A Large Multi-Purpose Auditorium for Boston

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B. Arch., Massachusetts Institute of Technology
1960

This Thesis is submitted in partial fulfillment of the requirements for the degree Master in Architecture at the Massachusetts Institute of Technology, September, 1961

Lawrence B. Anderson
Head, Department of Architecture.
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Dear Dean Belluschi:

This thesis, entitled, "A Large Multi-Purpose Auditorium for Boston", is submitted herewith in partial fulfillment of the requirements for the degree Master in Architecture.

Very respectfully,

Howard D. Hershberger

M.I.T.
August 15, 1961
ABSTRACT

This Thesis briefly investigates the problems of the large multi-purpose auditorium. Some general research is incorporated. The specific needs of Boston are used to arrive at the architectural solution presented in accompanying drawings.
INTRODUCTION

The intention of the written part of this Thesis is to provide information that could be useful to one designing a theatre. Little of this data is original; but its being brought together here may save some effort for the initial researcher. Although references are made to the specific project that this Thesis has as its title, the material contained here is hoped to be more generally informative than a mere description of the problems of this specific project would be.

The building design in the accompanying drawings is only one of many that might be offered to solve the problems posed here in words. The specific character that has been given to this design considers its site and the cultural environment of the Boston area.
Acknowledgement

Far too many individuals have aided me in the generation and development of the ideas expressed in this thesis for me to be able to separately thank them for their help. I do hereby thank them all.

I must mention, however, that a Ford Foundation grant to study theatre design during the summer of 1960 with the Bayreuther Festspielhaus Meisterklassen has immeasureably stimulated my ideas, and has enabled me to gather much of the material presented here.

For this, I owe thanks to my design teacher of that summer, Thomas Meunter; to Friedelind Wagner, who administered the school; and to the Fords. For help during my years at Heidelberg College, I am indebted to Dr. Donald Kleckner.
Most of the illustrations for this essay are from "Theatergeräude I", by Eberhard Werner. Readers are requested not to reproduce any of the illustrations in this paper, and to use them for educational purposes only.

Where illustrations have not been otherwise credited, they are from "Theatergeräude."

Several designs have been particularly influential in the development of the architectural part of this thesis. So much so, that their authors should be credited. They are: Symphony Hall, Boston, by McKim, Meade, and White; the Shakespearian Globe Theatre in London, designer unknown; and Gordon Bunshaft's unpublished and as yet unbuilt design for the new Pittsburgh Symphony Hall.
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Appendices
Appendix A: Articles from 1937 Encyclopedia Britannica Theatre Section. 1-53.


Appendix: C: "An Auditorium for Every Use: Can It Be Built?" by David Klepper

Appendix D: "Auditorium Acoustics for Music Performance" by Russell Johnson

Appendix E: "Audience and Seat Absorption in Large Halls" by Leo L. Beranek
Because the architectural forms of the theatre currently seem to be influenced -- and increasingly so -- by certain historic ancestors, notably the Italian Baroque horseshoe auditorium, the theatre designer may profitably examine the derivation of these forms. Then the specific inspiration and evolution, and hopefully, the appropriate use of these forms may be more clearly understood. Alternatively, the architect may defend his rationalization on the imperious grounds of personal predilection.

The first theatres were simple structures intended to place the audience and the spectacle in a specific, communicative relationship, I believe that the fundamental intention of all theatres should be this simple one. Since the earliest theatres were built, however, many non-dramatic, non-theatrical influences have determined theatre form. Examples are the invention of perspective, Baroque politics, and the necessities of economics. Perspective produced the axial audience-stage relationship and the picture frame proscenium, as well as promoting the large, high, fly gallery for wing and border scenery. Baroque court politics -- and later the sharply stratified Victorian society -- demanded the box-lined horseshoe-shaped auditorium, where only a part of the show was behind the proscenium. In our own country and century, the high, unsubsidized costs of theatrical production have forced theatre designers to incorporate a number of seats inconsistent with the demands of artistic quality.
The best short essays on theatrical form and intention that I have encountered are included as Appendix A. Originally, they formed a part of the "Theatre" section in the 1937 Encyclopedia Britannica; and they were written then by the leaders in theatrical design. The ideas expressed in these essays tally with my own. Because of this and because they may not be otherwise readily available, as well as for their persuasiveness and trenchancy, it seems appropriate to include large portions of them verbatim.

The ideas expressed in the appended articles are not currently in vogue. They represent the cumulative progression of Nineteenth Century romantic thought, interpreted and transformed by pioneering design geniuses of the early Twentieth Century: Appia, Craig, Steele, Reinhardt, and the authors themselves. At the time that these pieces were written, the revolution of "modern" architecture and industrial design had made the dreams of these men seem to be possibilities. But, the depression, World War II, and the deaths of these men prevented the tangible expression of their ideas.

In the nearly quarter century since 1937, little seems to have been contributed to the art of building theatres. Perhaps we have regressed. In any case, some theatres are being designed today which disregard the aims that these men, had sought to achieve -- the aims that were demanded by the drama itself. Instead, theatres appear to be designed as architectural monuments, rather than as places in which drama is not only possible but probable. Notable exceptions are the Hugh Stubbins Loeb Drama Center; the small theatres at Mannheim and Gelsenkirchen;
Wright's Dallas Theatre; The Teaching Theatre at the University of Miami by R.M. Little and M.I. Manley; and the Arena Stage Theatre in Washington, D.C., designed by Harry Weese. The worst contemporary designs are influenced by such criteria as the number of seats that must be included in the auditorium to make it pay; and by a finite limit set on the distance that sightlines may take. Such criteria may disregard the type of production to be presented, the vertical angle of the viewer to the stage, the possibilities of perspective tricks to make the spectator feel psychologically closer to the stage, etc. The designer may be pushed by either his or his client's preference for a particular shape or "effect"; or by an outmoded technical system of production and highly inhibited, not to say uninspired, scenic designers. Today's theatre designer is not a theatre expert, he is an architect. He must call in all sorts of consultants to tell him what to do. Yet there is no generating force -- at least no theatrically generating goal -- to pull the whole design process together to produce a theatre. We do not even seem to have the directors or the producers today who are able to tell the architect what they would like to have, if what they would like to have is at all different intellectually from what they have had. I suggest that because we may be designing in a contemporary theatrical vacuum, we may profitably remember the ideas expressed in the accompanying essays.

The chief inhibitors of drama, in rooms usually designated as theatres, seem to me to be the proscenium picture frame which forcefully separates the audience from the drama; poor sightline angles as well as distances;
strong architectural forms that are broken by the proscenium and the scenery; and a manner of staging that tries to duplicate the real outside world leaving nothing to the imagination of the beholder.

I believe that a theatre should be a room, a complete room, in which an audience watches and can become involved in a play. The proscenium inevitably destroys the effect of a complete room. Any incomplete architectural form also tends to destroy the effect of a complete room.

Two approaches to housing the drama seem possible. The first, is to build a complete room which is architecturally tangible. Within this room both the play and the audience are situated, with as few separations as possible between them. Little realistic scenery should be used so that the spectator will begin to use his imagination immediately. The room should be simple and dignified in character; a room in which nobility, comedy, tragedy or any emotion might believably occur. The other way of building a theatre would be to destroy the visual architecture of the space in which the drama occurs, as Werner Ruhnau has attempted to do. One means might be to surround the audience and the actors with a cyclorama that could assume a mood appropriate to the play, instead of painting the walls black, as was done at Gelsenkirchen and at Münster, or instead of using glass walls as Mies and Ruhnau have suggested. The ancient Greek theatres combine these approaches. The natural scenery of the countryside provided the "complete room" while obliterating any extraneous architectural distractions. The stadium, itself, was the simple, dignified setting against which the drama occurred.

The essays follow in Appendix A.
PROGRAM FOR A LARGE MULTI-PURPOSE THEATRE IN BOSTON
General. This problem, as an academic thesis, will not adhere strictly to Boston's actual needs. Presently, the city intends to rebuild the temporary Arts Center Theatre on its existing foundations as a first-rate drama theatre of 1600 to 2000 seats. They plan to build a large opera house in addition, to house large scale touring attractions.

Because it is the purpose of this Thesis to develop a theatrical building type that best combines many theatrical facilities in a flexible way, it will be assumed that the present Arts Center Theatre is to be built, according to the program that follows. According to a recent Arthur D. Little report to the Boston Arts Center, such a theatre as is proposed in the program might expect to be filled a large proportion of the year - up to 340 days. This report is included as Appendix B.

The program selects more generous stage manufacturing facilities than might be required for Boston, again in the interests of developing a building type.

Functions. This proposed theatre is intended to accommodate:

1. The major touring ballet and opera companies of the United States and Canada.
2. Concert and theatrical touring groups of all varieties.
3. The most active local arts groups, as well as local concerts, theatrical productions, and lectures.
4. Various sized meetings, congresses, and convocations.

Size. Based on the functional requirements above, and on the facilities already existing in Boston, principally in the 1200-1600 and 7000-14,000 seat ranges, this new hall should have a maximum of 5,000-plus seats for the largest convocations and attractions. This basic space should be capable of division into smaller theatres of 500-800, of 2,000 and 3,000 seats, each of which shall be capable of mounting productions either in 3/4-round or modified proscenium presentation.

Acoustics. The acoustical solution is expected to be as variable as the various types of presentation may demand. Extensive use may be made of electronic reinforcement and reverberation, subject only to the necessities of lifelike sound realization.

Facilities.

A. Site. -development permitting future realization of a "Tivoli-like" park and recreation area around the Arts Center. Parking for 1000 cars.

B. Front of House.

1. Entrance lobby and foyer - 2 plus square feet per seat.
B. Front of House, Cont'd.

a. Telephones
b. Toilets
c. Check Rooms

2. House Manager's Office - 600 sq. ft.
   a. First Aid
   b. Lost and Found

3. Usher facilities - 1000 sq. ft.
   a. Lounge
   b. Locker Rooms

   a. Lockers
   b. Storage
   c. Water, vacuums, etc.

5. Box Office - 900 sq. ft.


7. Executive Offices - 1000 sq. ft.
   a. General Manager
   b. Treasurer
   c. Press Director
   d. Two Producers

8. Bar and Intermission Lounge - 2 to 3 sq. ft. per seat

9. Restaurant - 300 people - 4500 sq. ft.
   dining room and 4500 sq. ft. kitchen

10. Projection Booth

11. T.V. camera locations and control booth

12. Radio control and announcing booth

C. Auditorium. - Flexible, to provide seating spaces of 2000, 3000, and 4000, and 6000 seats. If possible, an experimental theatre of 500-800 seats.
D. **Stage.** Also flexible, to provide the possibility for pro-
scenium as well as non-proscenium and 3/4-round produc-
tions.

E. **Back Stage.** Sufficient to support a small repertory opera
company.

1. Manufacturing departments - may be utilized by
other Boston theatres.
   a. Paint shop - 6000 sq. ft.
   b. Carpenter shop - 6000 sq. ft.
   c. Cloth shop - 3000 sq. ft.
   d. Property shop - 1000 sq. ft.
   e. Metal shop - 1000 sq. ft.
   f. Plastics shop - 1000 sq. ft.
   g. Tailor shop - 2000 sq. ft.
   h. Wig shop - 500 sq. ft.
   i. Photographer - 500 sq. ft.
   j. Print shop - 500 sq. ft.
   k. Montage Room - stage size
   l. Locker Rooms (2) - 1000 feet sq., each

2. Stage Departments - must be located immediately
adjacent to the stage.
   a. Electrical - 6000 sq. ft.
   b. Hardware - 500 sq. ft.
   c. Cloth - 1000 sq. ft.

3. Storage.
   a. Set piece storage - 15 productions at 500 sq.
      ft. each, 30 ft. height
   b. Properties - 3000 sq. ft., 9 ft. high
   c. Costumes - 6000 sq. ft., 7 ft. high

   a. Heating and ventilating equipment
   b. Electrical transformer and dimming equipment.

5. Music facilities.
   a. Sound booth at rear of auditorium
   b. Orchestra pit - 90 musicians at 12-15 sq. ft. each
c. Locker room - 1000 sq. ft.
d. Tuning and instrument room - 1000 sq. ft.

6. Rehearsal Rooms.
   a. Large orchestra - 3000 sq. ft.
   b. Ballet - stage area and shape
   c. Chorus - stage area and shape
   d. Small rooms (15) - 150 sq. ft. each

7. Offices - 120 sq. ft. each
   a. Stage manager
   b. Chief engineer
   c. Chief carpenter
   d. Chief electrician
   e. Chief painter
   f. Ballet master
   g. Chorus master
   h. Chief conductor
   i. Assistant producers and directors (7)

8. Lounges.
   a. Canteen - 1500 sq. ft.
      Kitchen - 750 sq. ft.
   b. Green room - 1500 sq. ft.
   c. Artist's Lounge - 750 sq. ft.

9. Dressing Rooms.
   a. 12 Soloists (6M,6F) - 120 sq. ft. ea.
   b. 2 Chorus - 1000 sq. ft. each
   c. Supers (2) - 500 sq. ft. each
   d. 2 Ballet - 250 and 750 sq. ft.
   e. 12 for 4 persons - 120 sq. ft. each
   f. 3 conductors - 120 sq. ft. each
NOTES ON THE DESIGN OF THEATRES
PROBLEMS AND ASPECTS OF FLEXIBILITY IN THEATRES
The flexible theatre is one in which various audience capacities can be accommodated. For each of these various audience sizes several possibilities of stage production form should be available to the producer. Theatrical form ought not to prohibit flexibility of audience capacity - except within limits which will be discussed.

By theatre, I refer to the usual spoken species of drama, with possible attendant recorded or "live" incidental music; to musical dramatic shows from light comedy to grand opera; to lectures; to motion pictures; and to concerts of music, whether solo, chamber or symphonic.

By theatre, I do not refer to prize fights, horse shows, bicycle races, circuses, ice shows or the sort of traveling attraction normally booked into Madison Square Garden.

At least two basic architectural approaches to the problem of the flexible theatre are possible. The first, and most usual, is to provide a basic space large enough for the largest contemplated audience size, in whatever shape that number of people best can be seated, for the particular type of production that would be likely to attract them to the theatre. This basic space then can be cut-down or subdivided to reduce its capacity and apparent size. No provision is made to utilize the left over space when the auditorium is operating at a reduced size.
One of the first United States theatres to employ this philosophy was Adler and Sullivan's Chicago Auditorium of 1887-89. In this theatre, the top two balconies can be excluded from the main space by hinged panels that swing down from the ceiling and from the soffit of the top balcony.

More recently, in the Malmö Stadstheater of 1941-44, a "curtain" of wooden slats can be drawn through tracks in the auditorium ceiling to create various auditoriums that will seat 453, 497 or 1157 spectators -- all within the basic large auditorium. When both the main floor and the balcony are used, 1595 people can be accommodated. At Malmö the shape of the stage can be changed from the normal proscenium of variable widths, into a deep forestage or apron that extends in a semicircular fashion into the main audience floor. No matter what the audience size or what stage shape is used at Malmö, however, the viewers always maintain the same axial relationship to the stage. The new Portland, Oregon Colosseum by Skidmore, Owings, and Merrill also exhibits the design philosophy of subdividing one main space; but in it, variously oriented proscenium theatres are possible.

In both of these examples, the premise for flexibility is that portions of the permanent seating sections shall go unused when the auditorium is arranged to contain less than its maximum audience. This approach has the acoustical advantage that parts of the auditorium need not sound isolated from each other, because they never will be used simultaneously. Thus the mechanical aspects of flexible partitioning can be greatly sim-
plified, and can be much lighter in weight than if sound isolation were required. (Incidentally, it should be noted that in spite of statements to the contrary, the Malms theatre DOES work well from the viewpoint of its flexibility. According to statements by its resident director of last summer (1960) its size is changed weekly with little trouble, and in a very short time. I personally witnessed the change from the theatre's smallest to its largest size. The whole shift took less than an hour and required only three men. All mechanisms were manual.)

Another primary architectural approach to the flexible theatre is to provide, again, the basic space large enough to accommodate the largest anticipated audience in whatever shape that particular number of people best can be seated, etc., as in the previous scheme. Again, the space is subdivided as varying seating capacities and stage forms may be required. The difference is that the subdivisions are so designed - by their orientation, shape, and mobility - that they, themselves, may be used simultaneously as separate theatres. Here the concept of flexibility is that of a large auditorium that can be transformed into several smaller auditoriums - capable of simultaneous use.

While this second basic approach may be stated simply and in general terms, its solutions: acoustical, theatrical, and architectural, become highly complex. In any proper solution to the acoustical problems of a multi-purpose space, some compromises are enforced from the start, just as certain sightline and technical compromises will be necessitated. There, then ARE limits to flexibility; and good solutions to the problem
posed by flexibility can come only from recognition of these limits. The first goals of the multi-use-flexible-form-theatre scheme should be to define the limits of intended flexibility, to set the basic approach to the problem (i.e. to subdivide one space, or to interrelate various spaces capable of simultaneous or of common use), and to designate the primary function of the main space - and thus the criteria by which the space will be designed and by which, hopefully, it will be judged.

The Limits of Flexibility

The basic theatre forms in current use are the arena, the three-quarter round (or thrust-forestage or extended apron), and the proscenium hall. For drama, the audience size should be smallest for the arena form, and may be larger when the viewing angle of the audience area around the playing area is decreased. This does not mean that a proscenium theatre necessarily can handle a larger audience more adequately than can the three-quarter round shape. To the contrary, I believe that the latter form can best accommodate very large audiences because it includes the largest audience angle while retaining a focal axis -- and it thus allows the largest number of spectators to be near the stage. At its deepest, however, the three-quarter round form may require speech amplification, especially where background noise levels are high. These criteria are evolved primarily from sightline considerations, but also from acoustical requirements; and they assume that the most intimate relationship between spectator and spectacle is desired.
Some experience has shown that for a flexible theatre design the prime problem is the creation of a good proscenium hall. The most obvious solution to the problem is to provide a form that surrounds the acting area, one section of which is used as the proscenium theatre. However, in this country, more people usually want to see the proscenium productions -- opera and ballet -- than want to view productions in the other theatrical shapes. Thus, it is the flexible proscenium theatre that must be provided, rather than the flexible arena theatre.

The flexible arena theatre would provide a somewhat simplified acoustical problem in that the acting area is more-or-less stationary, the audience shape being the flexible factor. The geometry of the flexible proscenium theatre on the other hand shouts to us that the show must move in relation to the audience, as the form of the show is changed. If approximately the same sized audience is to witness variously presented spectacles within a given floor area, then for proscenium productions where the audience angle is narrow (14 degrees to either side of the proscenium opening, according to George Izenour) the playing area will have to be displaced to one end of the theatre space, allowing the longest possible audience area. When the three-quarter round and area forms are utilized, the playing area will move progressively toward the center of the theatre space.

Variations are possible, however. For example, a second theatre might be placed adjacent to the proscenium theatre. With moveable walls and the provision for variously orienting certain seating sections, these two theatres could be used separately and simultaneously as two pro-
scenium halls; together, they could form an apron, three-quarter round, or arena theatre of vastly increased size.

The limits of flexibility should be imposed according to the needs of the building program. A clear statement must be made of how many theatres are needed, and of what shapes and of what sizes. From this definition of functional requirements might evolve logically any combination of simultaneously used parts - up to six (limited by the central stage area) -- or a single subdivided auditorium such as Malmφ.

Do acoustics play no part in setting the limits of the flexible theatre? No, except for the general observation that when electrically unamplified sound is desired, the depth of the seating area should vary inversely as to the angle by which the audience meets the playing area.

I am convinced that if maximum flexibility in both size and shape is required, with the hope of maximum simultaneous use of the subdivisions, the basic subdivisions must:

1. Have portable sound isolating walls between them.
2. Have their seating areas rotateable so that their focal axes may be variously oriented.
3. Have distinct visual personalities.
4. Have suitable acoustic characteristics whether isolated or coupled.
Acoustical Problems of Flexibility

Shall we favor music or speech? Movies and recorded effects can be made to take care of themselves, with a suitably designed and located electric amplification and reproducing system. Thus, we must decide whether music or speech shall find a naturally perfect home in the basic theatre spaces. Why make a choice? Because for any particular activity certain acoustical standards prevail for optimal hearing; and these standards vary for various activities: specifically music and speech.

Whatever we are hearing, we will hear it well if:

1. It is sufficiently loud; i.e. if its energy level is enough higher than surrounding background energy levels to permit the ear to distinguish it separately, distinctly, and wholly.

2. It is sufficiently clear; i.e. if the sound is adequately dispersed through the space without detrimental echoes, flutter, intensity variations, etc.

3. It is acted upon by the space which contains it to assure appropriate reverberation characteristics.

The optimum reverberation times for music and for speech may vary by as much as a full second. Further, we generally appreciate speech most if its sound comes to us from a single, visible source. Music has its greatest success when the richness of its hall reverberations surround
us with sound -- even though a single visual direction may occupy our attention.

Again, two courses for design present themselves. We could choose a compromise reverberation time that would be perfect for neither music nor for speech, but that would be acceptable for either. The position of reflecting surfaces similarly might be compromised. Or, the hall could be designed as perfectly as possible either for music or for speech. Then it could be adjusted for the other use by mechanical and electrical means. The higher reverberation time will be for music, of course; the lower, for speech. If music predominates in the design, the highest desirable reverberation time might be designed into the hall. Then, when speech sound is to be heard properly the reverberation time can be mechanically lowered by decreasing the volume of the space, or by increasing the absorbptive surface area. Alternatively, the speech sound could be electronically amplified and directed in such a way that the full reverberation time of the room is unexcited. If speech is to predominate, a reverse solution is possible. The PROPER solution will depend upon a careful analysis of each auditorium requirement, its appropriate size, shape and correlation with such locally variable factors as maintenance, staff, and construction costs, etc.

Usually the auditorium must be used at some time for simultaneous speech and musical activity, as for an operetta or opera. If we are to use every means presently available to achieve a good acoustical environment, a compromise in physical reverberation time and reflecting
panel hardly can achieve the best results. The reverberation time of the hall should be designed to suit music. Thus, even though the volume may demand electrical amplification of speech sounds, the selective, directional "squirting" or speech sound by loudspeakers into an audience enveloped by an acoustical environment appropriate for music would seem to provide the near-perfect solution to the dual requirements of speech and music (the "tyrany of the microphone" quite aside.)

As often has been pointed out, the acoustical design of an auditorium never must set the architectural concept. Yet, an auditorium is properly named: it is a room for listening -- especially when sightlines become attenuated as they do in the large proscenium theatre. Paradoxically, the more the architectural solution heads toward other than naturally suitable acoustical shapes, the more visually apparent the acoustical corrective measures are likely to be. For example, Boston's Symphony Hall might be contrasted with M.I.T.'s Kresge Auditorium. Both auditoriums were "acoustically designed." Yet Symphony Hall, by virtue of its simple rectangular shape, by its propitious proportions, by its diffuse wall and ceiling surfaces, by its orchestra location, and by its shallow balcony overhangs, is a superb place acoustically for symphony concerts, though its design appears acoustically artless. Kresge, conversely, by using a domical ceiling surface has forced the use of "clouds" to keep reflected sound "away" from the curvature above. While handsome, and in many ways dramatically effective, the Kresge solution looks "ganz akustische".
For the design of the multi-shape-size-use-theatre some recommendations can be made:

1. Clarify the program, setting forth the number of desirable subdivisions, the degree of hoped-for simultaneous use of adjacent spaces, the forms of theatrical production that are to be realized, and the anticipated audience sizes.

2. Decide what acoustical and theatrical criteria shall be favored, and what means shall be used to produce geometric flexibility, compatible with the various performance requirements.

3. Use shapes that are naturally advantageous acoustically, and that will not need "correction."

4. In so far as possible, plan buffer zones between adjacent simultaneously-used stage and auditorium areas.

5. Because the playing zone must shift in relation to the audience -- and vice versa -- plan the ceiling reflectors for variability in position and angles. The auditorium ceiling might be a shallow continuation of the stage loft facilities.
6. The volume of the auditoria need not be limited by acoustical considerations, if electronics will be trusted to help the sound quality, and if economics necessitate such large halls. Whether a sound is amplified by mechanical or by electrical means, the result can be the same (when the electrical means are properly handled and designed and installed): the sound may be heard. And well heard. Sound that is amplified is not necessarily "dead sound" or "canned sound." Nor is it consequently a more inaccurate reporter of the prime activity of the hall more than unamplified sound would be.

The preceding discussion has been non-technical and generalized; and it was derived from an architectural and theatrical viewpoint. Obviously, various good solutions are possible. (Theoretically.) After considering the dramatic, formal, and acoustical realities, the architect should take a strong direction, keeping in mind at each step precisely what he is attempting. One direction could be the workshop solution: the theatre is seen as a space in which the reflectors, visual divisions, etc., can be arranged and rearranged almost at will. An almost opposite effect might be had if the elements are handled architecturally as definite, but variously related, parts. One must face the realization that in a project such as this, the most difficult - and never solved - problems are not the acoustical requirements, or indeed any specific category of requirements.
The Flexible Theatre

The possibility of building a flexible theatre has intrigued theatre designers for centuries. Although the earliest flexible designs did not change the form of the theatre, they did break it up into parts. The well known theatre project by Joseph Furttenbach, of 1655 does this, for example, as does a very recent design for the Dusseldorf Competition.
Bild 98. Theaterprojekt für eine fürstliche Hofhaltung von Joseph Furttenbach 1635
- Grundriß -
Project for a flexible theatre, submitted by U. Hausmann for the Dusseldorf Competition.

From ARCHITECKTUR WETTBEWERBE # 29, July, 1960.
One of the most usual ways of making a theatre flexible in form is to divide off sectors of it when they are not needed. One of the first theatres in the United States to include this system was the Adler and Sullivan AUDITORIUM in Chicago. In the section that follows, from Carl W. Condit's "American Building Art, The Nineteenth Century", note the sections of the ceiling that fold down to close off the top balcony; and the moveable section that folds down from the soffit of the top balcony to close off the balcony just beneath it.
14 The Auditorium Building (now Roosevelt University), Michigan Avenue and Congress Parkway, Chicago, Illinois, 1887–89. Adler and Sullivan, architects. Longitudinal section through the building.
The famous Total Theater project by Walter Gropius.

From "Walter Gropius" by Siegfried Geidion
"In my 'total theater', which was originally planned for Erwin Piscator, I have tried to create an instrument so flexible that a director can employ any one of the three stage-forms by means of simple, ingenious mechanisms: deep stage, proscenium stage or circular arena."


144. THE "TOTAL THEATER" in deep-stage position. Section through auditorium.

146. THE "TOTAL THEATER"
with stage in front of proscenium.
combined with deep stage.

147. THE "TOTAL THEATER"
with arena stage.

"A complete transformation of the building occurs by turning the stage-platform and part of
the orchestra through 180°. Then the former proscenium stage becomes a central arena,
entirely surrounded by rows of spectators! This can even be done during the play."
"This attack on the spectator, moving him during the play and unexpectedly shifting the stage
area, alters the existing scale of values, presenting to the spectator a new consciousness of
space and making him participate in the action." "Convegno di Lettere", October 1934, in
Another round flexible theatre, this time, one that actually was built. It is by Robert M. Little and Marion I. Manley for the University of Miami. The illustrations are from Roberto Aloi's "Architettura per lo Spettacolo."
Pianta / plan / Grundriss


Schemi di disposizione della sala / les différentes dispositions de la salle / stage and seating arrangements / Verwandlungsmöglichkeiten der Bühne und des Zuschauerraumes.

A third round, flexible theatre design is by Andre Perrottet and Erwin Stoecklin for a new Stadttheater in Krefeld, Germany. It was not built. The drawings are from the April, 1951 BÜHNENTECHNISCHE RUNDSCHAU.
Stadttheater Krefeld:
Stellung für Theieraufführungen

Stadttheater Krefeld:
Stellung als Festsaal
Das festliche Theater: Ringbühne etwa 140 m Ausdehnung (mittlerer Umfang). Zentrale Bestuhlung auf der Drehscheibe. Platzzahl: 1200


Der Kongressaal oder das Konzerthaus: Freie Zentral- und Peripherie-Theaterbestuhlung. Platzzahl: 3400


Der Ausstellungssaal: Ringbühne frei, keine Bestuhlung. Drehscheibe horizontal
Perhaps the best known contemporary flexible theatre in Europe is the Kleines Haus at the Mannheim National Theater. It is by Gerhard Weber. The illustrations are from Roberto Aloi's "Architetture per lo Spettacolo."
Schemi di disposizione del teatro / les différentes dispositions du théâtre / stage and seating arrangements / Dispositionschema

1. palcoscenico con fossa d'orchestra, 606 posti / scène avec fosse d'orchestre, 606 places / stage with orchestra pit, 606 seats / Schauspielbühne mit Orchester, 606 Plätze

2. palcoscenico con avanscena allargata, 606 posti / scène avec avant-scène agrandie, 606 places / stage with extended forestage, 606 seats / Schauspielbühne mit erweiterter Vorbühne, 606 Plätze

3. palcoscenico montante dalla platea (Shakespeare), 606 posti / scène montante du parterre (Shakespeare), 606 places / ascending stage from pit area (Shakespeare), 606 seats / Schauspielbühne ansteigend aus dem Parterre (Shakespeare) 606 Plätze

4. sala per conferenze e concerti, 775-871 posti / salle de conférences et concerts, 775-871 places / lecture and concert hall, 775-871 seats / Vortragsraum und Konzertsaal, 775-871 Plätze

5. teatro a scena centrale, 674 posti / théâtre à scène centrale, 674 places / central staged theatre, 674 seats / Areanbühne, allestiss 674 Plätze

6. teatro a scena centrale, 674 posti / théâtre à scène centrale, 674 places / central staged theatre, 674 seats / Areanbühne, allestiss 674 Plätze.
Sven Markelius; Model of Stockholm City Theatre from "Aus der Welt der Oper"
AUDITORIUM GEOMETRY

Auditorium geometry depends upon the three-dimensional shaping of the auditorium enclosure, upon the arrangement for seating the audience within that enclosure, and upon the finite dimensions involved.

What normally are called sightlines may refer to the vertical angle between the stage and the viewer, or to the horizontal angle, or to the distance between the stage and the spectator, or to the degree to which the viewer's scope of sight is unobstructed. Good sightline design must consider all four references. Additionally, optimal sightlines must be adjusted to the psychological proportions of the space. For example, to specify that a seat may bear some certain geometric relationship to the stage is insufficient. In one situation, the specification may prove to be reliable; while in another, because of a sharply sloping ceiling and floor, the same geometric relationship to the stage will prove to be unsatisfactory. In this second case, although the spectator can see the stage well enough, he will be seeing it through a slanting slot.

In general, the geometric configuration of an auditorium must be adjusted to the form of the production. Obviously, if the "show" is to be seen
NOTES ON THE TECHNICALITIES OF THEATRE DESIGN

In the following rudimentary and brief discussion, I shall deal only with selected problems of theatre designing. I do this because I lack qualification to explain such major design problems as structure and mechanical equipment in detail. Some topics, such as acoustics, are omitted here because they are a part of the student's general knowledge -- at least in so far as I could discuss them here. Thus, the reader should understand that this survey of some technical problems is in no way meant to be exhaustive.

The subjects to which I shall devote a passing nod are: auditorium geometry; the forestage - orchestra pit area; certain mechanical facilities; basic scenery shifting systems; organization for the production facilities; and circulation patterns.
through a picture-frame proscenium arch, any part of the audience must not be seated very far to either side of that arch, if they are to see the whole stage. False stage perspective also is a factor for limiting the width of the audience seating area for proscenium production, because as one goes farther off the perspective axis, the stage picture will appear increasingly distorted. As the show moves toward the audience, however, the audience width can increase. In the three-quarter theatre, there is no proscenium to block one's scope of vision, and thus the audience nearly can surround the stage. In effect, the stage is thrust into the seating area. The full arena stage makes the proscenium - or any sight-blocking obstruction - impossible. We ought to note that as the audience begins to wrap around the playing area, the effect of visual obstacles is different for different parts of the audience. Thus, if essential action - as opposed to painted scenic vistas - is to be communicated to the audience, an entirely changed mode of production must be substituted for that used behind a proscenium arch. The latter essentially is two-dimensional because an audience's depth perception will be severely limited by its fixed axial relationship to the stage and the consequent impossibility of comparing stage action with any depth-measuring scale. Although the wrap-around audience demands simplicity of production to keep visual obstacles at a minimum, it also makes shifting what scenery there is more difficult.
HORIZONTAL SIGHTLINES

THIS figure indicates that for a given proscenium width and stage depth, the possible audience width is severely limited. George Izenour of Yale tells me that the audience must not be seated more than 14 degrees beyond the proscenium arch. Of course, this angular limit often is exceeded; but the audience will not see the whole stage, and will not willingly sit beyond the 14 degree line.
VERTICAL SIGHTLINES

One must decide at the start just how well the audience is to see. The higher the hall, i.e., the greater the number of tiers, the poorer will the vertical viewing angle become as one goes to the top. The angle from the stage to the spectator should not exceed 30 degrees. In practice, this often means that the orchestra floor is given an insufficient slope so that the gallery will not be excessively high.

Fig. a.

Fig. b.
To calculate a proper floor slope:

Referring to the two small figures on the previous page,

1. Make a point at the curtain line "A"

2. Determine the first row floor height
   (not more than 3'-6" below stage height)

3. Determine $H_1$, the first row spectator's eye height at 3'-8" above the floor.

4. If seating is staggered, use Fig.a; if not, skip back one row instead of two, using Fig.b. Draw a vertical, V. The top of the first row head will be $H_1$ plus $h$, or 3'-8" plus 5". Thus, connect $R_1$ at 4'-3" above the first row floor, and point A with a line extended to intersect V. This will be the eye height for unobstructed second (or third, in case of staggered seating) row vision, and its floor level will be 3'-8" below it. Continue this procedure to find the entire floor slope. Alpha never should exceed 30 degrees, even at the topmost side balcony.

By this method, the floor slope will be a parabolic curve. In practice, it is best to approximate this curve with straight line segments for safety. Where the slope is so steep that steps become necessary, the slope must be uniform, so that there always will be the same number of the same height risers between rows.
It may be of interest to note the comparative maximum vertical sightline angles of some new and antique European theatres. In the table to the upper left of the diagrams, maximum sightline distances are listed in meters. (From Theatergebaude II, by H. Gaussman, Berlin, 1954. Unless otherwise noted, all diagrams are from this source.)
Much is heard these days about the maximum distance that can separate a playgoer from the stage. Usually, a finite number is mentioned, such as 60' or 65, or 67'. Most would agree that the farther one gets from the actor, the less detail one can comprehend. The actor often adjusts for this, however, by exaggerating his words or facial expressions. To set any definite limit on the distance of the last row from the stage seems much less sensible to me than to limit the vertical sightline angle to 30 degrees - beyond which only the top of the actor's head can be seen. The top of one's head tends to be somewhat inexpressive.

Many factors can influence the limits beyond which the audience should not be seated. Among them are:

1. Lighting level on the actor
2. Visual contrast between the actor and the background against which he plays
3. Complexity of the stage picture
4. Level of audible sound
5. Distractions from audience, lights, etc.
6. Seating slope and the number of perceptible planes between the spectator and the stage
7. Horizontal and vertical sightline angles
8. Psychological feeling of closeness; ie. did one enter at the rear of the theatre or at its center; does the perspective effect of the theatre's interior
diminish or increase the apparent distance of the spectator from the stage; does the theatre seem to be divided into parts, or does the proscenium separate the audience from the actors unduly, etc.?

These factors are difficult to evaluate and particularly difficult to predict. Yet, I feel that they are more important than any particular distance. In the theatre especially, nothing can be finite. All is only what it seems to be. It seems perfectly possible to make a theatre incorrectly so that one feels farther away from the stage than he "really" is. Conversely, we know that the side columns and steep audience rake at the Festspielhaus at Bayreuth produce the opposite effect, causing the spectator to feel very close to the stage though he may be 100 feet from it. Because the orchestra pit is obscured there, it causes almost no visual barrier. I have tried to estimate the width of the gap between that pit and the stage. Later, when measuring it, I found that I had thought it to be fifteen feet less than it in fact was.
The relationship between vertical sightlines and stage height must not be forgotten. Simply, as the stage height decreases in relation to the level of the first row, the orchestra floor slope must become steeper. Conversely, the higher the stage platform above the first row, the shallower the floor slope may be. A low stage platform has a theatrical advantage because the drama will be less separated from the spectator by it than by a higher platform. A high platform, on the other hand, is advantageous because the whole hall can be lower. Further, the greater the distance of the first row from the edge of the stage, the shallower the floor slope may be. These effects are illustrated in the figures below.
These cumulative effects, if not carefully handled can make the hall excessively high, the first row too far from the stage, or the stage, itself, too high. These bad consequences can be attenuated somewhat by arbitrarily flattening the floor under the first few rows of seats, or by inserting a wide orchestra pit between the stage platform and the first row. This is illustrated by the comparative diagrams below. These figures also illustrate that compromises often are made in theatre design. The upper curve in each diagram represents the proper slope for unobstructed vision. The lower curve indicates the floor slope actually employed.
The relationship of the spectator to the stage platform again is shown in this figure:

Distances $H$, and $S$, must be worked out psychologically as well as for their influence on the floor slope. In general, $H$, can be less as $S$ increases.

The angle of vision of the actor may not be a determining factor in the design of an auditorium; but it is well to recall just how much of an audience the actor is able to see at one time. Diagrams showing the actor's angle of vision are included on the next page.
Within the geometric limitations just presented, various shapes can be given to the auditorium. Some of these shapes are illustrated in the plans and the sections that follow. The basic planometric shapes are: rectangular, circular or horseshoe, fan, and various combinations. Also, there are the various assymmetrical plans. Vertically, we note that circular sections sometimes are imposed on basically rectangular schemes. The fan plan usually carries with it a single steep main floor slope; and often, a series of balconies at the rear of the auditorium. Typically, the circular or horseshoe form will contain tiers of boxes or balconies that encrust its walls and end at the proscenium. The rectangular plan occasionally receives its vertical treatment in any of the described ways.
Basic auditorium plan shapes for the proscenium theatre, within given sightline limitations.
Next page:
Top: Variant on the rectangular plan.
Left: Circle
Right: Fan plan and intersecting circle.
Bild 23. Vorentwurf für den Wiederaufbau der Volksbühne Berlin (Arch. Prof. Henselmann 1950)
Eine enge Verbindung von Zuschauerraum und Bühne ist angestrebt

Bild 24. Wiederaufbau des Opernhauses Hannover (Arch. Kallmorgen)

Multiple-rectangle plan.

