PLANNING CRITERIA FOR AUDIO-VISUAL FACILITY WITH SPECIAL REFERENCE TO CINEMA AUDITORIUM

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MASTER OF ARCHITECTURE

By

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C E R T I F I C A T E

Certified that the dissertation entitled 'PLANNING CRITERIA FOR AUDIO-VISUAL FACILITY WITH SPECIAL REFERENCE TO CINEMA AUDITORIUM', which is being submitted by Shri MOHAN N. KHANTE, in partial fulfilment for the award of the degree of MASTER OF ARCHITECTURE, Department of Architecture, University of Roorkee, Roorkee, India, is a record of student's own work carried out by him under my supervision and guidance. The matter embodied in this dissertation has not been submitted for the award of any other Degree or Diploma.

This is further to certify that he has worked for a period of 11 months from 1st January, 1972 to 30th November, 1972 for preparing this dissertation at this University.

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A C K N O W L E D G E M E N T S

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M.N. KHANTE

P R E F A C E

The exhibition of films has played a dominont role in getting popularity of cinema which has further resulted into the growth of film industry to such an extent, that it has become one of the major industry in India. This could be done through the theatres for exhibition of films, where the architect is involved for their planning. Therefore he must have the guidelines for planning the cinema theatre, which will offer the conducive performance. Considerable data is available for planning the cinema but it is in scattered form and moreover, the standards for planning factors are not suitable to Indian conditions. As such this study shall fulfil this need to some extent.

This text may serve the architects as a guide to plan a cinema, keeping in view the comfort and safety of the patrons. It must be pointed out that this study is restricted to the cinema auditorium only and not the accessory requirements of the cinema theatre. It is hoped that the architects will find this text useful for planning the cinema auditorium more functionally.

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INTRODUCTION

Audio-visual facility is one of the most important tool of communication, which is an art of transmitting the information, ideas and attitudes from person to person, by seeing and hearing simultaneously. It is playing the significant role not only in the field of recreation but also in education, business and commerce, and communication process.

There are various means and methods of recreation and entertainment. Magazines, newspapers, books etc. can help those who have attained a certain standard of proficiency in language. Radio and television requires some initial investment and the cost of maintenance. Man feels tired and bored after the day's work, so the talking and reading at such time requires too much of an effort. The common man cannot afford to join institution like clubs, societies, hotels etc., merely because of their economic standards. But the audio-visual facility, employed for recreation which is known as 'CINEMA', provides recreation as well as knowledge to general masses at cheaper rate. Today, it has merged deeply in the social life of the common masses. Due to rising demand of cinema, film industry flourished to such an extent that it has been placed in second position in the list of major industries in India. In short, the recreational value of audio-visual facility has been recognised as the highest amongst the educational, business and commerce and communication.

India is the second largest producer of films, but it is the matter of utmost regret that the number of the theatres in the country has not kept pace with the increase in population and in the production of films. For the population of 55 crores, we have only 7400 theatres which is not even one cinema for every 76,000 people. Similarly, it is only in the cities and important towns that enterpreneures come forward to build theatres and not in the villages and lesser populated areas. As a consequence, the majority of population is denied the facility of economical entertainment with educational value attached to it. In nut shell, there is an acute shortage of cinema facility in the country.

More recently, the services of architects have been increasingly recognised and there are less and less chances of theatre structures being constructed without professional guidance. Significant work has been done in this field in foreign countries. But, in India, research in this field is lacking. With the results the architects adopt the standards from foreign countries, which do not function upto the optimum efficiency. Under these prevailing circumstances, there are many chances of having draw-backs in the design of theatres and thereby deteriorating the quality of theatres. Hence, due to substandard quality of theatres and increasing number of theatres in the future, the need of formulation of planning standards should be realised. This gave the incentive to the author to contribute his efforts in this direction. This study is made under the following heads:

i) The basic study of planning considerations through books, literature, and discussion with persons in the field.

ii) The study of prevailing conditions through the survey of cinema theatres.

iii) Formulation of planning standards for the functional requirements i.e. comforts (auditory, visual and physical) and safety within cinema auditorium.

For the sake of simplicity, this text is divided in five parts. First part, headed as Historical background, deals with birth and development of motion pictures in western countries and in India.

It also gives the review of developments in film, sound and screen. Modern techniques such as Cinerama, Cinemascope, Vistavision, Todd-A.O., Mirror Screen Arrangement etc. have been discussed very exhaustively. Similarly a brief survey of advancement in motion picture theatres has been introduced to make out the old concepts of theatre design. Lastly, the various social aspects of cinema are discussed for the study of general behavioural pattern of the population.

Second part i.e. Planning Criteria governs the various planning considerations with special reference to functional requirements (comforts and safety) for audio-visual performance in the cinema auditoria. They cover the planning factors, conditions for comfort and safety, and equipments.

The third part, named as case study, is dealt with the observations of survey of 10 cinema theatres in Delhi with varying capacity. The observations were taken after experiencing their performance personally, for collecting the required information. This was done for the exploration of the prevailing conditions of existing cinema theatres for preparation of the standards.

The fourth part, termed as Evolution of Planning Standards, is discussed with the methodic approach to achieve the planning standards.

The fifth and the last part of text is recommendations and conclusions which includes the formulation of planning standards exclusively prepared by Indian Standards Institution and finally, it is tied up by conclusions.

PART -1

CHAPTER -1

HISTORY OF MOTION PICTURES

1.0 General

The art of casting shadow on screen by means of light i.e. shadow-play performance is as old as Indus civilization, but the history of motion pictures is said to have begun with the invention of photography, originated by LEONARDO-DA-VINCI. Further development in photography gave birth to moving pictures. When it became possible to show movement by projecting number of pictures within a particular time to register a complete movement. The next boost in the technique came in, when the sound and the moving pictures could be synchronized. The moving pictures got popularity due to its novelty and uniqueness, and the growth of motion pictures reached to such a level that the motion picture industry became one of the major industries in the world.

1.1 Birth of Motion Pictures

The motion picture is the latest machine tool in the service of expression. The efforts to transmit emotional stimuli and experience by recreating events have resulted in language, oral and written, the plastic and graphic arts, the stage, music and lastly the screen[1].

Perhaps, LEONARDO-DA-VINCI was inspired by the shadowplays in originating the idea of photography which is the basis of motion picture screening. Later, other scientists developed the idea further in their respective fields. In 1860, COLEMAN SELLERS, a mechanical engineer in Philadelphia, made first effort to relate photography to the principle of 'ZOETROPE'. He designed a machine and patented as the 'KINEMOTOSCOPE' in U.S.A., in 1861.[2] In France, LOUIS ARTHUR D. HAHRON , had also patented the idea of complete anticipation of motion picture, in 1864. The SELLER'S method of photographing 'posed phases of motion' was applied to projecting Zootrapic device by HENRY R. HEYL, an another engineer of Philadelphia, which was exhibited in 1870, but the idea was originated by BARON UCHATIUS[1]. In 1872 , a method of photography with a camera with electric shutter control, was achieved by JOHN D. IAACS in cooperation with EDWARD MUYBRIDGE who was interested in animal photography[2]. Further E.MUYBRIDGE invented ZOOPRAXISCOPE for reproducing actions of animals in motion. After that many scientists in England, France and U.S.A. were simultaneously engaged in the research on movie

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1. Worthington, Clifford, 'The Influence of Cinema on Contemporary Auditoria Design', (London: Sir Isaac Pitman and Sons, Ltd.) page no.8.

2. 'Motion Pictures', Encyclopaedia Britannica, Vol.15, page no.851.

photography.

In 1887, THOMOS EDISON approached the problem of moving pictures with phonograph idea. His first motion picture machine recorded a spiral of tiny pictures on a cylinder in the pattern of phonograph groove. The pictures were given an intermittent motion and viewed through a microscope, but the results were inadequate. Hence he tried for longer images on tape and designed a device for this purpose but the tape material was not satisfactory.

In 1889, a 'nitro-cellulose base' photographic film was invented and manufactured by GEORGE EASTMAN to meet the mechanical problem of 'Roller Photography'. Edison tried this film successfully in his picture machine and demonstrated at WEST-ORANGE, in 1889 and made the motion picture a reality. In 1891, he patented his machine as 'KINETOSCOPE'* in U.S.A. It was displayed at Columbia Exhibition in Chicago. Then the machine came for the public show in 1894, in Newyork. This was the starting point of commercial history of motion pictures.(2)

During the course of time a demand arose for the machine which should combine the Kinetoscope's film record with the magic lantern, so that the

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* KINETOSCOPE- It is a peep-show device in which the film runs with the continuous movement between the magnifying lens and a light source.

picture might be enlarged from peep-show and shown to a larger audience for more returns. But the belief that the exhibition to large audiences would rapidly exhaust the novelty of motion picture, discouraged this idea of expansion.

Edison's work inspired many inventors to solve the problem of projection of film. In 1895, Major W.LATHAM from Verginia, invented and exhibited his 'PANTOPTIKON' projecting kinetoscopic film but failed due to technological shortcomings.[2]. However, a more satisfactory machine known as 'CINEMATOGRAPH' was developed by LOUIS and AUGUSTE LUMIERE, the photographic manufacturers in France. They took out French patent and demonstrated their machine in 1895 in LYONS.[1]

During the same time, THOMAS ARMAT of Washington invented the principle of modern projector with film movement which gives the each successive image, a period of rest , and illumination in excess of the period of movement from image to image. This machine was known as 'VISTASCOPE' and was publicly exhibited in 1895 at Atlanta. It displayed pictures very much like Kinetoscope. In 1896, ROBERT W.PAUL of London, manufactured a projection machine 'THEATRAGRAPH' on the same lines[2]. Thus the development in the projection machine took place for better performance, during the course of time. The typical projection machine which is in vogue, is the outcome of such developments. (Fig.No.1.1).

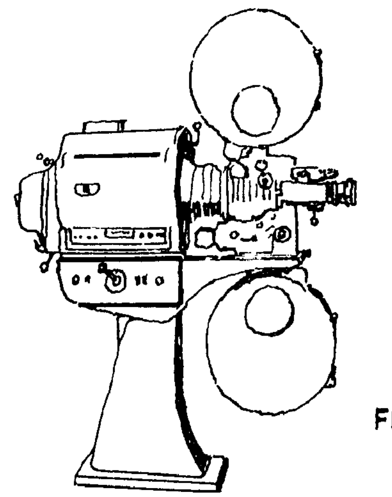

FIG. NO. 1·1

A TYPICAL PROJECTION MACHINE FOR 35 MM FILMS WITH OPTICAL OR MAGNETIC MULTICHANNELS.

1.2 Growth of Motion Pictures in Western Countries

Various types of cinematograph machines came into existence and their inventors felt the need of public exhibition of their machines. Hence they used to screen the 'short events' shooted for this purpose. But from the commercial point of view, the first exhibition of such 'short event', was held at KASTER AND BIALS MUSIC HALL at New York on 23rd April 1896[3]. During the same time, L.LUMIERE also performed a show for the paying audience in London.

In the beginning, the motion picture industry was considered as a source of making money rather an art. There was absence of individual creativeness, composition and imagination. GEORGE MELIES, a french cameraman, who invented 'MAGIC TRICKS' and used them in motion pictures, gave the push to the film industry by novelty. Thus the foundation of film techniques was laid. In 1903, EDWIN S.PORTER, Edison's cameraman, established the principle of editing. He compressed all the known inventions of the screen into single picture, 'The Life of the American Fireman'[3]. The success of this film encouraged to produce more films. The pictures occupying the whole reel in length which established the 'story picture', introduced the art

3. Jain, Dr. Rikhab, 'Economic Aspects of Film Industry', page no.24.

of narration for motion pictures and placed them on an independent basis. Popularity of motion pictures encouraged to produce many pictures. U.S.A., England, Germany and France were the leading countries in the production of films.

1.3 Growth of Motion Pictures in India

In India, no technical and scientific development in motion picture industry had taken place. However the motion pictures came from west and shown a new direction towards the combination of dramatic and photographic arts. The first show was given by LUMIER BROS on 14th July 1896 at NOVELTY THEATRE, now known as EXCELSIOR CINEMA at Bombay(3). SIGNOR COLONELLO and CORNAGLIA from Italy, continued giving successful cinema shows in Bombay during 1897-98(4). They were followed by Indian like P.B.MEHTA, who established his own cinema 'AMERICA-INDIA'. Some europeans also started casual cinema shows at various places in Bombay.

In 1904, M.D.SETHANA started regular shows at Bombay. Later, Mr. PATHE also came in the field(4). Similarly, growing public patronage gave gravity to many other promotors of the film industry to start

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4. Rodger, J.Ross, 'Papers Committee Activities Abroad', Journal of Society of Motion Picture and Television Engineers', Vol.73, Jan. 1964, page No.31.

