The O'Keefe Centre for the Performing Arts

Toronto

BY EARLE C. MORGAN AND FORSEY PAGE

IF any architect feels envious of an auditorium commission such as O'Keefe's let his envy be for the satisfaction of doing an unusual and interesting job, one that may come only once in a lifetime, if ever, but not for the commission profit because the time required bears little relation to the time required for the usual buildings done by architects.

The commission was given to Earle C. Morgan early in March of 1956, with the appointment of Page & Steele as joint architects coming within the following two weeks. The building was open to the public October 1, 1960, which means that four and one-half years of the two architectural firms' time has been devoted, to a large extent, to this project.

By the Fall of 1956 work had progressed beyond the preliminary stage and it was decided that a separate office should be established specifically for this project. This separate office was maintained until after the main contract, for the superstructure, was let in March of 1958. A site office was established with the letting of the contract and, for nearly a year, consisted of a staff of six architectural, three structural, three mechanical and two electrical employees. During the second year of construction this on-the-site staff gradually decreased but even during the last six months there was a site architect and one assistant on the job full time.

The demolition contract for existing buildings on the site was let during the Autumn of 1957 for completion by the end of the year and by September, 1957, working drawings had progressed to the point where it was practical to let an excavation contract by tender to the Pigott Construction Company. This contract subsequently was extended to include some foundation work.

Tenders were called for the superstructure early in 1958 and the contract awarded to Anglin-Norcross (Ontario) Limited, on March 8th, 1958, with a completion date set for the Fall of 1959. The general strike of that year eliminated any possibility of such an early completion date, and missing an Autumn opening in one year meant that the opening had to be postponed to the following year because of the theatre seasons. As it happened, the full extra year was required and, without tremendous effort, even that date would not have been met.

The owners' original concept was a civic centre on the two properties north and south of Front Street from the

Architects
Earle C. Morgan and Page & Steele
Toronto

Consultants

Structural
M. S. Yolles & Associates, Toronto

Mechanical
G. Granek & Associates, Toronto

Electrical
Jack Chisvin & Associates, Toronto

Acoustical
V. L. Henderson, Toronto

Interior Decorating
T. Eaton Company
Robert Simpson Company

General Contractors
Anglin-Norcross (Ontario) Ltd
Toronto

Esplanade to Wellington Street, with an auditorium, concert hall, legitimate theatre, exhibition space, as much open park space as possible and a large office building to help defray the cost of operating an auditorium. The so-called "tight money" situation changed these plans and it was decided to do only one building, which would include a large auditorium, a small legitimate theatre and enough exhibition space to attract conventions and exhibitors similar to the Colosseum Building in New York.

The next problem was to decide whether this single building should be placed north or south of Front Street. The property south of Front Street is a little larger and has the added advantage of a slope of some nine feet from north to south, which allows a floor under the auditorium, largely at grade level. We proceeded with intensive studies for the development of the south property, but our studies soon showed that the requirements were a little too much for that property and undoubtedly would exceed the budget set by the owners. Gradually the exhibition space dwindled to elimination and after several months more of study the small, separate legitimate theatre had to be abandoned, mostly because of cost but also because it was crowding other essential elements in the building.

The loss of the legitimate theatre was a staggering blow and we made a serious attempt to make the large auditorium as flexible as possible, but we know this can never be completely successful. We have facilities for cutting out the rear half of the orchestra seats but, without being able to bring in the side walls and lowering the ceiling, this will not make it an ideal legitimate theatre.

All architecture beyond a one-man office is a matter of team work and this building must have had one of the largest teams ever employed on a building in Canada. The owners, in their earnest desire to provide the best, required and provided United States consultants to cooperate with our Canadian consultants for acoustics and mechanical engineering, and provided stage and stage lighting consultants, also from the United States. We provided the architectural consultant in the firm of Eggers & Higgins of New York at the beginning of the job, when the concept was a civic centre, but the need for this consultant diminished with the scheme. We are none the less grateful to Mr Ted Young, the present head of that firm, who is himself a University of Toronto graduate.

It should be clear that this whole scheme and its requirements was fluid for a long time and that should explain the two-year period from the beginning of sketch drawings to the letting of the main contract. More than one full year was devoted to studies and to the actual examination of such buildings as the Royal Festival Hall, London; The State Opera House, Vienna; the Ford Auditorium, Detroit; Severance Hall, Cleveland; the Shakespeare Memorial Theatre, Stratford-on-Avon, England, and numerous others, before working drawings were started. The amount of crumpled and discarded paper on this job has been staggering, but it has been an experience that none of us would have missed and, if the building is successful, the satisfaction will more than make up for all the time, trouble, frustration and expense involved.

The statistics of the building and articles by consultants can be found in other places in this issue. This is an attempt to give our fellow architects some idea of our problems in the design of a building as complex as this. The Queen Elizabeth Building at the Canadian National Exhibition provided some useful experience, but the difference in seating capacity, from 1,200 to 3,200, presented problems of sight-lines, distance from the stage, acoustic requirements, sound amplification, etc., not previously encountered. In the O'Keefe Centre every seat has an unobstructed view and no seat in the house is further from the stage than 124 feet.

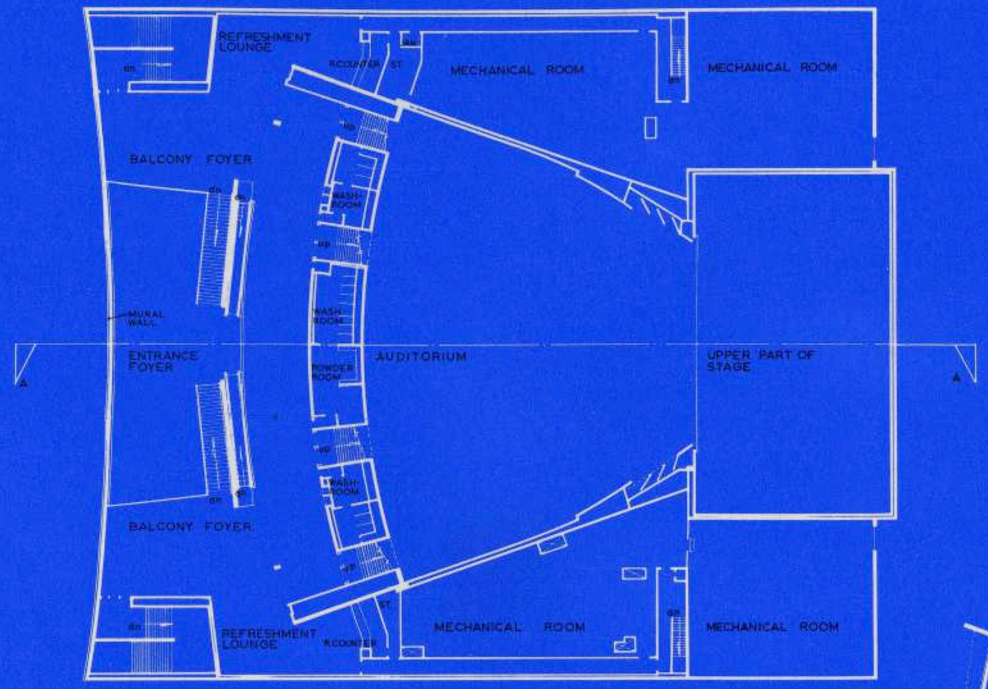
The seats themselves are patterned after those of the Royal Festival Hall, as is also the very liberal area devoted to main foyer, mezzanine foyer, side lounges and lower level main lounge. This vast circulation space should come as a pleasant surprise to Toronto theatre goers, who have not enjoyed that luxury in the past.

The selection of materials for a building intended to last for a long time is in itself a serious problem. The elimination of the smoke producing steam engines on the nearby main line railway, together with the City's determination to curtail smoke nuisances, generally encouraged the use of the Alabama limestone exterior. The owners' preference for bronze trim, doors, cladding, etc., and their intention to see that doors and trim are kept in a bright condition, influenced the choice of that timeless material. Our acoustic consultants were firm in their opinion that there is no substitute for wood for auditorium walls and although the fireproofing of that material, in a manner that would not reduce its acoustic properties nor mar its natural wood finish, presented a new set of problems, nevertheless these problems were overcome after exhaustive experiments.

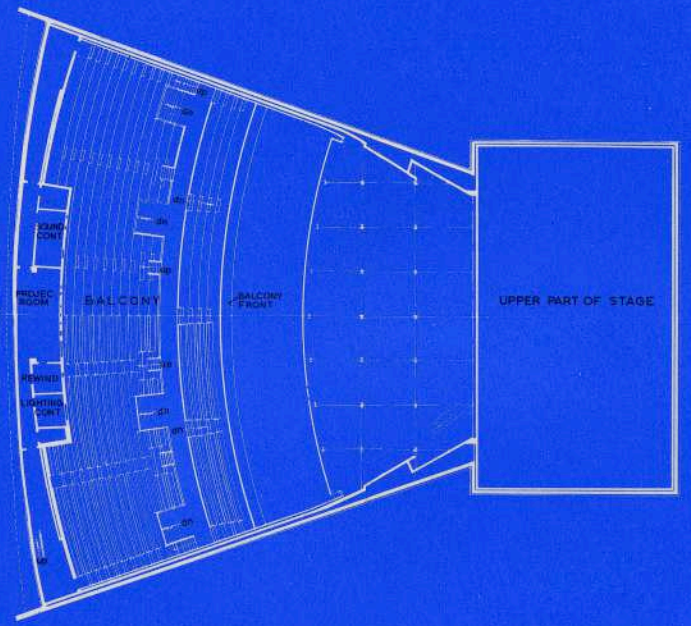
Admirers of beautiful marble, and that includes most people, will appreciate the wide use of that enduring material and the skill with which it has been matched. All the marble was selected personally in the quarries in the mountains of Carrarra, Italy, the very quarries that were worked by the Romans 2000 years ago and to which Michaelangelo journied to select blocks of marble for his famous sculpture which is still the pride of Florence and Rome.

THE O'KEEFE CENTRE FOR THE PERFORMING ARTS, TORONTO

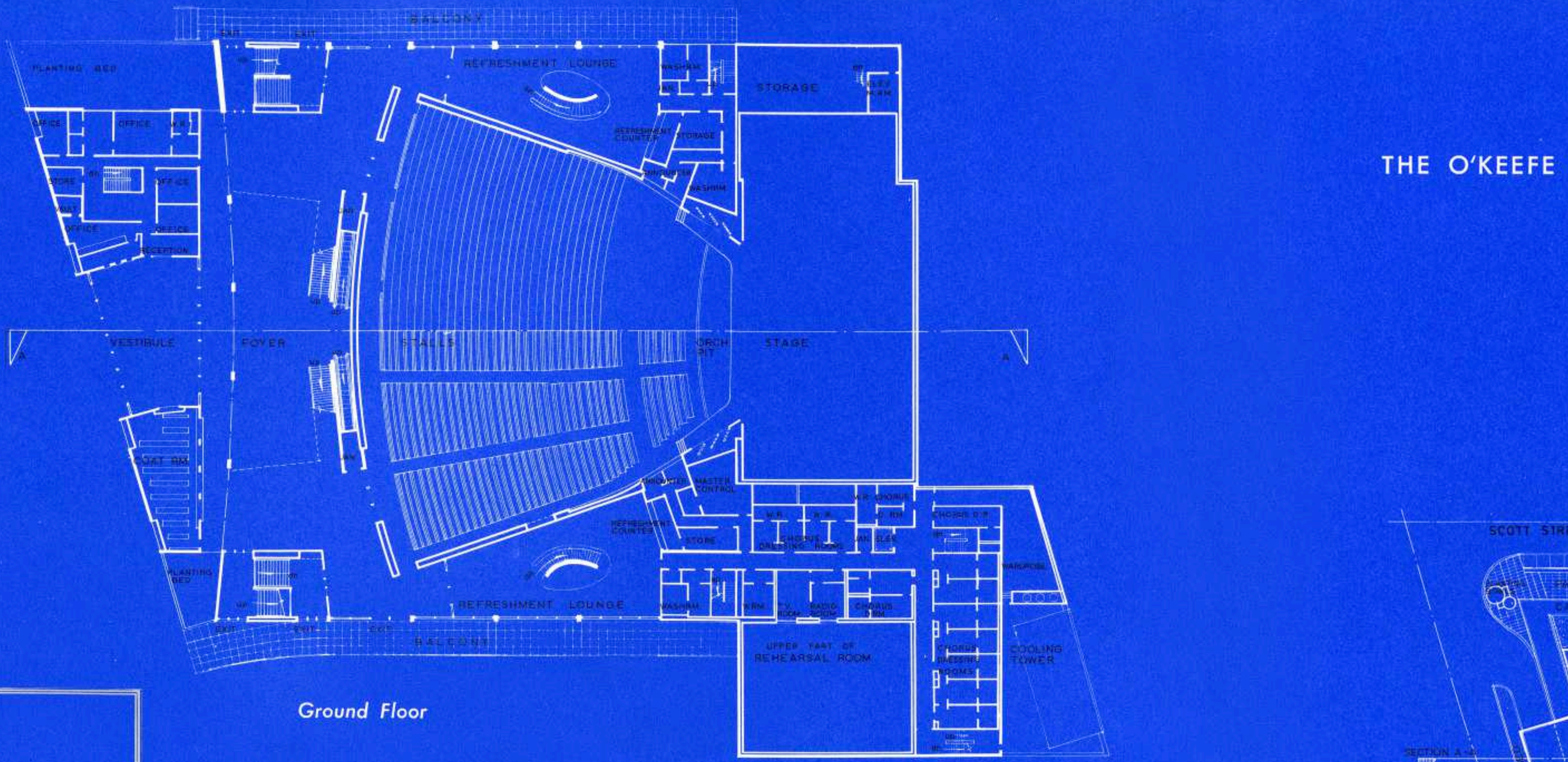
Architects, Earle C. Morgan and Page & Steele