Bild 222. Theater-Typenprojekt für 1000 Zuschauer  
Architekt: A. W. Wlasow  
- Grundriß -
Rectangular plan. Note the rear balconies in the section on the following page; as well as the elaborate stage elevators and cyclorama.
Bild 217. Das Schauspielhaus in Dresden 1913 – Architekten: Lossow und Kühne – Längsschnitt

Bild 218. Das Schauspielhaus in Dresden 1913 – Architekten: Lossow und Kühne – Hauptansicht
Bild 94. Das Stadttheater in Ulm 1641
Architekt: Joseph Furttenbach
A Bauhaus rectangular plan by Walter Gropius. Rectangles have been consistently applied even to the interior decorating scheme. Next page.
138. CITY THEATER, JENA, 1923: Entrance.

139. Plan.

140. Interior view.
Combination circular and rectangular plans. Next page.
Circular balcony plan superimposed over a basically rectangular main floor.
Bild 294, a und b) Theaterprojekte der Staatlichen Akademie für Architekten der UdSSR
a) Grundriß für 800 Zuschauer – Architekt G. A. Sacharov
b) Grundriß für 800 Zuschauer – Architekt G. A. Sacharov
Die allgemeine internationale Weiterentwicklung des Theatergebäudes

Bild 300. Theaterprojekt für Komsomolska 1939
Architekten: B. D. Landa und W. A. Minjajew
- Grundriss -
Fan plans included in rectangles, and modified by them (top).
Der Entwurf zu einem monumentalen Festspieltheater in München, den Gottfried Semper 1862 im Auftrag König Ludwigs II. nach den Ideen Richard Wagners gleichzeitig mit einem Projekt für ein provisorisches Festtheater im Kristallpalast ausarbeitete, ohne daß einer der Pläne zur Ausführung kam.

Assymetrical Plans.
Main Floor Level
Entrance Level.

Der Raum der Halle reicht bis zu dem aufgetreppten Dach. In offenen Schalen schrauben sich breite Treppe auf und von ihnen schwingen sich frei durch den Raum zarte Stege hinüber zu den Galerien, die den Rängen vorgehängt sind. Jedem Rang ist eine Hochebene zugeteilt, die quer durch die Halle hindurchreicht. Wer sich nicht in den frohen Strom mischen will, kann da verweilen und auf ihn herabsehen. Er sieht hinunter auf die vielen Stege, Ebenen und auf den Boden der Halle und sieht sie alle mit Bildern...
Winning Project for the new Essen Opera House by Alvar Aalto. From ARCHITEKTUR WETTBEWERBE.
Balcony Level
4 EG 1:500 / Ground floor 1:500
1 Eingang / Entrance; 2 von den Garagen / from garages; 3 Kassen / Ticket windows; 4 Garderoben / Check-rooms; 5 Restaurant / Restaurant; 6 Küche / Kitchen; 7 Orchestergraben / Orchestra pit; 8 Seitenbühnen / Side stages; 9 Probobühne / Rehearsal stage; 10 Hauptbühne / Main stage; 11 Lagerraum / Utility-room; 12 Warenlift / Freight elevator; 13 Hinterbühne / Rear stage; 14 Lagerraum / Utility-room; 15 Freilichttheater / Open-air stage

5 Längsschnitt AA 1:500 / Longitudinal section AA 1:500
6 1. OG 1:500 / 1st floor 1:500

Seite 78 / Page 78:
7 Rückwand des Saales / Back wall of auditorium
8 2. OG 1:500 / 2nd floor 1:500
9 Modellaufnahme von Südosten / Model view from south-east
1 Modellaufnahme von Westen / Model view from west
2 Unterirdische Verkehrswege 1:2500 / Underground traffic routes 1:2500
3 Lageplan 1:2500 / Site plan 1:2500
THE FORESTAGE - ORCHESTRA PIT AREA

This is one of the most difficult parts of the theatre to design because of its importance, its complexity, and its need for flexibility with all of the demands of contemporary presentation.

Considering the pit area first, the sections on the next page show some of the possibilities. Obviously, the first prime requisite for flexibility here is a series of elevators for the floor of the orchestra pit.

From the top of the page down, the sections illustrate:

1. Orchestra Concert
2. Chamber Concert or Thrust Stage Drama
3. Drama
4. Congresses
5. Lectures
6. Intimate Opera
7. Grand Opera
1 Orchesterkonzert

2 Kammerkonzert oder Schauspielbühne (oben)

3 Schauspielbühne (gestaffelt)

4 Kongress-Saal

5 Vortrags-Saal

6 Kleine Opernbühne

7 Großer Opernorchesterraum
Careful study of the plans and sections on the following page of the Augsburg Stadtheater forestage area, taken from BUNENTECHNISCHER UND RUNDSCHAU, January, 1957, will indicate some of the complexity of the area in a well planned scheme. In this theatre the fly loft extends over the pit. (The first theatre to do this was the Schauspielhaus at Bochum, whose stage arrangements are shown on following pages. Gelsenkirchen, whose plans are included later to illustrate remarks on production organization, also has its loft extending over its orchestra pit.) Such an arrangement is valuable chiefly because major stage equipments normally located behind the proscenium, such as lighting bridges, sound curtains, tormentors, and the fire curtain, can be made to work for the orchestra pit area. Sensibly, if the pit is to be used for drama, it must be lit, curtained, screened, and enclosed for safety. Placing major elements in such a forward location also makes the proscenium opening more flexible in width and in height — as well as in depth.
Die verschiedenen Möglichkeiten zur Verwendung der verschiebbaren Portalanlage im Stadttheater Augsburg
Forestage and Stage Elevator Arrangements at the Schauspielhaus, Bochum, Germany.

The many possibilities for arranging these elevators show the usefulness of such elevators for providing basic theatrical and musical forms. Such elevators, especially if they are hydraulic, are very expensive, however. In such an elaborate installation as this one they would constitute the most expensive single item of stage equipment. This design for Bochum was so costly that only the pit elevators actually were installed. The plans that follow were taken from a booklet, "Schauspielhaus Bochum, 1953."

For grand opera, below, the stage elevators can be in various positions depending upon the demands of the particular operatic situation. The pit elevators are lowered, at various levels to accommodate a large orchestra. That part of the loft over the pit is screened off.
For operetta, below, the arrangement is much as for grand opera. The orchestra pit has been made smaller, however, and a narrow part of the forestage surrounds it, passing between the orchestra and the audience. Here, again, the stage elevators can be at a single level or they can be arranged to suit particular circumstances.
For drama with a small orchestra, the tiny first forestage elevator can be lowered to accommodate a few musicians. If desired, additional players can be placed just under the first few rows of audience seating. As shown below, the loft is screened off, though this would not always be so.
When the entire stage is to be used for pure spoken drama, the pit elevators are raised to form a low forestage that connects the action intimately with the seating area. The stage elevators then can be arranged as desired. An upward sloped arrangement is illustrated below. Note that the loft above the forestage area now is cleared for action and use with the drama taking place on the forestage.
Another possible arrangement for drama is the one shown below. Most of the action would take place on the forward part of the forestage, while the sloping rear portion could be useful for mass entrances and exits. Stairs are placed at the sides of the forestage to provide entrances down to the lower pit area. Here the loft is nominally closed off.
Another alternate drama stage can be created by arranging the whole series of elevators in a series of rising steps from the pit to the rear of the stage. Entrances can be effected easily from the pit.
One interesting variation is to raise up the whole pit, intact, to stage level. Now, the elevator that normally overhangs the rear of the pit forms a cantilevered platform over a part of the stage, making "double-decker" scenery possible without special construction.
Below, we note that the pit elevators can be used to support a revolving stage in various positions.

The plan on the right, below shows the arrangement when the audience seating area is to be extended, or when the stage is to be used partially at auditorium level.
If the auditorium is to be used for concerts, the stage can be set much as for pure spoken drama. If desired, the orchestra should be placed on the stage elevators at various heights.
This drawing shows the section of the forestage area of an elaborate, but reasonably inflexible, opera house, that of the East Berlin Staatsoper. Because this theatre never is used for chamber works or for drama, the orchestra pit is composed of a single elevator. The pit is 7.75 meters in width - about 25 feet. Note the elaborate catwalk systems that are necessary to allow circulation from one side of the stage to the other, both above and below the proscenium zone. On the next page is a drawing showing arrangements for the prompter's box. All dimensions are shown in meters.
Bild 72. Anordnung eines Souffleurkastens mit Zugang vom Orchesterraum und von der Unterrühne
The most recent example of the flexible forestage, with which I am familiar - the new Carnegie Institute of Technology drama theatre is soon to be built - is Loeb Drama Center at Harvard. George Izenour of Yale designed the forestage area and the mechanisms that allow it to operate. Unfortunately, I have no section of this theatre; but the plans that follow, taken from Herbert Graf's "Aus Der Welt Der Oper" do indicate some of the possibilities. Here, the chief emphasis was on making possible varying theatre forms: proscenium, three-quarter round, opposed and at the upper right, indeterminate. Few elevators are necessary for this scheme, the main mechanisms consisting of motors that whirl the front seating sections. In some of Mr. Izenour's plans, the front seating sections must be raised on pistons to clear their twin member, before they can be turned.

The chief difficulty with this theatre is the proportion between the permanent seating area at the rear of the auditorium, and the moveable part. In any but the proscenium position, the audience at the front of the theatre feels separated from that at the rear. Worse, they tend to feel intimidated by the large rear portion because the front ones are necessarily so much smaller. Further, the front seating sections tend to "take part" in the action of the drama much more than do the back sections.

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One oddity that I came across in the March, 1953 BUHNENTECHNISCHE RUNDSCHAU, is the sliding forestage at La Scala in Milan. Although the orchestra pit at La Scala is on elevators, the forestage is not. Moreover, for Italian opera, most conductors do not favor an overhanging orchestra pit as was included at Bochum. The sliding forestage neatly solves this dilemma by providing both a means of extending the forestage apron toward the audience, and a means of gaining some pit overhang when Romantic operas are presented. Even when an open pit is wished during the musical parts of the performance, the sliding forestage can be extended electrically for curtain calls.
CERTAIN MECHANICAL FACILITIES

While the mechanical facilities of any theatre are extremely complex, several must receive attention in the earliest design considerations.

Heating and ventilation equipment is especially heavy and bulky in theatres. Cooling loads are heavy; and consequently, cooling towers will be unusually large, heavy and noisy. Ductwork will be oversized because of the heavy volume flow demand, and because this volume flow must be accomplished at extra low velocities to permit necessary conditions of quiet to exist in the auditorium. Fans, compressors, and the cooling towers all are noisy. They should be carefully mounted to isolate them from structural noise paths, and they should be located as far away from the auditorium as possible. Contrary to some published data, the air flow in an auditorium should enter at the top of the room, and should leave near the bottom. This route allows the air to equalize in temperature and velocity before reaching the spectators. Reversing the flow direction will blow hot or cold air at the spectators' ankles, and dust from the floor in their faces.
Almost every theatre requires sound amplification of some sort, whether for movies, sound effects, or for weak-voiced lecturers. A large, high quality, central loudspeaker system, properly designed and installed, nearly always is the most satisfactory solution. Because these systems are large, and because their placement is critical, their inclusion into the design must not be omitted until last. Below is an indication of a typical theatre loudspeaker system. Note the dimensions and orientations. Both are approximate only, and must be carefully worked out for each particular design. Loudspeakers are best put one above the other. High-frequency units are shown below, at the top of the installation above the low frequency unit.
Adequate facilities for lighting the stage also must be planned into the auditorium from the start.

Overhead lights and spotlights often are located on a 45 degree line from the bottom of the main curtain. See the drawing below. Often, however, more than one position is desirable for these overhead lights. The second group should be located on a 60 degree line from the curtain bottom. Allow enough room for these lights. Note the space that the operators must have to work in. The minimum slot opening for these lights should be three feet. Sometimes glass is used to close the light slot to prevent noises from the catwalks entering the auditorium. Because light spill from these overhead lights is particularly distracting, they must be located and oriented to minimize this situation.

Sometimes these spotlight facilities are housed at the rear of the auditorium. Sometimes they are placed in a chandelier, as shown in the lower illustration on the next page. In some instances, the whole chandelier assembly can be lowered or raised. Occasionally, a slot is cut in the stage side of the chandelier for the spotlight beam.
The accompanying plan diagram indicates approximately where lighting facilities usually are located in a theatre. The side lights shown at both sides of the stage and in the auditorium are very important for dramatic effects and must not be omitted. Those lights in the center of the diagram indicate the ceiling lighting bridges. Of course, if the lighting men had their way, lights would be placed all over the auditorium. There never are enough.
BASIC SCENERY SHIFTING SYSTEMS

Of course, the most basic way to shift scenery is to lug it by manpower. This system has the advantage of demanding very little mechanical expenditure, and comparatively little space. Many theatres still use this system, among them the great opera theatres of Covent Garden in London, the Metropolitan in New York, and the Wagner Festspielhaus at Bayreuth. In these days of high union wages, this system of transferring scenery is too costly. It also takes too long. In Bayreuth, for example, where intermissions - if all goes well backstage - usually last an hour, I have watched sets being dismantled and then rebuilt piece by piece. Elaborate sets.

In the latter days of the Renaissance, opera, the horseshoe shaped auditorium, and wing and border scenery all began to influence theatre building. As long as painted, drop scenery was the only scenery used, the high fly gallery produced by these circumstances was sufficient to allow rapid shifts of scenery. Very little side stage space was required, except for actors' circulation. All of the theatres mentioned above were built for opera and for wing and border scenery. Early in the Twentieth Century, however, plastic scenery began to be in vogue. The "single set" idea
became increasingly popular. The box set gained wide use. None of these forms of scenery can be suitably handled by the fly loft. They demand storage space. They are heavy. They cannot be assembled quickly by hand.

One of the first means sought to relieve this situation in theatres that had only fly galleries and no side or back stage space was to build elevators into the stage floor. There long had been traps, but now the elevators could be used to shift - and even help to form - scenery. This basic scheme is illustrated in the diagram below.
A theatre such as the Theatre Pigalle in Paris illustrates the elevator stage. While this theatre has more elaborate equipment than the system just described, the basic scheme is the same.
Gradually, this system was elaborated and it reached its height at the Dresden Schauspielhaus in 1913. The diagram below shows that the smaller elevators have been enlarged, and in some cases a wall or enclosure separated the last set of elevators from the front of the stage. This system sometimes is referred to as the "Pater Noster" system. Scenery is placed on the forward elevators which then are raised into position - all scenery shifting is done in the basement, thus requiring no side stages. Note that the scenery is not really placed on the elevators themselves. Rather, it goes on wagons, which in turn are put on the elevators. Beneath the scenery which has been placed into position at the front of the stage is a duplicate set of wagons that roll on tracks. The second scene is placed on these wagons, which then are rolled to the rear of the stage, where they are placed on the rear elevators and lifted to the rear of the stage. The partition that separates the rear from the front of the stage is useful in preventing the noise of the scenery shifting from being heard in the audience. When the first scene is over, its scenery is lowered to the basement scenery loading area where it is cleared away. Meanwhile, the second scene has been rolled into position at the front of the stage. As the scene progresses, the third scene is being loaded in the basement, and then brought into position at the rear of the stage.
If scenes are long enough to permit preparation of the ensuing scene's required scenery, the actual shift can be accomplished rapidly. Of course, the fly gallery is used in conjunction with this and most other scenery shifting systems. The disadvantages of this system are that the cyclorama must be gotten out of the way at each scene shift to permit the scenery at the back of the stage to be rolled to the front. At Dresden, they got around this by putting the cyclorama at the back of the stage. However, this necessitated keeping the second scene in the basement until the main curtain was closed. It is a moot point which means is more speedy; i.e., whether it takes longer to clear the cyclorama, or to raise the scene up from the basement.

The Dresden theatre is included again in section on the next page. Below is a schematic diagram of this system.
Bild 217. Das Schauspielhaus in Dresden 1913 - Architekten: Lossow und Kühne - Längsschnitt
An alternate to the elevator system for scenery shifting was the revolving stage. It is diagramed below.

The trouble with this system is that it does require a certain amount of side stage space if the whole show cannot be set up in advance on the turntable. Further, unless the diameter of the turntable is considerable, the settings that can be placed on it will be very small if one wishes to have more than two. Usually, space was too restricted to allow large enough turntables. Except for specialized settings where the stage can revolve in full view of the audience, this system is little used today. Even theatres that have auxiliary turntables, as does the Vienna Opera, seldom use them, especially if stage wagons or the elevators are available.
The Residenztheater in Munich exhibits a revolving stage that is of adequate size, about 50 feet in diameter. George Izenour assures me that any diameter less than 40 feet is completely useless.
The great mammoth of turntables - the largest in the world - was installed at the Frankfurt am Main opera house when it was rebuilt after World War II. This monster - some call it a white elephant - has a 120 foot diameter. Its real fault is that it left absolutely no side stage space. As can be seen from the plans on the next pages, this large turntable takes up the space that normally would, and could, have been devoted to side and rear stages. Within this great table is a smaller turntable as well as elevators. All scenery is shifted from stage level or above, however.

In practice, the rear half of the large table serves as storage space. Many complete sets can be erected on it at once. Further, this rear portion can be closed off from the front by a large metal door. Because of the high edge velocities resulting from the great diameter of the table, it requires several minutes to make a single revolution. Thus, it cannot be used for large, quick scenery changes. Its users assert that if only they had a few more feet of side stage space, the system as a whole would be admirable.
"GROSSES HAUS" FRANKFURT M.
WIEDERAUFBAU SCHAUSPIELHAUS
ERDGESCHOSS
Naturally, there were combinations of several of the basic systems. The plans below show two revolving stages, one within the other. In addition, there is enough rear stage space for one wagon and considerable storage.
Another, and very popular combination, is the revolving stage with enough side stage space for one wagon. Thus, one very elaborate scene can be set up in advance of the show, and only less complicated ones will have to be handled during the course of the play.
Another combination possibility is the Pater Noster and revolving stage. This form has the advantage that the elevators can be turned at any angle to the audience and thus they become much more useful to the scenic designer. Also, when the second scene is to be brought to the front of the stage via the Pater Noster system, it can be moved there by revolving the turntable rather than by rolling on separate wagons.

The great disadvantage of this mechanism is its expense. All of the elevator machinery must be included within the base of the turntable. Thus, these revolving Pater Noster schemes must go very deep under the theatre. That at the Vienna Burgtheater is 14.7 meters deep to its base track, or about fifty feet. The depth depends, of course, upon how high the scenery is to be. Thus, in an operahouse that used scenery 40 feet high, the turntable could easily be over one hundred feet deep. This scheme is shown in the diagram below, and is illustrated by plans and sections of the Burgtheater turntable on succeeding pages.
Grundriß der Bühnenanlage

Grundriß der Zylinderzuebbühne, Höhe −14,15 m, mit den Antrieben
Sections through the Vienna Burgtheater turntable.
The preceding Vienna Burgtheater plans and sections were taken from the December, 1955 BÜHNENTECHNISCHE RUNDSCHAU. As far as I have been able to find out, the Burgtheater is the only one to have so complete and elaborate an installation of the revolving Pater Noster. It was installed there because the old stagehouse which had been bombed during the war, could not be enlarged. Further, the proscenium was small enough and the demands of a repertory drama house slight enough that it could be built with a depth of only fifty feet.

As side and rear dimensions could be increased in the theatres, wagons could be employed. But where they could not be, elevator schemes became increasingly elaborate. The Hamburg opera house has double-decker elevators which can have one scene set up above or below the other. (Oddly, at Hamburg, when the theatre was bombed, the fire curtain worked in reverse, saving the stage, while the auditorium burned.) In Munich, at the old National Theater, where the first two installments of Wagner's "Ring" were premiered, there was a double-decker revolving stage. This was destroyed in the air attacks, however.

Wagon systems demand large subsidiary stage spaces. Seldom are more than three wagons used. If three are utilized, then three scenes can be set up prior to the performance; and the stagehands will have at least the time of two scenes to reset any scenery.
Basic wagon schemes, and combinations of wagons with turntables, elevators, etc., are shown in the diagrams below. On the following pages illustrative plans are grouped.
Bild 252. Das Opernhaus Hannover, Wiederaufbau 1951
Architekten: Werner Kalimorgen und Klaus Hoffmann
– Parkettgrundriss –
Plan für das neue Große Theater in Warschau (Teatri Wielki Opery i Baletu), 1957
The last of the basic theatre systems for shifting scenery is perhaps the most elaborate. Certainly, it is the most space consuming. This is the ring system. As far as I know, it is a completely theoretical system, in that one has never been built. Two variants are shown in the diagrams. The first consists of a great moveable ring that surrounds the audience. Various scenes can be placed on the ring, which then revolves from scene to scene. The second, has the ring backstage, surrounding the storage facilities. Neither system can be thought a space saver.
Although none of the existing theatres of the world included the ring system, it still is being proposed. The most recent proposal to be published was that of Fritz Bornemann, the architect of the new West Berlin opera house, for the Essen opera house, published in ARCHITEKTUR WETTBEWERBE #29, June, 1960. Note in the plans and sections on the following pages that Herr Bornemann not only has a ring stage, but he includes elevators as well.

After this, I have included a 1938 ring stage proposal which was to have included regular stage elevators and a cyclorama behind the ring. There is no doubt that this system could produce startlingly quick scene changes.

All of these systems apply to the proscenium theatre. As has been pointed out, in other forms of presentation, such as the thrust stage or the arena stage, scenery must become highly simplified. Further, it often must be shifted before the audience's eyes. While a revolving stage might be employed for the three-quarter stage, the only satisfactory way of shifting scenery for the arena theatre is by elevators, from underneath. There is little need for a fly loft in the arena theatre.
Entwurf / Project:
Dipl.-Ing. Fritz Bornemann, Architekt, Berlin-Wannsee
1 Lageplan 1:2500 / Site plan 1:2500
2 Eingangseite 1:1000 / Entrance side 1:1000
3 Bühnengeschoß 1:1000 / Stage floor 1:1000
4 1. OG (Foyer) 1:1000 / 1st floor (foyer) 1:1000
5 Längsschnitt 1:1000 / Longitudinal section 1:1000
6 Eingangsgeschoß 1:1000 / Entrance floor 1:1000
Bild 326. Anregung für eine „Totalbühne“ als Ringbühne in Verbindung mit einer Freilichtbühne – 1938  
Architekt: Wilhelm Käb – Lageplan für eine mittlere Größe (2500 Sitzplätze)

Architekt: Wilhelm Käb – Zentraler Längsschnitt
ORGANIZATION FOR THE PRODUCTION FACILITIES

Most American theatres do not have scenery production facilities associated with them. In Europe, however, it is the exceptional civic theatre that does not produce its own scenery. There are opera houses, such as the Metropolitan in New York, that will do their own scenery making. Further, this is done in many high schools and colleges in this country. Thus, it may be appropriate to say a few words about the proper organization of these facilities.

There seems to be little to be said for locating the scenery shops immediately next to any stage. True, this often is done; but adequate sound isolation between the two spaces is almost impossible to achieve. Sometimes, the designer hopes to make double use of the space for scenery construction by making it available for side stage or wagon space when scenery is not being built. But when, in any busy rehearsal schedule is scenery not being built. Never, from my experience. Aside from saving space, there seems to be no functional reason for placing the scenery workshops next to the stage. Scenery is built to be broken down into small units that are easily carried. Thus, there should be no more difficulty in carrying newly built scenery to the stage from the shops than there would be to carry it from a storage room.
Several theatres that I have seen have not located their scenic work rooms in the main theatre building. One, at Hamburg, has its shops housed in a former towing basin at the edge of town, half-an-hour to forty-five minutes from the opera house. The Hamburg storage facilities also are in the same building as are the shops. Another German theatre, that at Mannheim, has located its shops just across the street from the theatre building. There they have special trucks and a special elevator for the trucks to get the scenery into the house during inclement weather. Neither of these opera organizations has suffered any ill effects by separating their facilities.

There do seem to be some advantages to separation. Functional circulation always is a problem in a theatre, especially in a repertory company that has a tight schedule. Why should carpenters, painters, clothmakers, metal smiths, etc., add to the theatre confusion? Then, there is the sound isolation problem. If the shops are distant from the stage, there can be no problem. Perhaps the ideal solution would be to have the shops in the same structure or series of structures as the main theatre, but well removed from it. Then, both sound and confusion could be isolated, while the scenery could still be transported indoors.
If the shops must be adjacent to the stage, then the examples of Gelsenkirchen and Cologne might well be emulated. Certainly Gelsenkirchen has the best production circulation and organization of any theatre that I have seen. Plans and sections both for Gelsenkirchen and for Cologne follow this discussion.

In general, the backstage organization and circulation must depend on the stage configuration, especially on the proscenium height; and on the scenery shifting systems employed. Usually, all construction shops should open into the montage room through a direct connection. (The montage room is a room the size of the stage acting area, with a ceiling height equal to or exceeding the proscenium height, that is used to check and assemble the scenery sections at various points in their construction. Generally the finished set is completely assembled there just prior to painting and again before going to the stage or to storage.) A direct path from the cloth shop to the montage room is of secondary importance. (See the program of this thesis for a list of necessary production spaces.) The flow schedule of construction is from the carpenter shop to the montage room, to the paint shop, to the montage room, to the stage, or to storage. The cloth shop should be adjacent to both the carpenter shop and to the paint shop, rather than opening into the montage area. If the workshops are on the stage level, the montage area may be a part of the back or the side stages. In any event, the metal and carpenter
shops shall be on the same level with each other and with the montage room. The paint shop and the montage room both should have connections to the elevator or to the storage area if it is on their level. The transportation-loading dock should be directly related to the stage, to the montage area, and to the storage areas if only one dock is provided. One usual mistake that is made in planning these areas is to provide insufficient storage space for the wood, cloth and other raw materials that are used in the shops. Actually, these shops form a small factory; and they ought to be as carefully and as efficiently designed as a factory would be.

Other production facilities might include the dressing rooms, rehearsal spaces, and costume storage areas. It is imperative that the dressing rooms be placed as close to the stage as possible to minimize the elapsed time for an actor to reach the stage from his dressing room. Similarly, the rehearsal room ought to be near the dressing rooms; although they need not necessarily or even desirably be near the stage. Costume storage, especially in a repertory company should be split up near the dressing rooms, so that all the costumes to be used during a season by a set of dressing rooms, always will be near them. Larger, dead storage rooms for costumes might well be used as buffer zones between rehearsal spaces.

One problem that usually asserts itself in designing the theatre, especially on a restricted urban site,
is the architectural organization of the backstage rooms. All too often they are distorted and mashed into whatever is left over when the auditorium, stage and fire stairs have been tended to. Too frequently, one encounters endless, twisting corridors that seem to lead nowhere, and are oriented toward nothing. Under these conditions, it is nearly impossible for one not to get lost.

Happily, both the Gelsenkirchen and Cologne plans have allotted sufficient space for the backstage needs; and they have simplified and oriented the circulation paths to a considerable degree. In this, the straight line paths of Gelsenkirchen are much more successful than the rectangular ones of Cologne, that go all around the stage house through many vertical storys. I have found that any complete, regular, circulation circuit, whether rectangular or circular, tends to be confusing and disorienting.

The first Gelsenkirchen plan, that of the upper level, explains that the left string of rooms houses the dressing rooms. They are located on that side of the theatre because a small theatre is joined on to the main building at the left, and is not shown in this plan. Over the left side stage area the rehearsal rooms are placed, with easy access from the dressing rooms. The right hand string of small rooms includes the administrative offices for
the theatre. The montage room is over the rear stage, the carpenter shop in the right rear corner of the building, and the paint shop is over the right stage area. The next plan, at the lower balcony and box level, continues the previous arrangements, now indicating the connection to the little theatre.

It can be seen here that the stage proper is intended as a three wagon system with two side stages and a rear stage. To either side of the rear stage area are scenery storage magazines. Between the right magazine and the side stage is what is often called a "drop cut" in this country. It is a vertical space with shelves in which the rolled-up drops are stored. It may be located at, or below, stagelevel. Below is a section of the drop cut at the Staatsoper in East Berlin.
In the main floor level plan of Gelsenkirchen one ought to note the arrangement of the lobby. The main space surrounding the auditorium is designated as a smoking room, while non-smoking rooms are at either side. Quite the opposite of American practice. The entrance level plan shows cloak room areas on either side of the auditorium and stairs leading up to the main lobby at the front of the theatre. The main bank of dressing rooms is to the left, at stage level, while more offices are at the right. The lowest level plan seems to be unfortunately cut-up. The main theatre entrance extends from the front of the main theatre block; and the ticket offices are placed there. The principal cloak room areas are at this level as are the main rehearsal spaces.

The plans and section for Gelsenkirchen were taken from ARCHITEKTUR WETTBEWERBE #25, February, 1959. I visited the Gelsenkirchen theatre and most of the other theatres discussed here, in the summer of 1960.
14 2. Rang 1:500 / Upper circle 1:500
15 Rohbauaufnahme - Eingangseite / Photograph of shell -
Entrance side
11 Längsschnitt 1:500 / Longitudinal section 1:500
12 Robbaufnahme = Blick von der Bühne / Photograph of shell - view of the stage
13a/b 1. Rang 1:500 / Dress circle 1:500
8/9 Rohbauaufnahmen / Photographs of shell
10 a/b Saalgeschoß 1 : 500 / Hall floor 1 : 500
Before passing on to the plans and sections of the new Cologne opera house, it may be amusing to note the plan below. While the rooms behind the stage area cannot all be thought to be workshops, this early theatre does exhibit the same proportions of form and space that both Gelsenkirchen and Cologne have. This plan is interesting too, in that it is just after the famous scheme by Cochin, done in 1762. Both schemes share the tripartite division of the stage and are heading toward the single proscenium arch from the usual five permanent arches of the Roman-Palladian theatre. But more of this later.

Bild 130. Entwurf eines Theaters 1771 von Ferrarese
The sections and plans of the Cologne opera house that follow were originally published in the BUHNENTECHNISCHE RUNDSCHAU of July, 1957.
CIRCULATION PATTERNS

General theatre circulation may be separated into several categories:

1. Entrance and exit circulation; vehicles and people.
2. Audience circulation within the theatre.
3. Actor circulation

As with the subject of mechanical facilities, only a few general aspects of circulation can be discussed here. Every specific solution will vary. Philosophically, circulation can mean several things. It can refer to the richness of perambulation patterns, or to diagrammatic functional routes, or to the possible paths of mass movement, or to the usual flow of traffic.

Several of these ideas about circulation apply to the theatre, at different times and at different places in the building. For example, the entrance and exit circulation pattern for the audience ought to be as clear, direct and simple as possible. When the audience is trying to reach its seats before the show; or is trying to leave them after the show or during a fire; the designer should not attempt to add "richness" to the path that the audience must traverse.
Längsschnitt durch die Pariser Oper, erbaut 1862-75 nach Plänen von Charles Garnier (Zeichnung von Pichot und Meyer in der Leipziger Illustrierten Zeitung).
During intermissions, however, there must be suitable space and goals provided in the theatre design to permit and inspire the audience to walk leisurely about.

For the audience, then, two types of circulation ought to be provided. First, direct routes into and from the theatre auditorium from the outside. Second, leisurely perambulation paths for intermissions.

The first sort of circulation, in today's design, must not ignore the automobile. In almost any theatre location, a large portion of the audience will arrive from vehicles: taxis, buses, and private cars. These private cars must be parked; the taxis and buses must be unloaded. The happiest solution is one that brings the parts of the audience arriving both by vehicle and on foot together in an outer space; and then provides a single route for both groups to the auditorium.

One possible way to provide both sorts of circulation for the audience is to have a very direct route from the outside to the auditorium. Opening off this direct route, however, will be the perambulatory path that circles around and above it. One famous instance of this sort of circulation is Charles Garnier's Paris opera house. Another, modeled closely on the Paris design, is that for the Vienna opera house. Plan and section of the latter follow on the next page.
1 Loggia
2 Foyer
3 Marble Hall
4 Tapestry Hall
5 Teesalon
6 Centre Box
7 Anteroom
8 Sitting-room
9 Stage
10 Rear Stage
11 Side Stage

12 Workshops
13 Scenery storage
14 Directors' and stage inspectors' offices
15 Courtyard
16 Chorus dressing rooms (men)
17 Chorus dressing rooms (women)
18 Building administration
19 Juvenile ballet dressing rooms
The preceeding plan was taken from the April, 1958 BUHNENTECHNISCHE RUNDSCHAU, while the section came from the official Guide Book of the Vienna State Opera.

Although this scheme is admirable in many respects, it shares a fault common to nearly all theatre designs: the dead-end. Nearly always, the circulation paths on either side of the auditorium end at the proscenium line. Sometimes this situation is relieved, as at Paris, by placing stairs at these dead ends to provide some vertical continuity. This was done at the Bochum Schauspielhaus. The plan below was taken from the April, 1958 BUHNENTECHNISCHE RUNDSCHAU, as was the section.

Schauspielhaus Bochum
The postwar Dusseldorf opera house also used this scheme for circulation. However, it is much more successful than the Bochum design because the amount of circulation space is more generous. Compare the plans below of the prewar and the new Dusseldorf houses. The effect of the new theatre in these circulation spaces really is quite grand. The plans and section that follow were published is the BUHNENTECHNISCHE RUNDSCHAU of June, 1956.
Grundriss des alten Stadttheaters

Grundriss des neuen Hauses (Parketageschoß)

Opernhaus Dusseldorf
The plans of the prewar Hamburg opera house exhibit the dead end circulation scheme at its worst. The newly rebuilt house could not be much improved, however, because most of the former side auditorium circulation space had to be used for the fire stairs. The stairs, in turn, were required because the restricted site forced the architect, Gerhard Weber, to build a high auditorium in order to include the necessary seating capacity within the auditorium. The plans and section of the Hamburg theatre that follow are from the June, 1956 BÜHNENTECHNISCHE RUNDSCHAU. The first plan is of the original building by Carl Friedrich Schinkel, 1825; the next is of the 1926 modernization, when the double-decker stage elevators were installed; and last are the section and plans of the new auditorium, built in 1955.
Grundriß der Hamburgischen Staatsoper nach dem Umbau 1926. Hauptbühne mit sechs Bühnenpodien (je 15×2,50 m), zwei Seitenbühnen mit direkt anschließenden Bühnenwagen (je 11×2,50 m) und Hinterbühne (als Doppelstockpodium 15×7,50 m gebaut).
Längsschnitt in der Mittelachse mit Ansicht auf die seitlich gelegenen Logen

New Hamburg Opera House
New Hamburg Opera House
A very recent design for stairs to end the dead-end circulation alleys is that of Philip Johnson for the Repertory Theatre at Lincoln Center in New York. Fortunately, or otherwise, this design was scrapped when a repertory dance company could not be assembled. The Eero Saarinen "Experimental" Theatre for the same complex also has this circulation scheme, though it is not as free as the Johnson design. The Repertory Theatre design below was included in the January, 1961 Bühnentechnische Rundschau.

The happiest intermission circulation plan surrounds the auditorium and permits an easy traffic flow that does not have to turn back on itself. This is particularly important in today's theatres that must make some of the circulation spaces do double duty both for intermissions and for entrances and exits to the outside. In the Paris Opera or Vienna Opera plans, intermission spaces were quite separate from the main exterior entranceways.

The plans that are on the next page, from the Essen Opera House competition, of 1959, are by Eckhard Schulze-Fielitz. They indicate one contemporary solution to the circular circulation idea. Note the generosity of the spaces, and that they are modulated to form a series of separate spaces, rather than an even ring. In this sort of scheme, great care must be taken that the audience does not become disoriented during their stroll, as would happen in walking around a cylinder.
Two other plans are interesting for their audience circulation paths, as well as in many other respects. The winning design by Alvar Aalto for the Essen Opera House exhibits the "funnel" scheme. Ostensibly, the "excuse" for his assymetrical auditorium was that the audience flow path should naturally diminish as it reaches fewer and fewer seats. This scheme is very straightforward, however, and allows little variation for intermission walking. It also is a dead-end plan.

The plan and section on the next page are from ARCHITEKTUR WETTBEWERBE #29, July, 1960.
4 EG 1: 500 / Ground floor 1: 500
1 Eingang / Entrance; 2 von den Garagen / from garages; 3 Kassen / Ticket windows; 4 Garderoben / Check-rooms; 5 Restaurant / Restaurant; 6 Küche / Kitchen; 7 Orchestergraben / Orchestra pit; 8 Seitenbühnen / Side stages; 9 Probabühne / Rehearsal stage; 10 Hauptbühne / Main stage; 11 Lagerraum / Utility-room; 12 Warenlift / Freight elevator; 13 Hinterbühne / Rear stage; 14 Lagerraum / Utility-room; 15 Freilichttheater / Open-air stage

5 Längsschnitt AA 1: 500 / Longitudinal section AA 1: 500
6 1. OG 1: 500 / 1st floor 1: 500

7 Rückwand des Saales / Back wall of auditorium
8 2. OG 1: 500 / 2nd floor 1: 500
9 Modellaufnahme vom Südosten / Model view from south-east
Another competition-winning design is that of Jørn Utzon for the Sydney Opera House. Perhaps, other than the fantastic shell, the circulation scheme is one of this design's most interesting features.

Automobiles enter beneath the main flight of steps. There are to be six lanes of traffic. Unfortunately, this means that pedestrians will have to cross automobile paths before they can reach the stairs that will take them to the upper level. Note that this scheme integrates the vehicular arrivals with the main pedestrian traffic flow before it reaches the auditorium areas. The main flow space is extremely generous, and will enable the theatre-goers to form a "grand procession" - in Mr. Utzon's words. During intermissions, the spectators will not have to double back on their entrance route. Instead, they may continue to the promenades and bars at the rear of the auditoriums, thus obtaining a fine view of Sydney Harbor.
1 Ansicht von der „Sydney-Bucht“ / View from the „Sydney-cove“
2 Ansicht von Osten 1 : 1000 / View from East 1 : 1000
3 1. OG 1 : 1000 / 1st floor 1 : 1000
4 Eingangsgeschoss 1 : 1000 / Entrance floor 1 : 1000
5 Modellaufnahme / Model view
6 Längsschnitt 1 : 1000 / Longitudinal section 1 : 1000
7 Saalgeschoss 1 : 1000 / Hall floor 1 : 1000
The most successful contemporary circulation scheme, from an audience viewpoint, is that of the Mannheim National Theater by Gerhard Weber. Although it does not consider the automobile, the interior circulation is completely admirable. The audiences for both theatres enter a common lobby with the separate cloak room spaces for either theatre at the ends. Opposite the entry is the main bar that serves both theatres. From this single lobby-foyer, stairs lead to the separate auditoriums at the ends of the theatre building. For those who do not wish to retrace their steps during intermissions, small foyers are located at the rear of the two auditoriums as in the Utzon scheme. This design works beautifully. The audiences of both theatres mingling in a single intermission space is delightful.

