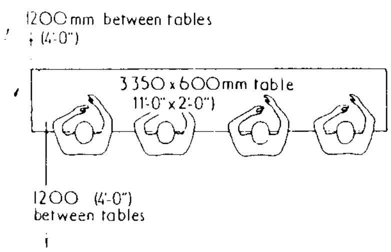
...inimum dimensions for six-person reading tables



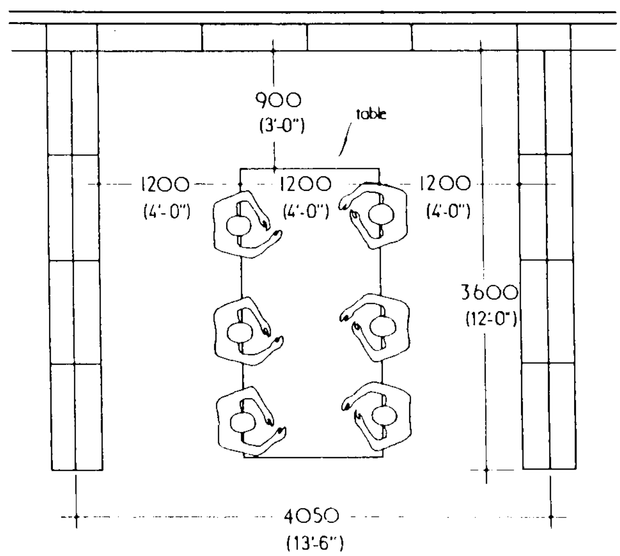
Recommended minimum dimensions for one-person reading table



...inimum dimensions for eight-person reading tables



...inimum dimensions for single-sided table for four persons



Minimum dimensions for six-person reading tables in alcove

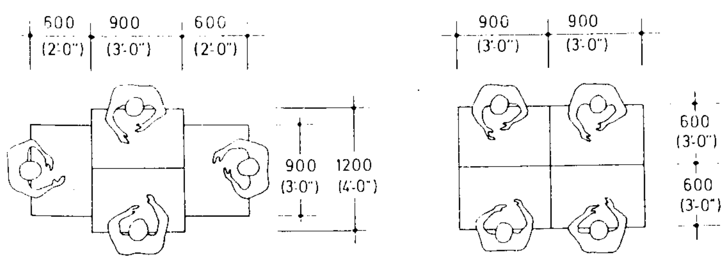
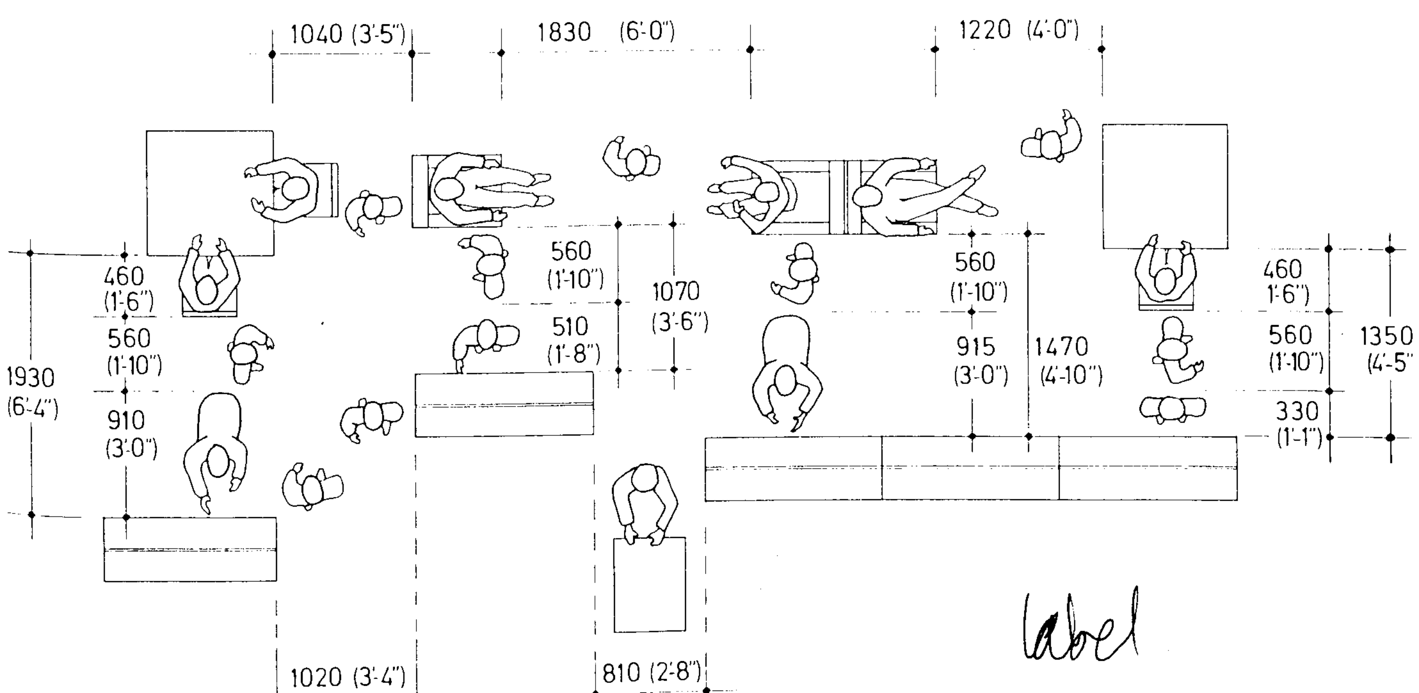


Table space requirements for readers



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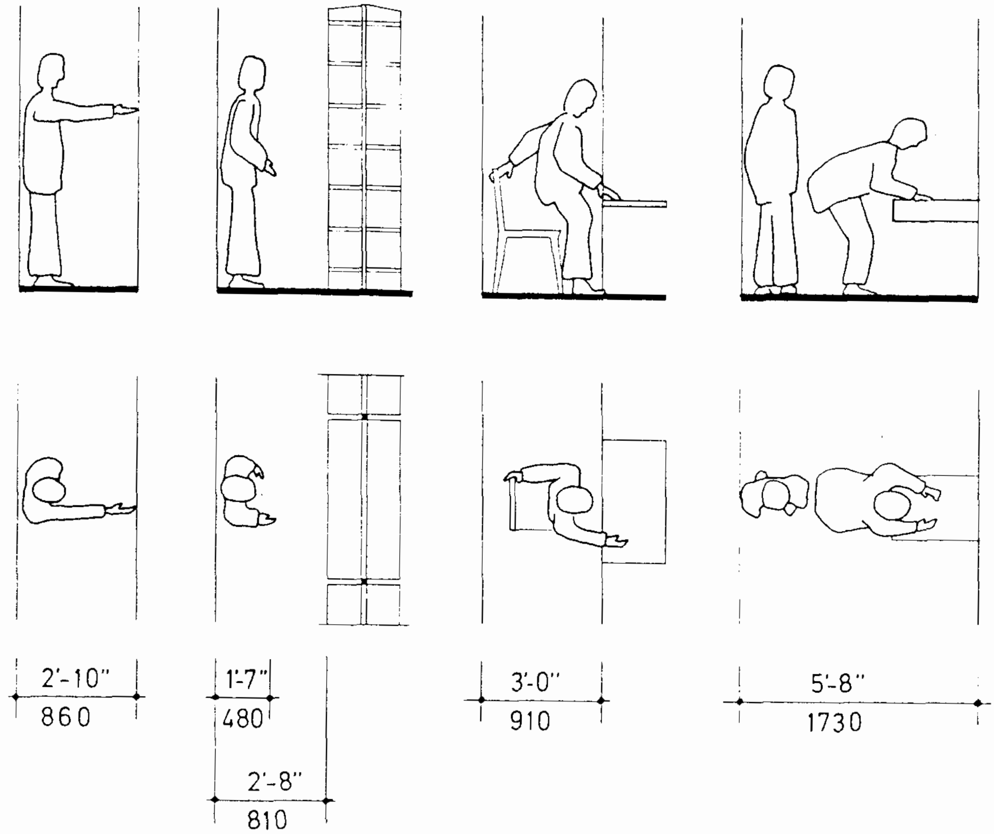
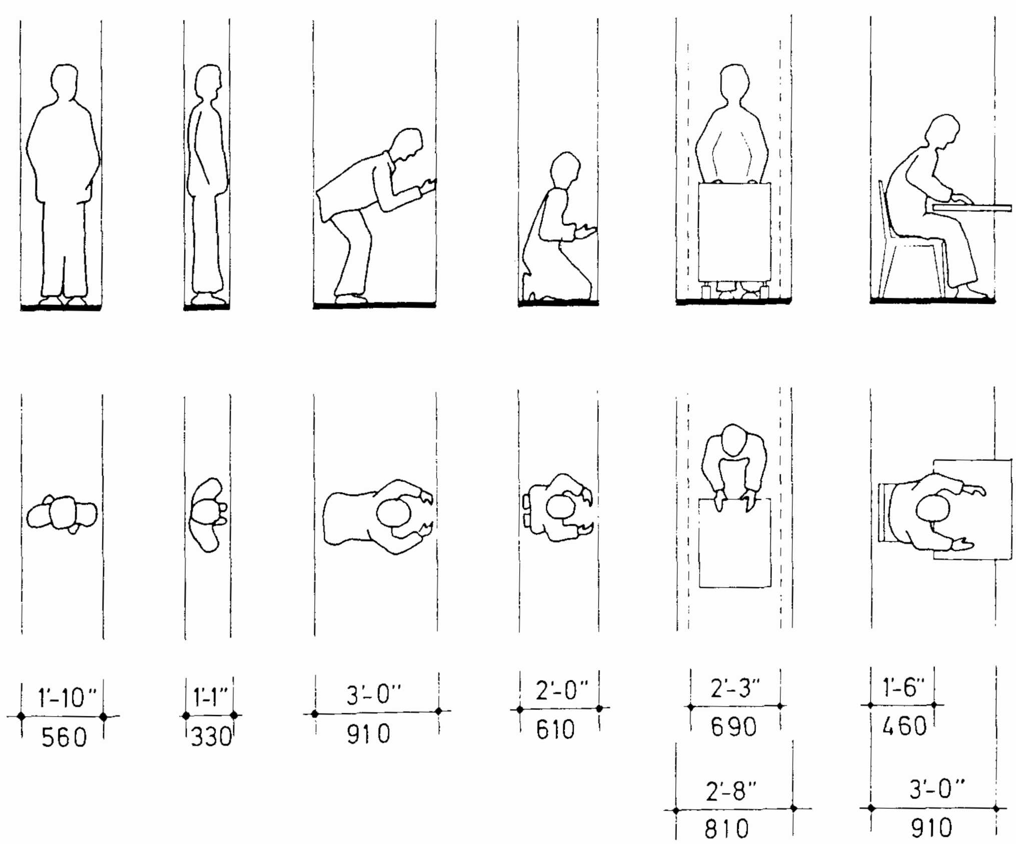
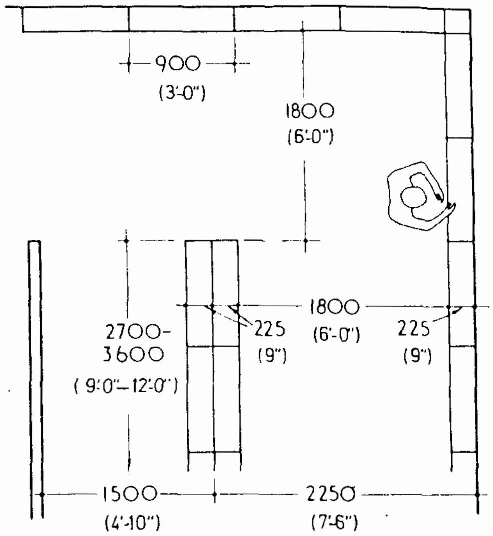
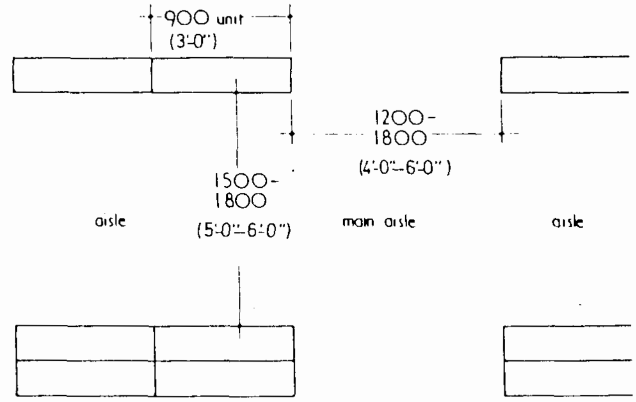




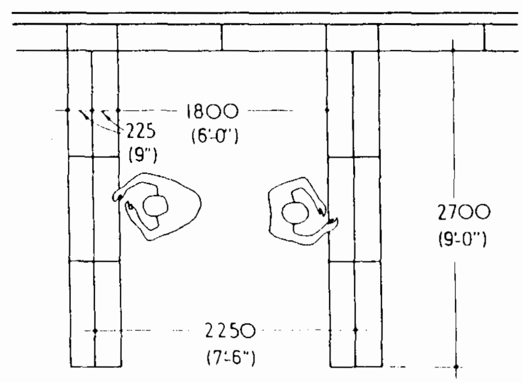
This page and facing page: Minimum clearances for various attitudes in shelving areas



