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# **An Introduction to Architectural Design: *Theaters & Concert Halls, Part 4***

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# An Introduction to Architectural Design: Theatres and Concert Halls, Volume 4



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*(This publication is the fourth in a series under editorial development dealing with the design of theatres and concert halls.)*

**1. INTRODUCTION.** This section contains collected technical information and equipment requirements for the construction and operation of Music and Drama Centers (MDC). This section is intended to give the designer and reviewing agencies an understanding of the scope of equipment and detailed study needed to produce a fully functional performance facility. It is not to be considered a substitute for technical expertise essential to project development. However, project participants will find it a useful reference in making statements of functional requirements and as a budget preparation checklist.

## **2. THEATER LIGHTING.**

**2.1 OVERSTAGE POSITIONS.** Pipes and bridges extend the width of the acting area in pairs 7 to 10 feet apart up-stage and down-stage for the full depth of the stage, and are adjustable in elevation. Instruments are clamped in place, adjusted in place, and powered through pigtail interlocking plugs to a cable carried in a raceway or tied to the pipes. The cables run to an interconnect panel or patch board on stage. Bridges permit maintenance and manual adjustment without lowering the entire line of instruments and without the use of ladders. Bridges are recommended for the most used first pipe “teaser” position and for the cyclorama backdrop position, where large quantities of several kinds of instruments are common. Bridges extend to the fly gallery for access, and are invaluable where box sets interfere with lowered pipes.

**2.2 SIDESTAGE POSITIONS.** Pipe booms are floor supported and ladder frames are hung from the gridiron. The fly gallery and wall-mounted ladders may also be utilized, as well as tormentor locations just behind the proscenium arch. One sidestage position on each side of the stage is generally associated with each overhead pair of pipes.

**2.3 STAGE FLOOR POSITIONS.** Footlight troughs, cyclorama pit and deck boxes called “floor pockets” accept sub-surface instruments for washlighting scenery and drops; footlights are rarely used to light actors but are commonly used to light scenery. There may also be individual instruments on portable stands.

**2.4 PROSCENIUM POSITIONS.** Slots alongside and above the proscenium on the house side contain specials, wash, strip and spotlights in proximity to a personnel ladder giving access to the overhead catwalk.

**2.5 SIDEWALL POSITIONS.** Vertical slots in the house walls or surface-mounted arms carry spotlights essential for down-stage and forestage lighting.

**2.6 CEILING POSITIONS.** Catwalks at or above the house ceiling carry the bulk of front lighting. They extend wall to wall. Critical dimensions are incident angle to the actor's face, distance of throw, and angle of adjustable aim. Frontlights must be adjustable in place from the technicians' catwalk, and each spotlight must have a clear shot at the whole stage.

**2.7 BALCONY POSITIONS.** Supplemental spotlighting is sometimes mounted on fascias. The mount must have a pan to catch dropped filters and burst lamps. Electricians also stand in the pan to adjust the spotlights.

**2.8 FOLLOWSPOTS AND PROJECTORS.** At least two instruments per booth or platform is recommended. One center position may be augmented by one at each side. Booths may be shared with film projectors for scenic images. An incident angle of 30° to 35° to the leading edge of stage may in some cases permit movie projection on an elevated screen. However, a separate film projection booth under the balcony or at the back aisle is preferred.

**2.9 LIGHTING CONTROL SYSTEMS.** With the possible exception of house and worklight autotransformer dimming from a position on stage, theater lighting makes use of indirect electronic dimming controls operated from a small console in or behind the house. The remotely controlled dimmer bank is normally located in low-value space under or alongside the house and between the control center and patch panel. It is preferably nearer the patch panel to minimize highload wiring, but the location of power service entry of 300-800 KVA to the dimmers may rule the choice. The bank needs no access during performance, but the patch panel is located on or near stage, again to minimize load-circuit wiring to the lighting positions. The patch panel requires continuous access from the stage. Low-voltage control circuits activate the dimmers which feed load circuits selected at the patch panel and into which circuits the lighting instruments are plugged. A more recent and economical development is the dimmer-per-circuit system. The interconnect (patch panel) function takes place at the control center in low-voltage circuitry.