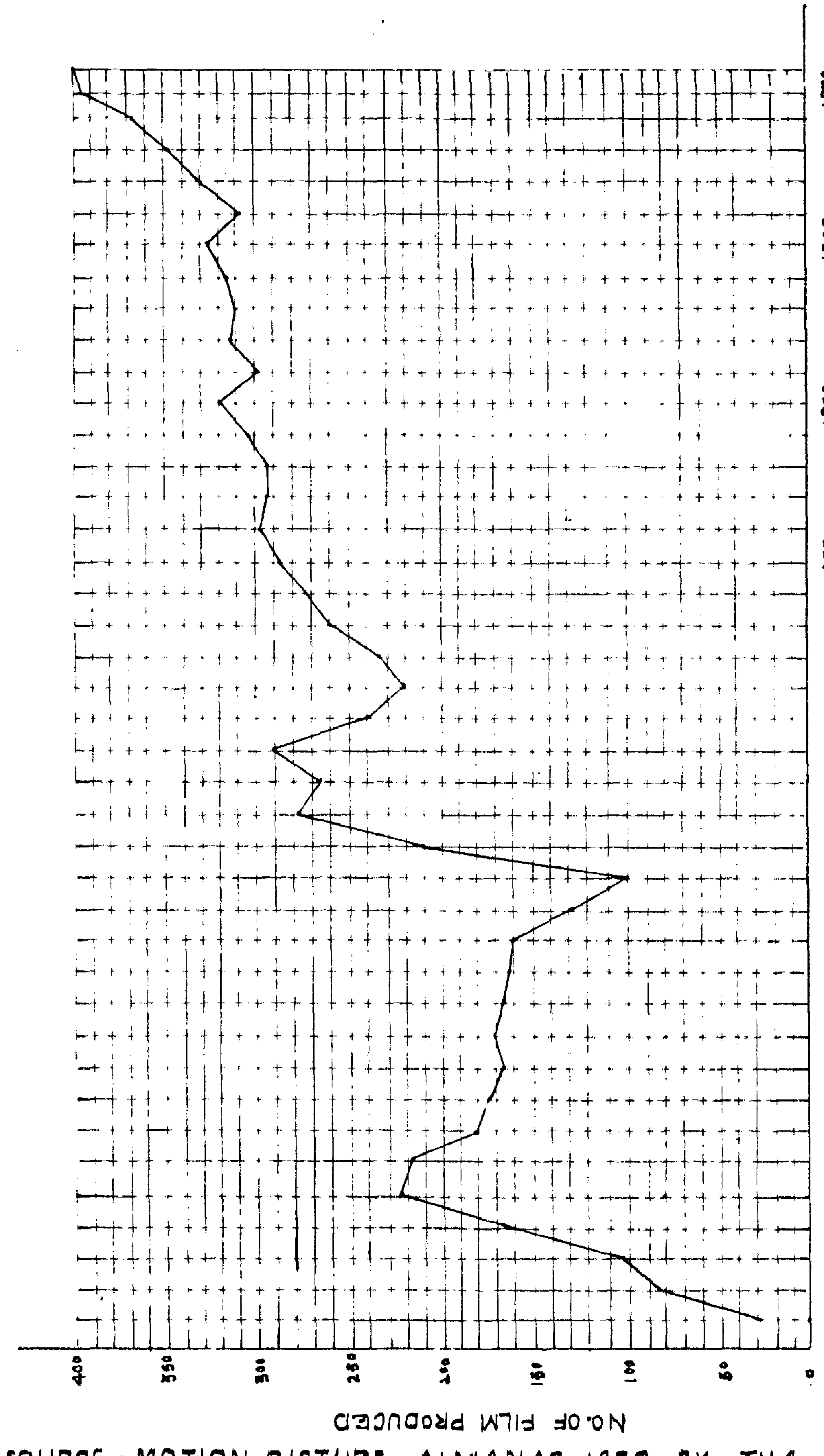
cinema shows in other part of the country and continued to exhibit western films till the birth of Indian motion pictures.

'RAJA HARISCHANDRA' was the first Indian film of 3700 ft. length. It was born on Indian soil and produced by DADASAHEB PHALKE. It was released with a great success on 17th May 1913, at CORONATION theatre, in Bombay[3]. During the same time a full length feature film 'QUEEN ELIZABETH' was released in London, which is regarded as a significant coincidence in the movie world.

The success of 'Raja Harishchandra' led Dadasaheb Phalke to make more pictures. He produced near about 100 films during 21 years of his active career and became a prominent personality and pioneer of motion picture industry. In 1917 , J.F.MADON formed the first film company in CALCUTTA and started with the first film 'NAL-DAMAYANTI' in Bengal.[4]

The great success and increasing popularity of motion pictures led the Government to pass the first act , entitled 'INDIAN CINEMATOGRAPH ACT OF 1918'. The Government, further, appointed an enquiry committee in September 1927 to examine the position of film industry in the country. The Committee felt the need of the organisation in the motion picture industry, which gave birth to 'MOTION PICTURE SOCIETY OF INDIA', in 1932[3]. Later, the organisations related to motion picture industry, came in being. Thus the period of organised film industry had started with the gradual growth of production of motion pictures.

In 1931, ARDESHIR IRANI introduced sound in his movie 'ALAM-ARA', which was the first talkie after 1500 silent films produced in Bombay, Calcutta and Madras[4]. Day by day, the number of talkies increased as compared to silent movies. The graph (Plate No.2) shows the growth of motion pictures produced during 1931 to 1970 in almost all Indian languages. In 1945, the production of film went down drastically due to the war time. Today, the production of movies placed India in the list of major movie producing countries. Government of India also took initiative to meet the current demands in this field by establishing FILM AND TELEVISION INSTITUTE OF INDIA at Poona in the year 1961.



GRAPH SHOWING THE GROWTH OF FILM PRODUCTION IN INDIA

GRAPH. NO. 1

SOURCE - MOTION PICTURE ALMANAC 1970 - BY JHA.

PLATE NO. 2

CHAPTER -2

DEVELOPMENT OF TECHNIQUES

2.0 General

As has been explained that the development of motion pictures first emerged from the laboratories of abstract science in 1894, as Edison's KINETOSCOPE. By 1925 , simplification and refinement in techniques started with the help of physical sciences, i.e. mechanical, optical, chemical and electronics.[1]

The film is the most important factor to enhance the entertainment values of motion pictures. Constant research and improvement in the film material have benefited the motion picture industry and its spectators throughout the world.

Sound in movies was another a notable contribution and was introduced by the method of photo-electric cells and electrical amplification invented by the ELECTRIC AND RADIO LABORATORY in 1927.[1]

After the World War II, radio, television and other audio-visual facilities for recreation and entertainment, emerged in the competition with motion pictures. This competition posed the scientists to develop new techniques of presentation of motion pictures such as CINERAMA, CINEMASCOPE,

1. Worthington, Clifford, 'The Influence of Cinema on Contemporary Auditoria Design' (London: Sir Isaac Pitman and Sons, Ltd.) page No.9

VISTAVISION, TODD-A.O. etc. to recapture the lost audience.

2.1 Development in Photographic Film

The flexible support or base that makes possible motion pictures is called film.(2) Film for motion pictures requires a base that is tough enough to withstand tension and flexible enough to wound on spools. From optical and photography point of view, film must not change the tone or colour values of pictures, must be uniform and able to receive the photographic emulsions.

In the beginning, EASTMAN invented 'CELLULOSE NITRATE' plastic film in 1889(2). He standardised the image proportion, film size and shape, projection speed and screen proportion etc. which facilitate the production, distribution and exhibition of films throughout the world. This film remained in vogue until about 1950, when 'CELLULOSE TRIACETATE' film came in use.

In 1956, a POLYSTER base film, thinner than cellulose film was invented by DU PONT DE NEMOURS and CO., which is in use till today(2). It has

2. 'Motion Pictures', Encyclopaedia Britannica, Vol.15, Page No.852.

proportioes of optical clearity, resistance to wear and tear, low sensitivity to moisture, relative stiffness and immflamable. Eastman, Du Pont and other film makers started manufacturing of BLACK and WHITE films for reasonable speed and film grains to satisfy the needs of the motion pictures. Fine grains are needed to permit the maximum magnification. /

Colour in the motion picture is one of the wonders of 20th century. In the beginning, individual picture was coloured by hand with two basic colours which was followed by three basic colours. Then a system of three negatives with three primary colours came in practice and was followed by MONOPACK method in which colouring of all primary colours was made possible on single strip of films. This method was originated by a frenchman, LOUIS DUCOS DU HAURON, in 1928.(2)

Further development like multi-colour was achieved through research by EASTMAN KODAK and TECHNICOLOUR. 'BECKY SHARP' was the first movie in technicolour, produced in 1935.(2) The production of technicolour film were further refined and inspired. Later, by other companies like CEVACOLOUR, FUJI COLOUR. Similarly, development in size of film was also done

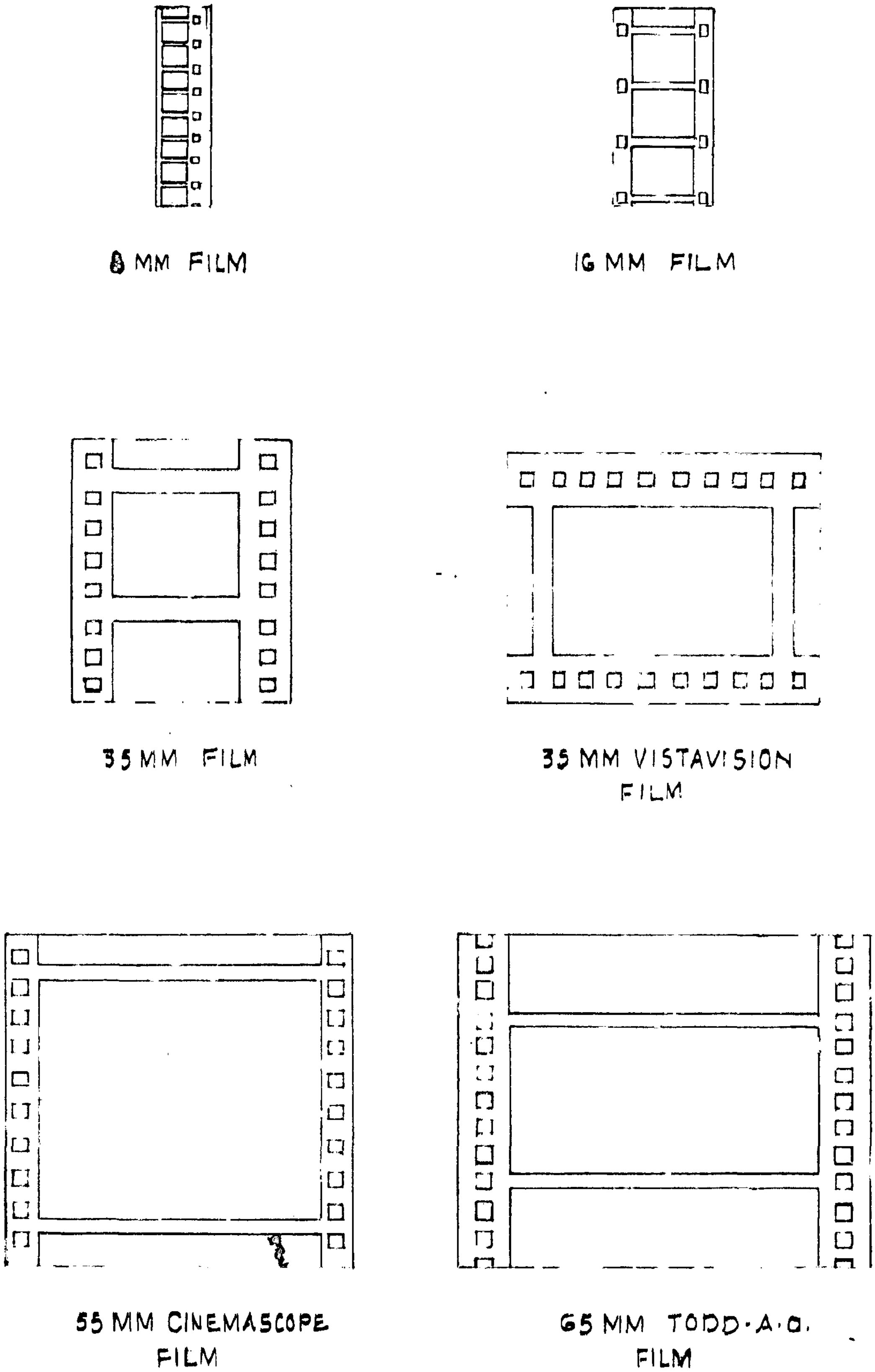


FIG. NO. 2·1

TYPICAL FILM SHAPES USED IN VARIOUS TECHNIQUES.

for various types of projection techniques (Fig.No.2.1).

In 1867, WORDSWORTH DONISTHORDE putforth the idea of combination of phonograph with motion picture, but Edison implemented this idea and combined the phonograph with projector in 1887, however the synchronisation was not satisfactory[1]. So the audience could not appreciate talkies over the silent movies and the interest in the sound in movies remained inactive for long period.

In 1926 , the sound era began with 'DON-JUAN', featuring synchronised music only and in 1927, music and dialogue was introduced in 'THE JAZZSINGER'[2]. Both the films were presented in the VITAPHONE system in which the sound was on discs, developed by Western Electric Company, U.S.A.

Soon after, recording of sound on the film itself became possible. In this system, the sound tracks were recorded at the edges of the film, synchronising the visual images. At present, principally there are two methods of recording sound, i.e. i) Optical sound recording, (ii) Magnetic Sound recording.