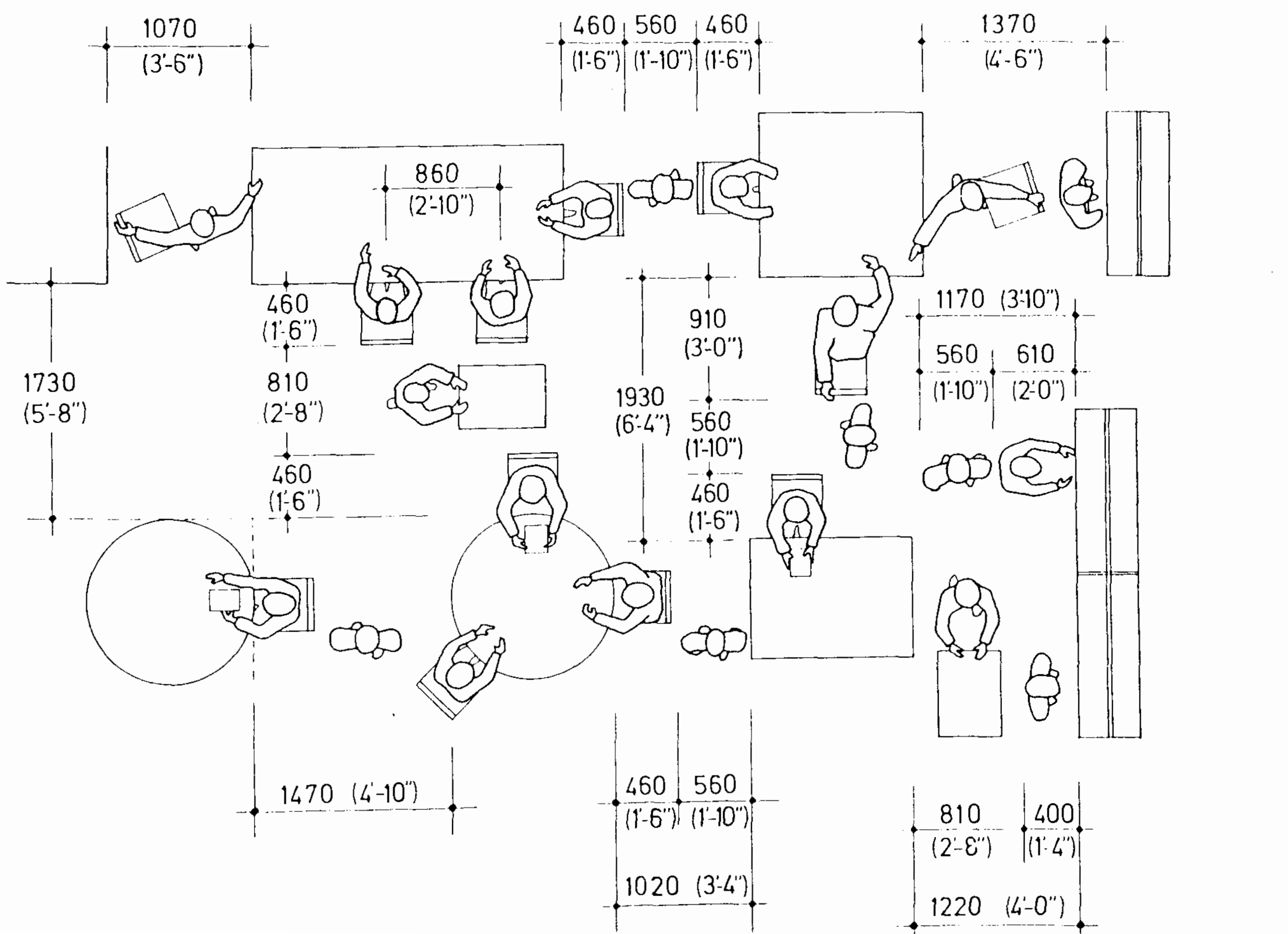
Recommended minimum plan dimensions in open access book stack area

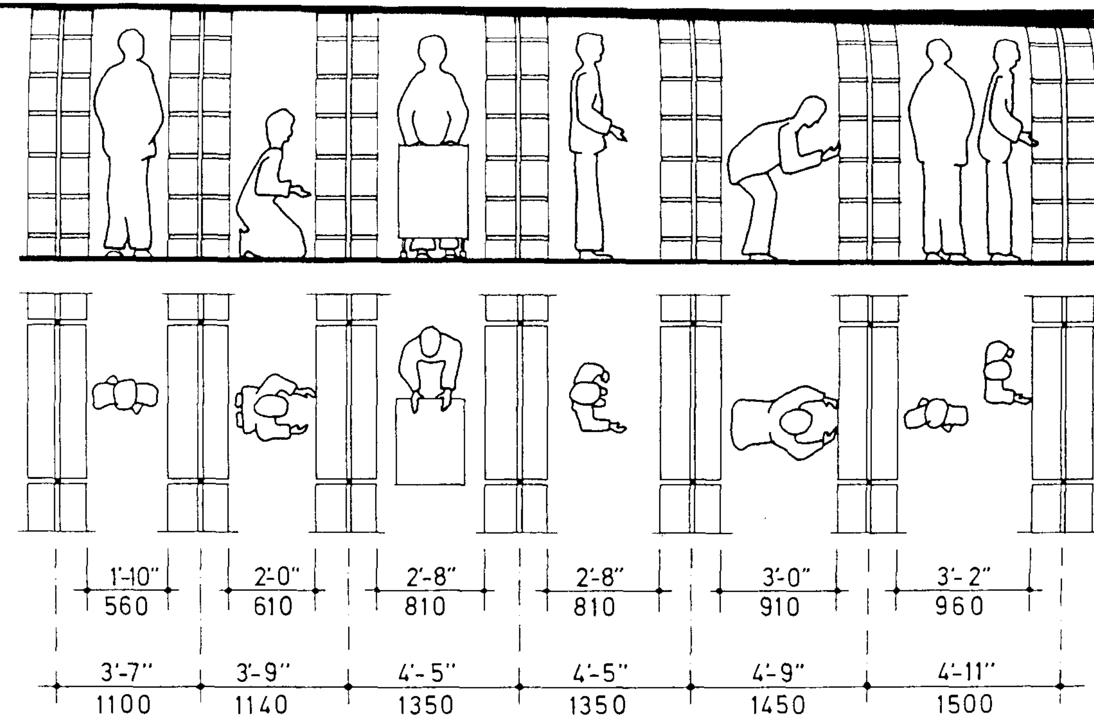


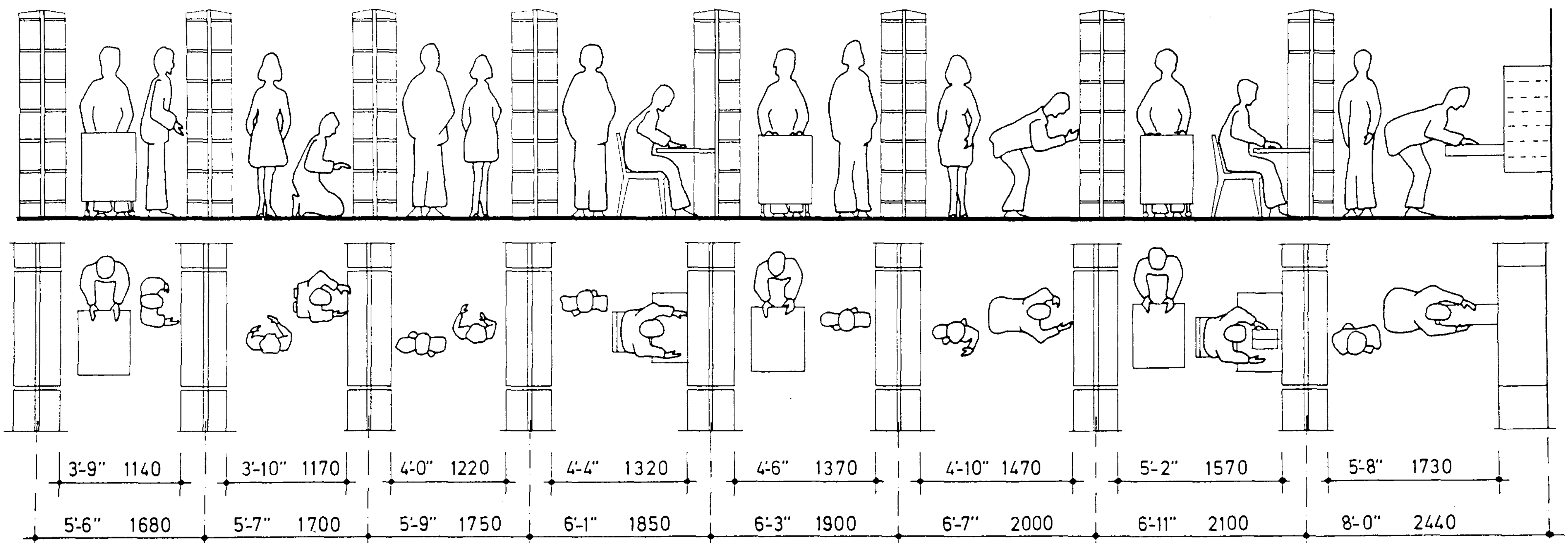
Recommended minimum plan dimensions in open access book stack area with shelving arranged in alcoves



Minimum clearances in reading rooms




1'-10" 560
2'-0" 610
2'-8" 810
2'-8" 810
3'-0" 910
3'-2" 960
3'-7" 1100
3'-9" 1140
4'-5" 1350
4'-5" 1350
4'-9" 1450
4'-11" 1500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3'-10" 1170
4'-0" 1220
4'-4" 1320
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4'-10" 1470
5'-2" 1570
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5'-6" 1680
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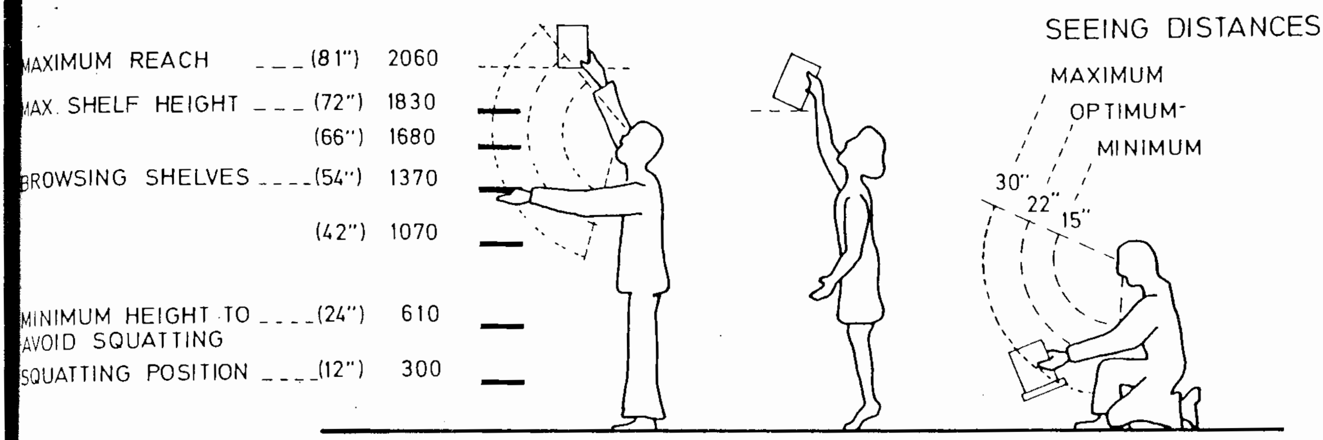
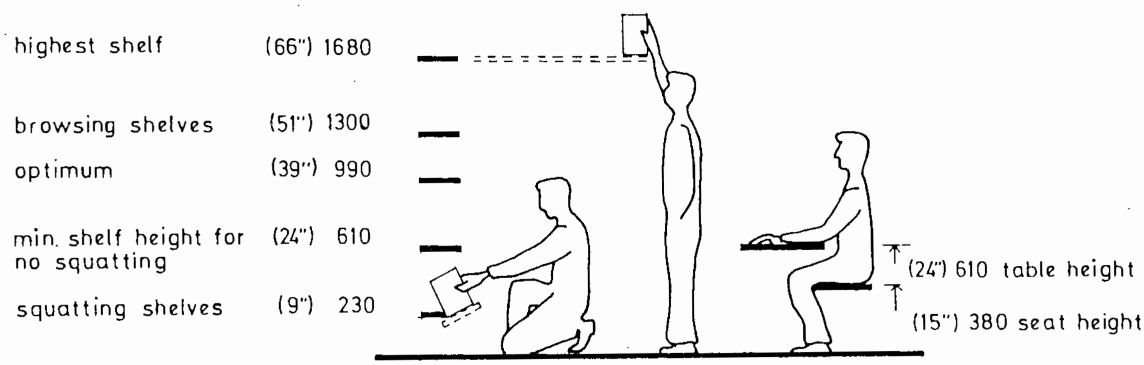
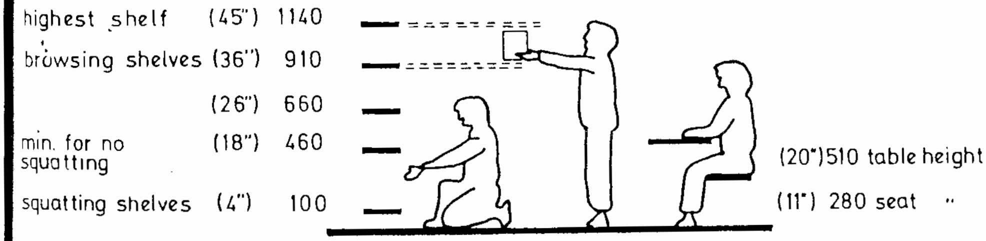
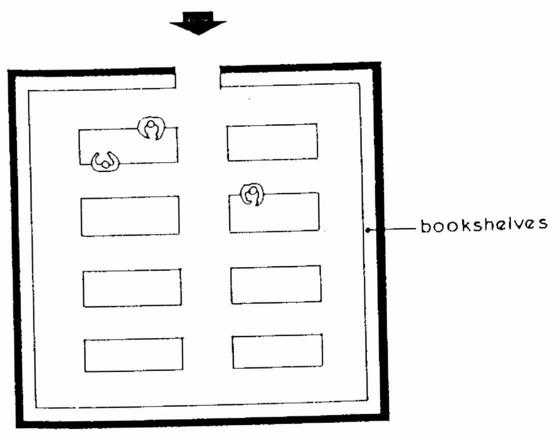
6'-3" 1900
6'-7" 2000
6'-11" 2100
8'-0" 2440



