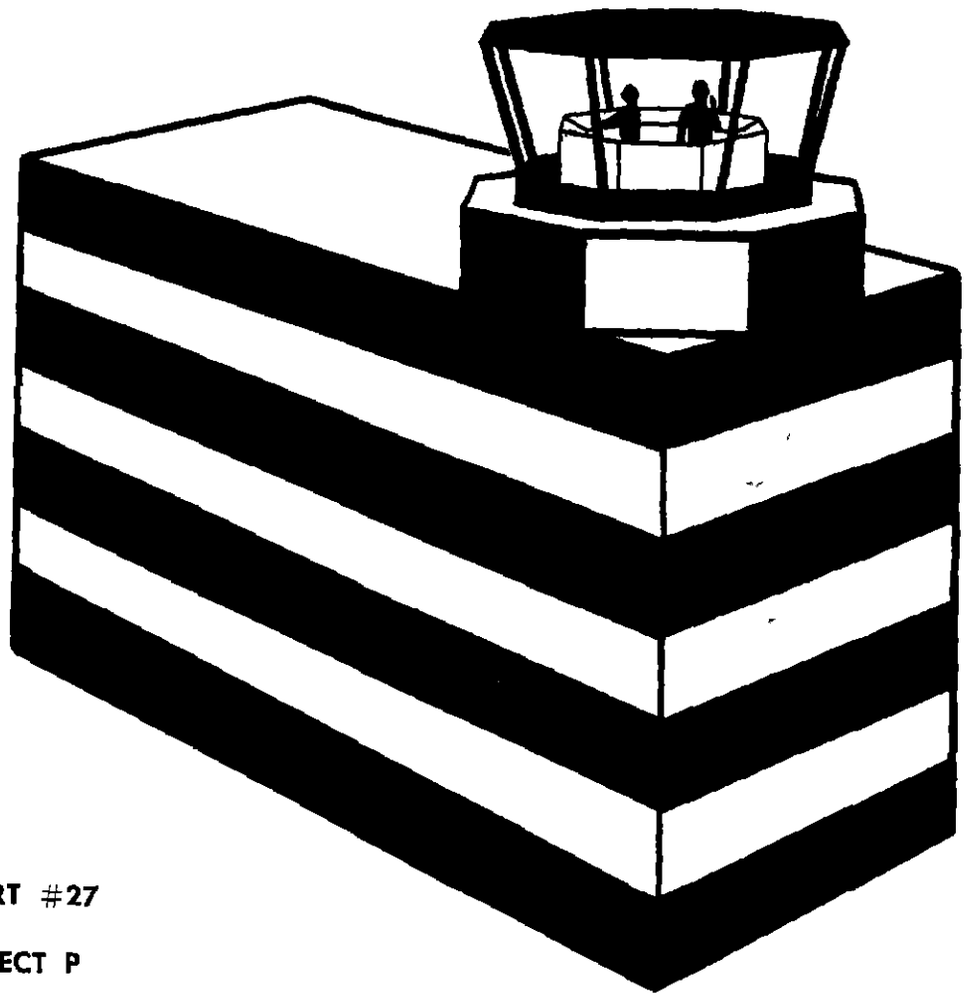
HUMAN FACTORS CONSIDERATIONS IN THE DESIGN OF AIRPORT TRAFFIC CONTROL QUARTERS

(SECOND INTERIM REPORT)



REPORT #27

PROJECT P

1 JUNE 1959

COURTNEY AND COMPANY

HUMAN FACTORS CONSIDERATIONS IN THE DESIGN OF AIRPORT TRAFFIC CONTROL QUARTERS

(Second Interim Report)

Preliminary Engineering Layouts

Report #27
Project P

1 June 1959

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PREPARED

FOR

Bureau of Research & Development
Federal Aviation Agency
Washington 25, D. C.
Contract FAA/BRD-89

BY

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ACKNOWLEDGMENTS

In developing the materials for this report we have received so much constructive advice and counsel from Airways Operation Specialists in towers, centers, and communications stations throughout Region One and other regions that we do not know how to acknowledge each and every contributor to this report. Let it suffice to say that in every one of these facilities we have received hospitality, cooperation, and major idea contributions from working controllers. We should like to hereby acknowledge their continued contribution.

Special appreciation is hereby expressed to

... Dr. H. Richard van Saun, Chief, Human Factors Branch, Operations Analysis Division, Bureau of Research and Development, Federal Aviation Agency, as current Project Manager.

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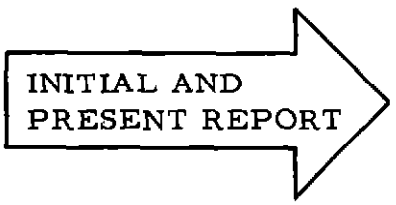
INTRODUCTION

As a preface to this report the contract tasks are set out below identifying the reports in which they are found.

"TASK I Provide written recommendations and drawings for the over-all space requirements and general layout of air traffic control quarters including the tower cab, IFR room, controller ready room, training space, and visitors observation area. The space requirements will be defined in the number of square feet required for each room or area, and the desired shape of the room. The general layout will include the geographic relationship of each room or area to each other. Space requirements should be established in more than one category, if required, based on the type and volume of operations to be conducted.



"TASK II Provide recommendations and drawings for the design of control tower cab windows to minimize problems of glare, light reflections and condensation on the windows. These recommendations shall include consideration of problems to be encountered with various sky conditions throughout the day, and of problems encountered from light sources on, or in the vicinity of, airports, or within the tower cab during the hours of darkness.

"TASK III Provide written recommendations and drawings for the detailed layout of operating consoles, desks and other furniture or furnishings for control room quarters as they may affect the controller's operations. This includes the positioning and space requirements of the above items in the

a. Tower cab.
b. IFR control room.
c. Controller ready rooms.
d. Training space.
e. Space and means of providing observation of operating quarters by visitors.

"TASK IV — Provide written recommendations and drawings or sketches for detailed design of control desks and consoles in the control tower quarters.

"TASK V — Provide written recommendations and drawings or sketches for detailed design of indicators and controls to be used by control personnel in the tower cab and IFR room.

"TASK VI — Provide written recommendations and drawings or sketches for the general location on the airport and height of the control towers. The tower cab must permit visual observation of runways and taxiways on the airport, visual observation of the airspace used for the approach and departure paths from each runway, and visual observation of the airspace used for traffic patterns around the airport.

"TASK VII — Prepare written recommendations from the human factors standpoint for revisions to Technical Standard Order N-13b. 'Requirements for Air Traffic Control Quarters'. The written recommendations shall be supplemented with drawings as necessary."

This second interim report is a more tangible form of the work that has been done to date in giving human factors consideration to the design of airport traffic control quarters. It includes all of the work of the first interim report[1] plus certain refinements and addition that have been made to those recommendations since that time.

There are five important assumptions underlying the presentation of this report.

Assumption #1 is that this report is a human factors report as opposed to an engineering report. Although engineering drawings have been supplied and although these are true representations of the human factors considerations known to us, the engineers responsible for construction may wish to make a variety of modifications to meet full engineering requirements. The only hope is that the basic human factors considerations will be fully considered in any modifications that seem appropriate.

Assumption #2 underlying this report in the work done leading to it is that the human factors considerations have been met by a fully modular design. By modular design we mean reducing the equipment components to units that can be moved from place to place and providing the instruments and other data display equipment necessary for any or all of the information which the human controller must have. Using a modular design, it is possible to meet or adapt these modules to the great variety of airport conditions found across the

1. Douglas Courtney, Kenneth W. Colman, Anthony W. Silvestro, and John B. Kelly Human Factors Considerations in the Design of Airport Traffic Control Quarters (Interim Report). Courtney and Company Report #26, Project P, 15 April 1959.

country. For example, each airport has a different runway configuration tower siting is different for every airport, traffic patterns and density are different, and, last but not least, the experience and desires of the chief controller may dictate the arrangements of the modules. By having a console and other components in modular form, it allows the final layout to be made in full consideration of the specific airport configuration.

