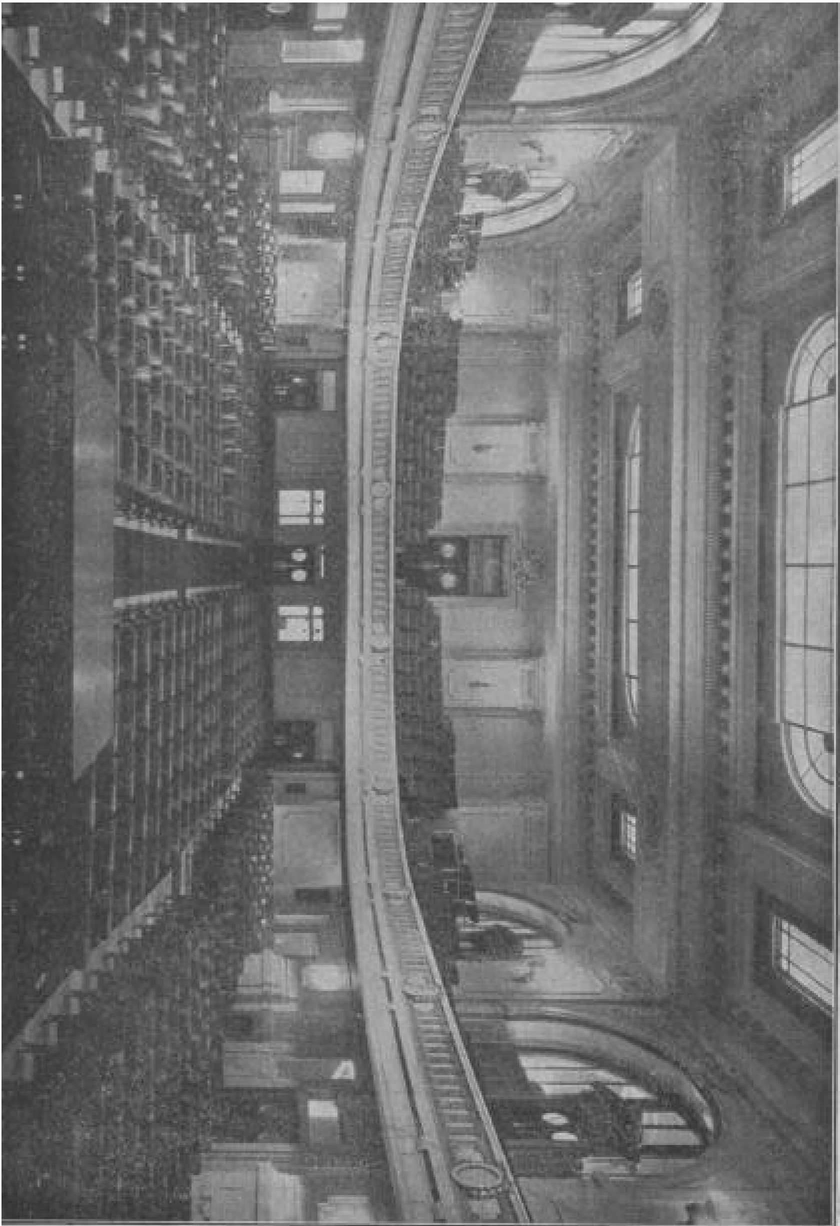
ILLUMINATION OF THE ENGINEERING SOCIETIES BUILDING, NEW YORK.

By C. E. Knox, *Member*.

The Engineering Societies Building, as is generally known, was a gift of Mr. Andrew Carnegie to three of the four large engineering societies, namely, The American Institute of Electrical Engineers, The American Society of Mechanical Engineers, and The American Institute of Mining Engineers. Although invited to join the three societies above named in the ownership and occupation of this building, The American Society of Civil Engineers, by a vote of its members, decided not to accept the invitation. The land on which the building was erected was purchased jointly by the three societies. The building is located on Thirty-ninth street, New York City, between Fifth and Sixth Avenues, and connects with the property of the Engineers' Club, which was erected at the same time, although owned by an entirely distinct and separate organization.

The building consists of a basement and thirteen stories, and a part (mezzanine) or fourteenth story, as shown in Fig. 2. The building is a fireproof structure throughout, with terra cotta arches and partitions. The floors, with few exceptions, are of concrete, tile, or mosaic. The flooring in the library, main auditorium and lecture rooms, however, is of wood. The basement is occupied in part by the boiler room, pump, ventilating and other machinery and storage places. Space has been reserved for an isolated plant, so that one may be installed at any future time, if it is decided advisable to do so and if money be available for that purpose. At the present time, the current supply is derived from the mains of the New York Edison Company. On the first floor are located the entrance hall, writing room, administration offices, reception room, smoking room, corridors, etc. The second floor is occupied principally as a coat room. The third and fourth floors are occupied by the main auditorium which has a seating capacity of about 1000 persons. The fifth and sixth floors are used for assembly and lecture rooms. The seventh to eleventh floors, inclusive, are used as office floors, three of these floors being used by the three founder societies. The twelfth floor is used as a stack room for the library, which is located on the thirteenth floor.



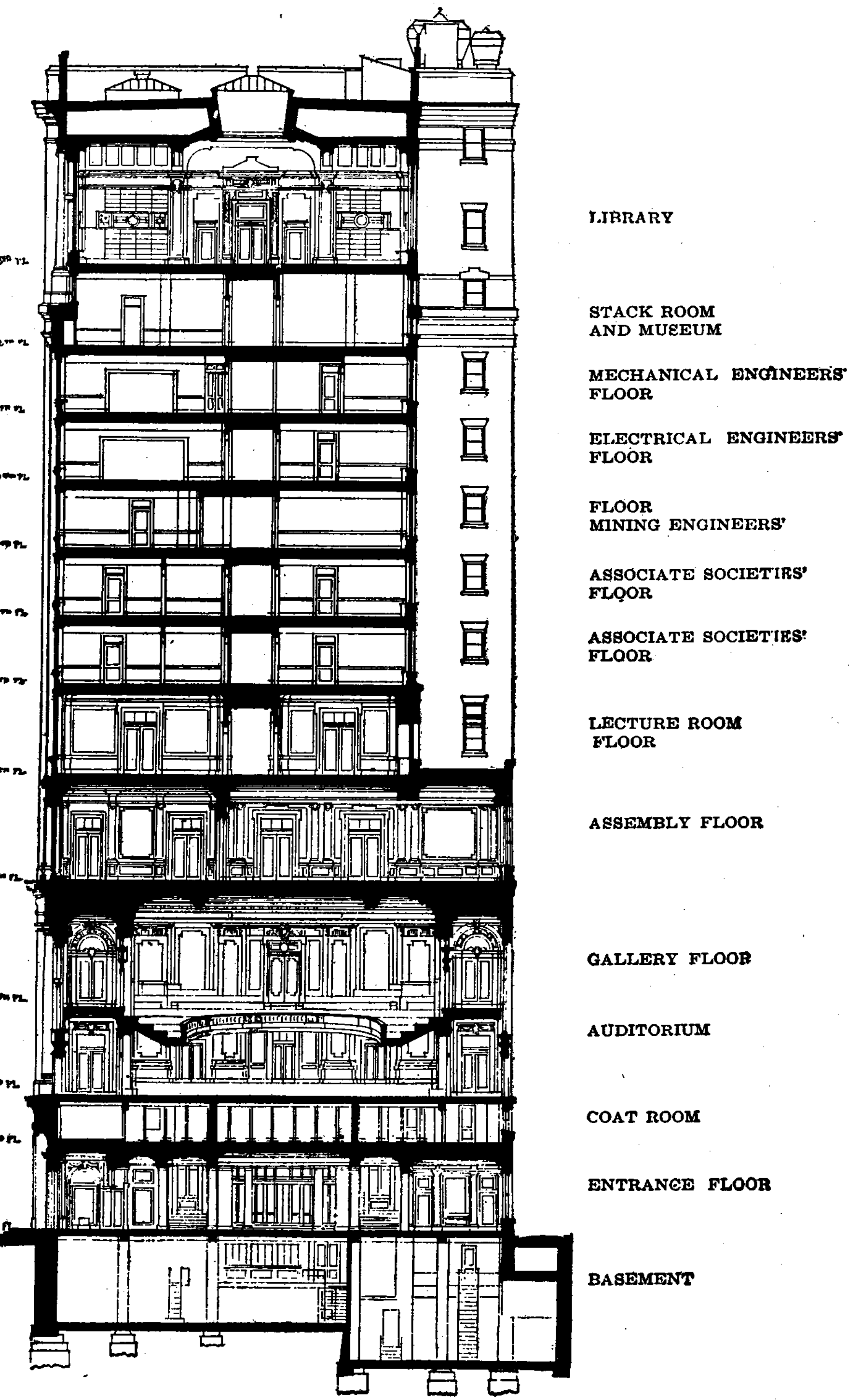


Fig. 2. — Sectional Elevation of Building.