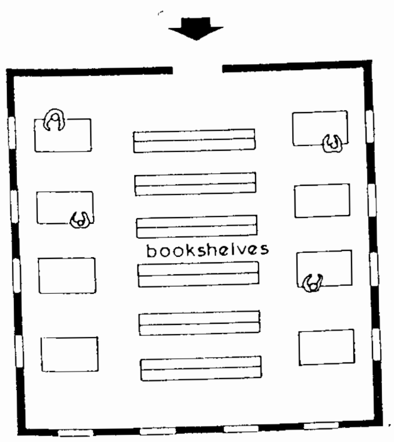




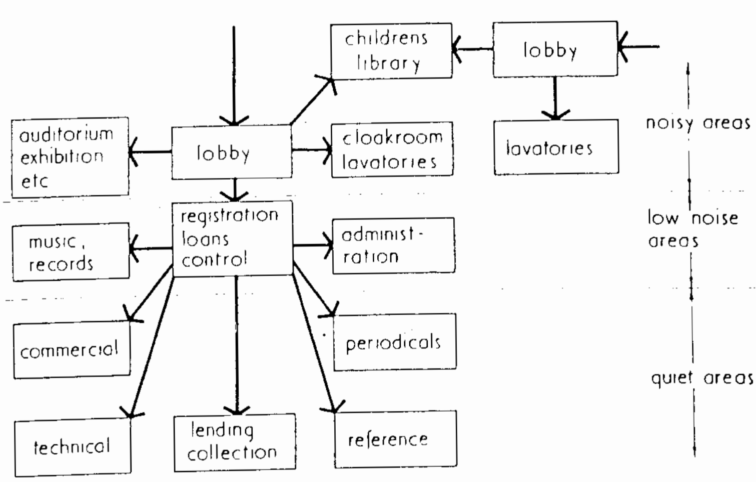
Optimum shelving conditions for adults (top) teenagers (centre) and children (bottom)



Reference library with shelving round wall



Reference library with shelving in centre



Progress of readers through a public library

APPENDIX C

Classes of Research Facilities

The Public Health Service divides research facilities into four classes: *Class A Laboratories* are designed with maximum capability for conversion from one program use to another. These are primarily intended for research in the basic scientific disciplines of biology, chemistry, and scme aspects of the physical sciences. The design criteria are intended to protect the integrity of individual research programs from interference by other research within the same structure and to reduce the possibility of infection or toxic hazards to personnel in present or future research projects.

Class B Laboratories are designed with limited capabilities for conversion. This laboratory class is suited for a narrow range of activities in such disciplines as the social sciences, psychiatry, public health work, or epidemiology and could not be used for research involving the basic disciplines of chemistry and biology without major alterations in the heating, air conditioning, ventilation, plumbing, and electric power systems. The original design provides for individual room temperature control.

Class C Facilities are designed for research support, including such structures as stock barns, animal pens and runways, storage sheds, and utility structures. This class is considered functional without utility services and does not require noncombustible construction.

Class D Facilities are designed for special research functions that require a specialized environment. Their structural provisions render them inherently unsuited for conversion. The design criteria must be determined for each project. This category includes biotron or betatron buildings, hyperbaric chambers, germ free animal production facilities, biohazard control facilities, and other research buildings with specialized functions.

Planning

A health research laboratory building must have the capability to satisfy research operational needs, allowing for variation both in research projects and in occupancy, for at least 10 years. Planners and designers must recognize that the structure will have to meet a variety of functional needs, rather than the specific requirements of a single group of occupants.

The most effective administrative device for planning a health research facility that will meet both current and future requirements is a written description of the total functional needs of the program(s) expected to operate in the building. Generally called the Program of Requirements (POR), this written description lists the functions and operations that will be housed in the structure, the design criteria for those functions, and their space needs. It also provides information on the projected staffing and the equipment which will be needed in the building. This written Program of Requirements is most valuable if it is prepared before any drawings and preferably should precede the preparation of space function relationship diagrams.

Space Blocks Where the first full occupancy staff is available to advise on the functional requirements of the structure, planning and design can be directed to smaller units of space such as individual laboratory modules, suites, or departmental laboratories. Where only a small staff is available for planning the total long-range scientific research program and its space needs, the administrator must approach planning and design with a different philosophy.

In this situation, it may be best to consider the research programs in terms of functional space blocks ranging from 3,000 to 6,000 ft each. The size of the space planning blocks can be determined by using the POR to assess the anticipated programs and staffs that will occupy the building in the first phases of its occupancy. Generally, a space block is selected that will accommodate a group of two or three of the smaller programs, satisfy the moderately-sized programs and that, in multiples, will meet the needs of the proposed major operational units.

For example, if the POR indicates that 4,000 sq ft roughly equals the special needs of each of several functions, that there are a number of smaller functions requiring 1,000 and 2,000 sq ft each, and some larger functions with space requirements of 6,000, 8,000, 10,000, 12,000, and 16,000 sq ft, it is a reasonable approach to adapt a 4,000-sq-ft space block as a planning unit. The utility systems, the circulation systems, and supporting elements are planned to make each one of the 4,000-sq-ft space blocks self-sufficient. It is then possible to assign one medium-sized program element to a space block, assign multiple smaller units to a single space block, and use several space blocks for one major component.

Space planning strategy is associated with the development of space function bubble diagrams. These diagrams can be used to relate the individual space blocks functionally and to pool several space blocks to handle one major program.

Building Shapes Planners and designers sometimes try to meet laboratory functional needs with esoteric shapes and dimensions. Although circles, hexagons, and tall slim towers may have esthetic appeal, none of them are as efficient as, or have the capability of, rectangular designs. Rectilinear laboratory equipment and office furniture and the anticipated continual interplay between rooms call for utilitarian solutions. Buildings with simple rectangular configurations, commensurate with standard laboratory equipment and furniture, and with unrestricted accessibility to mechanical utility systems, are the easiest to adapt to the changing needs of research.

Flexibility and Capability The term *flexibility* is frequently used in discussing the design characteristics of research laboratory buildings. However, *flexibility* should be interpreted with caution because most research laboratory structures should be designed with the concept of capability in mind. The structure's capability to meet varying ventilation needs for different research functions, its ability for temperature control of varying heat loads, its capability to meet the needs for fume hood, air supply, and exhaust in different concentrations with time in various areas in the building are all critical. The ability to supply electric power in high concentrations to any localized area without the need to reposition electric distribution lines within the building is a measure of the facility's capability to meet the needs of the research program that will eventually occupy the building.

Flexibility is emphasized by considering the possible location and utilization of chemical fume hoods. Saying that the building can provide for 50 chemical fume hoods is meaningless unless it is specified whether only up to a maximum of 10 can be utilized on any one floor, or whether the design capability is such that all 50 can be installed and used on one floor. A more detailed examination of the building's capability might reveal that no more than two hoods could be installed in any one laboratory module due to the limitations on supplying and exhausting air in that particular room. This approach contrasts with the method of determining the location of hoods according to requests by the initial occupants of the building. Providing supply and exhaust hoods in specific areas or rooms according to desires of the first occupant limits the capability of the building for future occupants.

THE LABORATORY BUILDING[1]

To a large extent the design of a laboratory building will be dictated by the heating, ventilating, and air-conditioning systems, and the utility distribution layout. If these factors are carefully planned first, the laboratory building design will be an efficient one, and it will still be possible to plan for structural flexibility and growth needs as well as for engineering capability.

The module plan is the most useful for the design of health research facilities. This section will briefly discuss how various groups have met some of the challenges of research laboratory design, using the module as the basis for a grid pattern. Experience with industrial and academic laboratories can prove instructive for those working with health-related facilities.

Planning for Flexibility and Growth

Architects have been trying to develop comprehensive systems which will relate the needs

Health Research Laboratory Design, National Institute of Health, U.S. Department of Health, Education, and Welfare, Washington, D.C., 1968.

[1] This section is based on an article by Jonathan Barnett in *Architectural Record*, November 1965, volume 138.

of various departments and disciplines and provide ways of sharing certain facilities, such as lecture halls and teaching laboratories. In addition, such a system can provide an architectural recognition of the increasingly interdisciplinary nature of much scientific research: for example, by placing bio-physics between biology and physics, with the capability of expanding in either direction.

The system developed by Sir Leslie Martin (Fig. 1) consists of a *regular grid derived* from considerations of space, lighting, and an integrated system of structures and services. The grid forms 35-ft squares separated by 5-ft strips. Ducts and services can be introduced at any point within these strips. The system is also divided vertically, with large areas such as lecture halls, workshops, and special laboratories for heavy equipment at the lowest level, teaching laboratories above, and research areas on top. As shown in the drawings, the grid can be applied to a site, giving a rough indication of present areas and future expansion possibilities. Architectural development can go on in stages, in relation to the grid, forming segments of a larger system rather than single buildings.

Industrial Laboratories Industrial research facilities do not yet require such a comprehensive solution. Industrial laboratory space is likely to be more uniform than a university or government facility. The range of research is relatively narrow, and, as there is no strong tenure system, industry is less likely to design a laboratory around the requirements of a particular scientist. At present, therefore, industry tends to think of new laboratory space in terms of adding blocks of a set size and type. The long-range outlook, however, is probably toward the more flexible approach already employed by the universities.

University Laboratories The Chicago office of the architectural firm of Skidmore, Owings and Merrill has been working on the development of comprehensive laboratory grids for universities (Fig. 2). Such grids lend themselves to growth of almost any shape and in almost any direction.

Planning the Laboratory Complex

There are four basic areas in any laboratory complex: the area for research itself; the administrative offices; general support facilities, such as an auditorium or a cafeteria; and service facilities, such as shops and the boiler plant. The addition of teaching requirements does not change this pattern significantly. Elementary science courses are taught in special teaching laboratories and demonstration lecture halls; but more advanced students are quickly integrated into the research organization.

The chief difficulty with the nonresearch elements is to prevent them from interfering with the design of the research areas. A badly located auditorium or boiler plant can strangle expansion and interfere with efficient operation. The most comprehensive method of avoiding such difficulties is the overall planning grid.

A master plan must make provision for independent growth of all four of the basic elements of the laboratory complex, either through a campus type of development or through sufficient articulation and separation of each area.

Research Areas The research portion of the laboratory is itself divided into several basic elements. Most research areas require desk space as well as bench space; and many experiments require some sort of controlled environment, with closely regulated temperature and humidity, or the elimination of outside contamination. Controlled environment installations and other ancillary facilities frequently cannot be accommodated within the ordinary research areas. In addition, scientists frequently wish to have conference rooms directly associated with research, and there are usually some fairly extensive storage requirements.

Construction Factors Economy of construction can conflict with efficient operation. Bench areas and special installations require elaborate piping services and air conditioning; desk space, conference rooms, and storage areas do not. Bench space and special installations are usually fairly large areas; desk space, conference rooms, and storage form smaller units. In terms of economy, it makes sense to group like functions and like areas, and to separate desk space and conference rooms from research. Unfortunately, most scientists prefer desk space to be near their research, and special installations need to be associated with research as well.

The design of teaching laboratories provides an analogous situation, with less need for desk space but a requirement for preparation rooms. Resolving these contradictory requirements, while still providing for flexibility and growth, is perhaps the most difficult problem in designing a laboratory.

The possible solutions range from placing all desk space in a separate building to incorporating all offices within the laboratories. The degree of separation possible, and the ratio of one type of space to the other, varies from discipline to discipline. Figure 3 shows some of the possibilities, within a flexible space system which can be used for either purpose.

The comparative study of eight different teaching laboratory layouts (Fig. 4) assumes that all office space is located in a separate wing. Each method of organization is evaluated in terms of economy of construction and mechanical equipment, circulation, and flexibility.

A comparison of four basic types of industrial laboratories is shown in Fig. 5. The first one places the desk space within the laboratory itself. The second places the offices on one side of the corridor and the laboratories on the other. The third plan provides core laboratories and perimeter offices; the fourth provides a peripheral corridor and interior laboratories, with the desk space again incorporated in the research area. These four plans are representative of standard practice: most laboratories will be found to conform to one or another of these basic classifications.

There are, however, other possibilities. Eero Saarinen's design for the IBM Research Headquarters in Yorktown Heights places both laboratories and offices within a peripheral corridor system. If one accepts the concept that all working accommodation should be interior space, this is a highly efficient and consistent method of organization.

Some laboratories are organized as towers, rather than horizontally. Ulrich Franzen's laboratory tower at Cornell (Fig. 6) also provides interior accommodation, with laboratories that can be entered either directly from the corridor, or through the offices. Vincent G. Kling's science building at Barnard College is a tower, as are, of course, Louis I. Kahn's Richards Medical Laboratories at the University of Pennsylvania. Kahn's first towers provide completely undifferentiated space, which can be used as laboratories, offices, or corridors. The later towers have desk space around the periphery on some of the floors. The plans of both of these buildings are also illustrated in Fig. 6.

UTILITY DISTRIBUTION

General

Utility services within a research laboratory building require a great deal more emphasis than is customary in the design of the average building. Heating, ventilating, and air conditioning systems and the multiple pipes of the various laboratory services such as water, gas, vacuum, and oxygen create a demand for cubic space as well as floor space. In more recent designs, utility systems have taken a higher percentage of the gross area, with consequent reduction in net space. This special aspect of the research laboratory building sometimes comes as a surprise to architects and engineers whose experience has been mainly with commercial buildings, which need much less utility service capability. Associated with this need for additional space for utility services is the need to provide functional space for the unseen occupants of the building: maintenance and operating engineers, and the craftsmen who provide for the continual changes and adjustments in utility systems which mark an active research program.