The modular system is carried beyond the operational levels (Cab and IFR Room) to include the entire building. This allows complete usage for the maximum facility, and though the Cab and IFR Room will be retained, the other levels may be removed or their important elements combined with the IFR facility. But if the location of an airfield is such that a marked increase in traffic load is expected, it might be well to retain all levels at the time of construction so that the facility will have the potential for future traffic increase. Those floor levels not in use could be utilized as rental space for additional revenue.

Assumption #3 underlying this and other reports on this project is that we are preparing a design in terms of a Class I airport. All that this really means is that the design of the human factors have been considered in terms of the most complex situation as opposed to the least complex situation. We have provided for the use of complex radar, ASDE, closed-circuit TV, and related equipments which might not be present in a smaller airport. However, despite this fact, it is recommended that the over-all configuration of the

Tower Cab and the IFR Room should remain the same no matter where the airport is to be built or where the airport control quarters are to be placed. By keeping to these recommendations, we offer full provision for future growth, yet, even with a relatively small traffic density, we do not have a tower that is too big for any airport.

Assumption #4 is an assumption that ought to be present in the design of any system. It is that these recommendations cannot be considered final until they have been placed in some simulated form The usual simulation for this kind of equipment is in the form of an operating mock-up, and we very much hope that such a mock-up does become the next logical stage in the development of a fully practical set of recommendations.

Assumption #5 concerns the relation of these recommendations to current and future TSO's. One of the basic reasons for carrying out this project was to bring to current and hence future TSO's full consideration of the human operator, at the same time incorporating the extensive experience and background that has led to the formulation of the current TSO's. To the extent that human considerations dictate modification of current TSO's, full discussion of these points will be carried out within the FAA in order to establish a sensible and acceptable compromise between equipment and engineering requirements and the requirements of the human operator.

The third and final report will incorporate the work done heretofore in the previous reports as well as the following areas

A. Workspace and Equipment Layout in

1. Tower Cab
2. IFR Room

B. Environmental Elements in Cab and IFR Room

1. Living
2. Lighting
3. Heating
4. Air Conditioning
5. Ventilation
6. Humidity
7. Color Treatment
8. Floor Covering
9. Acoustics Treatment
10. Safety
11. Efficient Operating Level of Controllers

SECTION ONE

GENERAL LAYOUT OF TOWER BUILDING

The general layout of the tower building as with the layout of other portions of the airport traffic control quarters has been specifically indicated in the drawings and figures which accompany each section of this report. These drawings and figures should bear the major burden of the presentation. However, in each case, breif statements describing the shape and square footages of each room or area on a given level are appended and where it is desired to call specific attention to certain details this has been done in writing and accompanies each drawing and figure. Generally speaking, the layout of the tower building has one general characteristic which may be somewhat unusual, and that is that all of the airport traffic control quarters are included under a single roof. Seven operating levels have been constructed in the tower building. The eighth or ground floor level was added for two main reasons (1) It was felt that some objection might have been voiced about relegating the Administrative level to the ground floor, and, (2) the optimal Cab level height of 125 feet necessitated the addition of another floor level. Traditionally the Tower Cab is at the top of the structure. Below the Cab is a Cab Access level. This Cab Access level, being octagonally shaped to preserve the external sight lines from the Tower Cab, is not very large but does provide space for toilet facilities, facilities for approaching and leaving the Cab, and a swift exit for Cab occupants in times of emergency. The Equipment Room is placed between the Tower Cab level and the IFR Room for the chief purpose of reducing

cabling in these areas. The Controller Ready Room level has been placed between the IFR Room and the Training level, again because it reduces the amount of travel for the greatest number of people, thus those in Training and those in Administration have as easy access to it as do those in the IFR Room and Tower Cab.

A. General Considerations

There are five general considerations in the over-all layout of the tower building

(1) All of the airport traffic control quarters have been placed under one roof.

(2) Provision for a straight run for elevator, stairs and cabling race-ways has been made.

(3) Toilet facilities have been provided on every floor, excluding the Tower Cab level.

(4) The office space, stairwell, storage room, elevator, raceway and rest rooms all located at the forward end of the building, have been standardized, as far as possible, from level to level.

(5) 1907 square feet have been allotted for control areas. 1912 square feet have been allotted for the administrative areas. 1600 square feet have been allotted for the training function. 494 square feet have been allotted for visitors' observation area. The observation area has been fairly equally divided between the Tower Cab and IFR Room levels.

B Considerations to which Special Attention is Called

(1) The Equipment Room has been placed between the Tower Cab and IFR Room to reduce to a minimum cabling requirements

(2) Controller Ready Room has been centrally placed between the IFR Room and Training level to provide the shortest possible distance for personnel at the upper and lower levels, thus reducing elevator and stairway use

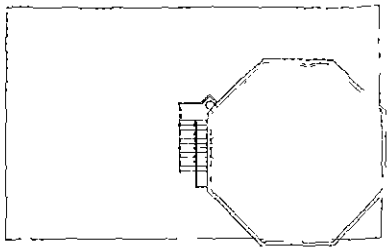
(3) The Telephone Company equipment has not been placed in the Equipment Room for the following reasons

(a) Telephone equipment must be adequately isolated and insulated from radar gear because of the visual noise it causes on radar scopes

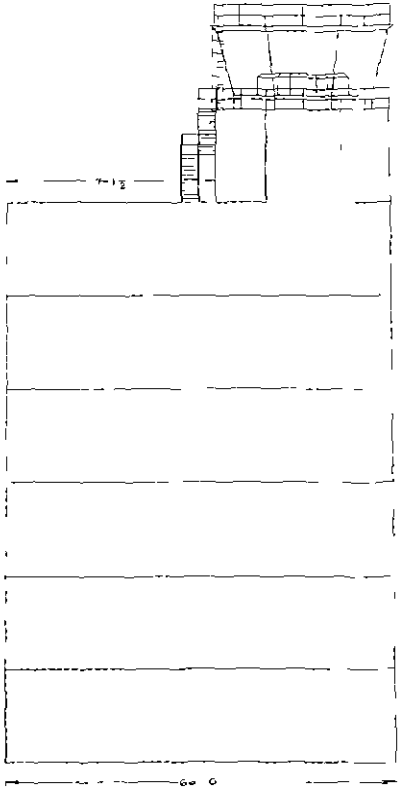
(b) Since the best insulation is distance and since the nearest available space was at the Administrative level, it was placed at that level

(c) Traditionally the telephone equipment may only be maintained by personnel from the Telephone Company Hence such a separation will eliminate possible conflict with those maintenance men servicing the radar and radio equipment

(4) All stairways, even to Cab level, are less than a 40° incline to lower the fatigue factor and maintain a high degree of stairway safety



C PLAN VIEW



A SIDE VIEW

TOWER CAB LEVEL

CAB ACCESS LEVEL

EQUIPMENT ROOM LEVEL

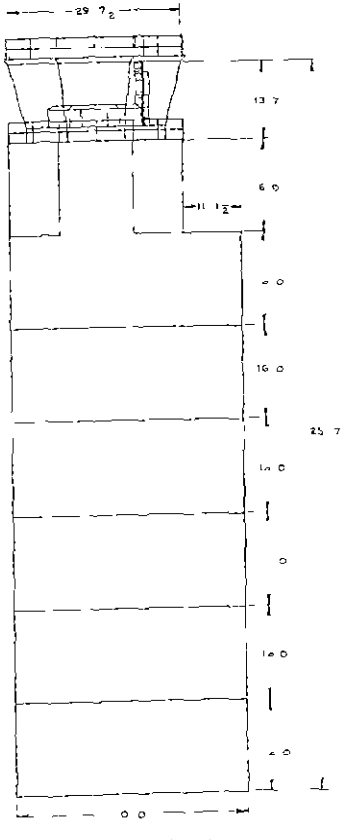
IFR ROOM LEVEL

CONTROLLER READY ROOM LEVEL

TRAINING ROOM LEVEL

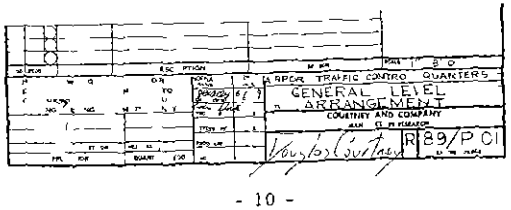
ADMINISTRATIVE LEVEL

GROUND FLOOR



B FRONT VIEW

Drawings A B C Side and Front Elevations and Plan View of Airport Traffic Control Quarters Building



SECTION TWO

AIRPORT TRAFFIC CONTROL QUARTERS

I. TOWER CAB LEVEL

SECTION TWO

AIRPORT TRAFFIC CONTROL QUARTERS

I TOWER CAB LEVEL

A. General Considerations

1. Shape

The Tower Cab is in the shape of a regular octagon.

