AN ADDITION TO THE
ALBRIGHT ART GALLERY, BUFFALO, N.Y.

Submitted in partial fulfillment
of the requirements for the degree
Bachelor of Architecture

Massachusetts Institute of Technology
9 May 1960

Signature redacted
Richard Datther

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

In partial fulfillment of the requirements for the degree Bachelor of Architecture, I herewith submit my thesis, "An Addition to the Albright Art Gallery, Buffalo, N. Y."

Respectfully yours,

Richard Dattner

RD:mmm
ACKNOWLEDGEMENTS

I would like to thank Dean Belluschi, and Professors Beckwith, Brown, Catalano, Newman and Gelotte for their criticism and assistance; Professor Hansen of the Civil Engineering Department, without whose generous help the structural calculations would have been impossible; Mr. Gordon Smith, Curator of the Albright Art Gallery, for his assistance and interest; Miss Caroline Shillaber, librarian of the Architectural Library, for her help; Iris Moldaw and Jerry Judkins, whose smiling countenances provided a cheerful passage to and from the thesis committee meetings; David Paul for his assistance in the acoustical studies of the auditorium; and to the Massachusetts Institute of Technology for allowing me to graduate before the next raise in tuition fees.
DEDICATION

To that "torreador" who does not dance the beautiful movements or kneel for the crowd or swirl the cape to cover the empty space between him and the animal.

To that man who fights, in fear and in silence and in courage, close to the horns--where all is risked.
ABSTRACT

This thesis is divided into three parts. The first examines some general aspects of the art museum—such as its purpose, functions, and some problems in the consumption of its functions. The second part outlines the history and aims of the Albright Art Gallery. The program for the proposed addition is included in this section as well as an interview with the curator of the Gallery and a short description of the site. In the third section, the proposed solution is discussed.

The appendices discuss structure and acoustics.
The ultimate purpose of a museum is education--from the simple arousing of curiosity to the most scholarly research. The museum is much more than a storehouse of objects--it is a social instrument with great responsibilities toward the community which it serves. By preserving and presenting examples of man's highest achievements it stimulates new creation and freedom of ideas; it reminds us of our common humanity in all ages and is a positive force for the preservation of freedom.

"The antidote to cunning misinformation by emotion rousing posters and enslaving prejudices is honest science, popular symbolic art, and the growth of independent judgement. Museums are powerful visual instruments to bring these gifts to the public."¹

Museums are forces for understanding the present as well as the past. If presented properly, objects from the past provide insights into the ideas of our own time. To this end, the museum must do more than provide vast collections--it must actively collaborate with the work of art in stimulating and moving the beholder.

Our system of democracy depends on the education of the public. A museum has an obligation to the public and not merely to an intellectual elite. Our civilization is changing faster now than at any other time in history and museums must be ready to initiate man into the mysteries of his emerging civilization before ignorance and suffering destroy the world.

The civic art museum has three important functions. In the order of their importance these are:


2) The acquisition and preservation of objects.

3) The advancement of knowledge by the study of art objects.

The museum shares with the university and public media the task of educating the public. The most efficient use of our resources demands that each of these agencies, while collaborating to the fullest possible extent, perform the functions for which they are best suited.

Classes in art appreciation are best performed by the university, while in recent years television has become an important medium for the presentation of panel discussions, films, and other aspects of art education. In the near future, with the probable advent of a country-wide system of educational television, these programs will reach
an ever-increasing audience. However, both television and the lecture room must rely heavily on reproductions and facsimiles. The meeting of an individual and an original work of art is the realm of the museum.

The primary specific function of the museum is exhibiting art—bringing people and works of art together in a manner that will be both stimulating and rewarding. The works of art must be made to have reference to modern life if they are to have meaning to the general public. Since the museum is concerned with people and their understanding it must show that the art of the past and the present can be an inspiration as well as an aid in everyday life.

The challenge of exhibiting art is to provide for the imaginative showing of all the art forms which we are familiar with as well as any new media which may develop. Museums which display modern art face obsolescence unless they are flexible enough to house future art. (Which promises to manifest itself in a variety of sizes and forms.) Most of the American art museums which were built about the turn of the century presently face great problems in the exhibition of modern art.