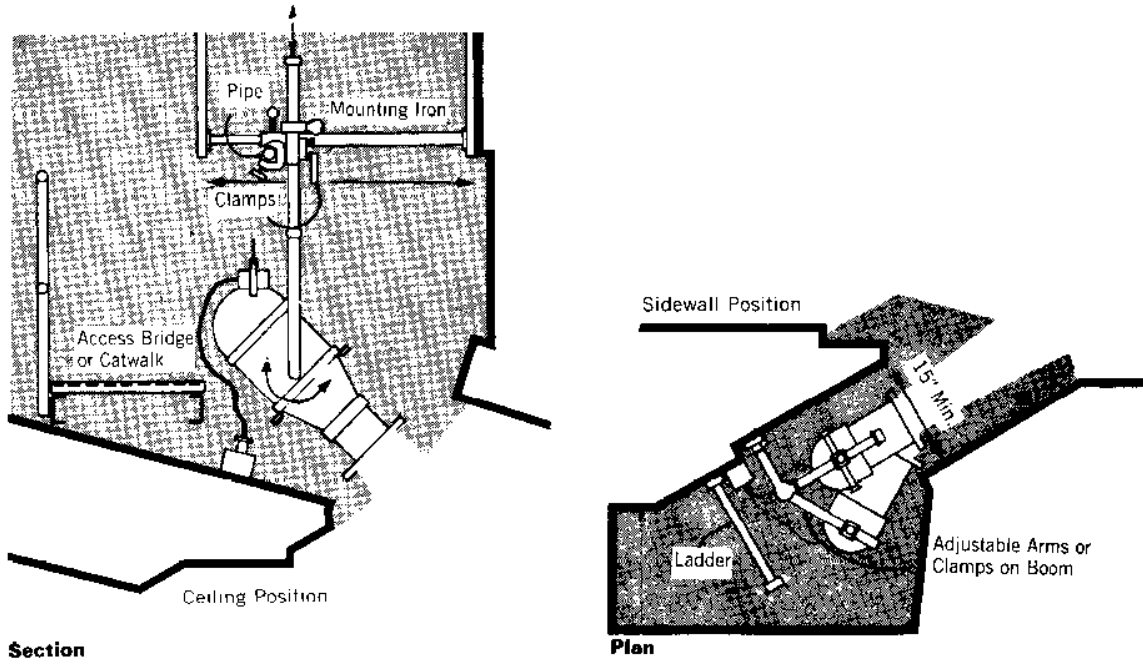


Figure 1  
Ceiling and sidewall slots

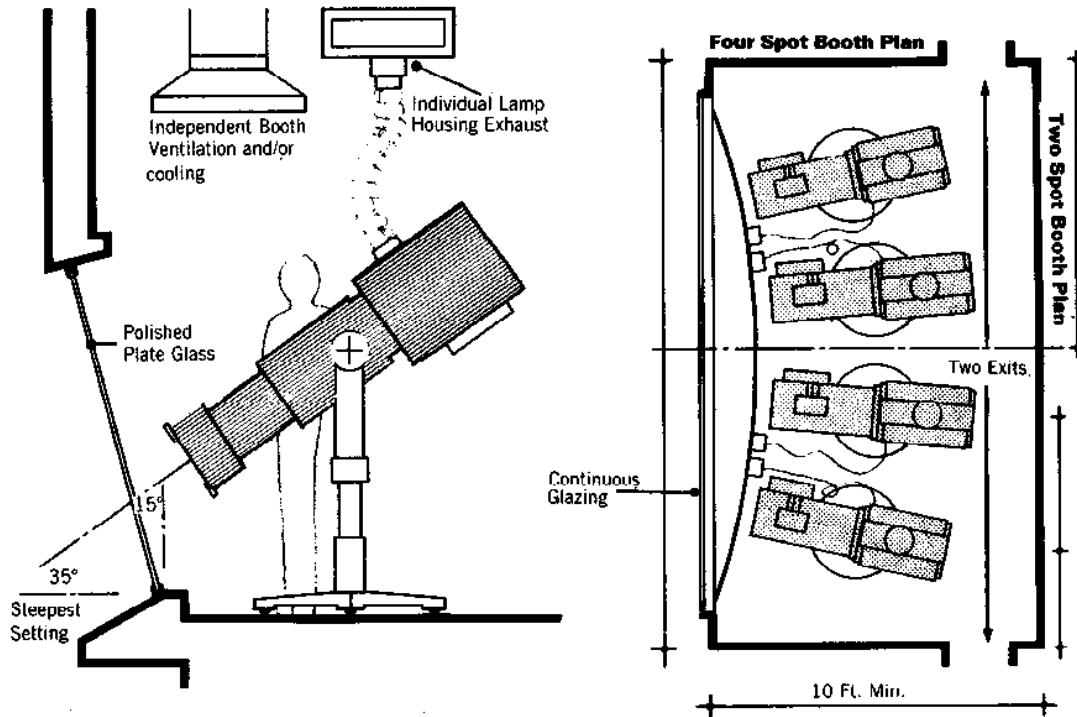


Figure 2  
Follow spot elevation/four spot booth plan

Dimmers are installed in racks in or adjacent to the stagehouse; one dimmer per loaded circuit into which instruments are selectively plugged. Remember that dimmers make noise and should be isolated.

**2.10 CONTROL CENTER EQUIPMENT.** Controls include manual and automatic preset potentiometers, or memory systems, or both. Power levels are set manually as the lighting plot is developed. These are recorded when satisfactory and a fade-duration established for cross fading from one scene to the next. The operator can manually set the levels and durations during performance, thereby activating the sequence on cue, or the entire plot can be fed into a memory system that operates the cues and displays the status of the plot for on-the-spot adjustments. Except in very small systems, the memory controls are less expensive, more capable, and therefore preferred. In any case, house lights, work lights and lecture lights are separately controlled to avoid disturbing console setups. Touring groups often travel with their own lighting equipment, including controls, and are provided a power takeoff and company switch in the stagehouse. This is another reason for careful consideration of power service entrance location and selection of the most common compatible system interconnections to enable use of the facility's control center.