2. Area

a.	Operating Platform	134 sq. ft.
b.	Maintenance and Observation Walkway (minus consoles)	226 sq. ft.
c	Total area inside sill line	427 sq. ft.
d.	Outside Walkway	263 sq. ft.
e.	Total area of floor plan	729 sq. ft.

B Considerations to which Special Attention is Called

Note

1. That in Drawing 1, Sections BB and CC, the Operating level is located on a raised platform.
2. That the Maintenance Walkway also serves as the Visitor's Observation area.
3. That the stairways to the Cab from the level below (exterior and interior) and steps from the Maintenance Walkway to the Operating

Platform are each located at or as near to the rear of the Cab as practicable for good visibility.

4. That the Equipment Lift is located near the rear of the Cab to move equipment from Cab Access to Tower Cab level.

5. That in Drawing 1, Section BB of the Tower Cab, alternative types of console writing surfaces, fixed and drop-leaf, are offered. The latter enables the controller to have increased visual angle to both the ground and skyward.

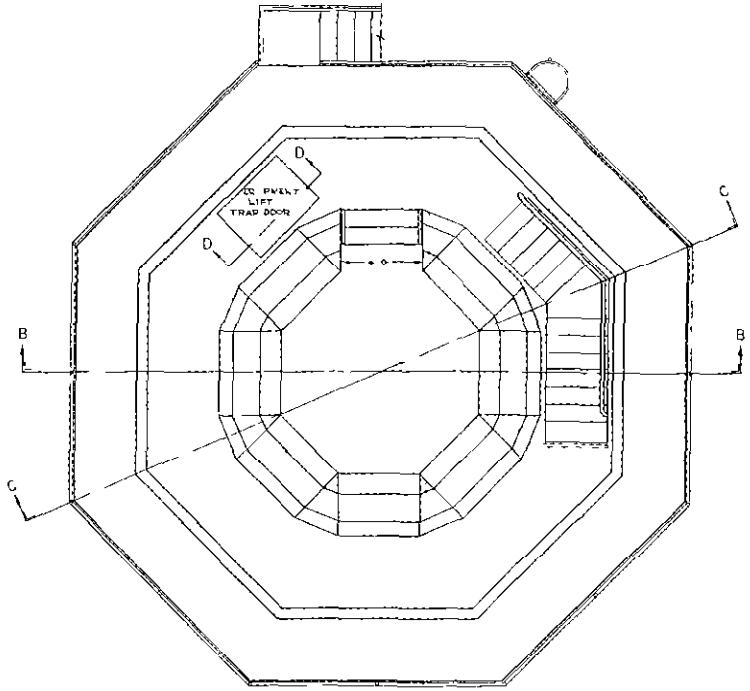
6. That standard station and console size allows interchangeability of working positions to fill specific requirements of a given airport.

7. That the stairway to the Cab level has a foldable platform over it to allow maintenance of the adjacent consoles.

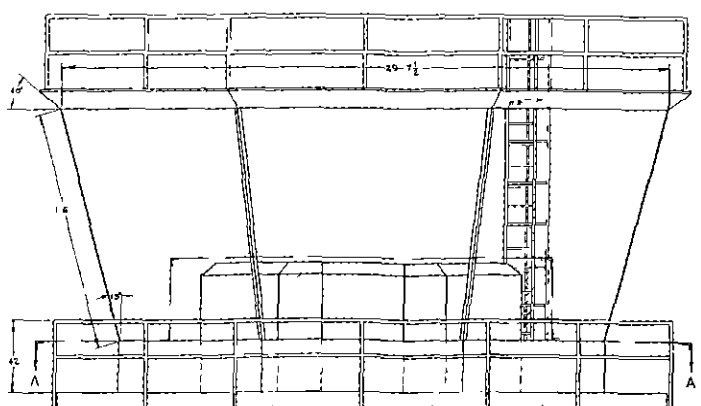
8. That the drop-leaf console writing surface is offered as an optional arrangement The inclusion of such a feature provides an increase in visual angle when the writing surface is in the "down" position.

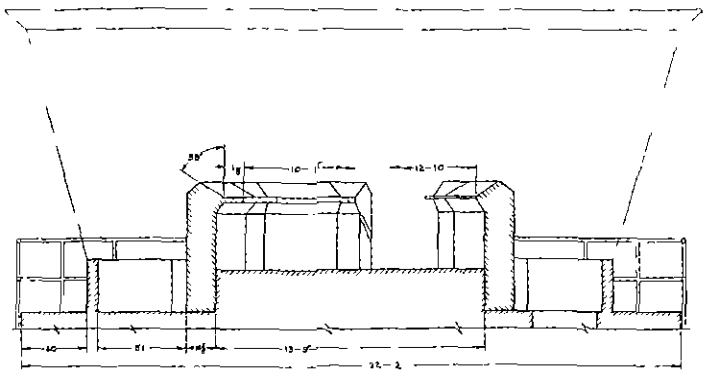
9 That not shown in the drawings is an optional emergency exit from the Tower Cab to the outside walkway It can be used if, for any reason, the normal Cab exit is obstructed in times of impending danger. This exit is located at the rear of the Cab in the sill, across the Maintenance Walkway from the platform steps.

10 That in order to provide as much incoming information as possible for the visitor at the Cab level, earphone jacks should be installed on the Observation Walkway.

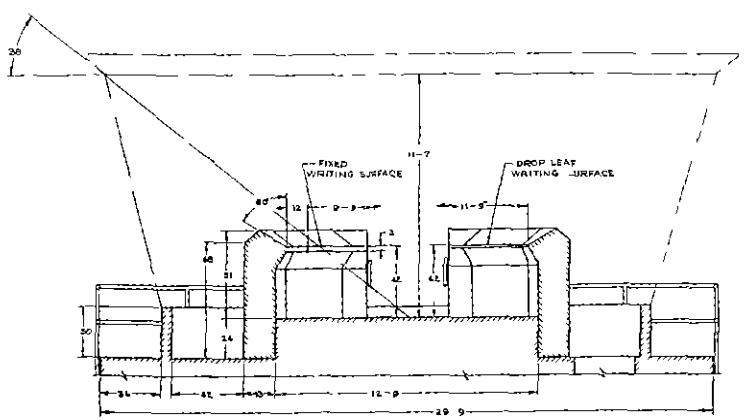


SECTION AA

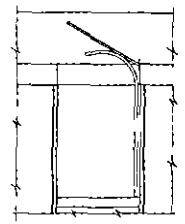




SECTION CC

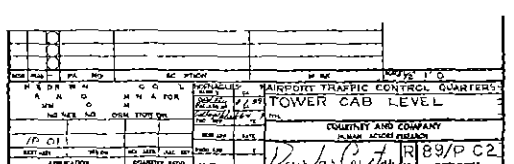


SECTION DD



EQUIPMENT LIFT DETAIL
SECTION DD

Drawing 1 Tower Cab Level



II. CAB ACCESS LEVEL

II. CAB ACCESS LEVEL

A. General Considerations

1. Shape

The Cab Access level is in the shape of an octagon.

2 Area

a. Stairwell	96 sq. ft.
b. Storage room	48 sq. ft
c. Elevator shaft	96 sq ft
d. Raceway	62 sq. ft.
e. Lavatory	70 sq. ft.
f. Equipment Lift and Motor	29 sq. ft.
g. Hallway area	391 sq. ft.