The plans and section included on the following pages are taken from Roberto Aloi's "Architetture Per Lo Spettacolo", Milan, 1958. After the regular illustrations of the Mannheim theatre, I have included the design for the original competition by Mies van der Rohe. Interestingly, the circulation in Weber's scheme is much more economical. Mies, however, does provide the luxurious circuit path for intermissions totally around not only one, but both, theatres.
Pianta del piano terreno (−4,76 m) / plan du rez-de-chaussée (−4,76 m) / ground floor plan (−5,20 yd.) / Erdgeschoss (−4,76 m)


Pianta al piano della platea (±3,33 m) / plan au niveau du parterre (±3,33 m) / plan at stalls level (±3,63 yd.) / Parkettgeschoß (±3,33 m)

Pianta al piano della balconata (+6,66 m) / plan au niveau du balcon (+6,66 m) / plan at balcony level (+6,66 m) / Ranggeschoss (+6,66 m)

1 piano pieghevole nella piccola sala / plaque pliante dans la petite salle / small theatre folding plate / Fallplatte im kleinen Haus

2 scala / escaliers / staircases / Treppen

3 zona di trasporto / zone de transport / transport zone / Transportzone

4 sala del balletto / salle de ballet / ballet hall / Probebühne

5 deposito strumenti / dépôt instruments / instrument storage / Instrumentenmagazin

6 zona di regia della piccola sala / zone de régie de la petite salle / small theatre stage-management / Regiezone kleines Haus

7 scale / escaliers / staircases / Treppen

8 retro palcoscenico della grande sala / arrière scène de la grande salle / large theatre backstage / Hinterbühne grosses Haus

9 zona di accorgare gli strumenti / salle pour accorder les instruments / tuning room for instruments / Stim Zimmer

10 sala di prova / salle de représitions / rehearsal hall / Probebühne

11 sala di prova dell'orchestra / salle de répétition de l'orchestre / orchestra rehearsal room / Orchesterproberaum

12 deposito sedia della piccola sala / dépôt chaises de la petite salle / small theatre chair storage / Stuhlmagazin kleines Haus

13 sala di prova dell'orchestra / salle de répétition de l'orchestre / orchestra rehearsal room / Orchesterproberaum

14 podio abbassabile della piccola sala / estrade abaissable de la petite salle / small theatre sinking podium / Hebebühne kleines Haus

15 fossa dell'orchestra della grande sala / fosse d'orchestre de la grande salle / large theatre orchestra pit / Orchestergruben grosses Haus

16 deposito strumenti / dépôt instruments / instrument storage / Instrumentenmagazin

17 sala per accordare gli strumenti / salle pour accorder les instruments / tuning room for instruments / Stim Zimmer

18 sala di prova / salle de représitions / rehearsal hall / Probebühne

19 sala di prova dell'orchestra / salle de répétition de l'orchestre / orchestra rehearsal room / Orchesterproberaum
Sezione trasversale / coupe transversale / cross-section / Querschnitt.

Sezione longitudinale / coupe longitudinale / longitudinal section / Längsschnitt.
Pianta del piano terreno / plan du rez-de-chaussée / ground floor plan / Erdgeschoss Grundriss

1. entrata al grande auditorium / entrée au grand auditorium / entrance to large auditorium / Eingang zum großen Auditorium
2. sala di prova per l'orchestra e deposito strumenti / salle de répétitions de l'orchestre et dépôt instruments / orchestra rehearsal and instrument storage / Probesaal für Orchester und Depot für Instrumente
3. deposito costumi / dépôt costumes / costume storage / Kostümdepot
4. sala di prova / salle de répétitions / dressing rooms / Künstlergarderoben
5. vestibolo / hall / lounge / Vestibül / 6 camerini per gli artisti / loges d'artistes / dressing-rooms / Künstlergarde-roben
6. entrata al piccolo auditorium / entree au petit auditorium / entrance hall to the small auditorium / Eingang zum kleinen Auditorium
7. laboratorio costumi / atelier costumes / costume workshops / Kostüm Schneidererei
8. caffè e cucina / café et cuisine / cafeteria and kitchen / Kaffee und Küche
9. uffici / business offices / Büros
10. uffici tecnici / bureaux techniques / technical and design studios / technische Büros
11. amministrazione / administration / Verwaltung

Pianta del piano superiore / plan étage supérieur / top floor plan / Grundriss des oberen Stockwerks

1. palcoscenico principale del grande auditorium / scène principale du grand auditorium / main stage for large auditorium / Hauptbühne des grossen Auditoriums
2. retro palcoscenico / arrière-sce ne / backstage / Hinterbühne
3. laboratori scenografi / ateliers scénographes / paint shops / Werkstatt für Bühnenbildner
4. palcoscenico principale del piccolo auditorium / scène principale du petit auditorium / main stage for small auditorium / Hauptbühne des kleinen Auditoriums
5. laboratorio scenari / atelier décors / scenery workshop / Werkstatt für Kulissenmalerei
6. deposito / dépôt / storage / Depot
7. camerini per solisti / loges des solistes / changing rooms for soloists / Garderoben für Solisten
8. ristorante del teatro / restaurant du théâtre / theatre restaurant / Theaterrestaurant
9. passeggiata / promenade / promenade / Wan-delhalle
The previous section concerned with backstage organization has commented sufficiently on the necessary circulation patterns for actors, scenery, and so forth.

Ideally, actors should have an entrance separate from the backstage workers. In addition, their traffic paths around the immediate stage should be kept as separate as possible. Actors should enter the stage near the proscenium, while scenery and stagehands ought to enter and exit from the stage at the rear. The plans of Cologne and Gelsenkirchen are ideal in this respect; as is that of Mannheim.
NOTES ON THE EVOLUTION OF THEATRE FORM
The Evolution of Theatre Form

Not meant to be a regular history of theatrical form, this section of the thesis intends to present some aspects of the evolution of such theatrical forms as the proscenium arch, the horseshoe auditorium, the fan plan. To do this I have assembled many plans and sections, interspersed with enough narrative to bind them into some sort of sequence.

There may be factual holes in my argument. This section should be regarded as an interpretation of theatre form rather than an absolutely factual account of its formation and change.
Early theatres, that considerably antedate the well known Greek examples, were pits. Perhaps they were originally suggested by fortuitous rock formations. Gradually, they became more elaborate, with steps for the spectators, and a platform for the actors. The example pictured below, and taken from ARCHITEKTUR WETTBEWERBE #25, bears a striking resemblance to certain contemporary experimental theatres.

Our example here is a drawing of the theatre from the palace at Knossos, ca. 1700 B.C.
In the Greek era, in the Sixth Century B.C., the great theatres began to be constructed. While they sometimes are thought to be built in a fan plan, I believe that they are not. Usually, their form, as at Priene, below, was roughly rectangular. This rectilinear form included circular rows of seating. Note that in the Greek theatres, the angle of the spectators around the acting area is somewhat greater than 180 degrees. The problem with this form was that it tended to focus all attention on the round place occupied by the chorus. Increasingly, the acting was done outside this semicircle, and thus, some seats did not have good sightlines. Note the steep audience rake. The scene house located just outside the seating area was used for dressing rooms, as well as serving for a background to the play. Here, it has three entrance doors.

The illustration on the next page of the great theatre at Priene comes from Theatergebaude I.
Bild 23. Das Theater von Priene – Geänderschnitt und Grundriss
The Romans took the Greek forms whole and transformed them for the theatre as they did with architectural forms in general. Gradually, the theatre became a true semicircle, and the scene house became very elaborate. This scene house was, of course, permanent.

The Romans also used the Greek Odeon form, which had been used mainly for musical events. Contrary to popular opinion, the Greeks had found their great open air amphitheatres inadequate acoustically for music; and so, brought these events indoors. The Romans sometimes placed these roofed-over boxlike buildings in conjunction with their open air theatres so that in inclement weather the performance could be continued.

An instance of this practice occurred at Pompeii; and is illustrated on the next page. Naturally, this theatre dates from the First Century A.D., or before. I suspect it to be slightly earlier because its form has not yet assumed that of a semicircle, exceeding 180 degrees by just a bit.
Bild 47. Das Große und Kleine Theater in Pompeji nach Fiechter

- linke Hälfte Grobes Theater, rechte Hälfte Grobes und Kleines Theater in der späteren Gestalt -
The classical form of the Roman theatre is shown on the following pages. Below is a sketch from ARCHITEKTUR WETTBEWERBE #25 of the theatre at Orange, of about the Second Century, A.D.

The next page shows a plan of the theatre at Herculaneum, of about the same period. It is included in Herbert Graf's "Aus der Welt der Oper". Note that the seating area is exactly 180 degrees; that the scene house has become a veritable wall, as high as the seating section, and closing off the formerly open side of the theatre entirely. The scene house now has the classical five doors. The one in the center is slightly emphasized.
Various projects in our own time have sought inspiration from these Greek and Roman prototypes. Generally, the seating angle has been decreased considerably from even the Roman 180 degrees. Certainly, the large assembly hall for the Soviet Palace in Moscow, a project by Walter Gropius, owes some of its shape to the ancient theatres. The illustration is from "Walter Gropius" by Siegfried Giedion.
155. SOVIET PALACE, MOSCOW, 1931:
Side elevation of assembly hall and theater.

156. Plan of large assembly hall (15,000 seats)
and theater (5,000 seats).

157. Longitudinal section of assembly hall and theater.
Just in passing, one cannot resist noting that the Utzon design for Sydney also owes a debt to the Greek and Roman theatres. The shape of the larger theatre is remarkably like that of Priene, and that of the smaller one resembles the Odeon.
Although the historical line now points directly at Palladio, we should mention that another, spontaneous theatre form was developing in the inn courtyards of Spain and England. This finally became the famous three-quarter theatre of Shakespeare's era. A Nineteenth Century interpretation of this antecedent is below.
Back in the Italian orbit once more, we recall that the architects of the Renaissance rediscovered the glory that was Rome, and Greece too. In Palladio's famous theatre at Vicenza, ca. 1585, we see that he essentially has roofed over a Roman theatre. The ceiling is painted to resemble sky, however. The famous perspective vistas were added to the five classic Roman doors after Palladio's death. Remember the flattened, semicircular shape of Palladio's auditorium, when we look at the project by Nicholas Cochin in a few pages. Already in the Vicenza theatre the center door is becoming more important visually than it was in Roman days. The illustration below is from "Aus der Welt der Oper".

*Teatro di Vicenza*
Only fifteen years after Palladio's theatre at Vicenza, in 1600, Aleotti designed the Farnese theatre for Parma. (Both of these theatres, incidentally, are still in existence.) This was a great barnlike space roofed over with wooden trusses. But for the first time we see the proscenium arch, and the prototype of a horseshoe auditorium. The proscenium arch, as we have seen, was descended directly from the Roman doorways in the scene house. As perspective began to be used for scenery these doors became more and more difficult to handle. The scheme at Vicenza has many problems in that most of the audience cannot see all of the vistas. Moreover, as painted, moveable scenery began to gain favor, the audience had to be more or less on the axis of the drawn perspective to make it seem real. Parma exhibits all of these changes.

It should be noted that the the five Roman doors still are there, though four of them have become mere niches in the walls of the proscenium area. Though at a larger scale, the planometric section of these walls closely resembles the contours of nearly ever proscenium theatre built after this one. The illustration on the next page is from Mr. Graf's "Aus der Welt der Oper".
About seventy-five years after the Parma theatre had been built, the one below was illustrated in a treatise by Fabrico Carini Motta. Note that the almost happenstance features of the Parma theatre now have been codified into a form very nearly approaching the traditional horseshoe opera house. If we count every niche in the proscenium wall we still may find the five Roman doors.
Although the first operas were not composed until around 1650, and heavy scenic demands were not added to their production until considerably later, the horseshoe auditorium and proscenium theatre grew arm in arm with opera and with the influence of the various Dukedoms of Italy. By 1737, San Carlo in Naples had been built for the King of Naples, and in it we see the traditional Italian opera house, now complete with boxes.

The plan of San Carlo follows, on the next page; and that of La Scala in Milan, ca. 1779, is another page further. Both of these plans come from Graf's "Aus der Welt der Oper."
La Scala Opera House, Milan
The Roman doors did not die out completely with the coming of the single proscenium arch for opera. The famous project by Nicholas Cochin of 1765, for instance, used both the flattened semi-circle of Palladio's Vicenza auditorium, and three of the five doors. Scenery of course was to be placed behind these openings. We recall that the scene house of the greek theatre of Priene also had just three doors.

Bild 79. Theater-Reformprojekt 1762 von Charles Nicole Cochin 1765
The ideas of Cochin have reappeared in two Twentieth Century designs. The three doors are incorporated into August Perret's Paris theatre of 1925 as a tripartite division of the proscenium area by structural columns. (The new festival theatre at Stratford, Connecticut also has this scheme.) The plan that follows on the next page shows some of the stage form possibilities that could be accomplished within the design.

The other design that has been compared with Cochin's efforts is that of Eero Saarinen for the experimental theatre at Lincoln Center. In this plan, however, there is no tripartite division of the stage. But the plan of the auditorium is remarkably similar to that of Cochin. Perhaps this is not so surprising, because Cochin was trying to reform the elongated shape of the horseshoe auditorium of his day, and thus to get his audience closer to the stage. Saarinen may well have similar motives. A comparison of these plans, from the BÜHNETECHNISCHE RUNDSCHAU of January, 1961, follows the Perret plan.
Die allgemeine internationale Weiterentwicklung des Theatergebäudes

Bild 319. Theater der Kunstgewerbausstellung in Paris 1925
Architekten: A. und G. Perret
5 Grundrisse und darüber die entsprechenden Längsschnitte, die verschiedenen Einstellungsmöglichkeiten des Proszeniums darstellend.
Die kleinen Quadrate stellen die Lichtquellen dar.

Bild 320. Das Theater der Kunstgewerbausstellung in Paris – 1925
Architekten: A. und G. Perret
Ansicht der dreigeteilten Bühne
Theaterprojekt von Codin (1765)

Lincoln-Center Repertory Theater, New York. 
Parkett-Grundriß mit und ohne Vorhalle. 
Architekten Eero Saarinen und Jo Mielziner, Projekt 1960
By the mid-Eighteenth Century, the small court Baroque theatre was as well established in the German-speaking countries as the horseshoe auditorium was in Italy.

A plan of the Stuttgart opera house of 1751 shows the very small auditorium connected to the huge stage, that was required for the elaborate stage spectacles and perspective vistas that were then so much enjoyed. A typical section is that of the old Bayreuth opera house. Note the relative size of the attic and the stage to the auditorium. When Richard Wagner was looking for a suitable place to produce his mighty RING, the Bayreuth opera house boasted the largest stage in Germany. Supposedly, that is what first brought Wagner to the little Bavarian town where he later was to built his great Festspielhaus.
Bild 127. Das Stuttgarter Opernhaus um 1751 - Umbauplan von Louis de la Guépière

Bild 125. Opernhaus in Bayreuth 1748
Architekten: Joseph St. Pierre und Giuseppe Galli-Bibiena
- Längsschnitt -
Although it often is impossible to ascribe precise ancestors to a particular contemporary design, comparisons sometimes are illuminating. On the next page, we see plans for the old drama theatre at the Carnegie Institute of Technology juxtaposed with a design by Morelli, ca. 1780. Even the poor reproduction of the Carnegie interior has a distinctly Baroque flavor.

If one reviews the various operahouse and theatre plans already presented in this essay, the influence of the various Baroque forms will be apparent. These forms worked so well in their own time because they really were suitable to the needs of their day. The theatre was a festive occasion. Further, the proscenium did not seem to produce the visual break with the auditorium that it does today, because the Baroque stage settings were so stylistically consistent with the architectural treatment of the auditorium. Wagner, for example, realized that the Baroque Court Theatre would not be suitable for the production of his operas because the stylistic differences would separate the spectator from the intended dramatic impact. Wagner also wanted his audience to be able to see the whole stage.
Bild 313. Das Theater des Carnegie-Institute of Technology in Pittsburgh

Architekt: Cosimo Morelli - Grundriß

Bild 80. Das Theater zu Imola 1779 bis 1780
Architekt: Cosimo Morelli - Grundriß

Bild 314. Das Theater des Carnegie-Institute of Technology in Pittsburgh
- Zuschauerraum -
As early as 1797 Friederich Gilly had produced plans for a drama theatre based on sightline considerations. Gradually a reform movement began in Germany; and we can recognize a direct connection between the designs of Gilly, Schinkel, Semper, and of course, Wagner.

The plans and sections on the following pages by these designers all were taken from THEATERGEBAUDE I. Note the gradual progression from the remnants of the horseshoe auditorium in Gilly's design to the full fan shape of the Wagner Festspielhaus. Thus, my idea is that the fan plan was almost totally a result of the German reaction to the bad sightlines of the Italian opera house.
Bild 133. Entwurf zu einem Schauspielhaus um 1797
Architekt: Friedr. Gilly

Bild 135. Entwurf zu einem Schauspielhaus um 1797
Architekt: Friedr. Gilly
— Perspektivische Innenansicht —
Bild 134. Entwurfskizze zu einem Schauspielhaus um 1797
Architekt: Friedr. Gilly
Bild 136. Schinkels Bühne 1817 für den Umbau des Schauspielhauses in Berlin
- Grundriss -

Bild 150. Ideenskizze Schinkels
Bild 142. Hoftheaterentwurf für Dresden 1835
Architekt: Semper

Bild 154. Entwurf zum prov. Festtheater – Projekt A
Architekt: Gottfried Semper – Längsschnitt
Bild 155. Entwurf zu einem Monumentalen Festspieltheater in München 1865
Architekt: Gottfried Semper - Grundriss

Bild 156. Entwurf zu einem Monumentalen Festspieltheater in München 1865
Architekt: Gottfried Semper - Längsschnitt

Bild 161. Das Wagnersche Bühnenfestspielhaus in Bayreuth 1876
Architekt: O. Brückwald
- Grundriß -
Die Reform des Zuschauerraumes in Anlehnung an das antike Vorbild

Bild 162. Das Prinzregententheater in München 1901 - Architekt: Max Littmann - Grundriss

Bild 163. Das Prinzregententheater in München 1901 - Architekt: Max Littmann - Längsschnitt
Typical of the German designs that followed this sightline revolution in theatre form was the Berlin Schauspielhaus. This design is peculiar because of its connection, via a bridge above the street behind the theatre, to the storage magazines and scenery shops in the adjacent building.
Architekt: Preußische Staatsbodenverwaltung
Bild 139. Das Schauspielhaus auf dem Gendarmenmarkt in Berlin – Um- und Erweiterungsbau 1935
Architekt: Preußische Staatsbodenbauverwaltung

Bild 140. Das Schauspielhaus am Gendarmenmarkt nach dem 2. Weltkrieg
Moving on to the contemporary theatre, I include the most recently built opera house first: the new Festspielhaus at Salzburg. After the plans and sections of the new house, I have added some of its predecessors, projects as well as buildings. The new Salzburg drawings are from the BUHNENTECHNISCHE RUNDSCHAU, June, 1960. The drawings of the older buildings are from "Das Neue Salzburger Festspielhaus."

After the presentation of Salzburg, I have placed various contemporary theatres that I find interesting. After reading my previous comments, the reader will be able to infer any analysis that I might make of these projects. Therefore, I shall refrain from any further analyzing.
Plan of the former Salzburg Festspielhaus, used until summer, 1960.
Project by Hans Poelzig for a great Salzburg Festspielhaus in a park. 1920.
Bild 324. Theater für Massenaufführungen und musikalische Darbietungen für 4000 Personen
Wettbewerb Theater Charkow 1931 – Architekt: Wilhelm Kreis, Dresden
– Längsschnitt –

Bild 325. Theater für Massenaufführungen und musikalische Darbietungen für 4000 Personen
Wettbewerb Theater Charkow 1931 – Architekt: Zdenko von Strizic
– Längsschnitt –
Project for a new theatre at Bahia, Brazil. by Jose B. F. Filho and Humberto L. Lopes

from:
ARCHITEKTUR WETTBEWERBE #25
1. Lageplan / Site plan
2/3. Modellaufnahmen / Model views
4. Längsschnitt / Longitudinal section
5. Eingangseite / Entrance side
6. 2. OG (Bühngeschoß) / Second floor
7. Modellaufnahme / Model view
8. Saalgeschoß / Hall floor
EIN WETTBEWERB FÜR DAS STADTTHEATER IN LUXEMBURG
Project by Walter Gropius, 1930.
From "Walter Gropius" by
Siegfried Giedion
150. UKRAINIAN STATE THEATER, KHARKOV, 1930. Perspective.

151. Side elevation.

152. Longitudinal section.

149. Plan.
Project by Walter Gropius for the Civic Center, Halle
From "Walter Gropius" by Siegfried Giedion
160. CIVIC CENTER, HALLE an der Saale, 1927: West elevation.

161. Section of town hall. Roof and ceiling suspended from steel towers.

162. Plan of entrance level.

163. Plan of hall level.
Three projects from the Dusseldorf Schauspielhaus Competition of 1959-60, follow. The drawings are from ARCHITEKTUR WETTBEWERBE # 29, July, 1960.

The first project is by Bernhard Plau. It is one of the very few contemporary designs to use curved exterior forms.
5 2. OG (Bühne) 1:500 / 2nd floor (stage) 1:500
6 Längsschnitt 1:500 / Longitudinal section 1:500
7 Modellaufnahme von Norden / Model view from north
8 3. OG (Saal) 1:500 / 3rd floor (auditorium) 1:500
The second of the Dusseldorf Competition designs is by Herbert Balg.
1 Lageplan 1:2500 / Site plan 1:2500
2 EG (Eingang, Garderoben) 1:1000 / Ground floor (entrance, check-rooms) 1:1000
3 Querschnitt 1:1000 / Cross-section 1:1000
4 2. OG 1:1000 / 2nd floor 1:1000
5 1. OG 1:1000 / 1st floor 1:1000
6 Innenraumperspektive / Perspective of interior
7 Isometrie / Isometry
The third Dusseldorf plan is by P. Lanz and L. Schlor.
1 Lageplan 1:2500 / Site plan 1:2500
2 Innenraumperspektive / Perspective of interior
3 Längsschnitt 1:1000 / Longitudinal section 1:1000
4 1. OG (Saal) 1:1000 / 1st floor (auditorium) 1:1000
5 EG (Eingang) 1:1000 / Ground floor (entrance) 1:1000
6 Variationen der Bühne / Variations of stage
The last of the four Dusseldorf Competition designs is by Roland Ostertag.
1 Längsschnitt 1:1000 / Longitudinal section 1:1000
2 Foyer-Geschäft 1:1000 / Foyer floor 1:1000
3 EG (Eingang, Garderoben) / Ground floor (entrance, check-rooms)
4 1. OG 1:1000 / 1st floor 1:1000
5/6 Variationen der Bühne / Variations of stage
Some contemporary designs are interesting, but impractical for one reason or another. Thus, this next group of drawings might be called "wild schemes."
Bild 184
Entwurf für ein Volksopernhaus in Paris 1875
Architekten: Davioud und Bourdais
Grundriß

Bild 185. Entwurf für ein Volksopernhaus in Paris 1875
Architekten: Davioud und Bourdais – Längsschnitt
Bild 301. Das Theater der Roten Armee in Moskau 1940
Akademischer Architekt: K. S. Alabjan und Architekt W. N. Simbirzew
- Grundriß in Höhe des oberen Ringes - (Hinweiszahlen ohne Bedeutung)
Bild 298. Projekt „Dworza Sowjetow“, Saal für 6000 Personen
Architekten: W. G. Gelbfreich, B. M. Jofan, W. A. Schukow
- Grundriß -

Bild 299. Projekt „Dworza Sowjetow“, Saal für 6000 Personen
Architekten: W. G. Gelbfreich, B. M. Jofan, W. A. Schukow
- Innenansicht -
Die allgemeine internationale Weiterentwicklung des Theatergebäudes
Bild 286. Projekt für ein großes Theater der BSSR in Minsk 1934
Architekt: N. A. Trotzki – Parkettgeschoß

Bild 290. Theaterprojekt für Swerdlowsk
Architekt: A. J. Golosow
- Grundriß in Höhe des Zuschauerparkeits -

Bild 291. Theaterprojekt für Swerdlowsk
Architekt: A. J. Golosow
- Grundriß in Höhe des Hochparkeits -
Bild 176
Das Sebaldische Terrassentheater in Berlin 1904
Umbau des ehemaligen Panoramas am Alexanderplatz

Bild 331. Entwurf zu einem Raumbühnentheater für 6500 Zuschauer – 1940
Architekt: Ottmar Schuberth
Grundriß des Erdgeschoßes (1. Ring)
Das Einraumtheater

Raumbühnentheater
wie Bild 331
Bühnenstellung A: mit ganzer Vorbühne als Spielfeld
Hauptbühne mit 25 m Durchmesser

Bild 332

Raumbühnentheater wie Bild 331
Bühnenstellung B: mit Orchester und großem Teil der Vorbühne als Spielfeld

Bild 333

Raumbühnentheater wie Bild 331
Bühnenstellung C: Versenkthebe der Hauptbühne, stufenweise hochgelassen

Bild 334

Raumbühnentheater wie Bild 331
Bühnenstellung D: Versenkthebe der Hauptbühne, stufenweise versenkt
Eindruck für die Zuschauer: Blick von der Höhe ins tiefe Tal

Bild 335

15 Werner, Theatergebäude
Schnitt durch das Projekt Opernhaus Essen:
Foyer und Spielläche in einer Ebene, dort hineingestellt die Zuschauertribüne.
To conclude the examples of theatre buildings, I have added two designs that have especial appeal for me. The first is for a " Q-Theatre" for London by H. Herrey. I enjoy this design because it comes very close to providing a complete, unbroken architectural enclosure for both audience and players. It does not do so completely, however, and to me, this is its failing. Frank Lloyd Wright's Dallas theatre is an essentially similar theatrical conception. Because the Wright plan is so familiar, I have not included it here.
Bild 310. Das Community-Theatre (Q-Theater) für London
Architekt: H. Herrey
- Grundriß in Bühnenbühne -

Bild 311. Das Community-Theatre (Q-Theater) für London
Architekt: H. Herrey – Längsschnitt
The last plan to be included is that of Hans Scharoun which won the competition for the Berlin Philharmonic Hall. Often one must turn to the concert hall to find a really complete theatrical form. Most concert halls would, for me, make admirable theatres - if one does not demand too much scenery. Although this plan completely surrounds the stage, it gives a single principal focus, and it puts most of the seats in an optimum relationship to the stage.

These plans are from ARCHITEKTUR WETTBEWERBE # 25, of June, 1959. The last plan covers two pages and must be folded out.
1. Preis:
Prof. Dr.-Ing. E. H. Hans Scharoun, Berlin
5 Lageplan 1:2500 / Site plan 1:2500
6 Modell des Saales / Model of hall
7 3. OG - Soalgeschoß 1:500 / 3rd floor - hall floor 1:500
Enterschossen / Entrance / Entrance floor 1:500
BIBLIOGRAPHY

As in the other parts of this thesis; there is no attempt in this bibliography to be encyclopedic. I merely list sources that I have found useful, rather than a compendium of titles. After my own list, I include an additional list of recent publications on theatre architecture, prepared by the Department of Speech, University of Pittsburgh. For this list, I owe thanks to Leon Shiman. Rather than include works on both lists, I have double-starred those on the University of Pittsburgh list that I have found to be of particular value.
BOOKS:

1. Aloï, Roberto. ARCHITECTURE PER LO SPETTACOLO, Ulrico Hoepli Editore, Milan, 1958. This is the most recent basic book of theatre plans to be published.


5. Gussmann, Hans, THEATERGEBAUDE - TECHNIK DES THEATERBAUS, Verlag Technik, Berlin, 1954. This, with its companion, Theatergebaude, Vol. I, is a most basic work concerning theatre design. Unfortunately, it is in German, and it is published in the East Zone of Germany.


ARTICLES:

The articles from the 1957, Encyclopedia Britannica have been of great help to me, in the section about THEATRE. I have included those that I found most interesting: in Appendix A.

In Vol. III of Talbot Hamlin's FORMS AND FUNCTIONS OF TWENTIETH CENTURY ARCHITECTURE, Columbia University Press, New York, 1952, articles by Lee Simonson, and the editor on Auditoriums, by Ben Schlanger on Motion Picture Theatres, by Arthur Harmon on Auditoriums are conservative but sometimes interesting. Some of the plans and sections included in this series are difficult to find elsewhere.

Periodicals:

The whole series of the German Magazine BUHNENTECHNISCHE RUNDSCHAU, from about 1950 on, are very useful if one can find them and if one understands some German. This magazine is published in Berlin by Klasing and Co.
RECENT PUBLICATIONS ON THEATRE ARCHITECTURE

This bibliography is provided as an activity of the Theatre Architecture Project, American Educational Theatre Association. Suggestions and comments are welcomed. Further information regarding these publications is available through Ned A. Bowman at the above address.


2. "Arts and Cultural Centers; An Exhibition at the Octagon Gallery," American Institute of Architects Journal (May '60), p. 50,51. Illustrations only: Canadian Shakespearean Festival, Stratford, Ont.; Kleinhans Music Hall, Buffalo; Lincoln Center, New York; Municipal Opera House, Sydney, Australia.


5. Brustein, Robert. "Scorn Not the Proscenium, Critic," Theatre Arts, XLIV, No. 5 (May '60), 8-9. The major ills of Broadway theatre are not to be solved by architectural reform, but by better plays and more originality.

6. "Building for the Performing Arts," Architectural Forum, CXII, No. 6 (June '60), 86-107. A series of four articles, liberally illustrated. Constitutes a sampling of recent architectural conceptions, with emphasis on types other than educational theatres.

7. Cole, Wendell. "The Theatre Projects of Frank Lloyd Wright," Educational Theatre Journal, XII, No. 2 (May '60), 86-93. DISCUSSION of eight projects by Wright, only two of which have been realized. Also see: "FLLW'S Dallas Theatre," Architectural Forum, CXII, No. 9 (March '60), p. 130-35.


Notes:


3. Educational Theatre Journal has announced completion of the following graduate theses:


RECENT PUBLICATIONS ON THEATRE ARCHITECTURE

This bibliography is provided as an activity of the Theatre Architecture Project, American Educational Theatre Association. Suggestions and comments are welcomed. Further information regarding these publications is available through Ned A. Bowman at the above address.

   Page 31: "Satisfactory instruction requires that the following facilities be available for pupils in grades 7 and 8: (1) a well-stocked library; (2) a gymnasium with locker rooms and showers; (3) specially equipped home economics rooms for girls and industrial arts rooms for boys; (4) an auditorium or assembly space for at least half the student body; (5) cafeteria space for at least one-third of the student body."
   Page 32: "Student assemblies are an important device for promoting school spirit as well as a useful instructional aid, especially in music and dramatics. As with the library, however, a note of caution is in order. Too often handsome auditoriums are not used extensively enough, probably because of scheduling problems. Frequently the auditorium is satisfactory combined with the cafeteria, which, like the gymnasium, may not be a necessity in every school throughout the country."


24. Moro, Peter. "Theatre Today," Architectural Design (September '60), p. 358-68. Prognostication on building design, with sections treating Germany, France, Luxembourg, Roumania, the United Kingdom, Canada, the United States, Brazil and India. Several less-publicised examples. Photos, plans & sections.

25. "Das neue Festspielhaus in Salzburg," Bühnentechnische Rundschau, Nr. 6 (December '60), 32-42. A comprehensive report with many illustrations, including a color photograph of the auditorium.


29. "The Theatre Automatique," Architectural Forum (October '60), 90-96. Excellent coverage of the completed Loeb Drama Center at Harvard, with much attention to Izenour's contributions. Also see: "Drama Center for Harvard," Architectural Record (September '60), Cover, p. 151-60. Extensive graphic information, with several photographs of the exterior and audience areas.


31. Werk (Winterthur), XLVII, Heft 9 (September '60). Special issue on theatre architecture: Hans Curjel "Tendenzen im heutigen Theaterbau," 297-300; Werner Ruhnau "Aus der Sicht des Architekten," 309-311; Teo Otto "Aus der Sicht des Bühnenbildners," 326; Aus der Sicht des Akustikers," 338-40. Also features on Wright's Dallas, Texas; Stratford, Ontario; Gelsenkirchen; Salzburg's Festival Hall; Luxembourg National Theatre; Bahia, Brazil; Brasilia, Tampere, Finland; Teatro Vittorio Gassmann in Rome; Theater am Hechtplatz in Zurich. Project photographs of Alvar Aalto's Essen opera house, and competition submissions for the Schauspielhaus Düsseldorf.

Notes:


2. The first annual conference of the United States Institute for Theatre Technology will be held February Fourth and Fifth at the Juilliard School of Music, New York. Panels are scheduled on theatrical presentation, theatre architecture, engineering, construction, administration, and publication and research material. Further information is available from USITT, P. O. Box 291, Cathedral Station, New York 25, New York.
APPENDICES:

Material included in these next parts all is by other authors, and it is included verbatim. It has been put here to simplify research for others.
Appendix A:

ARTICLES FROM THE ENCYCLOPEDIA BRITANNICA, 1937,

Section concerning THEATRE.
ARCHITECTURAL DEVELOPMENT OF THE THEATRE BY SHELDON CHENEY

In considering the form of the modern theatre building, its physical aspect, and in tracing the origins and development of that form from the earliest known theatres of Europe, the investigator does well to keep constantly in mind the basic meaning of the word "theatre." From the Greek, it means roughly "a place for seeing." In a short survey of the subject it is not necessary to mention pre-Greek theatres, beyond saying that there is no known connection between those of earlier civilizations and the playhouse with which the history of drama in the Western world is supposed to start -- the theatre of Dionysus at Athens.

Greek Theatre. The first Greek theatres, according to those who have studied the subject most thoroughly, were little more than marked-out dancing-circles, each around an altar, at the foot of hillsides on which spectators stood or sat. From this natural form the first 'built' theatres took their main outlines: a circle or 'orchestra' for the chorus and actor or actors, and rising tiers of wooden seats, built against a hillside for the spectators. These seats extended usually around two-thirds or more of the orchestra, since at this time dancing or movement was more important than acting, and there was no stage for the spectators to face. The type of the first built theatres is shown in figure 1. It should be kept in mind, however, that in no period were any two Greek theatres exactly alike, and exceptions to this general type were common.
FIG. 1.—PLAN OF GREEK THEATRE OF EARLIEST TYPE

FIG. 2.—THE THREE-PART THEATRE ARRANGEMENT OF SEATS, ORCHESTRA AND SCENE
Taking the theatre of Dionysus as an example, one notes that the temple of Dionysus Eleuthereus appeared in relation to the theatre approximately as indicated in the diagram (all within the precinct sacred to Dionysus on the south-eastern side of the Acropolis). One conjecture is that the architectural form of this 6th century temple helped to determine the shape of the stage building which was later to be added at the edge of the circle opposite the seats. But the more widely accepted theory is that out of necessity a hut or tent was added at the edge of the orchestra as a retiring-room for the actors, for changes of costume, etc.; and that the stage building was in all later ages an elaboration of this rude shelter -- dressed, in the Greek period, with those beautiful architectural forms with which the Athenians adorned all their important structures.

Just when this skene, became truly a stage building, with definite and studied relationships to the orchestra and auditorium, is a matter of conjecture. As a step in the development of the larger theatre form, we may think of the three parts of the theatre as developing gradually into a set arrangement as shown in figure 2.

Here one sees the accretion of the three features that characterized theatre building through many succeeding centuries: (1) auditorium; (2) orchestra; and (3) scene, names which persist even today. But at this time players appeared only in the orchestra, the scene remaining an architectural background to the action and a practical retiring-house for the actors, structurally separated from the auditorium, by entrances or runways.
Such was the theatre form when the 5th century B.C. dawned, and such it remained, with only slight changes, in all probability, during the period of Aeschylus, Sophocles and Euripides. The architectural features and the height of the skene are still only to be conjectured, though recently excavated foundations at Athens indicate clearly the plan and limits of an early stage building, wider than the dancing circle and with ends projecting forward toward the auditorium.

Archaeologists have waged one of their bitterest battles over the question as to when the raised stage made its first appearance, but in the "high" period of Greek drama it is now almost unanimously agreed that there was no platform stage. The theatre at Athens had taken this general form, with probably a portico at the front of the scene building, between the 'paraskenia' (figure 3).

In Greece the theatres were regularly built in hillside hollows, thus avoiding any need to build supporting framework for the tiers of seats, except perhaps at the ends of the "rings." The auditorium was broken by up-and-down aisles with steps, into a number of wedge-shaped "segments" of seats, and sometimes by one or more lateral aisles.

The student of later forms may profitably transfer his attention to a point beyond the controversy about the introduction of the raised stage to that time when there was, without doubt, an auxiliary platform for acting. The next well-differentiated type of theatre is that in which the stage building is characterized by a high narrow platform on the audience side, called at times the 'proskenion' (from which our "pro-
FIG. 3.—PORTICO ADDED TO FRONT OF SCENE BUILDING

FIG. 4.—A PLATFORM ADDED AS PART OF THE SKENE

FIG. 5.—PLAN OF TYPICAL ROMAN THEATRE AS A STRUCTURAL UNIT
scenium" is derived), and at other the 'logeion' or "place for speaking."

As acting has become more and more important, the 'skene' has developed into a combined architectural background and platform for lifting the actor into clearer view (figure 4). It is to be noted here that the typical Greek separation of auditorium and scene building still exists, although acting now is divided between the orchestra and a stage in our later sense. Through the late Greek and the so-called Greek-Roman periods, the narrow 'logeion' doubtless went through a gradual widening process.

Roman Theatre. The existing ruins of Roman theatres give absolute evidence regarding the arrangement of the Roman stage and auditorium. The two heretofore separate buildings have now been pushed together to form one structure, which is not placed as in Greek times against a hillside hollow, but is erected as a free-standing building supported by arch construction; the orchestra has been contracted to a half-circle, and is now added to the seating space; and all the acting is done on a platform stage, behind which the greatly enlarged 'skene' and 'paraskenia' rise, with rich architectural ornamentation, to a considerable height. The type plan is shown in figure 5. A special type of theatre with wooden platform stage, for comedies, as shown in many extant vase paintings, is disregarded here as having little or no influence on the traditional or persisting form of theatre.

In the Roman theatres there were no built-in facilities for scene changing, and it may be assumed that in general there was no painted scenery and no effort to indicate change of locality, though elaborate "stage machinery"
for trick effects, apparitions, etc., is described by contemporary writers. In general, the architecture of the stage wall was the "scene." This wall was regularly pierced by five doorways, three at the back and one in each of the 'paraskenia'. The large centre door was the "palace entrance."