**2.11 POWER CONSUMPTION.** By its very nature, stagelighting power demand tends to be related to the acting area dimensions, as is the number of instruments needed. It is unwise to underestimate potential connected load in sizing the service. Common practice is to apply a factor of 80% to the total dimmer capacity, but this should be carefully considered (50% to 80% for dimmer-per-circuit systems). Planners must ask themselves if the installed capacity take into account likely future growth (it always grows), and the arrival of a road show with super power amplifiers and motorized devices as well as lighting equipment. The sizes and quantities of stage lighting equipment are determined primarily by the net stage area and secondarily by the type of use.



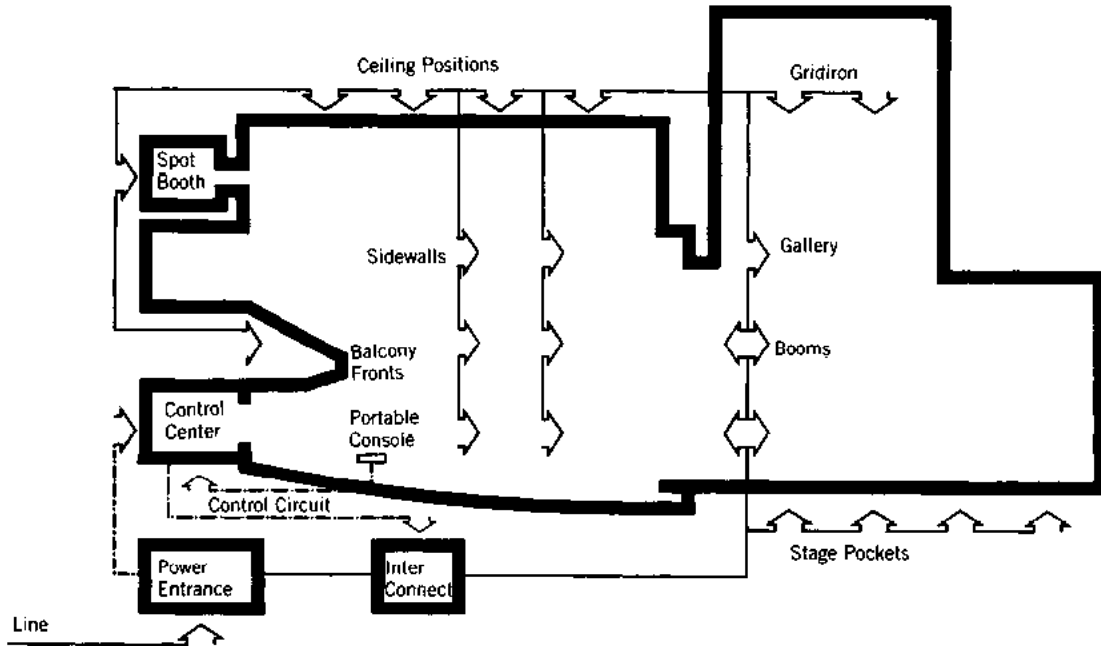
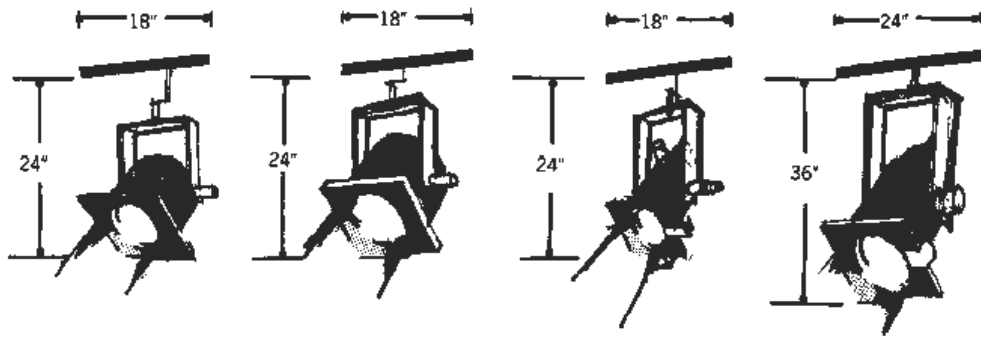


Figure 3  
Powr center distribution



<b>Instrument</b>	6" Fresnel	8" Fresnel	6" Ellipsoidal	8" Ellipsoidal
<b>Wattage</b>	750W	1,000W	750W	1,000W
<b>Absolute Maximum Distance</b>	25'	40'	40'	60'
<b>Use</b>	Spotlight	Spotlight	Framing Spotlight	Framing Spotlight

Figure 4  
Lighting instruments

**3. SCENERY AND SOFTGOODS.** The topic of stage dressing and sets is discussed elsewhere in terms of its influence on stage shape, vision criteria, movement, sound absorption and production activities. In short, it relates to many functional requirements of theater design primarily because it is an indeterminate element of the artist's stagecraft. This discussion seeks only to ensure free 'reign to his creativity'. From this viewpoint, the major concern is to define adequate space, built-in mechanisms, lighting, safety provisions and organization to facilitate set construction and use. Draperies and softgoods, however, must be either furnished or built custom-fit. More detailed discussion on this will follow below.