With this brief description of the building and its uses, we will proceed to briefly outline a few of the more novel and interesting features of illumination designed by the writer for this building.

When we were appointed consulting electrical engineers for the building, no mention was made with reference to matters of illumination or fixtures, and inasmuch as both Mr. Mailloux and the writer are members of the American Institute of Electrical Engineers, we were rather reluctant to bring the matter to the attention of the committee. However, before the plans had progressed very far, we were instructed to proceed with and prepare plans and specifications for the illumination and for the fixtures for the building, as well as for the electrical equipment. By virtue of this, and because of the splendid support and co-operation on the part of the architects and also of the Building Committee, we were able to obtain results in a great many cases which would have been impossible by any other arrangement. Experience has shown that in order to obtain the best results as far as illumination is concerned, the engineer must be consulted before the plans have progressed beyond the point where it is possible to make slight changes in the design of rooms, etc., to accommodate features of special illumination, and the person who locates the outlets should also have a guiding hand in the design and selection of the kind and type of fixtures to be used. At the same time, it must be realized that illumination is only one of the features of the building, and that in most instances it must be subordinated to features of architecture and decorative treatment. To ignore this fact is unwise, because it must be borne in mind that the architect is the "leader of the orchestra" and the advisory engineers should be under his direction and act in harmony with him in order to obtain the best results. The engineer, however, should have sufficient individuality and originality to devise new and improved methods of illumination, when the use of such new methods are warranted, and to present them to the architect with sufficient force to command his attention and his co-operation. This fact is becoming well recognized by architects and owners, and in practically all of the recent electrical equipments now in our hands the illumination has been included with the rest of the electrical equipment. This arrangement, of course, does not and should not interfere with the prerogatives of the architect nor of the plans of the fixture designer, as it is of course impossible for either one

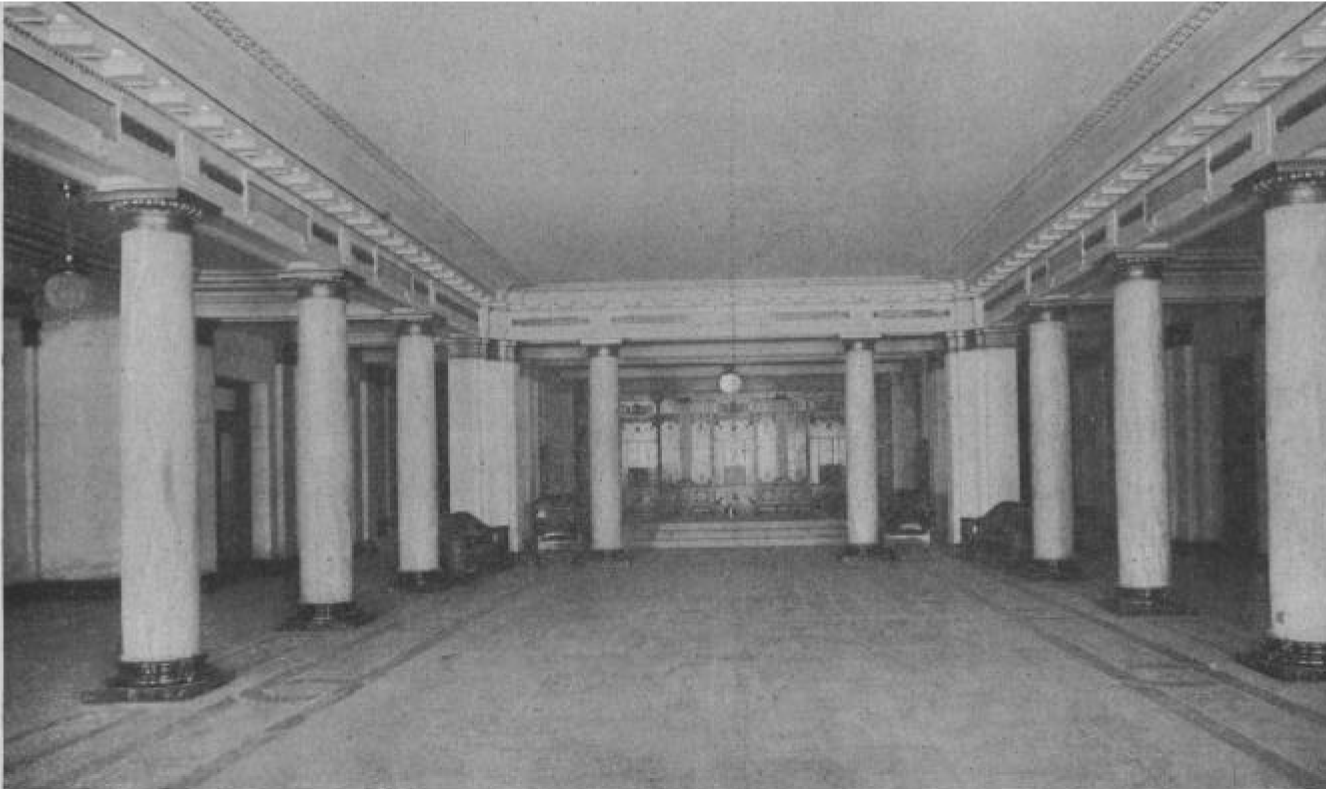


Fig. 3. — Entrance Hall or Foyer, Ground Floor, Engineering Societies Building.

of them to be as well posted on matters of illumination as the engineer who has made a special study of the subject and of the latest developments in the various forms of illuminants, reflectors, and other kindred matters. Besides, their interest lies in the direction of the æsthetic and decorative side of the proposition and there they should be supreme.

We will not attempt in this paper to cover the illumination of all of the building, but will discuss the principal features or those which may be of most interest to the members of this Society. The portions of the building which we will consider are:

1. Entrance hall.
2. Auditorium.
3. Assembly and lecture rooms.
4. Library.
5. Offices.
6. Corridors and halls.

1. ENTRANCE HALL.

The entrance hall, see Fig. 3, or central portion of ground floor, is lighted by means of individual reflector lamps placed above small glass panels between the dentils forming a rectangle inside of the line of columns. These are so well concealed that it is difficult to see them in the photograph, Fig. 3. The corridors around the entrance hall sides are lighted by means of beaded ball pendants containing single "Gem" No. 4 lamps. It was impossible, in the case of the crystal ball fixtures, to place a glass shade or reflector in the upper portion owing to the small neck of the beaded ball; and in order to obtain a proper reflecting surface, the inside portion or cap of the supporting fixture was given a thin coat of silver plating. The lighting of the central portion of the entrance hall is sufficient to illuminate not only the central space, but the surrounding corridors without the aid of the crystal ball fixtures and without glare. Small additional bracket fixtures were installed, but these were only necessary for decorative purposes. A complete crystal ball fixture, installed in one of the upper elevator halls, and similar to those in the entrance hall, is shown in Fig. 4.