All Roman provincial towns of any importance possessed at least one theatre and many of these are partly preserved. Covered theatres were sometimes built, whether on account of climatic conditions (as at Aosta) or more commonly for musical performances. These latter were generally called Odea (a place for singing). The best preserved is the Odeum of Herodes Atticus, at the south-west angle of the Athenian Acropolis, which has a semi-circular orchestra. It was built in the reign of Hadrian by Herodes Atticus. Its cavea which is excavated in the rock, held about 6,000 people; it was connected with the great Dionysiac theatre by a long and lofty porticus or stoa of which considerable remains still exist, probably a late restoration of the stoa built by Eumenes II. of Pergamum. It was also a common practice to build a small covered theatre in the neighborhood of an open one, where performances might take place in bad weather. We have an example of this in Pompeii.

The Romans used scenery and stage effects of more elaboration than did the Greeks. Vitruvius mentions three sorts of movable scenery: (1) for the tragic drama, facades with columns representing public buildings; (2) for comic plays, private houses with practicable windows and balconies such as are shown on Graeco-Roman vases of the latest type, with paintings of burlesque parodies of mythological stories, and (3) for the rustic scenes in the satyric drama, with mountains, caverns and trees.
Renaissance Theatre. The classic theatres were discussed after Roman civilization faded, but it was the classic theatre that determined the form of the playhouse built by the learned academies in the cities of Renaissance Italy, and they were the links between the ancient theatre and that of today. At Vicenza, the Renaissance theatre of the Olympian academy, sometimes called the Palladian theatre after its famous architect, still exists, with all its distinctive architectural features and ornament intact. It is, in effect, a small Roman theatre roofed over and made more compact, with typical Renaissance modification of Roman motifs in the decoration. The stage wall is heavily encrusted with architectural ornamentation and statuary, and the five classic doorways are in orthodox position. One addition, made by Scamozzi in 1585, links this classic stage with the theatres of later times. In that year were constructed the vistas or "perspectives" behind the five doorways of the stage wall, forming the earliest "make believe" scenes that have been preserved for posterity. (Already the mystery and miracle stages had in cases been characterized by a combination of half-formed architectural "stations" and realistic localized scenes like the famous "Hell-mouth"; and the court masques were being staged with picture scenes, including the "perspective" type.) The Roman-type building and the added vistas at Vicenza form a plan as shown in figure 6.

The picture scenes were not yet designed as localized backgrounds for the action so much as an added spectacular attraction, in the Italian masques, and at first the "new style" settings had little effect on the form of the classic-revival playhouses; but the appeal of such pretty
Fig. 6.—Plan and stage wall of the theatre of the Olympian Academy, Vicenza, Italy: sometimes called the Palladian theatre after its famous architect, Andrea Palladio (1518–1580). It preserves the Roman form with the five classic doorways and provides for introducing scenery (not as yet changeable).
playthings could not be long denied, and the modern playhouse emerged where the two currents met. Thus the Palladian theatre at Vicenza takes on double importance as historic evidence: (1) as preserving the Roman playhouse form, including the rigid architectural stage; and (2) as providing for introduced "scenery" (not yet changeable). The backgrounds of the Roman and Palladian Renaissance stages are shown in figure 7. There are extant plans which indicate that certain artists of the time, trying to think through to a more practical combination of the classic stage with provision for pictorial backgrounds, saw a means in the widening of the central "palace" doorway to provide acting space within the "vista." Thus Inigo Jones made a plan and an elevation similar to those shown in figure 8. And the theatre at Sabbioneta (of which the scene unfortunately no longer exists) showed the whole stage as one narrowing vista (1588); see figure 10.

The next step is illustrated in the playhouse that is usually called "the first modern theatre," the Teatro Farnese at Parma (1618 or 1619), diagram of which is shown in figure 9. Here the entire stage may be said to have been pushed through the central doorway of the old stage wall, the ornamentation of the Roman skene remaining only as decoration of what is now the proscenium arch. The stage within is curtained off from the auditorium (figure 9A) and is thus adapted to changing pictorial settings. From this time on the curtained stage and proscenium arch are unfailing features of the theatre. The plan of the Farnese theatre is particularly interesting, too, as showing the entry of another influence into the shaping of the auditorium: instead of a semicircular bank of seats, as illustrated in the diagrams so far, the auditorium is U-shaped
FIG. 7.—BACKGROUND OF THE ROMAN STAGE SHOWING THE NARROW CENTRAL "PALACE" DOORWAY WHICH WAS MODIFIED IN THE RENAISSANCE THEATRE, AS SHOWN IN FIG. 6, TO PROVIDE A MORE EXTENDED "VISTA".

FIG. 8.—PLAN AND ELEVATION BY INIGO JONES OF A WIDENED CENTRAL "VISTA," DESIGNED NOT ONLY TO GIVE A PICTORIAL BACKGROUND BUT TO PROVIDE ACTING SPACE WITHIN THE "VISTA".
FIG. 9.—PLAN AND ELEVATION OF "THE FIRST MODERN THEATRE" (1618–19), THE TEATRO FARNESE AT PARMA, ITALY. (A) SHOWS THE STAGE CURTAINED OFF FROM THE AUDITORIUM. (B) THE U-SHAPED AUDITORIUM, A NEW INFLUENCE IN THEATRE DESIGNING

FIG. 10.—PLAN OF NARROWING VISTA THEATRE (1588) AT SABBIONETA, ITALY, BUILT BY SCONOZZI
(figure 9B). This influence entered because the masques and court plays had been produced largely in ballrooms or banquet-halls, where one end of the hall had been reconstructed for an auxiliary stage, the main floor left free for dancing, or as in an "arena" for pageantry, etc., with the spectators ranged around the three sides away from the stage, perhaps in chairs on temporary platforms, perhaps in balconies. Architects combining this U-shaped auditorium with the curtained proscenium-frame stage soon determined the theatre form that was the basic plan of the famous horseshoe auditorium (fig. 11).

It was this Italian plan that became the standard of theatre building throughout the Western world, conquering successively the French courts, the courts of Austria, Bavaria and other countries to which the Italian Renaissance influence extended, then England (where the Elizabethan theatre form was cast aside - having only the slightest influence after the Restoration), and indirectly America. "Scenery" was soon standardized, so that the wings and backdrop restricted the playing space to a wedge-shaped section of the stage floor; and the auditorium lines roughly followed the lines formed by the edges of the wings (figure 12). This picture scene persisted through two and a half centuries, with ever greater elaboration, demanding larger and larger stages; and the auditorium half of the building kept its many galleried horseshoe plan. With variations toward rounder or narrower auditorium, the general form persisted until late in the 19th century, from smaller court playhouses to immense opera houses.
HORSESHOE-SHAPED AUDITORIUM

FIG. 12.—PLANS SHOWING TYPES OF THEATRE DESIGN USED FROM MIDDLE 17TH TO LATE 19TH CENTURY: (A) DRURY LANE, LONDON, (B) THEATRE-FRANÇAIS, PARIS (1790), (C) LA SCALA (1778), MILAN
At first the arena portion of the auditorium was merely a flat floor, and consequently the best seats were not there but at the front of the first balcony; and almost throughout the period of the horseshoe theatre; the main floor sloped but slightly, thus allowing three, four or five superimposed balconies or galleries.

Modern Theatre. The main changes in the construction of the 20th century theatre have been the exclusion of all but one balcony, and the steeper tilting of the main floor, thus throwing the best seats into the orchestra. Even to-day, however, in France and Italy, where the 17th-18th century theatre form stubbornly persists, the orchestra is contracted, and the more expensive seats are in the slightly raised ring of loges and the first balcony above.

During the 19th century there were efforts to reform the "picture" scene, and with it the horseshoe auditorium, which almost invariably had possessed the disadvantage of providing a considerable number of seats, at the gallery ends, which had a poor view of the stage. The first attempts of importance to design a more democratic type of theatre, and one in which "sight-lines" would more logically determine the form occurred in Germany. The Festival theatre at Bayreuth is the most noteworthy example, greatly antedating the present general movement toward the fan-shaped auditorium. Its main outlines are shown in figure 13.

The impulse was taken up by Max Littmann, the most notable theatre architect of the century-end; his Prince Regent theatre and Künstlertheatre in Munich, and his Schiller theatre in Charlottenburg, Berlin, all with simpli-
FIG. 13.—MAIN OUTLINES OF FESTIVAL THEATRE AT BAYREUTH, AN ADVANCE IN "SIGHT-LINES"
fied banks of seats, had great influence in both Europe and America. Littmann experimented also with the proscenium frame in an effort to adapt the theatre to the demands of modern stage lighting. More recently architectural practice, particularly in Germany and the United States, has come to the fairly standardized form that is shown in figure 14. Here the architects restrict the horseshoe bowing-out, since the scene is no longer wedge-shaped but more usually box-like, and the auditorium is narrower in relation to the width of the proscenium opening. (In larger cities where ground-value is such an important consideration, the commercial theatres are commonly built with wider proscenium openings and wider auditoriums, but on the fan principle. Standard fire laws impose the necessity for a certain number of aisles and adjacent doorways, and have caused minor differences from the type as it developed in Germany.) In general it may be said that the modern auditorium presents a single bank of seats, on a floor uniformly sloping or slightly saucer-shaped, more tilted than during the horseshoe period, and restricted at the sides along lines determined by the edges of the proscenium opening. There is usually a single balcony, with a steeply sloped floor, at the rear. There are seldom boxes, (unless at the back of the orchestra); and modern engineering and steel construction make it possible to dispense with pillars and posts. The outline plan is not unlike the plan of the arena or pit portion of the many-galleried opera houses, with the surrounding galleries sliced off. Along with this simplification of plan there has been a general simplification of decoration.
FIG. 14.—TO SHOW STANDARDIZED FORMS OF MODERN THEATRE

FIG. 15.—EXAMPLES OF FLOOR PLANS FOR MODERN THEATRE BUILDING:
(A) THE LITTLE THEATRE, NEW YORK: HARRY C. INGALLS AND F. B. HOFFMAN, JR., ARCH'TS. (B) VOLKSBÜHNE (PEOPLE'S THEATRE), BERLIN: OSKAR KAUFMAN, ARCH'T
Two examples of 20th century theatre building may be considered typical of progressive practice (figure 15). The more radical experimenters have already called for the scrapping of the entire proscenium-frame house, and a return to the principles which determined the theatre form before "picture" scenes were introduced - with reference, however, to modern lighting advances. It may be assumed that some such change will come shortly, and that the return to an architectural stage will demand radical changes in auditorium construction. But as yet the several theatres built with formal stages, without proscenium arch, are too different, and their advantages too tentative or too special, to warrant any generalization beyond the proscenium-frame house illustrated above.
MODERN THEATRE EXTERIORS AND INTERIORS BY JOSPEH URBAN

The theatre, with its special restrictions, naturally calls for special architectural treatment. The peculiarly public nature of dramatic art stamped one primary requirement on theatre architecture long before the advertising mania of the present age appeared to reinforce it: it must attract attention and its function must show in outer aspect.

The essential architectural beauty of the exterior of a theatre must come not from decoration but rather from the massing of those portions of the walls which reveal the three essential inner parts of the playhouse - the stage, the auditorium and the foyers.

**Importance of Site.** The art of theatre building has reached its height in Europe where every period developed and perfected its own rich style of architectural expression, and where the conditions of life in the larger cities permitted the theatre to attract attention to itself and its structure through appearance of three or four facades. In Europe a theatre was usually built on a wide street or square - the Paris Opera House (Ch. Garnier, arch.); the Schauspielhaus in Berlin (Carl Friedrich Schinkel, arch.); the Champs Elysees, Paris (A. and G. Perret, archs.); Staatsoper, Vienna (Van der Nüll and von Siccardsburg, archs.); or the Prinz Regenten theatre in Munich (Max Littmann, arch.) - or even in a park, as in the case of the twin State theatres of Stuttgart (Littmann, arch.), and many others. Everywhere we find that it is growing more and more difficult to find such ample and predominant sites in the larger cities on account of the high value of land, the lengths of blocks, and the type of buildings
FROM "AMERICAN ARCHITECT"

PLAN OF THE SHAKESPEARE MEMORIAL THEATRE, PRIZE WINNING DESIGN IN THE PROCESS OF CONSTRUCTION IN STRATFORD-ON-AVON, ENGLAND

FROM BOSTON AND BETTS, "AMERICAN THEATRES OF TO-DAY" (ARCHITECTURAL BOOK PUBLISHING CO.)

PLAN OF THE EASTMAN THEATRE, ROCHESTER, N.Y., DESIGNED BY GORDON AND KAELBER, ARCHITECTS, AND MCKIM, MEAD AND WHITE, ASSOCIATE ARCHITECTS
dominating the view. Difficult conditions reach their acme in New York. The Metropolitan Opera House (Cady, Berg and See, archs) alone occupies an entire block. The Radio City Music Hall, which is reputed to be the largest theatre in the world, with a seating capacity of approximately 6,206, is situated in a relatively inconspicuous place in the group of buildings which constitute Rockefeller Centre. In London among many examples showing one facade only there are the new Carlton theatre (F. Verity, arch.), and the Fortune theatre. The theatre architect in all countries has now usually only one facade available to tell the story which two, three or even four told in the past.

Modern Conditions and Restrictions. The architect limited to one facade facing a narrow street, has found it hardest to show in the outer form of his building the anatomy that lives within. Yet even under these conditions the Guild theatre (C. Howard Crane and Kenneth Frazenheim, archs.) manages to mark off handsomely the stage-house like an Italian brick tower above the stucco front of the lower auditorium.

Congestion and fire regulations play particular havoc with theatre architecture, yet several more or less successful attempts have been made to combine necessity with beauty. In the bold Martin Beck theatre (G. Albert Lansburgh, arch.) and in the charming Music Box (Crane and Franzheim, archs.) the inevitable fire-escapes required by law find a pleasant hiding place within porticoes. The Henry Miller theatre (Paul R. Allen and Harry Creighton Ingalls, archs.) conceals unsightly alleyways -- again required by law -- within its Georgian walls. The law does not re-
quire the builder of a theatre to protect his patrons from the rain while they wait for taxis and motor-cars, yet the marquee becomes inevitably one of the most important items of the facade, unless an arcade or portico has been designed to protect the waiting crowds.

Electric Signs. The worst problems of the architect who builds theatres in a great city come from the primary requirements of such a building—that it must be seen and tell its story at the greatest possible distance. The set-back laws, new treatments of L-shaped, U-shaped, or H-shaped courts in front of tall buildings, and the enormous height of the skyscrapers make period fronts on three or four-storied theatres an insufficient and even ridiculous attraction against the gigantic, varied and vital proportions of the neighboring buildings. To compete for visual notice under these conditions, the theatre owner turns to enormous electric signs, and blankets the facade behind flashing bulbs and painted tin. London examples of good exterior lighting arrangements are the Plaza theatre (F. Verity, arch.), and the Astoria cinema (E.A. Stone, arch.).

The modern architect has to consider as the main requirements in the exterior design of theatres three things which the architect has never before had to deal with. These are electric advertising signs, fire escapes and marquees. Not until we have made these necessities a part of our architecture, not until these necessary evils have been fused into a thing of beauty and have formed their own architectonic style and expression, can we hope for a new, adequate and handsome theatre facade.
Type of Entertainment Determines Type of Auditorium. Each type of dramatic entertainment -- including the motion picture -- demands its own type of auditorium. In the ancient world the Greek theatre developed along lines suited to drama and comedy that employed large choruses, while in Rome something nearer the modern stage came into being as the chorus disappeared. Unfortunately the theatre architect of to-day is much too uncertain of the type of entertainment which will ultimately make use of his creation. He may intend the building for popular melodrama, but financial misfortunes may turn it over to motion pictures or to musical revues. It is only in the smaller communities that a theatre should be built for general usage, and some compromise arrived at which will suit both stage and auditorium to almost any kind of entertainment.

The Motion Picture House. In a motion picture theatre, where the attention of the audience is concentrated on a silver screen and figures of actors that are well over lifesize, the auditorium may be very deep without incommoding the spectator. On the other hand, it must not be too broad or too high, for that would distort the appearance of these two-dimensional figures on the flat screen. The mass of the audience must be concentrated in the centre and placed on two main floors. The theatres that carry this out most notably are the Marmorhaus, Berlin (Hugo Pal, arch.), the U-T Theater, Berlin (Fritz Wilms and Max Bischoff, archs.), the Capitol theatre, New York (Thos. W. Lamb, arch.), the Roxy theatre, New York, the Plaza theatre, London, the Empire theatre, London, The Piccadilly theatre, London.
The Revue Theatre. The theatre intended for the use of the big musical revue is rather closely related to the moving picture house, though it, too, has its peculiar requirements. Here the main interest lies in the stage picture, the beauty of costumes and scenery, and so a large auditorium is possible. Care must be taken, however, to avoid too great a depth, for comedy scenes and solo singing demand more intimacy and a closer view of the performer than in the case of the motion picture. Here it is of great importance that the height of the seats in relation to the stage floor shall permit everyone in the house to see the feet of the dancers. For the revue house, as well as for any theatre, that is not used on the one hand, for the motion picture, or on the other for the strictly realistic, peep-show type of drama, the architect must take great care to avoid anything in the proportions of stage and auditorium that may indicate a separation between the actors and the spectators. He must strive to use every means for uniting both groups in close spiritual contact.

The realistic play of the type which presupposes the presence of a fourth-wall between the actor and the audience has set special problems for the modern architect. Hitherto he has solved these as perfectly as possible -- and, of course, by the very nature of the case he has not achieved anything exhilarating, notable or truly theatrical. In the main he has had to restrict himself to a small auditorium and if he sought larger capacity, a single balcony hung far out over the or-
checstra floor. He has done away with boxes as obtrusions between the audience and the picture frame. And this picture frame has become a definite and complete separation between the audience and the actors. In decoration he has been forced to subdue the colour of his auditorium so as to leave the audience in peep-show darkness while the play goes on. Two of Ingall's playhouses in New York, the Little theatre and the Henry Miller, meet these stultifying conditions as well as they can be met.

Problems of Site and Seating Capacity. Within the limits of the particular piece of land on which he has to build, the architect must work out as large a seating capacity, and as roomy and convenient an arrangement of stage, dressing rooms, and foyers as possible. Where the site is rectangular the problem is comparatively simple, but where the site is irregular it is often difficult to accommodate the auditorium and stage.

The architect has generally to secure the largest seating capacity possible on a given site. Usually this has meant widening the stage and still further widening the fan-like auditorium until only revues can be properly presented. The architect plans one very large, overhanging balcony because the higher prices that can be charged in a balcony, compared with a second balcony or gallery, more than make up in financial capacity for the greater number of seats that a double-decker arrangement provides.
Occasionally the architect tries some new method of getting a large but intimate auditorium on a piece of property of restricted size. A popular method is to place the stage in one corner of the site instead of along the back, and then to throw the auditorium diagonally across the lot. Though this arrangement is better suited to the almost stageless motion picture theatre, it has been used in a "legitimate" theatre, the Ambassador, New York (Herbert J. Krapp, arch.). Among the large motion picture houses with well-equipped stages which have also utilized this seating plan are the Paramount theatre, Palm Beach, Fla. (Joseph Urban, arch.), the Bondi theatre, Sydney, N.S.W. (C. Bohringer, arch.), "the Majestic," Leeds (Messrs. Skinlet and Maxwell, archs.) and the Roxy, New York.

Auditorium Shapes. The shape of the auditorium itself, which used to be invariably a horseshoe, is now most apt to take the form of a fan with convex sides curved in towards the front and rear. An elliptical form has been tried with good decorative effect in the theatre of the Carnegie Institute of Technology, Pittsburgh, Pa. (Alden and Harlow, architects) and in the Ziegfeld theatre, New York (Urban and Lamb, arch.). The New Cinema, Portsmouth (A.E. Lutte, arch.) is also a good example of this type. The fan with straight sides and a wide splay was used in the Beyreuth Festspielhaus (Manfred Semper, arch.) where the boxes are located in a straight row across the back of the theatre and the "diamond horseshoe" of boxes eliminated.
LONGITUDINAL SECTION OF THE ZIEGFELD THEATRE (TOP), PLAN OF BALCONY (CENTRE), AND OF THE ORCHESTRA (BOTTOM), DESIGNED BY JOSEPH URBAN AND THOMAS W. LAMB, ASSOCIATE ARCHITECTS.

PLAN OF THE BAYREUTH FESTSPIELHAUS, MANFRED SEMPER, ARCH'T.: THE FAN WITH STRAIGHT SIDES AND A WIDE SPLAY WAS USED.

SECTION OF MUNICH ARTISTS' THEATRE, SHOWING THE STEEPLY SLANTING FLOOR.
Visibility. A problem of theatre construction which has not had as complete a study and formulation as it deserves is the line of slant in auditorium floor and balconies in relation to the height of the stage. The essential aimed at is the most perfect visibility from every seat in the house. One of Germany's theatre reformers, Littmann, in a desire to give the last row as clear a view as the first, prescribed a very steeply slanting floor, but made the grave mistake of making it merely a straight inclined plane. The result was that the front rows suffered from the feeling of looking down a narrow tunnel. The better method, which is generally followed today, is to begin with little or no inclination at the front, and then to increase this radically towards the rear. The slant of the auditorium floor is not so restricted, and can be worked out freely to give the whole auditorium a complete and comfortable view of the actors upon the stage. It is often very badly handled.

The slant of the floor and the arrangement of the balconies bring out many interesting possibilities. Krapp combined the "bleacher," "stadium," and "single balcony" types in a so-called "arena" arrangement used experimentally in Chanin's Forty-Sixth Street theatre, New York, and better worked out in another Chanin playhouse, the Majestic, New York. The purpose is to get a very deep orchestra floor by running the entrance foyers under its steeply slanting rear. The Guild theatre, New York, (on a suggestion by Norman-Bel Geddes) managed to place its roomy lobbies under the auditorium without raising the latter so far above the street as to bring it into conflict with the fire regulations.
LONGITUDINAL SECTIONS OF VARIOUS TYPES OF THEATRE

A. One floor type, B. Bleacher type,
C. Stadium type, D. Single balcony type,
E. Balcony-mezzanine type
German Seating Arrangements. In most countries fire laws have prevented the wider use of arrangement of the seats themselves which has found general popularity in Germany. This arrangement abolishes the aisles dividing the floor into sections, and the seating of the audience in one unbroken mass of solid, continuous rows from wall to wall. Adequate entrance and exit are obtained by spacing the rows a little wider apart than in the ordinary arrangement, and making the walls of both sides of the auditorium a succession of doors emptying into the lobbies. The effect of this arrangement is that the spectators are seated in one solid mass. An equally important consideration -- which should argue a change in fire regulations -- is that a house seated on the German model can be cleared in half the time it takes an audience to press into and up the ordinary narrow aisles. This German seating arrangement has been used with success in the Kenneth Sawyer Goodman Memorial theatre, Chicago (Howard Shaw, arch.), which happens to be located outside the jurisdiction of the Chicago fire commissioners.

Stage Lighting from the Auditorium. The stage arrangements, except as to adequate dressing rooms, property rooms, and scene stacking space, are matters for the theatre technician -- scene designer, electrician, etc. -- not the theatre architect, although the architect should see that there is ample space allowed. Something should be said, however, on one point connected with lighting arrangements; this is the necessity of providing room in the auditorium for the placing of lights for the illumination of the stage and the actors. In 1914 Granville Barker introduced at Wallack's theatre in New York a row of powerful incandescent lamps around the balcony rail to replace the footlights. David
Belasco took the next step forward by installing such lights in a recess in the balcony rail closed by doors automatically controlled from the stage switchboard. Some such provision, or perhaps a light bridge concealed in the ceiling beams, as in the Yale University theatre, New Haven, Conn. (C.H. Blackall, arch.), or the Guild theatre, New York, ought to be a part of every architect's plan of a new house.

Decoration. The decorative problem within the auditorium has found many solutions, depending on the kind of dramatic entertainment to be presented. The modern decorative movement towards larger, smoother and less ornamented surfaces has its peculiar applicability to the playhouse, where the eye should not be distracted from the players by too ornate detail. Yet there is something undeniably exciting and truly theatrical in the rococo interior of the Residenz theatre in Munich (Cuvilliés, arch.), and Oskar H. Kaufmann, beginning with a rigid simplicity in the Volksbuehne and other houses in Berlin, has had delightfully amusing recourse to the Chinese baroque for the Theater am Kurfuerstendamm and the Komodie also in Berlin. The limitations and the values of decoration depend, after all, on the interpretive genius of the architect.

The new attempts to break away alike from the old horseshoe opera house and the realistic peep-show theatre all look back for their justification to the history of the development of playhouse architecture and borrow heavily from the past.
Development of the Opera House. Following the Fall of Rome and the
decline of the classic culture, the classic theatre disappeared save
for a renewal of some of its form and spirit during a few brief
decades of the Renaissance. The theatre, and especially the early
opera, supposed ironically enough to be founded on classical tragedy,
became a mere excuse for brilliant court festivity. As a result of
the desire on the part of the audience to be observed by one another,
good visibility for the stage suffered. The style of the popular
Italian opera predominated. The singers delivered their important
arias as close to the prompter's box as possible, while the chorus
stood practically inanimate. Contact between the stage and the
auditorium disappeared and with it the spiritual union of performers
and audience. Good acoustics and a brilliant social display were the
demands made upon the Baroque theatre. The decorative style of
auditorium with its heritage of richness of the Renaissance and the
charm of the rococo had originally been a thing of gorgeous, festive
yet graceful beauty.

In the course of years it added to the pernicious Italian shape new
horrors of decoration and became that horrid overladen gold-and-
plush spectre of its former self of which unfortunately we still see
examples.

Toward the latter part of the nineteenth century, however, came evi-
dence of change and reform. Splendid acting was increasingly in demand
and rich settings and appropriate historical costumes were considered
essential to enhance the beauty of operatic music. The problem of displaying these adjuncts began to make even the architects of the opera houses see that their art had reached a standstill and that some attempt had to be made to recapture the spirit and some of the form of the classic stage. Their efforts were partly compromises in the shape of the auditorium, partly a simplification of the baroque theatre following the more serious and less social tendencies of the legitimate theatre.

The reform dates from the work of the Sempers in mid-Victorian days and is punctuated with March's Fesbühne for Worms in 1887. The attempts at a new type of auditorium seldom aim at a direct return to the classic but only to one of its descendants, the Shakespearian stage. Already the results in projects and even a few completed playhouses have been notable.

The Circus Theatre. Steele MacKaye, actor, playwright, artist, director, and inventor, was the first to produce a notable plan for a circus-theatre. In 1892 he had almost completed in Chicago as part of the World's Fair a remarkable structure called the Spectatorium. Like so many efforts at the "theatre of the 10,000" it strove to gather together the huge audiences of Greek days and to bring them into close contact with all the possibilities of the stage. MacKaye devised a means of bringing his actors and choruses up from under the audience through steps in the orchestra pit. He invented a proscenium opening that could be made wide or narrow, thin or deep. He provided
PLAN OF STEELE MACKAYE'S SPECTATORIUM-THEATRE DESIGNED TO SEAT TEN THOUSAND PEOPLE AND TO INTRODUCE SLIDING STAGES, A LIN-OLEUM CYCLORAMA AND MANY OTHER MODERN STAGE REFORMS.
FROM ZUCKER, "THEATER & LICHTSPIELHÄUSER (WARMBUTH)

FLOOR PLAN OF SECOND AND THIRD BALCONY OF THE GROSSES SCHAU-SPIELHAUS, BERLIN, DESIGNED BY HANS POELZIG, ARCHITECT
a crescent-shaped stage with scenery sliding on tracks. This stage could be flooded with water. He closed in the back of his semi-circular stage with a linoleum cyclorama. He invented cloud machines for projecting moving clouds on the sky. There were few reforms of modern stage technique that this remarkable man did not foreshadow in this project, which the American financial panic of 1893 arrested when only half built.

It was along the lines of this MacKaye theatre that Max Reinhardt built when he developed his performances of Greek tragedies in circus buildings into the finally realized Grosses Schauspielhaus in Berlin (Hans Poelzig, arch.). Here he came close to the true conditions of the classic stage, with the actors appearing on a semi-circular orchestra floor almost in the midst of the spectators, and then retreating up steps to a completely equipped stage with sky-dome, revolving stage, and all the modern appurtenances. The son of Steele MacKaye, Percy MacKaye, realized many of the values his father had planned in his open air performances of "masques" at St. Louis, New York and Cambridge, Mass., between 1912 and 1927.

Copeau's Theatre. At the opposite extreme in size, Jacques Copeau created in the Theatre du Vieux Colombier, Paris, a playhouse which united the actors on a naked architectural stage with an audience seated within auditorium walls that continued back unbroken by a proscenium to make the walls of the stage itself. The Theatre du Marais, Brussels (Loyis Jouvet, arch.), and other projects were offshoots of this pattern.
Non-Realistic Theatres. The stimulus of trying to give Shakespeare's plays as he wrote them and not garbled and condensed to fit the modern realistic theatre has resulted in a number of attempts to revive the conditions of the Shakespearean stage on the stage of an ordinary theatre. This has brought back canvas make-believe, the portals of proscenium doors which all English theatre rejoiced in a century ago. First merely represented as part of the scenery, these means of linking the actor and the auditorium have now been built into the actual prosceniums of many new houses, especially in the "little theatres" built here and there about the United States. Some such theatricalizing of the stage is present in the Werkbund Theatre, Cologne (Van de Velde, arch.), with its tripartite division of the stage, and in A. and G. Perret's and A. Granet's theatre in the Arts Decoratives exhibition in Paris. But certainly the handsomest playhouse of the formal and ultra-theatrical sort is the Theatre in der Redoutensaal, Vienna (Sebastien Heinrich, arch.), a stage with permanent walls, but no proscenium or fly gallery, set down in a ballroom of Maria Theresa. From productions in this house Reinhardt turned to the rejuvenation of a lovely old Viennese theatre, the Josephstaedter, and then created in Salzburg in the Reitschule a non-realistic playhouse which he hopes finally to replace by a magnificent, neo-classic festival theatre from the plans of Poelzig.

Radical Projects. Radical designs, which are as yet largely projects, include those of the distinguished American pioneer architect, Frank Lloyd Wright. Norman-Bel Geddes has devised a remarkable theatre with
SECTION AND PLAN OF THE REINHARD THEATRE, NEW YORK CITY, DESIGNED BY JOSEPH URBAN, ARCHITECT

FROM WASMUTH, "MONATSHEfte Für BAUKUNST"

PROJECT OF A CIRCULATORY STAGE IN A THEATRE, DESIGNED BY OSKAR STRNAD, VIENNA

FROM WASMUTH, "MONATSHEfte Für BAUKUNST"

SECTION OF A THEATRE DESIGNED BY OSKAR STRNAD, VIENNA
PLAN OF THE THEATRE GUILD THEATRE. NEW YORK CITY, DESIGNED BY C. HOWARD CRANE, FRANZHEIM AND BETTS. ARCHITECTS.

This theatre provides for a stage and auditorium both under one domed roof. The triangular stage in the lower right corner includes the basement for storage and后台.
the stage in one corner, the whole auditorium and playing floor surrounded by a single dome of light. He has also devised a long rectangular playhouse with the action passing on a stage stretching down the middle from end to end, and with the audience on both sides, as well as a circular playhouse with the stage in the centre, a scheme suggested by Robert Edmond Jones's project for Shelley's *The Cenci* in a prize ring. Variants on the usual relations of stage and audience are many, including a scheme by Friedrich Kiesler for two opposing auditoriums sharing the same stage. One of the most remarkable is Oskar Strnad's circular theatre with the audience seated in the centre and the big ring of the revolving stage coming into view a segment at a time.

Out of all these attempts and projects, a really healthful new theatre is slowly but surely evolving. IT WILL NOT REACH ITS FULL MATURITY UNTIL ACTORS CAN ENTER NATURALLY AND EASILY FROM THE AUDITORIUM AS WELL AS FROM THE STAGE AND STEP DOWN FROM THEIR OWN LEVEL TO THE LEVEL OF THE SPECTATORS. WHEN EVERY DIVISION BETWEEN THE WORLD OF THE ACTORS AND THE WORLD OF THE SPECTATORS IS ELIMINATED, AND WHEN THOSE WHO GIVE AND THOSE WHO RECEIVE ARE -- IN THE SPIRIT OF THE CLASSIC THEATRE -- ONCE MORE SURROUNDED BY THE WALLS OF THE SAME ROOMS, THEN AND ONLY THEN WILL IT BE POSSIBLE TO MEET COMPLETELY ALL THE DEMANDS NOT ALONE FOR PROPER ACOUSTICS AND PROPER VISIBILITY, BUT FOR PURELY SPIRITUAL PLEASURE ACHIEVED WITHOUT HAMPERING PHYSICAL EFFORT.
MODERN THEORY OF DESIGN

To the Greeks, the theatre was their most vital creative expression, and they succeeded in achieving results that for "pure theatre" have never been surpassed. They built them to look like theatres and to dignify what transpired within them. The Greeks lived in an age of imagination. Their knowledge of the material world was much more restricted than ours. It was as uncharted to them as the universe is to us, and life had a greater interest for them because of this mystery. In this mood, they created their drama. Their tragedy penetrated the mysteries of nature beyond the humdrum of ordinary life. Their comedy was carried to an extreme that, to our gradually neutralizing mind, appears exaggerated and vulgar. Civilization has by degrees impoverished its audiences from an enthusiastic appreciation of extremes toward a glorification of the commonplace mean.

We live in an industrial age. We should have theatres that belong to our time, drama that voices this time. Instead, our theatre is secondary. We exercise our emotions by reading daily papers, riding in automobiles, listening in on the radio, playing bridge and seeing mediocre motion pictures. The theatre is a state of sham. The plays, the actors, the scenery, all try to make audiences forget they are in a theatre. The buildings themselves are made to look like office buildings, taverns, museums, Renaissance palaces, Spanish missions or casinos. To plan a practical theatre, the designer, architect, or engineer should possess a knowledge of theatres, past and present, and of the latest experiments toward the future, with an experience in the theatre that would class him
with such specialists as are called upon to build our sky-scrapers, suspension bridges, and subway tubes. In exterior design, the most conspicuous elements, such obviously dominating features as the electric signs, the porte cochere, the huge cubical mass of the flying space above the stage, offer problems of unusual contrast specifically in theatre design.

Primarily, the theatre in this modern world, from every standpoint, lacks style. Inside and out, it should be distinguished. It should look and be "theatre," in its architecture, plays, acting or staging. Theatres naturally vary in size, requirements and class of entertainment. The point of view of the artists engaged in the theatre should likewise vary. The working parts of a theatre must possess the utmost flexibility, must be alterable, in simple practical terms, from one person's use of it to another's, hampering experiment as little as possible. Until the theatre, architecturally, becomes more flexible, the dramatist, producer, designer, will continue to have difficulties in exploring new forms. For any radical or improved or experimental idea, in dramatization or staging, beyond what has been developed in the last 15 years, the present stage is inadequate. It suffices for only a few types of plays, and is completely impractical for any style out of this groove. It is probably the most restricting theatre man has ever conceived. New basic ideas of architecture will materially stir the imagination of everyone connected with it. Instigate a type of stage of a three dimensional order and see what happens in the actual creative work in the theatre.
To any student of the subject, the development of the theatre since the Greeks shows gradual deterioration. The single item that has most influenced these changes is the proscenium arch. There was no arch in the Greek theatre, but by successive stages from that time to the present, the arch idea has developed. Its two-dimensional aspect imposes an effect which is deadening, as compared with the exhilaration of an audience to look at a play through a proscenium arch than there would be in asking them to watch a prize fight through one. At a prize fight, although each individual looks into the ring from one point of view, a more intensified atmosphere is gained by the sight of the audience seated on all sides of the ring. In an art gallery, looking at a piece of sculpture, you instinctively walk slowly around the object to view it from different directions, rather than merely standing and looking at it as you would a painting. The exaggerated importance of the picture-frame stage of the past generation is undoubtedly due to lack of imagination of the minds working the theatre. After all, the proscenium in its present maximum form has only existed over one-fifteenth of the time that has lapsed since the theatre of Dionysus.

In thinking of the theatre, we naturally begin with the stage. The auditorium is built around the stage and a relationship must be maintained between these two major elements. In nearly all modern examples, the stages are too small in proportion to the auditoriums. Half of the audience is in a poor position to see and hear. The inadequacy of the stage is accepted as a matter of course, since the actors have sufficient
space to move in during a performance. Actually, the part of the stage that the actor utilizes during the playing of a scene is only about a tenth of the total cube required for stage purposes. The off stage space (to both sides and rear of the acting area) should equal three times the floor space of the acting area in order to handle adequately the changes of settings. In most modern theatres, it is not even equal to it. The entrances and exits for actors, the facilities for handling scenery, properties, and electrical apparatus are neglected correspondingly. The flying space (above the stage) should be four times the height of the maximum scene, but seldom is. The present-day stage does nothing for the dramatist but cause him to worry as to how this or that idea will be visualized in two dimensional terms, and this has gradually reduced the actor to an immobile loud speaker. The last few years have brought out various mechanical features, such as the application of the hydraulic, revolving, sliding and turning-over principles for changing part or all of the stage with its scenery; and a permanent plaster cycorama to replace the drop cloth painted to represent a sky, upon which light of any colour can be thrown. But although all of these are important, they fail to get at the root of the difficulty, which is the adjustment of the style and proportions of the theatre to its uses and needs while the building is being planned.

The auditorium should be designed so that everyone may enter easily, reach his seat without annoying other people, sit comfortably, see and hear everything on the stage. The best angle of vision between the stage and the seats, because we are most accustomed to it in everyday
life, is shoulder height, yet in our theatres to-day, the best seats, judging from the scale of prices, place the spectator's eye on a level with the actors' feet. Each successive row of seats should be at an angle in relation to the stage, so that the spectator does not have to peer between the heads of those in front of him.

The audience is the governing factor of drama. There can be no drama without it. All the dramatist, director, designer and actor do is to project elements which will create a certain effect in the audience's imagination. A dramatic production has no significance until it is performed in conjunction with its audience. This is why each type of play sifts out its particular audience. THE THEATRE TAKES ITS PLACE AMONG THE ARTS WHEN THE AUDIENCE NOT MERELY WITNESSES A REPRODUCTION OF LIFE AS IT IS OUTSIDE THE THEATRE, BUT TAKES PART IN AN EXPERIENCE THAT DOES NOT EXIST ANYWHERE OUTSIDE THE THEATRE.