There are two extreme approaches to the problem of flexibility. One possibility is the creation of a dominant architectural environment in which the art works are relegated to certain fixed locations and are essentially
immobile. The Solomon R. Guggenheim Museum by Frank Lloyd Wright is an example of this approach. Large canvasses are permanently excluded as is the possibility of variety in exhibition techniques. The architecture overpowers the individual work of art and competes for the viewer's attention. The alternate approach allows the works of art themselves to determine the scale and shape of their environment. This is analogous to a stage with facilities for the presentation of various performances, and calls for a flexible, architecturally anonymous environment.

One of the drawbacks of this "complete" flexibility is the problem of orientation. The complete absence of architectural points of reference makes it difficult for the visitor to find his way or grow familiar with the building. A great disparity then exists between the anonymous interior of the building and its exterior.

An ideal solution would combine great flexibility and a fixed architectural framework. The architecture would then be a bridge between the outside world of the viewer and the world of the work of art (much as the proscenium is to a stage performance).

The largest single factor in the inducement of museum fatigue seems to be the monotony of the museum surroundings. One solution is the creation of a very dynamic museum space. However, this is easily overdone at the ex-
pense of the art. A more satisfactory solution to the problem of monotony is the creation of a variety of spaces designed to provide a change of pace, a chance to pause and rest, etc. Flexibility is needed in the presentation techniques, the three-dimensional organization of spaces, and the circulation paths.

The perception and understanding of a work of art is a solitary task—for an instant the object and the viewer alone exist. In the ideal situation nothing distracts from this essential relationship. Yet this "flight" into the reality created by the object is only part of the process; just as important is the "return" to the reality of everyday life. It is then that the event is completed, evaluated, and fitted into a frame of reference. The feeling of community in a museum helps the individual to relate his individual experience to that of others. Both relationships have their place in a good museum.

One of the methods of preserving the link between the interior of a museum and the "outside world" is to allow some of the natural variation of daylight to be sensed in the museum. This lessens the psychological distance between art and everyday life. Some objects should also be displayed outdoors where they can be compared to the creations of nature. Artificial lighting should be used as a supplement to daylight—at night; when additional intensities...
are desired; to achieve special effects. Nighttime lighting should be sufficiently different from daytime lighting to provide an interesting contrast.
THE PROBLEM -

THE ALBRIGHT ART GALLERY
THE ALBRIGHT ART GALLERY

"The Albright Art Gallery is a public museum, open free at all times to the public. The Gallery is open daily from 10 A.M. to 5 P.M., except on Sundays and Mondays, when the hours are from 2 to 6 P.M. It is closed on Thanksgiving, Christmas and New Year's Day. The building, which is located on City land in Delaware Park, was dedicated in 1905, the gift of John J. Albright to The Buffalo Fine Arts Academy. It is built of white marble, its central feature based on the east porch of the Erectheum on the Acropolis at Athens. Eight monumental caryatid figures in marble symbolizing the arts, the work of Augustus Saint Gaudens, are installed on the east facade of the building. The Gallery is governed by 27 Directors, elected by the Life Members of the Academy for three-year periods.

"The major financial support of the Gallery comes from the City of Buffalo, which contributes approximately 65% of the operating funds. In addition the Gallery receives an annual grant from Erie County, and its limited endowment funds, the income from which may be used for building maintenance and general activities. All paintings and other works of art are purchased with the income from funds earmarked by their donors for this purpose.

"On the main floor there are 10 galleries for paintings and a large court with two transepts devoted to sculpture."
Also on this floor is the Sales Room, where art books, reproductions, post cards, note paper and Christmas cards are on sale.

"In the basement is located the Members' Room and kitchen, available to groups for meetings, small suppers, and teas. The Members' Gallery, sponsored by the Members' Advisory Council, is housed in the Members' Room and makes available to members, for rental or purchase, paintings, graphic arts, sculpture and crafts selected from the work of Western New York artists and from leading New York dealers.