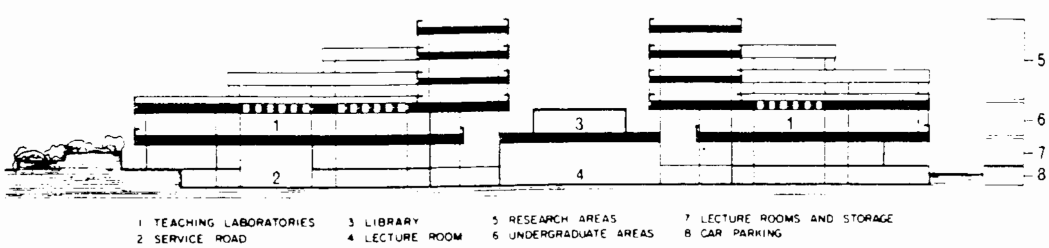


Fig. 1 Studies by Sir Leslie Martin of a comprehensive planning grid for university laboratories and of the type of development that can be based upon it.

of various departments and disciplines and provide ways of sharing certain facilities, such as lecture halls and teaching laboratories. In addition, such a system can provide an architectural recognition of the increasingly interdisciplinary nature of much scientific research: for example, by placing bio-physics between biology and physics, with the capability of expanding in either direction.

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A comparison of four basic types of industrial laboratories is shown in Fig. 5. The first one places the desk space within the laboratory itself. The second places the offices on one side of the corridor and the laboratories on the other. The third plan provides core laboratories and perimeter offices; the fourth provides a peripheral corridor and interior laboratories, with the desk space again incorporated in the research area. These four plans are representative of standard practice: most laboratories will be found to conform to one or another of these basic classifications.

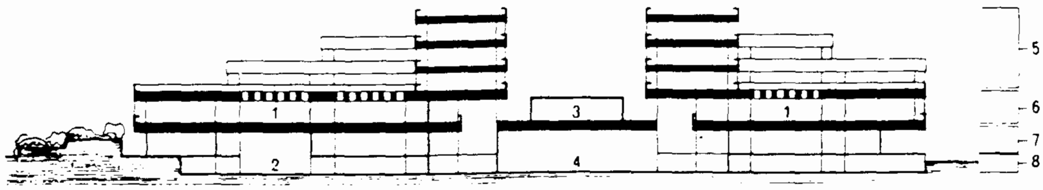
There are, however, other possibilities. Eero Saarinen's design for the IBM Research Headquarters in Yorktown Heights places both laboratories and offices within a peripheral corridor system. If one accepts the concept that all working accommodation should be interior space, this is a highly efficient and consistent method of organization.

Some laboratories are organized as towers, rather than horizontally. Ulrich Franzen's laboratory tower at Cornell (Fig. 6) also provides interior accommodation, with laboratories that can be entered either directly from the corridor, or through the offices. Vincent G. Kling's science building at Barnard College is a tower, as are, of course, Louis I. Kahn's Richards Medical Laboratories at the University of Pennsylvania. Kahn's first towers provide completely undifferientiated space, which can be used as laboratories, offices, or corridors. The later towers have desk space around the periphery on some of the floors. The plans of both of these buildings are also illustrated in Fig. 6.

UTILITY DISTRIBUTION

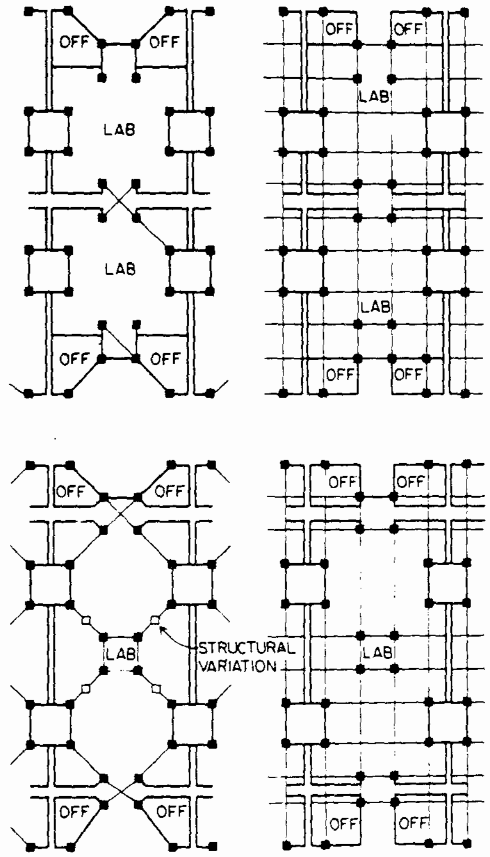
General

Utility services within a research laboratory building require a great deal more emphasis than is customary in the design of the average building. Heating, ventilating, and air conditioning systems and the multiple pipes of the various laboratory services such as water, gas, vacuum, and oxygen create a demand for cubic space as well as floor space. In more recent designs, utility systems have taken a higher percentage of the gross area, with consequent reduction in net space. This special aspect of the research laboratory building sometimes comes as a surprise to architects and engineers whose experience has been mainly with commercial buildings, which need much less utility service capability. Associated with this need for additional space for utility services is the need to provide functional space for the unseen occupants of the building: maintenance and operating engineers, and the craftsmen who provide for the continual changes and adjustments in utility systems which mark an active research program.



1 TEACHING LABORATORIES
2 SERVICE ROAD
3 LIBRARY
4 LECTURE ROOM
5 RESEARCH AREAS
6 UNDERGRADUATE AREAS
7 LECTURE ROOMS AND STORAGE
8 CAR PARKING

Fig. 1 Studies by Sir Leslie Martin of a comprehensive planning grid for university laboratories and of the type of development that can be based upon it.



(a)

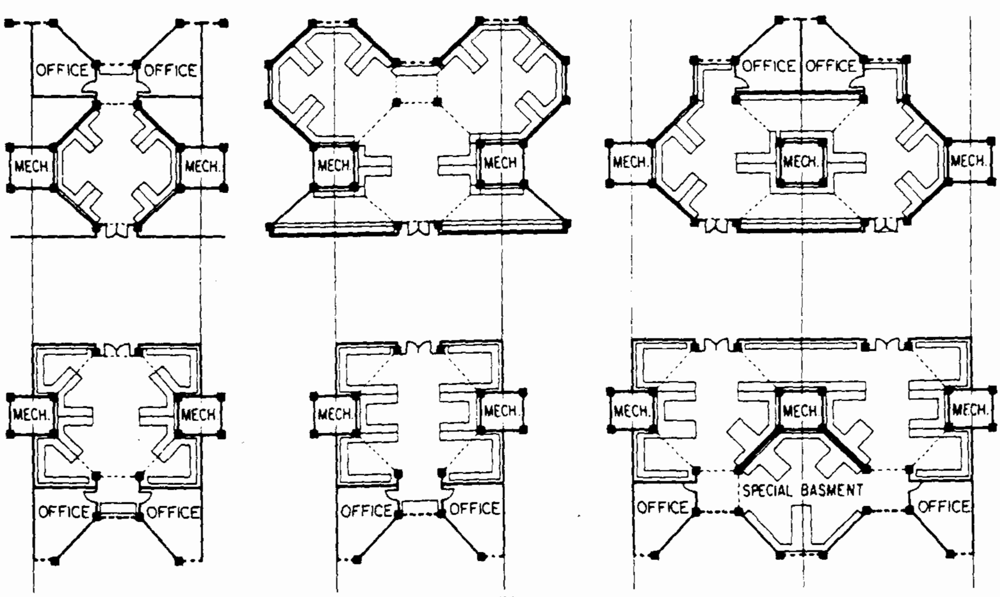
Selection of Systems

Selection of the utility distribution systems strongly influences the configuration, design, and cost of a research laboratory building. The type of utility system used should be selected as early as possible in the planning process, always before the room arrangement is fixed. Room arrangement and equipment location should follow the utility distribution pattern once this has been standardized. Arranging rooms and equipment according to the preferences of the first occupants usually results in costly, complicated utility distribution systems.

Planning a nonstandard room arrangement makes it difficult to visualize—without elaborate mockups—the configuration of space and equipment in the completed building. Then too, successive occupants are not always happy with the room arrangements selected by the first occupants. The rearrangement of plumbing and duct systems to meet preferences of successive occupants is usually costly unless these systems are installed on the standard repetitive pattern. Then a minimum of time and materials is required to rearrange the ventilation, lighting, and the plumbing and draining systems.

Standard Configuration

Utility services should be laid out with an identical configuration for every floor. This layout should be designed to meet the capability needs of the programs that will occupy the building over its life and with appropriate consideration of costs. Where it is not practical to provide an identical layout in each floor, a standard utility layout should be established for the floor which requires maximum utility services and this standard used for all the other floors, with deletions made where it is anticipated the services will not be needed for



(b)

Fig. 2 (a) Laboratory planning grid by Skidmore, Owings and Merrill. A system of square bays which accepts either a diagonal or a rectilinear planning grid. Column clusters mark out circulation areas or service shafts. (b) A building unit in this system which employs a diagonal grid, and some laboratory arrangements that would be possible.

a considerable time. The arrangement of utilities should be such that installation of missing portions of the plumbing and duct systems can be made with a minimum of labor and materials.

It may be difficult for the architect and the initial user to accept an arrangement of space based on a standard utility and mechanical system distribution system rather than on the preferences of the first occupants of the space. This is somewhat similar to installing water mains, gas lines, electric power lines along the streets of the city, and then building the houses on lots in such a way that they can be connected to the public utility systems. It would be uneconomical and exceedingly difficult to maintain adequate service in the future if the building utility supply mains were installed in the streets according to the needs of each individual house.

Types of Systems

Utility services are usually provided within a research laboratory building by either a horizontal or vertical distribution system or a combination of the two. Five systems are generally used to distribute laboratory utility services:

- The utility corridor system
- The multiple interior shaft system
- The multiple exterior shaft system
- The corridor ceiling with isolated vertical shafts
- The utility floor system

Utility Corridor System In the utility corridor design all service mains and ducts are brought to the various floor levels by means of a vertical central core which distributes the utilities by vertical mains, usually from a basement, sometimes from a roof mechanical room. The horizontal distribution of utilities from the central core may be at the ceiling and downward to individual casework or it can be directly along the floor through the wall in the pipe space behind the base cabinets.

This design provides access for maintenance and service personnel to the utility piping and duct work throughout the life of the structure. It has a high degree of flexibility for meeting the needs of changes in research program and has a high capability to meet a wide range of criteria with regard to environmental control and ventilation, temperature controls, lighting, electric power, etc. Its efficiency in terms of the net assignable area and the gross area is not high. It usually runs somewhere between 50 and 60 percent.

The utility corridor design is most applicable to multistory buildings—with a square rather than rectangular shape—and it should be used with reservation for laboratories with only one or two floors. This system results in functionally efficient laboratory buildings. It is extremely useful where future expansion, either horizontal or vertical, is planned and is particularly adaptable to those arrangements where offices with window exposure are separated from the interior laboratory units. In its simplest form the system provides for a single large room on each side of the utility corridor. The first refinement of this basic plan is the horse stall arrangement, which provides for partitions separating the various work areas but provides for no doorways or divisions from the circulation area around the perimeter. The refinement continues with the installation of walls and doors to separate the circulation perimeter from the laboratories.

1. Advantages
   - Excellent flexibility
   - Moderately high initial cost
   - Low modification cost
   - Low replacement cost
   - Low cleaning (maintenance) cost
   - Permits full utilization of walls
   - Modifications do not interfere with conduct of work in adjacent modules
2. Disadvantages
   - Fair net to gross area efficiency which improves when units are located in parallel, thus saving one corridor
   - All rooms are "inside rooms"

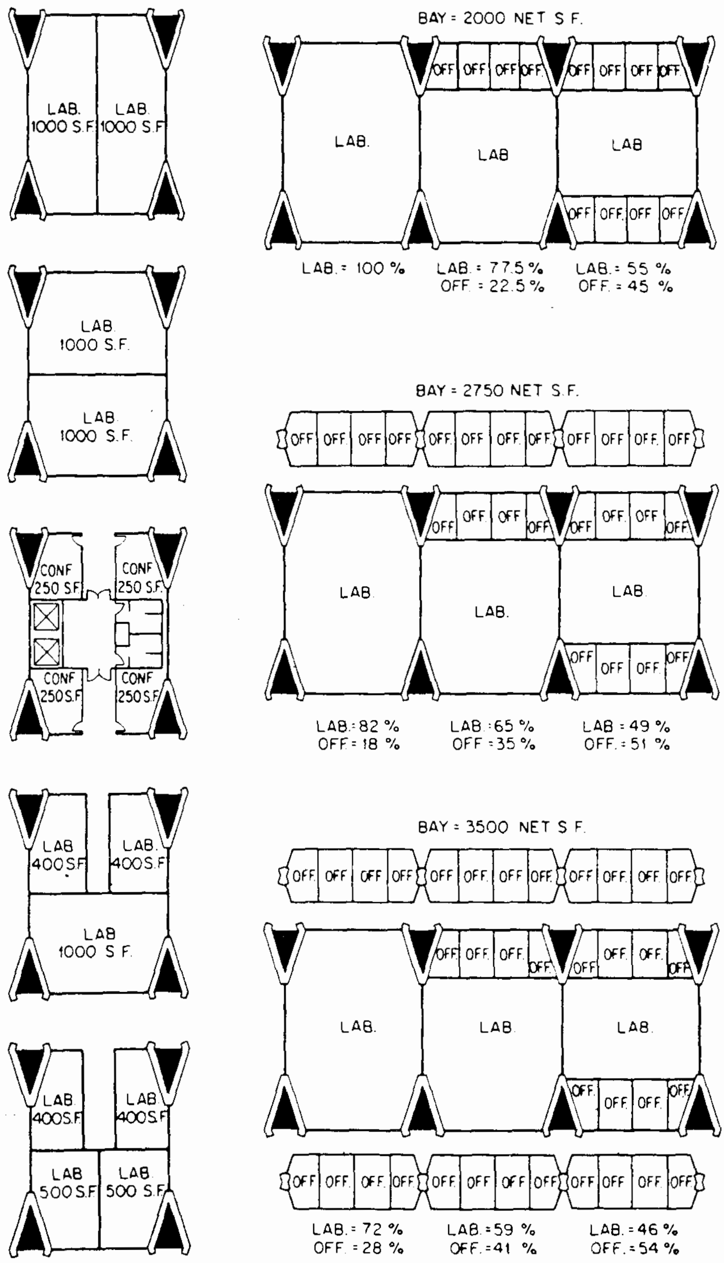
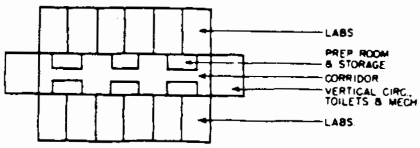
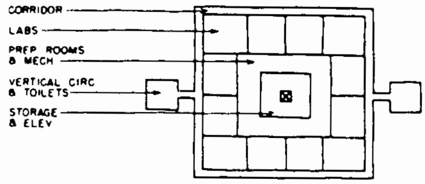


Fig. 3 A comparative study by Skidmore, Owings and Merrill of different ratios of office and laboratory space possible within a single, flexible system.