B. Considerations to which Special Attention is Called

Note

1 That the stairwell custodial storage area, elevator and raceway terminate at this level just below the Cab.

2. That the lavatory is located one floor below Cab level.

3 That the area beneath the stairway to the Cab level houses spare parts equipment used in the control operation, such as mikes, earphones, loudspeakers, flight strips, etc. Rather than

concentrate on an operations storage room at one specific floor level, it was thought more advantageous to have the operations equipment located on or as close to the floor level most in need of it. Hence, operations storage areas will be found on the Cab and Cab Access levels, the IFR Room level, and the Administrative level

4 That although outside wall dimensions have been excluded from the drawings as a general rule, it was felt that since these dimensions are intimately related to the outside walkway at the Tower Cab level they have been included here

5. That the double doors leading out to the roof of the rectangular level below serve a dual purpose, it provides a quick exit for Tower Cab personnel to the fire escape at the rear of the building in cases of emergency, and it also allows maintenance access to the outside walkway and the roof of the Cab without possible interference with Cab operations. Equipment located on the roof of the level below is also easily available through these doors.

6. That the ladder to the Cab roof is located at the landing between flights of the exterior stairway. It was placed in this position so that it kept below the line of sight any group of men waiting to use the ladder to the Cab roof until actually engaged in climbing.

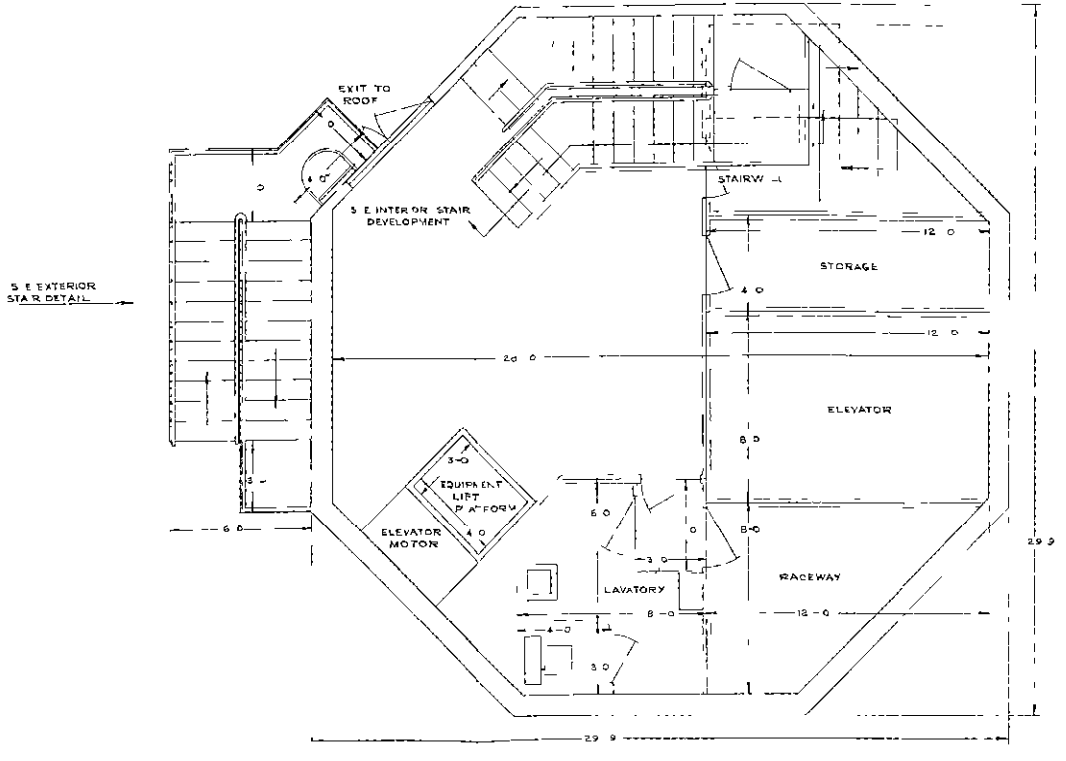
7. That the raceway at this and succeeding levels provides electrical and electronic cabling, as well as air conditioning ducts and plumbing to each level. Lead-ins channel these lines into the Cab under the

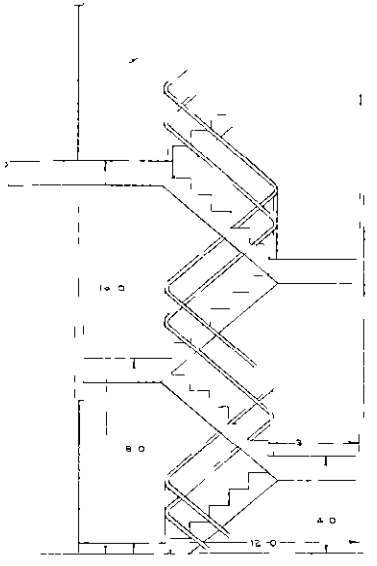
Operating Platform to the consoles. This system again allows maintenance of equipment without disturbing the operators. The raceway is accessible from each level.

8 That the three stairway details represent the types of stairs employed in this building. The "Typical Stairwell Detail" shows the stairs used between floor levels up to the Cab Access level. Not shown on the plan view is a modification of the octagonal shape of the Cab Access level in order to provide the necessary 7 foot headroom clearance at the first landing of the stairwell below this level. "Interior Stair Development" represents the stairway detail between the present level and the Tower Cab level. The "Exterior Stair Detail" shows the stairway outside the Cab Access level leading to the Outside Walkway of the Cab and also the ladder to the Cab roof.

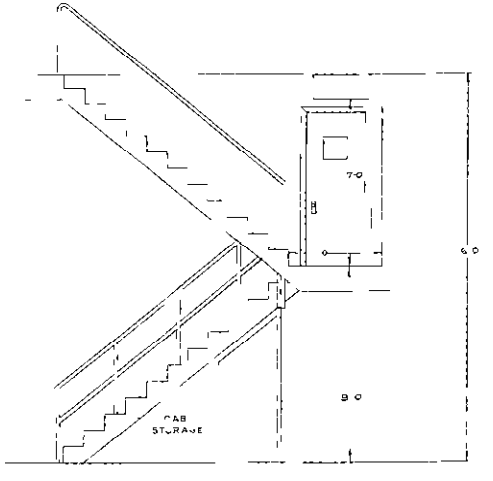
9. That not shown in drawing, but at the discretion of the particular facility, an additional lavatory may be installed on this level. Therefore, if the local facility deems this necessary, it is suggested that additional plumbing lines be brought up to this level for this purpose

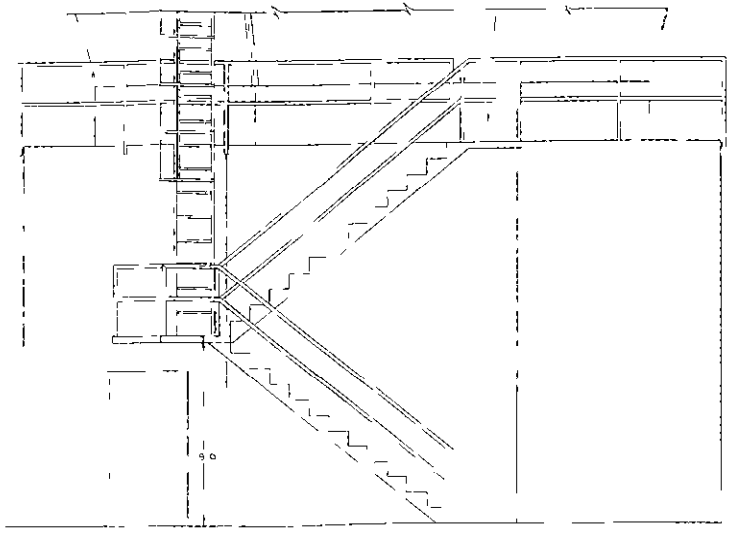
10. That personnel-freight elevators have been provided for every level of the tower except the Cab proper. For this last level, personnel must walk from the Cab Access to the Cab level. There is an equipment lift to transport electronic or electrical equipment directly to the Cab level. This eliminates any possible conflict with outside delivery personnel as to how far their union allows them to manually carry their packages into the building.