Optical sound recording was invented by C.E.FRITTS, in 1880, in U.S.A., but it was introduced in motion picture in 1926[2]. There are two methods of recording sound optically (a) Variable area method and (b) variable density method. In both cases the sound tracks are photographically recorded on the edges of film. For reproduction of sound, the light from an exciter lamp, is focused through an optical system on the tracks of film with optically recorded sound, (Fig.No.2.2). The light fluctuating in intensity on account of the gradiations on the tracks are converted to electrical energy by photoelectric cells. These electrical signals are fed to the amplifire which amplifies them and finally fed to the speakers behind the screen.

Magnetic sound system ~~was~~ achieved by the Germans after World War II, but the magnetic stripping of sound on the same film was introduced by REEVS in in 1951(2). In this system, the film is coated with iron oxide and then it is passed at uniform speed through a magnetic field. The microphone output is fed to the magnet and the sound is recorded by the changes in the magnetic flux. Reproduction is the exactly reverse process (Fig.No.2.3). No processing of any kind is required and excellent quality of sound can be achieved. As such, it had replaced optical sound.

In 1953, STEREOPHONIC sound system was invented by BELL TELEPHONE LABORATORIES, which gave the first demonstration in Washington. This system necessitates multiple channel to give the sound life like qualities and proper spacial relationship. The first use of stereophonic sound was made in 1954, with four track optical stereophonic sound system designed by

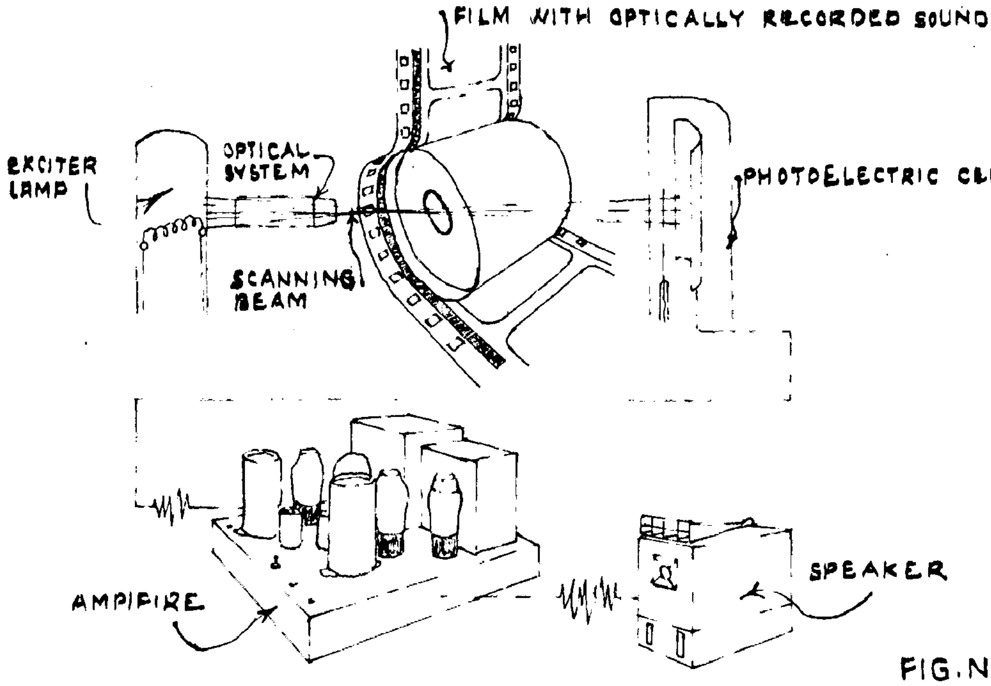


FIG.NO.2 2

MONO-CHANNEL OPTICAL SOUND SYSTEM

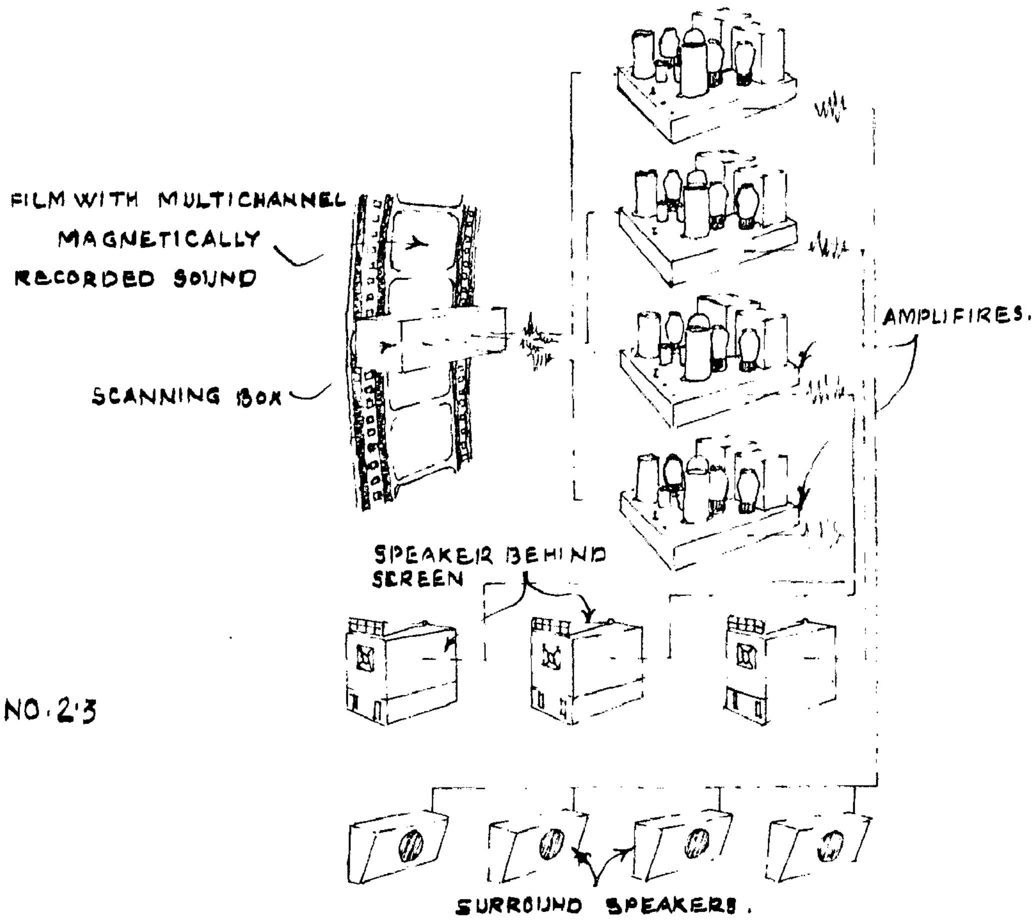


FIG.NO.2.3

MAGNETIC MULTIPLE CHANNAL OR STEREOPHONIC SOUND SYSTEM.

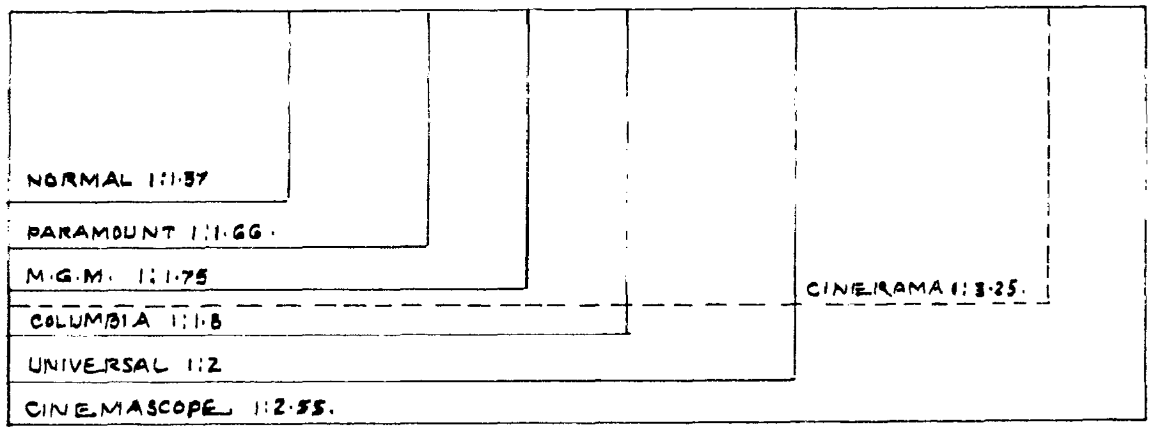
PLATE NO. 4

RADIO CORPORATION OF AMERICA(1). Promotors of cinemascope advocated this system for cinemascope presentation.

Stereophonic sound is a method of recording and reproduction which in effect, recreates the original sound performance on the screen as though the performance were actually there. It requires the use of multiplicity of microphones with separate indivisual recording channels and records for each, the reproducing system requires the same number of separate channels and loudspeakers. Stereophonic sound includes directionality or localization of the sound sources corresponding to visual location of the source on the screen.

2.3 Development of Wide Screen

The development in techniques of wide screen had been taken place long before, but the prior use of these has been avoided because they necessitated costly reequipping of studios, laboratories and the theatres. Later when the movies came in direct competition with television, the use of development in screen was realised. To increase the attraction of film, three dimensional films were developed. But they failed as they required special spectacles which caused inconvenience to the patrons. Then the cinerama process was invented to achieve the high degree of audience



COMPARATIVE SIZES OF SCREENS USED IN VARIOUS TECHNIQUES OF PRESENTATION.

FIG. NO. 2.4

PLATE NO. 5

participation.

It was the development and refinement in cinematography techniques, by which changes in wide screen became possible. They are as follows.(2)

(i) Anamorphic lenses to permit 'SQUEEZING' in the photography and 'UNSQUEEZING' in projection of wider image.

(ii) The insertion of film in the cameras horizontally to achieve panoromic effects.

(iii) The invention of 'BUG-EYE' lens, for expanding the camera range upto 130°, and of other lenses designed to widen the camera range and to increase the illusion of audience participation. With the result , various techniques such cinemascope, vistavision, Todd-A.O etc. came into existance.Each of these techniques requires screens of different aspect ratios (Fig.No.2.4).

2.3.1 CINERAMA

The opening of cinerama in New York, in 1952, became the most important milestone in the screen history.(2) The basic idea was originated by RALPH WALKER, an American architect, who formed a company 'VITARAMA CORPORATION' with his associates and

This system requires large size reflectors. Glass mirror cannot be employed, firstly, because they are available in small sizes and secondly, the method of interconnecting small mirrors, is unsatisfactory for several practical reasons like cost, ease of alignment and safety to spectators from accidental breaking of glass mirror. But it is possible to make large size reflectors from metallised polyster film called mirror film which is stronger and durable.

Application of Technique

Figure No.2.8.A.shows the plan of existing theatre. The floor area of auditorium can be divided in three regions. It is necessary to leave some vacant area in front of the screen for the minimum screen clearance which is generally equal to the screen width as per the Cinematography regulations. In fact, this area is waste region. It is followed by uncomfortable region which usually extends upto twice the screen width distance and accommodates lower class seats. Comfortable region starts after uncomfortable region which extends upto about four times the screen width distance and accommodates upper class seats. For installation of MSA in existing theatre, it is required to lower down the half auditorium floor by about 8 ft. and to shift the position of screen exactly between the waste region and uncomfortable region (Fig. No.2.8-B and 2.8-C). Regular screen serves the seating area leaving minimum screen clearance on the main floor , whereas the mirror screen serves the seating area on the lowered floor, which starts from just in front of the reflector, because the spectators see the mirror screen of back illumination in the reflector at equidistance of regular screen.

CHAPTER -3

ADVANCEMENT OF MOTION PICTURE THEATRES

In the beginning, the inventors of cinema had no idea about the commercial feature of their achievements. They were working for scientific curiosity, but in later stage, they knew the glimpses of commercial stage of cinema; hence they had to house the cinema in the existing buildings, originally intended for stage performance.