"While the Albright Art Gallery's collection is particularly noted for its paintings of the 19th and 20th centuries, there is a group of outstanding English paintings of the 18th century, with unusually fine examples by Hogarth, Reynolds, Gainsborough, Romney and Lawrence. In the American room there are important works by Homer, Ryder, Eakins, Inness, Sargent, Harnett, Bellows and others. The 19th century French is well represented by Seurat, Cezanne, Gauguin, Daumier, Degas, Pissarro, Renoir, Sisley, and Toulouse-Lautrec; and from the 20th, there are three Picassos, also works by Kokoschka, Matisse, Rouault, Utrillo, Modigliani, Soutine, Braque, Chagall, Tamayo, Klee, Dufy, Leger, Mondrian, Kandinsky, de Chirico, Miro, Feininger, Metzinger, Kirchner, Gleizes, and LaFresnaye, as well as such Americans as Burchfield, Hartley, Rattner, Ben Shahn, and many others."
"In recent years, the Gallery has built up one of the most outstanding collections of modern paintings in the country. The Contemporary Art Collection, founded in 1939, includes, in addition to the works of the early 20th Century mentioned above, important examples of such leading artists of the present day as Pollock, Kline, deKooning, Gorky, Francis, Afro, Gottlieb, Nicholson, Rothko, Hofmann, Brooks, Guston, Motherwell, Okada, and Still.

"The Albright Art Gallery is well known for its collection of sculpture, which ranges from 3000 B.C. to the present, covering many countries and periods. Examples include African, Cambodian, Chinese, Egyptian, French Gothic, Greek, Indian, Italian Baroque, Javanese, Roman, and Mexican as well as 19th Century French, contemporary German, British, French, Italian and American sculpture.

"During the fall, winter, and spring seasons, the Gallery has frequently changing loan exhibitions of paintings, sculpture, industrial design, contemporary crafts, and occasionally antiques. Other activities include free public concerts on Sunday afternoons; weekly Sunday Gallery tours; evening lectures; demonstrations of various art techniques; luncheons, previews; dramatic presentations; and a subscription film series.

"The Gallery has a very active Educational Department. Bus loads of 6th grade school children come to the Gallery daily from the city and surrounding towns for a visit and
lecture. There are free lectures and discussion groups for adults; also, for the children, creative art classes including modeling and graphics and special holiday programs. The department has a very large collection of reproductions for teaching purposes, which are available for lending to schools, church groups, libraries, clubs and other organizations."  

The following is the program of needs for the new addition proposed:  

1) Auditorium

Approximately 350 seats. Should be equipped for film projection. To be used for lectures, films, concerts. It is desirable, but not necessary, that the auditorium be suitable for the presentation of small amateur and experimental theatre productions not requiring elaborate scenery and for small dance groups and chamber music ensembles.

Since the audiences at these events vary in size (from 100 to over 300), it would be helpful, if, in some way, the auditorium could be divided to accommodate smaller or larger groups.

2) Cafeteria and Lounge

This area is envisioned as a dual purpose, one providing for a lounge for members (and public) and to provide refreshments to visitors. A snack bar for 15 to 20 people and perhaps 5 or 6 tables to accommodate 25 to 30 people should be sufficient for ordinary daily use. On occasions, however, for special luncheons and for gallery suppers followed by talks as many as 150 should be seated in the entire lounge area.

2. Program courtesy of Skidmore, Owings & Merrill.
The thought is that perhaps one end of the room could be a snack bar and small cafeteria set off from a larger lounge area which when needed could be combined with it.

3) Kitchen

Suitable for needs outlined above (under 2).

4) Gallery

Approximately 2500 sq. ft. of additional gallery space is needed. This space should allow for complete flexibility of arrangement of paintings and sculpture possibly with the use of demountable partitions. This gallery space should be designed with the collection of contemporary art in mind particularly.

5) Storage

Approximately 1200 sq. ft. of additional storage space is needed. Cupboards and closets on the wall against which the racks would abut are desirable. Doors should be same height as ceiling. Paintings and sculpture of large dimensions (6' - 12' high) must be accommodated. Storage should be well ventilated. (It is hoped that this new storage area can be found adjacent to the present storage in old building and that packing, receiving, shipping, storage, can be centralized but with access to the new addition or annex.)

6) Rest Rooms and Cloakroom

New rest rooms for men and women are badly needed. Probably should be located near auditorium.

Cloakroom (or cloakrooms) to take care of audiences varying form 400 - 500 and, once or twice annually 1000 visitors.

7) Offices

The chief reason for requesting new offices is to move them from their present basement location to an above ground spot with light and fresh air. The administration offices should be accessible but also quiet and away from the flow of visitors.
The following are needed:

1. Reception and Director's Secretary - 600)
2. Director's Office 400)
3. Assistant Director's Office 350) 2,000
4. Assistant to the Director's Office 350)
5. Curator's Office 300)
6. A Conference Room is desirable. The offices need not be large (15' x 12'? ) especially if a room is provided for meetings of committees, for the presentation of paintings and other objects under consideration, etc. 500

Needs for the present building:

1) Hemicycle

The old auditorium (seating 144) which has been condemned, should be converted to other use. The shape and height of this area presents a problem.