Suffering from the limitation that it is not a single-vision medium, as that of painters, sculptors, poets, musicians, and architects, the usage of the theatre is contradictory to what is accepted as the ordinary working procedure of an artist. The dramatist works in a composite medium which is stage, actor and audience. The designer takes the play and develops it for production in all its visual setting, costuming, lighting. Finally the director, whose position is synonymous to that of the orchestra conductor but who uses actors instead of musicians, rehearses all of these elements into an unified performance. The dramatist reaches his audience indirectly through the director, designer and actors.
His work may be limited by these people, or his stimulation may inspire them to develop his ideas further than he could have done alone. The result, good or bad, is the very element that gives the theatre its unique qualities, its advantages and disadvantages, over other forms of expression.

The end we seem to be going toward has a more plastic three dimensional stage structure, formal, dignified and neutral, as a basis, its various acting platforms inviting a variety instead of the cramped condition of the present. Such a structure is designed for the playing of a sequence of scenes of diverse mood, locale and character, not imitative in geographical terms, but creative in dramatic terms, with emphasis on the intensity of dramatic action and its projection to an audience. It will give the impression of being very solid and enduring, and will be composed of a variety of levels, ramps, platforms, aprons projecting into the audience, high stages towering to the rear, the whole achieving pictorial qualities by the composition of actors on various levels and their movements in conjunction with lighting. Portions of these settings may or may not be changed to vary as a play goes on. Any adequate technique for staging plays should permit of a play being run off in any combination or series of rhythms and not destroyed by such crude makeshifts as darkening the stage or lowering of the curtain to make changes in the setting.

Theatres for motion pictures are bound to alter and become distinct from theatres for plastic drama, and in the same way that screen drama is of
necessity going to emphasize two dimensional vision, the stage drama, as it develops away from the picture medium in a mental sense, will likewise grow away from it in a physical sense and become decidedly more three dimensional.
MODERN TENDENCIES IN PRODUCTION AND DIRECTION BY KENNETH MACGOWAN

At one time or another the theatre has used some part of every method of production that we so fervently hail -- or condemn -- as the last word in modernism to-day, for in 25 centuries it has been all things to all men. It has been religious and blasphemous. It has been as noble as its god-heroes and as petty as its bourgeoisie -- whether of Rome or London. It has been fantastic and formal in the temples of the living masks where men meet the gods throughout the East. It has been minutely realistic. Back in Greece, when someone painted wave-lines on the "periaktoi," and thus let the audience know that it stood by the shore of the sea, the theatre was expressionistic. A performance of The Tempest on Shakespeare's open stage, with the sailors swarming up the ropes into the canopy overhead, would have satisfied the constructivism of Meyerhold. And when Reinhardt puts Oedipus Rex into a circus or gives Calderon's The Great World Theatre in a cathedral he is merely imitating with conscious art the naive habit that the ancient theatre had of playing cuckoo and laying its eggs of art in amphitheatres, chancels, inn yards, bear-pits, tennis courts, market places, and court ballrooms.

Enter the Regisseur or Director. Yet, in a narrow sense, there are modern tendencies in the theatre -- two major tendencies, both founded on a new attitude towards the complex business of getting actors to speak lines in an effective ensemble. The new attitude is seen in the commanding presence of a director. Some one has always insisted that the actors learn their lines, speak them with a certain skill, and walk
where they will not trip over one another's heels or become entangled with the properties. But the commanding director -- or régisseur -- is the notable contribution of the theatre of the past half century. From Duke George II of the little German State of Meiningen -- who fused supers into true mobs, put ceilings on box sets, and created the first modern ensemble acting in the middle '70s -- through Otto Brahm, first master of naturalism at the beginning of the 20th century, Max Reinhardt, Brahm's disciple to begin with, then pioneer in every form of theatre from cabaret to cathedral and little theatre to circus, Meyerhold the Russian, who preached and performed the "theatre theatrical" -- from these masters on to the director of the tiniest of community theatres in some Californian town, the régisseur has taken his place as the centre of the modern theatre. His business has been to dominate, synthesize, and unify each production, and thus to bring forth a single work of theatrical art instead of a histrionic accident.

Realism Versus the Theatric. Without the régisseur neither of the two great schools of modern production could have developed. A single mind was needed to shape the performance, set its character, give it its pace, provide its atmosphere in scenery and lights. It did not matter whether the result was to be a realistic production or a production in which the true theatricalism of the stage was to be liberated -- one creative spirit had to dominate.

In terms of the past century, realism is a much older thing than the theatric, although the theatric goes far deeper into the historic past.
Realism is likely to dominate the stage as long as machine civilization dominates life. It has already come to a fine perfection, and we are more familiar with it than with the theatric. We have seen realism at its height in Stanislavsky of the Moscow Art theatre, and occasionally in David Belasco or Basil Dean. We have not seen much theatric acting outside Russia and Germany. In America and England the theatric and imaginative movement has expressed itself largely in things of the eye -- in the scenery of the new stage-craft. The battle of realism and the theatric -- first with a common enemy, then with each other -- can in many ways be seen best through the activities of the regisseurs of scenery the stage designers who have given it outward physical form. Nothing but the theatre could harbour artistic tendencies so diverse. But, though one is photographic and one is imaginative, both began in fierce opposition to the theatre of Victorian days. The thing that both hated in this theatre was typified in its scenery, ugly, unillusive, accidental.

Thus two very different types of artists were leagued as allies. One was the realist, like Belasco, who wanted solid, plausible rooms on the stage. The other was the man of imagination, like Gordon Craig, who wanted beauty of something full of expressive artifice. There was a little of each in the first great regisseur of the 20th century, Max Reinhardt. Together, the realist and the artist of the imagination banished the mechanism of the older stage. They banned false perspective and shallow pretence, muddy colour on flapping backdrops.

Realism triumphed first. It had the great dramatists of the day behind it, and the mood of 20th century audiences. Maeterlinck and von Hof-
mannstahl and d'Annuzio put up an anaemic front to Ibsen, Hauptmann, Sudermann, Brieux, Pinero, Jones, and Shaw. The régisseur developed actors who could convey emotion by the quiver of an eyelash, and he found ways to surround them with the solid world of reality.

Mechanical Progress. But how were the solid columns, weighty staircases, well-braced walls to be moved? How were scenes to be shifted quickly and economically? The problem was not alone a problem for the realistic producer, for when the régisseur put on Shakespeare the new settings were solid, plastic, three-dimensional, and he had dozens of these scenes and no long intermissions in which to change them. The answer -- the typical answer -- was modern machinery. America led -- for just a moment or two in 1888 -- when Steele MacKaye, régisseur, actor, playwright, painter and mechanist, installed his double elevator stage in the Madison Square Theatre, New York, to shift scenery, actors and all. The great bulk of mechanical reform, however, has come from Germany, and dates from 1896 when Lautenschlaeger of Munich borrowed the revolving stage from Japan. Other scene-shifting machines from Germany include the sliding stage, which carries whole settings on great wagons, and sinking stages, which bring up the scenery from the basement. Arthur Hopkins, the first American régisseur of imagination to follow MacKaye, introduced, about 1914, stages that swung on pivots, and Lee Simonson, the American designer, has made most ingenious use of small revolving units in Theatre Guild productions such as Peer Gynt.
Progress in Lighting. Even more energy and resourcefulness has gone into the improvement of lighting equipment since the days of gas, and this has served both the realist and the producer of imagination. The first notable attempt was made in Germany by the Venetian, Fortuny. His aim was to provide diffused and softened light, more like the reflected sunlight of a shaded spot. He threw all the light rays of an arc upon screens of coloured silk, which reflected them upon the stage. His sky-dome or "Kuppelhorizont" further diffused the light while producing an illusive sky of almost infinite depth. From the mechanism of Fortuny and the ideas of Gordon Craig's great rival, Adolphe Appia who first called for the shadowed, sculpturesque lighting that comes from large sources of illumination; instead of the blank glare of the footlights -- electrical invention has gone on to a surprising degree of perfection in Germany and America. Through Max Hasait and Adolph Linnebach, both working at Dresden in hot rivalry, devices were at last perfected for projecting scenery by means of light on to backdrops or cycloramas. Simonson made fine use of the Linnebach process in Back to Methuselah and Peer Gynt.

There is, after all, a considerable difference between a decoration thrown on a backdrop by electric light and interiors so solid and heavy that they must be shifted by machinery. And yet both extremes fall easily within the limits of the revolt which realist and theatricalist began in the name of the new stagecraft. Even the old-fashioned backdrops of the opera house, painted in false perspective, have their place
in the modern movement of the imagination if only they are painted
with the boldness, the dramatic vigor, and the expressive colour of a
Russian like Bakst or Roerich or Golovin. If the artist can create
an effect upon the stage just as characteristic of the play and its
emotion as anything the actors may do, then he has done the work ex-
pected of him. The medium and the method do not matter.

Pioneers of the New Stage Craft. This was not quite so clear when
Gordon Craig and Adolph Appia began their campaign of scenic enlighten-
ment about the beginning of the 20th century. All about them the stage
was filled with flat and shallow artificiality. There was neither
beauty nor truth to life in the jaundiced meadows and mildewed moun-
tains and splayed rooms which the hack scene painters spread over back-
drops and wings in very, very false perspective. The realist and the
imaginative artist had to hate them equally. Craig and Appia might have
accepted the stage conventions of the old theatre -- the simple flats
and backdrops, and awakened them to new life as the Russians did. In-
stead they fought them, and fought them on the one legitimate issue on
which they can be fought. Paintings in two dimensions do not and can-
not harmonize with three dimensional actors. So away with false pers-
pective and its painted shadows. Make room for solid plastics, for rocks
and walls against which the actor may lean.

Gordon Craig did a great deal more than argue against backdrops and wings.
In his articles and books he showed that the theatre is a composite art
made up of the contributions of playwright and actor and painter and mu-
sician. He demanded unity upon the stage and he declared that the ideal
artist of the theatre must be the man who can write the play, direct the actors, design the scenery and lights, and provide any other element such as the music or the dance that may be needed. Only in this fashion can the theatre have the creative unity which is at its heart. And in all his writing and through all his brilliant designs, Craig sought to interpret in as dramatic a fashion as possible the emotion of the play.

Appia, a Swiss doctor, who began theorizing and sketching in the early '90s, stood likewise against false perspective and in favour of the plastic stage. Like Craig, he was truly a régisseur. His great contribution was a sense for the value of light. In his book describing and picturing the production of Wagner's music-dramas, Appia provided many appropriate and striking sketches, dictating the movements of actors as well as lights. He showed how spotlights, used instead of footlights, produce shadows; how light and shadow give a sculpturesque quality to everything on the stage, and how changes in the light can indicate the passage of time and the development of the drama. To demonstrate this, he drew a series of sketches of scenes from Wagner's music-dramas following the light changes throughout each act.

When the theories of Craig and Appia annihilated the old stage setting, they opened the way for something they were not the least bit interested in -- realism. Fortunately they also provided the corrective for it. When realism is most complete it is at its worst. It then furnishes an absolute photograph of life. A room becomes a junk shop. It is solid, real and wooden, and utterly confused. There are so many knick-knacks
about that you can hardly find the actors. The eye is tempted to wander off and count the bowls of flowers and admire the woodwork and discover curios all over the place. Belasco and all the realists have now learned better than this. So far as America is concerned, Arthur Hopkins and the artists of the new stage-craft have taught them how to make a room seem real and plausible and yet never distracting, and how to make it express something of the drama that goes on within.

Making Scenery Abstract. The modern theatre has been quick to realize that the mood created by the background is the important thing, and that, generally speaking, the less the material world is involved, the more the actor can summon up an ideal world of the theatrical imagination. Directors and designers tended, therefore, towards experiments with more and more abstract settings. Craig began with curtains, using them for walls. In a scene for a modern play, Robert Edmond Jones painted his curtains brown and green and hung them in folds that, under proper lighting, suggested a forest. Other artists -- Norman Wilkinson, for example, working in England under its one modern regisseur, Granville Barker -- go a step further and treat curtains frankly as curtains, painting them with a landscape or a formal arrangement of stars, and then -- so there cannot be the least possible mistake about it -- draping the curtains in folds, and banishing even the quasi-illusion of the old backdrop.

Screens can be used even more abstractly. About 1912, Craig worked out a scheme for equipping a theatre with a set of folding screens of all
sizes which could be rearranged in an endless variety of ways. When Stanislavsky tried to use this system of screens for *Hamlet* at the Moscow Art theatre, he found grave difficulties in the way of its practical employment. These difficulties were largely removed in a scheme devised by a pupil of Craig's, Sam Hume, which he used at the Detroit Arts and Crafts theatre.

In all this talk of scenery, you must note implication after implication of how the régisseur will direct the company towards an art far, far removed from the realism of the Moscow Art theatre. When the theatre goes still further into the abstract or the fantastic in stage setting, it must carry the actor along with it, or it is nothing. Already designers have thrust upon the stage the expressionistic methods of modern painters like Picasso -- himself a designer for the Russian ballet of Diaghileff. In America, and in most of the Continent outside Russia, the régisseurs have done little to match these backgrounds with acting. The outstanding exceptions -- Meyerhold, Yevreynoff, Komisarshefsky, Tairoff and Zemach, all of Russia -- have laboured to infuse into the actor and the ensemble a stylized vitality which distinguishes their performances from anything in the Western world.

**Expressionism and Constructivism.** Expressionism, whether of acting or scenery, postulates that the expression of inner emotion -- which ought to be the emotion of the playwright and his play -- comes before any resemblance to the outer aspect of life. Expressionistic productions use distortion to arrest and excite the attention. Doorways assume strange forms, as in that notable attempt in *Macbeth* which Robert Edmond
Jones and Arthur Hopkins made in New York some years ago without acting to back them up. Walls topple. The floor shoots up at weird angles. Lights flare in with no relation to reality, and shift in colour almost word by word. The make-up of the actors is startlingly obvious in its distorted lines, and the clothes of even modern characters are painted with high lights and shadows.

One can almost go back to Appia for the beginnings of constructivism, for Appia was the first to stress the necessity of varied levels on the stage. They have become increasingly important in the work of the more radical régisseurs. Leopold Jessner, Germany's outstanding director since Reinhardt, added these levels to the formal stage of the more conservative expressionists. By using steps and parapets, he was able to move his people in three dimensions, and make their physical relationships more vivid and significant. In each of his Shakespeare productions he stuck to a single arrangement of steps, upon which he arranged a few of Emil Pirchan's simply sketched indications of locale, all within the neutral wall of the often unlighted cyclorama.

From Jessner one leaps to Russia to find Meyerhold, a great theatrical pioneer, developing in constructivism an art which seems to steal its settings from the American skyscraper. High platforms, skeletonized structures, inclined planes, all manner of bare, unsentimentalized construction provide the footing as well as the background for the actors, and three or four locales are shown at one time -- a trick of the Renaissance. Tairoff mingle canvas expressionism with this when he mounts Eugene O'Neill's The Hairy Ape or Desire under the Elms. In
the musical studio of the Moscow Art theatre Dantchenko has refined and humanized constructivism in performances of *Lysistrata* and *Carmen*.

**New Theatres for Old.** Certain attempts at formalizing the existing stage carry us clear out of this phase and into new types of playhouses. Robert Edmond Jones's *Hamlet*, for instance, turned a Romanesque hall into a permanent setting for the whole drama. Such a scheme makes no pretense at the illusion of turrets, woods or any place except the theatre, tinged with the color and mood of the drama. This recognition of the playhouse as a place of frank make-believe has carried many modern directors into experiments in theatre architecture that recall the stages of Greece and Elizabethan England. Reinhardt, after producing Greek tragedy in one-ring circus buildings of Germany, reconstructed one of these houses into the Grosses Schauspielhaus. Here the actors could appeal on the orchestra floor in the midst of the audience or retreat to a fully equipped modern stage with sky-dome and revolving floor.

Half a dozen artists have designed theatres of even more revolutionary character. One of these, not yet built, however, is Norman-Bel Geddes's project for a stage in the corner of a sky-dome completely arching in the auditorium as well. The stage itself sinks into the basement for changes of scene to be made by means of rolling platforms already set. MacKaye's Spectatorium, conceived and partially built for the World's Fair in Chicago, was to seat 10,000 people. The stage itself was to introduce a number of reforms now adopted abroad - the sky-dome, the adaptable proscenium opening and fore stage, the cloud machine, and a sliding
stage on wheels. The whole stage could be submerged in water for the discovery of America by Columbus.

Europe created two theatres of outstanding novelty in the Vieux Colombier of Copeau and the Theater in der Redoutensaal opened in Vienna by Adolf Vetter, then head of the State theatres. The Vieux Colombier was a tiny playhouse without a proscenium opening in which the audience and stage were contained in a single room. The stage itself was provided with a permanent architectural setting of steps and balcony which could be converted, for example, from a classic exterior into a scene for *Twelfth Night* by altering parts of the decoration.

The Theater in der Redoutensaal is again a theatre with no proscenium and, therefore, no fourth wall and no peep-show. At one end of this great and glorious ballroom of Maria Theresa, Vetter and Oberbaurat Sebastien Heinrich placed an acting platform without proscenium or "flies." Upon this platform is a curved wall perhaps 15 ft. high, carrying out the decorative motifs of the hall and making a permanent background for the stage. In the middle, double stairways curve up to a balcony above. Upon the balcony are great doors leading to other rooms. The shell of the cream and gold wall is pierced by openings for doors and windows. Screens or simple set-pieces serve to vary this setting, and to indicate mood and place. The *Marriage of Figaro* was there presented by the forces of the State opera, and Max Reinhardt has staged many classic comedies in the Redoutensaal.
The bulk of this effort to match the realistic theatre with a theatre of imagination has gone forward unsupported by proper plays. The classics have served best. Some modern dramas have been badly distorted to fit them to the Procrustean beds of expressionism. In Germany a certain number of playwrights, led by Georg Kaiser and Walter Hasenclever, have made valiant and none too successful efforts to provide free and vivid plays of to-day cast in a nervous, fast-moving, subjective form. The success of the Russians in matching plays to constructivist production had not been so notable as to pass the frontiers by 1928. The only distinctly promising efforts towards new dramatic form have come from America and largely from the pen of one writer, Eugene O'Neill. Elmer Rice's *The Adding Machine* and George S. Kaufman and Marc Connelly's *Beggar on Horseback*, adapted from a German original, have succeeded in enkindling a public response, but the pioneer work of John Howard Lawson, Francis E. Faragoh, John Dos Passos, and Em Jo Bassche has failed to meet the requirements of the audiences of to-day. O'Neill's expressionistic drama *The Hairy Ape*, his constructivist experiment *Desire Under the Elms*, his drama of masks, *The Great God Brown*, his nine-act exposition of spoken thoughts *Strange Interlude*, and his printed play *Lazarus Laughed*, seem the only completely mastered attempts of a playwright to strike out along the paths that modern pioneers in direction, scenery and acting have marked out.
Theatrical art has always been collective, arising only where poetical-dramatic talent was actively combined with the actor's. The basis of a play is always a dramatic conception; a general artistic sense is imparted to the theatrical action by the unifying, creative genius of the actor. Thus the actor's dramatic activity begins at the foundation of the play. In the first place, each actor, either independently or through the theatre manager, must probe for the fundamental motive in the finished play -- the creative idea that is characteristic of the author and that reveals itself as the germ from which his work grows organically. The motive of the play always holds the character developing before the spectator; each personality in the work takes a part of conforming to his own character; the work then developing in the appointed direction, flows on to the final point conceived by the author.

The first stage in the work of the actor and theatre manager is to probe for the germ of the play, investigating the fundamental line of action that traverses all of its episodes and is therefore called by the writer its transparent effect or action. In contrast to some theatrical directors, who consider every play only as material for theatrical repetition, the writer believes that in the production of every important drama the director and actor must go straight for the most exact and profound conception of the mind and ideal of the dramatist, and must not change that ideal for their own. The interpretation of the play and the character of its artistic incarnation inevitably appear in a certain measure subjective, and bear the mark of the individual peculiarities of the manager and actors; but only by profound attention to the artistic individuality
of the author and to his ideal and mentality, which have been disclosed as the creative germ of the play, can the theatre realize all its artistic depth and transmit, as in a poetical production, completeness and harmony of composition. Every part of the future spectacle is then unified in it by its own artistic work; each part, in the measure of its own genius, will flow on to the artistic realization aimed at by the dramatist.

The actor's task, then, begins with the search for the play's artistic seed. All artistic action -- organic action, as in every constructive operation of nature -- starts from this seed at the moment when it is conveyed to the mind. On reaching the actor's mind, the seed must wander around, germinate, put out roots, drinking in the juices of the soil in which it is planted, grow and eventually bring forth a lively flowering plant. Artistic process must in all cases flow very rapidly, but usually, in order that it may preserve the character of the true organic action and may lead to the creation of life, of a clear truly artistic theatrical image, and not of a trade substitute, it demands much more time than is allotted to it in the best European theatres. That is why in the writer's theatre every dramatization passes through eight to ten revisions, as is also done in Germany by the famous theatre manager and theorist, K. Hagemann. Sometimes even more than ten revisions are needed, occasionally extending over several months. But even under these circumstances, the creative genius of the actor does not appear so freely as does, for instance, the creative genius of the dramatist. Bound by the strict obligations of his 'collectif,' the actor must not postpone his work to the moment when his physical and psychic condition appears propitious for creative genius. Meanwhile, his exacting and capricious artistic nature
is prompted by aspirations of his artistic intuition, and in the absence of creative genius is not reached by any effort of his will. He is not aided in that respect by outward technique -- his skill in making use of his body, his vocal equipment and his powers of speech.

Production. It is evident that under these conditions, the staging of a play, which will satisfy highly artistic demands, cannot be achieved at the speed that economic factors unfortunately make necessary in most theatres. This creative process, which every actor must go through, from his conception of the part to its artistic incarnation, is essentially very complicated, and is hampered by lack of perfection of outward and inward technique. It is also much hindered by the necessity of fitting in the actors one with another -- the adjustment of their artistic individualities into an artistic whole.

Responsibility for bringing about this accord, and the artistic integrity and expression of the performance rests with the theatre manager. During the period when the manager exercised a despotic rule in the theatre, a period starting with the Meiningen players and still in force even in many of the foremost theatres, the manager worked out in advance all the plans for staging a play, and, while certainly having regard to the existing cast, indicated to the actors the general outlines of the scenic effects, and the 'mise-en-scène'. The writer also adhered to this system, but now he has come to the conclusion that the creative work of the manager must be done in collaboration with the actor's work, neither ignoring it nor confirming it. To encourage the actor's creative genius, to control
and adjust it, ensuring that this creative genius grows out of the unique artistic germ of the drama, as much as the external building up of the performance -- that in the opinion of the writer is the problem of the theatre director to-day.

The joint work of the director and actor begins with the analysis of the drama and the discovery of its artistic germ, and with the investigation of its 'transparent effect'. The next step is the discovery of the transparent effect of individual parts -- of that fundamental will direction of each individual actor, which, organically derived from his character, determines his place in the general action of the play. If the actor cannot at once secure this transparent effect, then it must be traced bit by bit with the manager's aid -- by dividing the part into sections corresponding to the separate stages of the life of the particular actor -- from the separate problems developing before him in his struggle for the attainment of his goal. Each such section of a part or each problem, can, if necessary, be subjected to further psychological analysis, and subdivided into problems even more detailed, corresponding to those separate mind actions of the performer out of which stage life is summed up. The actor must catch the 'mind axes' of the emotions and temperaments, but not the emotions and temperaments, that give colour to these sections of the part. In other words, when studying each portion of his part, the actor must ask himself what he wants, what he requires as a performer of the play and which definite partial problem he is putting before himself at a given moment. The answer to this question should not be in the form of a noun, but rather of a verb: "I wish to obtain possession of the heart of this lady" -- "I wish to enter her house" -- "I wish to push aside
the servants who are protecting her," etc. Formulated in this manner, the mind problem of which the object and setting, thanks to the working of his creative imagination, are forming a brighter and clearer picture for the actor, begins to grip him and to excite him, extracting from the recesses of his working memory the combinations of emotions necessary to the part, of emotions that have an active character and mould themselves into dramatic action. In this way the different sections of the actor's part grow more lively and richer by degrees, owing to the involuntary play of the complicated organic survivals. By joining together and grafting these sections, the 'score of the part' is formed; the scores of the separate parts, after the continual joint work of the actors during rehearsals and by the necessary adjustment of them one with another, are summed up in a single 'score of the performance'.

The Score Condensed. Nevertheless, the work of the actors and manager is still unfinished. The actor is studying and living in the part and the play deeper and deeper still, finding their deeper artistic motives; so he lives in the score of his part still more profoundly. But the score of the part itself and of the play are actually subject by degrees during the work to further alterations. As in a perfect poetical production there are no superfluous words but only those necessary to the poet's artistic scheme, so in a score of the part there must not be a single superfluous emotion but only emotions necessary for the 'transparent effect'. The score of each part must be condensed, as also the form of its transmitting and bright, simple and compelling forms of its incarnation must be found.
Only then, when in each actor every part not only organically ripens and comes to life but also all emotions are stripped of the superfluous, when they all crystallize and sum up into a live contact, when they harmonize amongst themselves in the general tune, rhythm and time of the performance, then the play may be presented to the public.

During repeated presentations the theatrical score of the play and each part remains in general unaltered. But that does not mean that from the moment the performance is shown to the public the actor's creative process is to be considered ended, and that there remains for him only the mechanical repetition of his achievement at the first presentation. On the contrary, every performance imposes on him creative conditions; all his psychical forces must take part in it, because only in these conditions can they creatively adapt the score of the part to those capricious changes which may develop in them from hour to hour, as in all living nervous creatures influencing one another by their emotions, and only then can they transmit to the spectator that invisible something, inexpressible in words, which forms the spiritual content of the plays. And that is the whole origin of the substance of dramatic art.

AS REGARDS THE OUTWARD ARRANGEMENTS OF THE PLAY -- SCENERY, THEATRICAL PROPERTIES, ETC. -- ALL ARE OF VALUE IN SO FAR AS THEY CORRESPOND TO THE EXPRESSION OF DRAMATIC ACTION, I.E., TO THE ACTOR'S TALENTS; IN NO CASE MAY THEY CLAIM TO HAVE AN INDEPENDENT ARTISTIC IMPORTANCE IN THE
THEATRE, although up to now they have been so considered by many great scene painters. The art of scene painting, as well as the music included in the play, is on the stage only an auxiliary art, and the manager’s duty is to get from each what is necessary for the illumination of the play performed before an audience, while subordinating each to the problems of the actors.
APEENDIX B:

Excerpts from an Arthur D. Little, Co. report to the Metropolitan Arts Commission of Boston, concerning the theatrical situation in Boston. This report is included because of its methods of getting and presenting information about a Boston Civic Theatre project, as well as for the information that it presents.
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I. SUMMARY

A. PURPOSE AND SCOPE

The Metropolitan Boston Arts Center, Inc. (MEBAC) is a nonprofit institution incorporated under the laws of the Commonwealth of Massachusetts. Its purpose is to give the public a program of dramatic, visual and musical arts.

To achieve this aim, MEBAC is planning for the most appropriate first-class performing arts facilities. The proposed facilities are to be operated on a basis that will not compete directly with, but are intended to supplement, existing facilities in Boston.

The purpose of this study was to identify potential users and to define their building requirements and indicated usage of the facilities considered under the auspices of MEBAC. It was not within the scope of this study to define or describe in depth the present facilities in Boston, architectural considerations pertaining to a multipurpose, flexible hall, operating expenses and potential revenue, or reactions to the site. However, for the sake of greater clarity and completeness of information, we have discussed these aspects as comprehensively as possible in Sections IV, VII, VIII and IX. Furthermore, our study does not include a determination of the cultural need for new facilities in Boston nor the problem of audience saturation vis-à-vis the performing arts. Based, however, upon the experience of concert managers, producers, booking agents, and others, Boston is ranked as a cultural center, and its audiences are considered highly receptive to first-class performing arts events.

The new facilities would be principally used for the following:

1. Events, both of local and out-of-town origin, that must now be performed in facilities considered unsuitable artistically and/or economically.

2. Events not appearing in Boston because of a lack of suitable facilities.

3. Events requiring a subsidy (including those sponsored by nonprofit organizations).

4. Situations where a longer run is possible.

5. Events unable to come to Boston because of schedule conflicts with other events for the use of existing facilities.
Our field interviewing program concentrated mainly on the above respondent groups and sought information regarding the following:

1. Seating requirements by type of event.
2. Indicated days' usage by the type of event.
3. General staging and other layout requirements.
4. Equipment requirements.
5. The general conditions under which the proposed facilities would be considered desirable.

Our field interviews were directed not only toward potential users, but also operators of existing and proposed facilities in Boston and other cities in the United States and Canada, and experts in theater staging, lighting, and architecture. In addition to this field work, we made an extensive literature search for background information on the design of performing arts facilities and other related problems.

It is not within the scope of this study to recommend the most suitable facility(s) to be constructed. Rather, its purpose is to provide the data necessary to enable MEBAC to reach such a decision and to select the hall(s) that will contribute most significantly to the artistic and cultural life of the community without at the same time being an excessive financial liability.

B. CONCLUSIONS

1. Based upon an analysis of user requirements, three distinct building sizes emerge as being the most desirable for Boston. These size categories are sufficiently distinct as to suggest three different building alternatives, each ideally suited to certain kinds of events:

   a. 600-800 Seats - This size of building would house the local company known as the Charles Playhouse or a similar stock or repertory group.

   b. 1600-2200 Seats - This size would be used principally, but not exclusively, by locally sponsored and produced events, such as the Cambridge Drama Festival, New England Opera, the Opera Group, etc.
c. **2800-4000 Seats** - The principal tenants of this size building would be touring groups, such as the Metropolitan Opera, American and foreign ballet companies, and miscellaneous events sponsored by the major booking agents in New York.

2. There exists a considerable amount of overlapping demand for facilities. That is to say, most events can be successfully presented in a wide range of different sized facilities. Thus, the final size selection of new facilities must reflect a careful consideration of all types of events that may be fitted into a single hall.

3. The most desirable and realistic solution seems to call for a multi-purpose, flexible facility designed to be used by a variety of performing arts groups. A flexible facility is one in which many different performing arts events can be suitably staged by adjustment of the seating capacity, acoustics, stage and sight lines. However, an analysis of past attempts to design a truly flexible facility indicates that the solutions are extremely complex; few really successful halls have been designed that proved to have a wide range of operating flexibility over a period of time. This is not to say that flexibility is impossible, but MEBAC should have full grasp of the problems and limitations inherent in its final design selection and should equate this with usage levels.

4. Construction estimates made on a very preliminary basis indicate that the total cost of an attractive, first-class, 2000-seat theater constructed in 1962 would fall between six and eight million dollars, based upon construction costs for similar buildings in the United States. The cost of a 3000-seat hall constructed in 1962 would be between eight and ten million dollars. Except for land acquisition costs, these estimates are total figures and include hall construction cost and all interior furnishings, foundation, parking facilities, architectural fees, a 5% annual inflation factor, contingency fees, special equipment to achieve building flexibility, etc.

C. **RECOMMENDED AREAS FOR FURTHER INVESTIGATION BY MEBAC**

The principal theatrical requirements in Boston are not so much new seating capacity per se but a proper stage for opera and the ballet with outstanding acoustics. There is not a single facility in Boston that can be considered desirable for the presentation of opera and ballet because of these limitations. However, we feel that MEBAC should consider several alternative solutions as well as the construction of new facilities, because a considerable amount of time is available from three legitimate theaters in the 1200-1800 seat range. Furthermore, the proposed City Auditorium (with some facility revision) might provide a combination of large seating
capacity with at least adequate stage facilities and acoustical properties that would make it useful for the large touring opera and ballet companies.

Therefore, it is recommended that MEBAC carry out a detailed analysis of the suitability and availability of existing and/or planned facilities in Boston. The analysis would consider the following:

1. Feasibility of utilizing the proposed Boston City Auditorium for large-scale events, with particular reference to the adequacy of stage facilities and acoustical arrangements and to restrictions imposed by its prospective schedule of other uses.

2. Cost and feasibility of preparing the Metropolitan Theatre for large-scale opera and ballet performances, with particular reference to enlargement of its stage and scenery storage capacity to adequate proportions.

3. Feasibility of using already existing theatrical facilities for events sponsored or produced locally.

4. A study of various operating expenses and revenues. Our estimates of operating expenditures and revenue per performance for a 3000-seat hall are very rough estimates and may change significantly in the light of more detailed analysis.
II. INTRODUCTION

The Metropolitan Boston Arts Center, Inc. (MEBAC) is a nonprofit institution whose purpose is to give the public a program of dramatic, visual and musical arts. To this end, MEBAC has entered into a contractual agreement with the Metropolitan District Commission (MDC) under which a site on the banks of the Charles River has been provided for the construction of performing and visual arts facilities. A summer theater and an art gallery have already been erected on the site. It is MEBAC's intention to plan for whatever additional facilities are necessary to provide a pre-eminent Arts Center for the citizens of Boston and surrounding communities.

More specifically, MEBAC's objective is to provide high quality productions and exhibitions in the performing and visual arts, of local, national and international importance, and to make these available to the largest audiences at the lowest cost practicable. In the area of the performing arts, MEBAC desires to provide facilities ideally suited to the presentation of opera, ballet and the drama. It is not intended that the Arts Center compete directly with established commercial facilities; rather, it should present productions for which the facilities of the Arts Center would be uniquely suitable. Furthermore, it is MEBAC's intention to be satisfied with nothing less than first-class facilities that place the city of Boston among those with outstanding facilities not only for musical presentations, but also the opera, ballet and theater.

In the beginning of 1960, MEBAC requested us to undertake a program of research designed to assist it in determining the size and type of facilities to construct. Our conclusions are based upon a comprehensive survey of the market for new Arts Center facilities in Boston. It is not within the province of this market research program to analyze local cultural requirements or audience saturation and to recommend the facility(s) most suitable. Rather, the market potential information and conclusions derived during our study are intended to serve as the basis on which MEBAC can decide what the most realistic building alternatives are for the Arts Center and for the city of Boston.
In carrying out our field work, we approached each potential user to determine the ideal facilities required for his particular needs and the number of performances he would use the new facilities. These findings were tabulated and analyzed and then used as the basis of our final conclusions.

As the first step in our program, we designed a comprehensive set of questionnaires for our field interviewing program. Appendix A contains copies of these questionnaires. Over one hundred personal and telephone interviews were conducted during the course of the program to gather the information necessary for a definition of the market potential and facility requirements. Those interviewed included executives of local facilities, local concert managers and booking agents, city officials, directors of local performing arts activities, the principal concert managers in New York City and elsewhere, theatrical producers (including those responsible for major foreign companies' coming to the United States), business and artistic directors of the major performing arts groups, and representatives of comparable facilities throughout the country and Canada. In addition, we interviewed a number of leading experts in the field of theatrical seating, lighting, acoustics, staging and architecture. Entertainment industry representatives also gave us valuable information on over-all trends. All individuals and organizations contacted are listed in Appendix B.

Although it is impossible to estimate the extent of our market coverage with statistical certainty, we feel that our survey includes the vast majority of potential users for the new Arts Center facilities, namely:

1. The major touring ballet and opera companies of the United States and Canada.

2. Concert and theatrical managers who handle most of the touring events, both domestic and foreign.

3. The most active local performing arts groups, as well as leading local impresarios and concert managers who would be interested in using the new facilities.

4. Other organizations that might need new facilities.
IV. EXISTING FACILITIES IN BOSTON

Since it is the intention of MEBAC to supplement rather than compete with present facilities in greater Boston, it is appropriate to enumerate and describe those facilities, to indicate what types of facilities are in adequate supply, and what types are not. With the exception of the Charles Playhouse, we shall not deal with those facilities used exclusively by the owner or one tenant, e.g., the 495-seat theater of the Boston Conservatory.

Figure 1 lists facilities in Boston in order of size and indicates the percent of days they are booked during the nine-month winter season and the three-month summer season.

A. COMMERCIAL LEGITIMATE THEATERS

Boston currently has three commercial legitimate theaters, all located in the downtown area: the Shubert, the Colonial and the Wilbur. These theaters are available both for out-of-town tryouts before New York openings and for rerun tours of successful New York shows. In addition, they are used for small dance companies and similar events. The Wilbur has been used in the recent past by a Boston repertory drama group and by a local opera group. It is the consensus of our respondents that all three houses are perfectly adequate theaters in their size ranges. Seating capacities are as follows:

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</table>

Usage of these theaters varies greatly from year to year, depending, in the case of tryouts, upon the number of openings in New York and, in the case of reruns, upon the number of successful shows in preceding New York seasons. Thus, during the 1959-1960 season, which runs from Labor Day to May, the Wilbur was dark 21 weeks, the Colonial, 19 weeks, and the Shubert, 16 weeks; these theaters were not in use for a total of 56 out of the 120 theater weeks available. It would appear that present commercial legitimate facilities furnish adequate capacity, even though there are occasional booking conflicts when all three are occupied.
### Present Usage

#### Percentage of Days Facilities Booked

<table>
<thead>
<tr>
<th>Facility Name</th>
<th>Winter</th>
<th>Summer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Charles Playhouse</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td>Loeb Drama Center</td>
<td>300</td>
<td></td>
</tr>
<tr>
<td>New England Mutual Hall</td>
<td>600</td>
<td>39</td>
</tr>
<tr>
<td>Jordan Hall</td>
<td>913</td>
<td>13</td>
</tr>
<tr>
<td>John Hancock Hall</td>
<td>1019</td>
<td>8</td>
</tr>
<tr>
<td>Sanders Memorial Theatre</td>
<td>1100</td>
<td>15</td>
</tr>
<tr>
<td>Kresge Auditorium</td>
<td>1236</td>
<td>55</td>
</tr>
<tr>
<td>Kresge Auditorium</td>
<td>1238</td>
<td></td>
</tr>
<tr>
<td>Wilbur Theatre</td>
<td>1241</td>
<td>45</td>
</tr>
<tr>
<td>Colonial Theatre</td>
<td>1590</td>
<td>47</td>
</tr>
<tr>
<td>Shubert Theatre</td>
<td>1714</td>
<td>59</td>
</tr>
<tr>
<td>Symphony Hall</td>
<td>2631</td>
<td>96</td>
</tr>
<tr>
<td>Donnelly Memorial</td>
<td>3400</td>
<td>58</td>
</tr>
<tr>
<td>Metropolitan Theatre</td>
<td></td>
<td>100</td>
</tr>
<tr>
<td>Boston Auditorium</td>
<td>4442</td>
<td>100</td>
</tr>
<tr>
<td>Boston Arena</td>
<td>5800</td>
<td>90</td>
</tr>
<tr>
<td>Boston Garden</td>
<td>7200</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>14,000</td>
<td>4</td>
</tr>
</tbody>
</table>

Figure 1
B. SYMPHONY HALL

Symphony Hall has a capacity of 2631 seats. Its acoustics are universally regarded as superb for orchestral performances. Being designed as an orchestra hall, however, it does not have a theatrical stage, and its shape and flat-floor seating are considered undesirable for theatrical or dance events by the majority of our respondents. In short, Symphony Hall is well suited only for symphony concerts, recitals, and lectures. In any event, Symphony is in use for the latter events for all except ten to twelve days from September 15 to July 1. From July 1 to September 15, only three or four events of short duration are booked in a typical year. As Symphony Hall is not air conditioned, it is not a good facility for summer events, and the pressure of bookings during the rest of the year precludes any great increase in the number of events held at that time.