Balcony Foyer

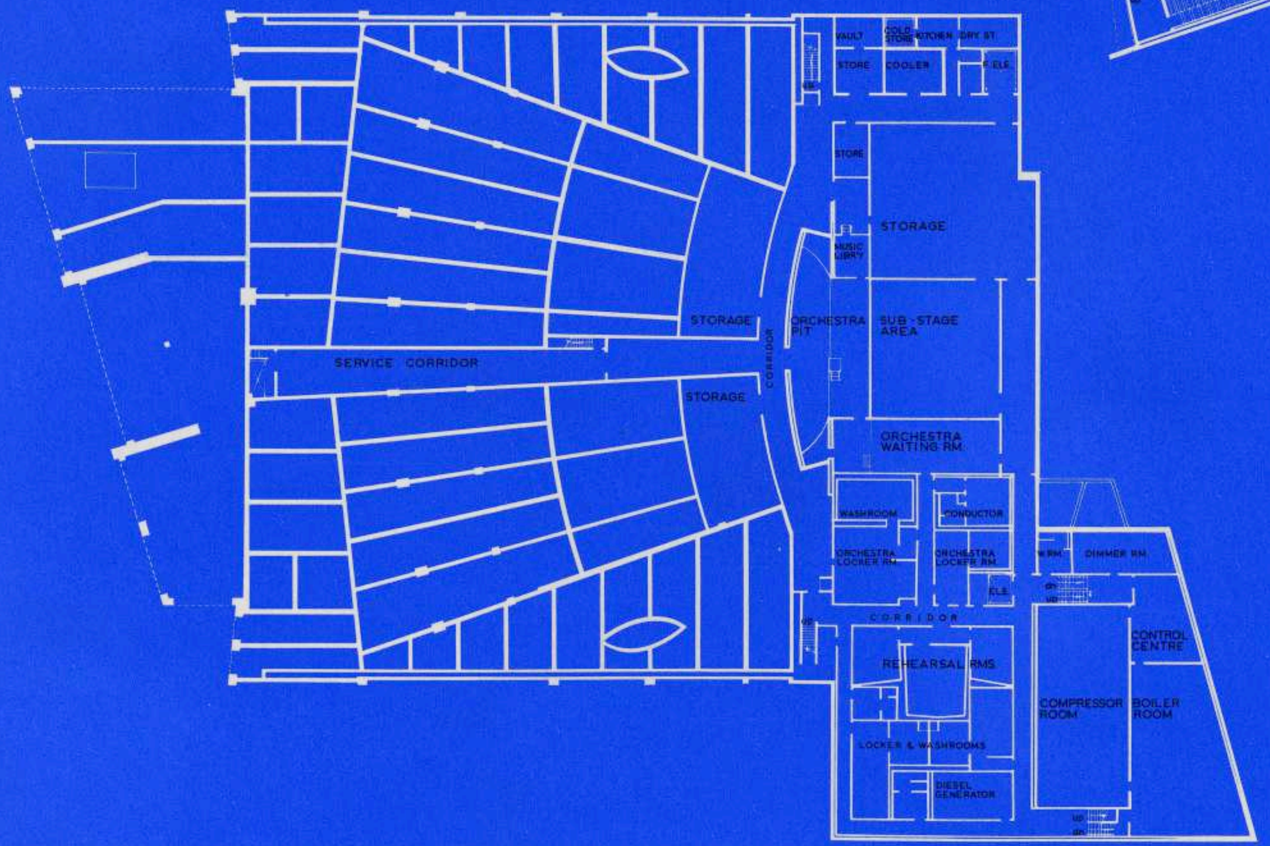


Balcony

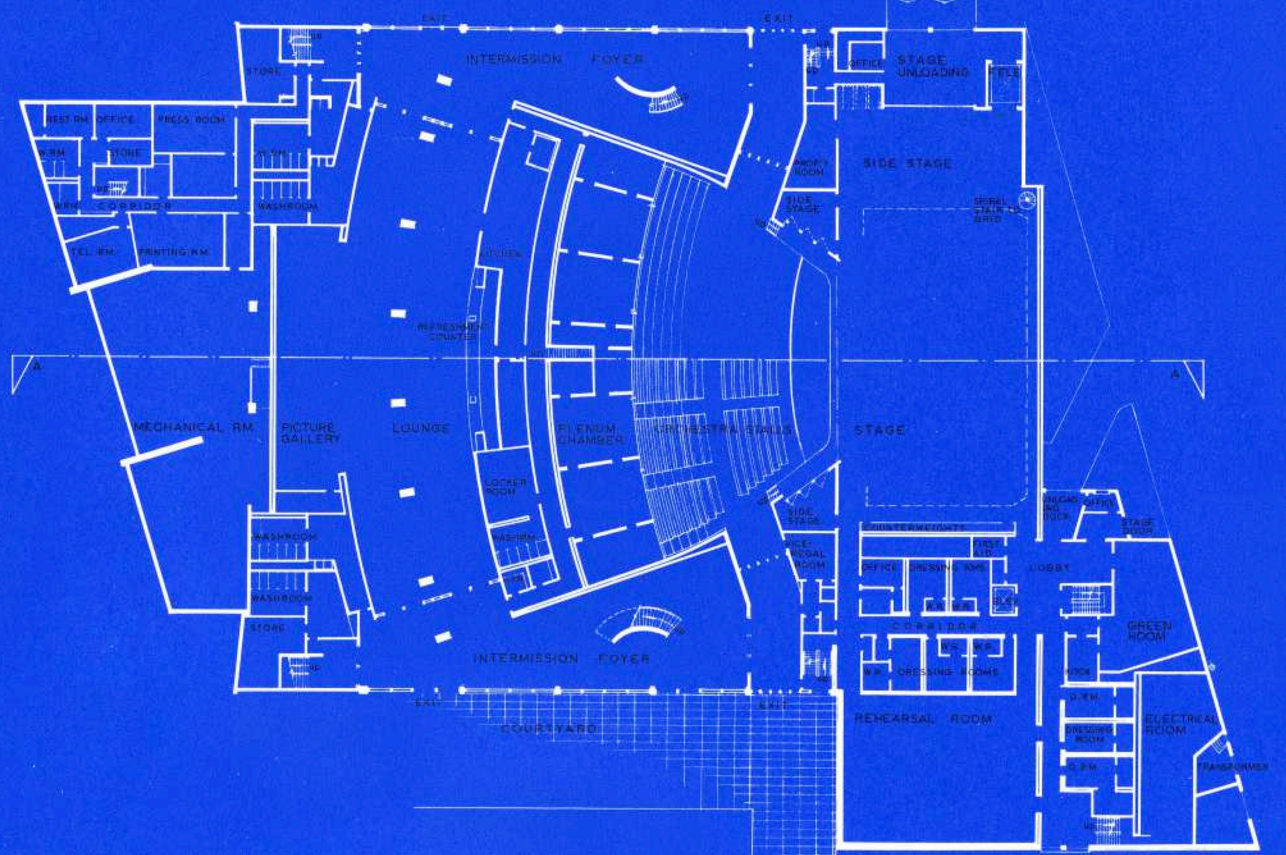


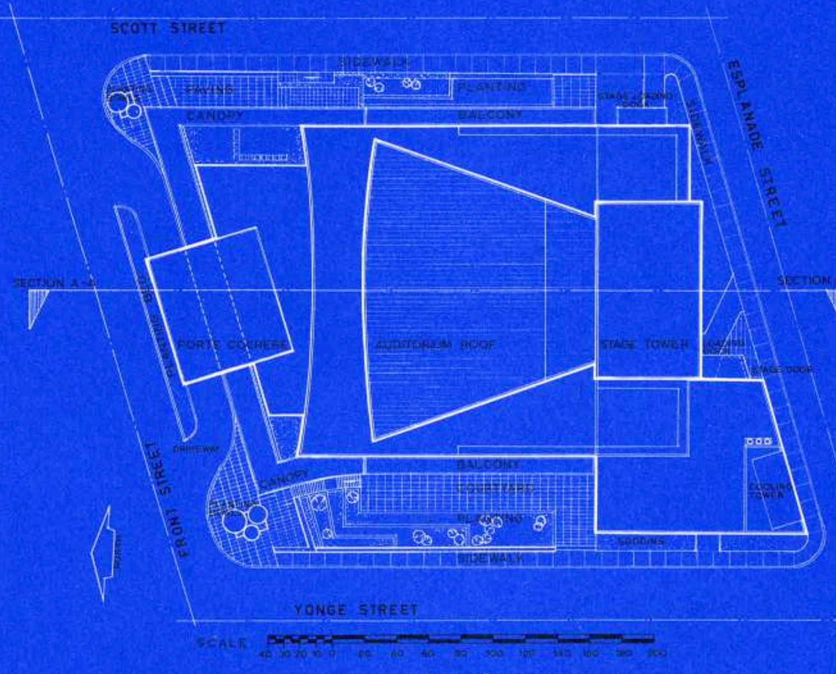
Ground Floor

Basement



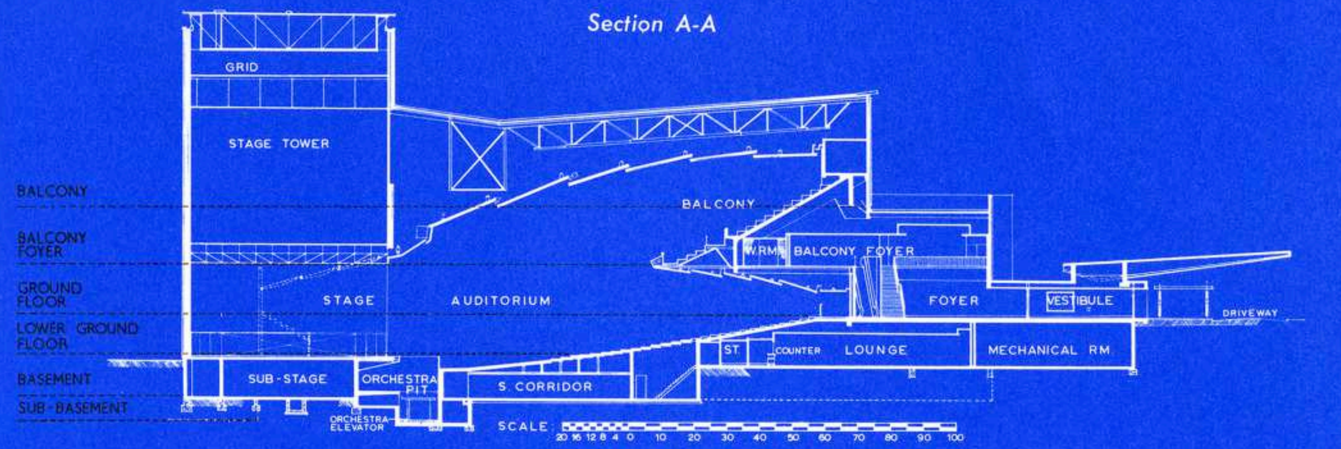
Lower Ground Floor

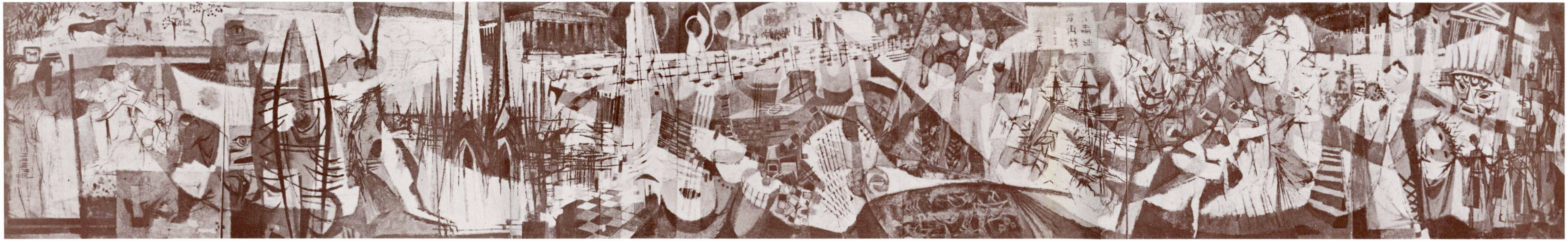




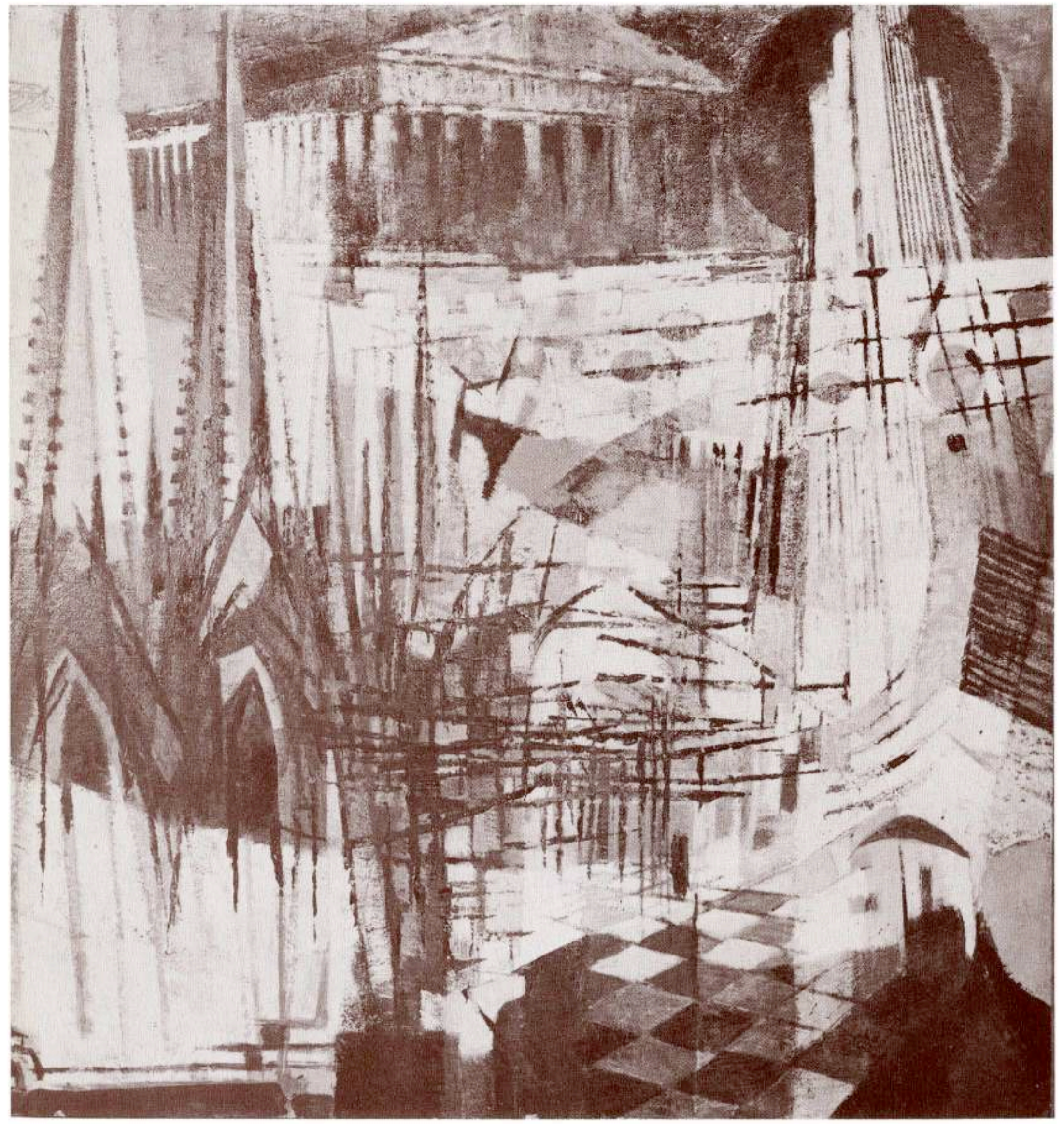
Site Plan

Section A-A

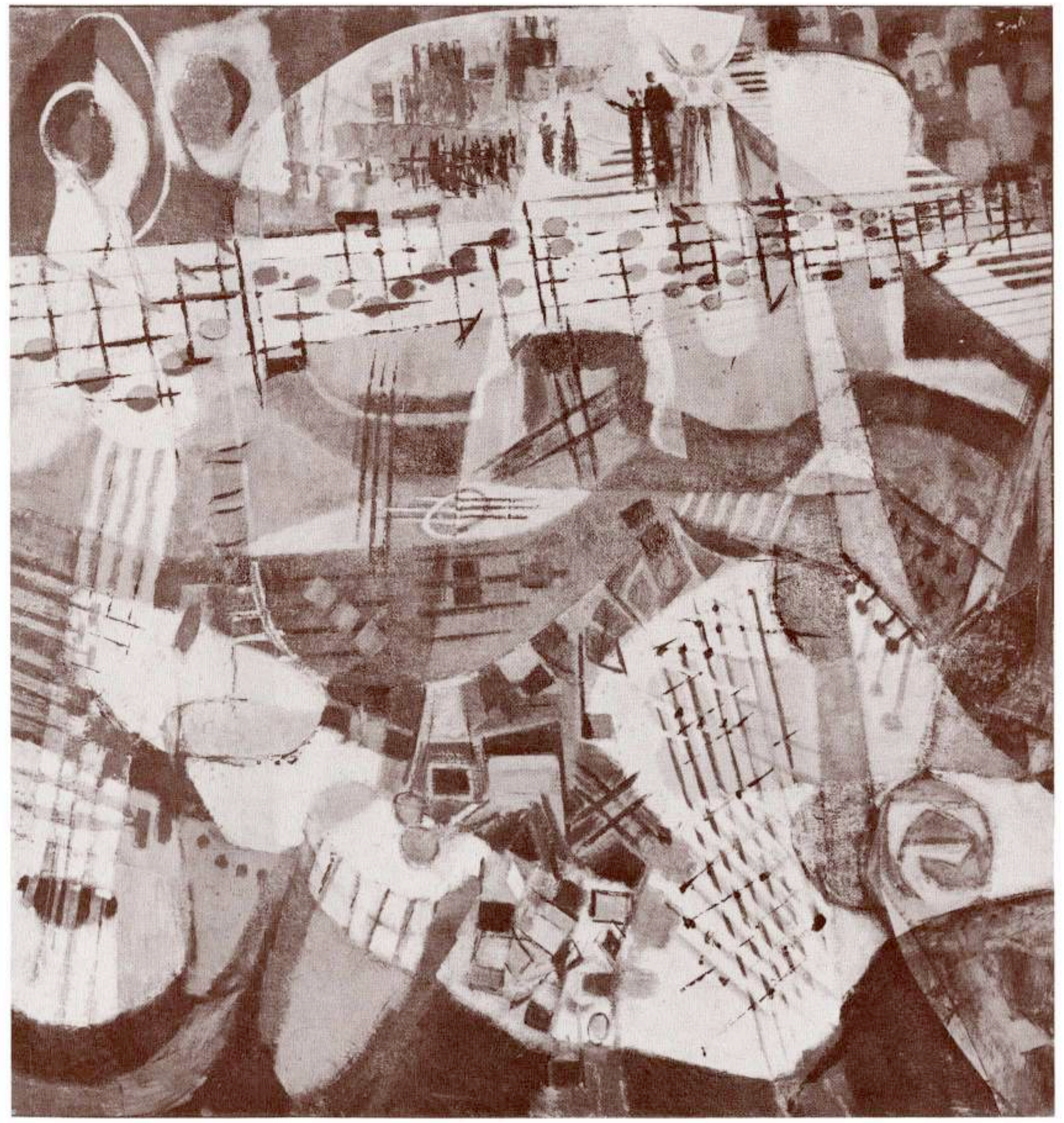




DETAIL OF 'ARCHITECTURE'



DETAIL OF 'MUSIC'



DETAIL OF 'DRAMA'

THE SEVEN LIVELY ARTS

The mural by R. York Wilson, RCA, OSA, in the O'Keefe Centre for the Performing Arts. The work, 15 feet by 100 feet, is in dry pigment in vinyl acetate on a cement on metal lath base.

The subject is in seven sections, from left to right:

PAINTING — Four periods: Lascaux, Altamira and other caves; Egyptian; Renaissance religious and, for the present day, a non-figurative painting.

SCULPTURE — Showing early Hittite bas-relief; classical Venus de Milo; a sphinx; a totem pole and a contemporary non-figurative welded steel piece.