The problem of lighting the auditorium, which occupies the larger portion of the third and fourth floors, was naturally the most difficult, and at the same time the most interesting feature of illumination in the building. It is a well known fact that the

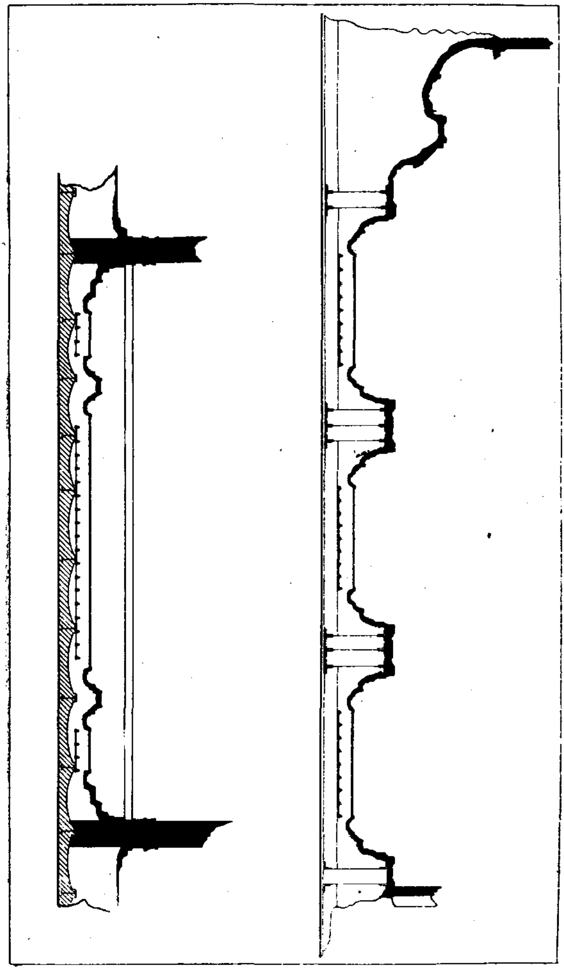
Fig. 4. — Beaded Glass Ball Fixture.

lighting of large places, notably theatres, is nearly always objectionable from many locations, particularly in the balconies and galleries, on account of glare, and owing to the fact that the source of illumination comes within the range of vision. At the outset the writer sought to overcome this difficulty, and evolved a plan in which the source of light is entirely screened from view by placing the illuminants behind special glass panels forming part of the ceiling design.

The general arrangement of the auditorium, including the balcony and ceiling, is shown in the photograph of the auditorium (see Fig. 1). As will be seen from the photograph, there are no ceiling lighting fixtures whatever, the light being obtained by what might be called the direct-indirect method of lighting, the lamps being placed back of a glass septum or screen in the ceiling.

In order to support the floors above the auditorium without placing columns in the auditorium itself, two sets of enormous girders were installed, resting on the outside walls and dividing the auditorium ceiling into three panels. These three panels were originally intended to be flat plaster panels, to be placed as close to the floor arches above as possible. Before the architects' definite plans had been made, the writer conceived the idea of replacing these plaster panels by glass panels, and by lowering them slightly and changing their design, endeavored to obtain sufficient space for the lamps and to gain access to them without changing the ceiling design to such an extent as to incur the opposition of the architects. The scheme was worked out in full detail before being submitted to the architects (Herbert D. Hale and Henry G. Morse, associate), and when the plan was submitted it was received with enthusiastic support and hearty co-operation. The glass area required in order to obtain the proper amount of illumination was carefully calculated, and these data and other details were submitted to the architects, who proceeded to design the architectural features necessary to make the scheme a success. Figs. 5 and 6 show longitudinal and transverse sections of the ceiling, indicating the large transverse girders and the small overhead beams, also showing the location of the glass and of the lamps.

The question of the kind of glass was naturally a most important one, because it was essential that the glass should be such that it would reduce the intrinsic brilliancy, and at the same time not have an excessive co-efficient of absorption. A considerable number of samples of glass were obtained and examined and rejected, and the glass finally adopted was that known as silver ripple glass, manufactured by a Boston glass company, each piece used being carefully examined and selected. The glass has proved very satisfactory, and much of the success of this scheme of lighting undoubtedly depends on the kind of glass, its uniformity, diffusing quality, etc.



Figs. 5 and 6. - Sections of Auditorium Ceiling.

In order to obtain access to the space above the glass ceiling for re-lamping and for cleaning the glass, the writer arranged with the ventilating engineer and with the architects to provide entrances through the ventilating ducts serving to exhaust the air from the auditorium. Entrance to these ventilating ducts is obtained through a trap door in a closet on the fifth floor. The ventilating ducts are sufficiently large for a man to crawl readily through them to a point opposite each of the three panels; at these points, boards have been provided on which he can crawl to any point above the glass panel.

The maximum distance from the top of the glass panel to the bottom of the floor beams was seventeen inches, which was the maximum space the architects could allow, although we were anxious to obtain a greater distance if it were possible. Owing to this limited space, the question of type of illuminant was naturally limited, and the lamp known as the reflector incandescent lamp was finally adopted, because it was a self-contained unit, was the shallowest lamp on the market, was quite efficient in the downward direction, and, requiring no reflector and shade, was easy to replace and handle in the small space available. Furthermore, by selecting a proper voltage and not trying to run it at a maximum efficiency, it would probably have a life of from 1,000 to 1,200 hours. The writer met considerable opposition on the part of the lamp companies when the use of this lamp was suggested to them, as it is a lamp they do not care to make; but he believes results have proved, that for the present at least, it is as satisfactory a lamp as can be obtained. At any rate, it will be a simple matter to replace this lamp by other more improved lamps at any time.

The lamps above the glass ceiling are wired in alternation, so that either half or the entire number may be used as desired. One-half the number of lamps gives ample illumination for ordinary purposes. Furthermore, in order to avoid interruption of the lighting in the auditorium, there are two separate feeds connected to two separate street service mains, so that in the event of the failure of one outside service the other would still remain in use.

Additional screened lighting was provided underneath the balcony by installing a curved glass cove in the angle formed by the intersection of the wall line and the balcony. A determined effort was made to have this cove continuous, but owing to the structural difficulties caused by the unusual steel structure necessary to support the balcony, and the floors above the auditorium, it was necessary to interrupt this cove at each of the columns. In order to avoid relatively dark spots on the columns, Holophane glass shields were installed at six points under the balcony on the columns.

The lighting of the auditorium is entirely controlled by a special switchboard placed in the passageway back of the stage. Dimmers have also been provided so that any amount of light from minimum to maximum may be obtained by small gradations. This is a very desirable feature in case the room is darkened for the exhibition of lantern slides or for other reasons, as it enables the operator gradually to increase the amount of light, and thereby avoid the unpleasant sensation on the eye of changing from relative darkness to a high degree of light.

For the lighting of the stage, a row of lamps has been placed in the cove back of the proscenium arch.

While there have been instances where lamps have been placed back of glass skylights and ceilings and the illumination screened, so far as the writer knows this is the first instance where a glass ceiling or glass screen has been employed solely for the purpose of artificial lighting, in a case of this kind. Certainly there could hardly be a condition where, at the outset, it would seem more difficult to accomplish this method of lighting than in the present case, because the steel structural problem was in itself a very difficult one, and the space available was so discouraging as to make it problematical whether the desired result could be obtained or not. However, the very favorable remarks and criticisms which have been made of the scheme of lighting would certainly indicate that the method is one which meets with the approval of the general public. It is to be hoped that many of the defects in the lighting of theaters and large auditoriums, in the near future, will be avoided by screening the lamp or the source of light itself, in some similar manner to that used in this case. It would certainly seem in theaters that similar methods could be devised with much more ease than in this case, because of the greater space available above the auditorium ceiling. It might be carried even further than was possible in this case, by using the indirect or reflected method of lighting in addition to the glass septum or screen. This of course would be almost ideal; and although the efficiency would be lower than in this case, in many instances it would be warranted, because it must be remembered that the length of time that the light is used in auditoriums is relatively short and the cost is consequently of correspondingly minor importance. As a matter of fact the cost of lighting this room is much less than would be supposed, and for an ordinary lecture is less than the cost of ventilating the room. This method of lighting is unquestionably superior to the so-called "cove" method of lighting, and furthermore is practicable in many cases where the "cove" method could not be employed.