C. OTHER SMALLER HALLS

There are three other small halls available for cultural activities in Boston: John Hancock Hall, Jordan Hall and New England Mutual Hall. Their seating capacities are as follows:

<table>
<thead>
<tr>
<th>Hall</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>John Hancock Hall</td>
<td>1132</td>
</tr>
<tr>
<td>Jordan Hall</td>
<td>1019</td>
</tr>
<tr>
<td>New England Mutual Hall</td>
<td>913</td>
</tr>
</tbody>
</table>

John Hancock Hall was booked at 57% of capacity last winter and 8% in the summer, largely with meetings. It is only filled to seating capacity, however, four to seven times per year. It is air conditioned and has a small, proscenium type stage, 40 feet deep and 71 feet wide. Proscenium arch dimensions are 34-1/2 feet wide by 19 feet high.

Jordan Hall is principally devoted to the activities of the New England Conservatory, being a part of the main Conservatory building. Bookings equaled 79% of capacity last winter and 13% in the summer. Jordan Hall is not air conditioned.

New England Mutual Hall, like John Hancock, is used principally for meetings. It is air conditioned. At one time it housed a summer theater. At present, however, its only summer events are a film series. It is booked at 80% of capacity in winter and 39% in summer.
D. FACILITIES OCCASIONALLY AVAILABLE

There are five facilities whose primary purposes are other than the housing of cultural events for the general public but which are, nevertheless, occasionally available for performances. These are: The Metropolitan Theater, Donnelly Memorial Theater, Sanders Memorial Theater and Loeb Drama Center at Harvard, and Kresge Auditorium at M.I.T.

The Metropolitan Theater, a motion picture theater, is now rented annually for one week for the presentation of the Metropolitan Opera on tour. The remainder of the year it is used exclusively for motion pictures. It has a shallow theatrical stage, a large orchestra pit, dressing rooms, scenery lines, etc., having been built as a vaudeville theater, but it has inadequate storage space for presentations on the scale of the Metropolitan Opera. The seating capacity is 4442, of which slightly over 4000 seats are used during opera performances.

Donnelly Memorial Theater is primarily devoted to religious activities but is available for outside bookings. It seats 3400. Like the Metropolitan Theater, it was built as a vaudeville house and thus has a limited theatrical stage, dressing rooms, etc., but it has no orchestra pit and only limited storage space for scenery. It has been used by local opera groups, but to date winter bookings have totaled 58%. The building is closed in summer.

Sanders Memorial Theater is available for bookings of non-University events only by chartered educational institutions and nonprofit, tax-free corporations. Events charging admission must be endorsed by the mayor of Cambridge. Thus, many events are not in a position to book it. In any case, available open dates in winter approximate only 5% of the total usable time. It is used for such events as the Boston Symphony, the Cambridge Drama Festival, the Chorus Pro Musica, etc. Seating capacity is 1236.

The Loeb Drama Center at Harvard is not yet in operation, and it is not yet definitely known whether it will be available for use by outside organizations. There is a distinct possibility, however, that it will be available, probably under the same criteria used at Sanders, when not occupied by Harvard presentations. Because of the amount of booking expected by Harvard, free dates will probably be rare, at least in the winter season.

The facility seats 600 and is uniquely flexible, being equipped for use with a proscenium arch stage, an extended-apron stage or a stage in the round. It is air conditioned and highly mechanized.

Although almost ideal for use by a repertory group, the lack of large blocks of free booking dates would seem to preclude its use for that purpose by an outside organization.
Kresge Auditorium seats 1238. Every event booked must have M.I.T. sponsorship or an affiliation with M.I.T. This limitation is broad enough, however, that events are booked by such organizations as the Cambridge Drama Festival, the Poets' Theater and the United Fund. Its stage is not considered ideal for conventional dramatic productions. Like Sanders Theater, it is 95% occupied in winter. Summer bookings take up 55% of available time.

E. THE PROPOSED BOSTON AUDITORIUM

The proposed Boston Auditorium, to be built on the site of the Prudential Center, is expected to be completed in 1962 or 1963. Present plans include seating for 5800 people, 4000 on the main floor and 1800 in the balcony. It is to have a theater stage 150 feet wide and 45 feet deep, with 25-30 lines for scenery (assuming 12-inch spacing) and a lighting gridiron. The stage height will be 51 feet, which is rather low for a theater stage and generally considered too low to accommodate major ballet and opera productions. The auditorium is to be provided with acoustical reflecting panels at the request of the Boston Symphony, but it is not expected to have outstanding acoustical properties. Movable equipment will probably be available to provide a raked floor for theatrical performances. It is not now possible to predict bookings in the building. However, its primary purpose is to provide a facility for conventions. Thus, convention activities take first precedence, and exhibits like the Home Show have next preference. Cultural events could then be scheduled in any open dates. The number and duration of such dates is likely to be greatly influenced by the proposal to build an all-weather, 51,000-seat sports arena at Columbia Point.

F. SPORTS ARENAS

There are two large facilities in Boston that are designed and used primarily for hockey, basketball, ice shows, boxing, rodeos and other sports events. They are the Boston Arena, with 7200 seats, and the Boston Garden, with 14,000. The Garden is privately operated for profit; the Arena is operated by a State Authority. Both have flat arena floors and stadium seating. Each has been used for cultural events such as local opera, the Royal Ballet, the Moiseyev Dance Company, band concerts and other events that draw large audiences. Cultural events constitute approximately 2 to 3% of their schedules for brief engagements. The Arena is booked 90% of the winter season and 33% of the summer; the Garden is 70% booked in winter and only 4% in summer. Neither has a permanent stage, but stages are erected specially for the events, and appropriate lighting can be provided. The orchestra must be placed in the seats to the side of the stage. Both facilities have sufficient dressing room space.
The cultural attractions, presented in the Boston Garden and the Boston Arena, are forced to use very large facilities because of their wide public appeal and high production and travel costs. However, though use of these facilities is economically justifiable, they are generally regarded as unsuitable from an aesthetic point of view. Their acoustics leave much to be desired, and the distance from spectator to stage in many parts of the halls is excessive.

In Figure 2 the facilities described above are arranged in order of size, and the average number of days' availability of each during summer and winter seasons is indicated by the height of the respective bar.
Figure 2

AVG. DAYS AVAILABLE IN BOSTON FACILITIES - ARRANGED BY SIZE - SHOWN BY SEASON

WINTER SEASON
(SEPT.-MAY)

SUMMER SEASON
(JUNE-AUG)

air conditioned - •
V. BOOKING PROCEDURES

Although there are many minor variations in financial arrangements in booking events, the principal distinction in method depends upon who assumes the financial risk of an engagement. If the producer or impresario assumes the risk and takes the profits, we refer to the event as "un-sponsored." If another party or group acts as guarantor, we refer to the event as "sponsored."

In general, the commercial legitimate theater books on an un-sponsored basis. Typically, the producer of a show planning a pre-Broadway tryout in Boston deals with one of the local theaters directly or through a booking office. The theater is occasionally rented for a fixed price for the duration of the run or, more commonly, is rented for a percentage of gross. Typically, this percentage is allocated 70% to the producer and 30% to the theater up to a $25,000 weekly gross. Above $25,000 the percentages change and vary between 65-35% and 75-25%. Thus, aside from a minor participation in risks and profits by the theater, it is the producer who assumes the risk and takes any profits. Legitimate tryouts and reruns, certain lecture series, some dance companies, and events that are produced and staged locally use this method of booking.

Under sponsored or guaranteed booking, a local sponsor (either an entrepreneur seeking a profit or a nonprofit organization) guarantees the producer a fixed amount plus a percentage of gross, hires a facility and arranges for supporting services including publicity. This system, too, is subject to variations, and the local promoter may act at times as direct agent for an impresario rather than as a sponsor.

This method is commonest in the booking of special events, concerts, recitals and lecture bookings. The theater may be rented on a "four walls" basis (under which the promoter rents the hall without services and makes his own arrangements for stage hands, ushers, etc.), or it may be hired with complete staffing.

Bookings of "un-sponsored" events depend entirely upon what is produced, the type of hall required, and the availability of halls. In the case of sponsored events, however, the management of a facility can increase usage by acting as a sponsor or promoter. Thus, for example, the Bushnell Memorial in Hartford, Connecticut, sponsors a lecture series. There is no reason, other than market saturation, why an aggressive management for any facility MEBAC might build could not influence usage by sponsoring lectures, motion pictures, concert series, etc., for the new hall. The ingredients for success appear to be good judgment in selecting events for the potential audience, an understanding of the handling of publicity, and adroitness at promotion.
VI. INDICATED USAGE AND SIZE FACTORS

Our analysis and conclusions for new facilities are based upon a thorough investigation of potential users to determine the amount of usage and size of facilities respondents indicated as being required. In presenting these findings, we did not attempt to interpret usage or size requirements except in those cases where a respondent's reply was stated in terms of a range rather than a specific figure, or when potential usage was an estimate of long-term needs. Furthermore, the total days' usage for each facility does not reflect any reconciliation of possible conflicts between two events wanting to use the facilities at the same time. These scheduling conflicts are bound to occur during the course of the year, but since immediate total demand does not approach year-round usage the number of schedule conflicts is not expected to be excessive.

"Audience saturation" has also not been taken into account in our estimate of number of performances. This problem is a subjective one and cannot be answered scientifically within the context of this report, but there are some related considerations that should be noted. The problem is, of course, related to the facility(s) required to serve Boston over many years in the future, and MEBAC still must determine to the extent possible how many performances of ballet, opera, etc. Boston audiences will support during one season. To underscore this problem, one has only to consider that a 3000-seat hall filled to capacity 12 months of the year would have to sell over one million tickets annually.

Bostonians, however, have historically shown considerable enthusiasm for the arts, as can be seen by the repeated sell-out of the Boston Symphony Orchestra, the success of the Cambridge Drama Festival, the increase in applications for the Metropolitan Opera season and the growing vigor of locally produced opera and drama. In consequence, potential users with knowledge of the Boston audience for artistic performances of merit have reflected confidence that Boston in fact does and will continue to support first-class productions. This, then, means that if individual users or producers pass from the scene, others will take their place so long as the fundamental public demand continues.

Outstanding productions, aggressively promoted and presented in first-class facilities, should certainly assist in encouraging and perhaps even enlarging the present audience demand. However, the question of future audience demand and saturation in Boston is one that MEBAC must seriously consider in its final decision.

Figure 3 shows the cumulative total of days' usage by type of event for several alternative sized facilities. We have not attempted to estimate the influence of schedule conflicts or audience saturation.
BY EVENTS DIVIDED INTO FOUR ALTERNATIVE STRUCTURES

Figure 3
To achieve the level of usage indicated by respondents would probably require several years of operation, during which time the facility would have to be actively and successfully promoted. Wherever possible in our interviews with respondents, we also obtained estimates of potential growth in demand.

A. GENERAL REQUIREMENTS UPON WHICH DEMAND IS BASED

Before we discuss the factors of usage and size, it is important to understand the general requirements upon which these factors are predicated. It should be clearly understood that each respondent estimated his usage on the assumption that he would have a facility that met his requirements. To attract users, therefore, the facility must be as ideal as possible in the major categories listed below. The points are presented as general guidelines; more specific requirements are discussed in Section VII.

1. Capacity

For a small local stock company such as the Charles Playhouse, the ideal capacity of the house should be about 600-800 seats, or a loss of intimacy and audience rapport is liable to occur. The need for a "full house" (the majority of seats are occupied, or the hall has been cut down in size in such a manner as to give this impression) is a real one in the performing arts world. It touches on and affects both the economics and artistic success of a performance. This problem is essentially one of matching the hall to the type of performance rather than vice versa. Thus, a pattern of ideal hall sizes has evolved; characteristically, any marked departure from this pattern results in half-empty houses, subsequent loss of the artistic level of performances and a resulting drop in audience interest and appreciation. For local stock opera, the indicated ideal facility size should be approximately 1600 seats; at the other end of the spectrum the realistic size (primarily dictated by economics) for grand opera in the United States is about 3500 seats. (In Europe, where opera is subsidized, the ideal facility size is closer to 2000 seats.) Thus, any facility that can be designed with maximum flexibility (the capability of easily and temporarily reducing or expanding the number of seats with compatible adjustment of the stage opening and sight lines) will be suitable for a wide range of events.
2. Stage Size

The optimum size and opening of the stage varies greatly from intimate dramatic presentations to grand opera or large-scale ballet. In the construction of a facility, full consideration must be given to providing a stage with the proper dimensions and proportions.

3. Distance of Spectators from Stage

It is generally agreed that 75 feet is the maximum distance for proper viewing of a dramatic presentation. This figure can be substantially expanded for opera or ballet, and if a facility is to be used for various types of events, provision must be made for cutting off the rear part of the house when an intimate house is required.

4. Acoustics

Acoustical requirements vary considerably, depending upon the type of event. In a multipurpose, flexible hall, the cubic volume plays the most important acoustical role.

The cubic volume of the hall has two important relationships to the acoustics: first, the cubage of the hall must be as small as possible to conserve the energy produced by voice and musical instruments; second, the length of the reverberation is directly dependent on the cubage. Reverberation is the persistence or lingering of sound in a hall after the originating sound has ceased. This acoustic effect arises from the multiple reflection of the original sound wave as it strikes the various surfaces of the hall. Thus, in a multipurpose hall some events ideally require a short reverberation time while others require a longer time. Table I lists optimum reverberation times for various events.

It can be seen that the solution to ideal acoustics is a highly complex one, especially in the design of a multipurpose hall. The above comments on acoustics are intended only to point out a few of the most important problems. Additional factors, such as the shape and proportions of the hall and the tonal characteristics of the hall (determined by the nature of the material finishes of the walls, ceiling and floors) are also important. The final solution lies in the hands of the acoustical consultant and the degree to which his design recommendations can be followed.
<table>
<thead>
<tr>
<th>Activity</th>
<th>Optimum Reverberation Time (seconds)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Motion pictures</td>
<td>0.6 - 1.2</td>
</tr>
<tr>
<td>Lectures, convocations, and any other activities using sound amplification</td>
<td>0.6 - 1.2</td>
</tr>
<tr>
<td>Musical comedy or related forms</td>
<td>1.0 - 1.4</td>
</tr>
<tr>
<td>Drama</td>
<td>1.0 - 1.4</td>
</tr>
<tr>
<td>Opera</td>
<td>1.2 - 1.6</td>
</tr>
<tr>
<td>Piano recital</td>
<td>1.2 - 1.6</td>
</tr>
<tr>
<td>Voice or violin recital, string quartet, chamber orchestra</td>
<td>1.4 - 1.8</td>
</tr>
<tr>
<td>Symphony orchestra (contemporary works)</td>
<td>1.3 - 1.6</td>
</tr>
<tr>
<td>Symphony orchestra (Brahms, Wagner)</td>
<td>1.8 - 2.0</td>
</tr>
<tr>
<td>Liturgical choral music, organ</td>
<td>1.8 - 3.0 and up</td>
</tr>
<tr>
<td>Medieval liturgical works</td>
<td>4.0 - 8.0</td>
</tr>
</tbody>
</table>
5. Dressing Rooms, Storage Space and Other Architectural Considerations

Adequate facilities must be provided for the complete range of events that are considered potential users of a new hall.

6. Lighting

Basically, the amount of lighting built into a new facility is contingent upon the type of user event. Touring shows normally carry their own lighting and require only a sufficient number of circuits and power in the house. Resident companies naturally must have the lighting equipment built in as part of the facility; if these are the principal tenants, the equipment should be designed to suit their needs.

7. Promotion of the Facility

It is important to note that the success of any new facility will very largely depend upon how vigorously and professionally it is promoted by both local impresarios and also by the facility management.

B. RELATIONSHIP OF FACILITY REQUIREMENTS TO TYPE OF EVENT

Because the most realistic solution calls for a multipurpose, flexible hall, it is desirable to discuss briefly the facility requirements by various types of events. These are summarized in Table II.

C. DAYS' USAGE BY SIZE OF FACILITY

Our selection of four size ranges or categories tends to represent a concentration of demand, but there is considerable overlapping, which must be taken into account when considering the alternatives. Actually, three basic building alternatives emerge upon analysis of user requirements:

1. 600 – 800 seats.
2. 1000 – 2200 seats.
3. 2800 – 4000 seats.
<table>
<thead>
<tr>
<th>Event</th>
<th>Size</th>
<th>Stage</th>
<th>Type of Hall and Dimensions</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dramatic (primarily local repertory and stock)</td>
<td>Normally not exceeding 800 seats</td>
<td>Can be either 3/4-round or proscenium, but 3/4-round type more generally preferred</td>
<td>As intimate feeling is required, seats must be quite close to stage</td>
<td>Small cast</td>
</tr>
<tr>
<td>Legitimate theater</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. Drama</td>
<td>1100-1600 seats</td>
<td>Proscenium-arch stage (40-50 lines total)</td>
<td>No seat further than 75 feet from stage</td>
<td>Small cast</td>
</tr>
<tr>
<td>B. Musicals</td>
<td>1600-2000 (because of economic pressures)</td>
<td>Proscenium-arch stage (50-60 lines total)</td>
<td></td>
<td>Large cast requires extra dressing room space, orchestra pit, etc.</td>
</tr>
<tr>
<td>Small or light opera</td>
<td>1600-2200 requested by local opera group</td>
<td>Proscenium-arch stage generally used</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grand opera and major ballet troupes</td>
<td>2000-2200 seats in Europe - considered ideal</td>
<td>Very large stage required (wall-to-wall width of 125 ft, depth of 80 ft, 80 sets of lines)</td>
<td>Up to 130 feet from stage to last seat (ideally)</td>
<td>Very large cast and orchestra require rehearsal space, extra dressing rooms, etc.</td>
</tr>
<tr>
<td>Large touring events (misc.)</td>
<td>Same as grand opera</td>
<td>Stage requirements usually not as large as above</td>
<td>Primary interest is in hall large enough to insure financial success</td>
<td>Varies</td>
</tr>
</tbody>
</table>
The first would be used for local small stock or repertory drama, the second for locally produced events such as opera, ballet and smaller touring companies, and the third for large touring events. However, to represent accurately the broad range of answers to our survey, we have charted and discussed the usage and size on the basis of four categories.

Figure 3 indicates the total currently realizable usage by each alternative facility and breaks down the usage by types of performing arts events. It is extremely important to note that these usage figures are those estimated by our respondents and represent the sum of their estimates. In each of the alternatives a certain percentage of the usage must be considered speculative and contingent upon the success of individual promoters and producers to meet their respective potentials and the ability of Boston to properly support each event. From left to right the facilities and usage are as follows:

Category I. Total usage would be approximately 225 days annually. Only one respondent indicated interest in a facility under 1000 seats (the Charles Playhouse stock players). The present Charles Playhouse has a seating capacity of approximately 300 and a 3/4 in-the-round stage. Their current season runs some 41 weeks per year, but it might be shorter if a larger facility were used. This group has indicated interest in expanding its operations within the next several years, and on this basis they would be the principal tenant of a small (0-999 seat) stock theater.

Category II. Total usage in this facility (1000-1999 seats) is estimated to be 170 days for the first several years of operation, with an estimated potential growth to approximately 200 days annually if all of the events are successful and demand increases significantly for local ballet and opera presentations. It should be noted that approximately 90 days of the events in this category are also included in Category III facility on the assumption that the latter could be reduced in size to under 2500 seats. The principal types of users for this facility would be: 1) events sponsored by the Cambridge Drama Festival; 2) local and touring opera groups such as the New England Opera Association, the Opera Group, and the New York City Opera; 3) ballet performances sponsored by the New England Conservatory and others; 4) several weeks of legitimate Broadway productions, which might desire to use the Arts Center because of a schedule conflict in existing facilities; and 5) meetings and other miscellaneous events, including lectures. Future usage would include expansions by present users and productions of new companies such as that proposed by the Metropolitan Opera. Plans are underway to create a special opera company designed to perform in smaller halls. The works given would be different from those of the standard Metropolitan repertoire, including more intimate works as well as modern or experimental works. Musically the productions would be equal to the highest quality attainable.
Many of the above events are already performed in Boston but in less than ideal facilities. Making available a really suitable hall should contribute significantly to the performances themselves and also provide the opportunity for more people to see and enjoy these productions.

Category III. Total usage in this 2000- to 3499-seat facility is estimated to be approximately 168 days, with a potential growth to 179 days after the first several years of operation. The principal tenant in this category is again the Cambridge Drama Festival, which was included in Category II. Naturally, the Drama Festival requires only one facility; either II or III will meet its requirements, provided approximately 2000 seats are made available. Miscellaneous events of the kind promoted by the large New York concert managers such as Music Corporation of America and William Morris Agency account for the next largest usage. This category includes dance troupes, individual "star" performers, popular orchestras, and others. Opera and touring ballet troupes also account for significant portions of this category and include the Opera Group, the New York City Ballet, the Lyric Opera of Chicago (which is not yet touring but hopes to do so in the future), the National Ballet of Canada, the New York City Opera, the Metropolitan Opera's proposed new company, the Ballet Russe de Monte Carlo, etc. Based on our estimate of the average days' booking per year over several seasons for legitimate Broadway rerun productions that might realistically use the new facilities, a Category III facility could expect several weeks of a Broadway musical. It should be noted that some 40 days of usage included in this category might shift to Category IV.

Category IV. Total indicated usage in this 3500+ seat facility is 65 days annually, with an estimated long-range growth to 75 days. Most of the use is concentrated around a requirement for 3500 seats and overlaps partially into the previous category. Principal events would be: 1) foreign touring ballet troupes such as the Royal Ballet, the Bolshoi Ballet and the Royal Danish Ballet; 2) grand opera such as the Metropolitan Opera of New York and the Lyric Opera of Chicago (these events are also partially included in the previous category because they could use the upper size end of that category); and 3) large musical events such as the Handel and Hayden concerts, Chorus Pro Musica, jazz concerts, etc.

A certain portion of respondents in Category IV indicated that they would be agreeable to using the proposed City Auditorium if it were available and properly equipped. Consequently, a significant portion of the usage could be shifted over to that facility if it provides the necessary stage facilities and proper acoustics.

In Figure 4 we have summarized the usage by totaling the demand, which tends to "cluster" around three distinct facility sizes. Thus, the first cluster of demand for a facility requires a size range of 600-800 seats with a total usage of
225 days. It would be used for stock or repertory productions and its principal tenant would be the Charles Playhouse or a similar group. The second cluster of demand indicates a facility with a size range between 1600 and 2500 seats, with the main concentration of demand centering between 1600 and 2200 seats. To arrive at its usage and size range, we analyzed the answers of all potential users whose facility requirement centered around this size facility (2000). From their answers, we totaled the days' usage for each size range. We found that the heaviest demand in this "cluster" is for a facility of approximately 2000 seats. However, there was also heavy demand for a 1600-2000 seat facility and some additional demand for one with 2000-2500 seats. Thus, the demand builds up through these stages (1600-2500) to a total usage of 170 days for a facility with a seat range of 1600-2500. However, we feel that little or no usage would be lost if the facility had a size range of 1600-2200 seats.

The third facility (2800-4000 seats) was built up in the same manner with the heaviest concentration of demand around 3500 to 4000 seats and with some additional demand around 2800-3500 seats. When we lump these together, total demand reaches 145 days annually. Much of the demand in this large facility may shift into the proposed Boston Auditorium, subject to stage house and acoustical revisions and acceptable scheduling.

Now if we superimpose these three facilities over existing facilities in Boston (see Figure 5), we can see how they help to fill in some facility gaps that exist.
ESTIMATED DEMAND FOR NEW FACILITIES

Figure 4
RELATIONSHIP OF ESTIMATED DEMAND TO PRESENT AVAILABILITY

AVERAGE ARRANGED

DAYS

SEATING CAPACITY IN HUNDREDS

Figure 5
APPENDIX C:

"An Auditorium for Every Use: Can It Be Built?"
By David Klepper

Reprinted from the May, 1961
Architectural and Engineering News.
May 1961

by David L. Klepper*

The acoustical problems in the multi-purpose hall increase with the degree of flexibility required of the hall, but the basic principles of good hearing remain the same. They are: exclusion of external noise; satisfactory loudness in all seats at all frequencies; proper distribution of sound; and adequate separation of notes and syllables. More and more multi-purpose halls are being planned throughout the country, and the author here discusses solutions to acoustical problems inherent in the requirement for flexibility.

The word “auditorium” has been employed to describe a great variety of spaces, including anything from a small 200-300 seat lecture room or theater to 10,000-15,000 seat coliseums and exhibition halls. What are some of the events that people are hopeful will be accommodated by these buildings? We may list the major ones as follows:

1. Lectures
2. Drama
3. Musical comedy
4. Opera
5. Instrumental recitals and chamber music
6. Vocal recitals
7. Orchestral concerts
8. Choral concerts
9. Organ recitals
10. Trade show and exhibitions
11. Conventions
12. Boxing and wrestling matches, basketball, ice hockey, and other team sports
13. Rodeos, circuses, etc.

The first group of activities, 1 through 9, may be grouped as the cultural events that are of primary benefit to the population within the city and its environs. The next group, 10 and 11, are activities which most often provide the economic justification for constructing such a building and securing business interests; it is hoped that exhibitions, trade shows and conventions will lure people to the city, increasing the income of its residents. The last group includes those spectator sports that are of primary interest to the city’s population, but again it is expected that certain of these activities will draw people from considerable distances. In general, we may say that the first group of activities are seldom self-supporting, while the latter two groups invariably are.

Acoustical requirements

In discussing a building designed to accommodate a large number of these activities, we may first review the different acoustical requirements. These acoustical differences are, of course, only part of the problem an architect faces when he attempts to design a space flexible enough to be used for a large number of activities. These differences have their influence on acoustical criteria, and it is the acoustical criteria that are perhaps the least obvious.

The acoustical environment for these activities should provide adequately for live and amplified sound. Sports events require only announcements which can conveniently be made over a well-designed public address system. Trade shows, exhibitions, and conventions, may include speech and music activities requiring good hearing conditions for both, but no one will object to the use of sound amplification as necessary for these activities. Sports coliseums and exhibition halls may, therefore, be large enough to be economically feasible without hearing conditions necessarily being compromised. The acoustical design of these spaces remains comparatively straightforward requiring only:

a. The proper location, orientation and selection of loudspeakers and other sound amplification system components,
b. Adequate quieting of noise from mechanical equipment and outside the building, and
c. Suitable treatment of the interior surfaces of the space to insure control of reverberation and elimination of echo.

*Mr. Klepper has been associated with Bolt, Beranek and Newman, Inc., Acoustical Consultants, since 1957. He holds B.S. and M.S. degrees in electrical engineering from Massachusetts Institute of Technology.
There is, in any case, no inherent acoustical limitation on the size of such sports coliseums and exhibition halls.

It is for cultural activities that "quality versus quantity" becomes an important consideration. These activities use sound amplification only incidentally to supplement natural sound. Even when the acoustical engineer has complete control over the shaping and materials of the interior surfaces, there is a maximum size "house" for any of these activities, above which quality will fall off.

The equations illustrating the relationship of sound intensity level to the absorption present in the room and the power level of the sound source are available in acoustical textbooks. We can easily realize, however, that any sound source, whether it is a human voice, a violin, or a whole symphony orchestra, is capable of producing only a given amount of sound power and that a larger capacity auditorium, with a greater amount of sound-absorbing audience, will result in a lower average sound intensity level at the ears of the audience. All the cultural activities we are discussing, from lectures through dramatic presentations and opera performances to orchestral concerts, require the listener to hear the program over a wide dynamic range. When an actor shouts he should be heard loudly; when an orchestra plays fortissimo, it should be heard fortissimo. Likewise, when the actor is whispering, his voice should continue to be heard intelligibly by the audience, and a pianissimo orchestral passage should not disappear into the audience background noise or the background noise of a ventilating system.

**Background noise**

Too much stress cannot be placed on background noise as being a determining factor in the maximum size of an auditorium for "live" activities. Not only must we consider the background noise within the auditorium, but the noise environment the audience is accustomed to in the auditorium's surroundings. A 6000 seat concert hall is successful at Tanglewood primarily because the concertgoer has grown accustomed to the absence of normal city noises and Tanglewood's Berkshire Mountain environment. A low background noise level within the Music Shed, resulting both from the attentive audience and the avoidance of any mechanical air handling system, then allows the softest pianissimo passages to be heard clearly by the entire audience within the Shed and the contrasting fortissimo passages to be heard as loud, even though the actual loudness levels achieved in the hall are 8 or 9 db less than those heard by listeners in Boston's Symphony Hall.

Work on a wide variety of auditorium projects has suggested the following guide for the maximum size "house" that will allow optimum hearing conditions without amplification for various uses.

<table>
<thead>
<tr>
<th></th>
<th>SEATS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lectures</td>
<td>1200</td>
</tr>
<tr>
<td>Drama (assumes trained actors)</td>
<td>1800</td>
</tr>
<tr>
<td>Musical comedy</td>
<td>2100</td>
</tr>
<tr>
<td>Opera</td>
<td>2200</td>
</tr>
<tr>
<td>Instrumental recitals and chamber music</td>
<td>1500</td>
</tr>
<tr>
<td>Vocal recitals</td>
<td>2200</td>
</tr>
<tr>
<td>Orchestral concerts</td>
<td>2200</td>
</tr>
<tr>
<td>Choral concerts and Organ recitals (depends greatly on size of choir, determined type of organ, period of music, etc.)</td>
<td>mined</td>
</tr>
</tbody>
</table>

(Continued on page 12)

### THE FLEXIBLE AUDITORIUM

(Continued from page 11)

The above seating capacities are only to be taken as a rough guide. They are based upon modern seat spacing; more people can be accommodated with no real change in the acoustical characteristics if the tighter and less comfortable seat spacing of older halls is employed. Larger houses that are successful are, of course, possible, but the compromises inherent in larger auditoriums are illustrated by the fact that most actors, conductors, and informed critics rate as acoustically excellent only those halls with seating capacities not exceeding the ranges listed above.

#### Reverberation time

We can see that even with the "cultural" uses of an auditorium there are certain conflicts as to the proper size. There are other acoustical conflicts as well. The optimum reverberation time differs for auditoriums having different uses. Considerable experience in the design of auditoriums indicates the following optimum mid-frequency reverberation times again as a rough guide:

<table>
<thead>
<tr>
<th></th>
<th>SECONDS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lectures</td>
<td>0.9-1.1</td>
</tr>
<tr>
<td>Drama</td>
<td>0.9-1.5</td>
</tr>
<tr>
<td>Musical comedy</td>
<td>1.2-1.5</td>
</tr>
<tr>
<td>Opera</td>
<td>1.5-1.8</td>
</tr>
<tr>
<td>Instrumental recitals and chamber music</td>
<td>1.4-1.8</td>
</tr>
<tr>
<td>Orchestral concerts</td>
<td>1.8-2.0</td>
</tr>
<tr>
<td>Vocal recitals</td>
<td>1.5-1.8</td>
</tr>
<tr>
<td>Choral and organ concerts (the upper limit depends largely upon period of music, etc.)</td>
<td>2.0 minimum</td>
</tr>
</tbody>
</table>

Note that the figures above are for the mid-frequency reverberation time in the frequency range 500-1000 cps. The spaces for music performance should generally have a higher reverberation time at lower frequencies, and nearly any auditorium will have a lower reverberation at higher frequencies.

The lower values of the reverberation time ranges suggested above are for comparatively small auditoriums, approximately 1000 seats or less, while the higher value in each case is for the largest size considered optimum for the particular use. Again, we must remember that these are a general guide to optimum reverberation times and that satisfactory (as opposed to outstanding) results can be obtained outside of the above values.

#### Reflection and diffusion

We discussed the conflicts that arise concerning optimum size and optimum reverberation time for the different "cultural" uses of a multi-use auditorium; now let us review two other conflicts worth mentioning. Orchestras and choruses must be surrounded by a heavy sound-reflecting enclosure. In addition to reflecting sound to the audience, this enclosure should be carefully designed to mix and blend sound energy so that the conductor or any member of the audience hears the entire orchestra or chorus, not just a portion of it. Heavy enclosures are necessary to reflect (and therefore mix and blend) low frequency sound energy in addition to high frequency sound energy. Yet, the entire enclosure must be moved out of sight and out of the way to permit the employment of scenery for drama, opera, or musical comedy.

More subtle than any of the three previously
mentioned conflicts is the difference in the directional characteristics of the sound energy arriving at the listener’s ear that is optimum for these various uses. Speech activities are most intelligible and most natural sounding when all sound energy appears to come from the direction of the person speaking, while the emotional impact of orchestral, choral, or organ music is greatest when a listener is literally surrounded by sound. This does not mean that a listener should hear a rear wall echo, but researchers in concert hall acoustics both in Europe and in this country have found that some return of sound energy from the rear of the hall to the listeners’ ears creates a desirable subjective liveness apart from the liveness associated with the room reverberation time. By careful design, such a return of sound energy is possible without an obvious echo.

On the other hand, the sound-reflecting surfaces most important to high speech intelligibility as well as music intelligibility (sometimes called “definition”) are those that provide “close-in” reinforcement of sound from the front of the auditorium. By “close-in” we mean that the reflected sound energy should reach the listeners’ ears within 30 milliseconds after the direct sound energy. Suspended sound-reflecting panels are often required to provide this reinforcement.

To illustrate possible acoustical design solutions to the conflicting requirements of a multi-purpose auditorium, we shall review two typical projects. The first, a 10,000 seat “auditorium,” provides means for presenting cultural activities, with satisfactory results, in a building designed basically for sports, exhibition, and convention events. The second, a 2700 seat auditorium, illustrates methods for assuring really good hearing conditions for a variety of cultural activities in one auditorium.

10,000 SEAT AUDITORIUM

Support for this hypothetical project was enlisted from citizens interested in furthering the city’s cultural activities, in improving facilities for spectator sports, and in providing facilities for conventions, trade shows and exhibitions. Fortunately, the building is located away from airports, primary waterways, or railroad lines, and the site does not pose any particular problems for isolation of exterior noise. Also, the architect has decided to avoid a shape inherently unsatisfactory acoustically, such as a dome, thus simplifying the acoustical engineers’ task. (See plan and section, page 18.)

In general, the wall and ceiling surfaces of a large coliseum or exhibition building are too far away from the performers or audience to act as useful sound-reinforcing surfaces. Sound energy reflected from these surfaces is heard as an echo, interfering rather than reinforcing speech intelligibility. The basic acoustical treatment, therefore, includes the treatment of as much as possible of the interior boundary surface of the room with sound-absorbing material.

The ceiling is constructed entirely of a sound-absorbing formboard. The material serves an acoustical function in addition to a structural function. The absorption coefficient of this material is sufficiently high (.50 to .70 in the mid-frequency range) to eliminate any possibility of echoes from the ceiling. Interruption of this sound-absorbing treatment by concrete beams or roof trusses or the sound-reflecting panels hung vertically is not particularly critical in terms of the area occluded. This material may be employed as formwork for a poured concrete ceiling and then left in place, or, alter-

nately, it may be employed as the structural ceiling material, spanning up to 3 ft. gaps between roof joints, with the visual built-up roofing above.

Considerable wall treatment is required to eliminate echoes both from the announcements of sports events, exhibitions, etc., and for stage production. It is very important that the sound-absorbing treatment be reasonably efficient throughout the speech frequency range (300-4000 cps), and this requirement rules out most of the “applied” materials such as acoustic plaster.

With the majority of the wall and ceiling surfaces treated, we can be sure that the acoustical properties of this large space will somewhat approximate that of the outdoors. This is the best we can hope for in the large exhibition hall, sports, or convention space; but it is not the desirable acoustical environment for either a theater or a concert hall.

Movable enclosures

Conversion of this large “outdoor-like” space into a theater or opera house can be accomplished to some extent by the use of suspended sound-reflecting panels and portable or movable side walls that actually form a lower and narrower sound-reflecting enclosure when the space is used for important stage productions. A third movable device is the stage orchestral enclosure which is employed along with the suspended panels and movable side walls in the main space for orchestral, choral, or chamber music concerts.

Let us explore the reasons why these three elements must be made movable. The suspended sound-reflecting panels are designed to provide optimum reinforcement from the stage end of the space. Therefore, when they are lowered, the room assumes a non-symmetrical appearance undesirable for athletic and exhibition events. To increase the amount of ceiling sound-absorbing treatment exposed, they are hung vertically for sports, convention, or exhibit activities.

The movable side wall panels actually eliminate about 1000 seats when they are in place for theatrical or concert activities. Loss of these seats for such activities is, if anything, desirable since these seats are too far to the sides of the stage to be satisfactory either acoustically or visually. The sound-reflecting side walls must be movable, however, to allow these seats to be used for sports events, conventions, exhibitions, trade shows, and similar activities.

The heavy stage enclosure that forms the “hard sending end” for an orchestra or choral group must be removed to allow the stagehouse to be used for stage productions requiring scenery. These activities include not only legitimate drama, musical comedy, and opera, which will continue to employ the movable walls and ceiling panels in the main space, but also include certain stage productions that will rely on sound reinforcement to provide a satisfactory acoustical environment during conventions and trade shows. The stage itself must be capable of handling anything from automobiles to singers!

In our example, the suspended sound-reflecting panels are lowered in place by the use of pulleys mounted in the truss space immediately below the roof. Whether in the raised or lowered position, the suspended sound-reflecting panels form a “visual” ceiling of the auditorium, with the truss space above painted flat black. Lighting is accomplished by fix-
turers mounted within the sound-reflecting panels and by fixed down-lights suspended from the ceiling structure. Air is supplied to the clear space above the sound-reflecting panels. The weights of these sound-reflecting panels are determined by the requirement that they must reflect low frequency sound energy, down to 35 to 50 cps for orchestral music.

Similar weight requirements exist for the sound-reflecting movable side walls. Here, these panels are all oriented vertically, the solution employed uses hung sound-reflecting lead impregnated draperies having a surface density of approximately 3 lb/sq. ft. These "hung walls" are cut to fit the seating slopes as required, are hung in place when the auditorium is used for cultural activities, and are stored elsewhere during other uses.