ARCHITECTURE — Begins with the Parthenon; a large area of Gothic shapes; an interior of no particular period and a sky-scraper of today.

MUSIC — Drums for the early musical form; various wind and string instrument shapes; a bar of music from a well-known opera and a scene from Wagner.

LITERATURE — Symbolically man and woman represent the largest area; a sailing ship for adventure and travel; the equestrian battle indicates conquest; a Chinese proverb typifying the oriental contribution and the abstract shapes relating to abstract thought.

DANCE — War and sun worship dances, symbolic of the earliest dance forms; an Indonesian dancer representing the orient and the corps de ballet of Swan Lake for the nearly contemporary dance.

DRAMA — The Oedipus Rex masks, symbolical of early drama; a religious parade represents the medieval period and Hamlet is the most contemporary form shown.

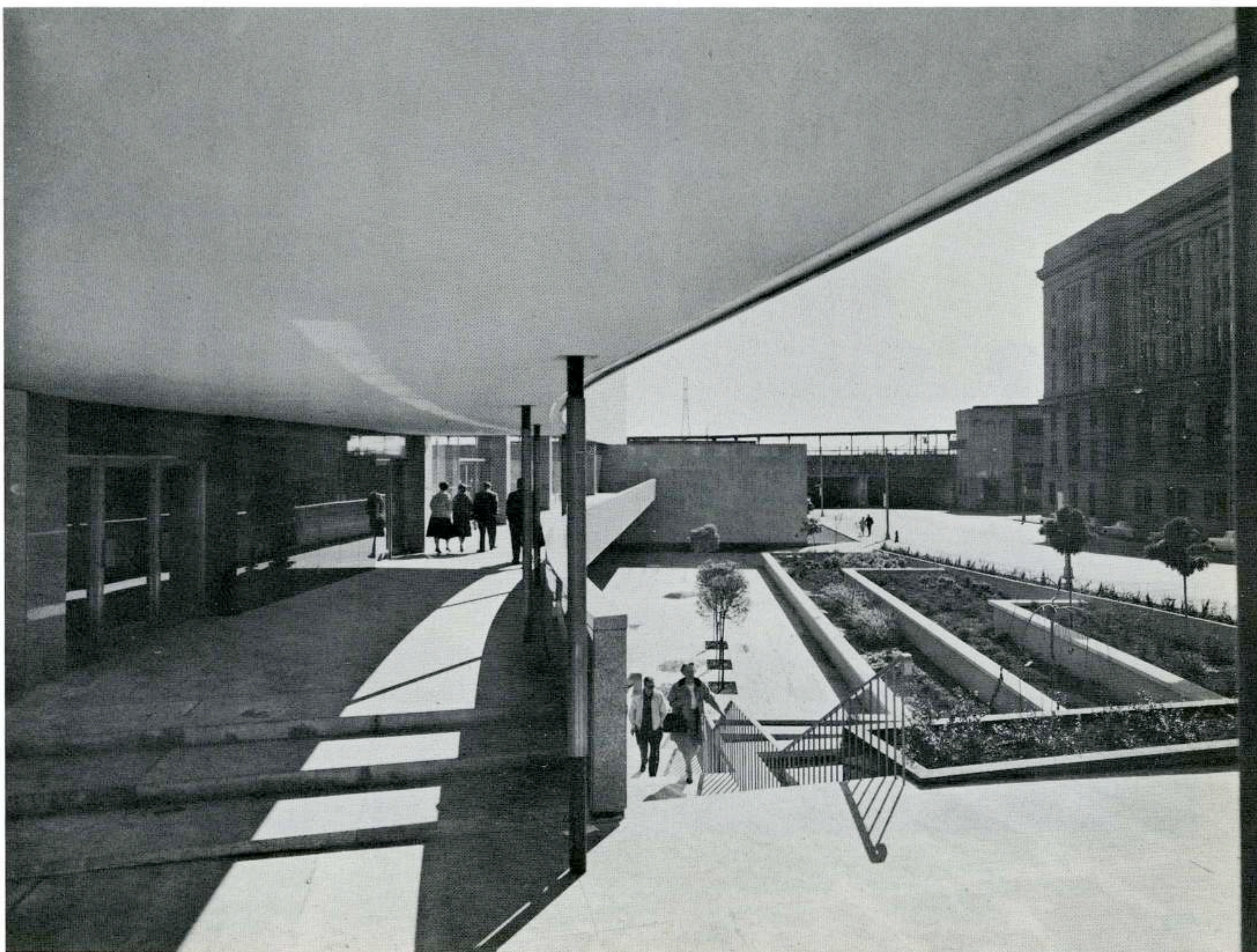
View looking towards main entrance from the North West