3. ASSEMBLY AND LECTURE ROOMS.

Assembly Room No. 1. At a conference with the architects and the Building Committee it was deemed advisable to use the

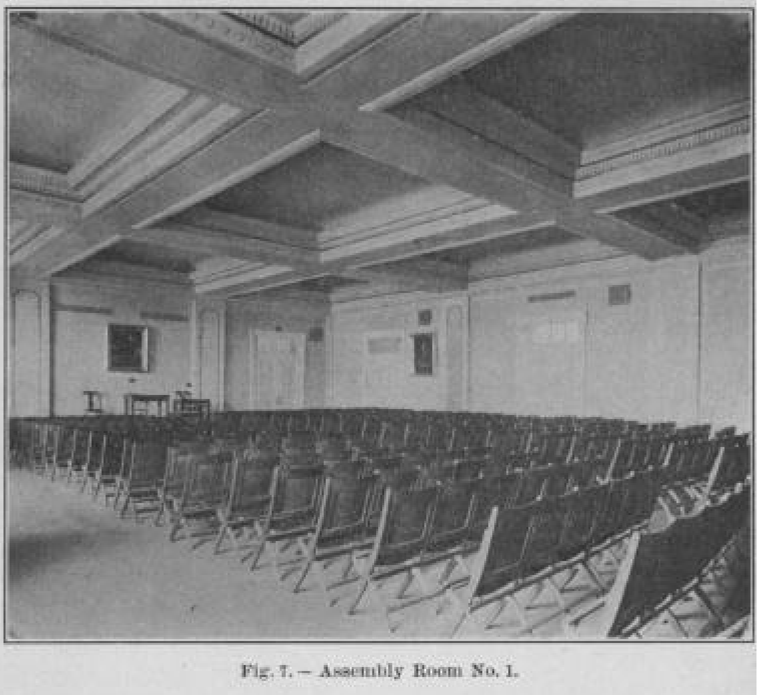


Fig. 7. — Assembly Room No. 1.

diffused or indirect method of lighting if possible for these rooms, and schemes were submitted to the architects for the purpose of obtaining the principal lighting from lamps placed in coves. While it was realized that the "cove" method of lighting had disadvantages, nevertheless it was deemed the best system for rooms of this character which will be used almost entirely for lectures, as no reading is done except by the lecturer, and any exposed lamps or glare would be objectionable to the auditors, particularly during protracted sessions.

On the fifth floor there are two large and one small assembly rooms. The large assembly room, Fig. 7, has a seating capacity of 450 persons, and is approximately 51 feet wide by 66 feet long, and about eighteen feet high. It was obvious from original

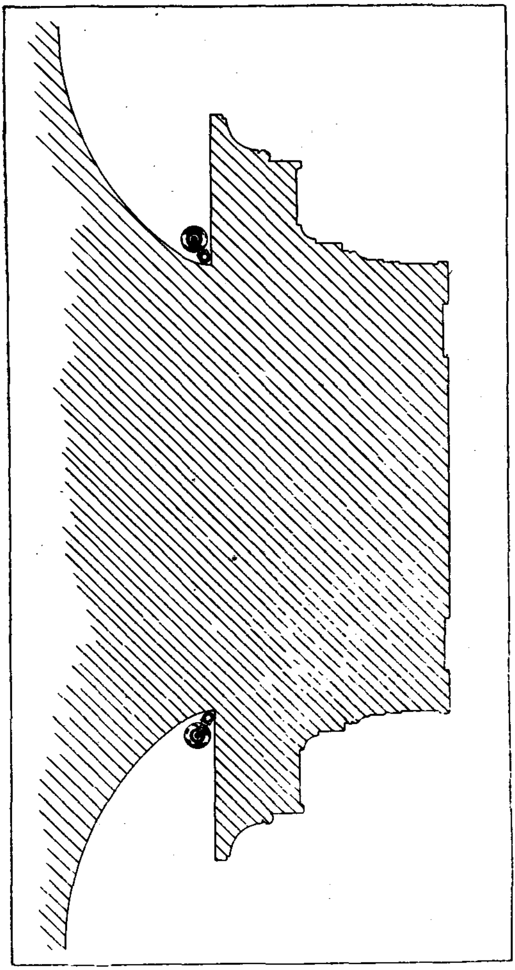


Fig. 8. — Section of Cone in Assembly Room No. 1.

calculations that it would be impossible to illuminate this room entirely by lamps placed in coves at the edges of the room. After consultation with the architects, a scheme was devised by adding some false girders in the room which would divide the ceiling into nine panels. Each of these panels was provided with coves, as shown in the section (Fig. 8). This section is through one of the longitudinal girders and shows the cove with a lamp on either side of the girder. The total number of lamps provided for this room was 420 sixteen-candle-power lamps, the total kilowatt capacity being 21 kilowatts. Additional ceiling outlets were provided in the center of each panel, in case they should be desired for special lighting at any time.

The lamps, being placed above the girders, tend to throw the latter in silhouette, which bring out the architectural details of the girders.

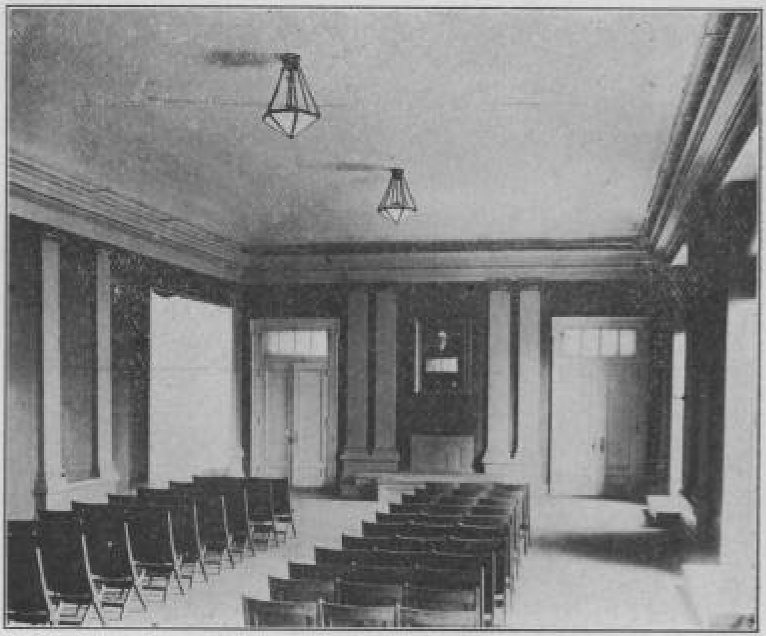


Fig. 9. — Assembly Room No. 2.

Assembly Room No. 2. This room has a seating capacity of approximately 300, and is 29 feet wide, 66 feet long and about eighteen feet high. It is illuminated partly by lamps placed in coves and partly by three special inverted ceiling fixtures (see Fig. 9.) A section of the cove showing a lamp with a reflector used in this case is shown in Fig. 10. There are a total of 268 eight-candle-power tubular lamps used with special Frink reflectors. In the case of all of the assembly and lecture rooms, it was impossible, for architectural and structural reasons, to obtain the

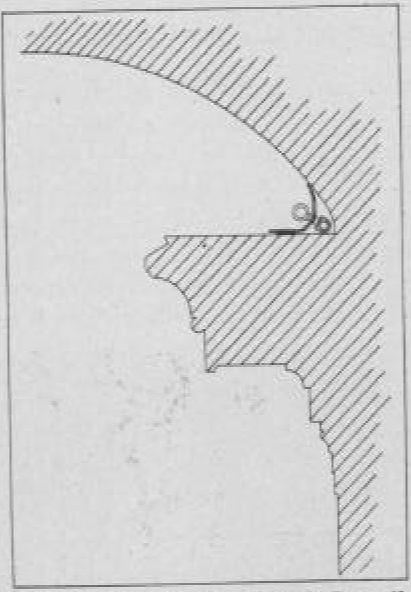


Fig. 10. — Section of Cove in Assembly Room No. 2.