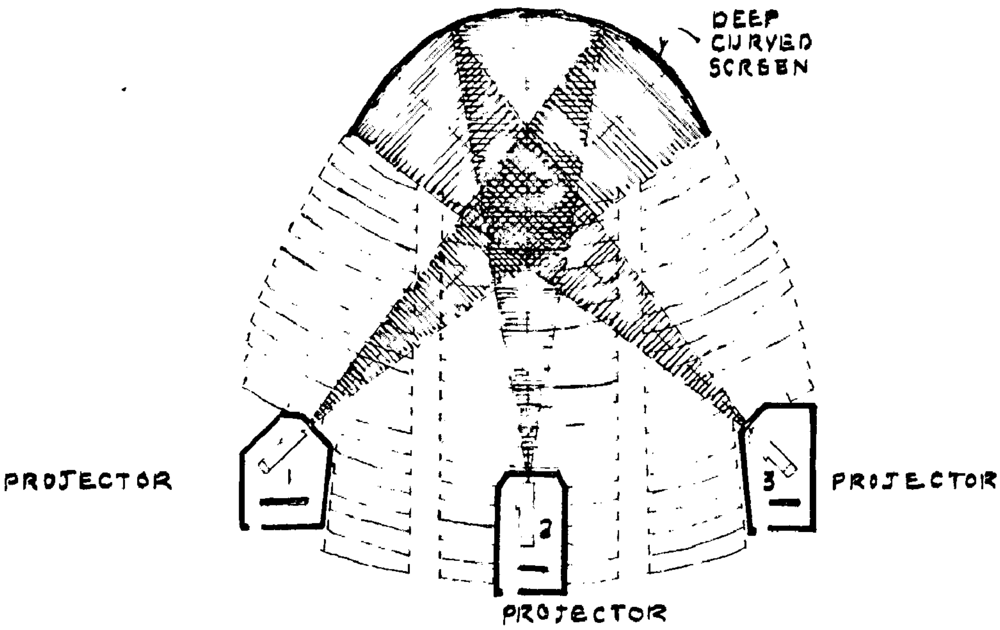
In Europe, during the early days, the isolated displays of films were performed at the places of entertainment. Soon, there was an increasing demand for continuous display of motion pictures and empty shops were converted for this purposes. When the audience outgrew the capacity, the exhibitors realised the necessity of large assembly halls. Hence, they started using the stage theatre for cinema performance. Of course this was the invasion of cinema on stage theatre. In 1913 , 'HIPPODROME', Paris claimed to cater for over 5000 cinema patrons daily[1]. After many years, the internal design of building began to reflect the practical needs of the picture theatre. In London, SHEPHERD'S BUSH PAVILION, the earliest cinema of architectural interest was opened in 1924 and was

1. Worthington, Clifford, 'The Influence of Cinema on Contemporary Auditoria Design', (London: Sir Isaac Pitman and Sons, Ltd.) page No.9.

developed the screen and projection for cinerama. After the war, in 1950, REEVES took initiative to establish a new cinerama company and presented the first film 'THIS IS CINERAMA'.(1)

This technique uses the camera equipped with three carefully matched lenses covering a field of about 146° for photography, and three projectors are employed to project the standard 35 mm. films in synchronism. (Fig. No.2.5) These three images are projected side by side without overlapping by each other, on the screen to achieve a panoromic view. Three dimensional effect is created which can be further enhanced by employing stereophonic sound system. In this typical installation, the screen with aspect ratio 1:3.55, is curved to maximum of 17'-6".(2) This screen is made of more than 1000 vertical strips of perforated material, to avoid the reflection of projection due to curvature of the screen.

Existing theatres had to be modified to install cinerama, as there were three projectors to be set up at one level, which are no more than 5° out of alignment with the screen. These projectors could be placed at any distance from the screen, provided correct alignment was made with the section covered by each projector. The first cinerama theatre was constructed in OSAKA,



CINERAMA INSTALLATION DIAGRAM

FIG. NO. 2.5

PLATE NO. 6

Japan, in 1954.[2]

2.3.2 CINEMASCOPE

The principle of anamorphic lenses and their application to motion pictures dates back many decades before cinemascope. But the system of ANAMARPHIC LENS was developed in 1953 by '20th CENTURY FOX FILM CORPORATION and was named as 'CINEMASCOPE', 'THE ROB' the first feature film in cinemascope released in 1953[1].

The popularity of cinemascope had increased to such an extent that 16500 cinema theatres in America and 13500 cinema theatres elsewhere in the world, started showing the cinemascope films by 1956.[2]

This technique involves the use of anamorphic lenses at the camera and projector. The effect of anamorphic lens system is to squeeze the picture horizontally and expand it to normal proportions in projection. Cinemascope picture must always be projected through cylindrical lens or a prism attached in front of the projector which expands the picture to a normal appearance.

Cinemascopic screen has Aspect ratio of 1:2.55 which is the widest except that of cinerama. It gives stereoscopic effect while watching the panoromic screen view. The wide screens of cinemascope, especially in large theatres, requires a three to five track stereophonic sound system to enhance the illusion.

2.3.3 VISTA-VISION

This technique was developed by 'PARAMOUNT PICTURE CORPORATION', U.S.A. which used a large negative method. Standard 35 mm. film is passed horizontally instead of vertically through a specially modified camera. Each picture frame occupies the space of two ordinary picture frames, which results in approximately double the negative area. For regular exhibition, vistavision images are optically reduced, turned 90° and printed in standard fashion of 35 mm. film. By printing from double frame negative, the vistavision 35 mm. image print is sharper than that obtained by direct contact from standard 35 mm negative. The increased size of the film is benefitial in theatres equipped with screen of moderate width. Further vistavision advanced the film art by reducing the magnification factor.

2.3.4 TODD-A.O.

In 1953, MICHAEL TODD, an associate in cinerama company, worked on a camera with wide angle system and achieved the similar effects of cinerama set-up[2]. He formed TODD-A.O. CORPORATION and developed a wide screen, single camera, single projector system. In 1955, 'OKLAHOMA' - stage musical, the first film in this technique was released at Rivoli-theatre, New York, and 7 tracks magnetic system had been used(2).

This technique of presentation requires the use of 70 mm. wide motion picture film as against the normal 35 mm, with consequent increase in image size. It advocates the use of wide and deep-curved screen, as well as an aspect ratio of 1:2 measured on the chord of the arc of the screen.

2.3.5 MIRROR SCREEN ARRANGEMENT

In India, Dr. C.R.MARATHE, Indian Institute of Technology, POWAI, Bombay invented technique of Mirror Screen Arrangement in 1963(3). He gave the first public demonstration at Powai on 16th April 1964 and patented his invention, which revolutionised constructional aspects of future cinema theatres. Government of India honoured Dr. Marathe and awarded Scientist Prise on Independance Day, 1972.

Mirror Screen Arrangement is a ultra modern technique of projecting film. It is neither an imitation nor a modification of any existing projection technique.

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3. Marathe, Dr. C.R., Mirror Screen Arrangement (Bombay: Mirror Screen Exportise) page No.3.

Because of MSA, which skillfully uses a translucent screen and mirror, it is possible to obtain two useful cinema screens with the help of one projection. This technique can also be used in existing cinema theatres, but more efficient and economic design is possible in the proposed cinema which offers 20% economy in the construction cost[3]. It can be used for any type of projection such as 35 mm., cinema-scope, vistavision, 70 mm. etc. MSA offers 30% increment in existing or estimated capacity, with comfortable seats from visual comfort point of view[3]. With the result, the profit can be doubled. It also helps to improve the auditorium acoustics and quality of screen illumination.

Basic Principles :- When the picture is projected on one side of translucent screen, its other side gets likewise illuminated. If the screen is perfectly white and suitably translucent, then the back illumination can be obtained as bright, sharp and clear as front illumination (Fig. No.2.6). But the back illumination is lateral inversion of front illumination. If this back illumination is seen in the reflector or mirror, it will be seen inverse of the same which is exactly similar to the front illumination and is known as mirror screen. (Fig. No.2.7).

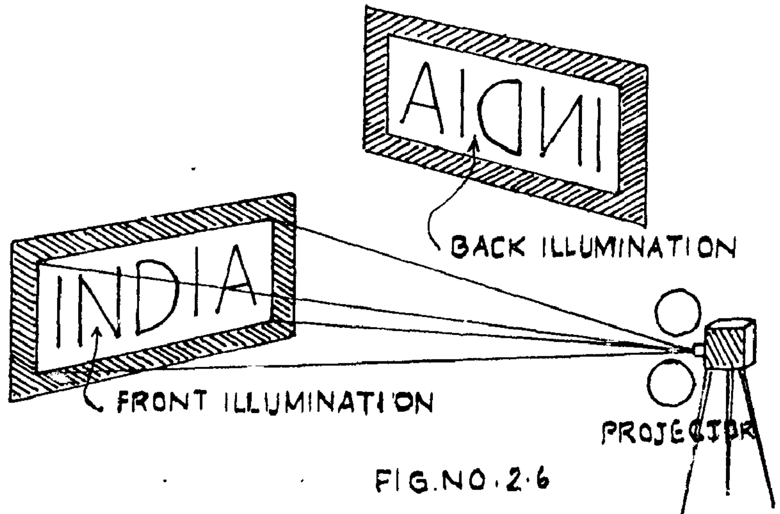

FIG.NO.2.6

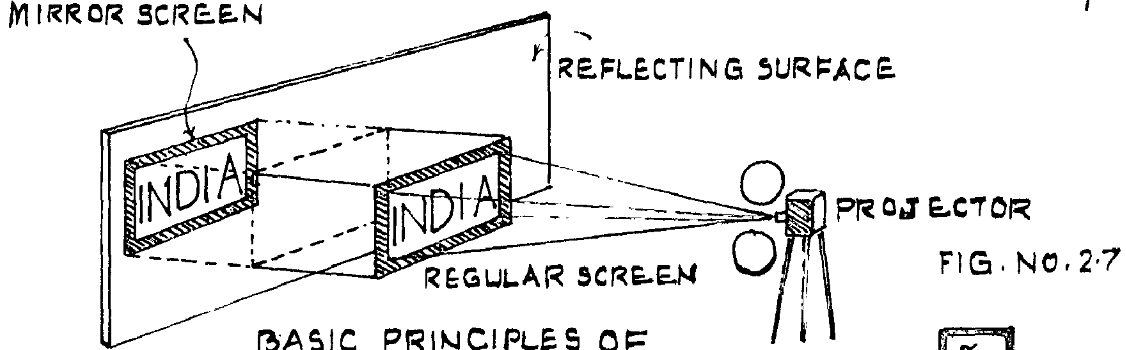

FIG.NO.2.7

BASIC PRINCIPLES OF MIRROR SCREEN ARRANGEMENT

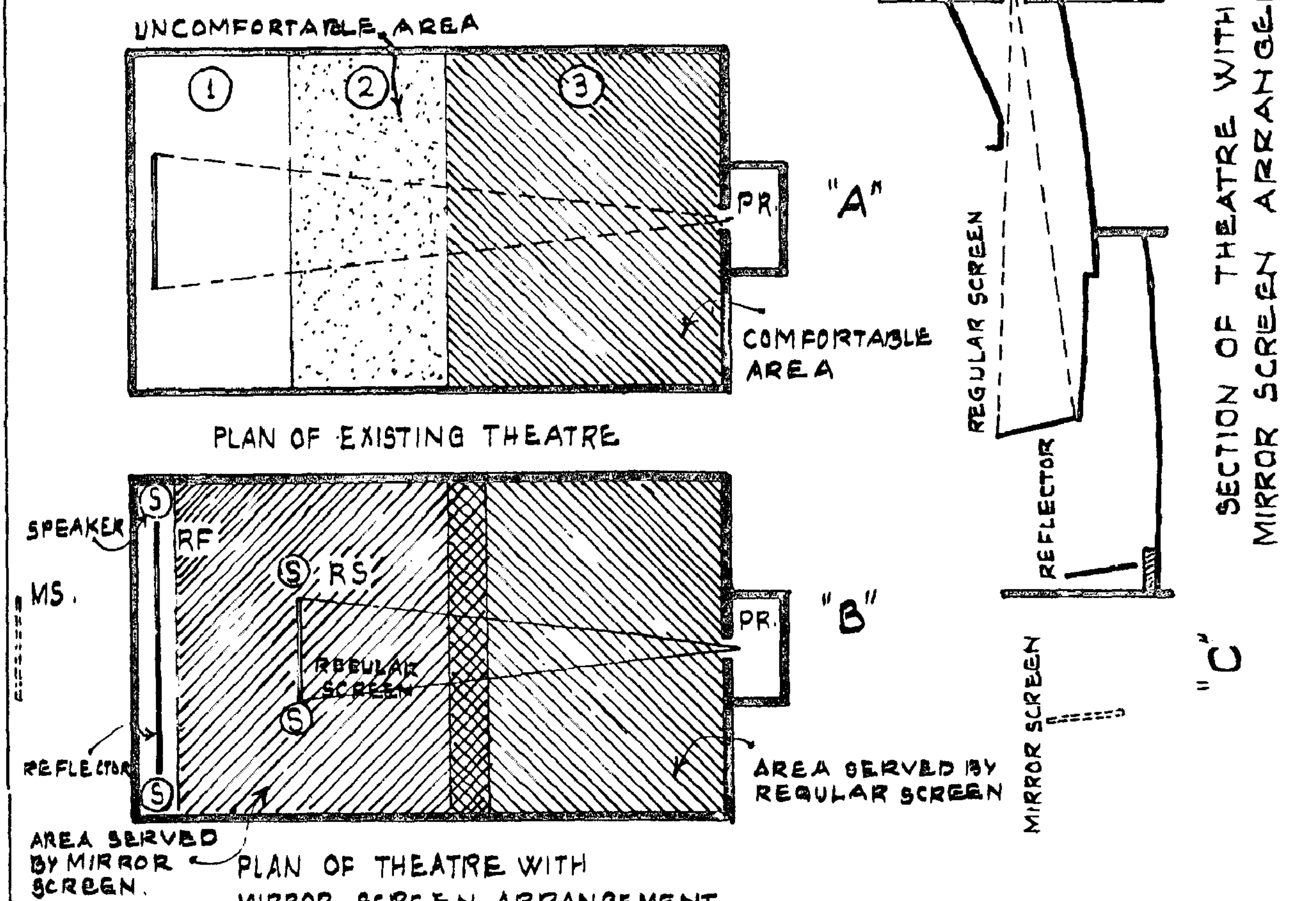

FIG.NO.2.8.

designed by FRANK T.VERITY[1].

In America, KOSTER AND BIAL'S music hall at New York, was used for the exhibition on commercial basis. NICHELODEON was the first permanent motion picture hall opened in 1905 at PITTSBURG(2).