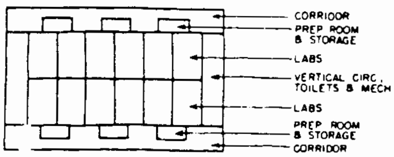
Multiple Interior Shaft System This sytem provides for concealed utilities with duct work and plumbing services in a series of regularly spaced shafts located either on both sides or on one side of a circulation corridor. All service mains and ducts are brought vertically to the various floor levels either upward or downward from the mechanical room. The shafts are located in each (or alternate) laboratory module or room on both sides of the central corridor. Distribution of utility services from the vertical shafts into the laboratory working areas is generally in the pipe space behind the laboratory benchwork. With the exception of the plumbing drains, in some designs the utility services are extended from the utility shaft below the ceiling in the laboratory and then



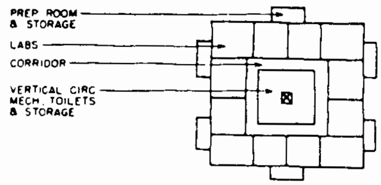
Feasibility: *Structural:* Compact plan may reduce cost. *Mechanical:* Although cores are separated, short mechanical runs reduce cost. *Circulation:* Double loaded corridors most economical. *Flexibility:* Changes may be made easily.



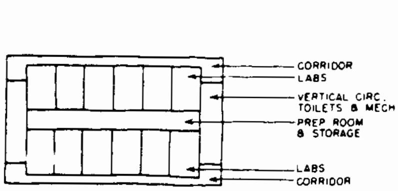
Feasibility: *Structural:* Economical arrangement. *Mechanical:* Very compact and economical. *Circulation:* Excessive corridors. *Flexibility:* Fair.



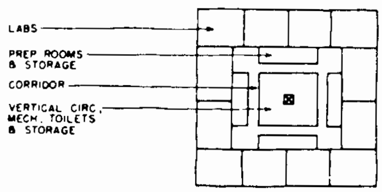
Feasibility: *Structural:* Compact plan. *Mechanical:* Separated cores and double runs of ducts, etc. may add to cost. *Circulation:* Doubling number of corridors is uneconomical. *Flexibility:* Rooms may be changed and added with ease.



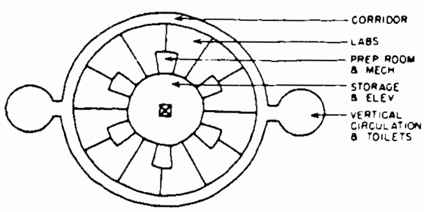
Feasibility: *Structural:* Fairly economical. *Mechanical:* Very compact and economical. *Circulation:* Very economical corridor arrangement. *Flexibility:* Fair.



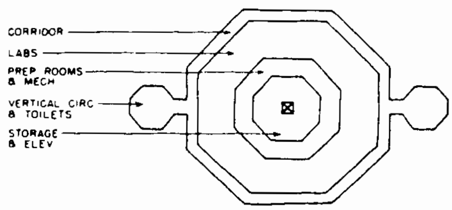
Feasibility: *Structural:* Compact plan may reduce cost. *Mechanical:* Compact system may reduce cost. *Circulation:* Double corridors uneconomical. *Flexibility:* Not as flexible as scheme above.



Feasibility: *Structural:* Economical arrangement. *Mechanical:* Very compact and economical. *Circulation:* Minimum length of corridors. *Flexibility:* Rooms changed and additions made easily.



Feasibility: *Structural:* Good form for economical structure. *Mechanical:* Very compact and economical. *Circulation:* Excessive corridors. *Flexibility:* Not too flexible.



Feasibility: *Structural:* Economical structure. *Mechanical:* Very compact and economical. *Circulation:* Excessive corridors. *Flexibility:* Not too flexible.

Fig. 4 Comparative study of different teaching laboratory layouts by Hellmuth, Obata, and Kassabaum, with an evaluation of each in terms of economy and flexibility.

downward to the laboratory benches. The interior utility shaft system is not a good selection for buildings with only one or two stories; it is most efficient in multistory buildings and is frequently found in those with a long rectangular shape.

1. Advantages
   - Good flexibility
   - Moderate net to gross area efficiency
   - Moderate initial cost
   - Moderate modification cost
   - Moderate replacement cost
   - Easier to service than the exterior shaft system
2. Disadvantages
   - More expensive and not as flexible as exposed systems
   - Available space usually does not permit individual supply and exhaust of fume hoods
   - Servicing interferes with traffic flow in corridors

The Multiple Exterior Shaft System This system brings service mains and ventilation duct work to the individual floor levels by a series of exterior wall vertical shafts located at each or alternate laboratory rooms or modules. Utility services are distributed from these exterior shafts into the laboratory rooms by means of the pipe space behind the base cabinets of the fixed equipment, or at the ceiling level. The multiple exterior utility shaft system generally should be considered only for multistory laboratories since its cost does not justify its use for one- or two-story buildings.

1. Advantages
   - Good flexibility
   - Moderate net to gross area efficiency
   - Moderate initial cost
   - Moderate modification cost
   - Moderate replacement cost
   - Low cleaning (maintenance) cost
   - Permits full usage of walls
   - Utilities are common with duct work and drainage systems
   - Good appearance
2. Disadvantages
   - More difficult to service or modify than other recommended systems
   - Requires removal of one section of case work
   - Modifications interfere with conduct of work in adjacent modules

More expensive and not as flexible as exposed systems
Available space usually does not permit individual supply and exhaust of fume hoods

The Corridor Ceiling Distribution In this system, utilities are located in the corridor ceiling and in some cases above the ceilings of the rooms on each side of the corridor and are supplied by one or two vertical pipe shafts. Distribution from the ceiling mains to the laboratory areas may be downward to the floor and upward through the floor above in order to supply two floors from one ceiling distribution arrangement. Generally, it is preferable to provide the distribution downward within each room to avoid perforation of the floor slab and consequent leaks and flooding due to accidents in later years.

This system is commonly used in research buildings with only one or two stories or where a single research floor is inserted in a multistory building primarily designed for other than research purposes. Designs employing exposed utilities are ideal for two-story or one-story-and-basement buildings where economy of construction is a major consideration.

1. Advantages
   Excellent flexibility
   Low first cost
   Low modification cost
   Low replacement cost
   High net to gross area efficiency
   Modifications do not interfere with conduct of work in adjacent modules
2. Disadvantages
   Requires increased ceiling height for same clearance
   Limits installation of wall cabinets
   Increased cleaning (maintenance) costs
   Requires independent type of air duct installation and drainage system
   Unsightly

The Utility Floor Distribution System This system probably provides the maximum of flexibility and capability in research laboratory structures. Utilities, consisting of the duct work and the plumbing systems, are in separate floors. From the supply, the service mains and truck ventilation ducts are brought to each individual utility floor by means of a centrally located vertical shaft or tower. Then distribution is made laterally on each utility floor with final distribution made by penetrating the floor below or above to service the research laboratory areas. Although this system has almost unlimited flexibility, its cost is high and it has an extremely low net gross area of efficiency. This system is primarily suitable only to multistory buildings and is not a good selection for one or two stories.

1. Advantages
   Excellent flexibility to any portion of room
   Low modification cost
   Low replacement cost
   Modifications do not interfere with conduct of work in adjacent modules
   May be used with up-feed at every floor or may be combined with down-feed and located at every third floor
2. Disadvantages
   Very high first cost
   Low net to gross area efficiency

Plumbing Systems

A plumbing system for the health research laboratory should be suited to the type of utility distribution system selected.

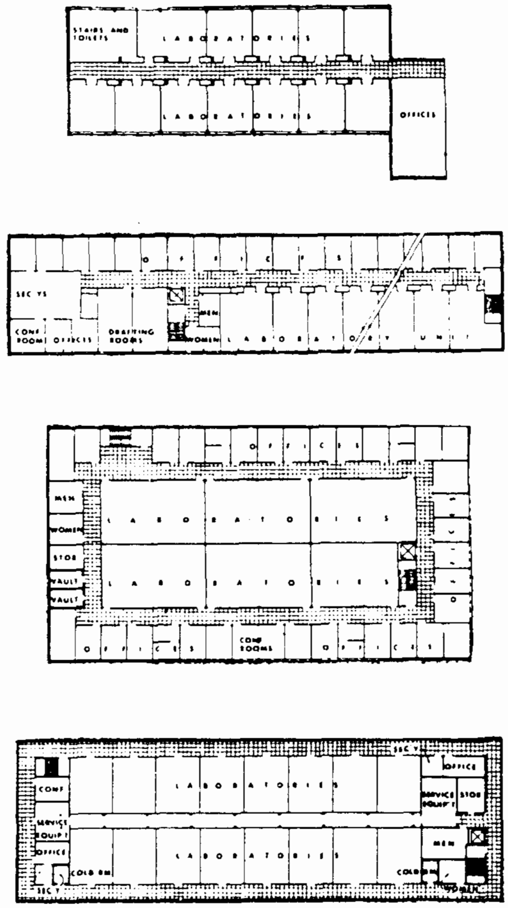


Fig. 5 Four plans by Walter Kidde Constructors, Inc. showing different basic methods of organizing an industrial laboratory.

Scope This discussion is limited to the piping systems within the laboratory building. Criteria for outside utility piping, water and sewage plants, and pumping stations are not included.

Flexibility and Capability Here again design incorporating long-term flexibility and capability is important. Focusing on the needs of individual laboratories or investigators leads to emphasis on the service piping or small services of various sinks and case work. Future revisions to such a system usually involve removal of the custom-provided service lines and either a relocation or resizing of the trunk mains in the building—a very expensive procedure.

The desirable approach is to determine plumbing service requirements either by floor or by large zones and to provide a trunk or a main distribution system that will reach all portions of the building. This should be supplemented by branch lines available to all rooms and spaces within the structure. Rooms and laboratory equipment can then be connected by small-size service piping to the nearest available branch drain bent or pressure service pipe.

As an example, plumbing stacks can be located to provide drainage capability within 10 ft of every square foot of the building, or plumbing vents and drains can be designed to provide drainage service within 20 ft of every square foot of the building.

Standardized laboratory services such as oxygen, vacuum, compressed air, hot and cold water, and gas should be designed so that the lines can be laid in parallel with a minimum of joints and elbows but appropriately equipped with valves to permit rearrangement of individual spaces without shutting off large areas of the building.

Code Requirements It is assumed that local governing codes will be followed. The following national codes may also be used for guidance: The American Insurance Association (formerly NBFU), The National Fire Protection Association, The American National Standards Association, The American Gas Association, The National Plumbing Code, and the American Water Works Association.

Functional Design Considerations

General The long-term capability and flexibility of the plumbing system requires special attention to the aspects discussed below. These considerations require that the piping follow a modular layout and, to a certain extent,

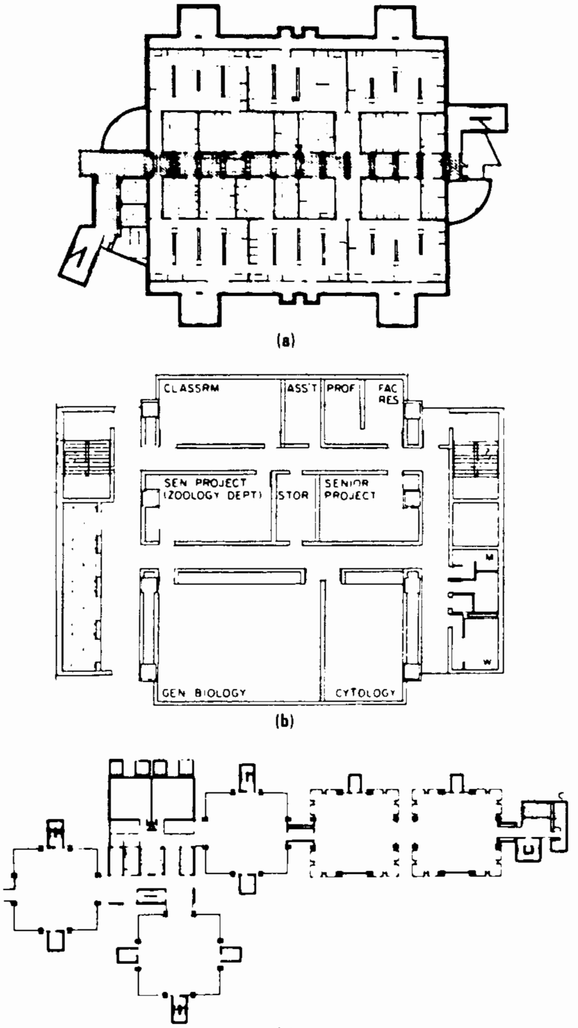


Fig. 6 Laboratory tower plans from (a) the Agronomy Building at Cornell University by Ulrich Franzen. (b) A projected science building at Barnard College by Vincent G. Kling. (c) Louis I. Kahn's Richards Laboratories.

limits the configuration and location of individual spaces as later defined by partitions.