**3.1 HOUSE CURTAINS.** The major proscenium drape was traditionally an ornate biparting curtain. It is often of heavy opaque material to muffle preparations on stage as the audience is being seated. It signals the beginning and end of major sections; the points at which house lights are lowered or raised, and the audience is returned to "the real world". Modern practice installs the house curtain on the first pipe or set of rigging, enabling it to be drawn both vertically aloft and horizontally on a traveller. Before performance, it is usually lighted with "curtain warmers".

**3.2 TEASER OR HEADER.** The second pipe holds the foremost border behind the house curtain. It forms the apparent frame during performance. The proscenium may be higher, and curved or splayed for acoustic purposes, while the teaser sets the initial scale of audience/performer contact. It may be moved up or down, and it hides the lighting bridge or pipe immediately behind it.

**3.3 TORMENTORS OR LEGS.** The third pipe holds the principal legs or side masks that can be moved on or offstage to set the width of the opening. In fact, both tormentors and teaser can be soft fabric draperies, wood or steel frames covered with fabric, or solid panel construction. The stretched fabric may be chosen for its appearance, ability to assume a particular shape, or its ability to screen temporary or permanent loudspeakers. It is usually required for trimming to a shaped music shell; some shells work better with

solid panel masks. Heavy tormentors can be mounted on tracks supported on the stage floor, and may carry lighting towers with them. The fabric is usually black velour.

**3.4 PERFORMANCE CURTAIN.** The fourth and sometimes fifth pipes usually hold lighting instruments. However, the fourth pipe may hold a second lightweight curtain that rises on the scene after lighting levels and audience vision have adjusted, the overture concludes, etc. It provides the intermediate veiling and unveiling of the stage set during performance without grossly interrupting continuity. The fourth pipe may also hold a scenic image for a transformation effect.

**3.5 LEGS AND BORDERS.** The remaining pipes are assigned as needed to lighting, scenery or more masking. Legs and borders form a series of parallel frames that screen lighting instruments, flies and wagon sets awaiting use, and actors or cast members offstage. The position of legs can be varied to alter the acting area shape and size, and borders can be raised or lowered to adjust the impression of great height or “interior” scale. With lighting alone, successive frames can create a wide range of depth illusion. Three to five such frames are provided depending on stage size, and are typically black velour fabric. This technique has particular application to Dance, Opera and some Drama where constructed “box sets” are not used.

**3.6 OTHER DRAPERIES.** Typical accessory draperies include a full size black velour backdrop, a full size mid-stage black velour drop, a black sharks tooth scrim, miscellaneous special purpose black velour pieces, and a projection screen. Sometimes variety acts are performed in front of the Act Curtain, usually the liveliest backdrop visually, which serves to screen scene changes being made behind it while the variety act is in progress. It is functionally much like the optional Performance Curtain, but hangs eight to twelve feet behind the House Curtain. Frequent use of a movie projection screen suggests a position in front of the teaser and Performance Curtain.