In India, LUMIERE BROS. performed the first show on 14th July 1896 at NOVELTY stage theatre, now known as EXCELSIOR Cinema, Bombay(3). After that many businessmen from outsides and the personalities from India came forward to start the cinema in existing stage theatres. There is no doubt that most of the audience of stage was captured by cinema due to its novelty. However, there was a audience due to whom, the stage retained its importance and the invasion of cinema on stage theatre was defenced to some extent. With the result, the need for separate theatres for cinema performance was felt. M.D.SETHANA started the touring cinema, during the same time. Thus the cinema theatre established its own identity in the field of recreation.

When the cinema became the commercial product all over the world, it was supposed as the best

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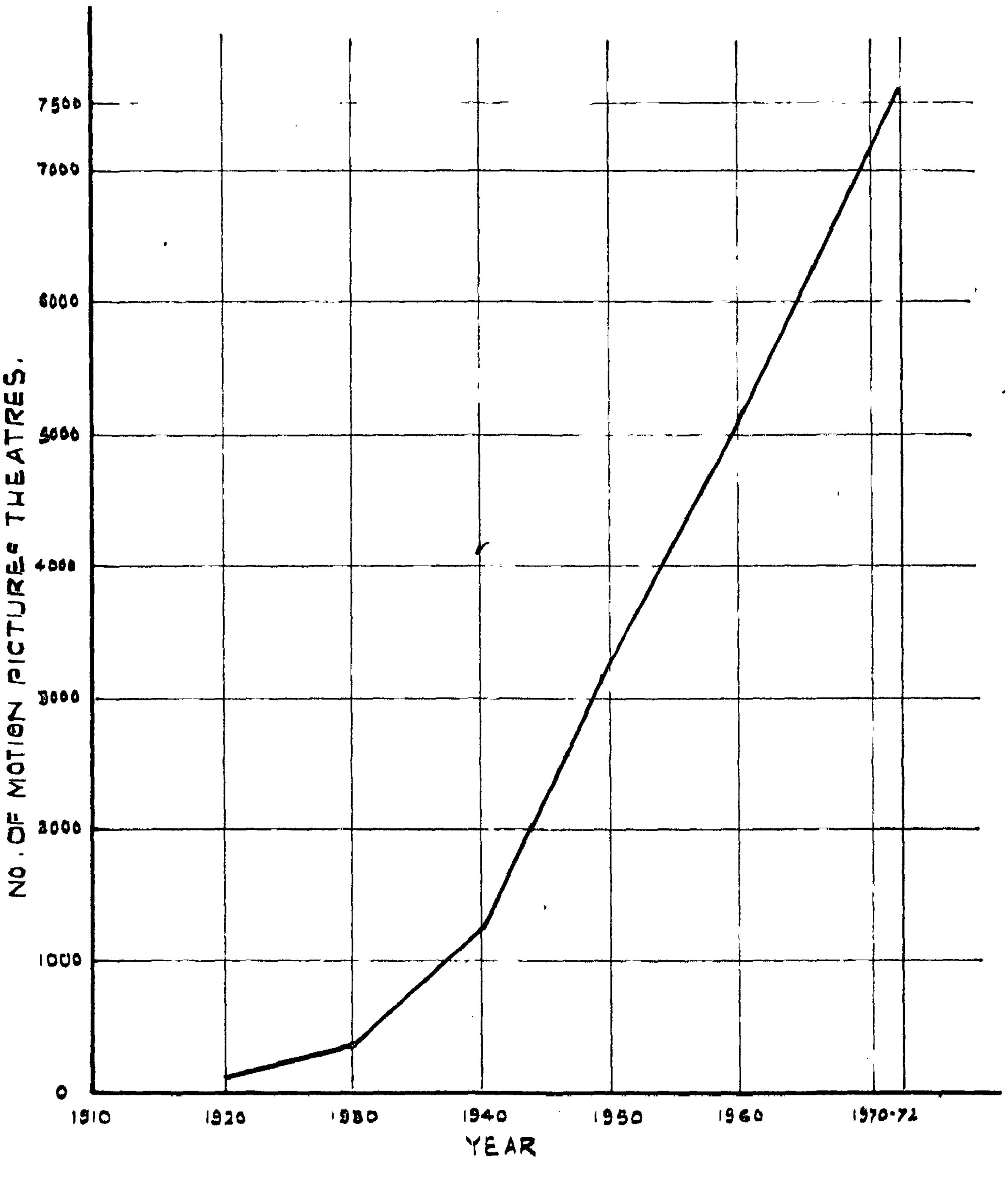
2. Motion Pictures, Encyclopaedia Britannica, Vol.15, Page No.855.
3. Jain, Dr. Rikhab., 'Economic Aspects of Film Industry', page No.20.



GRAPH SHOWING THE GROWTH OF MOTION-PICTURE THEATRES IN INDIA.

GRAPH. NO. 2.

SOURCES- SOCIETY OF MOTION PICTURE & TELEVISION ENGINEERS. U.S.A.
ENCYCLOPEDIA BRITANICA VOL. 15.
ECONOMIC ASPECTS OF MOTION PICTURE INDUSTRY- JAIN.
MOTION PICTURE ALMANAC-1970 - JHA.
REPORT BY MINISTRY OF INFORMATION AND BROADCASTING

PLATE NO. 8

means of recreation and its popularity went on increasing day by day. To cater the need of growing public patronage, many cinema theatres of permanent nature were constructed throughout India. The graph shows the growth of cinemas from 1920 to 1972 (Plate No.8). With this growth , the improvement in functional requirements and aethetics were made gradually.

During the course of time, the techniques of presentation were also improved very rapidly, which made designer to change the old concepts of cinema. In western countries organisations for regular research in this field are established. Recently Government of India took steps in this direction and established CENTRAL CINEMATOGRAPH INSTITUTE at Hyderabad. It aims that the theatre of today should be the outcome of their research and they should be planned considering the requirements of modern society.

CHAPTER -4

SOCIAL ASPECTS OF CINEMA IN INDIAN CONTEXT

4.0 General

Motion picture is the mirror in which, the reflection of progress and culture of a country can be seen. They played a dominant role in providing recreational needs in addition to their potentials for development of commerce and industry. More recently social scientists have found the role of motion-pictures in providing education and mass communication, which is more essential in a vast country like India.

Today, motion pictures have become a vital part of Indian Society, which has given an incentive to the production of films and development of related industries. This encouraged the social scientists and planners to study the overall behaviour of the patrons and other social aspects of cinema.

4.1 Importance and Impact of Movies

In early times, people had no time means of passing their leisure. It was passed at public houses or street corners. This position was almost in all countries. At later stage, people found many outlets such as horse races, matches , fairs etc. to pass the time. Today more leisure is considered to be the right of all. It is the outcome of industrialisation and changing socio-economic pattern, which has resulted in the reduction of working hours, increase in wages and development in communications and primary education. The economic motives have further commercialized this leisure. The popularity of cinema is due to the fact that, in big cities, the average man is either poor or belongs to middle class and for him, cinema provides the cheapest source of entertainment, giving some relief from the daily worries of life by putting him in imaginary world for some time. "It helps, in most cases, in toning up the deficiencies of real life, as the person finds a sort of self identification or imaginary realisation in movies loosing their self-consciousness atleast during the show. Moreover, the motion pictures arrived at the time when the best thought was already in the direction of society and world culture, and they made it possible to have a world wide communication of ideas without surmounting the ragged barrier of language" (1)

In India, the impact of movie is remarkable.

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1. Jain, Dr. Rikhab, " Economic Aspects of Film Industry," page No.34.

Indians are less found of western glittering ways of entertainment like night clubs, hotels, racing, gambling etc., mainly because, majority of the people cannot afford it. The musical gatherings, poetic symposium, dramas etc. remain too costly for the average man and do not attract large number of people. Cinema being cheap, can be afforded by every one and hence it has bettor patronage. Some people do not like films and condemns them as wasteful and demoralising in character. On the other hand, for majority of people, movies are not merely a source of entertainment but have become a habit. "All over the world, the cinema has brought a certain amount of anxiety to all those who are interested in the moral and spiritual welfare of humanity. This anxiety is due to cinema's unhealthy influence on society as a whole and men, women and children individually".(2)

2.2 Cinema and Society

The influence of cinema is much stronger than that exercised by any other means like press, radio and television etc. Today the motion pictures have a definite place in daily lives of the people and the popularity of cinema is growing day by day throughout the world. This calls for research to find out the impact of cinema on society, to take such measures which are necessary for the welfare of the society. Dr. RIKHAB JAIN from Meerut, worked in this direction for his thesis[(1)]. He conducted survey of random samples of 2,000 families in Delhi, Nainital and Meerut, to analyse the composition of the audience and their proportions, and pattern of general behaviour. The survey results are given in Appendix 'A' and the conclusions from the survey are as follows:-

i) The attendance in cinema is little higher in other months than summer.

ii) Women go less frequently than men,

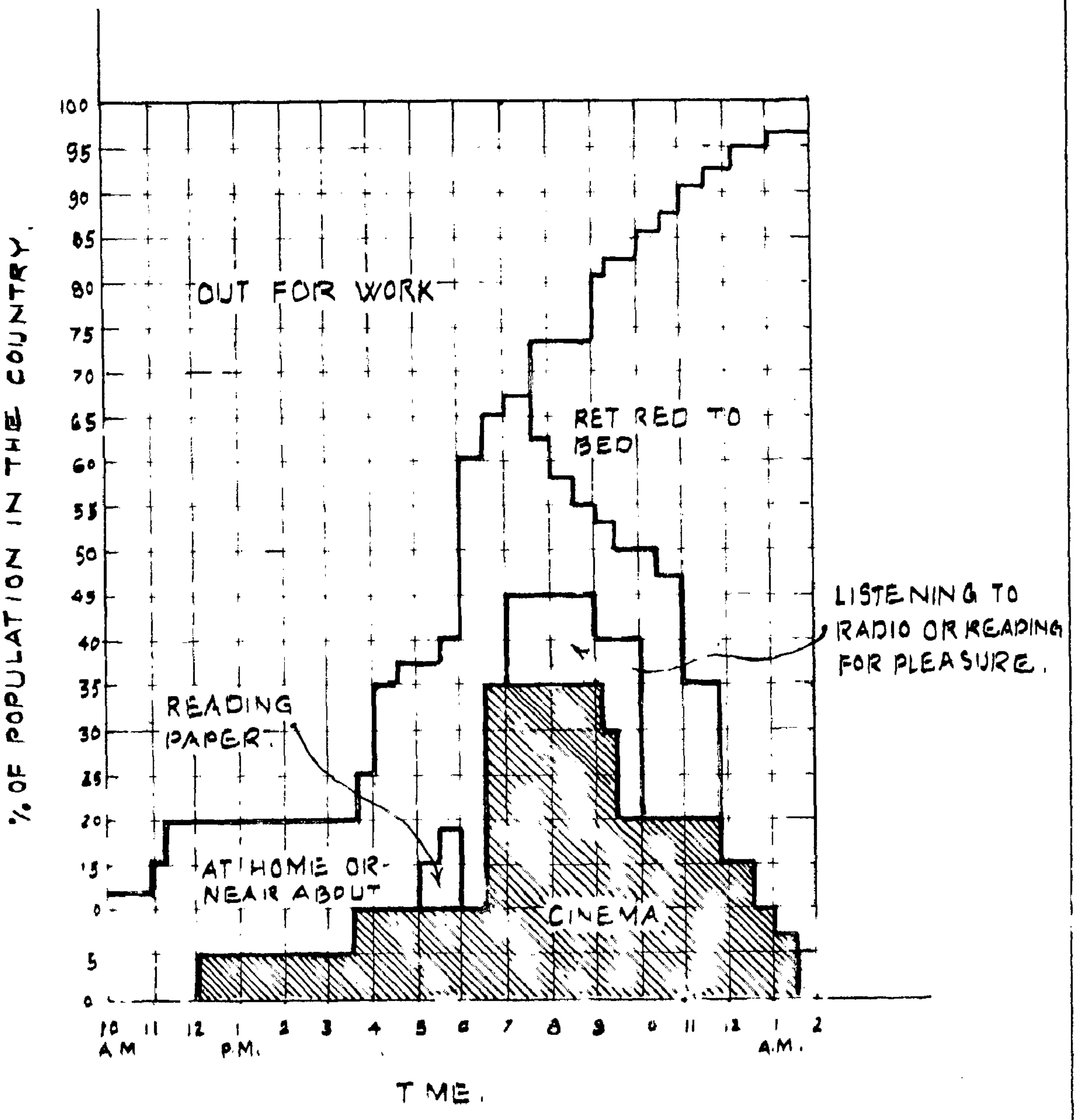
iii) Younger group is better represented than the middle age,

iv) Single persons go more often than the married,

v) Persons falling in lower group of income enjoy movies more than the rest.

vi) Children go more frequently than adults but less than young men and children of the families in lower groups go more than the children of the rich.

On the basis of this survey a pattern of general behaviour of the population in India, from 10 A.M. to 2.00 P.M. is graphically worked out by Dr. Jain



GRAPH SHOWS GENERAL BEHAVIOUR PATTERN OF POPULATION

RESULT OF SURVEY OF 2000 PERSONS REPRESENTING 2000 FAMILIES SELECTED AT RANDOM FROM DELHI, MEERUT AND NAINITAL.