The stage

The movable orchestral stage enclosure employed in this auditorium comprises wall panels and the ceiling panels. The sides and rear walls of the enclosure are made up of a series of hard wood panels each 5 ft. wide and 30 ft. tall. Braces are located at the back of these panels. Underneath the panels are frameworks incorporating four small wheels allowing the walls to be wheeled into position by two men. These wall panels are useful for other events besides orchestral and choral concerts. They can be used to provide a shallow enclosure, without a ceiling, for a solo singer or instrumentalist. They are far superior to sound-absorbing draperies as a back drop for jazz and popular musicians, providing mixing and blending of sound energy that is desirable even when amplification is employed. The number of combinations in which they may be employed, either by themselves or with the suspended stage sound-reflecting panels is too numerous to mention, and every stage show suggests new possibilities for their use.

The suspended sound-reflecting stage enclosure ceiling panels are constructed of 3/4" plywood, fireproofed. These are lifted high in the stagehouse and hung vertically when they are not in use to free a maximum amount of space for hanging scenery. Only half the number of stagehouse lines are required to carry them when they are hung in this position as compared with the nearly-horizontal position they assume when in use.

What kind of results can the audience within this auditorium expect? Certainly, the acoustical environment of the hall will not be identical with the finest concert halls or opera houses, buildings specifically designed for particular purposes. However, listeners in the forward half of the auditorium will hear a mixed and blended sound from an orchestra or chorus group, or a warm sound from an opera singer enriched by the multiple sound reflections from the wall and ceiling panels that will be quite satisfactory. Even actors should be heard clearly, without sound amplification, by a majority of listeners in these forward seats. Amplification will, of course, usually be required to allow everyone throughout the auditorium to hear clearly, but this amplified sound will only reinforce, not replace, the live sound. With careful design and operation of the system, the audience need not even be aware that the sound is being amplified. The location of the loudspeakers for reinforcement of stage pro-

Other events

When non-cultural, mass-audience events take place in this hall, the sound-reflecting side walls will be removed and the sound-reflecting ceiling panels will be raised. This will be not unlike the outdoors, and hearing conditions will depend upon the proper installation and operation of the sound amplification system. Two distinct sound-reinforcement systems are available for use during these activities. One is the loudspeaker cluster located over the center of the proscenium opening, used for reinforcement of cultural activities and also usable for stage productions in conjunction with exhibits or trade shows. For announcements, background music, etc., a central loudspeaker cluster will be used.

2700 seat auditorium

The other typical auditorium shown was planned on a more realistic basis. The basic decision to "separate the aesthetes from the athletes" was made in the basic planning stage, and the auditorium is to accommodate only the city's cultural activities.

In a building primarily for cultural activities, the citizens expect somewhat better results than merely a "satisfactory" auditorium or concert hall; they expect a "good theater and a fine concert hall, despite their being combined into one building.

The auditorium is designed to accommodate a 2700 seat audience, the largest expected for tour concerts of major symphony orchestras or performances by regional opera groups. The entire capacity of the hall is also expected to be employed by touring musical comedies. Because of the importance of concerts in the cultural life of this city, the interior design has been based upon the most successful concert halls, and the auditorium, as set up for orchestral or choral concerts, is basically a long, hard rectangular box with sound diffusing and scattering splays on ceiling and wall surfaces. Two elements, the suspended sound-reflecting ceiling panels and a movable orchestral stage enclosure are somewhat similar to the large 10,000 seat auditorium discussed earlier.

For use as a more intimate theater or chamber music recital hall, the auditorium's sound-reflecting ceiling panels are lowered to reduce the visual and acoustical height of the auditorium, and a visual screen is used to close off the upper portion of the balcony. Now, as a 1600 seat hall, the sight line from the most distant member of the audience is less than 100 ft. The close-in reinforcement of reflected sound energy provided by the lowered ceiling panels now assures that hearing conditions for live speech are excellent throughout the reduced size auditorium.

Depending upon the program presented, the orchestral stage enclosure may or may not be employed. The hard enclosure that surrounds the orchestra or the chorus on the stage must, again, be movable to allow scenery to be employed for plays, musical comedy, or opera. In this auditorium, the ceiling of the movable stage enclosure is broken into two component parts, the forward portion, roughly 55 ft. x 10 ft., is flown in a manner similar to the orchestral enclosure ceiling panels of the 10,000 seat auditorium. The rear portion of the stage enclosure ceiling, however, is merely folded back against the rear wall of the stagehouse. The
side walls of the stage enclosure are easily moved out of the way on a curved track and stored upright against the rear wall of the stagehouse wings. The back wall of the stage enclosure is permanent; it is merely the rear wall of the stagehouse itself.

**Reverberation time adjustable**

Adjustable sound-absorbing treatment in the upper side and rear walls of the auditorium is available to reduce the reverberation time of the hall to the optimum characteristics of speech activities. The ratio of the over-all volume of the hall to the seating area allows a greater than 1.8 second reverberation time to be achieved when the hall is used for orchestral music. Yet, even with a reduced size audience of only 1600, the reverberation time can be lowered by use of the adjustable sound-absorbing treatment to 1.2 seconds for lectures or dramatic productions.

Not strictly part of the adjustable acoustical treatment of the auditorium, the visual curtain can close off the upper rear balcony of the auditorium, effectively removing 1100 seats from the visual interior of the auditorium. The only acoustical requirement for this removable visual rear wall is that it be either sound-transparent or sound-absorbing. Sound energy that passes through this visual screen is absorbed by the upholstered seats behind and the adjustable sound-absorbing treatment on the rear wall.

We may expect the adjustable sound-absorbing treatment, together with the hinged ceiling of suspended ceiling panels, the movable stage enclosure, and most important of all, the basic shape of the auditorium, will assure that an excellent theater, concert hall, and opera house will be combined in one building. Supplementing the naturally excellent acoustics of this building for its various major uses, a central loudspeaker system, acoustically integrated with the room acoustics design, over the center of the proscenium arch will be employed to provide reinforcement for weaker voiced lecturers or to provide speech coverage for the entire 2700 seat auditorium. The acoustical conditions for each of the different uses of the auditorium may not be exactly optimum, but they will be very reasonably close.

If the conflicting requirements of the different uses of an auditorium are recognized in advance, detailed acoustical engineering can provide satisfactory and even very good results. Reducing the range of activities can allow a compromise more favorable to those remaining. The acoustical measures discussed in this article require detailed collaboration between the architect, theater consultant, acoustical engineer, structural engineer, lighting specialist, and others, if they are to make their proper contribution to the finished building.

Acknowledgment is given to the architects currently collaborating with the author's office on projects similar in some respects to the examples discussed in this article. These architects include A. G. Odell, Jr., and Associates of Charlotte, North Carolina; Hoyle Doran and Berry of Boston, Massachusetts; Biggs, Weir and Chandler and Overstreet Ware and Ware, Associated Architects in Jackson, Mississippi; and Lyles, Bissett, Carlisle and Wolff, Architects in Columbia, South Carolina. Theater consultant, George Izenour, of Yale University School of Drama, has been responsible for the design of the many mechanisms for adjustable devices similar to those discussed in this article.

May 1961
Acoustical measures include:

1. Sound-absorbing formboard roof deck.
3. Suspended sound-reflecting ceiling panels shown (solid) in lowered position and (dotted) in raised position.
4. Ceiling of orchestral stage enclosure shown (solid) lowered and (dotted) raised.
5. Walls of orchestral stage enclosure supported on wheels for ease of removal.
6. Removable side walls constructed of lead curtain material.
7. End or proscenium loudspeaker cluster for reinforcement of stage activities.
8. Central loudspeaker cluster for amplification during sports and arena events.

Definition:
The reverberation time is defined as the time required for the sound energy density to decay 60 db, that is to $10^{-6}$ of the original value.
APPENDIX D:

"Auditorium Acoustics for Music Performance"
by Russell Johnson

Reprinted from the December, 1960 Architectural Record.
Rapidly growing interest in the performing arts has stimulated the building of concert halls, theaters, opera houses and, particularly, multi-purpose auditoriums throughout the country. Contrary to some opinion, the acoustic design for these various facilities is not in any sense a cut-and-try process with a bit of magic thrown in to make some arbitrary shape work.

Rather, the acoustical characteristics of a hall designed for the performance of music are fixed by the size and shape of the hall, the materials used in it, and the nature of the stage enclosure. And recent studies have determined not only which halls throughout the world are most preferred, but also the acoustical reasons why they have made an almost universally favorable impression.

Ideally, each of the performing arts should have its own hall if the acoustics are to be “perfect.” But unfortunately, economics often dictate a multi-purpose auditorium which must accommodate everything from symphony to musical comedy to lecture—and which must be considerably larger than the classic concert hall or opera house. When this is the case, the architect, acoustical consultant and owner must determine which activities are most important; design the acoustics primarily for these; and make whatever provisions are feasible to get the best possible acoustical environment for the remaining uses.

SIZE VS. ACOUSTIC QUALITY

The most difficult concept to communicate to the public and to many architects is that it is not possible to take a space of any arbitrary size and make it into a good concert hall or opera house or multi-purpose hall. As a matter of fact, the size (cubic volume) of the hall is perhaps the single most important factor in determining its acoustical quality, first because the cubage affects the length of the reverberation time, and second, because the size of the hall must be properly related to the “size” of the source in order to conserve the energy produced.

Unfortunately, the size of a hall is equally crucial in terms of box office income. Economic pressures are so
Torroja Urges Automation in Construction

Dr. Eduardo Torroja, Spain's famed architect-engineer, told a recent meeting of the California Council of the A.I.A. that, in his opinion, stepped-up economic and industrial pressures requiring an increased use of prefabrication rank high among the many forces shaping present-day architecture. "It is necessary to pass on to the specialized workshop a large part of the total project and thereby reduce the cost by large-scale use of standardized units and mechanized labor." Further intensification of the trend toward increased automation through prefabrication is particularly important, he pointed out, since the problem of efficient site assembly is less easily solved. If field labor costs are not reduced, or offset by greater use of factory-produced components, the risk that the building industry will tend to be much more expensive than others will continue. This problem Torroja termed "perhaps the most serious one facing architecture."

Concrete Joinery: Neat, Efficient

The 6th annual convention of the Prestressed Concrete Institute held in New York gave convincing evidence that the problems—and possibilities—of prefabrication in building have not gone unnoticed at least by this segment of the industry. As if in anticipation of Torroja's prediction that efficient field assembly will be increasingly the key to economical building, many of the speakers addressed themselves to the techniques and economics of assembly and erection. Canadian consulting engineer Laurence Cazaly, for example, told the audience that "Neat Joints Are Good Business" and that joint and erection details should be given painstaking consideration by the top echelons of the design team. He dramatized this thesis with an only slightly tongue-in-cheek definition of a "neat" joint: "If a joint can be fabricated by a welder just going on vacation, placed in a mold by a carpenter with a linen tape, erected with the only piece of equipment within 50 miles on a rainy day by a man who has just quarreled with his wife; and if the engineer pronounces it safe, the architect says it is beautiful, and it did not cost you more than $5.00," he asserts, "rest assured that the design was a good one."

Concrete Joinery: A Design Theme

The real hymn to the joint, however, was sung by Louis I. Kahn, F.A.I.A., in discussing his approach to the design of the trend-setting Medical Research Building at the University of Pennsylvania (ARCHITECTURAL RECORD, September 1959; August 1960). "I began to realize," he said, "that the event of these large pieces coming together is the point from which wonderful decoration can occur . . . the beginning of ornament. It is not an applied thing, [but] stems from a strategic consideration of a building . . . from a challenge against the elements . . . from water tending to destroy the building, sun tending to make the building uncomfortable. Prestressed concrete should try to consider the joint-making not as a form of homogenizing one member with another but as a construction of itself."

Prestressing and Codes

The International Conference of Building Officials has formally approved the inclusion of prestressed concrete in the Uniform Building Code, one of the four model codes in the U. S. The section of this code covering prestressed concrete was first approved by the Structural Engineers Association of California. Other news involving prestressing and building regulations comes from New York and Chicago. While the New York City Building Code does not cover prestressed concrete, a provision in a temporary code set up for the 1964 World's Fair will permit its use. The Chicago Building Department, which earlier in the year forbade the use of prestressed concrete in buildings, changed its regulations in late August to permit it for most types of construction; excluded are industrial plants where there is "more than the average risk of fire."

This Month's AE Section

Symphony conductors rate these classic-shaped concert halls as the two best. Note the rectangular plan and parallel walls.

GROSSER MUSIKVEREINSAAL, VIENNA

SYMPHONY HALL, BOSTON

Symphony conductors rate these classic-shaped concert halls as the two best. Note the rectangular plan and parallel walls.

great in the planning and operation of new halls that building owners sometimes have a desire to throw in the sponge: build a hall large enough to pay off expenses readily, and solve the acoustical problem with the abracadabra of masonry bowls or broken glass beneath the auditorium floor or some other nostrum.

But the solution is not that easy. In general, the halls and opera houses with the best acoustics are smaller in terms of cubic volume, seating capacity and floor area allotted per seat than auditoriums being built today. The halls listed in Table I in bold face have received almost universal praise—and negligible criticism. The areas occupied by seats and aisles range from 8000 to 16,000 sq ft (bold face in table)—or 4.7 to 6.8 sq ft per seat—as compared with the 7.0 to 8.0 sq ft per seat allotted in many contemporary auditoriums.

Translated into present-day standards of seat spacing, these halls would seat between 1500 and 2200 people. For example, Boston Symphony Hall seats 2631 people, but its smaller seats, smaller row-to-row spacing in the balconies and narrow aisles could not be built today. If it conformed with current public safety codes and comfort standards, it would hold about 2200 people.

As might be expected, the highest-rated concert halls have, in addition to their relatively low seating capacities, relatively small volumes—ranging from 352,000 to 662,000 cu ft. Similarly, conductors' ratings of halls used for opera production (Table II) relate directly to cubic volume, the highest-rated being in the neighborhood of 300,000 to 400,000 cu ft.

It is impressive to see how extremely small these halls are compared to some of the giants that are being built in the United States, but it is far from unexpected. Since all instruments or ensembles have some reasonable output, to obtain optimum acoustics for various types of music performances the cubic of the auditorium must be matched to the musical sources, or vice versa.

Assuming that no sound absorbing materials are installed, the musicians performing in a concert hall of 900,000 cu ft must produce 80 per cent more sound than in a hall of 500,000 cu ft to obtain the same musical effect. This is of particular interest since most of the acoustically outstanding halls have cubicas in the neighborhood of 500,000 cu ft, whereas halls built today are frequently as large as 900,000 cu ft to 1,000,000 cu ft and even more. However, some of the concert hall-opera house-theaters built recently have rather low seating capacities, and many of them can be expected to have good acoustics if other acoustical precepts are not ignored. A few of these are: Municipal Theater, Munster, West Germany (opera house-concert hall-theater), 955; Concert Hall, Stockholm, 1110; Kanagawa Concert Hall, Yokohama, 1331; Opera House, Cologne, 1490; Municipal Theater, Malmo, 1695; Tivoli Concert Hall, Copenhagen, 1840.

The seating capacity and size of the hall usually receive some consideration during the early planning stages of new halls, although in many cases, box-office economics exert a controlling influence that never loses its grip on the design. The men who represent the box-office side of the story carry a big stick, so why is it that all halls are not designed on the basis of box-office income? The answer is simple—the building owner (or sponsor or principal tenant) wants good acoustics plus enough seats to pay, according to his calculation, initial costs and operating and production costs. These two factors must be balanced intelligently by the building owner. He must decide, with the help of the acoustics and economics counsel, how to divide the emphasis between income and acoustical excellence. Perhaps only with subsidy, as heavy as that which
flourishes across the Atlantic, can a cultural organization build and operate an opera theatre or concert hall of 2000 seats with "near perfect" acoustics.

Concert managers often point out that it is questionable to build a concert hall that will not seat all the citizens who would like to hear a particular performance. In rebuttal, the building owner often responds that the hall must be designed with all the activities to take place therein in mind; that it should not be planned only around the attractions that tax the seating capacity.

In any case, every city is unique, and all building sponsors must make their decisions on the type of hall to be built, seating capacity, etc., on the circumstances that prevail in the particular city.

**EFFECT OF REVERBERATION**

Reverberation is the persistence or lingering of sound in a room, hall or chamber after the originating sound has ceased. This effect arises from the multiple reflection of the original sound wave as it strikes the various surfaces of the hall: the floor, ceiling, walls. Each time the sound wave hits a surface, a portion of it is absorbed, and thus the sound gradually dies out.

Assuming that a multi-purpose hall is to be built, one of the first questions the acoustic designer asks the building owner and architect is: what activities will take place, and what is the relative importance of each type of activity?

The activities that are ordinarily housed in a multi-purpose theatre can be divided into two categories: (1) a group requiring a relatively short reverberation time—lectures, musical comedies, any activity using sound amplification, opera, assemblies, motion picture exhibition; and (2) another group requiring a relatively long reverberation time—organ, orchestra, chamber music, voice, violin and piano recitals, string instrumental groups. Although there are many acoustical design considerations other than reverberation time, the reverberation time is still the most useful key to gauge how satisfactory or unsatisfactory the acoustics of a hall are for various types of speech activities and music performances.

Within reasonable limits, the intelligibility of speech improves as the reverberation time is decreased. On the other hand, the acoustic environment for music considered best by both performers and listeners requires more reverberation. Organ and choral music require more reverberation than other forms of music. A piano, or an orchestra performing contemporary music have the most suitable acoustical environment when reverberation time is on the short side of the range for musical performance.

Opera and other musical theatre productions are a combination of music and speech, and accordingly, the reverberation time that should be provided for this type of activity is between that for music and that for speech. With such basic conflicts, it is obvious that ideal acoustic environment cannot be provided for all of the activities that take place in a multi-purpose theatre.

In addition to the varying optimum reverberation for speech, music, lyric theatre, etc., there is convincing evidence from subjective tests that acoustical preference varies with the type of music, ranging from a preference for high definition for some composers such as Mozart to fullness and blending for, say, Brahms.

Table III indicates the range of reverberation time (at 500-1,000 cps) generally suitable for various activities that take place in multi-purpose halls. At first sight, the differences between some of the reverberation
times listed below may seem ridiculously small, but if it is remembered that these are decimal parts of a second; and if it is borne in mind that in speech and music we are dealing not with just one sound reverberating, but with successions of sounds, each reverberating, it will be clear why a difference of 0.5 of a second is so vital.

The best concert halls, with full occupancy at mid-frequencies (500-1000 cps), have relatively long reverberation times—between 1.8 and 2.1 seconds. Optimum reverberation for opera is lower. (These numbers are by modern measurement techniques. Frequently higher numbers have been associated with existing halls, but many of the numbers previously published have been proven erroneous.)

Once the seating area and the cubicage of the hall are fixed, the maximum reverberation time is automatically determined. Assuming that no or very little sound absorbing materials are installed, the ratio of volume to audience seating area must be 45:1 for 1.8 seconds reverberation (concert); 36:1 for 1.4 seconds in the mid-frequency range (opera) and 32:1 for 1.3 seconds in the mid-frequency range.

The formerly universally used ratio of volume per seat has been proven invalid, and thus removes a stumbling block that has plagued acoustic designers for decades. Dr. Beranek’s research has shown that audience absorption should be calculated on an area basis, rather than on the former per person basis. Application of this technique results in significantly lower calculated reverberation times, particularly in newer halls with larger seating spacing.

The new, more accurate methods for calculating the sound energy absorption by the audience and the performing group present are particularly important because practically all of the sound absorption present in a concert hall is provided by the audience. Seated audiences in halls with a larger seating spacing absorb more sound by a factor of as much as two as was previously thought. This new technique produces reverberation calculations considerably closer to the measured data on existing halls than calculations made on the person basis (usually expressed in terms of volume per seat).

The profile of a hall intended to

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**TABLE I**

<table>
<thead>
<tr>
<th>Halls</th>
<th>Area (sq. ft.)</th>
<th>Volume in cu. ft.</th>
<th>R.T. occupied 300-1000 cps in seconds**</th>
<th>Ratio of volume to area of audience, orchestra stage-chorus areas</th>
<th>No. of seats</th>
<th>Area/Audience seat* (sq. ft.)</th>
<th>Width measured between balcony facias (ft.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Festspielhaus Bayreuth</td>
<td>8,500</td>
<td>364,000</td>
<td>3.4</td>
<td>1,800</td>
<td>4.7</td>
<td>84</td>
<td></td>
</tr>
<tr>
<td>Theatre de l’Opera Paris</td>
<td>12,120</td>
<td>332,000</td>
<td>2.2</td>
<td>2,156</td>
<td>4.8</td>
<td>66</td>
<td></td>
</tr>
<tr>
<td>Staatstheater Vienna</td>
<td>12,850</td>
<td>376,600</td>
<td>2.4</td>
<td>1,565</td>
<td>6.8</td>
<td>64</td>
<td></td>
</tr>
<tr>
<td>Academy of Music Philadelphia</td>
<td>16,000</td>
<td>533,000</td>
<td>2.8</td>
<td>2,093</td>
<td>5.5</td>
<td>54</td>
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<tr>
<td>Teatro Colón Buenos Aires</td>
<td>19,000</td>
<td>726,300</td>
<td>3.1</td>
<td>2,375</td>
<td>7.0</td>
<td>72</td>
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<tr>
<td>Eastman Theatre Rochester</td>
<td>20,030</td>
<td>1,045,000</td>
<td>4.4</td>
<td>3,347</td>
<td>6.0</td>
<td>130 (wall to wall)</td>
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**TABLE II**

<table>
<thead>
<tr>
<th>Name</th>
<th>Ratings by conductors</th>
<th>Cubage** (cu. ft.)</th>
<th>Area (sq. ft.) of Audience Seating</th>
<th>Width* (in ft.)</th>
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<td>352,000</td>
<td>12,120</td>
<td>66</td>
</tr>
<tr>
<td>Festspielhaus, Bayreuth</td>
<td>excellent</td>
<td>364,000</td>
<td>8,500</td>
<td>84</td>
</tr>
<tr>
<td>Staatstheater, Vienna</td>
<td>excellent</td>
<td>376,600</td>
<td>12,850</td>
<td>64</td>
</tr>
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<td>Teatro alla Scala, Milan</td>
<td>excellent</td>
<td>318,200</td>
<td>7,700</td>
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<td>good</td>
<td>700,000 (approx.)</td>
<td>24,050</td>
<td>62-68</td>
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<td>Auditorium*** over 3,500 seats</td>
<td>fair</td>
<td>902,000</td>
<td>26,240</td>
<td>140</td>
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<td>Auditorium*** over 6,000 seats</td>
<td>poor</td>
<td>1,270,000</td>
<td>37,214</td>
<td>160</td>
</tr>
</tbody>
</table>

* Width is face-to-face of opposite rings or balconies, or if there are no side balconies, side wall to side wall measured one-half way back on the main floor.
** **House only—concert enclosures, if any, not included.
*** Multi-purpose hall used for opera productions.

Table I gives related architectural-acoustical data on a number of famous concert halls and opera houses. Table II shows conductors’ ratings for several opera houses. Size of concert hall has a direct bearing on the acoustical environment because it is one of the two factors determining reverberation time. Boston Symphony Hall, for example, with a volume of 682,000 cu ft, has a reverberation time of 1.6 which is in the ideal range for symphony.
rank among the world's top ten would be a hall of relatively small cubage, but at the same time, in accordance with the volume to seating area ratios stated above, the total area used for audience seating would have to be restricted in order to maintain sufficient reverberation.

Since the reverberation time in a hall is not related directly to the number of seats, but rather to the area that the seats (plus aisles) occupy, an audience floor area of 15,000 sq ft (including aisles) will absorb the same amount of sound whether there are 2600 or 2200 seated persons in it. It is for this reason that the older halls (like Boston) could seat 2600 people for a volume of not over 700,000 cubic feet and still achieve satisfactorily long reverberation time, while a modern hall meeting present-day safety and comfort standards can seat only about 2200 in this same volume.

This however does not mean that sponsors of concert halls are doomed to obtain a poor acoustical environment if they build auditoriums larger than 2200 seats. As acoustical consultants we are constantly being asked to design halls with volumes approaching a million cubic feet. We have found it necessary, therefore, to examine carefully means for producing acceptable musical quality in larger halls. One of the important factors in the judgment of musical quality of a hall is the presence of short-time-delay reflections of the right magnitude at the listener's position. Such reflections come automatically in a smaller, narrower hall. How can they be introduced into a larger hall?

Study reveals that the only way to introduce short-time-delay reflections into a larger concert hall is to construct a partially-open, partially-closed canopy over the orchestra and the front part of the audience. The closed portions send short-time-delay reflections into the audience. The open portions permit the sound to rise into the volume above the canopy and to develop the essential reverberation. With a closed canopy, the reverberation will not develop properly. With no canopy, the short-time-delay reflections will not be provided.

SHAPE AND PROPORTIONS

The basic shaping and proportions of a hall are also very important factors. The correlation between acoustical results and basic room shape is far greater in a hall for music performance than in any other type of listening space.

Speech auditoriums, theatres, coliseums, and other facilities for speech activities can be designed with a wide variety of shapes. The acoustical consultant can then recommend compensating measures, including the use of sound amplification and installation of sound absorbing materials, and by these "corrective" measures, obtain satisfactory speech intelligibility. However, this procedure, which involves use of sound absorbing material, is inadmissible in the design of a recital or concert hall; for in this case, every possible effort must be made to conserve the sound produced by the voice or the musical instrument.

A hall for the performance of music should be relatively long, narrow, and rectangular, since relatively close, parallel walls provide desirable "short-time-delay" acoustic reflections. For good music performance acoustics, it is necessary that first reflections from the walls and ceilings of the hall should reach the listener's ears between 20 to 40 milliseconds after arrival of the direct sound. This characteristic occurs almost automatically in the seating areas most distant from the stage, providing the smooth tone and blended, homogeneous ensemble sound that is typical of these seats, but, unless special acoustical provisions are made, it is usually lacking in most of the seating areas.

In order to provide the required reflected "signals" during the first 20
to 40 milliseconds, it is essential to have wall and ceiling reflectors within about 25 ft or less of the sound source. This architectural provision can be met in a concert hall by establishing the width of the stage platform at about 50-65 ft and suspending sound reflecting panels overhead at a height of 22-28 ft above the stage floor. The reflecting surfaces should be almost parallel—wall parallel with wall; ceiling (and reflecting panels) parallel with the floor.

The short-time-delay acoustic reflections provided by a long, narrow, parallel hall and overhead reflecting panels also favor clarity, clean transient response, balance of various instruments of the orchestra as heard at all seats on stage and throughout the hall, and even distribution of sound energy throughout the hall. The use of overhead suspended sound-reflecting panels is particularly important for the violin section of the orchestra.

The width of the hall as measured from wall to wall should be 65 to 85 ft, if possible, for both concert and opera production—the narrower the better. A wide hall is likely to be unsatisfactory for speech also, as the long delayed acoustic reflections from widely spaced side walls arrive too late to integrate with the direct sound, producing muddiness, or a garbled effect. Sometimes the listener refers to areas suffering from this effect as “dead” spots.

In summary, existing halls with excellent acoustics are rectangular and relatively narrow (as narrow as 60 to 75 ft). In general, these halls are about twice as long (measured from the rear of the auditorium to the back of the stage) as they are wide, and are about as high as they are wide, the proportions being roughly 1:1:2 (width, height, length). Some are even longer than twice their width.

**TONAL QUALITY**

Another important aspect of music performance acoustics is the tonal characteristic of the hall—that is, the relative balance between the low, middle and upper registers—which is determined by the nature of the finishes of the walls, ceiling and floors. Some materials absorb sound efficiently in certain registers and reflect the sound in other registers, producing the varying amounts of reverberation at various frequencies that endow a hall with its tonal characteristics.

Sufficient and balanced reverberation at all frequencies provides the “warm and resonant” sound which pleases both listeners and performers. When a hall is judged as just a bit too mellow, it has insufficient high register reverberation. Sound which is too “dark” or “boomy” has insufficient reverberation in the middle and high registers. Sound which is “cold” or “sharp” has too much reverberation in the upper registers. This condition frequently results from the use of thin wood paneling which absorbs the low frequency sounds produced by the instruments of the orchestra. BBN’s concert hall survey has shown that of two halls that are equal in other characteristics, the one with the richer bass has the greater acceptability. What is surprising to most musicians is the fact that the walls and ceiling of a hall that is rich in low frequency sound are generally constructed of plaster or of very thick wood. Halls that are thought by many conductors to be finished with wood are actually more than 75 per cent plaster.

**THE “SENDING END”**

A part of the hall which plays a very important role in the success of the acoustics is the “sending end”: the surfaces in the vicinity of the stage.

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Drawings in this article were prepared by Wilfred Malmund of Bolt, Beranek and Newman. Architects for the halls on this page are: Oberlin Conservatory—Minoru Yamasaki and Associates; Queen Elizabeth Theater and Place des Arts—Affleck, Desbarats, Dimakopoulos, Lebensold, Michaud and Sise; Clowes Memorial Hall—John Johansen and Evans Woolen III, Associated Architects.
platform. These surfaces might be (a) permanent structure (floor, walls, ceilings), (b) permanent structure plus a suspended canopy or independent suspended panels or (c) demountable panels that assemble into a complete enclosure for a theatre stagehouse. All of these arrangements are simply variants of the "sending end", and the acoustical aims are the same.

In a concert hall (no stagehouse), a suspended canopy or a set of individual panels provide necessary close-in acoustic reflections and at the same time permit the cubage above to serve as a reverberant chamber. This provision not only improves the acoustical conditions in the auditorium, but also serves to help the various sections of the orchestra to hear both their own and other sections. This is a definite aid to the conductor and helps provide coordination. Halls which are very narrow (60 ft or less) and rectangular do not usually need suspended panels.

In a hall with a theatrical stagehouse, a complete demountable concert enclosure is essential for good music performance acoustics. The construction, rigging and operation of the large, heavy enclosure required in a multi-purpose hall used for symphony concerts is one of the major problems which confronts the operating staff.

Although the cost of construction and operation of a concert enclosure may seem unconscionably large when considered in relation to the available funds, the provision and use of this heavy device is essential.

A permanent stage platform enclosure in a concert hall is a heavy architectural structure, with side and rear walls constructed of 12-in. or thicker masonry construction, frequently faced with thick wood veneer. This heavy masonry enclosure is essential for the warmth and richness of tone of good concert halls, which is obtained by sufficient reverberation in the lower registers. However, it is obvious that a symphony orchestra cannot expect the building owner to provide a 12-in. thick masonry enclosure on the stage of a theater. Unfortunately, this is almost what would be required to obtain "concert hall" acoustics in a multi-purpose hall.

If it is essential for the building owner to obtain in one auditorium both an opera house and an outstanding concert hall, it might be valid to think of the cost of a truly adequate concert enclosure as the relatively small price to be paid in lieu of the cost of two separate buildings.

Enclosure walls of 2-in. thick wood, sufficiently braced by heavy steel sections, help maintain the desired warm resonant tone, and the box-like basic shaping of the shell provides a reverberant chamber that, by multiple reflections, mixes and blends the sound before it is projected into the auditorium. An enclosure design of this type does not do as good a job as the 12-in. thick permanent masonry "enclosure" of a concert hall, but does provide better acoustics in a large hall than the lightweight canvas or thin plastic and plywood "shells" currently in use in many multi-purpose halls.

The relatively high, sound-reflecting ceiling (in a completely enclosed demountable shell, about 32 ft) makes it possible for each musician more easily to hear the rest of the orchestra and this, of course, beneficial for balance and also enables the musicians on stage more readily to judge what the audience is hearing. An enclosure also conserves the energy produced by the orchestra, preventing it from being dissipated in the backstage areas and the fly gallery.

The initial construction costs of an adequate shell are one problem, but operational costs are often a more difficult problem. For this reason, it is wise to incorporate as much mechanism and ease of operation as possible into the original design of the enclosure. There are probably two methods of operation which are feasible for a heavy enclosure. One is the provision of a complete "box" which travels up and down stage, either on tracks in the floor or on overhead rails. This procedure is similar to that used in some continental theatres to move a plaster cyclorama up and downstage. The cost of building the portion of the stagehouse in which the enclosure is stored during theatrical productions must be included as part of the cost of the enclosure. Another method of operation which has been used is telescoping the side walls and the rear wall of the enclosure into the stage floor.

A properly designed enclosure will produce similar benefits for a choral group, and will also provide good balance between a choral group and an orchestra. A similar, but smaller, enclosure is recommended for small performing groups and recitals.

The reader will probably be interested in seeing how the acoustical requirements discussed above can be incorporated into a complete building design—how the conflicts and practical considerations can be resolved. Two of the projects are multi-purpose auditoriums. The third, a 600-seat hall is primarily for music performance.

THREE CURRENT DESIGNS

Oberlin Conservatory of Music

This hall design is a simple rectangle, which is significantly better for music performance acoustics than the so-called "intimate" audience seating arrangements so popular. The hall is more than twice as long as it is wide. The ceiling is high and horizontal and the width is narrow, about 65 ft. The proportions are in the neighborhood of 1:1:2. This hall is being designed for a music conservatory and will be used for all types of music performance.

There are two enclosures provided in this hall. The permanent enclosure consists of 11-ft high walls spaced about 50 ft apart, providing sufficient space for a symphony orchestra. Elements for acoustical diffusion are located at the side walls of the stage, concealed behind this 11-ft high acoustically transparent screen. The other enclosure is a hydraulically-operated wall about 14 ft high, recessed into the stage floor, for recital performances, string quartets and small instrumental ensembles. This enclosure is constructed of 2-in. wood plank braced with a heavy steel frame.

The audience is the largest and therefore most important source of absorption present in a hall. Since this hall will be used for performance for low to high capacity audiences, for rehearsals, and for recording, the audience size will vary from no one present to a capacity house. Under these conditions, it is essential in a hall of this size to provide some mechanism of adjusting the reverberation. This is particularly important since some of the performances will require rather short reverberation, while others will require rather lengthy reverberation.

To be able to make any significant change in the reverberation, modification of the acoustical properties of
The “sending” end of the auditorium plays an important role in the success of the acoustics. In the Stockholm Concert Hall (above) the suspended translucent panels provide necessary close-in acoustic reflections and help members of the orchestra hear each other better. The platform canopy in the headquarters for the Church of Jesus Christ of Latter Day Saints in Independence, Mo., aids the projection of music from the choir as well as speech. The stage enclosure for the Henry and Edsel Ford Auditorium in Detroit prevents sound from getting lost in the top of the stage house and projects it into the auditorium. It is heavy enough to reflect the low frequencies, which sometimes are absorbed when the enclosure is built of a lightweight material.

A very high percentage of the wall surfaces of a hall is required. Use of a reverberation adjusting device is required on practically all of the side wall area from floor to ceiling plus the rear wall, if one is to provide a worthwhile degree of variability. This design incorporates about 6000 sq ft of adjustable curtain, which, under certain conditions of occupancy and setting of the adjustable drapery, will provide reverberation times ranging from 1.2 seconds to 2.3 seconds in the mid-frequency range.

Clowes Memorial Hall
This 2200 seat multi-purpose hall is now under construction at Butler University in Indianapolis, Indiana, and is expected to be available for some use by the community. The building owner predicts about 170 performances each year in which over 105 will be music performances without electronic amplification. With as much emphasis as this, it is essential to provide an architectural-acoustical design which gives the musician a “square deal.” The acoustics for most of the speech activities in a hall of this size will depend on the installation of a carefully designed, highly directional amplification system.

In a hall with reverberation suitable for music, the acoustics for unamplified speech will depend in large measure on a narrow hall design. In the front of the original plan, side walls are 65 ft apart and, except for the two bays on each side for entrance and exit to the hall, the hall is not wider than 85 ft. The length of hall, including the symphony enclosure, measures about twice as long as it is wide. As the design proceeded, the proportions were modified to bring the rear rows closer to the stage for theatrical purposes. The average ceiling height of the concert enclosure is 33 feet. A smaller enclosure for recitals and small ensembles is included.

Each section of the auditorium walls is parallel to the center line of the hall to provide as much interreflection as possible. This aspect of the design will help provide a well-blended, homogeneous sound with high definition in the main floor seating area and in the balconies at the sides of the house. This is beneficial both for musical quality and speech intelligibility.

The volume of the original design, including the symphony enclosure, was about 685,000 cu ft in order to maintain a sufficiently long reverberation time. In order to provide this volume, it is essential that the

continued on page 182
STRUCTURAL FORMS—METAL DOMES: 4
by SEYMOUR HOWARD, Architect, Associate Professor, Pratt Institute

The Kaiser Aluminum and Chemical Sales Co., 919 North Michigan Ave., Chicago 11, Illinois, has designed aluminum domes based on Fuller's patents, and some of its own patents covering the system of stressed skin space truss using diamond shaped panels. Kaiser is currently marketing two basic series, each of three sizes of type A domes. (See table.)

The plan and elevation shown in Figure 2 are of Kaiser's type A-80-15.3 (approximately a quarter sphere.) In plan the surface is divided into five identical sectors, corresponding to the five upper spherical triangles of the spherical icosahedron; they are joined by a pentagonal lantern at the top. Each sector is supported by five symmetrically arranged piers: C in the center (highest); B, and A, to the left, looking up at the dome; B, and A, to the right.

The geometry of the division of the dome surface is described in detail on Sheets 28, 29 and 30 of "Useful Curves and Curved Surfaces," AB, April, 1958. A typical basic spherical triangle is shown between lines 8, 9, and 12 on both plan and elevation. The divisions are marked to correspond to those shown on Sheet 29; here the frequency (p) is 10.

The panels and struts are drawn in detail on two other similar spherical triangles: between sectors two and three in plan and between sectors five and one in elevation.

Each unit consists of a sun-burst-crease formed, diamond shaped panel of aluminum sheet (maximum length 140 in.) with the central cambered valley approximately a chord of a great circle on the inner sphere (radius 80 ft.) Six of these panels meet at a point on the inner sphere. The flanged edges of the panels go out to meet the struts, which form a hexagonal pattern with their vertices on the outer sphere (radius 81 ft). The creased valley and the four edges of the panel plus one strut comprise the six edges of the unit tetrahedron. (This is being patented by Kaiser Aluminum, Don L. Richter, inventor; other patents are pending.) Filler panels (as shown dotted in sectors five and one) can be hung from the lower edge to bring the dome down to a more uniform line.

In sector four, broken lines show the piers as they are required for the two small domes (A-80-11.5 and A-80-7.0), which can be built using the same panels but taking smaller portions of the same sphere.