1. Typical central services should be provided by means of vertical risers, horizontal mains, and individual room runouts, sizing the pipes in a manner which will permit, as far as possible, independent supply and control to various floors, zones, and/or individual rooms. This design approach should result in a repetitive and standardized (grid) arrangement of the risers, mains, and major branches.

2. Piped utilities should be accessible to permit extending the systems as required by future changes in research programs. Service pipe runouts (capped off when not used initially) at regular intervals in service shafts or cores will ensure maximum accessibility for future connections with a minimum of disruption to research programs in adjacent spaces.

3. To provide for future needs, the central service systems should include space for ducts and piping not initially required, pipe size which permits increased flows to meet larger demands, and adequate space to permit normal maintenance and repair.

4. Piping material should be selected on the basis of the properties required to maintain the quality of the flow material or to withstand corrosion or erosion by the various materials to be transported.

Horizontal Mains and Vertical Stacks Pipe mains and stacks may be run exposed or concealed in pipe chases or utility corridors. Pipe chases and utility corridors should have dimensions which will ensure properly spaced pipes and provide access for maintenance personnel. The chases and utility corridors will usually include air conditioning ducts and electrical conduits. The optimal arrangement of pipe spaces would provide utility mains adjacent to each health related space, so that the service to each laboratory would not be dependent on service to other spaces. The utility corridor located between rows of laboratory spaces would meet this criteria.

Pipe Runouts to Laboratory Space Satisfactory methods of installing runouts from vertical stacks and horizontal mains are overhead on exposed ceiling or behind laboratory casework and supported from the partition wall. Mains and risers located near nonlaboratory space should be provided with capped or plugged tees for ease of future connection.

Pipe Sizes in Mains and Risers The selected pipe sizes should include a factor for increased future use of the various gravity and pumped systems. For sanitary waste pipe, an anticipated increase of approximately 5 to 10 percent flow may be met by initially selecting the next larger size of pipe. Pumped services may meet future increased demand flows by an increase in pump head, while staying within acceptable pipe velocities.

Central Services Required Use of utility services will vary according to the department served. To provide greater flexibility, all laboratories should have air, vacuum, water, and gas services at all work areas.

Sanitary Piping System

Venting Each fixture should be back-vented into a circuit or loop vent in a manner prescribed by code. Locating plumbing fixtures in "peninsula" casework is not recommended, because of the difficulty in getting proper back-venting of the fixture.

Pipe Materials Ordinary galvanized iron or steel should not be used in waste pipe from laboratories intended for research in biology and chemistry, where concentrated acids may be accidentally or improperly discharged into the sanitary waste system. Acid-resisting piping materials should be used in all drainage systems serving laboratories in which acids will be used. A separate acid waste system may be necessary for areas of the building where large volumes of acids are used. This system should empty into a neutralization and dilution sump prior to discharge into the sewer.

Domestic Water Supply System

Sources of Water Supply Municipal or corporation supplies are usually preferred to other sources. A private supply of water is recommended only where public water is not available or it is impracticable to extend service to the site of the laboratory building.

Water Treatment A chemical analysis should always be obtained. Treatment of cold water supply is usually not necessary when the water is obtained from a municipality or from a utility corporation. Water softeners of the Zeolite type are recommended when the water has a temporary hardness of 10 or more grains per gallon, or a total hardness of 18 or more grains per gallon. Boiler feed water softeners are recommended if the temporary hardness is 4 or more grains per gallon.

Interior Water Piping

1. *Location of Mains* The water supply system should be distributed throughout the building and the mains should generally run near the ceiling of the lowest story.

2. *No Cross Connections* Cross connections between water supply piping and waste, drain vent, or sewer piping should be strictly prohibited, whether the connection is direct or indirect.

3. *Backflow Protection of Water Piping System* Water distribution systems must be protected against backflow [the flow of water or other liquids into the distributing pipes from any other source(s) other than its intended source]. Water supply connections or out-

lets to plumbing fixtures, tanks, receptacles, or equipment should be protected from backflow as follows:

a. The preferred method is by means of an approved air gap, as specified in American National Standard A40.4-1942.

b. Where it is not possible to provide a minimum air gap, the supply connection should be equipped with an accessibly located backflow preventer (nonpressure type vacuum breaker) installed beyond the last control valve in compliance with American National Standard A40.6-1943.

c. An alternate approved method is the use of an industrial water system to serve all laboratory work areas. This distribution system must be independent of the potable domestic system. This can be done by connecting the industrial water main to the building service line at the point of entry into the building, beyond the point of connection for the potable water and with a suitable backflow preventer inserted between the points of potable and industrial water system connections.

Distilled and Demineralized Water

Quality of Water The quality of the water required in health related spaces will determine whether distilled or demineralized water should be distributed through a central piped system. The analysis of local water characteristics will help determine if demineralization alone will produce water of the desired quality. Where demineralization alone will not suffice, distillation is required.

Size of System Stills and storage tanks should be large enough to assure an adequate daily volume of water. Still size can be determined on the basis of a continuous 24 hour operation of the still and the provision of adequate storage tank capacity. The system should be designed so that part of it can be shut down for servicing without cutting off the entire system.

Location of Stills Stills and demineralization equipment should be located at an elevation within the building sufficient to provide gravity flow to the outlets in the piping system. Mechanically pressurized systems are not recommended, since the pump and fittings may introduce impurities into the high quality water.

Materials of Construction "Black" tin (purity in excess of 99.9 percent tin) is recommended only when ultrapure water is required. Other materials which have been successfully used alone or as lining in tanks and piping are plastics, glass, aluminum, or stainless steel. The selection of a particular distribution piping and storage tank material must be based on water purity and contamination studies, previous experiences, and cost analysis.

Fire Protection

The requirements for standpipes and/or portable fire extinguishers are set forth in applicable local or national codes. Where the fire hazard in laboratories and ancillary spaces is above normal, an automatic sprinkler system or automatic detectors should be installed. Where the application of water by usual methods would be harmful or dangerous, an automatic or manual protective system should be installed, to suit the classification of fires from which protection is needed.

Gas Piping

Design All gas piping should be designed in accordance with NFPA Standard No. 54, Installation of Gas Appliances and Gas Piping. These lines should be sized to provide for expansion of the service and to maintain adequate pressure at the workbench. In general, gas piping should not be run in trenches, tunnels, furred ceilings, or other confined spaces where leaking gas might collect and cause an explosion.

Piping Materials Gas service pipe from the street to the building should conform to the regulations of the local gas company. Gas piping inside the building should be black steel with malleable - iron - banded fittings.

Valves Gas piping should have a shutoff valve just inside the building and at other points where it would be desirable to isolate certain sections.

Compressed Air and Vacuum Systems

Air Filters and Driers Compressed air must be of high quality—substantially free of oil, impurities, and water. Centrifugal compressors are ordinarily used to provide oil-free air. If a small amount of oil is acceptable at points of use, a main oil separator with additional separators at the using equipment will be adequate.

Air driers are required when moisture will create difficulty in laboratory instruments, or where compressed air piping may be exposed to freezing temperatures. Where laboratory requirements do not dictate dew points below 40°F, the dryness requirements can be achieved by the use of refrigerated water or direct expansion refrigeration in an aftercooler. The aftercooler may be air-cooled in the case of small compressors.

The pressure required at the workbench need not exceed 40 psig and flow requirements of 5 scfm at every station. The compressor pressure is based upon the needs of the equipment requiring the maximum pressure at point of use.

The vacuum requirements at the workbench are 5 cfm at 28 in. Hg at each service outlet. Receptor jars must be used between the equipment and the vacuum outlet, to prevent liquids and solids from entering the vacuum system. The air discharged from vacuum pumps should be exhausted outdoors, to prevent entry into the equipment room of toxic or flammable solvents.

Pipe material may be either copper or galvanized steel with threaded malleable-iron fittings.

HVAC Systems

Heating, ventilation, and air conditioning (HVAC) account for 25 percent to 50 percent of the cost of a health research facility. The design and functioning of the HVAC system should be considered very early in the planning process. Such early planning will avoid the extra expense and less satisfactory results obtained when HVAC engineering is limited to the inflexible confines of architectural design in progress.

The heating requirements of a health research facility do not differ significantly from those of a conventional commercial building, and have not been discussed here.

Electrical Supply

The power demand of laboratory instrumentation added to that of the building itself—for light, air conditioning, ventilating fans, etc.—makes the provision of electric power, and its distribution, of key importance in the planning of a health research facility.

Flexibility and capability in this case means more than planning excess capacity for future needs. When electricity stops everything in the laboratory is affected. Emergency sources of power must be provided, and a system of priorities set up to determine which functions will have first call on the emergency power supplies.

LABORATORY PLANNING

Laboratory planning is generally regarded as one of the most difficult assignments with which an architect can be confronted. It involves the development of a layout to meet an exacting set of conditions, and the integration of complicated engineering services.

It is essential that the module and layout of the individual laboratories be considered in detail before even preliminary sketch plans are prepared. This can best be done in the following sequence.

Module

A module of 10 ft is recommended; this is the distance from center to center of two peninsular benches, and it is based on a bench width of 5 ft with a space of 5 ft between. In a one-module laboratory it is the distance between the center of one partition and the center of the next; it is based on a wall thickness of 4 in, a bench 2 ft 3 in wide on one side and a table 2 ft 6 in wide on the other—to give a space between of 4 ft 11 in. Generally an entirely satisfactory and clean-cut layout can be planned with the 10-ft module, but if it is necessary to have greater flexibility (i.e. rooms 15 and 25 ft wide), then a module of 5 ft must be used. Of course, the module is dependent on the width of the benches and the space between them. The most convenient metric equivalent is a 3-m module.

Width of Bench In chemistry laboratories, the generally accepted width of benches fitted with reagent shelves is 2 ft 6 in for wall benches and 5 ft for peninsular benches. In physics laboratories, widths of 3 ft and 6 ft are sometimes preferred, with a wide shelf for electronic equipment. In some laboratories, a bench width of 2 ft or 2 ft 3 in is adequate. Where solid timber tops are used, the consideration of width in relation to cost is relatively unimportant, but where sheets of some material are being used, the width should be considered in relation to sheet size so that waste is reduced to a minimum.

Space between Benches As building costs rise, it is to be expected that the distance between benches will receive closer scrutiny. Some research laboratory planners maintain that the increasing use of mobile equipment justifies the adoption of a 6-ft space. If it is adopted, then in a building 200 ft long it means the loss of one 2-module laboratory; conversely, a decrease from 5 ft to 4 ft 6 in means a gain of one 1-module laboratory.

The distance should be determined by considerations of convenience and safety, i.e., one person should be able to pass another (working at the bench) comfortably and without risk of collision if the latter should step back unexpectedly. Experience has shown that 4 ft 6 in to 5 ft is ideal; 4 ft is cramped. It must be admitted that there are laboratories in which one man works between benches separated by as little as 3 ft 3 in, but such a small space should certainly not be thought of when planning a new laboratory.

In student and routine laboratories where there is less bench space per person and often two people will be working back to back immediately opposite each other, the space between the benches should be greater than 5 ft so that there is room for others to walk down the center.

Layout of Laboratory

Having established the module, it is now necessary to settle the size and position of laboratory offices, the depth of laboratories and the position of service laboratories, fume cupboards, and service ducts. All of these are vitally important in themselves, and of course they actually determine the type of layout which is to be adopted. Let us consider each of these items.

Laboratory Offices There are many scientists still alive today who have worked in laboratories where offices were not provided; the lucky ones had tables in the laboratory and the others just shifted some equipment off the bench to make space for report writing. For a number of years now, it has been standard practice to provide every scientist with an office; it is quite usual to provide individual offices for senior technical officers also, whilst laboratory assistants are expected to share offices or have writing spaces provided for them in the laboratories.

The best location for laboratory offices is always a controversial subject. Are they to be within the laboratory, adjoining the laboratory, on the opposite side of the corridor, or grouped in a separate part of the building? Is it essential for all offices to be on an external wall?

Some senior scientists consider an 8-ft by 6-ft office within the laboratory entirely satisfactory. These people spend most of their time actually working in the laboratory and the closeness outweighs the advantages of greater privacy and silence in a larger office across the corridor. In any case, for report writing it is much more satisfactory to use a carrell in the library. The internal office shown in Fig. 1 has a 6-ft by 2-ft 6-in table with bookshelves above and a filing cabinet beneath. This layout has the advantage that the full length of the building is available for laboratories and, with an off-center corridor, the service laboratories can be conveniently located along the opposite side.

Offices which adjoin laboratories also have the advantage of closeness and they can be larger than the internal office—one dimension is fixed by the module of 10 ft—but they do have the disadvantage that they use the more expensive serviced area. The alternative is to provide offices along the unserviced area on the opposite side of the corridor, but many scientists consider this separation from the laboratory undesirable, and the further the offices are from the laboratories, the more serious this becomes. In the case of offices grouped on another floor, the scientist may even think twice before making the effort to get to his laboratory.

Some scientists consider 10 ft by 10 ft an absolute minimum for an office, and others argue strongly for 10 ft by 12 ft, or even 10 ft by 14 ft. Certainly, when the offices are along one side of a corridor, a depth of 14 ft makes it possible to get a more satisfactory layout for stairs, toilets, etc.

For large projects, it is necessary to consider laboratories on both sides of the corridor; in this case, offices must be either in (or adjoining) laboratories or grouped in a separate wing of the building. For still larger schemes, the double-width layout provides the best solution.