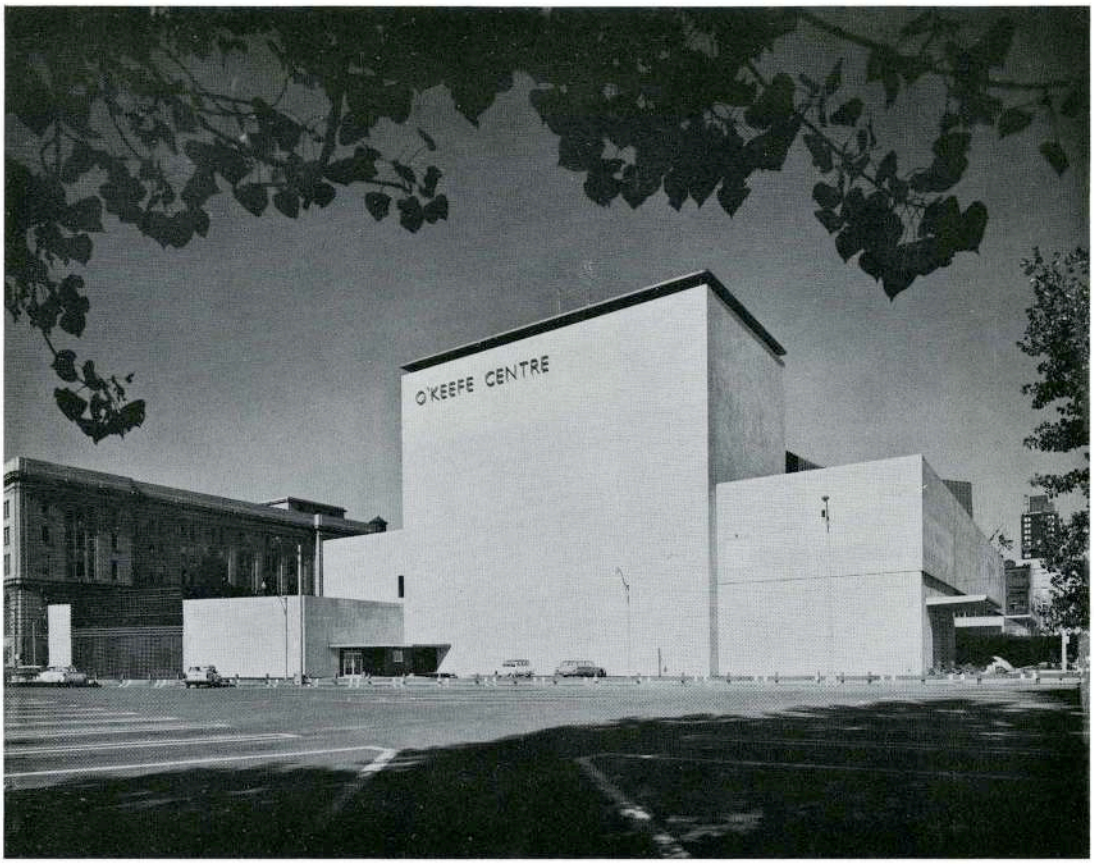
Auditorium, view towards stage showing orchestra stalls and ceiling of balcony above

Left: view of West Court

View of entrance and East Court from the North East and Front Street in the foreground

View of external balcony and West Court from North; Yonge Street on the right




O'KEEFE CENTRE

Top left: view of stage tower from the South showing stage door entrance lower left

Bottom left: general view of West Court and external balcony from the South West

Below: entrance foyer, view from top of stairs at balcony foyer level showing mural and vaulted ceiling

Right: detail at head of escalator, balcony foyer level, looking down to main foyer. The matched pattern of Loredo Chiaro marble of the South wall of the balcony foyer can be seen upper right above the lounge banquettes


AISLES

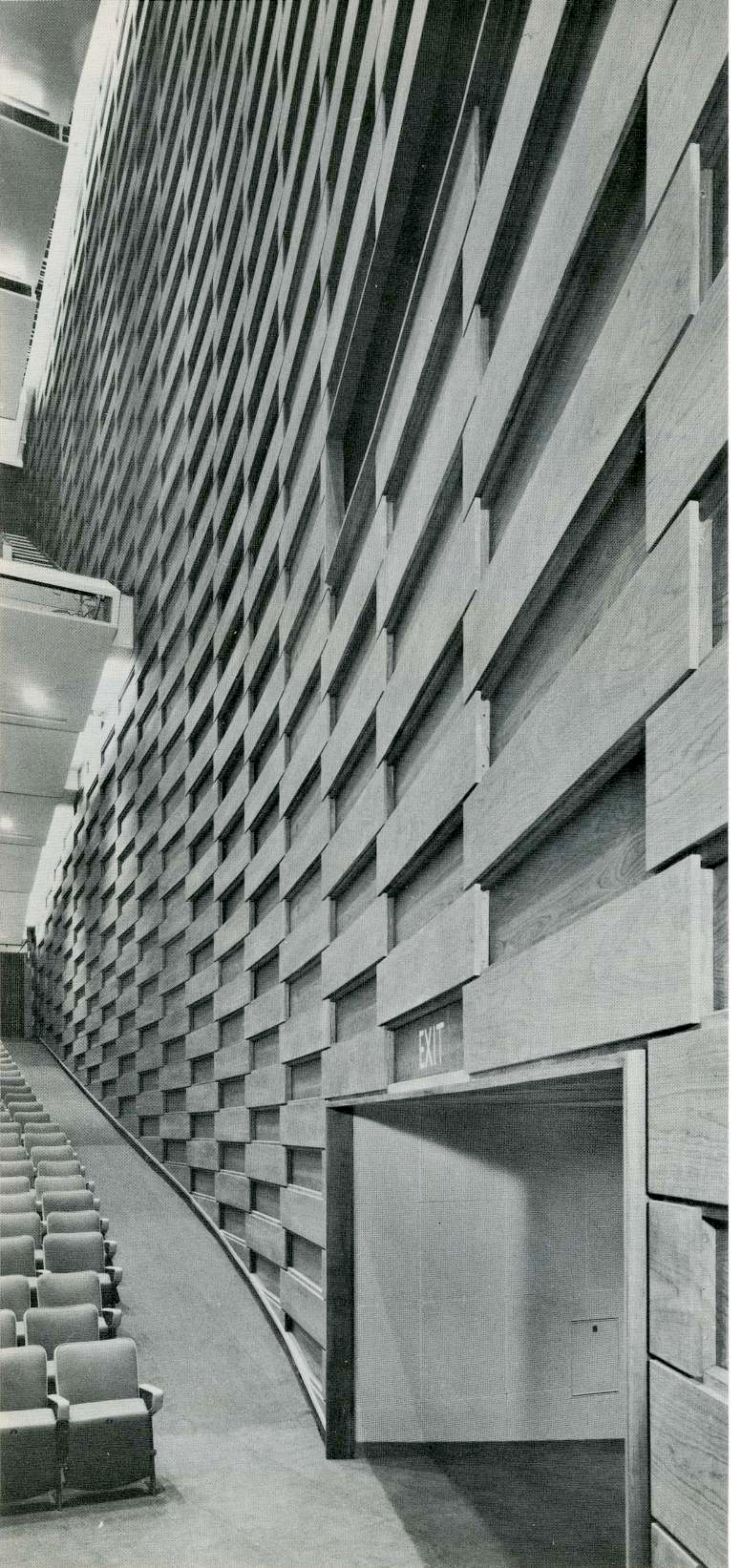
Extreme left: detail of vomitory staircase from balcony foyer to balcony proper showing acoustically treated bronze faced doors with contrasting marble

Left: entrance foyer showing cantilevered granite stairs, white marble winged walls, escalator and balcony foyer above

Below left: refreshment lounge in lower ground floor, showing refreshment counter right and picture gallery left

Below: West intermission foyer on lower ground floor showing curved walls supporting cantilevered granite stairs to main floor

Right: West intermission foyer on lower ground floor showing curved walls supporting cantilevered granite stairs to main floor



Acoustics

BY V. L. HENDERSON, P.ENG

The acoustic properties of a modern auditorium have been largely determined by the time the architect first places his pencil to paper. Decisions involving site, budget, capacity, and type of programming have as great an effect on the final acoustical results as any decisions that will be made later. From this point onward the acoustical environment develops from a series of compromises involving architectural consideration of layout and proportion, materials of construction and finish, mechanical equipment, and facilities, etc. For example, if acoustical conditions were the sole consideration, such noisy equipment as that associated with air conditioning and ventilation would be eliminated entirely, and the patrons could smother or freeze, depending on the season. This of course leads to a ridiculous situation, since it represents an outrage of one or more of the human senses and functions. So a compromise is accepted, where air conditioning and ventilation is specified with limitations on permissible noise.

For the O'Keefe Centre the owner defined the site, the budget, the range of use and the seating capacity. The architects developed around this definition a structure with due regard for architectural merit, struc-

Left: detail of side wall showing cherrywood movable acoustical panels. The view is from stage right and shows also the front stalls exit and side wall cove lighting tural simplicity, space for services and acoustical requirements. With each decision relating to any of these factors the range of further possibilities was narrowed. It is obvious then that the acoustical environment is not the result of the unilateral decision of any one person, at any one time, but the co-ordinated effort of the team, composed of the owner, the architects, and all the consultants. This team worked together from the beginning and it is only through the co-operation of all, that Mr Kodaras and I, as acoustical consultants, have been able to obtain the overall result which is the acoustics of O'Keefe Centre.

In addition to reflecting the sound into the regions farthest from the source, the reflected sound must follow the direct sound quite closely in time or it will register as an echo. Scrutiny of Figure 1 shows that for areas near the rear of the auditorium, both in the stalls and in the gallery, the maximum time differential for the direct and reflected paths is only a few milliseconds.

The balcony opening is quite high in order that the sound will have free access to the under-balcony areas, and to permit sound reflected from the ceiling panel, just forward of the proscenium, and from the auditorium loud speakers, to reach the farthest seat. This wide opening has the added advantage that it permits an appreciable slope to be built into the balcony ceiling which, when properly contoured, gives good control of the sound entering this area.

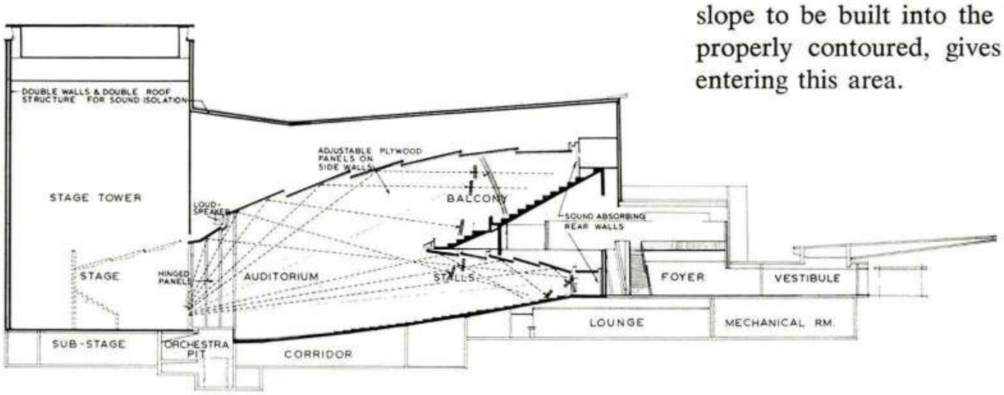


Figure 1

Since sound decreases at least six decibels with each doubling of distance from the source, compact seating arrangements to reduce the distance over which sound must be projected are indicated. A fan shaped space with a substantial balcony will accomplish this. In fact, the maximum distance from the proscenium to the farthest of the 3250 seats in O'Keefe is less than 130 feet.

Sight or hearing lines also warrant careful consideration, since high frequency sounds do not diffract around substantial objects such as heads. Therefore the sharply ramped floor is of marked importance in providing good acoustics.