2) Library

Present location of the Library in Gallery 16 occupies needed gallery space. It is hoped that a new location can be found possibly in the basement for the library which is used only by the staff, gallery members and qualified students. The space now occupied by the offices has been suggested.

3) Sculpture Court

Needs refurbishing and possibly new lighting.

4) Basement

A study of the whole basement area with a view to eliminating waste space is needed. Additional storage areas could probably be designed from existing space.

The following interview was held with Gordon Smith, the curator of the Albright Art Gallery on December 22, 1959:

interview with Gordon Smith
1) The philosophy of the Albright Art Gallery

The Albright is primarily interested in educating the public of the Western New York area. This education process includes such activities as special exhibitions, guided tours, art films, lectures and school programs. The Gallery limits its acquisitions to painting and sculpture. It aims at becoming an excellent medium-sized museum and toward that end a small collection of first rate examples of painting and sculpture is preferred to a larger collection of second rate examples. Travelling exhibits are often presented by the Gallery.

2) Flexibility

Flexibility in the new addition is of the greatest importance. At the present time when a travelling exhibit is installed it means that a complete wing is taken out of service for several months before and after the exhibit for purposes of alteration.

Quite a few functions occur in the main sculpture court: annual banquets, concerts, etc., and this necessitates complete removal of the sculptures for each event.

The new addition should have facilities for flexibility so that the existing museum could house the more permanent collection while the addition accommodates travelling exhibits, work on loan and special functions.

3) Lighting

At present the museum uses a mixture of natural and artificial lighting. It has a need for greater flexibility in the lighting arrangement.

4) An auditorium

Perhaps the greatest need of the museum is an auditorium on the premises. The museum supports a program of lectures and art films which now take place in the sculpture court. Chamber music concerts also take place in the sculpture court and would use the proposed auditorium. These functions are important in that they acquaint people with the Gallery.

5) The library

The existing auditorium has been condemned and plans exist to convert it into a library. This would allow
the existing library to be used as exhibition space. The semi-circular form of the old auditorium seems well suited for use as a library and allows an efficient shelf layout. The location would allow persons to use the library independently from the museum proper.

6) Curator's office

This office would ideally be located on the exhibition level where the curator would be accessible to the public to answer questions, etc. This might also be desirable for the other staff offices since a very limited staff is available and they could thus more easily devote some of their time to the general public.

7) Television facilities

It has been found by experiment that the location of the Albright does not allow TV programs to originate there, due to transmitting difficulties. Any TV programs would have to be filmed or taped and re-broadcast from station headquarters.

8) A sculpture garden

The Gallery sculpture collection is extensive and rather cramped at present. An outdoor sculpture court would be very welcome.

9) The museum axis

The axis could be a powerful means of integrating the new addition to the existing building. This is especially important to a visitor entering the museum for the first time.

10) Size of the proposed addition

A doubling of the existing facilities seems reasonable with provision for some further expansion. The museum does not wish to grow too large but does not plan to fix its size at the present time.

Buffalo itself is a strange mixture of visual impressions. The Prudential Building of Louis Sullivan, five houses and the Larkin Building by Frank Lloyd Wright, and several homes by McKim, Mead & White were built near the
turn of the century. At this time, also, the most beautiful residential areas appeared. Buffalo is very proud of its numerous elm-lined streets and stately old homes. Today, Buffalo is a sprawling industrial center—characterized by miles of suburban developments. Many fine old homes are being replaced by "modern" office buildings. (These are mostly two or three story affairs of brick and curtain wall.) The finest modern building in the city is the Kleinhans Music Hall by the elder Saarinen.