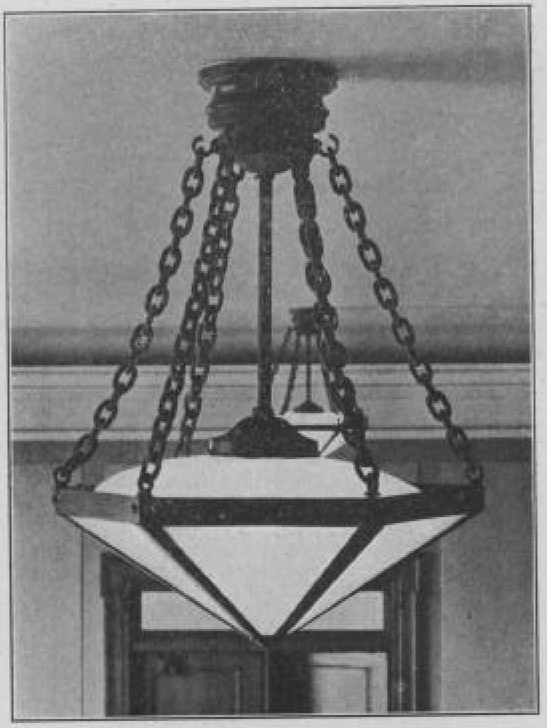


Fig. 11. — Inverted Ceiling Fixture (Assembly Rooms).

depth and form of cove desired and which was necessary to give the best results from an illuminating standpoint, and many difficulties were encountered and were met as well as the conditions would permit. At the outset sixteen-candle-power lamps were placed temporarily in the cove of this room, without reflectors, in order to have the room available for use before the opening of the building. Later the permanent reflectors were placed in position and a special inverted ceiling fixture designed for the

Fig. 12. — Lecture Room No. 6.

three ceiling outlets. A test was made with the original temporary illumination and also with the final arrangement, and these results are given hereinafter.

As already stated, with a room of this size it was practically impossible to obtain the necessary amount of illumination entirely from the coves, and three ceiling outlets were provided in the center of the room for additional lighting. Inasmuch as the principal lighting of this room was concealed, it was necessary that the ceiling fixtures should correspond in general with the concealed system of lighting, and the special fixture shown in Fig. 11 was designed by the author for this purpose. Each of these fixtures consist of an inverted hexagonal frame with a special white glass and a cluster of seven "Gem" No. 2 lamps placed under a nineteen-inch flat Holoplane shade above the glass. This fixture is very pleasing in appearance, and, the light being screened, it is absolutely unobjectionable from glare and at the same time contributes to a considerable degree in the illumination of the room.

Lecture Rooms Nos. 5, 6, and 7. Photographs of lecture

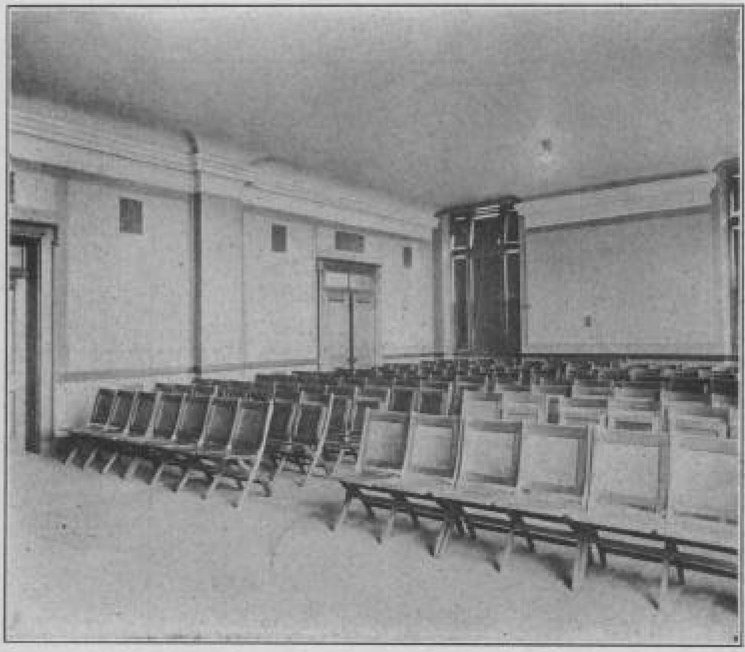


Fig. 13. — Lecture Room No. 7

rooms Nos. 6 and 7 are shown in Fig. 12. and Fig. 13, respectively, and the lighting of these three rooms is similar in a general way to that of assembly room No. 2, except that in lecture rooms Nos. 5 and 7 the permanent inverted fixtures have not yet been installed. A section of the cove in all three rooms is shown in Fig. 14. Owing to the fact that the cove was very shallow, it was necessary to put a strip at the edge to keep the lamps from being in the line of vision. It was quite difficult in all of these rooms to obtain satisfactory cove lighting, owing to the fact that the cove for architectural reasons had to be quite shallow; moreover, in lecture rooms Nos. 6 and 7 it was necessary to interrupt the coves at the window.

In the smaller lecture room on the sixth floor (Lecture Room No. 8), it was quite impossible to have any coves whatever, and it was necessary to use ceiling fixtures. Temporary fixtures have been installed and fixtures of the inverted type will be installed later.

The number of lamps and the kilowatt consumption of the principal lecture and assembly rooms, and tests of the illumination, are given hereinafter.

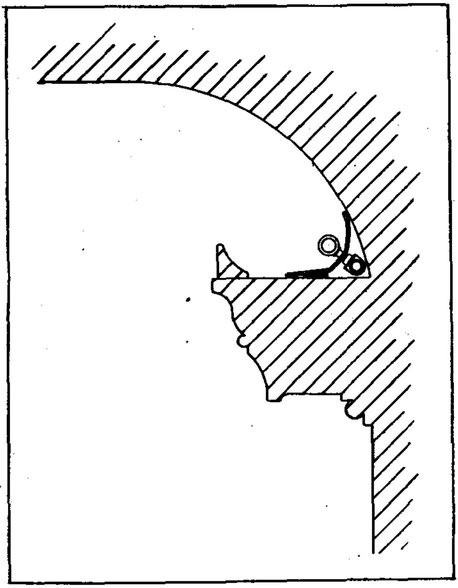


Fig. 14. — Section of Coves in Lecture Rooms, Sixth Floor.

4. LIBRARY.

The general illumination of the library, Fig. 15, is obtained by means of the indirect-direct method of lighting, the lamps being placed back of the four ceiling skylights, which also serve for daylight illumination. In this case the proposition was relatively simple, and not particularly novel, although the results are very satisfactory. At the suggestion of the writer, the same type of glass was used for the ceiling panels as in the case of the auditorium. In this case the available space was considerable, and it was possible to use more efficient and higher candle power lamps. The lamps used were No. 2 "Gem" units, with the concentrating Holophane shade; the lamps and shades were so located as to avoid casting shadows in the daytime.

The alcoves in the library were lighted by means of special eighteen inch glass globes, supported by chains from the ceiling in the center of each alcove. The globes consist of a special glass made especially for the purpose by Gleason & Tiebout Glass Company, and consist of a light opal globe, slightly ground inside. This glass was adopted after a great number of samples of opal and opalescent glass were examined and rejected by the writer and his assistant, E. R. Muller. These globes were also used

Fig. 15. — View of Library Looking Toward Entrance.

on the stair halls and some of the main halls. This glass has proved very satisfactory, as it is impossible to see the lamp through the glass, the intrinsic brilliancy is reduced to a minimum without an excessive loss in brilliancy, and at the same time a warm, pleasing opal glow is produced. This glass is now known in the trade as E. S. B. (Engineering Society Building) glass, in order to distinguish it from the numerous opal; opalescent, alabaster and ground glasses, which terms are quite indefinite.

The lighting of the tables in the library is shown in Fig. 16, which also shows the suspended ball fixtures.

Tests of the illumination and the current consumption of the library are given hereinafter.

Fig. 16.—Library Alcoves and Tables.

5. OFFICES.

The lighting of the offices on the seventh to eleventh floors is obtained principally in each case by a ceiling fixture placed close to the ceiling and varying from three lamps to twelve, depending upon the size of the room. Each socket is equipped with a special diffusing **Holophane** shade. Each fixture is controlled by a switch near the floor.