Not all of the sound energy which reaches the listener does so directly. Much of the sound energy generated on the stage must be reflected from the ceiling or side walls before it can reach the listener and, by judicious shaping of the surfaces, the sound waves can be directed towards the areas where they will do the most good; that is in general, the areas farthest from the source. Figures 1 and 2 show typical reflections from the ceiling panels and side walls.

The side walls are constructed of cherry plywood over concrete block, in a waffle pattern. This pattern carries the movable absorbing panels, which will be discussed later, and provides some diffusion of the reflected sound.

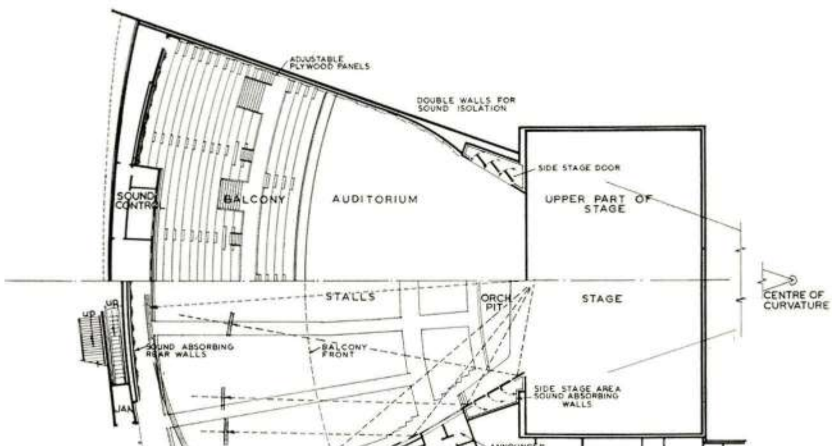


Figure 2

The rear wall is highly absorbent because sound reflected from it to a listener would be subject to long delays relative to the direct sound. A number of precautions such as placing the centre of curvature well outside the front wall of the stage, and undulating the surface of protective wooden slats, were taken to insure that no image of the source would be produced in the auditorium.

In addition to the first reflections considered here, there are many succeeding reflections to which the sound waves are subjected. These reflections produce the phenomenon of reverberation and give character to sound heard indoors.

For clarity and precision as required in speech, quick decay of the sound or short reverberation is indicated, but for continuity and fluidity of musical tone a longer reverberation is desirable. In O'Keefe Centre bookings will vary all the way from symphony concerts to commentaries on ladies' fashions, and nothing less than a range of reverberant conditions can do justice to all.

To this end the architects have provided approximately 2500 square feet of side wall area which can be varied progressively from hard resonant reflective cherry wood panelling, to rock wool with a perforated plywood cover.

Modern techniques of public speaking and certain phases of musical production having been built around the mental and physical support of a microphone stand, and the volume of the auditorium being 700,000 cubic feet, it seemed expedient to supply a sound amplification system as part of the permanent theatre equipment.

This system includes approximately 40 microphone outlets in the stage area and 60 distributed elsewhere in the building. Each microphone outlet is connected to Master Control where the signals are amplified and distributed to one of three radio control booths, Sound Control, or to the system of 100 loud speakers located in public and back-stage areas. At the front of the stage are three trick microphone stands which, from controls at the stage manager's station, can be raised or lowered from below floor level to head height.

The radio booths are available for broadcasters who have audio programs originating in the Centre, and each is provided with an announce booth and wire line facilities.

Sound Control is an area set aside at the rear of the balcony where an operator with "golden ears" will "mix" up to 21 microphone signals and adjust the overall frequency characteristics of the signal fed to the auditorium loud speakers, which are mounted above the proscenium arch and the first ceiling splay.

Provision has been made to convert the auditorium system to three channel stereophonic sound by the simple addition of components, if this should become desirable.

Communication throughout the production area is provided by an intercommunication set with control by the stage manager; and telephone communication is provided by both a house system and numerous Bell Telephone extensions.

Inherent in the location of the site at the corner of Yonge and Front Streets is a noise and vibration problem caused by the trains to the south, the subway to the northwest, and truck traffic on four sides. Extensive investigation of vibration at the site and observations in existing buildings adjacent to the subway showed that the vibration would not be a problem with the deep and heavy foundation which the structure required, and that noise would be adequately screened by double isolated walls.

To this end the walls of the stagehouse and that portion of the auditorium which projects above the surrounding service area are double, with an air space between. Wherever it was necessary, for structural reasons, to couple the walls together, it was done through vibration and sound isolation connections.

The roof also is double. It is formed of two relatively light layers of preformed concrete planks isolated one from the other. The two layers of planks are structurally different so that the natural frequency of one differs from that of the other. Thus while one layer may be relatively transparent for sounds of a given frequency, the other will be relatively opaque at that frequency.

Where the auditorium is surrounded by service areas, two walls are inherent in the structure. The service areas provide the isolation between the walls, except at floor level where the floors with the walls form an extremely stiff barrier, through which the transmission is very small indeed.

Because it is possible to use the auditorium and the lower foyer simultaneously, but with different programs, they are isolated one from the other by two concrete slabs, separated by a fiberglass blanket.

Inside the Centre, mechanical equipment is probably the chief source of noise. As far as possible the heavy equipment has been segregated at the south end, well away from the public areas. Air handling fans have been concentrated in three areas close to the auditorium from which they are separated by double walls. All fans, motors, pumps, etc. are effectively isolated from their supports to insure that mechanical vibration will not enter the structure. Air ducts are lined with acoustical absorption to prevent mechanical or air noise from being transmitted from the fans into public areas.

Virtually all ceilings in both public and service areas are treated with sound absorbing material, while the lounges and the foyer are carpeted. Thus noise due to occupation is kept to a minimum, and heavy metal-clad doors with effective seals around all edges insure that the residual sound does not reach the interior of the auditorium.

Within the auditorium rigid specifications of permissible noise level insure a quiet environment, while carpet on the aisles and in front of the seats eliminates most traffic noises.

Basically an auditorium has been provided free from interfering noises, and shaped to permit sounds from the stage to reach the patrons directly. Reflected sound has been controlled in direction and in duration, for speech and music to be heard under advantageous conditions.

Mechanical

BY G. GRANEK

It was determined that flexibility, in response to varying demands, had to be keynote for our design considerations. The building is a multi-purpose centre which will look after roadshows, ballet, opera, lectures, concerts, movies, TV and other uses. Since some of the areas, or even only parts of the auditorium, may be in use when other areas are empty, quick response to the varying thermal load had to be embodied in the design concept. To meet the requirements of great flexibility it was decided to use separate air handling units for each major zone. Ease of maintenance and noise and vibration isolation suggested concentrating the mechanical equipment in as few areas as possible, and as remote as possible from important occupied areas such as the auditorium and the stage. On the other hand, consideration of first cost suggested the location of air handling units as close as possible to the area supplied, and to the outside air source, to keep the supply air, fresh air and exhaust air ducts to a minimum length. As a compromise, three fan rooms were arrived at: two rooms at the east and west of the auditorium respectively and one at the north, containing all the air handling equipment for the building.

Cooling for the building, with the exception of the administrative or office wing, is provided by chilled water supplied by two 450 ton capacity hermetically sealed centrifugal compressors. These machines can be operated independently or in parallel. Should one of these compressors be out of order during a peak load performance day, cooling for the auditorium alone can be provided by shutting off chilled water supply to the fan coil units serving other areas. Chilled water is conveyed to the air handling units from three pumps located in the basement compressor room. The cooling tower is winterized, using a steam coil in the base pan, thus refrigeration can be provided even during marginal weather, in the Spring and Autumn seasons, when sub-freezing weather can occur in the morning or at night while outside temperatures may reach 55 or 65 during the day time. The back stage dressing rooms with their very high lighting and people loads require a large air supply volume. They are served by supply plenums forcing air through perforated metal ceiling pans. Straight line diffusers located above mirrors and makeup lights serve as return air grilles. A high velocity, double duct system looks after the varying thermal demands of these areas, with individual room thermostats controlling mixing dampers in attenuator boxes for each separate area.

Since the office wing will be in operation at times, and for long periods, when the rest of the building is closed, an independent air conditioning system was provided, consisting of a 15 HP radial, direct expansion, compressor with a low speed motor and an air handling system with room control by reheat supplemented by wall fin radiation.

Air conditioning for the rest of the building is handled by four independent air handling systems – each consisting of a return (relief) air fan, fresh air plenum with three reheat coils in series, mixing plenum, electrostatic filters, cooling coil, humidifiers, reheat coil for each zone, and a supply fan.

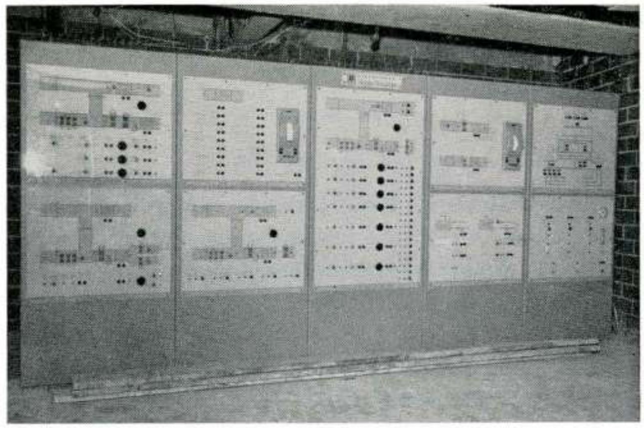
The auditorium is divided into three separate seating areas; the balcony, rear stalls below the balcony, and the orchestra stalls. For intimate shows the front portion of the auditorium can be divided off by a curtain. Three separate air handling systems serve these areas of the auditorium. Air distribution for the balcony and the rear stalls respectively is broken up into two zones each, in order to make allowance for the variation in height between sloping ceilings and sloping seats. The theory of air circulation adopted for the auditorium was to supply air from ceiling diffusers above and behind the audience, parallel to the ceiling plane, until the air loses most of its kinetic energy, drops, and slowly returns across peoples' faces back up to the return air openings located behind supply diffusers. This air pattern accomplishes two goals: it supplies air into the breathing zone across the faces of the audience without causing drafts along the most sensitive portions of the anatomy, necks and ankles, and it returns smoke laden air upward. The conventional method of using the return air plenum under seats in theatres was adopted for the orchestra stalls. Since smoking will not be allowed in this area and the throw of air to the orchestra stalls being abnormally high, the air supply pattern at seating level would be unpredictable.

Location and the type of air diffusers used in public areas required considerable study to suit the requirements of proper air distribution as well as aesthetics. In most instances, straight line diffusers of the aspirating type were selected. Due to the curved contours of some of the ceilings, special manufacturing methods had to be requested, followed up by special indexing and field assembly, in order to obtain the desired co-linear appearance of the frames and the blades of the diffusers. Individual sections are mitred and matched to present a uniform appearance. In some instances field cutting and measuring was required. Air supply and return requirements in the side lounges are very large. To avoid having the ceiling appear too "busy" special combination supply-return straight line diffusers were designed using the front portion of the diffusers for the supply and the rear portion for the return.

Due to the close proximity of the building to the railway tracks, and downtown and highway traffic, good filtration was considered very important. All air conditioning supply units are equipped with electronic filters with a minimum efficiency of 98%. These filters are equipped with a semi-automatic washing cycle with motorized moving washers and adhesive applicators. After filters are provided to prevent any of the moisture, remaining on cells after wash down cycle, from being transmitted into the ducts.

Due to the strict requirements for noise control within auditorium, stage and other important areas, great care had to be exercised in the design of all systems, the distribution media, the selection of the equipment, and the components. All ducts and high velocities are kept at the acceptable minimum. Velocity through apparatus is kept to 500 feet per minute maximum. Fans, pumps and other equipment were selected for quiet operation, rugged construction and are mounted on concrete inertia slabs supported on 95-98% efficient spring isolators. All motors are of special silent "design" reducing magnetic hum bearing noises and other nuisance noise generated to the absolute minimum. All check valves are of the radial spring type, thus reducing water hammer to a minimum.