TYPIC L STAIRWELL D TAIL





EXTERIOR STAIR DETAIL

Drawing 2 Cab Access Level

				REPORT TRAFFIC CONTROL QUARTERS	
				CAB ACCESS LEVEL	
				COURTNEY AND COMPANY	
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III. EQUIPMENT ROOM LEVEL

III EQUIPMENT ROOM LEVEL

A. General Considerations

1. Shape

The Equipment Room level and all rooms or areas within it are rectangular in shape.

2. Area

a. Electronic Maintenance Office	312 sq. ft.
b. Stairwell	96 sq. ft.
c. Storage room	48 sq. ft.
d. Elevator shaft	96 sq. ft.
e. Raceway	96 sq. ft.
f. Lavatory (Men's or Women's)	72 sq. ft.
g. Hallway	248 sq. ft.
h. Electronic Maintenance Workshop	250 sq. ft.
i. Electronic Maintenance Storage	150 sq. ft.
j. Equipment Storage	100 sq. ft
k. Equipment Room	1100 sq. ft.

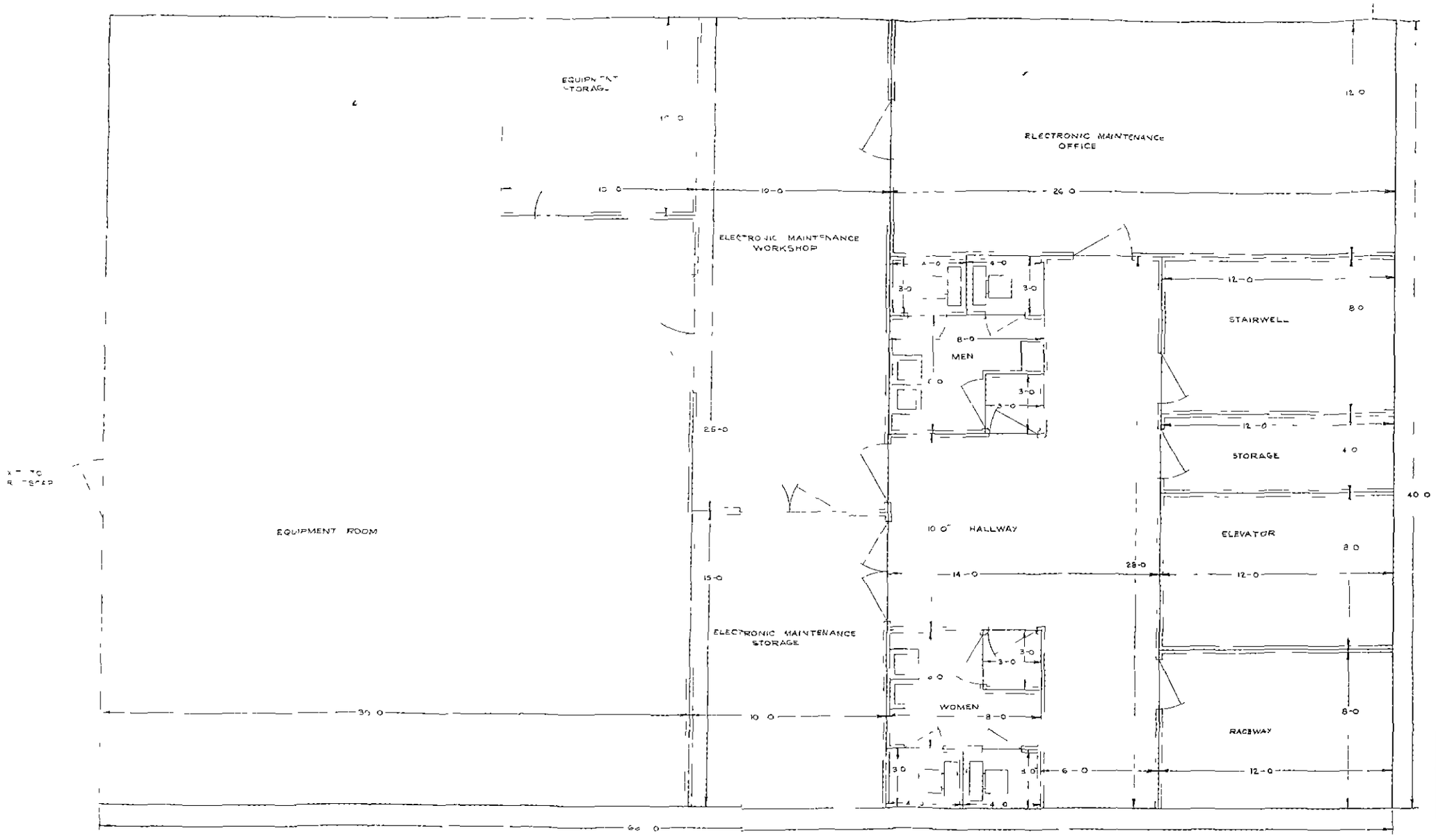
B Considerations to which Special Attention is Called

Note

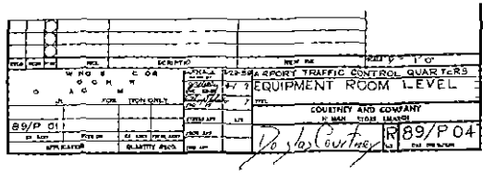
1. That the Electronic Maintenance and Storage areas are located adjacent to each other because of their functional relationship.

2 That the TELCO Room, for reasons stated previously, is located on the Administrative level.

3. That because of the high 15 foot ceilings, the possibility of double-decking future equipment will allow twice as much floor area for placement