In order to provide means for lighting desks, book stacks, tables, etc., a uniform scheme was adopted of placing a special wooden molding on the ceiling in all the rooms. At any point a small porcelain rosette could be fastened to the molding and connections made so a drop cord light with shade could be installed. It was believed that this scheme would reduce the fire hazard to a minimum as it would avoid the use of long flexible cord pendants.

A typical office showing the centre light and the molding is shown in Fig. 17.

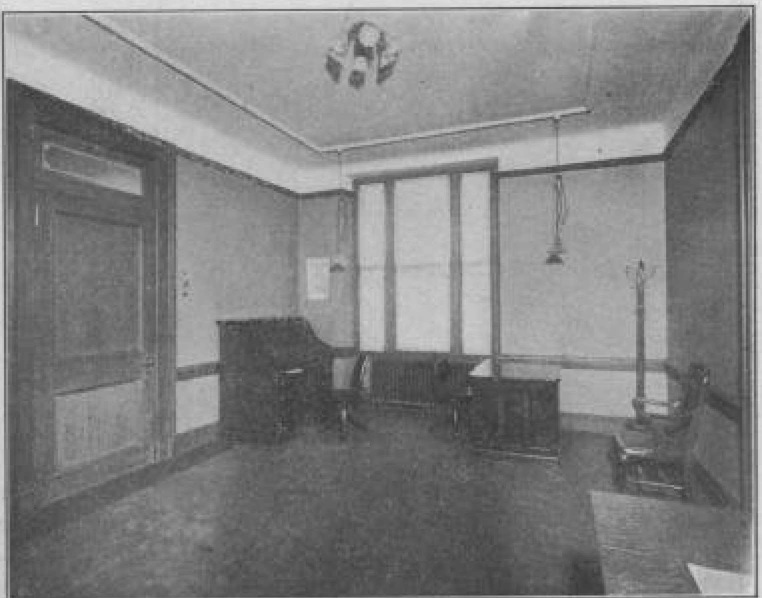


Fig. 17. — Typical Office, Showing Ceiling Fixture and Special Molding.

6. CORRIDORS AND HALLS.

Crystal glass balls using metallized filament lamps of various sizes from 50 to 250 watts are used on the principal floors, from the first to fifth, inclusive. In some instances, however, in order to subdivide the number of lights in the hall fixtures, several lamps have been placed inside of the crystal balls. In all instances the metal plate at the top of the fixture supporting the sockets has been silvered, to act as a reflector and to increase the efficiency as far as possible.

In the halls above the fourth floor, simple glass globe fixtures were installed. These globes were also of the E. S. B. glass already described.

The value of the services of an engineer for illumination was shown clearly in this case, by the saving made in the amount of the fixture contract. At the outset a preliminary figure was obtained by the architects for fixtures for the building, which amounted to $30,000. This exceeded their appropriation for fixtures, and when the matter was placed in the hands of the

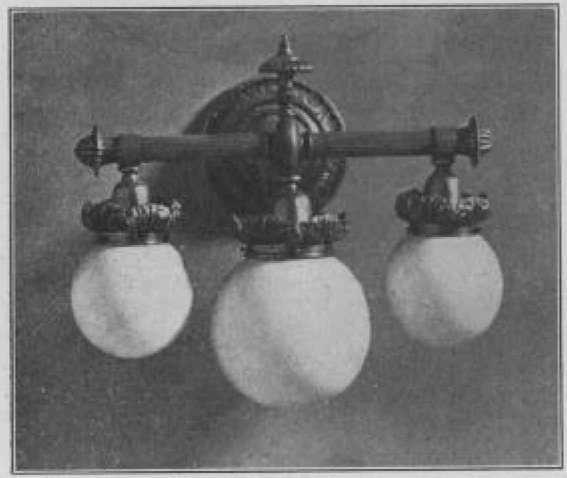


Fig. 18.—Typical Stair Bracket Fixture.

consulting engineers an allowance of $20,000 was made to cover all of the fixtures in the building. The actual contract amount for all of the fixtures in the building, as covered by our specifications, was under $10,000. The contractor for the fixtures was Mitchell, Vance & Company.

ILLUMINATION TESTS.

Illumination tests were made of the following portions of the building, and the results are given herein below:

Entrance hall (ground floor).
Auditorium (third and fourth floors).
Assembly room No. 1 (fifth floor).
Assembly room No. 2 (fifth floor).
Lecture room No. 5 (sixth floor).
Lecture room No. 6 (sixth floor).
Library (thirteenth floor).
Offices (tenth floor).

These tests are given for what they may be worth and are not guaranteed in any way as to accuracy by the writer, for the reason that the instruments which are now available for making such tests have not yet been sufficiently tried and proved to place them entirely above suspicion. Two entirely different types of instruments were used in making the tests, one the Marshall luminometer (temporary instrument lent the writer until the permanent instrument ordered could be furnished, and, the second, the Ryan candle foot photometer. The writer was assisted in these tests by J. J. Mahler, through the courtesy of W. D'A. Ryan, of the General Electric Company, and by one of the writer's assistants, F. R. Nugent. The readings of the Marshall luminometer was taken by the writer, and of the Ryan instrument by Mr. Mahler. The closeness of the majority readings was a surprise. They are reproduced here in each instance as taken originally without any attempt whatever to make them correspond. While this does not necessarily prove the accuracy of either instrument, it tends to show that if there is any considerable error in either instrument, a similar error probably exists in the other instrument. In some cases it was found that, owing to variation in the voltage of the Edison service, errors would occur in the Ryan instrument, as the candle-power of the standard lamp would correspondingly change. This accounts for most of the discrepancies that appear in the readings of the two instruments.

The writer has used, for a number of months, a Marshall luminometer, through the courtesy of the lamp works of the General Electric Company at Harrison, and has found it a very convenient and practical instrument.

In the tables and figures reproduced herein below, the following symbols or abbreviations are used:

○ indicates location of fixture outlet.

● indicates location of station at which measurement was made.

⊙ indicates location of outlet and also a station underneath the same at which measurement was made.

1, 2, etc. represent number of stations corresponding to readings given in the tables.

M designates Marshall luminometer.

R designates Ryan luminometer.

The figures given in the table are expressed in candle-feet.

Unless otherwise indicated, all readings were taken at a height of two feet ten inches from floor

ENTRANCE HALL, FIG. 3.

Lighted by nine crystal ball fixtures, eight of which each contain one No. 4 "Gem" lamp and one (in front of elevators) three No. 3 "Gem" lamps. The central main portion is lighted by 88 concealed 54-watt reflector lamps, four side bracket fixtures each having eleven round eight-candle-power frosted lamps.

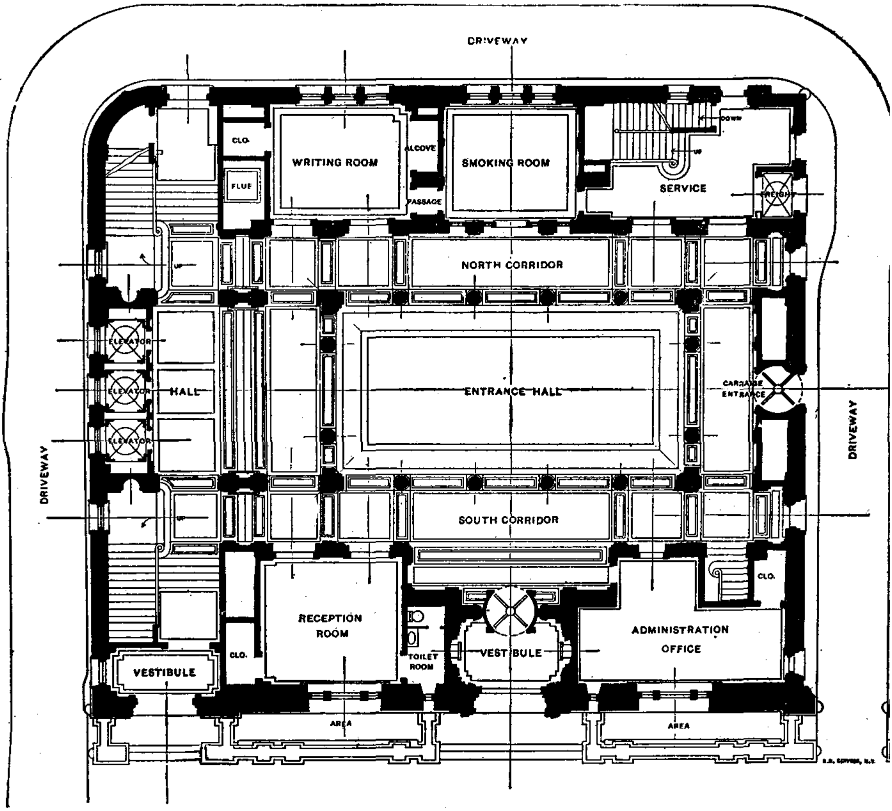


Fig. 19. — Plan of Foyer and Entrance.