To air condition the stage presented the following problems: a tower of 60 ft by 100 ft area by 100 ft high encloses a maximum acting area of about 60 x 40 ft. With the asbestos curtain closed, due to the pressurization of the auditorium, it is essential to equalize this pressure on the stage side of the curtain in order to offset tendency for the curtain to billow and possibly suffer damage. Back drops and curtains may be of such flimsy material that the slightest air motion may cause undesirable movement of the material. No perforations can occur on the stage floor because of the possible use for ballet or dancing. The thermal load on the stage may vary from a single occupant in near darkness, to a full opera company acting in front of stage lighting up to 90 watts per square foot of stage floor areas (the latter requirements set up by the owner's request to provide for future color TV productions). Noise control is even more critical than in the auditorium. After many discussions with the architects and the stage consultants, permission was obtained to requisition five vertical avenues below the gridiron. Borrowing from experience gained in air conditioned studios the following system was designed. Trunk supply ducts running around the perimeter of the stage tower supply five parallel branches of ductwork running at the gridiron each with its own volume control dampers, remotely controlled from a small panel at the stage floor level. Branch ducts in turn serve air outlet boxes suspended from flexible hose ducts dropping through the gridiron. These flexible hose ducts are counterweighted and suspended by special guy wires, and can be raised or lowered at will from the fly gallery panel. Air outlets will be through boxes equipped with motorized dampers, allowing volume control as well as changes in direction of air pattern to suit back drops and scenery changes. A central control panel on the stage will allow control of air direction in 54 different sub-areas on the stage. Return air will be carried at high level, along perimeter walls of the stage tower. Although the flexible ducts can be raised out of sight and left suspended high above the proscenium, it may be necessary to disconnect portions of stage ductwork to suit rigging for a particular show. For this reason, all branch ductwork extending across the stage is of bolted construction, allowing disassembly and storage of sections of ductwork. To prevent downdraft from the 100 ft stage tower wall to spill into the orchestra seats, extended wall fin radiation is placed along the backstage wall.



Supervisory data centre, at which all air conditioning controls can be registered and re-set.

Since the use of wall thermostats was objectionable to the architects, return air sensing devices located in concealed locations are used throughout the building. In the engineer's office, a central graphic control panel acts as a nerve centre for the whole building. Remote indicating pilot lights show when motors are operating. Temperature indication can be achieved for 130 different points. Thirteen miles of thermocouple wiring from the panel to the thermocouples, generally located in return air ducts, allows instantaneous checking on temperatures. Thermocouple settings can be altered from this panel simply by turning a knob; 35,000 feet of special cable alters these temperature settings. Graphic representation of the different systems allows an easy visual check for the operating engineer.

To prevent downdraft created by large glass panels in offices and side lounges, extended wall fin, protected by special bronze enclosures, are located between window mullions. Vestibules and side entrances are heated from recessed, cabinet unit heaters.

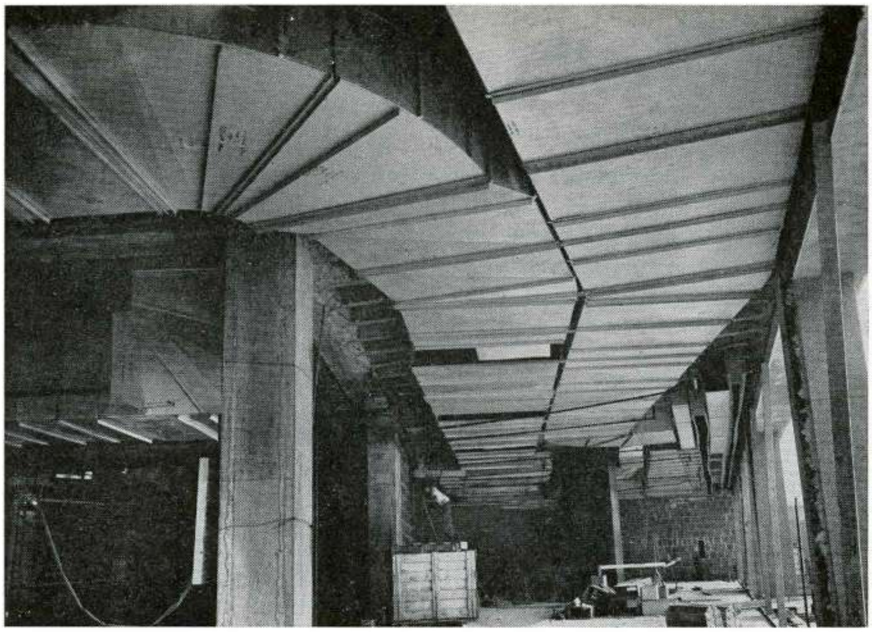
In air conditioned areas, heating is a part of the air handling systems. Steam to coils is supplied from three low pressure internally fired, fire tube boilers, equipped with forced draft rotary cup burners. Three chimneys, terminating above the low roof section, are concealed behind a steel enclosure.

Snowmelting systems for ramps and entrances to this building, using buried wrought iron pipes, ensure easy access in the winter time.

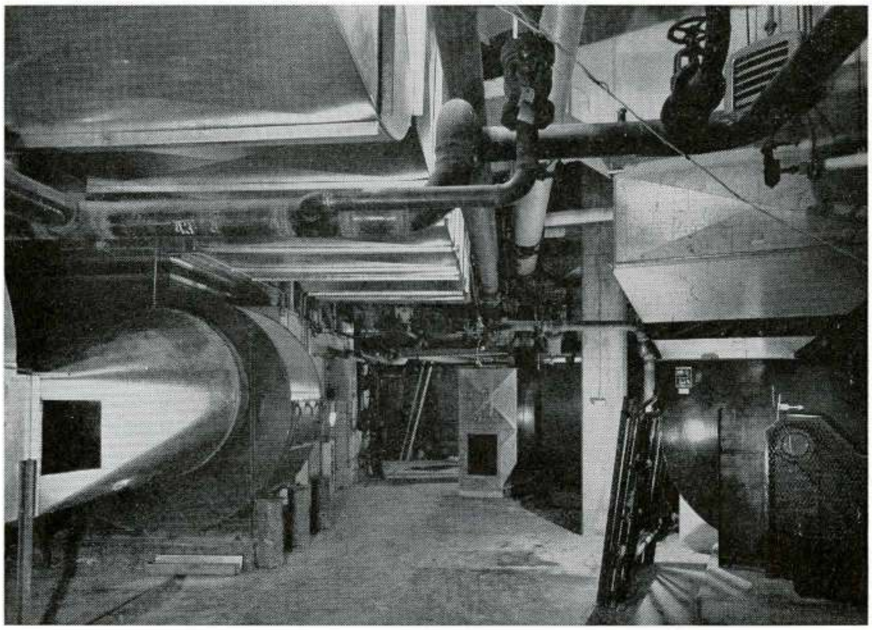
To reduce noise to a minimum, special quiet flush valves were selected for water closets and shock absorbers were installed in water feeds to all fixtures. All fixtures are wall-hung type for easy maintenance. Public washrooms have concealed flush valves with recessed pushbutton control for water closets. Urinal tanks and soap tanks are located in pipe spaces or janitor's closets, with concealed piping serving fixtures.

The sanitary drainage is split. All backstage drainage enters the suction side of the City Sewage Pumping Station on Scott Street. In order to avoid having washroom facilities for the public front stage area dependent on motor driven sewage pumps, permission was obtained for the sewer to empty into a Metro trunk sewer under the centre of Front Street.

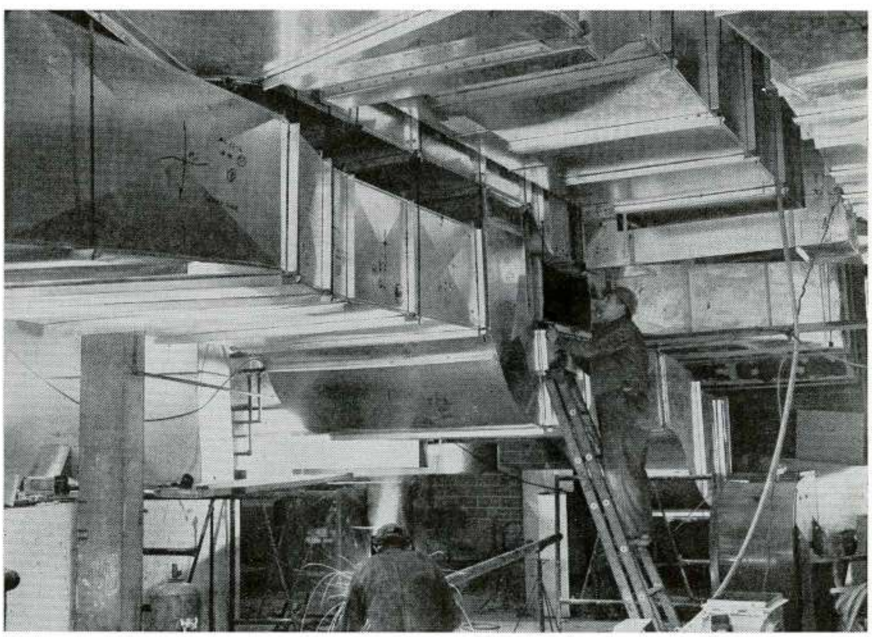
Duct work in west lower ground floor side lounge



A typical mechanical room installation



Duct work installation



Structural

BY M. S. YOLLES

Structurally, the building is divided into three parts: (1) the front house area containing the auditorium proper; (2) the backstage area consisting of the stage tower, the west wing for dressing and rehearsal rooms, and the side stage to the east; and (3) the boiler room area, located to the southwest of the backstage area. (See figures 1 & 2).

Four main factors governed the structural design: (1) soil condition; (2) functional and aesthetic requirements; (3) mechanical, electrical and acoustical requirements; and (4) unusual architectural features, such as the main entrance canopy and the structural Granox stairs.

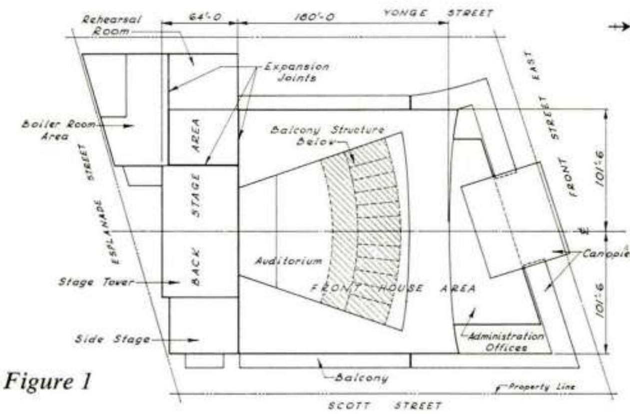


Figure 1

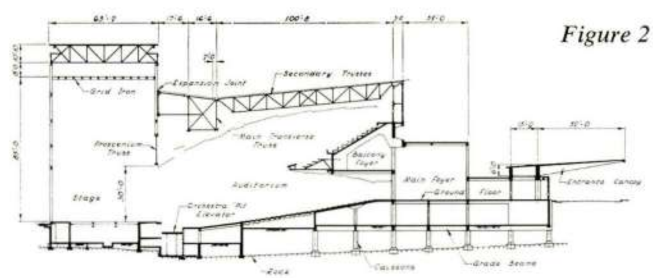
The soil over the entire site consisted of fill to a depth of approximately 16 feet. Immediately below the fill characteristic Dundas shale was encountered. In the front house area, the lower ground floor is approximately 12 feet above the shale. Here caissons, founded on shale, were employed to support the structure. Incidentally, for the historically-minded, it is interesting to note that the original shore line of Lake Ontario ran through the northerly part of the building. In the process of excavating caissons a number of well-preserved timber piles were encountered which formerly supported wharves. In the backstage area and boiler room, the basements extended into the shale and as a result footings on rock were used. The basement floors in these areas were below the watertable, so that structural slabs were used to resist uplift pressure. These were waterproofed with metallic waterproofing. All mechanical services below the basement slabs were carried in waterproofed trenches. Foundation walls were metallic waterproofed on their interior faces.

Among the functional requirements in the front house area were a large covered entrance free of columns, adequate foyer areas, a wedge-shaped auditorium area seating 2,100 persons on the ground floor and a balcony seating 1,030, both free of columns, as well as various ancillaries, such as mechanical rooms, washrooms, stairs, etc. These areas, of course, required air conditioning. Acoustically, the interior of the auditorium was to be designed in such a way as to allow for adjustments, which would provide satisfactory sound ranging from the single voice to the performance of an opera. In addition, the skin and roof of the auditorium had to be designed to prevent the intrusion of exterior sound, particularly from a concentration of railway lines 100 feet to the south of the site.

The structural system chosen to achieve cover for the entrance area was to employ reinforced concrete ribs and slabs cantilevering 52 feet from their supporting girder over the entrance. Ribs were 78″ deep at the support tapering to 12″ at the free end. (See Figure 2). A complex system of cambering was built into the forms for this canopy, because, due to the nature of support for the ribs, the anticipated deflection of the free end of each rib was different varying from 4″ to 6½″. The foyer areas, which in most cases are free of columns, are framed in reinforced concrete. Flat slabs were used where the spans were moderate and shallow concrete joists were used for greater spans. The maximum depth of joists was 17″ for those spanning a distance of 38 feet at the main foyer roof. This type of framing was adopted to allow the maximum depth for the extensive mechanical ducting within limited floor to floor heights and because of its proven economy.