The Albright Art Gallery is located in Delaware Park—the site part of the site of the Pan-American Exposition of 1900. The Albright overlooks Delaware Park Lake and can be seen from one of the main streets of Buffalo (which passes the opposite side of the lake, about two-thirds of a mile away). To the north, and also overlooking the lake, is the Historical Museum. This museum was originally one of the buildings of the 1900 Exposition and was preserved to house relics of local history. The two museums form one of the traditional sights of the city. The magnificent steps of the Albright are used for outdoor concerts every summer. Directly south there is a large municipal greenhouse which has been condemned and will shortly be dismantled. The Buffalo State Teachers College is to the west across Elmwood Avenue. There is a bus line on this street which stops directly behind the museum.
The following is an excerpt from the Buffalo Express of March 8, 1905 announcing the coming dedication of the Albright:

"Certainly the white marble palace, with its environment of fresh, green foliage and velvety grass terraces, rising above an assemblage of people in the fresh gaiety of early summer costumes should constitute a picture not soon to be forgotten. The view from the gallery, out over the lake, will be one which many a visitor will take away in his mind and will remember with pleasure."
THE SOLUTION
The addition to the existing building must have an integrity of its own rather than mirroring the old museum.

Inherent in the building are the essential services—lighting, ventilation, etc. These have an important role in the total organization of the spaces. Structure, form, services are not separate problems—a space cannot be separated from how it is made and how it is serviced. The tenets of "form follows function" and more recently "function follows form" only exist when the two concepts are separated. In all great architecture there is no such disparity.

The new building is annexed to the west side of the existing museum. To accomplish this, the existing hemicycle (which has been condemned) will be removed. Two open courts are formed between the two buildings for the exhibition of sculpture. The south court will also have facilities for outdoor luncheons. Both courts will be protected by low screens along their open sides. The entrance to the addition shall be on the main axis.

The greenhouse presently to the south has been condemned and will be replaced by a parking lot with access for automobiles from Elmwood Avenue and Lincoln Parkway. The east elevation of the existing building, the monumental stairs and the fountain are to be left unchanged.
The two buildings are linked by the new auditorium. Two exhibition wings center about a sculpture court and will be used mainly for temporary exhibitions with the bulk of the permanent collection remaining in the old building. The wings are column-free spaces measuring 80' x 80' on a level five feet higher than the main court level. These spaces may be subdivided to suit each particular exhibition with movable partitions.

On a level five feet below that of the sculpture court are the offices of the curator and the museum staff, the library, lounge, and print gallery, snack bar (with access to the outdoor court), rest rooms and cloak rooms. The lounge and print room are convertible into a large hall for banquets and special museum events.

Directly under the sculpture court are the sliding racks for painting storage, unloading space, and dressing rooms with access to the auditorium. This level is linked to the basement of the existing museum. Two large freight elevators facilitate the transfer of large or heavy objects.

The basement of the old building will be used for the storage of art works which need not be readily accessible, for mechanical services and restoration facilities.

Trucks will unload under the entrance platform on the Elmwood Avenue side. Musicians, performers and employees may also arrive by this entrance. Art works and exhibits may be taken directly up the elevators or stored. A small
platform elevator in the stage of the auditorium will allow pianos and other large instruments to be brought up to the stage.

In the exhibition wings, full height (18') temporary partitions may be installed anywhere on the twenty-foot truss grid. They may be held on by devices that expand against the floor and the truss. Small, standing or hanging partitions may be installed anywhere in the space. The partitioned spaces may be further altered by raising the floor level with platforms or hanging a ceiling from the main structure.

Daylight is supplied by two skylights along the east and west edges of the wings and by a ten foot deep trough extending along the center of each wing. Artificial lighting may be hung almost anywhere in the deep roof truss.

The structure consists of precast, pretensioned concrete Virendeel trusses, 10' deep and 80' long. These are braced laterally by precast concrete sections at 20' intervals. The entire structure is then post-tensioned to provide continuity.

A more detailed structural analysis will be found in Appendix A.
APPENDIX A

STRUCTURAL CALCULATIONS
APPENDIX A

Approximate calculation for the determination of sizing for a typical structural member.

Loads for calculation:

1) Roof slab - 4" reinforced concrete, lightweight.
   a) Dead load = 36# / sq. ft.
   b) Live load = 40# / sq. ft. (N. Y. Building Code)
   c) Roofing - built up 4-ply with gravel = 5.5# / sq. ft.
   Total roof load = 81.5# / sq. ft.
   No reductions allowed in this design load.