Readings were taken at four stations, as follows (see Fig. 19):

1. Center of entrance hall (central portion).
2. Diagonally and midway between stations 1 and 3.
3. Centre of entrance hall (central portion).
4. Under the crystal ball fixture in south corridor.

Height of readings, two feet ten inches from floor.

	M (Marshall Luminometer)	R (Ryan Luminometer)
Station No. 1,	2.05	2.6
Station No. 2,	1.2	1.3
Station No. 3,	.85	.8
Station No. 4,	.8	—

MAIN AUDITORIUM, FIG. 20.

Above glass panels in ceiling, 396 54-watt lamps and 414 30-watt lamps have been placed.

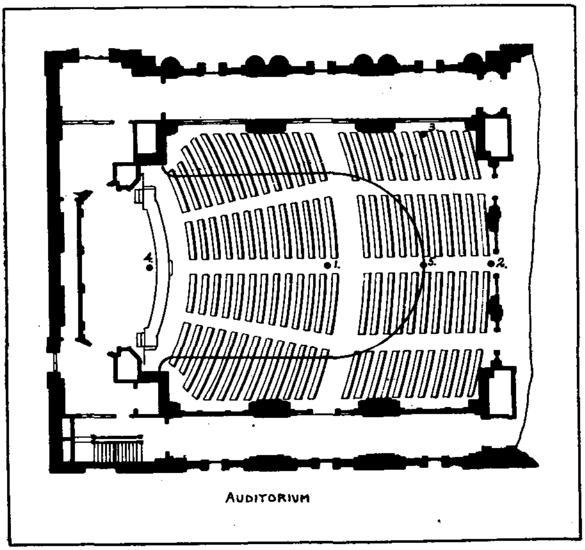


Fig. 20. — Plan of Auditorium.

In glass coves under balcony, there are 138 ten-candle-power ordinary carbon lamps. (These lamps were installed by error and are to be replaced bv No. 1 "Gem" 50-watt lamps, which will increase and improve the lighting under balcony.) There are six Holophane glass shields on columns under balcony, each containing one No. 2 "Gem" lamp, two Holophane hemispheres under balcony, each containing one No. 1 "Gem" lamp and six brackets over balcony, with eleven eight-candle-power round bulb frosted lamps.

In the stage proscenium arch are 38 No. 1 "Gem" lamps.

Summary:

Above glass ceiling,	33,600 watts
Under balcony in glass coves,	4,800 watts
Brackets, etc.,	2,770 watts
Proscenium arch,	2,060 watts
Total,	43,230 watts

Two sets of readings were taken in the auditorium, one set with half of the lamps above the glass in use, and the second set with all of the lamps in use.

With all lamps in use:

	M.	R.
Station........1	7.8	*
" 2	2.0	2.35
" 3	2.1	2.45
" 4	3.25	3.2
" 5	5.8	—

(Station No. 5 on edge of balcony railing.)

* Reading above the limit of the instrument.

With only one-half of lamps above glass ceiling in use:

	M	R
Station........1	4.3	4.55
" 2	1.7	1.75
" 3	2.2	2.0
" 4	2.0	2.05

ASSEMBLY ROOM NO. 1 (see Fig. 21.).

Dimensions: 51 feet by 66 feet by 18 feet high; 420 No. 1 "Gem" lamps (2,100 watts).

All lamps in use:

	M	R
Station........1	1.45	1.6
" 2	1.4	1.65
" 3	1.75	1.75
" 4	1.65	1.6

One-half the lamps in use:

	M	R
Station........1	.8	.8
" 2	.9	.83
" 3	.85	.8
" 4	1.0	.9

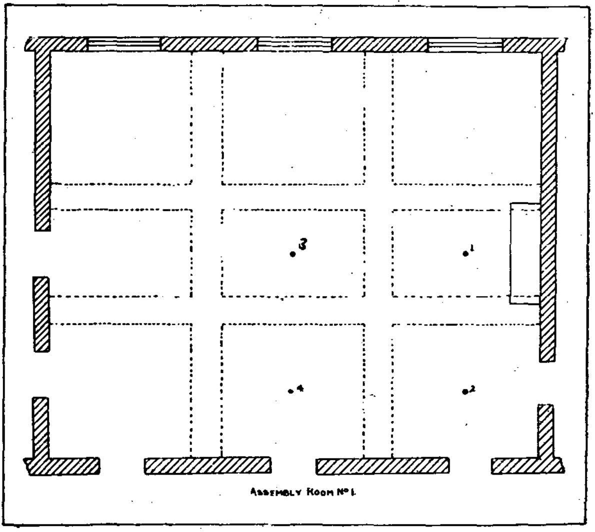


Fig. 21. — Plan of Assembly Room No. 1.

ASSEMBLY ROOM NO. 2 (see Fig. 22).

Dimensions: 29 feet by 66 feet by 18 feet high; 268 eight-candle-power tubular lamps with special Frink reflectors in cove, and three special inverted fixtures with seven No. 2 "Gem" lamps.

Watts in cove equal,	8,040
Watts in fixtures equal,	2,100
Total watts equal,	10,140

In the following table Ma designates readings taken with

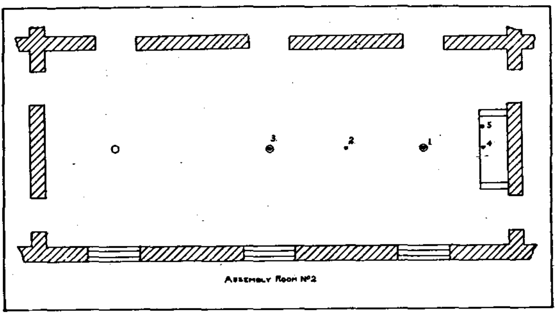


Fig. 22. — Plan of Assembly Room No. 2.

the temporary lighting used before the Frink reflectors and the special fixtures were installed:

	M	R	Ma
Station........1	2.5	2.5	.9
" 2	2.2	2.15	1.0
" 3	2.7	2.55	1.1
" 4	1.7	1.65	
" 5	10.7	—	

Station 5 was a reading taken on platform table under reading lamp, at a distance of about fourteen inches under lamp reflector. The same arrangement as above but with the cove lamps only, centre fixtures being turned off, gave the following results:

	M	R
Station........1	1.2	1.2
" 2	1.0	1.1
" 3	1.0	1.2
" 4	1.35	1.15

LECTURE ROOM NO. 5 (see Fig. 22).

Dimensions: 22 feet by 46 feet by 15 feet high; 190 eight-candle-power tubular lamps with special Frink reflectors in cove.

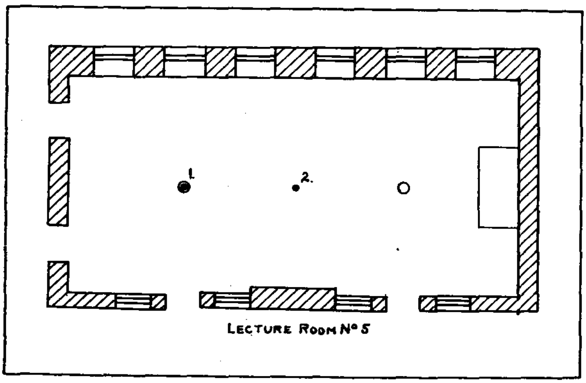


Fig. 23.—Lecture Room No. 5.