The roof structure over the auditorium had to be of the form required by the Architects, to be free of columns, to interfere as little as possible with the passage of mechanical services and cat walks and, finally, had to support the rather heavy double roof slab required for acoustical purposes. Extensive studies were made of various framing possibilities which would incorporate the above requirements, including thin shell concrete and folded plate concrete, but it was determined that the conventional solution of a structural steel truss system was the most desirable, both functionally and economically. The double roof slabs consist of an inner skin of shallow heavyweight precast concrete slabs (low frequency, high mass) and an outer skin of deep lightweight precast concrete channel slabs (high frequency, small mass). The skins are separated by insulation pads and shims. The roof slabs are supported on secondary steel trusses or steel purlins which in turn are supported on trusses framed as shown in Figure 2. The other ancillary areas of the front house are framed in reinforced concrete, primarily flat slabs.

Figure 2



The balcony structure is the most interesting structural feature in the building. The conventional structure used for a balcony such as the one in the O'Keefe Auditorium would consist of a main structural steel truss spanning the approximately 160 feet across the back of the auditorium and supporting a secondary system of sloped cantilevered trusses or beams. Furthermore, in order to gain sufficient depth for the main girder, it would be located back a considerable distance from the leading edge of the balcony. Because of this and because of the necessity to properly locate lateral bracing for the truss, considerable amounts of area are lost in the space made up by the inclined balcony slab and the balcony foyer slab. (See Figure 3). As this important area was required

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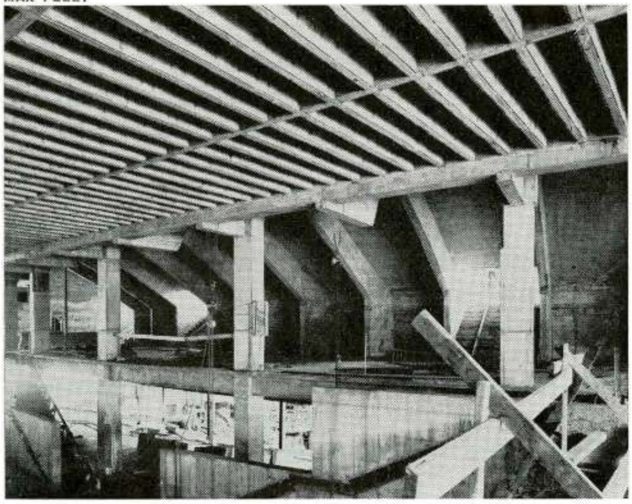

View showing the interior of the balcony box girders. Note the stiffening ribs, vomitories and supporting columns along the north.

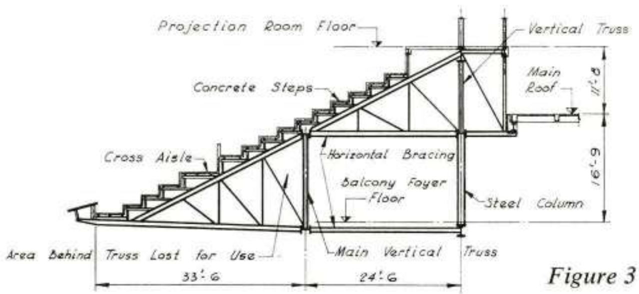

Figure 3

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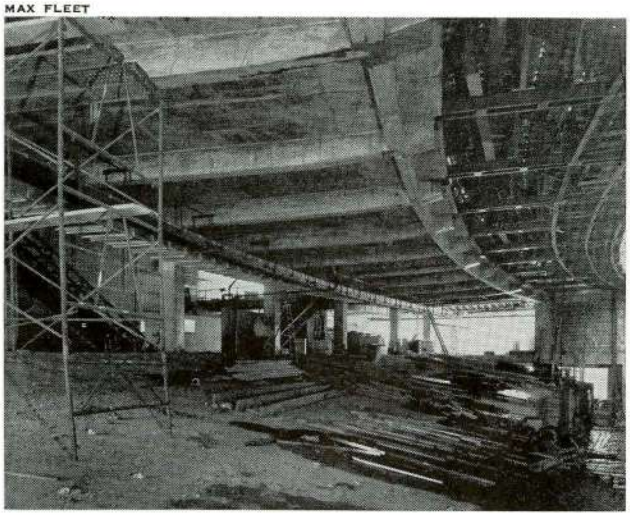


View showing the underside of the balcony box girder from the auditorium floor. Note the structural steel cantilevered brackets.

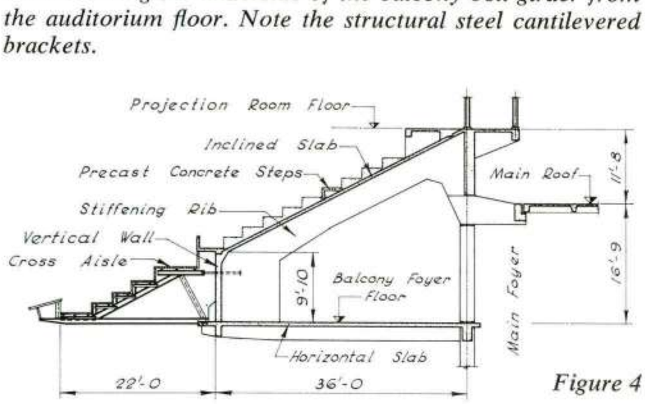


Figure 4

for washrooms and other facilities, the conventional approach proved unsatisfactory. It was concluded that a giant reinforced concrete open box girder spanning the 160 feet, which would increase the amount of usable space, would prove to be the most desirable solution, if such a girder could be made to work. Such a solution was complicated by the large vomitories opening onto the balcony at specific locations. Calculations proved that the proposed solution was feasible.

The girder consists of the inclined slab of the upper part of the balcony and the horizontal slab of the balcony foyer below, which are made to act together by the insertion of a vertical wall along the balcony cross aisle at the south. (See Figure 4). At the north, the box girder is open and the inclined and horizontal slabs are supported on reinforced concrete columns, whose upper extensions carry the structural steel trusses of the auditorium roof. The girder is curved on plan, to conform to the curve of the balcony, and is closed and supported at its ends by heavily reinforced concrete walls. Each wall in turn is supported by two columns, so that the entire balcony structure, with the exception of the columns along the north, is supported by only four columns. The system of slabs making up the girder is stiffened with ribs at approximately 12-foot intervals, the spacing being dictated by the location of vomitories and the spacing of the columns at the northerly edge of the balcony. The portion of the balcony to the south of the box girder is supported by a series of cantilevered structural steel triangular frames. Steel was used here in order to reduce dead load. The horizontal slab of the box girder forms the tension zone of the system and is heavily reinforced. A large amount of inclined reinforcement is also used in portions of the vertical and inclined slabs and in the end walls to resist the very large shear forces. The seating steps of the balcony are formed of lightweight precast concrete. Calculations indicated that the deflection of the box girder would be in the order of $1\frac{1}{4}$ inches at mid-span. Measured deflection at the point was $\frac{3}{4}$ inches, which indicates that the system is somewhat stiffer than predicted.

It is believed that the use of an open box girder of this magnitude is a unique solution to the problem of supporting a balcony. Though structural calculation and construction are comparatively difficult, it is felt that the advantage gained in being able to use considerably more floor area within the balcony warrants this type of framing in similar structures in the future.

The backstage area basement and stage slabs are of reinforced concrete, principally flat slab construction. The stage tower, extending 104 feet above the stage floor, is framed in structural steel and for sound insulation purposes is of double wall construction. A grid from which scenery is flown is suspended from the 10-foot deep roof trusses.

The stairs in the main foyer leading up to the balcony foyer and those in the side lounge are composed of polished Granox with a structural steel plate core. They are fabricated in units consisting of a tread and a riser. The units are cantilevered from reinforced concrete walls; the connection to the wall is by bolting to plates cast into the wall. The individual units are made to act together structurally by welding of the core plates at the junction of the riser and tread.

Electrical

BY JACK CHISVIN

If ever the opportunity for using light as a building element existed, it did so in the construction of the O'Keefe Centre. The designers were able to use light to paint and draw with, to apply it in its static form as well as to utilize light in motion in the design of the stage lighting. Here there was a true collaboration between architect and engineer in enlisting the force of light in the service of architecture. The design of the lighting not only provides the necessary illumination for the visual tasks to be accomplished but determines the entire architectural configuration of the space and controls the important psychological effects by its color and atmosphere. Light was used to create mood. It is beyond the scope of this article to deal with the entire electrical installation and all the lighting in the whole building; let us rather examine the design of the lighting in the main foyer, the stage lighting and the exterior lighting.

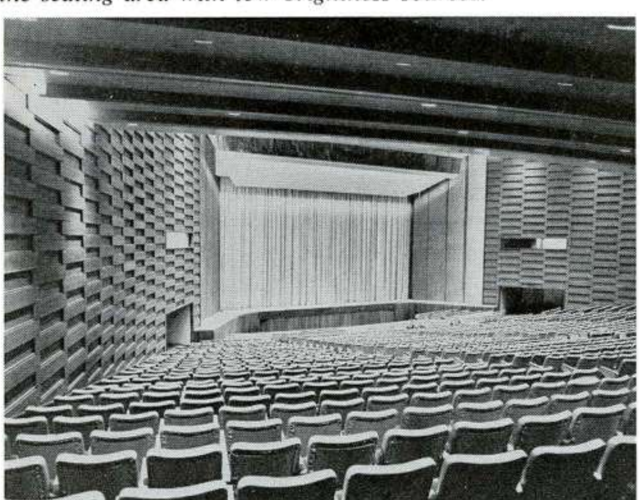
In the main foyer it was necessary that the lighting give us a clear and vivid impression of the space, and that preferably the sources should be concealed. Concealing the source of the main lighting was accomplished by integrating the architecture and the lighting. The high ceiling consists of a series of plastered barrelled vaults and these vaults are utilized to support and conceal the lighting sources. A continuous bronze lighting fixture runs along the intersection of each section of vaults, and in these bronze fixtures fluorescent lamps are mounted end to end. A small percentage of the light output of the fluorescent lamps filters through an albalite glass lens on the underside of the fixture, however, the greater part of the light of the lamps is directed into the vault and in turn is reflected down to the floor, thus the vaults in fact, become a total luminous source.

The ceiling for all intents constitutes an indirect method of lighting; however lighting of this type leaves something to be desired. The effect is rather flat and what is missing is the enlivening sunbeam, the supplementary component of direct light. To effect some sparkle and glitter, recessed down lights are employed to supplement the lighting from the luminous ceiling. In order to achieve the harmonies of intensity and avoid discord due to the harsh contrasts between the indirect lighting component and the direct down light, the recessed incandescent units are fitted with lenses, which have charcoaled risers, thus making them a direct source which, when seen from the normal viewing angle, are of very low brightness. To further reduce sharp color contrasts in mixing fluorescent and incandescent sources, the fluorescent tubes are all warm white, which comes closest to reproducing the colors of the incandescent lamps.

York Wilson's by now famous mural of the Seven Lively Arts covers one entire wall of the main foyer. It was imperative that this mural be highly but uniformly illuminated so that the bold colors would be reproduced as the artist envisioned them. The fixtures for illuminating the mural are concealed in a ceiling cove at the point of intersection between the ceiling and the wall. The lighting consists of PAR-38 lamps on 8″ centres. These lamps are alternatively 150 watt floods, 150 watt spots and 300 watt spots with each lamp carefully aimed and directed so that it covers a prescribed area of the mural. It is interesting to note that to adequately light the mural requires 30 KW of power, which is equivalent to the total power demand for approximately 10 normal residences. The necessary exit lights and other directional lights in the main foyer, as well as throughout the entire building, are specially detailed and designed so that they subtly and inconspicuously become a part of the architecture.

The design of the stage lighting was perhaps the most challenging aspect of all the lighting in the theatre. Although the designers were not required to light a particular show, it was necessary that the facilities of the stage lighting be such that it would be possible to light

House lighting illustrating high intensity illumination over the seating area with low brightness sources.



GILBERT A. MILNE

Stage lighting remote operating console and pre-set panel (Mr J. Fuller, stage electrician at the controls).