GRAPH. NO. 3.

SOURCE - ECONOMIC ASPECTS OF FILM INDUSTRY BY DR. RIKHAB JAIN

PLATE NO. 9

(plate No.9). The graph shows the percentage of people going to movies and time spent, from which it can be concluded that the attendance in cinema increases by 15% in the evening shows and goes down gradually in the last show.

The popularity of motion pictures depends upon the basic outlook of the consumers and their scale of value judgement, which, basically, depends upon the type of motion picture and level of mass taste. The feature films produced in India can be classified as under- (1) Love stories, 2) social , 3) Mythological, 4) Devotional and religious, 5) Historical 6) Biographical, 7) Stunt, 8) Crime Detective, 9) Melodrama, (10) Comedy, 11) Mystry, 12) Children.

In fact, we have a narrow scope for selection and one has to divert himself to motion pictures sometimes for his physical and mental health. In the absence of any scope for selection, one often finds neither entertainment nor diversion in wrongly selected film. With the result , we do not find taste for movies developed among the ordinary persons, there only exist a temperamental feeling in this respect because they do not have the art of appreciation. With the effects of all these factors, 85% of the people in India accept what is put before them and they do not select.(1)

2.3 Exhibition and Audience

It is obvious that the charms of good picture are spoiled by bad exhibition and bad picture can be improved by good exhibition. Similarly, the recreational and entertainment values for the audience are enhanced or minimised by the overall environment of the cinema.

The condition of cinema has to be good enough to attract more and more patronage, but the general conditions of majority of our cinemas are bad.[3] They do not offer comfort and convenience to the audience from whose pockets, the exhibitors receive their increasing flow of income. The responsibility of improving the conditions of cinemas, can be fixed on the Government, the exhibitor and the audience. Government can do much by passing effective rules in this direction and enforcing them strictly without confusion and multiplicity. Due to illiteracy and emotional impact of pictures, our audience do not demand the better comforts and forgive the exhibitor for bad conditions. Majority of picture goers have no respect for themselves as they cannot restrain their temptations of seeing the picture. On the other hand the exhibitors show the disregard for the comfort

3. Ravindranath, P.K., 'Money Rackets' (Times Weekly-15th August ,1972 page No.1.

of the patron. It cannot be denied that the patrons also show disregard for decency in the cinema. However, things will definitely improve if the atmosphere of cinemas is brought upto the required standards. It is not the outcome of habits, but it is observed that, when they go to a good cinema, such things do not happen. Exhibitors must realise and understand that good surrounding tends to put man on good behaviour because the improvement and rationalisation of livelihood in the people depend on the betterment of the environment. Hence efforts are required for the improvement in cinemas and its exhibition in order to contribute to betterment of environment.

PART II

CHAPTER -5

GENERAL PLANNING CONSIDERATIONS FOR CINEMA AUDITORIUM

5.0 General

The factors affecting the planning are the best criteria for planning the enclosure. There are numerous factors which affect the planning of cinema auditorium. The analytical study of these factors suggest the guidelines for planning process and provide concrete basis for functional planning. These factors are grouped under the following heads for the purpose of this study and their inter-relationship is shown in chart No.1 (Plate No.10).

i) Technical Aspect,

ii) Economic Aspect,

iii) Physiological Aspect,

iv) Social Aspect, and

v) Psychological Aspect.

5.1 Technical Aspect

It concerns mainly with functional requirements of man's activity. Planning without function is meaningless as it is vitally related with function. It goes hand in hand with planning, but it has a

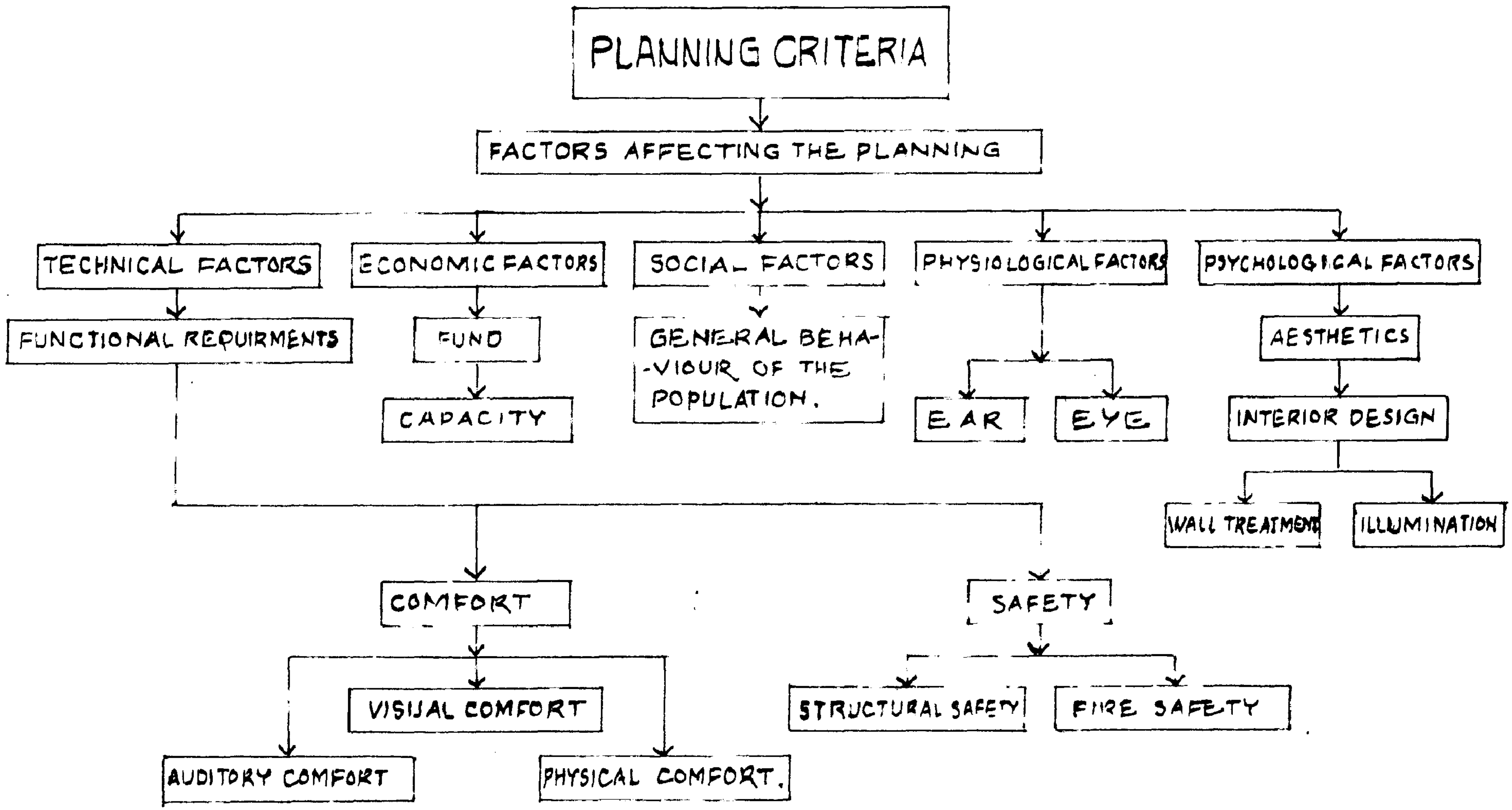


CHART NO. 1. SCHEMATIC DIAGRAM FOR PLANNING CRITERIA.

PLATE NO. 10

separate identity of its own and hence requires good deal of thoughts. The function of any activity can be satisfied by its requirements, i.e.,

1) Comfort,
2) Safety.

Comfort in the planning is of paramount importance as it is the very goal of planning. As far as audio-visual performance is concerned, it is expected that each patron must get comfort in the activity of performance. It can be achieved through, 1) planning, 2) equipments. Planning for comfort depends upon the physical planning factors which are under the control of architects. In addition, equipments have also major share in providing the comfort. Precise and efficient equipments can enhance the comfort to great extent, but it depends upon the technological advancement and their manufacturing. Comfort for audio-visual performance includes

i) Auditory comfort,
ii) Visual comfort, and
iii) Physical comfort.

These will be discussed later in Chapter Nos.6,7 and 8 respectively.

Safety is also an important functional requirements and cannot be neglected at any rate. It should ensure to both patron and auditorium or enclosure.

It includes:

i) Structural safety,

ii) Fire safety.

The structure should be sound enough to resist the dead and live loading and stresses created by the external forces such as wind pressure, shocks, machinery vibrations etc. The proper design, selection of materials and efficient construction techniques can ensure the structural safety. Similarly fire safety can be ensured through 1) proper planning, 2) elimination of ---combustible materials in construction, 3) fire fighting equipments.

Both structural safety and fire safety will be discussed in Chapter No.9.

5.2 Economic Aspect

It deals with the capital to be invested on the cinema theatre. Every client expects maximum returns from his investment. Therefore, it is in the interest of the client to provide maximum capacity of auditorium within the capital. But, it does not mean that other accessary requirements should be curtailed at the cost of providing maximum capacity which will further dwindle the function. Architect should be conscious enough in calculating the optimum capacity without hampering the other requirements of amenities and which will offer the maximum returns out of client's investment. Total investment of the project includes

i) cost of construction,

ii) cost of furnishing and

iii) cost of equipments.

There are various aspects on which the optimum capacity depends upon and they are mentioned in Chapter No.10.

5.3 Social Aspect

The detailed explanation has already been done in Chapter No.4. It is mostly governed by general behaviour of population which gives presentiments of many things such as,

i) popularity of cinema,

ii) leisure of population,

iii) age group of population going to cinema in large number and frequently, and

iv) habits of population.

Popularity of cinema can be gagued in terms of percentage of population wanted to witness the cinema. This will help in investigating the shortage of seats from which we can easily modify the standard for ratio of seat to population and it should further be coordinated with leisure of population. The shortage of facility may create disregard in the people, which may further develop the destructive mentality.

Age group and ethinic group of population which witness the cinema frequently and in large number should be the criteria for planning the facility, which will offer the comfort to the majority of population. Similarly, habits such as spitting, smoking, spoiling the facility etc. should be taken into account in planning.

5.4 Physiological Aspect

It deals with the functions of human organs which are activated in the performance. Ear and eye are mainly activated in the audio-visual performance. So the performance should be such that it should not cause discomfort to those organs. In other words, they should be activated within the range of their response and architect should alter the physical planning factors accordingly. This calls for necessary knowledge of human organs.

5.5 Psychological Aspect

Patrons go to cinema for entertainment. They expect conducive environment, for their entertainment. It is the psychological need of every patron which has to be satisfied mainly by aesthetics of interior and the exterior of auditorium. Interior design can be improved by surface treatment and illumination within the auditorium. It is in the hands of architects to create suitable environment by handling these factors skillfully.

In conclusion all the factors, mentioned above, which affects the planning, are equally important and their consideration leads to unified design. However, the scope of this study does not go beyond the functional requirements i.e. comfort and safety which are discussed exhaustively in successive chapters.

CHAPTER -6

AUDITORY COMFORT ASPECT

6.0 General

Auditory comfort has its own identity in the planning of auditorium. Therefore it should be considered as a major planning factor to achieve good auditory performance. In planning, human factors matter to great extent. Comfort in any task is vitally related to that particular organ of man and a detailed study of its structure and functions, suggest the comfortable range for that particular task. As far as auditory comfort is concerned, physio-anotomical study of ear seems to be an important one which will suggest the necessary alteration in planning considerations for cinema auditorium.

The factors affecting auditory comfort and their inter-relations are shown in Chart No.2 (Plate No.11). It depends upon,

i) Enclosure for the performance,

ii) Equipments to be used.