Two (temporary) No. 4 "Gem" lamps with No. 4D Holophane reflectors, gave the following results:

In cove,	5,700 watts
Ceiling,	370 watts
Total,	6,070 watts

With cove and ceiling lamps, these results were obtained:

	M	R
Station........1	1.85	1.35
" 2	1.4	.95

With cove only:

	M	R
STATION........1	1.15	.95
" 2	1.1	.65

An additional reading was taken at station No. 3 with ceiling lamps only in use, which showed 1.05 candle feet directly under light.

LECTURE ROOM NO. 6 (see Fig. 23).

Dimensions: 30 feet by 46 feet by 15 feet high; 174 eight-candle-power tubular lamps with special Frink reflector in coves.

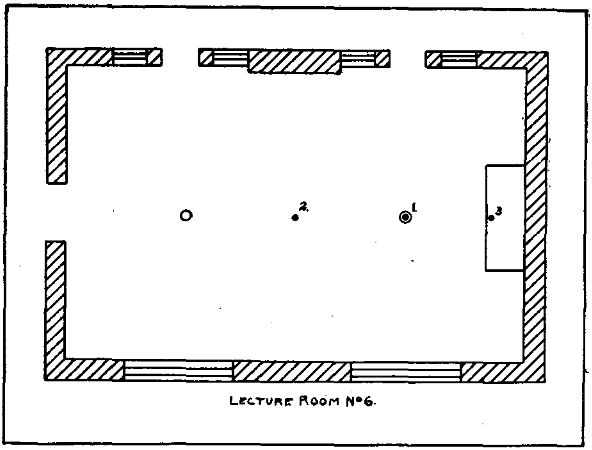


Fig. 24. — Lecture Room No. 6.

Two special inverted ceiling fixtures, each having seven No. 2 "Gem" lamps with 1911 Holophane reflector.

In cove,	5,220 watts
In ceiling,	1,400 watts
Total,	6,620 watts

The cove and ceiling lamps gave at:

	M	R
STATION........1	2.65	2.75
" 2	1.65	1.8
" 3	2.9	2.75

The cove lamps only gave at:

	M	R
STATION........1	1.15	1.25
" 2	1.15	1.45
" 3	1.8	2.1

LIBRARY, FIG. 25.

Here there are, above the ceiling, 144 No. 1 "Gem" lamps with Holophane reflector, eight eighteen inch (E. S. B.) glass ball fixtures, each with one No. 5 "Gem" lamp and Holophone reflector at upper part of ball inside, and four two light bracket fixtures with eight inch (E. S. B.) glass globes and one 44-watt tantalum lamp in each. On the tables are three standards, each with two ten-candle-power frosted lamps and porcelain cone shade (green outside).

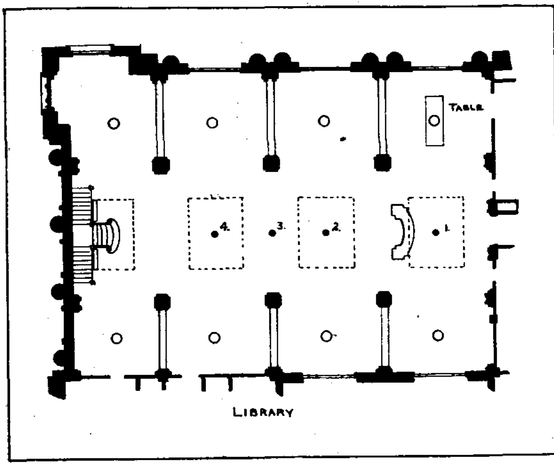


Fig. 25. — Plan of Library.

Above ceiling,	14,400 watts
Ball fixtures,	2,000 watts
Side brackets,	350 watts
Standards at tables,	420 watts
Total,	17,170 watts

With ceiling and ball fixtures, readings showed at:

	M	R
Station........1	2.7	1.95
" 2	2.0	1.95
" 3	2.5	2.5
" 4	2.3	1.95

With ceiling only:

	M	R
Station........1	1.65	1.9
" 2	1.8	1.9
" 3	2.1	2.3
" 4	1.8	1.75

TESTS ON LIBRARY TABLES, FIG. 26.

The tables are ten feet by three feet and three feet high.

Readings 1, 2 and 3 were taken one foot from table, and 4, 5 and 6 at edge of table.

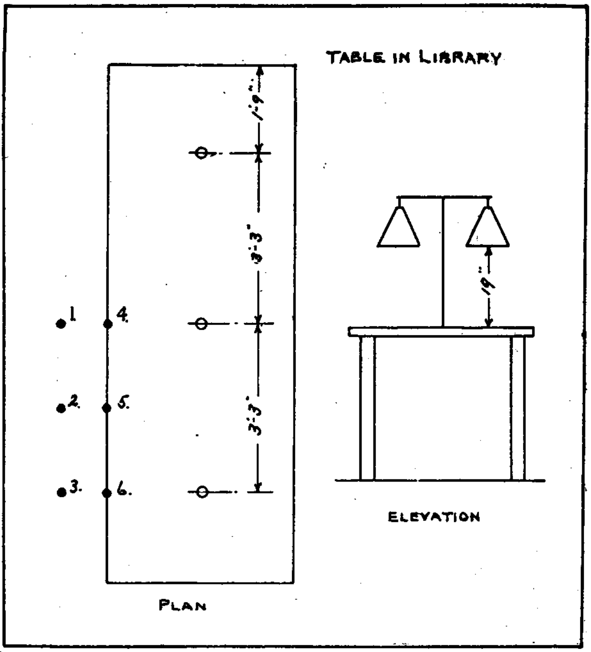


Fig. 26. —Plan and Elevation of Library Table showing Fixtures.

With table lamps only, these were the readings:

	M	R
STATION........1	1.2	1.15
" 2	1.4	1.4
" 3	1.5	1.1
" 4	*	2.35
" 5	*	2.95
" 6	*	3.

* No reading taken with Marshall instrument at these points.

With table lamps and glass ball fixtures:

	M	R
STATION........1	1.75	*
" 2	2.6	*
" 3	1.75	*
" 5	3.8	3 5

* No readings taken.

With ceiling ball fixture only:

	M
STATION........6	.6

OFFICES OF AMERICAN INSTITUTION OF ELECTRICAL ENGINEERING.

Main Office, Fig. 27—Dimensions: 24 feet by 32 feet by 11 feet high; one twelve-light ceiling fixture with ten-candle-power frosted lamps and Holophane reflectors.

Measurements gave the following results:

	M	R
STATION........1	5.4	4.4
" 2	.6	.35

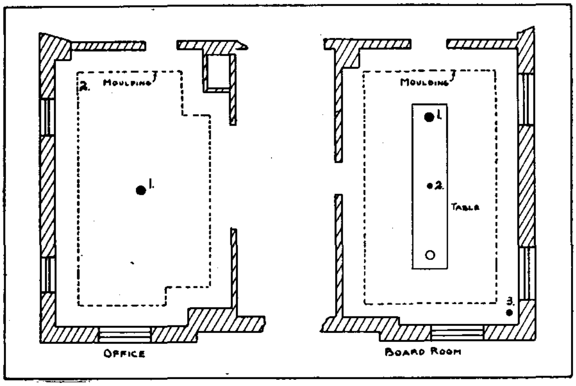


Fig. 27.—Plans of Main Office and Board Room American Institute of Electrical Engineers.

Board Room—Dimensions: 20 feet by 32 feet by 11 feet high; two six-light No. 1 "Gem" lamps and Holophane reflectors.

The tests gave the following:

	M	R
STATION........1	3.1	3.1
" 2	1.8	2.6
" 3	.55	.55

In the corners of both of these rooms at stations 2 and 3 if more light is desired it can readily be obtained by means of the molding circuit overhead.