Details of the various positions of offices are shown in Figs. 2, 3, 4, and 5.

Depth of Laboratories Over the last 40 years, the depth of laboratories has increased from about 16 ft to 24 or 25 ft, with some going to 27 and even 30 ft. This has resulted in a better utilization of space and, as the span is within economic limits, the additional area is obtained at a lower cost per square foot. For the standard type of peninsular bench layout, a clear depth of 24 ft is recommended.

Service Laboratories These laboratories are either planned to be integral with the laboratory and laboratory office unit or they are provided on the opposite side of the corridor; again, the various positions are shown in Figs. 2, 3, 4, and 5. Much of the equipment housed in these rooms is expensive and therefore it must be shared; it follows that this equipment must be located so that it is convenient to the maximum number of staff.

Fume Cupboards The risk of accident is greater in a fume cupboard [hood] than elsewhere in the

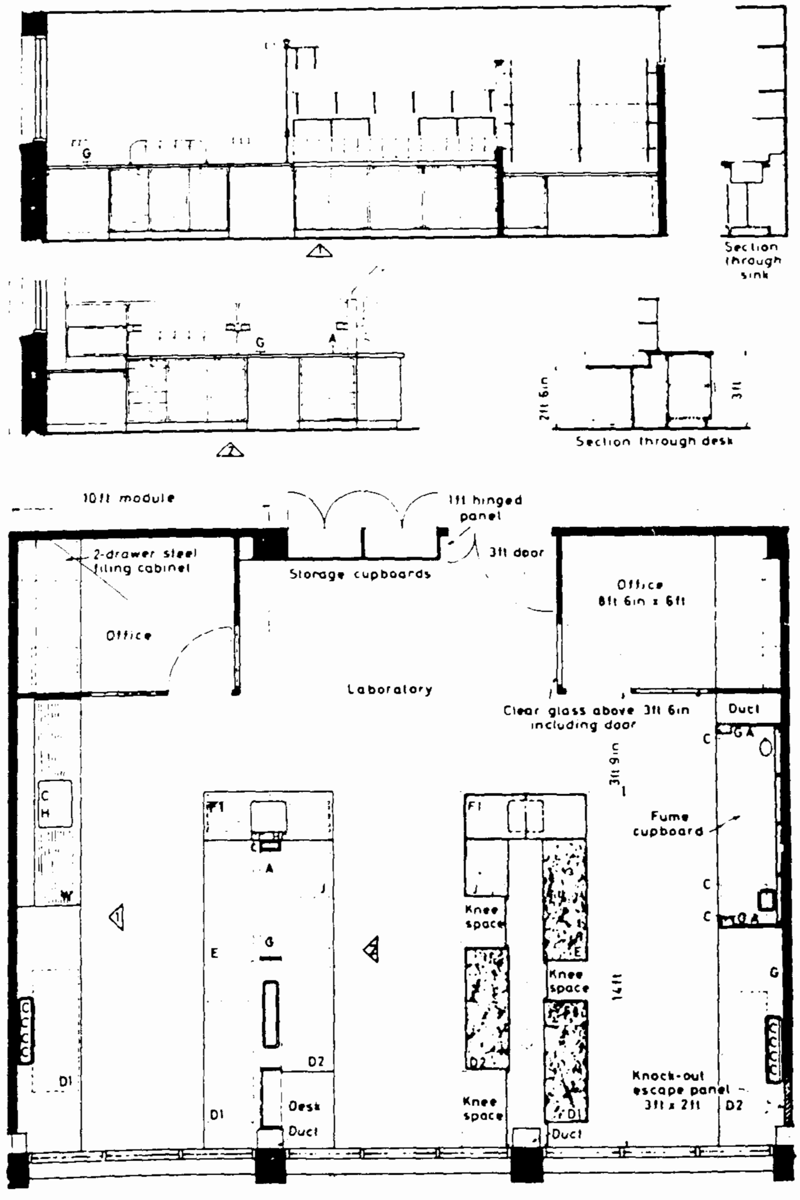


Fig. 1 Layout of a three-module, 30-ft by 24-ft laboratory.

laboratory; so, for reasons of safety, one should not be located where it will block an exit. Of course, if there is an alternative exit from the laboratory, this difficulty does not arise.

Fume cupboards require an exhaust duct with a diameter of from 8 to 12 in. Preferably the duct should connect from the top center of the cupboard and rise vertically to discharge the fumes above the roof. This does not present a problem in a single-story building—except, perhaps, when the architect insists on some symmetry in the positions of the outlets on the roof. However, in a three-story building, the position of the fume cupboards and the space required for exhaust ducts become more involved; if, in the preliminary planning stage, time is spent working out these details, it will obviate later troubles such as horizontal ducts which are too long or riser shafts which are too small.

The installation can be simplified by having the laboratories requiring the most fume cupboards on the top floor; quite often the entire ground-floor space can be allotted for rooms and laboratories without any fume cupboards.

Service Ducts The mechanical services are a major feature of any laboratory and, in order to achieve good design, location, and accessibility, they must be given a lot of thought. In some laboratories the installation will involve three or four pipes, and in others there might be six or more.

For benches serviced from the external wall, there should be horizontal and vertical ducts with removable covers. For benches serviced from the corridor wall, it is necessary to have a vertical duct accessible from the corridor. In some laboratories—especially if island benches are being used—the service pipes are reticulated in the space between the floor slab and the removable ceiling. This system does have the disadvantage that it requires many holes through the floor and, in the event of floods, these will cause trouble in the room below; also, repairs and alterations seriously disrupt work in the laboratory and, what is worse, it is somebody else's laboratory! Nevertheless, this system is preferable to the use of ducts in the floor because, even at high cost, it is quite difficult to get a cover which is removable, serviceable, rigid, neat in appearance, and perfectly flush.

For large projects where the double-width layout has been adopted, a service corridor is the obvious solution because it provides excellent accessibility to horizontal and vertical pipes and, in addition, space for fume cupboard exhaust ducts and miscellaneous laboratory equipment such as pumps.

Type of Bench There are three types of bench—peninsular, island, and wall. As the names imply, the peninsular bench projects from the wall and the island bench is free-standing.

With the greater depth of laboratories, the use of peninsular benches at right angles to the windows has become almost mandatory. They are preferable to island benches because the installation of services is easier and less costly, and there is minimum shadow when they are fitted with reagent shelves. Most laboratory workers will no longer argue that the extra space required to give access to four sides of an island bench is justified.

As a general rule, wall benches under windows should be avoided; facing the sun in front of windows on the east and west elevations makes working conditions quite intolerable. For windows facing north, screening the low-angle sun in the winter is not always satisfactory; even with south-facing windows, glare can be a problem. Wall benches between peninsular benches create inaccessible pockets on either side and, for this reason also, they are not recommended.

Whether it be a one-, two-, or three-module laboratory, the combination of peninsular and wall bench at right angles to the external wall produces the simplest layout. The one-module laboratory provides the most wall space per unit area; the three-module laboratory has the widest application because in many cases it accommodates the optimum number of staff to share equipment and facilities.

Details of a layout which has been used quite extensively are shown in Fig. 1. This layout can be adapted to meet a wide range of conditions—for example, one or both of the offices can be omitted, the number and type of bench units and service outlets can be varied, the reagent shelves can be reduced in length or omitted, or one whole bench can be omitted to leave space for equipment or a rig for setting up apparatus.

Prototype Laboratory or Bench For large projects, it is a very good idea to have a prototype laboratory, and for small schemes at least a prototype bench. If these are to achieve their real purpose, they should be complete with services and accurate to the smallest detail. Most scientists can read plans very well; however, there are always some who can't visualize the finished product, and for them, and for the builder and his subcontractors, a prototype is a great help. Invariably, after examination and discussion, some improvements or economies are effected. Also, when a prototype is available for inspection by tenderers, its cost can be offset by more accurate estimating.

Windowless Laboratories and Offices Given a choice, most people would prefer to work in a laboratory which has windows; it is very pleasant to be able to look out on a garden or landscape, or even to get a glimpse of the sky. There is a prejudice against working in rooms without windows because it is thought that they create a sensation of being confined. The objection to this feeling of lack of contact with the outside world can be partially overcome if it is possible to 'look out if you want to'—for example, in some double-width laboratories, the door to the internal laboratory is opposite the door of the external office, and both are in line with the window; the doors have clear-glass top panels. In one windowless laboratory I have visited, I was interested to see a brightly colored landscape hanging on the wall of an internal office; in another—a physics laboratory—many of the staff have worked quite happily for years in basement rooms; in yet another which has windowless laboratories and offices, the Director told me that, after 12 years' occupation, 'early apprehension that a closed-in feeling due to lack of outside windows would be a problem has not materialized.'

Laboratories without windows are shielded from the sun and external temperature variations, and it is possible to get much more accurate temperature control; another asset is more wall space. My impression is that windowless laboratories (and, to a lesser extent, windowless offices) are likely to be accepted more readily in the future.

Width of Corridors Factors which determine the width of corridors include the amount of traffic, the length of the building, and whether the doors open in or out; in overseas laboratories it is usual for doors to open into the corridors. Relevant details regarding five laboratories are:

Laboratory	Width of corridors	Length of building	Doors
Abbott	6 ft	224 ft	Single, 3 ft wide, opening out, serving rooms one side only
Battelle	7 ft 6 in	276 ft	Single, 3 ft 3 in wide, opening out
Bethlehem	7 ft	315 ft	Double, 2 ft 10 in + 1 ft wide, opening out from laboratory wall of service shaft at which point the corridor is 12 ft wide
Hoechst	6 ft 6 in	328 ft	Single, 3 ft 3 in wide, opening out from laboratory wall of service shaft at which point the corridor is 9 ft 9 in wide
National Bureau of Standards	7 ft	385 ft	Double, 3 ft + 1 ft 6 in wide, opening out from laboratory wall of service shaft at which point the corridor is 12 ft wide

There is very little traffic in the corridors of research laboratories, and in Australia, where the doors generally open into the laboratories, a width of 5 ft 6 in is adequate; furthermore, the narrower width helps to prevent the motley collection of refrigerators and cupboards which so often are lined up along one or both sides of the corridor. Nevertheless, 5 ft 6 in is an absolute minimum and assumes that there are no projecting columns; if the length of the building exceeds 200 ft, this width should be increased slightly to be visually acceptable.

Adoption of a Basic Laboratory Layout Every effort should be made to develop a basic layout which is standard throughout the building. This is not easy because on every job there is generally at least one scientist who, without any real justification, insists that his office or bench should be in a different position, and he will advance reasons why his idea of layout is necessary for some particular investigation. If he wins his argument and his laboratory layout is nonstandard, it so often happens that the project stops, or he leaves, and it is almost certain that his successor will require a different layout. On the other hand, there are some situations where it really is necessary to meet particular requirements, but these can and should be met by variations within the basic layout.

The establishment of a basic layout requires some firm decisions by the officer in charge, and these must be applied with a certain amount of ruthlessness if this proves necessary.

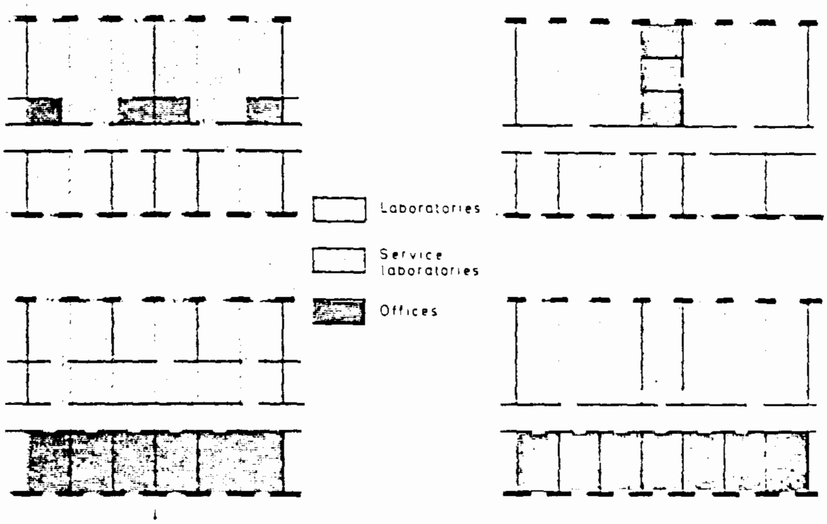


Fig. 2 Off-center corridor layouts, showing the relative positions of laboratories, service laboratories, and offices.

Layout of Building

Whilst the planning of each laboratory building has its individual problems, the range of layouts can be narrowed to a few which have been found satisfactory. Depending on the size of the project, the type of work, and the space available, any one of the following can be recommended.

Off-Center Corridor This layout has wide application for relatively small schemes—for instance, from a single-story building 100 ft long to several two- or three-story buildings about 200 ft in length. It has the great advantage that all the laboratories can have a south-facing aspect, and the two room depths provide flexibility in planning. Four variations of this layout are shown in Fig. 2.

Central Corridor This layout is more suitable for larger schemes. It has the advantage that the grouping of laboratories is more compact because they are on both sides of the corridor. Also, as the same width corridor is serving a wider building than in the case of the off-center layout, it provides a greater assignable space. However, it does mean that half the laboratories have a north-facing aspect. Two variations of this layout are shown in Fig. 3.

Double Corridor This layout provides a good interrelationship between laboratory, laboratory office, and service laboratory, and it sometimes offers the best solution when the width of the building is fixed within certain limits. It has the advantage that, as the service laboratories are windowless, it is easier to obtain accurate temperature control; in many cases, the absence of natural light is an asset. (See Fig. 4.)

Service Corridor The double-width layout shown in Fig. 5 is especially suitable for large schemes. As laboratory services become more complex, and temperature control more critical, it is likely that this type of layout will be more widely accepted. The increased area at one level contributes to more efficient operation because the scientific staff are brought closer together and the sharing of equipment is facilitated.