Efficient design can only be possible when there is proper attention to the factors affecting

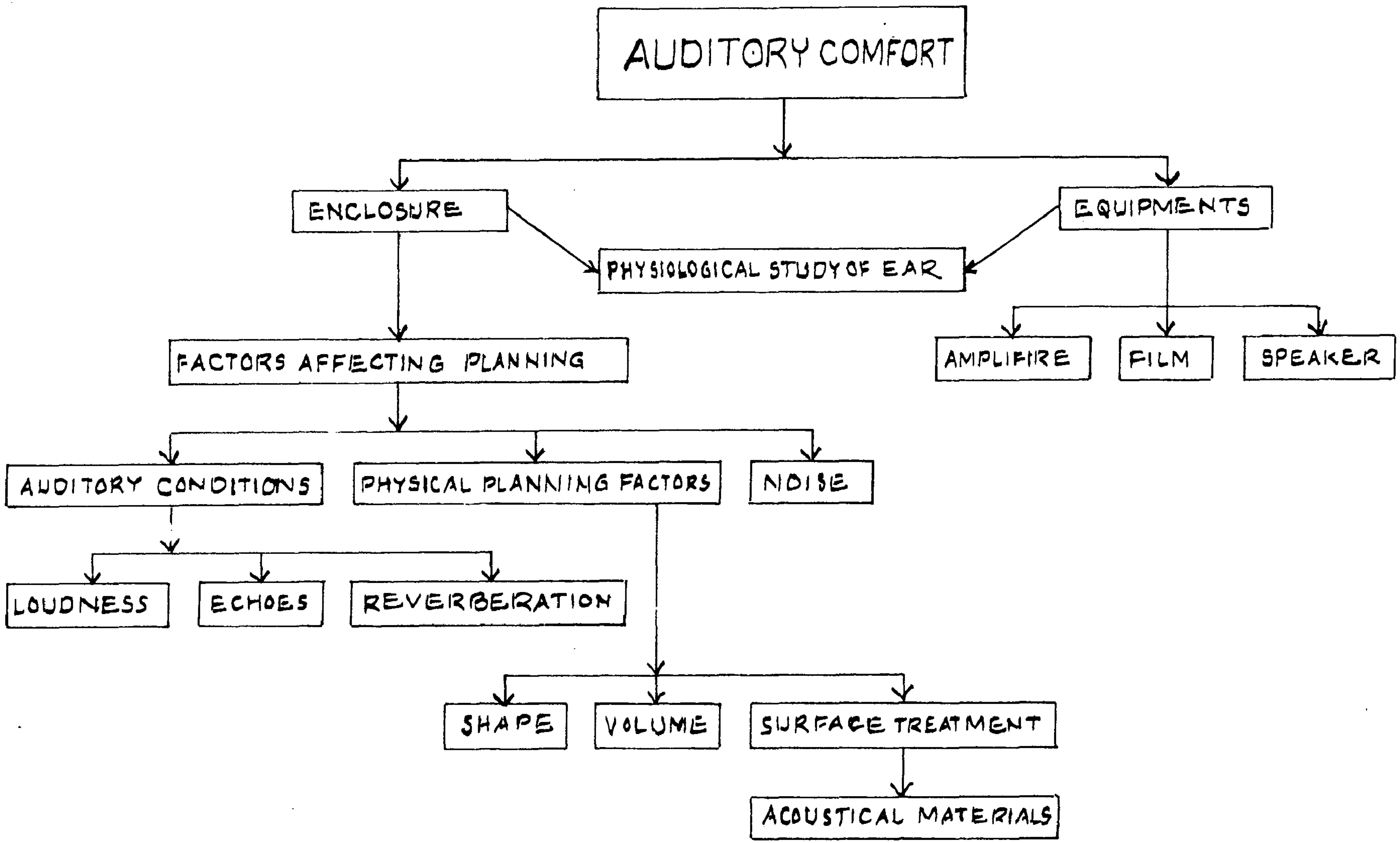


CHART NO.2. SCHEMATIC DIAGRAM FOR AUDITORY COMFORT.

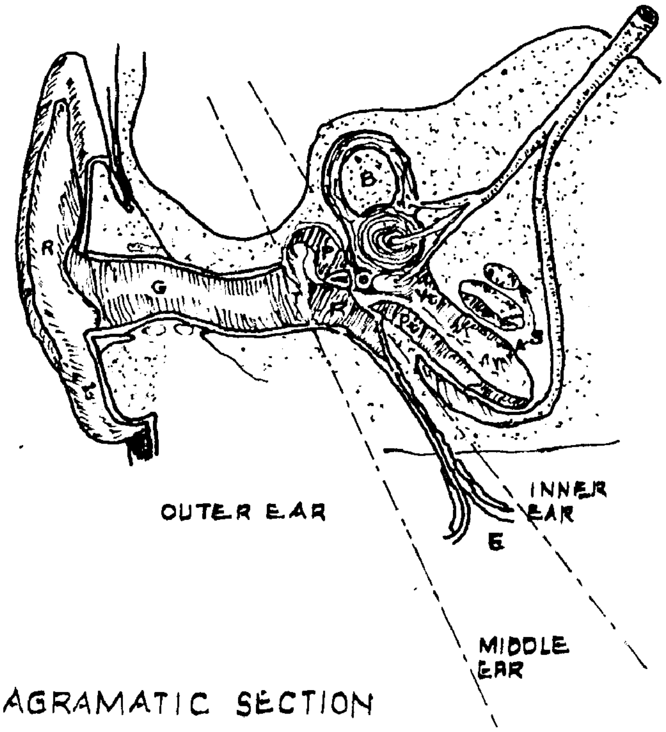
the planning. Similarly, equipments for sound reproduction requires some consideration to achieve desired effects. In short, both, good design of enclosure and efficient equipment can only provide the auditory comfort.

Outside noise is detrimental to the auditory performance; therefore there is a need to pay special attention to noise isolation problems. Similarly, to solve the problem of acoustical defficiencies, acoustical material can only help in this regard, so the knowledge of acoustic materials is also important to the designer.

6.1 Physio-anatomical Study of Ear

The auditory organ of man is made up of (i) External Ear, (ii) Middle Ear, (iii) Inner Ear (Fig.No.6.1).[1] The outer or external ear comprises the visible part- PINNA and the canal which is terminated in the eardrum TYMPANIC membrane. Behind the eardrum, is the middle ear, a small cavity in which three small bones- the hammer, the anvil and stirrup form the elements of the system for transmitting vibrations from eardrum to the aperture, termed as the

1. Wood, Alexander, 'Acoustics', (London: Blackie and Sons Ltd, page No.457).

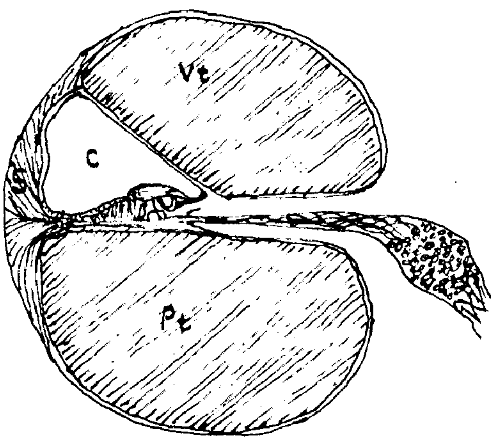


P – PINNA
G – AUDITORY CANAL
T – TYMPANUM
P – CHAIN OF BONES
O – OVAL WINDOW
S – COCHLEA
Vt – SCALA VESTIBULI
Pt – SCALA TYMPANI
B – SEMICIRCULAR CANAL
E – ENSTACHIAN TUBE
R – ROUND WINDOW.

DIAGRAMATIC SECTION
THOUGH THE RIGHT EAR

FIG. NO. 6.1

C – CANAL OF COCHLEA
S – SPIRAL LIGMENT
Vt – SCALA VESTIBULI
Pt – SCALA TYMPANI



DETAIL SECTION OF COCHLEA

FIG. NO. 6.2

SOURCE- ACOUSTICS, BY WOOD.

OVAL WINDOW of the inner ear. The cavity in the middle ear is filled with air by means of a pressure equilizing tube, termed as the EUSTACHIAN TUBE, leading to the NASAL PHARYNX. The casting of inner ear or COCHLEA is a bony structure of a spiral form. The Cochea (Fig.No.6.2) is divided into three parts by the BASILAR membrane and RIESSNER'S membrane. These three parallel canals are wound into the spiral. On one side of Basilar membrane, is the ORGAN OF CORTI, which contains the nerve terminals in the form of small hair extending into the canal of Cochlea. These nerves endings are stimulated by the vibrations in Cochea.

The physiological function of the auditory system is to react the sound vibrations. Most of the sound vibrations are caught by the Pinna of ear, transmitted down the external auditory canal, amplified by the combination of eardrum and auditory chain of bones-FOSSICLES. The movement created by the sound waves, is thus transmitted to the Cochea and to the Organ of Corti. Then they are further relayed to brain via the auditory nerve[2].

Ear is an extremely sensitive organ. It responds to the wide range of sound pressure without damage. Along with the auditory nerves and the brain, it

2. 'The Ear', Physiological Hygiene, (Toronto: School of Physiological Hygiene.) page No.511.

has an amazing sensitive ability to analyse qualities of (i) pitches, (ii) loudness and (iii) tones.

Pitch is the frequency of vibration measured as the number of complete vibrations passing in one second. Healthy people are capable of hearing sound from 20 cycles/second to 20,000 cycles/second, but the ear is more sensitive to sound from 1,000 to 5,000 cycles/second than those of lower and higher frequencies at same pressure level.(3)

Loudness is also intensive characteristics of auditory response. It is the strength and sensation received through ear.There are 120 perceptible steps in loudness of sound ranging from the threshold of audibility to threshold of feeling i.e. from the faintest perceptible sound to the highest sound that can be tolerated without actual physical pain.(3)

Tone is the characteristic which distinguishes the sound from another sound of the same loudness and pitch.(3)

6.2 Factors Affecting the Planning of Auditorium

6.2.1 Auditory Conditions

Constant research has removed the acoustical matter from the sphere of old concepts and established the science of sound on firm footings. There is no

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3. Sharpe, Kinsley, 'Environmental Technologies' in Architecture, page No.318.

necessity to alter acoustically faulty buildings, as the desired conditions can be predetermined and buildings can be designed on correct basis with an assurance of securing satisfactory acoustical results. It is possible when designer has correct knowledge of the acoustical conditions. We are more concerned with cinema auditorium, for which the acoustical conditions are,

i) Loudness,

ii) Reverberation, and

iii) Echoes.

6.2.1.1 Loudness- In cinemas, sound is reproduced by electro-acoustical equipments which can be easily made powerful to give adequate loudness in all parts of the theatre. But in large theatres it may create nuisance to the patron in the front part of auditorium. Therefore, the walls and ceiling should be made useful for the uniform distribution of sound. However, the basis of planning revolves around the necessity of projecting the sound to every part of seating area with a highest possible order of sound quality for every listener. The average sound level in cinema is usually 65 dbs.[4]. The speakers should be so placed that they will offer equal distribution of sound in all parts of theatre, because,

4. Knusen, 'Acoustical Design, 'Commercial Buildings, (New York: F.W. Dodge Corporation) page No.386.

insufficient or excessive loud sound looses naturalness of sound. In case of large theatres, due to the directiveness of the speakers, equal distribution can be furnished by placing suitably adequate number of speakers.

6.2.1.2 Reverberation- Prolongation or persistance of sound energy by successive reflections is called reverberation[5]. If the sound is produced in an enclosed space, it is repeatedly reflected by its boundries. At each reflection, a fraction of the acoustical energy is absorbed. Nevertheless, sound may persist for some time before it dies away to inaudibility. Reverberation time is defined as the time taken for a sound intensity to decay to one millionth part of its initial value after the source of sound has ceased.[5] It is expressed as

$$T = \frac{0.16V}{A}$$

where,

T = Reverberation time in seconds,

V = Volume of room in cu.ft.

A = Total sound absorption provided by audience, vacant seats and acoustically treated surfaces or bare surfaces in sq.ft.

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5. 'Acoustical Design of Auditoria, Halls and Theatres', Building Digest No.6, (Roorkee:C.B.R.I.), page No.2.

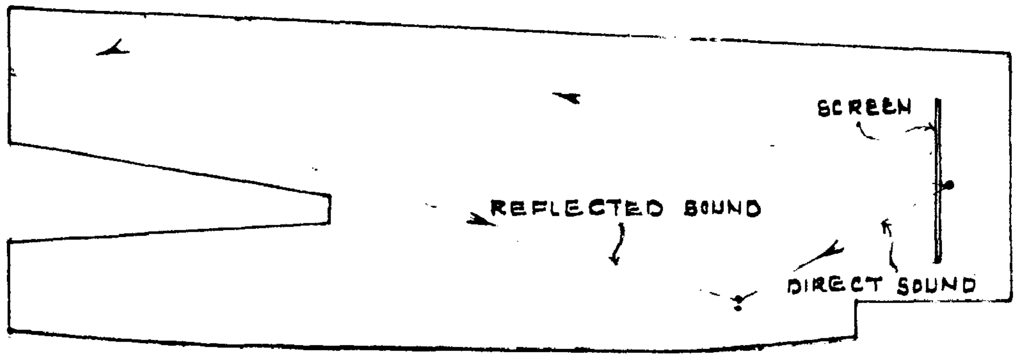
The functional utility of an auditorium is determined primarily by its reverberation time, which varies with the volume.The greater the volume of the room, the larger will be the reverberation time which is one of the most damaging and annoying defect that can be inflicted upon the auditorium. However, a limited amount of reverberation is necessary to enhance the sound, which should relate the frequency of 500 cycles/second, corresponding to the pitch in the middle of audible range.[6] Optimum reverberation time depends upon the volume of the hall and type of performance. For cinema it ranges from 0.6 to 1.2 seconds. Graph (plate No.13) shows the optimum reverberation time with respect to the volume of enclosure.[3]

The reverberation characteristics can be controlled by the amount and placement of absorptive materials on the surfaces. The total amount of absorption in properly designed room, determines the rate at which sound should decay. A large part of this absorption will be furnished by the agents other than acoustical materials e.g. seating, walls, ceiling, floor matting and audience. The absorption

6. Worthington Clifford, 'The Influence of Cinema on Contemporary Auditoria Design', (London: Sir Isaac Pitman and Sons, Ltd.) Page No.55.

furnished by seating is variable, due to which the reverberation time changes when the hall is partly empty. Therefore, seating should have the same acoustical characteristic as audience have.