Drawing 3 Equipment Room Level



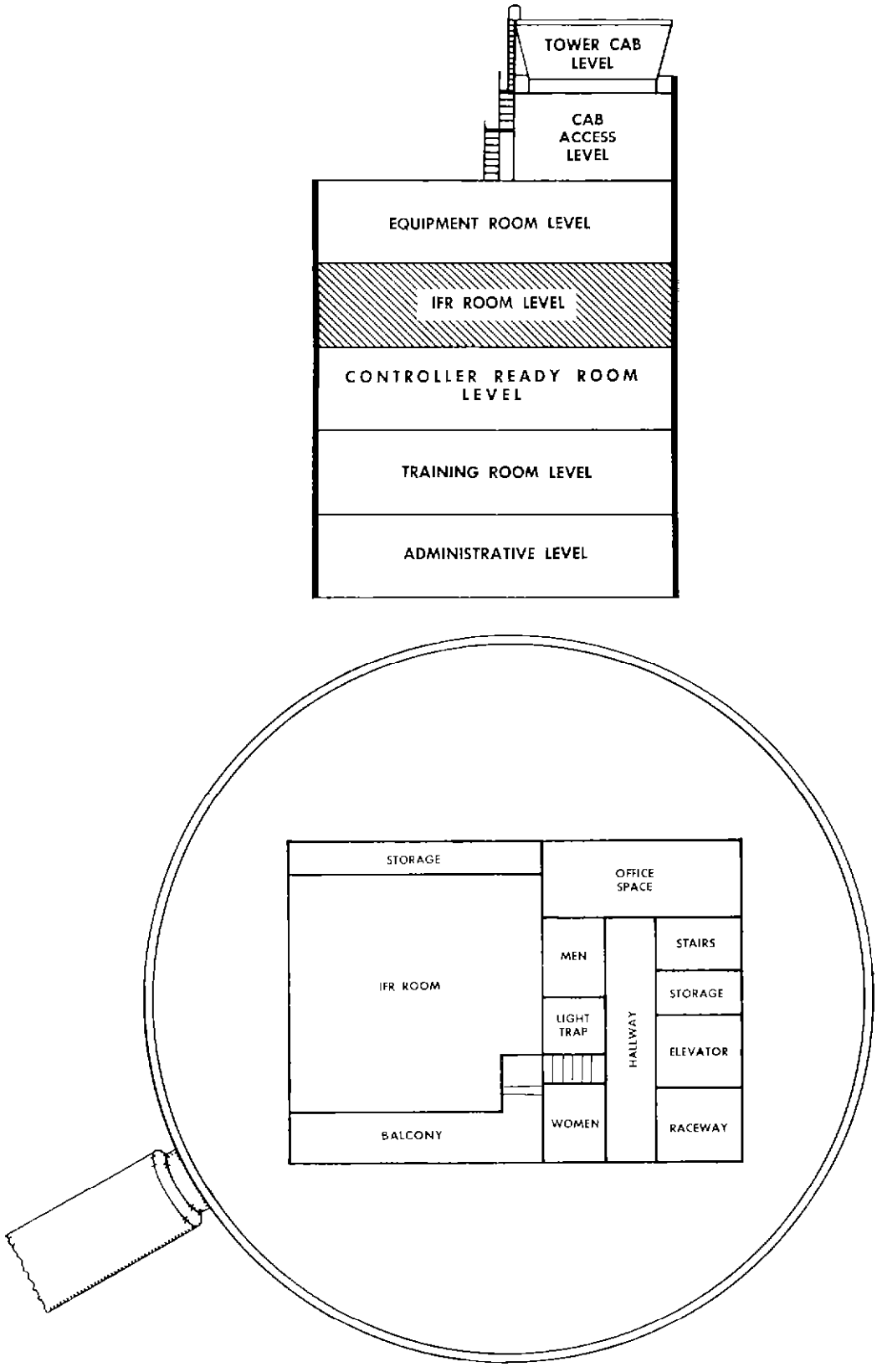


Figure 4 IFR Room Level

IV IFR ROOM LEVEL

A. General Considerations

1 Shape

The IFR Room level and all rooms or areas within it are rectangular in shape

2. Area

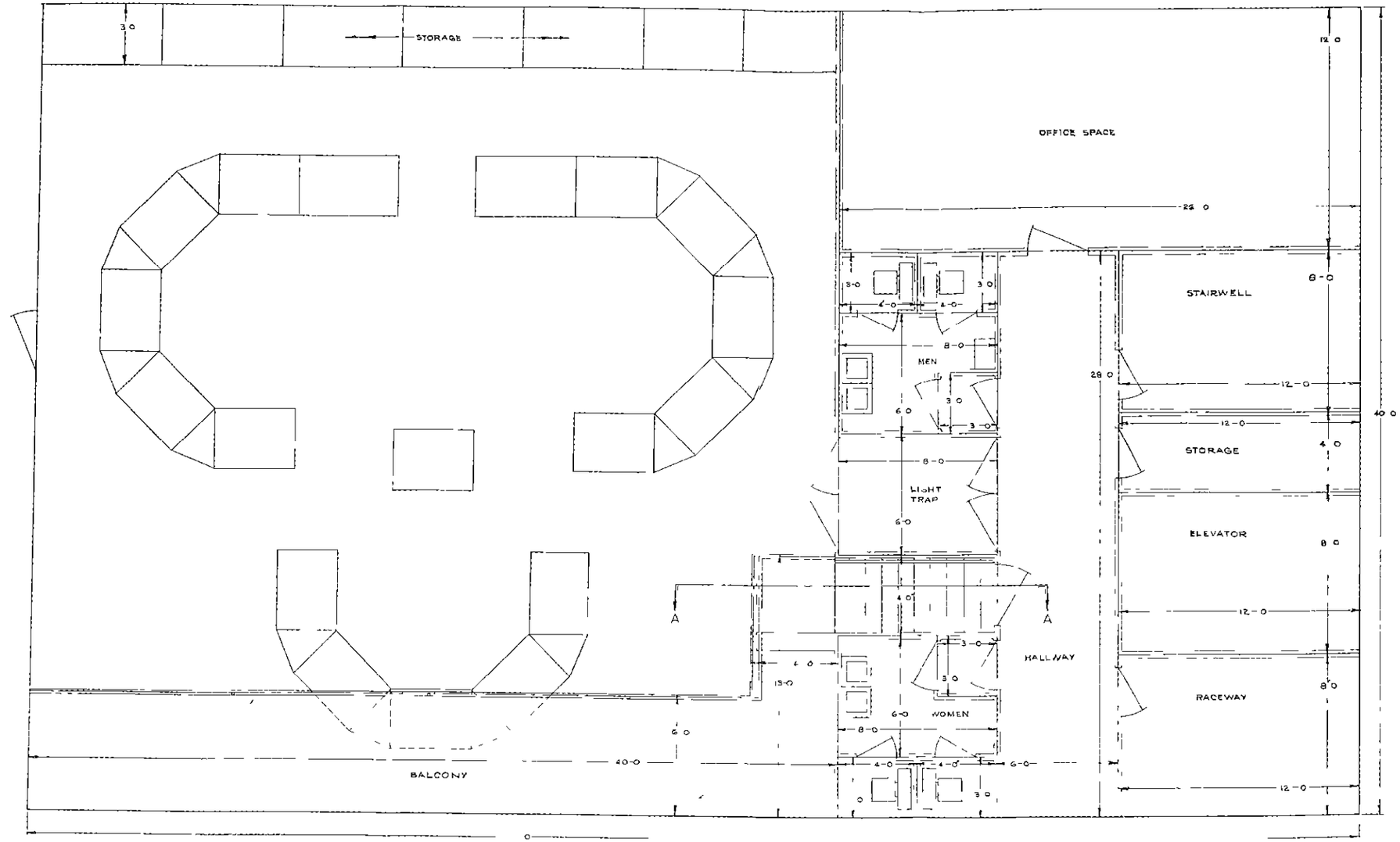
a. Office Space	312 sq. ft.
b. Stairwell	96 sq. ft.
c Storage Room	48 sq. ft.
d. Elevator shaft	96 sq. ft.
e. Raceway	96 sq. ft.
f. Lavatory (Men's or Women's)	72 sq. ft.
g. Hallway	168 sq. ft.
h. Light trap	48 sq. ft.
i. IFR Room	1480 sq. ft.
j Storage space in IFR Room	120 sq. ft.
k Visitors' Balcony	268 sq. ft

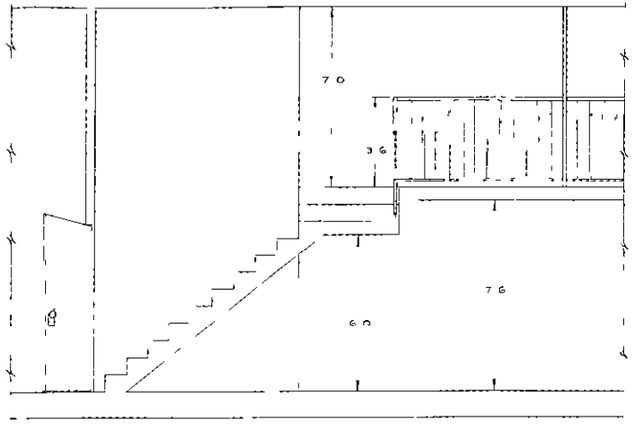
B. Considerations to which Special Attention is Called

Note

1 That the balcony in the IFR Room is constructed as observation space for use by visitors. Access to this balcony is available directly from the hallway.

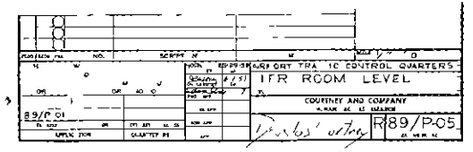
2. That the indicated equipment constellation is merely one of many possible layouts.
3. That operation storage space for equipment (earphones, mikes, flight strips, etc.) is provided for.
4. That in order to provide as much incoming information as possible for the visitor at the IFR Room level, earphone jacks should be installed on the Observation Balcony.





BALCONY DETAIL
SECTION AA

Drawing 4 IFR Room Level



V. CONTROLLER READY ROOM LEVEL

V. CONTROLLER READY ROOM LEVEL

A General Considerations

1. Shape

The Controller Ready Room level and all rooms or areas within it are rectangular in shape.