**3.7 ACCESSORIES.** Typical accessories in the softgoods include storage bags and demountable traveler tracks.

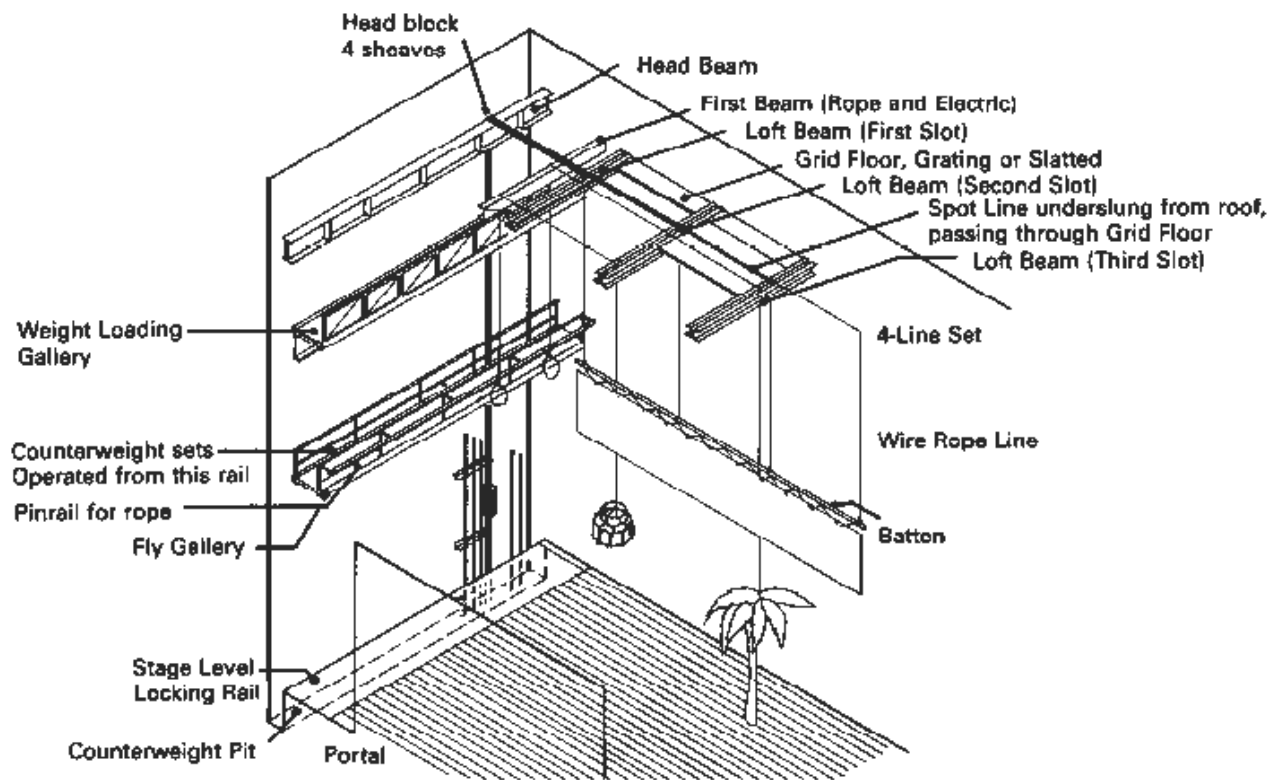


Figure 5  
Gridiron rigging

## 4. RIGGING AND STAGE MECHANISMS

**4.1 COMMENTARY.** Selection of systems is based on anticipated performance uses.

**4.1.1 FLY-LOFT COMPONENTS.** Scenery, drapes and lights are moved vertically by a system of lines, pulleys, counterweights and/or winches supporting a pipe, all of which constitute a set. Sets are supported on a structural grating, the gridiron, above the stage and fixed in place at a pinrail or locking rail anchored to the stagehouse wall, floor, or fly gallery. Gridiron is positioned to allow man-high working space below the roof structure. Loft beams comprised of 10 inch steel channels extend the full depth of the stagehouse in pairs, providing a cable slot every 10 or 12 feet. The grid floor normally consists of 1½" x 3" channel steel laid webup 6" on center, or 1½" subway grating. Individual lines can thus be dropped through almost anywhere on stage. At one end of the stagehouse, major head block beams resist the lateral and vertical loads imposed by the sets. Line sets consist of two or more rope or wire cable lines attached to each flown unit as it rests on the stage floor. The lines run up over moveable loft blocks mounted on the loft beams; blocks shift upstage and downstage for adjustment. Individual (single) rope lines may also pass through the grid floor. The lines of each set are collected at a head block with multiple sheaves and then pass downward. Each set is trimmed to equalize tension according to the load, and hoisted as a unit.

	<b>Recommended Minimum Number of Sets</b>	<b>Recommended Maximum Working Load</b>
<b>Elaborate Musical Comedy</b>	<b>30 or more sets</b>	<b>700 lbs./set</b>
<b>Ordinary Musical and Revue</b>	<b>10 to 20 sets</b>	<b>700 lbs./set</b>
<b>Opere</b>	<b>5 to 15 sets</b>	<b>1000 lbs./set</b>
<b>Presentation</b>	<b>5 to 10 sets</b>	<b>1000 lbs./set</b>
<b>Elaborate Drama</b>	<b>15 sets</b>	<b>700 lbs./set</b>
<b>Ordinary Drama</b>	<b>5 to 10 sets</b>	<b>700 lbs./set</b>

Table 1  
Typical line sets needed

Battens are loaded with a gross weight of 30 pounds per linear foot and usually extend 3 to 5 feet past the proscenium opening. Rope lines are tied off on a pinrail, which is the onstage edge of the fly gallery from which the flies are operated. Each line may be sandbagged to adjust tension. The fly gallery keeps this activity away from the stage floor, where space is highly valued. The gallery's elevation is usually set by the tallest piece of standing scenery and the ability to see into the flies; that is, 20 to 30 feet above the floor, and at least as high as the proscenium opening. Wire line sets are counterweight sets. After passing over the head block, the lines are fastened by chains and turnbuckles to a counterweight carriage. The turnbuckles enable the set to be trimmed. The carriage runs up and down, usually at the wall, travelling a distance equal to that travelled by the flown pipe. The weights are pig-iron, added incrementally until the set is counterbalanced to a degree that permits manual operation by pulling on a manila purchase line attached to the top of the carriage, running over the headblock, down through a rope lock to a tension block at the floor, and up again to the carriage.