2) Hung floor slab - 4" reinforced concrete, lightweight.
   (supporting only lights, ducts, occasional repairmen).
   a) Dead load = 36# / sq. ft.
   b) Live load = 40# / sq. ft.
   Total hung floor load = 76# / sq. ft.
   Reduction is allowed in the design live load (N. Y. Building Code).

\[
R = 100 \times \frac{D + L}{4.33 \times L} \\
100 \times \frac{76}{4.33 (40)} = 44\% \\
40# - 17.5# = 22.5# Live Load \\
Total hung floor design load = 58.5# / sq. ft.
\]
3) Weight of spacer truss - lightweight concrete:

\[ = (14)(2.25) + (2)(9.5)(2.25) \]

\[ = 31.4 + 42.7 \]

\[ = 74.1 \text{ cu. ft. of concrete} \]

\[ 74.1 \times 10^8 = 8000\# \]

**Total weight of one unit = 8000\#**
Assume loads distributed equally between top and bottom chords:

Consider member B-C fixed at both ends:

\[ L = 17.5' \]

\[ M = \frac{L}{2} (11K) = 96K \text{ ft.} \]

Consider member A-B fixed at both ends:

\[ M = \frac{L}{2} (33K) = 268K \text{ ft.} \]
Member C-H:

\[ M_1 = M_2 \]
\[ M_3 = M_4 \]
Forces in C-H are negligible

Member B-G:

\[ M = 288 + 96 \]
\[ M = 384 \text{K ft.} \]
\[ \text{Shear (S)} = \frac{384}{3.5} \]
\[ S = 110 \text{K} \]
Member A-F:

M = 375K ft.
C = 50K

Due to symmetry considerations:
A-B = D-E = F-G = I-J
A-F = E-J
B-G = D-I
B-C = G-H = C-D = H-I
Diagram of moments in the truss:
Truss treated as a simple beam for calculation of tension and compression in top and bottom chords:

\[
\begin{align*}
(22K)(40) &+ (60K)(20) - (104)(40) = M \\
880K &+ 1200K - 4160K &= M \\
M &= 2080K \text{ ft.} \\
2080K/10 &= 208K = F_2 = F_3 \quad \text{(in B-C at C)} \\
(22K)(20) &+ (60K)(10) - (104)(20) = M \\
440K &+ 600K - 2080K &= M \\
M &= 1040K \text{ ft.} \\
1040K/10 &= 104K = F \quad \text{(in A-B at B)}
\end{align*}
\]

We will check members A-B and B-G as they represent the extreme cases of stress.

Extreme fiber stress allowable in the concrete: \( f = 2500 \text{#} / \text{sq. in.} \)

Due to prestressing, the entire section of the concrete may be used in compression.

We will assume a section measuring 18" x 18" and check it.
Member A-B at B:

\[ C \text{ psi} = \frac{10^4,000}{324} = 320 \text{ psi} \]

\[ M = 288 \text{ (12)} = 3460 \text{K in.} \]

\[ F_1 = \frac{3460}{10} = 346 \text{K} \]

\[ 2.18 \text{ (18)(19)} = 354 \text{K} \]

\[ 354 \text{K} > 346 \text{K} \]

Therefore the cross section is correct.

Member B-G at B:

\[ M = 384 \text{K ft.} \]

\[ C = 22 \text{K} \]

\[ F_1 = 2500 - \frac{22,000}{288 + 414} = 2500 - 31.4 = 2468.6 \text{# / sq. in.} \]

\[ 384 \text{K (12)} = 4620 \text{K in.}, 4620 \text{K}/25 = 184 \text{K} \]

\[ (2.468)(17)(21) = 880 \text{K} \]

\[ 880 \text{K} > 184 \text{K} \]

This section is ample to carry the load.
Construction Procedure:

The basement floor slab will act as a footing for the main columns and secondary columns (with extra thickness or reinforcement at the point of contact). Prestress wires will be embedded in the floor slab and the columns will be lowered over these wires by a crane. Two of the six sets of wires will be immediately stressed to make the columns rigid. The secondary columns will be erected in the same manner and the floor slab then poured.

The 80' precast trusses are now erected. They will be seated over the remaining four wires and a preliminary stress will be applied to secure the truss firmly. Where two trusses butt they will be post-tensioned to obtain continuity.