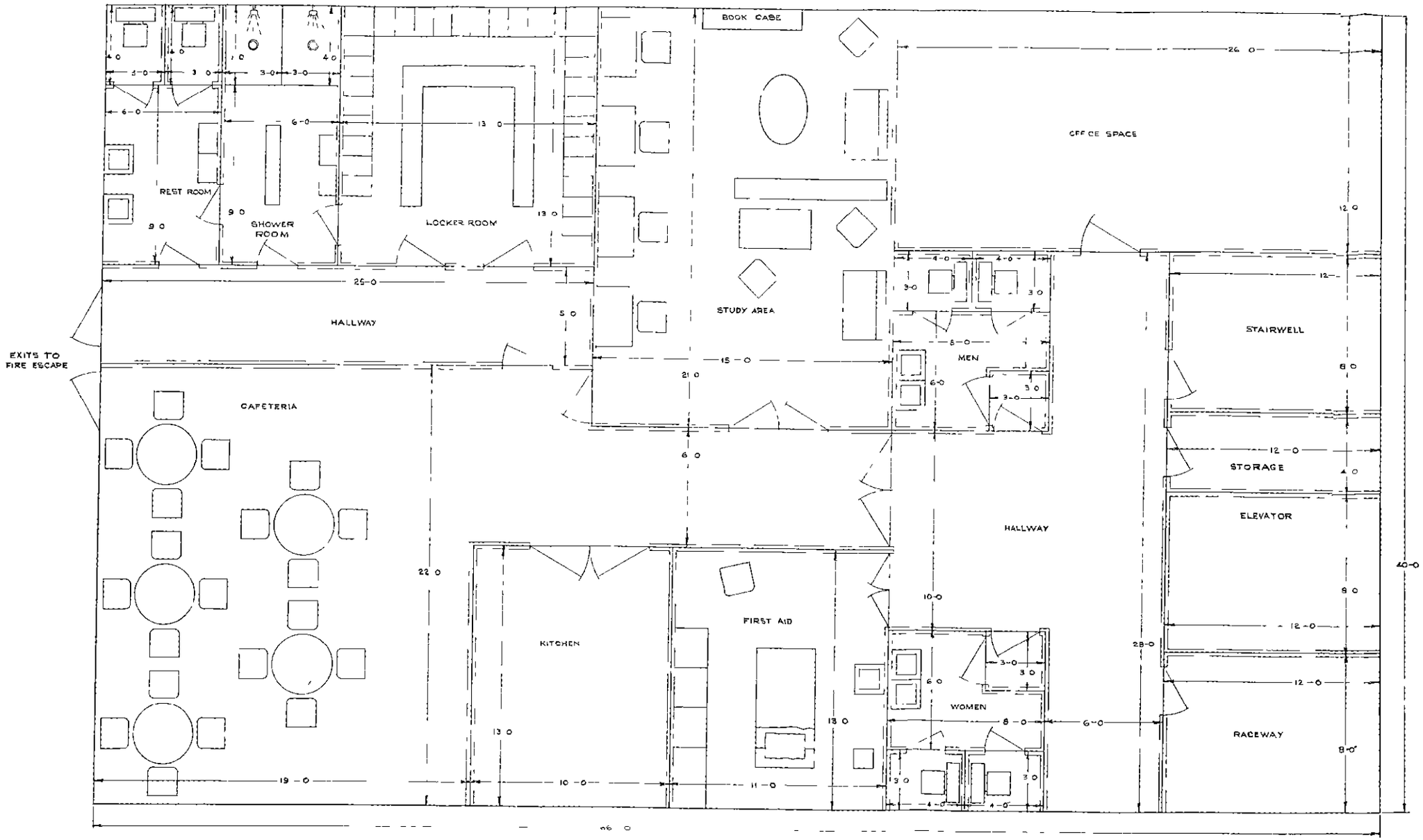
2. Area

a. Office Space	312 sq. ft.
b. Stairwell	96 sq. ft.
c. Storage Room	48 sq. ft.
d Elevator Shaft	96 sq. ft.
e Raceway	96 sq. ft.
f. Lavatory (Men's or Women's)	72 sq. ft.
g. Hallway	248 sq. ft.
h. Hallway (Rear)	125 sq. ft.
i. First Aid Room	143 sq. ft.
j. Kitchen	130 sq ft.
k Cafeteria	472 sq. ft.
l Rest Room	78 sq. ft.
m. Shower Room	78 sq. ft.
n. Locker Room	169 sq. ft.
o. Study Area	315 sq. ft.

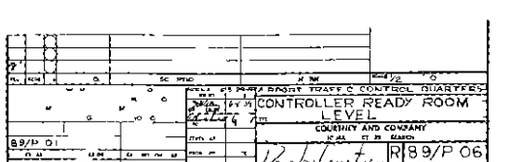
B. Considerations to which Special Attention is Called

Note

1. That the Study Area is equipped with desks, and ATC manual storage so as to enable personnel, when possible, to do necessary paper work away from control areas. It is also furnished with easy chairs, etc., for any duty hours' relaxation which is permitted.
2. That the Locker and Shower areas are for the personal comfort of the operators.
3. That a Dining area is provided for operating personnel who wish to avail themselves of this facility
4. That the First Aid area enables emergency treatment for on-the-job accidents.
5. That the present floor plan was laid out keeping in mind that the facility utilizing the entire tower design would be a maximum facility, that the tower would employ a sufficient number of operating personnel to justify the financial outlay It would seem, though, that if this tower design were standardized on a worldwide basis, the necessity of remaining at one's post for days, weeks, or even months might justify such living facilities as showers, cafeteria, first aid area, etc. Perhaps by providing the floor area for these various functions in the initial construction, they could be utilized differently according to the needs of the particular facility.