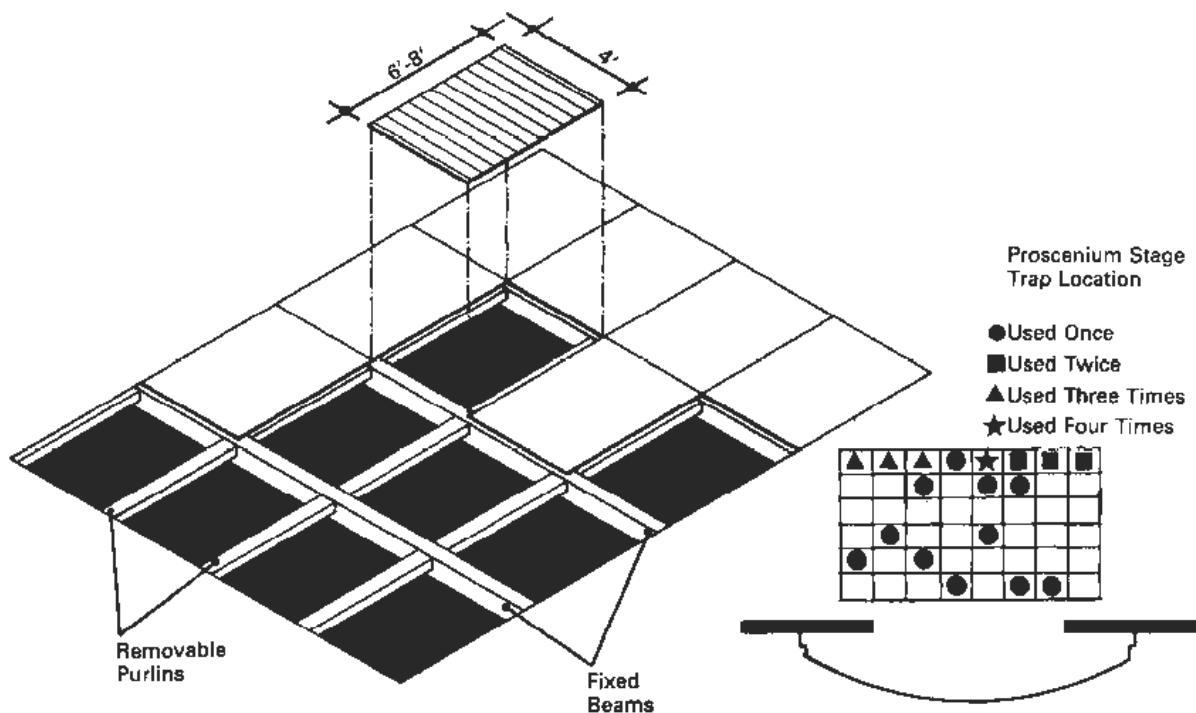


Figure 6  
Traps

The lines are operated from the fly gallery or from stage floor, but the weights are stored and added at a loading gallery at the top of the carriage run, level with the carriage bottom to minimize lifting. Dimensional difficulties in the design of counterweight systems usually require provision of a counterweight pit in the stage floor to increase carriage travel. If it is absolutely essential that the floor be kept clear (e.g., for the movement of scene wagons), a combination of pulleys can reduce carriage travel to half the fly by placing the tension block at fly gallery elevation, which is a complicated, expensive and inconvenient arrangement. There are three kinds of carriage guide systems. The least costly is the wire guide, two tensioned cables engaged by the carriage. Since there are no wall anchors, the sets can be moved upstage and downstage. Carriage sway requires they be spaced approximately a foot apart to avoid fouling. The maximum height of wire guide systems is 30 feet. T-Track guides are steel or aluminum rails standing out from the wall, each engaged by two carriages. The resultant close grouping of sets provides the maximum number of available sets per linear depth of stage, but where only a few sets are installed in a group, their effective gridiron coverage is limited by the divergent angle of lines passing over the head blocks. Lattice tracks for single carriages consist of two guide rails separated by ladder-like rungs. They are useful for isolated sets such as house curtains or fire curtains. Winch systems are based on a somewhat different organizational logic. The gridiron line set concept assumes that most flown material is arranged in parallel planes behind the proscenium. However, there are situations in which randomly located lines are of great value; for instance, for diagonal drops as well as flown orchestra shells and reflectors. The winch lines can be used in combination with conventional sets by locating the loft blocks above the gridiron, underslung from the roof structure. Each line is taken up on a rotating drum driven by a speed-controlled synchronous motor. Controls can be located anywhere and there are no weight guides, lines, sandbags or pinrails to deal with. However, winches are expensive and slow-acting. A similar single-line arrangement with overhead blocks can be used to hang lightweight objects above an open stage, with the lines tied back to catwalk rails. Counterweight sets can also be winch driven, which is considered safer because the winch takes up only part of the load.

**4.1.2 STAGE-LEVEL COMPONENTS.** Standing scenery is moved horizontally on casters and dollies, or on tracked chassis called wagons, or on turntables. The decision to employ roll-on scene pieces must be part of early planning, since it has a great impact on the organization of other stagehouse mechanisms. Wagon guide tracks, if used, must be recessed in the floor. This will affect structure, trap locations, details of wingspace layout, and the form of cyclorama and other accessories such as lightbooms that might otherwise be floor-supported. Steel plate tracks are needed to prevent damage to the softwood floor. Rolling sets have beneficial application to the open stage without flyloft, and to musical drama employing elaborate constructed scenery as well as flown pieces. Wagons are also commonly built by the user as part of a portable scenery. Wing space is used to hold these wagons when they are not on stage. Each scene change involves clearing the stage floor and moving the next set in. Each wagon must also have a storage area out of the scene space.