The spacer trusses are now: a) bolted into sets of two, in the case of the interior pairs, and seated; b) bolted directly to the main trusses in the case of the cantilevered spacers. All the spacer trusses are now post-tensioned. The hung floor slab and the roof slab are now poured in situ.
APPENDIX B
ACOUSTICAL CALCULATIONS
APPENDIX B - ACOUSTICAL CALCULATIONS

Reverberation times for 150,000 cubic feet volume room:

\[
T = 1.4 \quad \text{Opera}
\]

\[
1.4 \quad \text{Radio music studio}
\]

\[
1.8 \quad \text{Organ music}
\]

\[
1.4 - 1.6 \quad \text{Concert auditorium}
\]

A reverberation time of 1.5 seconds will be used.

\[
T = \frac{(0.05)(150,000)}{A}
\]

\[A = \text{absorption units}\]

\[T = \text{reverberation time}\]

\[
A = \frac{(0.05)(150,000)}{1.5} = 5000 \text{ sabins} \quad \text{(at 500 cps)}
\]

\[
\text{limit at 125 cps is } \quad 3560 \text{ sabins} \quad (1.4 \times T \text{ at 500 cps})
\]

\[
\text{limit at 2000 cps is } \quad 4160 \text{ sabins} \quad (1.2 \times T \text{ at 500 cps})
\]

The graph on the following page lists the materials used and the total absorptive units.
<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>( S )</th>
<th>( a_1 )</th>
<th>( a_2 )</th>
<th>( a_3 )</th>
<th>( A_1 )</th>
<th>( A_2 )</th>
<th>( A_3 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>AISLES - carpet with hair felt underlay</td>
<td>1040</td>
<td>0.60</td>
<td>0.11</td>
<td>0.80</td>
<td>624</td>
<td>104</td>
<td>832</td>
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<tr>
<td>SIDE WALL - wood panels</td>
<td>4800</td>
<td>0.06</td>
<td>0.08</td>
<td>0.06</td>
<td>288</td>
<td>384</td>
<td>288</td>
</tr>
<tr>
<td>CEILING - concrete unpainted</td>
<td>3840</td>
<td>0.02</td>
<td>0.01</td>
<td>0.02</td>
<td>77</td>
<td>38.4</td>
<td>77</td>
</tr>
<tr>
<td>STAGE FLOOR - wood</td>
<td>1100</td>
<td>0.03</td>
<td>0.05</td>
<td>0.03</td>
<td>33</td>
<td>55</td>
<td>33</td>
</tr>
<tr>
<td>STAGE REAR WALL LOWER - wood</td>
<td>800</td>
<td>0.06</td>
<td>0.08</td>
<td>0.06</td>
<td>48</td>
<td>64</td>
<td>48</td>
</tr>
<tr>
<td>STAGE REAR WALL UPPER - f. glass</td>
<td>450</td>
<td>0.72</td>
<td>0.12</td>
<td>0.80</td>
<td>324</td>
<td>54</td>
<td>360</td>
</tr>
<tr>
<td>REFLECTING CLOUDS - plaster</td>
<td>650</td>
<td>0.03</td>
<td>0.02</td>
<td>0.04</td>
<td>19.5</td>
<td>13</td>
<td>26</td>
</tr>
<tr>
<td>SEATS - audience</td>
<td>2800</td>
<td>0.88</td>
<td>0.60</td>
<td>0.93</td>
<td>2460</td>
<td>1680</td>
<td>2600</td>
</tr>
<tr>
<td>STAGE SIDE WALLS - wood</td>
<td>800</td>
<td>0.06</td>
<td>0.08</td>
<td>0.06</td>
<td>48</td>
<td>67</td>
<td>48</td>
</tr>
<tr>
<td>REAR WALL - 2'' roll f. glass</td>
<td>1340</td>
<td>0.81</td>
<td>0.70</td>
<td>0.79</td>
<td>1085</td>
<td>940</td>
<td>1060</td>
</tr>
<tr>
<td>PROJECTION BOOTH - 2'' roll f. glass</td>
<td>175</td>
<td>0.80</td>
<td>0.70</td>
<td>0.79</td>
<td>140</td>
<td>122.5</td>
<td>138</td>
</tr>
<tr>
<td>TOTAL</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5136.5</td>
<td>3521.9</td>
<td>5510</td>
</tr>
</tbody>
</table>

\( S \) = area of material used  
\( a_1 \) = sound absorptive coefficient at 500 cps  
\( a_2 \) = sound absorptive coefficient at 125 cps  
\( a_3 \) = sound absorptive coefficient at 2000 cps  
\( A_1 \) = total absorptive units in sabins at 500 cps  
\( A_2 \) = total absorptive units in sabins at 125 cps  
\( A_3 \) = total absorptive units in sabins at 2000 cps  

Side walls will be treated to eliminate flutter by slight canting.  
Reflective clouds will be mounted eccentrically.
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