DATA ON KAISER DOMES

<table>
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<th>Dome Code No.</th>
<th>Radius Inner Sphere (ft)</th>
<th>Plan Area X/100 Sq. ft</th>
<th>Surface Area X/100 Sq. ft</th>
<th>Volume X/100 Cu. ft</th>
<th>Plan Triangulation to High Point of Inner Sphere</th>
<th>Frequency (p)</th>
<th>Number of Piers Per Sector</th>
<th>(5)</th>
<th>Radius Inner Sphere Opposite Per, See Figure</th>
<th>90° (See Figure 2)</th>
<th>Pier Loads in Thousands of Pounds</th>
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<td>A 101'-4'/8&quot;</td>
<td>C 64.9</td>
<td>22.6</td>
<td>7.2</td>
<td>10.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A - 80 - 7.0</td>
<td>8.1</td>
<td>87</td>
<td>18'- 5'/8&quot;</td>
<td>10</td>
<td>A 51'-11'/8&quot;</td>
<td>39.7</td>
<td>24.6</td>
<td>15.2</td>
<td>12.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B 48'-6'/8&quot;</td>
<td>A 101'-4'/8&quot;</td>
<td>C 64.9</td>
<td>22.6</td>
<td>7.2</td>
<td>10.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A - 112 - 30.0</td>
<td>42.7</td>
<td>1180</td>
<td>64'- 5'/8&quot;</td>
<td>14</td>
<td>A 101'-4'/8&quot;</td>
<td>64.9</td>
<td>22.6</td>
<td>7.2</td>
<td>10.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B 99'-10&quot;</td>
<td>C 98'-7'/8&quot;</td>
<td>B 98'-7'/8&quot;</td>
<td>C 98'-7'/8&quot;</td>
<td>C 98'-7'/8&quot;</td>
<td>A 92'-10'/4&quot;</td>
<td>56.1</td>
<td>32.3</td>
<td>11.0</td>
<td>11.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A - 112 - 24.7</td>
<td>32.2</td>
<td>733</td>
<td>46'- 5'/8&quot;</td>
<td>14</td>
<td>A 92'-10'/4&quot;</td>
<td>56.1</td>
<td>32.3</td>
<td>11.0</td>
<td>11.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B 90'-4'/8&quot;</td>
<td>C 88'-9'/8&quot;</td>
<td>B 88'-9'/8&quot;</td>
<td>A 92'-10'/4&quot;</td>
<td>C 98'-7'/8&quot;</td>
<td>A 92'-10'/4&quot;</td>
<td>56.1</td>
<td>32.3</td>
<td>11.0</td>
<td>11.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A - 112 - 18.7</td>
<td>22.6</td>
<td>403</td>
<td>35'-10&quot;</td>
<td>14</td>
<td>A 82'-11'/8&quot;</td>
<td>47.2</td>
<td>42.5</td>
<td>15.1</td>
<td>18.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B 78'-2'/8&quot;</td>
<td>C 76'-10'/8&quot;</td>
<td>C 76'-10'/8&quot;</td>
<td>A 82'-11'/8&quot;</td>
<td>C 98'-7'/8&quot;</td>
<td>B 48'-6'/8&quot;</td>
<td>A 101'-4'/8&quot;</td>
<td>C 64.9</td>
<td>22.6</td>
<td>7.2</td>
<td>10.7</td>
<td></td>
</tr>
</tbody>
</table>

Note: All of these domes except A-80-7.0 can safely withstand winds of 125 m.p.h.; uplift and snag loads on piers will be increased by about 25% over those given here for 100 m.p.h. wind.
ceiling over the front rows of audience be extremely high. To make a smooth transition between the 35-ft high symphony enclosure ceiling and the 66-ft high auditorium ceiling, the design includes suspended sound-reflecting panels, which will provide the short-time-delay reflections required to eliminate the harsh tone and poor speech intelligibility that would otherwise be experienced in most of the seats on the main floor.

Two-thirds of the side wall area of the symphony enclosure is constructed of 2-in. thick wood plank mounted on a heavy reinforced steel frame. These heavy sections telescope into the floor. The remaining portions of the enclosure side walls are constructed of lighter materials and can be handled from the stage grid, or handled manually at the stage floor. The ceiling of the enclosure consists of three separate panels, each suspended from the stagehouse grid.

Place des Arts, Montreal

This 3100-seat hall is to be used for opera, touring musical comedy production, symphony, ballet, recitals, conventions, and motion picture exhibition.

In order to obtain a seating capacity of 3100 seats with sufficient comfort for the audience, it was necessary for the designers to stack the balconies. The balcony overhangs thus produced will acoustically shade some of the seats at the rear of the main floor and the two lower balconies. This compromise is necessary in order to keep the audience reasonably close to opera and musical comedy productions, maintaining satisfactory visual acuity. In order to obtain the desired 3100 seat audience capacity, it was also necessary to provide three tiers of boxes at the sides of the auditorium.

As in the 2200 seat theatre, the aisles are uncarpeted, the seating is fully upholstered and the area beneath the seats is finished with carpet and underlay.

Here again, as in the 2200 seat theatre, the suspended ceiling panels required for short-time-delay reflections are incorporated in the design, and, at the same time, the space above the panels is used to support the reverberation. In the design illustrated, the panels were hidden behind a continuous, acoustically-transparent screen of wood battens which also concealed the loudspeakers. A more recent design incorporates exposed acoustic reflecting panels in a handsome design.

The stage width of 60 ft maximum was established for the proper acoustical support of the string sections of an 85-95 instrument symphony orchestra. The podium location is at the main curtain line position, and the pit railing is removable so that audience seats can be installed to within a few feet of the conductor to eliminate the psychological “gap” between conductor and audience.

In summary, the answer to the question of what makes a hall good for music performance is at hand. The remaining question is whether economics of esthetic trends or both will prevent building sponsors from capitalizing on these findings in future concert hall-opera house design.
APPENDIX E:

"Audience and Seat Absorption in Large Halls"

by Leo L. Beranek

Audience and Seat Absorption in Large Halls*

LEO L. BERANEK
Bolt Beranek and Newman Inc., 50 Moulton Street, Cambridge 38, Massachusetts
(Received February 25, 1960)

From detailed acoustical studies made in over 40 large concert halls and opera houses in 15 countries, absorption coefficients are derived for audience, chorus, and orchestra areas, unoccupied seating areas, plaster walls and wood walls. It is postulated that the absorbing power of a seated audience, chorus or orchestra in a hall is proportional to the floor area it occupies. This postulate is validated for audience densities of between 4.5 and 8.5 sq ft per person, including aisles, and for halls with volumes between 200 000 and 1 500 000 cu ft. The “area” concept as opposed to the “per person” concept of audience absorption explains the serious differences reported repeatedly in the literature between reverberation times calculated during design and those measured after completion of the halls. This paper also presents graphical relations between empty and fully occupied hall reverberation times; shows the effect of seat design on empty hall reverberation times; and gives typical reverberation time vs frequency characteristics for fully occupied halls. The results of this study may not be applicable to rooms whose volume, shape, and materials are substantially different from the large concert halls and opera houses included in this study.

I. INTRODUCTION

A HALL in which music is played\(^1\) is only one link in an artistic chain that also includes the contributions of the composer, the conductor, the performers, and the listeners. Different types of music are best played and heard in different acoustical environments. But in actual practice, a music hall is generally used for many types of music. In addition, each conductor, soloist, and listener may have an individual preference as to the best “average” acoustics for the hall he uses. Yet in any one year, a hall must serve many performers as well as a wide spectrum of listeners.

But it is not these factors alone that have made acoustical design difficult. Until now, it simply has not been possible to predict from existing formulas with reasonable accuracy the most common acoustical characteristic of a hall, namely, the reverberation time, even when full architectural information is available. This fact is attested to in technical papers on the London Royal Festival Hall,\(^2\) the Edmonton and Calgary, Alberta Jubilee Auditoriums,\(^3\) the Tel Aviv, F. Mann Auditorium,\(^4\) and the Bonn, Beethoven Hall.\(^5\) It is also true for other halls on which details have not been published. In each of these cases the design calculations have been 0.3 to 0.5 sec higher than the measured results.

---

TABLE I. Coefficients of absorption at 512 cps.*

<table>
<thead>
<tr>
<th>Material</th>
<th>Coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plaster on lath</td>
<td>0.033</td>
</tr>
<tr>
<td>Plaster on tile</td>
<td>0.025</td>
</tr>
<tr>
<td>Glass</td>
<td>0.027</td>
</tr>
<tr>
<td>Wood, solid, hard</td>
<td>0.061</td>
</tr>
<tr>
<td>Drapery: Shelia</td>
<td>0.23</td>
</tr>
<tr>
<td>Drapery: Cretonne</td>
<td>0.15</td>
</tr>
<tr>
<td>Audience, per person (ft(^2))</td>
<td>4.75</td>
</tr>
<tr>
<td>Orchestra, per man (ft(^2))</td>
<td>5.15</td>
</tr>
</tbody>
</table>

---


\(^1\) In England and France a “music hall” is a “variety theater.” For simplicity, however, in the remainder of this paper we shall abbreviate the words “hall in which music is played” to “music hall.”


Admittedly, the situation has improved since Wallace C. Sabine, an assistant professor, 27 years of age, was approached in 1895 by President Eliot of Harvard to improve the acoustics of the Fogg Art Museum (now called Hunt Hall) in Cambridge, Massachusetts. His colleagues looked upon his new assignment as a grim joke, and his senior professor warned him that he was “undertaking a problem that fairly bristles with difficulties, the extreme complexity of which seems to indicate that a complete solution is hopeless.”

After five years of research, Sabine gave acoustics his classical reverberation equation. He spent considerable effort in making careful measurements of the coefficients of sound absorption of the principal materials associated with concert halls. These he tabulated for 512 cps in his first lengthy paper on the subject, “Reverberation”\(^6\) as shown in Table I. These numbers are very close to those published in texts and handbooks today. However, Sabine intended that they be used in this type of equation

\[ T = 0.0497/(S\Delta \alpha + 4 \Delta V). \]

---

\(^6\) William Dana Orcutt, "Wallace Clement Sabine, a study in achievement," privately printed in 1933. The Fogg quotation is from p. 104. The Krehbiel quotation is from p. 145. Only a few copies of this book, now a collector’s item, are available. (Send inquiries concerning this book to Leo Beranek.)

The 4-mV term was introduced by Knudsen much later.\(^7\)

In this equation, \(V\) is the volume in ft\(^3\), \(S\) is the total area of the floor, ceiling, and walls in ft\(^2\) and \(\bar{\alpha}_{\text{abs}}\) is the average absorption coefficient in the room defined as follows:

\[
\bar{\alpha}_{\text{abs}} = \frac{S\alpha_1 + S\alpha_2 + S\alpha_3 + \cdots + N_1\alpha_1 + N_2\alpha_2}{S},
\]

(2)

where

\[
S = S_1 + S_2 + S_3 + \cdots \text{ft}^2,
\]

(3)

and \(\alpha_1, \alpha_2, \alpha_3\), etc., are the absorption coefficients of particular surfaces in the room with areas, respectively, of \(S_1, S_2, S_3\), etc. (ft\(^2\)); \(N_1\) is the number of occupied seats with a total absorption each of \(\alpha_1\) (ft\(^2\)) and \(N_2\) is the number of empty seats with a total absorption each of \(\alpha_2\) (ft\(^2\)). The quantity \(m\) is the coefficient of molecular absorption in the room in ft\(^{-1}\), given approximately by Table II. It may be neglected below 1500 cps.

If the Norris-Eyring type of equation\(^8\)

\[
T = 0.049 - \frac{V}{S[-2.3 \log_{10}(1-\bar{\alpha}_{\text{Ey}})] + 4 \text{ mV}}
\]

(4)

is used the value of \(\bar{\alpha}_{\text{Ey}}\)—and, hence, of each of the \(\alpha\)'s and \(\bar{\alpha}\)'s in Eq. (2) (which is also valid for computing \(\bar{\alpha}_{\text{abs}}\))—must be less than \(\bar{\alpha}_{\text{abs}}\) by 10\% to 15\% if the same value of \(T\) is to be obtained.

Sabine, in one of his papers,\(^6\) tabulates audience absorption as measured in the Jefferson Physical Laboratory Lecture Hall at Harvard both on a "per person" and on a "unit area" basis. However, both he and subsequent writers used the "per person" concept [using \(N_1\alpha_1\) in Eq. (2)] in their published calculations.

A thing to observe is that when Sabine applied his own formula, using "per person" audience absorption values and absorption coefficients determined in certain Harvard lecture rooms, to the estimation of the reverberation time with full audience in two concert halls, his estimates were far from the reverberation times actually measured (see Table III).

---


\(^2\) This formula was the first published in America by C. F. Eyring [J. Acoust. Soc. Am. 1, 217–241 (1930)]. However, it was presented prior to that time (1929) by Norris at a meeting of the Acoustical Society of America. Norris' derivation was published as an Appendix to Knudsen's monumental book, V. O. Knudsen, Architectural Acoustics (John Wiley & Sons, Inc., New York, 1932). However, Knudsen also refers to work by Waetzmann and Schuster [Ann. Physik 1, 671–695 (1929)] that predates Norris. Probably one should refer to this equation as the Waetzmann-Schuster-Norris-Eyring Equation. However, American convention, the author will simply call it the Norris-Eyring equation.


\(^7\) W. Furter, Raum- und Bauakustik für Architekten (Birkhäuser Verlag, Basel and Stuttgart, 1956).
Because a very small change in reverberation time, for example, from 1.5 to 1.6 sec (7%), is detectable by an experienced listener, the error (nearly 2:1) that can occur in calculations from the uncertainty in seat absorption is intolerably large.

In this paper the results of an extensive program of acoustical measurements in over 40 halls in fifteen nations are used to derive a more meaningful measure of audience absorption. Because all halls have nearly the same average absorption coefficient, it is convenient to use the simpler Sabine reverberation equation in the calculations. Later, the absorption coefficients so determined can be reduced by 9 to 12% to yield numbers suitable for use in the Norris-Eyring equation. In presenting the results in this paper, tables valid for each equation are given.

Because both the Sabine and the Norris-Eyring equations treat the sound field on a statistical basis, they only take the shape of a hall into account insofar as the ratio of \( V/S \) is concerned. Most of the halls studied in this paper have volumes in the range from 250 000 to 1 000 000 ft\(^3\). The median value of \( V/S \) for these halls is about 10 ft. Except for a very few cases, \( V/S \) lies between 9 and 11 ft.

For full audience and for halls with no added sound absorbing materials, and at frequencies below 1500 cps, Eq. (1) reduces approximately to \( T = 0.049 \times (V/N_1)(1/a_1) \). The classical postulate is that \( a_1 \) is a constant. In other words, audience absorption is taken to be proportional to the number of people in the audience. Hence, approximately, the reverberation time should be proportional to "volume per seat." Therefore, the ratio \( V/N_1 \) has been spoken of by writers (e.g., see footnote 13) as an important criterion for determining the maximum expected reverberation time. It is a simple enough matter to check the concept of "volume per seat" by plotting measured reverberation times for a number of halls vs volume per seat. The result is shown in Fig. 1. The correlation is very poor. For example, contrary to Eqs. (1) to (4), the same reverberation time of 1.6 sec was obtained in halls with volumes per seat ranging between 200 and 340 ft\(^2\)/seat or of 1.85 sec with volumes between 230 and 400 ft\(^2\)/seat.

Because of the scatter of the data, as shown in Fig. 1, many observers have speculated that the reverberation time in a hall depends in a major way on the shape of the hall, or on differences from one hall to another in the acoustical behavior of the same finish materials or both. If the shape of the hall changed the reverberation time as much as is indicated by Fig. 1, this would be in direct opposition to Eqs. (1) to (4) and the Sabine-Norris-Eyring approach would have to be abandoned or modified in a major way.

Believing that Eqs. (1) to (4) are fundamentally sound and that the acoustical absorption of the materials does not depend in a major way on the shape of the hall or on differences in materials from one municipality to another, the author proposes the postulate that: The absorbing power of a seated audience, chorus or orchestra in a large music hall increases in proportion to the floor area they occupy, nearly independently of the number of seated persons in that area (uniform distribution of persons assumed).

Since the time that this paper was first presented, it has come to the author's attention that Meyer and Jordan\(^4\) had shown that the reverberation time in the pre-World War II Berlin Philharmonie Saal was nearly unchanged whether the attendance at a concert was 50 or 100%, even though the seats were not highly absorbent. Their result yields independent support to the postulate given above.

The author wishes to emphasize, however, that the data in the present paper are for near-100% occupancy with seating densities (including aisles) between 4.5 and 8.5 ft\(^2\) per person. No study was made of partial occupancy. Orchestra densities varied between 12 and 20 ft\(^2\) per musician, including their instruments and music racks.

III. TEST OF NEW POSTULATE

To test the new postulate let us arbitrarily separate the absorption in a concert hall into two categories: (1) the audience, chorus, and orchestra absorption, and (2) the remaining absorption. If we now limit our studies to halls without any significant area of added porous sound absorbing materials, then, at least for frequencies of 500 cps and above, we should have a homogeneous set for study. A few of the halls so selected had some of their surfaces made of acoustically flexible materials such as thin wood paneling, which are effective in absorbing sound at the lower frequencies. By assigning suitable absorption coefficients to those surfaces, these few halls were also included as part of the group (listed in Table VI) used for validating the new postulate.

To conform to the preceding stipulation, Eqs. (1) and (2) are rewritten:

\[
\tilde{\alpha}_{\text{Sab}} = 0.049(V/S)(1/T) - 4 m(V/S) 
\]

\[
\tilde{\alpha}_{\text{Sab}} = (STR \alpha_T + S_R \alpha_R)/S, 
\]

where \( S_T \) = the floor area (including aisle areas up to 3.5 ft in width\(^1\)) occupied by the audience, chorus, and the orchestra; \( S_R \) = the remaining surface areas of the room, including the undersides of the balconies; \( S = S_T + S_R \); \( \alpha_T \) = absorption coefficient for audience, orchestra and chorus for the floor area \( S_T \) occupied by them; \( \alpha_R \) = average absorption coefficient for all other surfaces of the room, including in that average the absorbing power of walls, ceiling, doors, ventilating grilles, glass areas, organ openings, statues, chandeliers, underbalconies, etc.

Equating the right-hand sides of Eqs. (5) and (6) remembering that \( S = S_T + S_R \) and assuming \( V/S \approx 10^{18} \) yields,

\[
20.4(ST_V/V)(\alpha_T - \alpha_R) + 2.04 \alpha_R + 81.6 m = (1/T). \quad (7)
\]

When \((1/T)\) of Eq. (7) is plotted vs \((ST_V/V)\), the result is a straight line, with a slope of \(20.4(\alpha_T - \alpha_R)\) and an intercept at \((ST_V/V) = 0\) of \(1/T = (2.04 \alpha_R + 81.6 m)\). Consequently, \( \alpha_T \) and \( \alpha_R \) can be determined.

Typical plots for 125, 250, 500–1000, 2000, and 4000 cps are shown in Figs. 2 to 6. Similar plots were made for halls with unoccupied upholstered seating of two types. The results of the entire study, yielding absorption coefficients for use in the Sabine equation, Eq. (1), are given in Table IV. The same results converted to absorption coefficients for use in the Norris-Eyring equation, Eq. (4), are given in Table V.

If the old postulate that \( V/N_t \) is roughly proportional to reverberation time were correct, then, of course, the points for the various halls would not fall on a straight line in Figs. 2 to 6 because the area per

\(^1\) In computing aisle areas, widths up to 3.5 ft (1 m) of aisles lying within audience areas are included. Also, a strip of aisle, 3.5 ft wide, around the edge of an audience area is included. No such allowance is made at the front edge of a balcony where the audience is seated against the balcony rail. If the aisles are wider than 3.5 ft the excess width is not included as part of the audience area. The reason for including the 3.5-ft width is diffraction of sound around the edges of the audience. One expects that a smaller width than this should be used for unoccupied seats—perhaps only about one-half as much.
seat (with aisles) varies between 4.6 and 8.0 ft². In that case either the shape of the hall or gross variability of sound absorption coefficients from hall to hall, or both, would have had to be introduced in the calculations. However, the points do determine straight lines and the intercepts are reasonable. It is true that due to the long extrapolation, any one intercept on Figs. 2-6 may be subject to some error. However, when graphs of \( \alpha_f \) and \( \alpha_R \) are plotted vs frequency with the ranges of uncertainty indicated at each frequency, lines can be drawn within the range bars that vary smoothly with frequency and in a manner consistent with other observations in the literature. These smoothed lines for \( \alpha_f \) and \( \alpha_R \) interact so that the results given in Tables IV and V are more accurate as a whole than one would judge from any one plot.

It is interesting to compare the results obtained from this study with those given in several books in the
literature. The table inserted on Fig. 2 shows that for the three groups of fourteen halls enumerated there, the group median area per seat ranges between about 5.0 and 7.8 ft$^2$ per seat (with aisles). Multiplication of these areas by $\alpha_T = 0.92$ yields sound absorption $a$ in sabins ranging between 4.6 and 7.2 for the Sabine formula (or by $\alpha_T = 0.82$ yields 4.1 to 6.4 sabins for the Eyring formula).

Knudsen and Harris\textsuperscript{12} and Beranek\textsuperscript{16} give coefficients (for use in the Norris-Eyring equation), applicable to relatively crowded seating, of 5.2 to 5.7 ft$^2$ per person. Furrer's number of 6.5, (for use in Sabine's equation) is applicable to quite comfortable seating of 7 ft$^2$/person. Note that if the calculated reverberation time of the hall is 1.8 sec, using the Norris-Eyring formula and an audience absorption of 4.5 sabins per person, and if the
The Sabine equation: \( T = 0.049V / (S\alpha_{ab} + 4mV) \).

**TABLE IV. Absorption coefficients of (1) occupied audience, orchestra and chorus areas; (2) unoccupied “average” well-upholstered seating areas; (3) unoccupied leather-covered thinly upholstered seating areas; (4) thin wood paneling areas with airspace behind; and (5) 1.0-in. thick damped plaster walls and ceiling or 1.5-in. thick wood walls. The numbers below are for use in:**

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Frequency, cps</th>
<th>Absorption coefficients, ( \alpha_{ab} )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Occupied audience, orchestra and chorus areas, ( S_T )</td>
<td>67</td>
<td>0.44</td>
</tr>
<tr>
<td></td>
<td>125</td>
<td>0.60</td>
<td>0.74</td>
</tr>
<tr>
<td></td>
<td>250</td>
<td>0.88</td>
<td>0.96</td>
</tr>
<tr>
<td></td>
<td>500</td>
<td>0.93</td>
<td>0.85</td>
</tr>
<tr>
<td></td>
<td>1000</td>
<td>0.70</td>
<td>0.64</td>
</tr>
<tr>
<td>2</td>
<td>Unoccupied “average” cloth-covered, well-upholstered seating areas (seats with perforated bottoms) ( S_T )</td>
<td>300</td>
<td>0.49</td>
</tr>
<tr>
<td></td>
<td>600</td>
<td>0.66</td>
<td>0.80</td>
</tr>
<tr>
<td></td>
<td>1000</td>
<td>0.88</td>
<td>0.82</td>
</tr>
<tr>
<td></td>
<td>2000</td>
<td>0.70</td>
<td>0.64</td>
</tr>
<tr>
<td>3</td>
<td>Unoccupied leather-covered upholstered seating areas</td>
<td>4000</td>
<td>0.58</td>
</tr>
<tr>
<td></td>
<td>6000</td>
<td>0.50</td>
<td>0.46</td>
</tr>
<tr>
<td>4</td>
<td>Thin (0.2 to 0.4-in. thick), wood paneling areas with airspace behind</td>
<td>125</td>
<td>0.44</td>
</tr>
<tr>
<td></td>
<td>250</td>
<td>0.54</td>
<td>0.60</td>
</tr>
<tr>
<td></td>
<td>500</td>
<td>0.62</td>
<td>0.58</td>
</tr>
<tr>
<td></td>
<td>1000</td>
<td>0.50</td>
<td>0.46</td>
</tr>
<tr>
<td></td>
<td>2000</td>
<td>0.46</td>
<td>0.42</td>
</tr>
<tr>
<td>5</td>
<td>1.0-in. damped plaster or thick (more than 1.5-in. thick) well-fitted wood walls (these absorption coefficients have averaged in them the absorption of usual doors, ventilating grilles, etc. in the room) ( S_R )</td>
<td>125</td>
<td>0.15</td>
</tr>
<tr>
<td></td>
<td>250</td>
<td>0.12</td>
<td>0.08</td>
</tr>
<tr>
<td></td>
<td>500</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td></td>
<td>1000</td>
<td>0.04</td>
<td>0.04</td>
</tr>
</tbody>
</table>

*The occupied areas include aisle widths up to, but not exceeding 3.5 ft. Orchestra areas include men, instruments, and music racks.*

**TABLE V. Absorption coefficients of (1) occupied audience, orchestra and chorus areas; (2) unoccupied “average” well-upholstered seating areas; (3) unoccupied leather-covered thinly upholstered seating areas; (4) thin wood paneling areas with airspace behind; and (5) 1.0-in. thick damped plaster walls and ceiling or 1.5-in. thick wood walls. The numbers below are for use in:**

<table>
<thead>
<tr>
<th>Item</th>
<th>Description</th>
<th>Frequency, cps</th>
<th>Absorption coefficients, ( \alpha_E )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Occupied audience, orchestra and chorus areas, ( S_T )</td>
<td>67</td>
<td>0.39</td>
</tr>
<tr>
<td></td>
<td>125</td>
<td>0.54</td>
<td>0.66</td>
</tr>
<tr>
<td></td>
<td>250</td>
<td>0.78</td>
<td>0.85</td>
</tr>
<tr>
<td></td>
<td>500</td>
<td>0.83</td>
<td>0.83</td>
</tr>
<tr>
<td></td>
<td>1000</td>
<td>0.75</td>
<td>0.71</td>
</tr>
<tr>
<td>2</td>
<td>Unoccupied “average” cloth-covered well-upholstered seating areas, (seats with perforated bottoms) ( S_T )</td>
<td>270</td>
<td>0.45</td>
</tr>
<tr>
<td></td>
<td>600</td>
<td>0.60</td>
<td>0.73</td>
</tr>
<tr>
<td></td>
<td>1000</td>
<td>0.80</td>
<td>0.75</td>
</tr>
<tr>
<td></td>
<td>2000</td>
<td>0.64</td>
<td>0.58</td>
</tr>
<tr>
<td>3</td>
<td>Unoccupied leather-covered upholstered seating areas</td>
<td>0.40</td>
<td></td>
</tr>
<tr>
<td></td>
<td>400</td>
<td>0.49</td>
<td>0.55</td>
</tr>
<tr>
<td></td>
<td>800</td>
<td>0.57</td>
<td>0.53</td>
</tr>
<tr>
<td></td>
<td>1200</td>
<td>0.46</td>
<td>0.42</td>
</tr>
<tr>
<td>4</td>
<td>Thin (0.2 to 0.4-in. thick), wood paneling areas with airspace behind</td>
<td>380</td>
<td>0.38</td>
</tr>
<tr>
<td></td>
<td>760</td>
<td>0.19</td>
<td>0.055</td>
</tr>
<tr>
<td></td>
<td>1520</td>
<td>0.045</td>
<td>0.035</td>
</tr>
<tr>
<td>5</td>
<td>1.0-in. damped plaster or thick (more than 1.5-in. thick) well-fitted wood walls (these absorption coefficients have averaged in them the absorption of usual doors, ventilating grilles, etc. in the room) ( S_R )</td>
<td>130</td>
<td>0.13</td>
</tr>
<tr>
<td></td>
<td>260</td>
<td>0.11</td>
<td>0.07</td>
</tr>
<tr>
<td></td>
<td>520</td>
<td>0.045</td>
<td>0.045</td>
</tr>
<tr>
<td></td>
<td>1040</td>
<td>0.035</td>
<td>0.035</td>
</tr>
</tbody>
</table>

*The occupied areas include aisle widths up to, but not exceeding 3.5 ft. Orchestra areas include men, instruments, and music racks. The values in rows 1 to 3 include the absorption of a reflective floor beneath the seats. Carpet under the seats will not affect the values in row 1. The increase in absorption for row 2 will not be great.*
Fig. 7. Plot for 500-1000 cps of decrease in reverberation time with full occupancy as a function of empty reverberation time. All types of seats ranging from folding steel chairs (No. 24) to exceptionally heavily upholstered seats (Nos. 3A and 16) and all shapes and volumes of halls are included. Halls Nos. 13, 19, 21, 23, 25, 26, and 27 are rectangular and very similar in shape and construction. Hall No. 19 was recasted and the empty reverberation time changed from 3.5 sec to 2.4 sec (points 19A and 19B).

and 2000 cps. As shown by the curves, the incremental differences are about the same between 250 and 2000 cps. At higher frequencies, where air absorption becomes more important, the differences should be less.

VI. SEAT DESIGN

An interesting discovery was made during the studies of unoccupied halls. It was found that in eight of the halls an unexpected absorption “peak” occurred in the vicinity of 250 cps. The reverberation times for these empty halls are shown in Fig. 10. A study of each of these halls reveals that the principal reason for this unexpected absorption peak is the seats. It is found that the seat bottoms are not perforated and the cloth covering (upholstery material) is nearly impervious to air flow, causing a sort of “bubble resonance.”

An attempt was made to correlate the scatter of points on the graphs leading to line 2 of Table IV (or line 2 of Table V) with the detailed construction of the well-upholstered seats. There was no correlation even though the seats have a large range in exposed area of upholstery material. One explanation for this result is that the larger upholstered seats are generally spaced more widely apart so that fewer of them are required to produce the “area” absorption coefficients of Tables IV and V. This study also indicated that, except for eliminating the peak in absorption shown by Fig. 10, perforated bottoms had little effect on the absorbing efficiency of well-upholstered seats.

The author does not mean to say that a careful study made in one hall would not show differences in the area absorption coefficients due to differences in details of seat construction, but the differences certainly are not outstanding enough to show up in comparisons made among seating areas in the different halls studied here.

| Table VI. Test of absorption coefficients of Table IV for 21 halls with full audience. All values in the tables are in sec. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Hall no. | 500-1000 cps | 125 cps | 2000 cps | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 1.4 | 1.7 | +0.1 | 1.6 | 1.8 | +0.2 | 1.8 | 2.0 | +0.2 | 2.0 | 2.2 |
| 2 | 1.5 | 1.8 | +0.3 | 1.7 | 1.9 | +0.2 | 2.0 | 2.2 | +0.2 | 2.2 | 2.4 |
| 3 | 1.4 | 1.6 | +0.1 | 1.6 | 1.8 | +0.2 | 1.8 | 2.0 | +0.2 | 2.0 | 2.2 |
| 4 | 1.6 | 1.9 | +0.3 | 1.8 | 2.0 | +0.2 | 2.0 | 2.2 | +0.2 | 2.2 | 2.4 |
| 5 | 1.5 | 1.6 | +0.1 | 1.7 | 1.8 | +0.2 | 1.9 | 2.1 | +0.2 | 2.1 | 2.3 |
| 6 | 1.5 | 1.7 | +0.2 | 1.7 | 1.9 | +0.2 | 1.9 | 2.1 | +0.2 | 2.1 | 2.3 |
| 7 | 1.6 | 1.8 | +0.2 | 1.8 | 2.0 | +0.2 | 2.0 | 2.2 | +0.2 | 2.2 | 2.4 |
| 8 | 1.7 | 1.9 | +0.3 | 1.9 | 2.1 | +0.3 | 2.1 | 2.3 | +0.3 | 2.3 | 2.5 |
| 9 | 1.8 | 2.0 | +0.2 | 2.0 | 2.2 | +0.2 | 2.2 | 2.4 | +0.2 | 2.4 | 2.6 |
| 10 | 1.8 | 2.0 | +0.2 | 2.0 | 2.2 | +0.2 | 2.2 | 2.4 | +0.2 | 2.4 | 2.6 |
| 11 | 1.9 | 2.1 | +0.3 | 2.1 | 2.3 | +0.3 | 2.3 | 2.5 | +0.3 | 2.5 | 2.7 |
| 12 | 2.0 | 2.2 | +0.4 | 2.2 | 2.4 | +0.4 | 2.4 | 2.6 | +0.4 | 2.6 | 2.8 |
| 13 | 2.1 | 2.3 | +0.5 | 2.3 | 2.5 | +0.5 | 2.5 | 2.7 | +0.5 | 2.7 | 2.9 |
| 14 | 2.2 | 2.4 | +0.6 | 2.4 | 2.6 | +0.6 | 2.6 | 2.8 | +0.6 | 2.8 | 3.0 |
| 15 | 2.3 | 2.5 | +0.7 | 2.5 | 2.7 | +0.7 | 2.7 | 2.9 | +0.7 | 2.9 | 3.1 |
| 16 | 2.4 | 2.6 | +0.8 | 2.6 | 2.8 | +0.8 | 2.8 | 3.0 | +0.8 | 3.0 | 3.2 |
| 17 | 2.5 | 2.7 | +0.9 | 2.7 | 2.9 | +0.9 | 2.9 | 3.1 | +0.9 | 3.1 | 3.3 |
| 18 | 2.6 | 2.8 | +1.0 | 2.8 | 3.0 | +1.0 | 3.0 | 3.2 | +1.0 | 3.2 | 3.4 |
| 19 | 2.7 | 2.9 | +1.1 | 2.9 | 3.1 | +1.1 | 3.1 | 3.3 | +1.1 | 3.3 | 3.5 |
| 20 | 2.8 | 3.0 | +1.2 | 3.0 | 3.2 | +1.2 | 3.2 | 3.4 | +1.2 | 3.4 | 3.6 |
| 21 | 2.9 | 3.1 | +1.3 | 3.1 | 3.3 | +1.3 | 3.3 | 3.5 | +1.3 | 3.5 | 3.7 |

VII. REVERBERATION TIME vs FREQUENCY

CHARACTERISTIC

It is interesting to construct from the lines on Figs. 2 to 6 plots of reverberation time vs frequency, normalized to the mid-frequency value of reverberation time. This was done for a $T_{500-1000} = 1.35$ sec and $T_{500-1000} = 1.8$ sec, and the results are given in Fig. 11. The two curves shown are not expected to be alike, because the walls have a greater part in the total absorption in the room for the 1.8-sec case than for the 1.35-sec case. We see that the reverberation time for these fully occupied halls, on the average, decreases about 0.07 sec for each octave increase in frequency between 125 and 4000 cps.

VIII. COMMENT

One naturally asks whether it is reasonable that the absorption coefficient $a_R$ should be as low as 4 to 5%
at 500 to 2000 cps. A 5% value for $\alpha_R$ means that if the seats were removed from these halls the reverberation times would be about 10 sec at those frequencies. In one lecture room in Boston, with a volume of 65 000 ft$^3$, and wooden schoolroom chairs, a reverberation time of 5.6 sec at 500 cps has been measured. In still another, with a volume of 58 000 ft$^3$ and wooden benches, a reverberation time of 4.0 sec at 500 cps has been measured. Because the ratio of volume to total surface area ($V/S$) increases about as $V^1$, a room with 10 times the volume should have a reverberation time about twice those times just quoted, if the rooms are constructed of the same materials. Hence, 10 sec at 500 cps for an “unseated” hall of 600 000 ft$^3$ volume does not seem unreasonable.

If the “seatless” reverberation time were found to be lower than 10 sec, one possible explanation is shown by some measurements of Balachandran. He found that the absorption coefficient of an area in a room is a function of the state of diffusion of the sound field in that room. For example, he showed that at 2000 cps in his reverberation chamber the absorption coefficient of an area was diminished as absorbing materials were introduced on adjoining areas. A similar change in the state of sound diffusion must occur in a concert hall after the chairs are installed.

It is apparent, therefore, that the results of the present paper may not be applicable to small lecture rooms, classrooms, reverberation chambers and other rooms whose volumes, shapes and materials are significantly different from those of the large concert halls and opera houses included in the present study. Furthermore, common sense tells us that if the area per person increases much above 10 ft$^2$, the area absorption coefficients of Tables IV and V must decrease. An interesting confirmation of this statement has been reported to the author by Mr. Lyle F. Yerges, formerly of the U. S. Gypsum Company. They found, using a 7.5 sabin functional (hanging) absorber, that there was no measurable reduction in reverberation time when the units were uniformly spaced more frequently than one per 10 sq ft of ceiling area.

Prior to its submission for publication, the author sent this paper to a number of acousticians for comment. Two of them commented that the 125 cps absorption for the seated audience, $\alpha_T$, seems too high. Meyer and Kuttruff suggest in Acustica that $\alpha_T$ at 125 cps should be as low as 0.25 instead of 0.60. One reviewer commented that a value for $\alpha_R$ (the absorption for the remaining areas) of 0.12 at 125 cps is too high. Inspection of Fig. 6 and Eq. (7) shows that if either $\alpha_R$ or $\alpha_T$ is made smaller, the other must be increased. If $\alpha_T$ is as low as 0.25 at 125 cps then we find from Fig. 6 and Eq. (7) that $\alpha_R$ must also equal 0.25. Obviously, the walls and ceiling are not as absorbent as the audience so that $\alpha_T$ cannot be as low as 0.25. W. C. Sabine in his


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**Fig. 10.** Reverberation time (empty halls) vs frequency for halls in which a peak in seating absorption occurred at about 250 cps.

**Fig. 9.** Same as Fig. 7, but for 125 cps.

**Fig. 11.** Graphs of reverberation times relative to reverberation time at 500-1000 cps vs frequency. The two curves are for reverberation times at 500-1000 cps of 1.35 sec and 1.8 sec. The data are taken from the lines drawn on Figs. 2 to 6. These curves are valid only for halls without added porous sound absorbing material or thin wood paneling. They apply to halls with damped plaster or thick-wood interiors and for full occupancy.
careful pioneering measurements, performed in a lecture room (volume 60,000 ft³) at Harvard with and without audience found \( \alpha_T = 0.72 \) at 125 cps.

The author believes that in some halls where the plaster is on solid backing (brick, concrete block or poured concrete) \( \alpha_R \) may be less than 0.12, say, 0.10 at 125 cps. None of the 11 halls shown in Fig. 6 were of this type. Most had plaster walls that were "damped," i.e., did not ring when tapped with the knuckles.

IX. ACKNOWLEDGMENTS

The author wishes to express his deepest appreciation to fourteen scientists in foreign countries who assisted him in obtaining the data reported herein. Detailed credits will be given in the published book. He also wishes to thank those members of his own organization who participated in taking reverberation data in American halls and who gave helpful comments during the course of the work.
Drawings