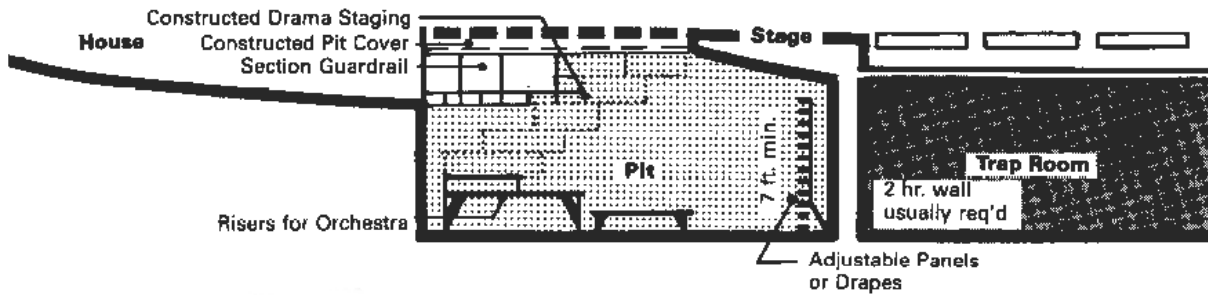


Figure 7  
Pit infill method

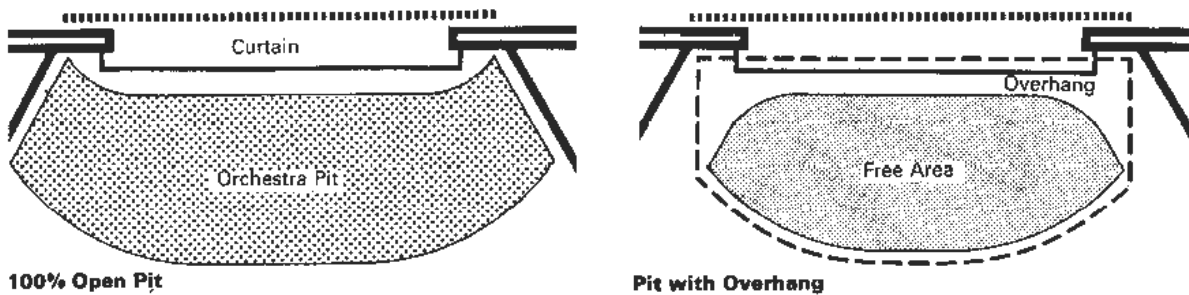


Figure 8  
Orchestra pit plan



Wing storage can be used in several ways. Wagons slightly wider than the acting area can be moved laterally in one motion from either wing; the total stagehouse dimension will be at least four times the proscenium width. Wagons half as wide can be brought together at center for one scene. A second pair upstage forms the next scene, if the stagehouse depth is sufficient. Wagons can jackknife at a downstage pivot point, reducing the wing dimension required, but sweeping a large area. Wing storage takes up a great deal of space, thereby congesting side entries. If more than two scenes are required, free storage must be associated with each wagon, so that one may be changed while the other is in use. In that case, any wing storage scheme involves an exceptionally broad stagehouse.

Upstage storage can be used to serve additional wagons or to minimize wingspace use. It has the advantage of avoiding pinrail and line sets for the flyloft, and only needs to be as high as the tallest piece of scenery. A deep stagehouse has other benefits in terms of multi-use and rear projection capability.

Offstage storage may be regarded as the logical conclusion. If wagons can be moved out of the stagehouse, scene changes can be effected without noise in the performance Room and under superior conditions of work-lighting and mechanical aids. At other times, the wagon room can be used for set construction and rehearsals. Turntables, while mechanically complex and somewhat more costly, avoid the problem of wingspace interference. Three or four scenes can be constructed on a large revolve and moved into place in no time. Even more scenes can be managed by resetting the segments facing the wingspace. The disadvantages of turntables include the geometric constraints imposed on the scene designer and the restriction of backgrounds to drops that cannot hang to the floor. If the table is demountable, the stage floor must be built up around it, thereby altering sightline conditions. All permanent mechanisms such as wagons and turntables are useful only to the resident user. Touring companies do not expect to find these devices and plan their shows without them.

**4.1.3 UNDERSTAGE COMPONENTS.** Scenery and actors are moved vertically from below stage through a system of removable traps, on lifts, hoists or stairs and ladders. Included in this concept are orchestra pit elevators and forestage lifts.

Traps are removable sections of the stage floor by which actors can enter or descend from the acting area, scenery pushed or hoisted up, or special lighting effects obtained. In comparison to other stage mechanisms, traps are among the best dollar value assets for the drama stage. Traps are most often used in open stage, projected and surround Rooms as an alternative to the run-on entry from the house, and sometimes are the only way to dispose of scene properties that can't be hoisted into a loft.