Drawing 5 Controller Ready Room Level



VI. TRAINING ROOM LEVEL

VI. TRAINING ROOM LEVEL

A General Considerations

1. Shape

The Training level and all rooms or areas within it are rectangular in shape

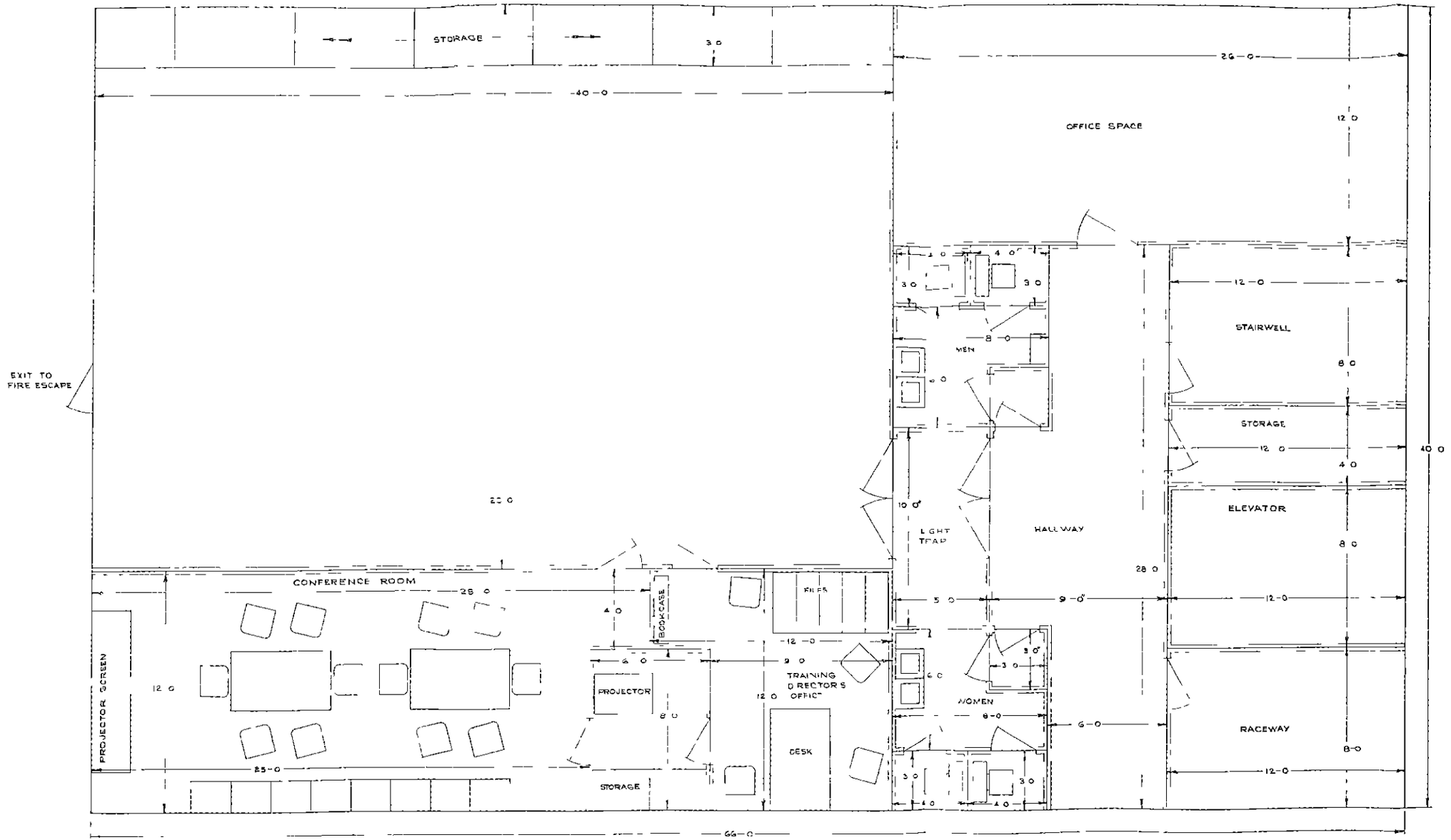
2. Area

a. Office Space	312 sq. ft.
b. Stairwell	96 sq. ft.
c. Storage Room	48 sq. ft.
d. Elevator Shaft	96 sq. ft.
e. Raceway	96 sq. ft.
f. Lavatory (Men's or Women's)	72 sq. ft.
g. Hallway	198 sq. ft.
h. Light Trap	50 sq. ft
i. Training Director's Office	120 sq. ft.
j. Projection Booth	48 sq. ft.
k. Conference Room	312 sq. ft.
l Training Room	880 sq. ft.
m. Storage Space in Training Room.	120 sq. ft.

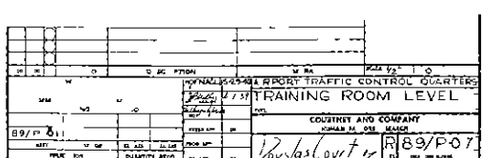
B. Considerations to which Special Attention is Called

Note

1. That a Conference Room provides an area for lecture, study, and motion picture projection for operator training.
2. That adjacent to the Conference Room is a projection booth for film projection and storage.
3. That adequate storage for training equipment is provided for.
4. That since the problem of training aids is not within the scope of this contract the training area proper has been left blank. It is suggested, however, that provision be made for not only making simulator equipment available, but also that the same informational inputs as are channeled into the Tower Cab and IFR Room be also made available to the Training level.



Drawing 6 Training Room Level



VII. ADMINISTRATIVE LEVEL

VII. ADMINISTRATIVE LEVEL

A. General Considerations

1 Shape

The Administrative level and all rooms or areas within it are rectangular in shape.

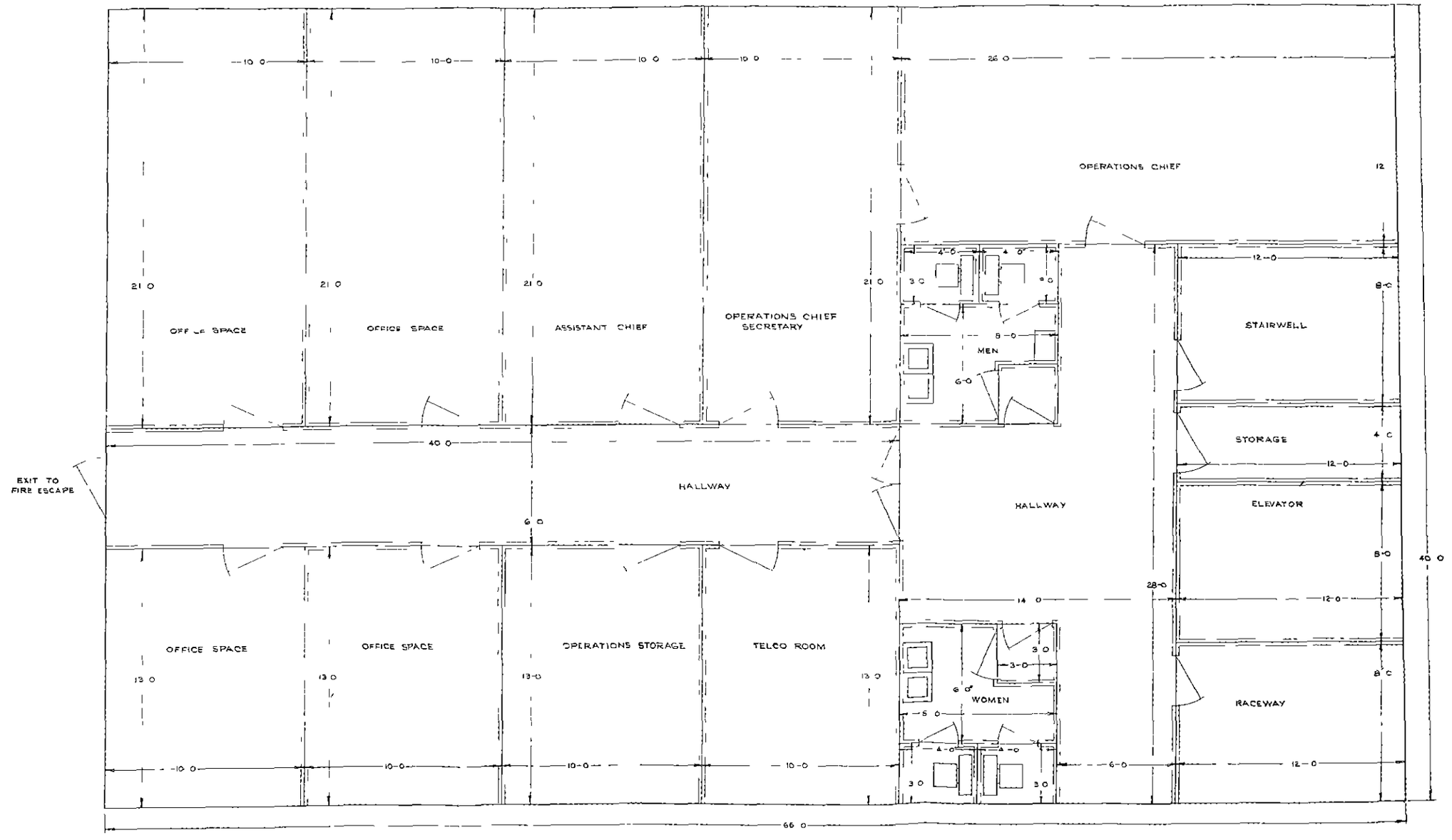
2. Area

a.	Operations Chief's Office	312 sq. ft.
b.	Stairwell	96 sq. ft
c.	Storage Room	48 sq. ft.
d.	Elevator Shaft	96 sq. ft
e.	Raceway	96 sq. ft.
f.	Lavatory (Men's or Women's)	72 sq. ft.
g.	Hallway	248 sq. ft.
h.	Hallway (Rear)	240 sq. ft.
i.	Telephone Company Equipment Room (TELCO)	130 sq. ft.
j.	Operations Storage	130 sq. ft.
k	Two small office spaces, each	130 sq. ft.
l.	Two larger office spaces, each	210 sq. ft.
m	Assistant Chief's Office	120 sq. ft.
n.	Office of Secretary to Operations Chief	210 sq. ft.

B. Considerations to which Special Attention is Called

Note

1. That for reasons stated in the introductory section, the Telephone Company electrical equipment was placed on the present level.
2. That adjacent to the TELCO room is the Operations Storage room This area houses all types of paper forms, etc., which should be accessible to the Operations Chief.
3. That the Operations Chief has been provided with over 300 square feet of office space A portion of this area could be utilized as a briefing or conference room, to acquaint new visitors with the facility, or to hold policy and similar meetings with the tower personnel.



Drawing 7 Administrative Level

AIRPORT TRAFFIC CONTROL QUARTERS
ADMINISTRATIVE LEVEL
COUSINS AND COMPANY
R89/P08