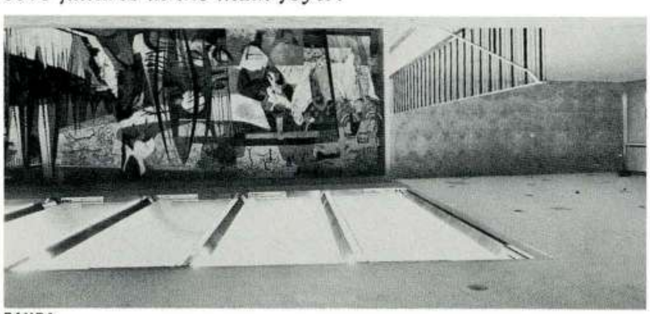
GILBERT A. MILNE

each show and every show ranging from soloist to full symphony orchestra, from intimate theatre to grand opera, from ballet to television productions. Stage lighting underlines the literary and portraying side of any performance, it enriches and deepens the work of the artists involved, and offers a spectacle that should never fail to find an appreciative audience. The success of stage lighting techniques depends not only on the proper selection and location of lighting instruments, but, to a great deal, on the method of control of these instruments. The O'Keefe Centre is equipped with two fully independent systems of stage lighting control. One system employs silicon control rectifier circuits to effect the light dimming and the other system employs motorized auto-transformer circuits. The first system is used principally for the production of dramatic theatre, whereas the second system is used for the performing of orchestras or soloists.

The silicon control rectifier dimming system was selected partly because of its instantaneous response. In a dramatic production a scene could reach a point of climax and if the response of the lighting effect were not fast enough to support the performing actor, it could very well destroy the entire mood and characterization established by the actor. The silicon control rectifier dimmer will operate in twenty cycles which is one-third of a second. The only real limitation to the speed of the change in light is the time of filament decay of the large incandescent lamp.

This light control system has four main elements: the dimmer rack, the stage patch panel, the remote control console and the scene pre-set panels. The main dimmer rack is located in a substage area and contains 48 5-KW circuits and 48 2.5 KW circuits having a total capacity of 360 KW. The dimming circuits are run to a patch panel located on stage right. 540 individual lighting loads are also wired to the patch panel, where it is possible to patch or cross-connect any one or any group of the lighting loads into any one dimming circuit. The dimming circuits are activated or adjusted in intensity from a control console remotely located in a booth at the rear of the balcony. The operator at this console has a full view of the stage and, in the event of any light failure or deficiency occurring during a performance, can instantly make the necessary adjustments. Adjacent to the control console are two pre-set panels containing ten scene pre-

Another view of the mural and installation of the ceiling cove fixtures in the main foyer.



PANDA

set controls for each of the 96 dimming circuits. This enables the operator to remain at least ten light cues ahead of the performance at all times. Using the cue sheet as a guide the operator sets up the pre-sets in advance, singly or in groups, and then switches or fades in the proper sequence as required. This board provides 960 x 960 possible combinations of light settings. Thus the most complex light changes become a simple matter to accomplish. Together with the possibilities of cross-connecting or patching the different lighting instruments into the different dimming circuits, the flexibility of this entire light dimming control system is virtually unlimited.

The auto transformer dimmers are motorized and are remotely operated by pre-set controls. The controls for these dimmers are located at the stage manager's position on stage, in the lighting control booth and in the movie projection booth. The capacity of this system is 175 KW. The house lights and the stage lighting used for concerts are controlled by the auto transformer dimmer system. Auto transformers were selected because of the possible long time range in controlling the lights from full on to blackout, which is most desirable for such an application. The motors driving the auto transformers are geared to 14 seconds for full range travel. In order to avoid duplicating lighting instruments used for dramatic lighting, which may also be used for concert lighting, certain designated instruments are wired through transfer switches, which permits their being controlled by either the silicon control rectifier dimmer system or the auto transformer dimmer system, depending on the type of stage presentation.

The theatre is equipped with a full complement of stage lighting units. In addition to conventional border lights, etc., located over the acting area on the stage, the design of the auditorium provides vertical wall slots, horizontal ceiling slots and enclosures in the balcony front for housing and concealing all the stage lighting units, so that during a performance the source of light is actually completely out of the view of the audience. High intensity carbon arc spotlights are located in the projection booth at the rear of the balcony. The footlights are the disappearing type and may be taken out of use without becoming a permanent obstruction on the stage apron.

The illumination around and on the exterior of the building is designed to create the feeling of gaiety and festivity which is usually associated with a theatrical performance, and is such that the approaching audience will be enveloped in excitement and be prepared for things to come once they enter the theatre itself. Most of the light sources used for floodlighting the building facades and entrances are incandescent, since in field tests incandescent proved to provide the best quality of light and gave the best color rendition of the bronze and marble building materials. The canopies leading to the main entrance are edge lit with a fluorescent fixture of special design and, when viewed from some distance, seem to direct you to the entrance and point out "This is it, this is the O'Keefe Centre".

The O'Keefe Centre

BY HERBERT WHITTAKER
Drama Critic of The Globe and Mail

Much of the great excitement attending the opening of the O'Keefe Centre was certainly because a new theatre – not a cinema, not a community hall – is such a rarity on the Canadian scene.

There have been Robert Fairfield's remarkable concrete tent at Stratford, the two Jubilee Auditoriums in Alberta and the Queen Elizabeth Theatre in Vancouver, but before them was a very long stretch of time in which no theatres were built in this land. It was such a long stretch that the wonder is that architects remembered how to build them.

To be frank, there was a rumor that the architects had forgotten. It probably sprang from seeing so many new school auditoriums, complete with windows even on the stage, with tiny dressing rooms, no storage space, high prosceniums and hardwood floors. They suggested that the modern architect wasted no time observing theatres.

It was a sad combination of circumstances which cut off the demands for new theatres four decades ago. The popularity of motion pictures, especially when they learned to talk; the radio, the increase in freight rates – all combined to put the legitimate theatre out of the touring business here.

It was a remarkable achievement that Toronto, of all the cities in the country, managed to remain a theatre-town for touring attractions, even after it lost all of its houses except the Royal Alexandra. Between that distinguished building and the Little Theatres (which are not theatres so much as basements, school halls or old churches) the ancient art of theatre was kept in practise.

When the novelty of radio, motion pictures and finally television wore off, it was perceived that they were not substitutes for legitimate theatre. They were, in fact, each interesting in their own way, but it was quite a different way.

So the need for theatres was felt throughout the land again. And so the architects have turned their attention to the problem: What is a theatre?

The answer is not easy. To some people, a theatre is the temple of a very ancient art. To others, it is a box-office surrounded by guesswork. To others again, it is a symbol of gaiety and enchantment. To a few, it is a public house of culture. And to many Canadians, it is simply a public house.

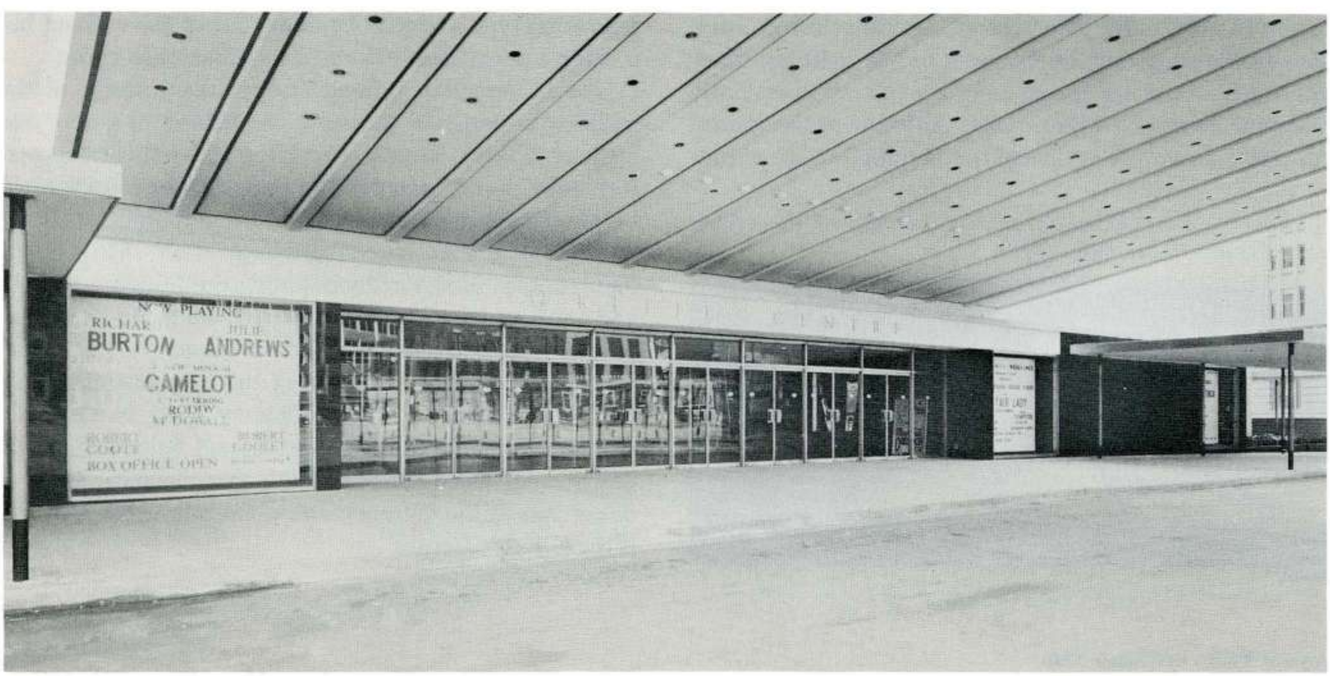
It all depends on your experience. Plainly, somebody who has never been in one is apt to suspect it of being a sinful palace of exhibitionism. On the other hand, those who were exposed to theatre at a tender age have the most glowing impressions.

Perhaps the most vivid image of a theatre is that of the high-galleried, gilt-and-crimson buildings which are the pride of so many European capitals. Here the audience hangs over the actor in dangerous expectancy, and the empathy runs high. No flick of the actor's eyebrow is missed, no stage whisper but sends chills up and down those spines so perilously perched on hard seats. The cheaper the seats, of course, the more dizzying the heights, the greater the discomfort involved.

To the Canadian architect who hasn't been hypnotized in one of these heavenly hell-holes at an early age, or at all, such conditions of viewing are naturally appalling. He is the product of a democracy, and a well-to-do one, at that. There must be room and comfort for everybody. The only difference between the most expensive seat in the house and the cheapest is that the latter will be further back. But the sightlines, even there, will be perfect. And there will, naturally, be no posts.

Moreover, there will be lobby-space, preferably with a mural, with marble, broadloom and soft pleasant lighting like the O'Keefe Centre.

Here you get one answer to the question: What is a theatre? A theatre is a place of light and beauty, in which there is room for all, a place one can approach with anticipation, preferably in one's best clothes. And when that anticipation is sharpened by the promise of a big



musical spectacle like My Fair Lady, it would seem that the architects of the O'Keefe Centre had hit it off perfectly and that the sponsors had got their $12,000,000 worth.

However, there is not just one answer to the question, as we have noted. Theatres have always come in different sizes, for different purposes. In fact, in London, at one time, it was possible to be sure of seeing a certain kind of play going to a certain theatre. If you wanted Shakespeare, you went to the Lyceum, if drawing-room comedy, Wyndham's, if it were to be spectacle, the Theatre Royal, Drury Lane.

It is still possible to follow this system in Paris and other European capitals.

No theatre suits all purposes. And without dimming one iota the glory of the theatre which this issue celebrates, we would like to hint that there is still work for architects to do in the new-old line of building theatres.

The generous, luxurious, comfortable Centre is in the tradition of Drury Lane – more so than we yet know. Because touring shows are self-sufficient, suspicious and so independent, we have yet to learn its true acoustical properties, or enjoy its full stage. I imagine the Metropolitan Opera, which comes from a home slightly larger than the Centre's 3,200 accommodation and needs no microphones, will satisfy us on both counts. Certainly the Royal Ballet will show us how spacious the new stage is.

When it comes to the theatre's less flamboyant charms though, we will not expect the Centre to turn itself into a jewel-box, no matter how accommodating it might wish to be. For "straight" plays involving no more than seven or eight people – and it is amazing how most of the greatest plays in the world have casts no bigger than that – we will be glad that we still have the Royal Alexandra, which is so much admired by the long line of distinguished actors who have played there.

But although, since the opening of the O'Keefe, the Royal Alexandra has started to talk about itself as an intimate house, these two theatres do not fully meet the demand of a maturing metropolis.

Toronto needs several more theatres, of varying sizes. It needs an 800-seat home for the company now squeezed into the narrow, dull confines of the Crest Theatre. It needs several theatres of about half that size to house the really intimate plays and the tiny revues, for which Canadians have a penchant. Of course, the need for such a small, intimate theatre was recommended to the owner and architects of the O'Keefe, and one was included in the original concept of the Centre, but, reportedly, the additional costs made it prohibitive.

So there is work for architects here still. A visit to the theatre once a month, at least, can be accounted as research which might well prove very valuable. The only way to find out what a theatre is involves a first-hand knowledge of acting, of drama, of staging and of the rare empathy possible between the players and the audience.