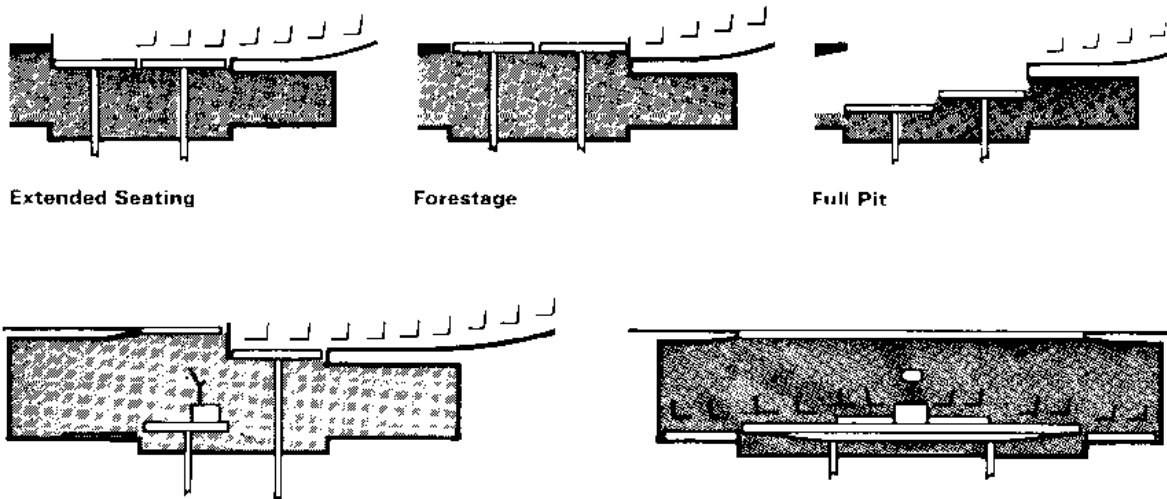


Figure 9  
Orchestra pit setups

Stage elevators used by major opera companies enable whole scene wagons to be brought from below, a luxury and too exotic for consideration at the scale of many MDC's. Large stages for music performance, in particular, may merit installation of low-speed geared or screwjack carriages designed to raise a portion of the stage rather than building up on it. An apron platform and/or hydraulic pit lift is also desirable but of questionable

priority in relation to regular use. The pit lift is probably more important than the stage lift. Only exceptional programming and high labor costs can justify the expense. The feasibility of limited travel platform lifts used in combination with a pit cover and infill units should be examined if a mixed program of full orchestra, orchestra and chorus, musical drama and/or dance is contemplated. Unfortunately, there is a tendency to leave things in place if they can't be altered easily. Correct sightlines must be planned for the full extension of the stage. The stage apron is in need of the same services as the rear portion of the stage, and should be provided with the same density of rigging, sets, electric pipes, and circuits.

**4.1.4 ORCHESTRA PIT.** This is indeed a valuable facility where any combination of music and speech is contemplated. In addition to the sightline considerations affecting the conductor's position, the key elements of pit design are adequate floor area, free area, overhang and depth. The best way to establish floor area and proportions is to mock up in full size the pit layout for the largest anticipated group, and be generous. The free area should be no less than 10 feet in the short dimension, and preferably 12 to 15 feet depending on orchestra size and the depth and proportions required to arrange them around the conductor (not in two sections). The overhang of the stage is very important, one of the means by which the acoustic impact of the orchestra can be adjusted. An ample overhang (5 to 8 feet) will permit flexibility of arrangement, modulation of direct intensity by moving in or out from under, and sufficient space for adjustable reflectors, absorbers, and unused instruments. A minimum depth (height) of 7 feet clear of stage structure is recommended. The user will usually cover the pit floor with portable platforms to tailor the heights of each instrument as needed.

**4.2 SUGGESTED RIGGING SET INVENTORY.** The basic needs of the fly loft are listed. The quantities given are for multi-use and drama Rooms. Large theaters follow these same rules. Very small theaters could use 4 borders, 8 legs, and 8 tabs. Where only occasional use will be made of the rigging, the spacing of sets can be increased to 8 inches or 12 inches, which are also standard spacings. In no case should the number of sets in a fly loft drop below 30. Rooms intended for symphonic concert music alone may

not need any soft goods for normal uses if the stage is totally masked with a permanent concert shell. Standard practice is to hang portable lights and masking inside the permanent shell for popular entertainment and amplified music. Winch sets and counterweight sets are frequently provided, which drop through the orchestra shell to pick up these portable pieces. A portable demountable concert shell consists of a ceiling and walls all around the sides and back of the stage. The ceiling is usually hung from standard counterweight sets. The walls are usually supported on rolling casters and are stored in the wings when not in use. Note that the permanent storage space for a shell could be 500 square feet. The ceiling panels must align with the electric pipes so that the concert can be lighted through the gaps between panels.