Assignable Area The gross area is the overall area of the building, the assignable area is the actual area of usable space, and the difference is the combined area of entrance halls, corridors, stairs, toilets, ducts, and wall thicknesses. The 'use factor' is the ratio of assignable area to gross area, and it ranges from approximately 50 to 70 percent.

The best utilization of space is obtained by having one corridor serving rooms on both sides. For example, in the simplest type of three-story building with minimum entrance hall, a 5-ft 6-in corridor with 24-ft deep laboratories along one side and 14-ft deep service laboratories along the other:

Gross area	201 × 47		9447 ft²
Assignable area			
Laboratories	196 × 24	4704	6762 ft²
Service laboratories (allowing five modules for stairs, toilets, elevators, and ducts)	147 × 14	2058	

$$\text{Use factor} = \frac{6762}{9447} = 71\%$$

Obviously, a corridor serving rooms on one side only, or two corridors serving three rooms, decreases the ratio of assignable to gross area and therefore increases the cost.

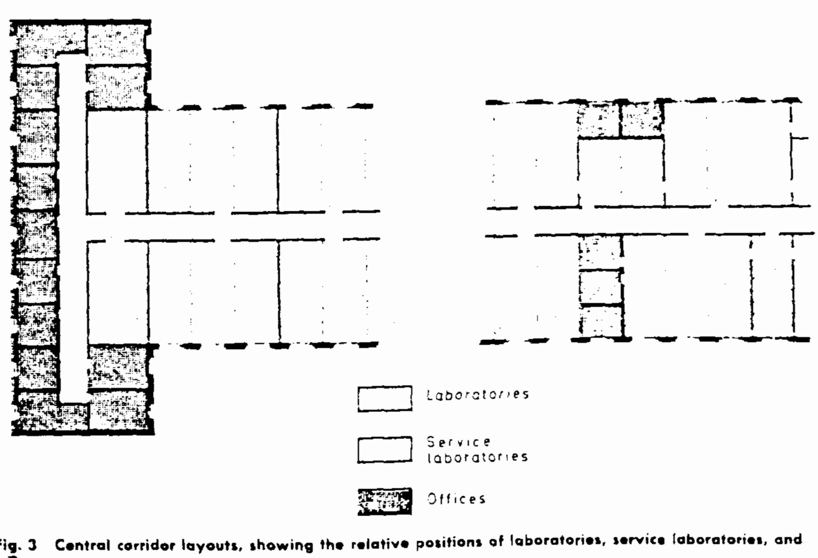


Fig. 3 Central corridor layouts, showing the relative positions of laboratories, service laboratories, and offices.

Floor Space per Person The space required by scientists varies greatly. Most require a laboratory, a laboratory office, and access to several service laboratories, but quite a number need additional facilities such as glass-houses, animal pens, or large areas for pilot-plant investigations or the preparation and storage of many hundreds of specimens. Then again, some scientists use equipment which is small and commercially available, whilst others must have large equipment which often has to be specially designed and fabricated in workshops on the site.

Bench Space per Person One measure of good laboratory accommodation is adequate bench space. The layout shown in Fig. 1 provides 62 lineal feet of bench; this represents 15 lineal feet per person for four (with a maximum of five) persons. A bench length of 12 to 15 ft per person is a generally accepted standard, and an uninterrupted length is preferable to several short lengths.

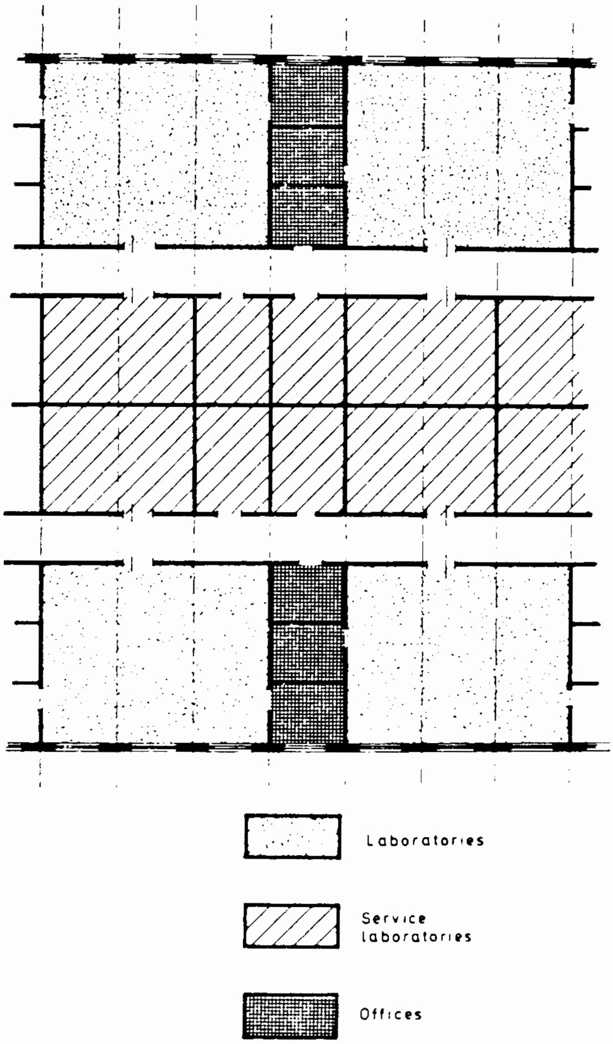


Fig. 4 Double-corridor layout, showing relative positions of laboratories, service laboratories, and offices.

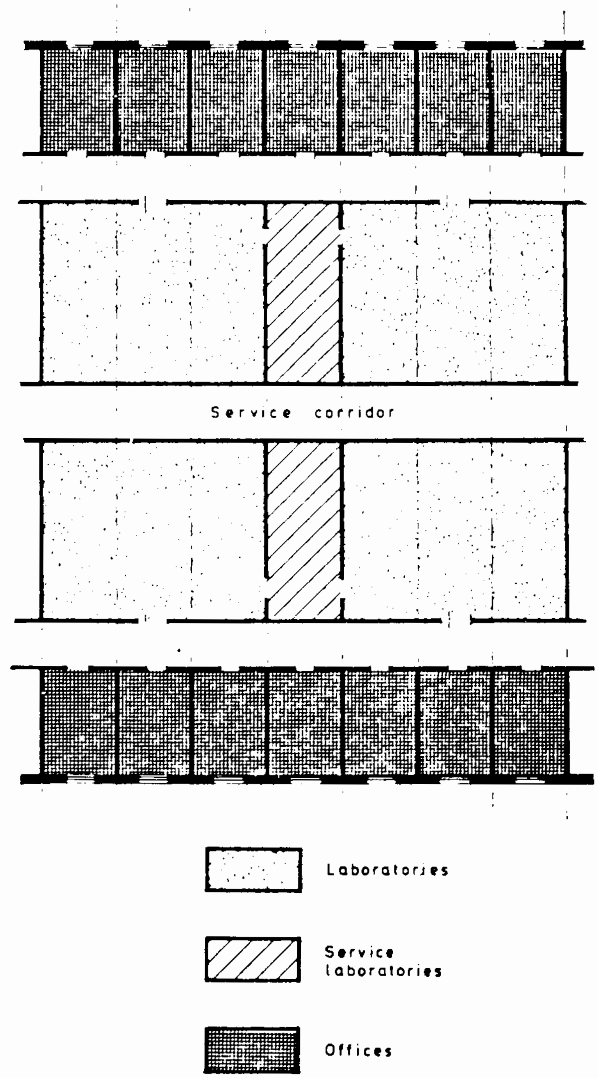


Fig. 5 Double-width layout with service corridor, showing relative positions of laboratories, service laboratories, and offices.

WAREHOUSING AND STORAGE

Warehousing Warehousing is the receiving, storage, and delivery of goods.

Receiving Receiving is the acceptance of goods with a degree of accountability therefor.

Storage Storage is the safekeeping of goods in a warehouse or other depository.

Delivery Delivery is the transfer of goods to transportation carrier or customer.

Distribution Distribution is a function of warehousing which includes the preparation and delivery of goods according to plan or special order.

General History

Modern warehousing has progressed in recent years to a point where old warehouse structures are costly to operate. The old-type warehouse buildings usually do not have sufficient floor-load capacity in the upper floors and do not allow the adoption of economical storage methods in the receiving and shipping areas. The emphasis today is on the maximum use of the "cube" rather than the square foot of warehouse space, on distribution rather than storage, and on power handling equipment rather than hand labor.

The design of a warehouse should be based upon the most economical methods of materials handling. High stacking, with minimum use of aisles, is the keynote of maximum "cube" utilization. Modern warehouse design generally includes clear spans ranging from 60 to 100 ft, roof elevation sufficient to allow 18 to 20 ft (and higher) stacking height, and shipping and receiving areas located at box car or truck level.

Fundamentals of Modern Warehousing

One-Story-Type Building (Fig. 1) The study of multistory vs. one-story warehouses is complex and requires a complete engineering survey. The factors for consideration are partially listed herewith.

One Story:

1. Low-cost ground advisable
2. Availability of land for expansion
3. Less time for erection
4. Less area lost—sidewalls, columns, elevators, stairways, etc.
5. Adaptability to long-span construction
6. High floor loads
7. Greater flexibility for layout changes
8. Greater handling efficiency possible
9. Supervision easy and effective
10. Maximum use of daylight and natural ventilation
11. Hazardous areas easily isolated

Two (or More) Stories:

1. High cost of ground
2. Limited area for site
3. Natural topography may permit entrance at different levels
4. Ease of expansion if foreseen
5. Floor load may be limited in upper levels
6. Product stored and handling equipment should be light in weight or small in bulk
7. Handling distances reduced with gravity flow
8. In some locations, less dirt and better ventilation on upper floors
9. Lower heat loss through roof

In general, the overall economic evaluation of the one-story warehouse indicates a lower investment per cubic foot of storage space. The low-cost types of roof construction and the reduction of steel and masonry for additional floors are the significant cost-reduction items. Another major point of concern is the demand for increased floor-load capacities to support industrial truck equipment and heavier unit loads.

Flexibility of Layout and Equipment Flexibility of storage allocations is obtained by the installation of minimum permanent storage aids. This can be accomplished by providing bolted-up types of pallet racks, bins, or shelves. The use of pallets and pallet pattern selection guides should provide the maximum cube utilization as well as stability. The large-size pallets are usually economical for warehousing operations.

Shipping and receiving areas should be designed for two-way operation over the same platform where possible. The main aisles of transportation within the warehouse should allow the passage of materials handling equipment in both directions.

Efficient material movement is best obtained by wheeled vehicles in a warehouse of peak demands. Goods can be stored or accumulated prior to shipping during off-peak periods.

The versatility of the fork truck and package conveyor is responsible for their wide acceptance. Fork trucks are made especially adaptable with a variety of attachments for special purpose handling.

Selection of Warehouse Materials Handling Equipment The proper selection and use of materials handling equipment is an important factor to initiate and maintain warehouse operation efficiency. Warehouse design is often evolved around a well-engineered handling technique.

Typical handling methods include the following:

1. Tow conveyor (dragline conveyor)
2. Pallet systems (skids, bins, racks, unit loads, etc.)
3. Tractor trailer and fork truck (wheeled vehicles)
4. Overhead systems (monorail, bridge crane, stacker crane, etc.)
5. Conveyors (vertical and horizontal movement)

Considerable emphasis has been placed on narrow-aisle handling during recent years. The narrow-aisle straddle fork truck with 100 percent selectivity of goods in stock on pallet racks has been much used. Space savings have been particularly attractive with small pallets where right-angle stacking aisles have been reduced in some cases to 6 ft. The aisle-space savings of the straddle fork truck are usually offset by increased operating cost due to the slow speeds in stacking and transporting inherent in the equipment. Increased side clearance between pallet stacks and the decreased stability of the truck chassis for high stacking heights are also items to be considered for overall evaluation.

When selectivity is not a prerequisite and bulk storage is possible, the straddle-type truck is less desirable on account of the clearance required between storage rows. A later design of the narrow-aisle type industrial truck provides forks which retract the pallet load within the wheelbase of the vehicle. Normal pallet side clearances can be maintained comparable to the standard fork truck. The front-wheel diameter has been increased to reduce floor wear experienced with the straddle fork truck with small steel wheels. The limitations of narrow-aisle equipment as listed above should not be overlooked in any warehouse operation where high turnover of inventory is required.

Tow conveyor systems have been installed in many warehouses and truck terminals where order makeup or sorting operations require maximum flexibility.

Tractor-trailer trains have been utilized to advantage where long horizontal movements are required. With a fork truck loading pallets on trailers and a second fork truck unloading pallets at the delivery point, maximum utilization of equipment is obtained. In this way, heavy tonnage can be handled in minimum time, or a tractor-train schedule can be set up for repetitive delivery to various points.

Overhead bridge cranes require no aisle space if the goods to be stored are handled with special lifting devices. Paper rolls and other large units are warehoused in this manner. Monorail systems are used as a general purpose method of handling bulky, extra long, or heavy loads in congested areas.

The stacker crane is recommended for evaluation when selectivity of pallets or unit loads is required in narrow-aisle operation. Maximum storage heights may be attained in safety for maximum vertical-height utilization. The hoisting mechanism is suspended from the overhead traveling bridge. Recent comparisons in warehouse floor-space requirements indicate that the stacker crane is more efficient then the straddle fork truck.

Fixed-route package conveyors are usually designed to handle a constant flow of material of similar products. Cases, boxes, drums, bags, etc., can be conveyed from production line, through warehouse, to shipping platform with minimum handling. Conveyors are usually engineered for a specific size and weight of product. A thorough study is required to select the most suitable and economical handling system.

William Staniar, M.E., Editor-in-Chief, *Plant Engineering Handbook*, 2d ed., McGraw-Hill Book Company, New York, 1959.