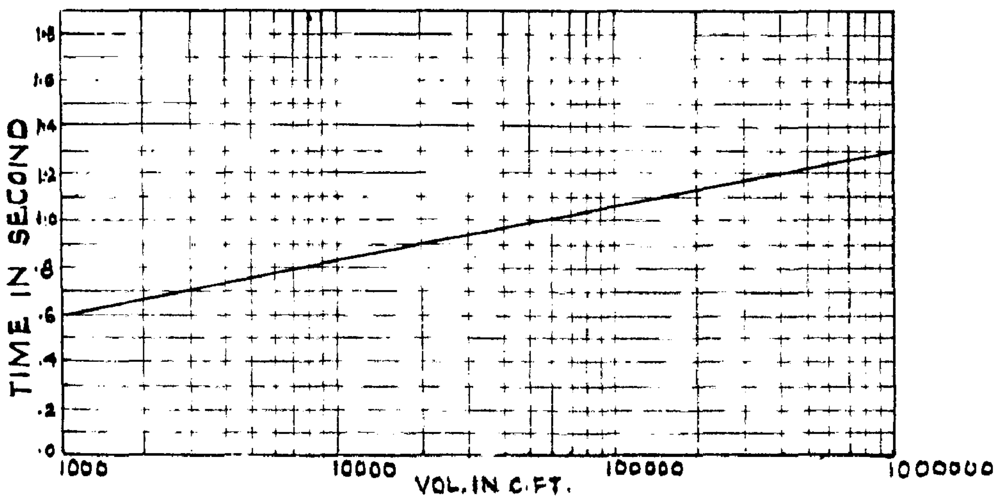
6.2.1.3 Echoes- It is essential that there should not be any possibility of creating echoes in any part of the seating area. The ear can easily distinguish sound with the interval of 1/15 second. Since the velocity of sound is 1200 ft/second, there should not be more than 75 ft. difference in the path of direct and reflected sound.(6) In short, the ear is conscious of the fact that reflected sound reaches it later than direct sound. In correctly adjusted conditions, this consciousness gives agreeable richness to the sound, whereas wrong conditions may lead to echoes which interfere seriously with original sound. Figure No.6.3 shows the reflected sound wave travelled nearly four times as compared to direct sound. In large auditorium, it might reach the ear after appreciable interval and result into repetition of sound. To avoid such possibilities, the portion of wall or ceiling, responsible for the formation of echoes, should be designed either to break or to absorb the sound. Similarly, no section of audience should get the reflected sound with a



SECTION OF AUDITORIUM

THE REFLECTED SOUND WAVE TRAVELLED NEARLY FOUR TIMES AS COMPARE TO DIRECT SOUND WHICH MAY REACH THE EAR AFTER APPRICIABLE INTERVAL AND RESULT INTO ECHOES.

FIG. NO. 6·3



OPTIMUM REVERBERATION TIME AT 512 CYCLE PER SECOND WITH RESPECT TO VOLUME.

GRAPH. NO. 4.

SOURCE- ENVIRONMENTAL TECHNOLOGY BY SHARPE KINSLEY.

PLATE NO. 15

time interval of not more than 1/15 second after hearing the direct sound from the loud speakers.

6.2.2 Physical factors

Above mentioned acoustical conditions i.e. loudness, reverberation and echoes have a great influence on the factors of physical planning of auditorium. The control over those acoustical conditions can be obtained through the following physical planning factors which also requires careful study,

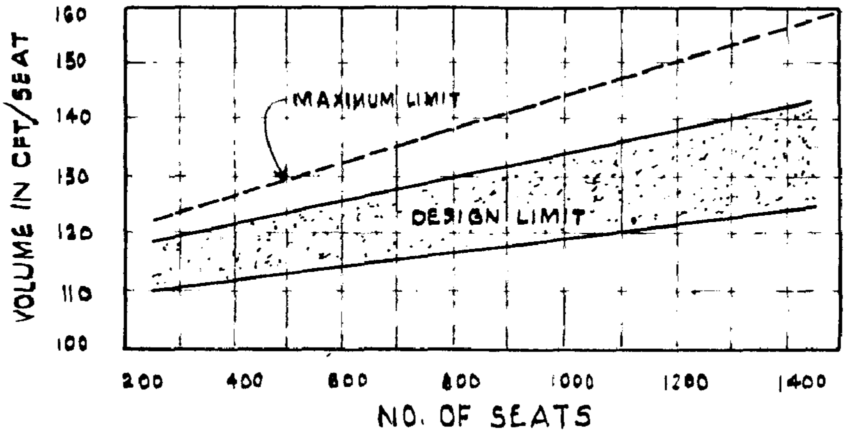
i) Volume,

ii) Shape, and

iii) Internal surface shaping.

6.2.2.1 Volume

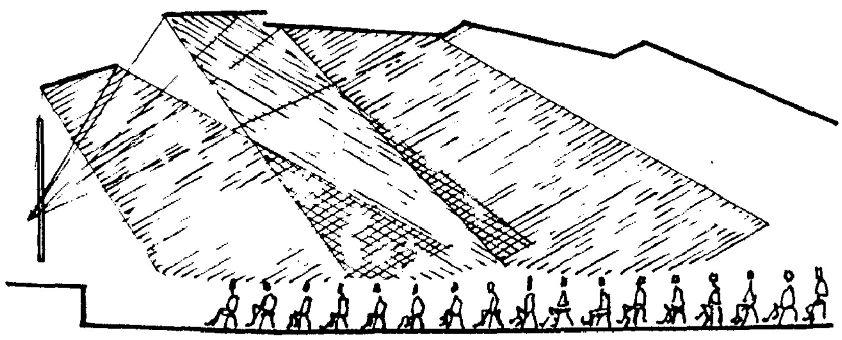
It has already been mentioned that volume determines the reverberation characteristics. Reverberation varies with the volume/seat which will require extensive acoustical treatment of surfaces. Less volume/seat may lead to the total elimination of acoustical treatment of surface. Graph (Plate No.14) developed by C.C.POTWIN, shows desirable limit of volume in c.ft. with respect to seating capacity. These values are based on controlling sound reflections and reverberation by proper shaping of internal surfaces. However, for the approximate calculations for volume of auditorium of average



DESIRABLE LIMIT OF C.FT. VOLUME IN RELATION TO SEATING, BASED UPON CONTROL BY INTERNAL SURFACE SHAPING

SOURCE- MOTION PICTURE THEATRE 'PLANNING' UPKEEP. EDITED BY H.M. STOTE.

GRAPH. NO. 5.



UNIFORM DISTRIBUTION OF REFLECTED SOUND CAN BE ASSURED BY PROPER CEILING DISIGN

FIG. NO. 6·4

PLATE NO. 14

size, it should not exceed 150 c.ft./seat (7). Volume below this limits will help in eliminating the absorbing materials. It is difficult to have an auditorium, which functions well in all respects with a volume lower than 100 c.ft./seat (6). In short, from economy point of view, it is better to have minimum volume.

The sound spread out from the source must diffuse in the room and reach remote portion with adequate intensity for easy audibility. Reflective surface help in this regard. However, the use of available surfaces as reflective sound distributing area, should be done skillfully (Fig.No.6.4). Limited volume can offer higher intensity, whereas excessive volume decreases intensity. Capacity of sound reproducing and amplifying systems is also dependent upon the volume of auditorium because the power of system has to be increased with the increase in volume to ensure the proper level of sound over the entire area.

6.2.2.2. Shape

Auditorium shape must not only direct sound energy from a source to an auditor but must also diffuse it uniformly. This condition can be achieved when the auditorium has high quality of reverberant characteristics. Most efficient control of sound

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7. J.P.Maxfield, 'Auditorium Acoustics', Motion Picture Theatre, ed. H.M.Stote, (New York: Society of Motion Picture Engineers) Page No.132.

reflections and the best distribution of sound energy can be obtained where the ratios of width to length fall within limits of 1:1.4 to 1:2[8]. Ratio above this range arises the problem of multiplicity of sound reflections occurring between the side wall surfaces (Fig.No.6.5). It necessitates treatment to the side walls to minimise the weakening of sound transmitted towards the rear seats and hence the side walls neither be highly absorptive nor obstruct unduly the flow of sound from front to rear. Splays and other functional deviation in the walls, can provide solution to the problem (Fig.No.6.6).

Ratio below the limit, do not offer proper sound distribution and vision to the side seats (fig.No.6.7). It requires additional sound system to offer adequate sound level to side seats, which will create excessive sound level in front and central seats. Similarly, it creates large rearwall which is often a source of objectionable sound reflections.

The condition of limiting the ratio do not imply that the floor plan should be rectangular but merely suggest the limit of average dimensions. In general, it is desirable to avoid a rectangle. A fan shaped or a rectangular plan of auditorium with splayed walls on either sides of screen, is the

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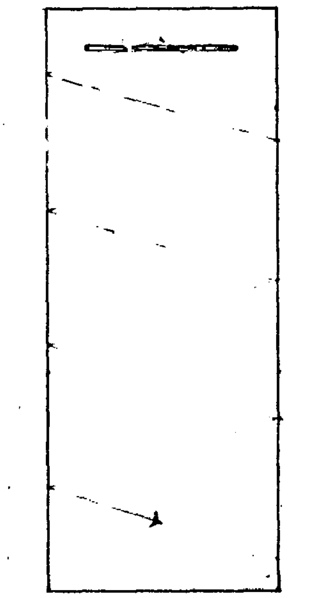
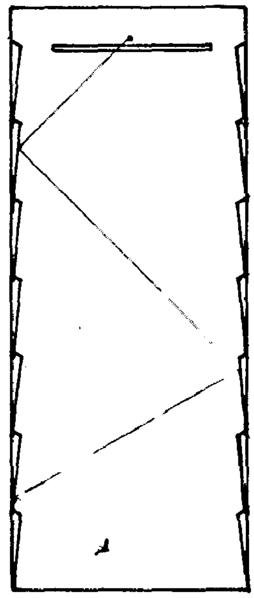
8. Newman, Robert, 'Architectural Acoustics', Time Saver Standards, ed. Callender, (New York: McGraw-Hill Book Company), page No.636.



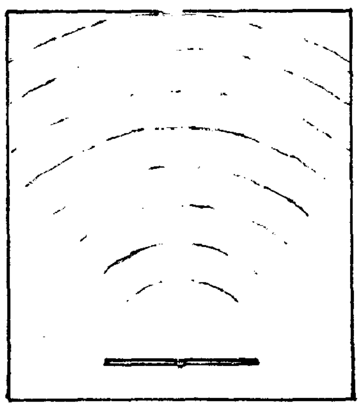
ROOM WITH RATIO ABOVE THE DESIRED RANGE CREATES MULTIPLE REFLECTIONS.

FIG. NO. 6.5



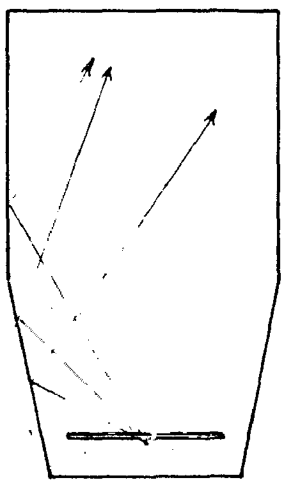
TREATMENT TO THE SIDE WALLS DISPERSE THE MULTIPLE REFLECTIONS.

FIG. NO. 6.6



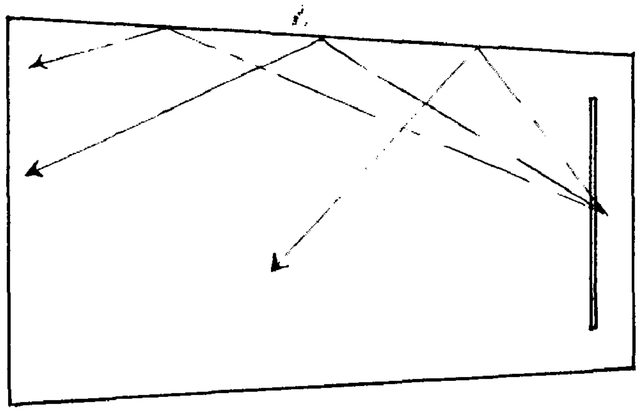
ROOM WITH RATIO BELOW THE DESIRED RANGE DONOT OFFER UNIFORM SOUND DISTRIBUTION TO THE SIDE SEATS.

FIG. NO. 6.7



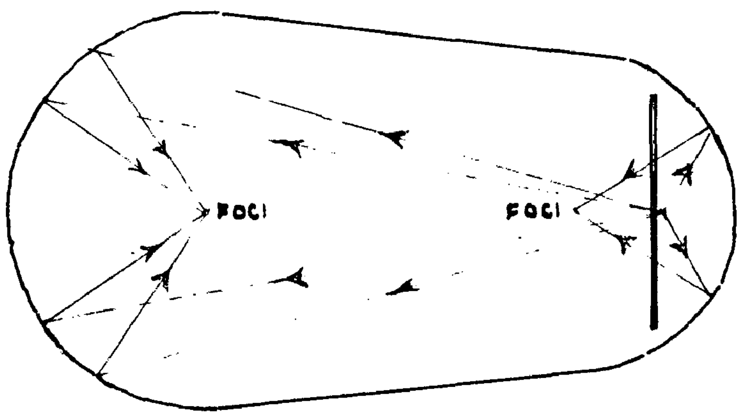
SPLAYED WALLS OFFERS UNIFORM DISTRIBUTION OF SOUND WAVES.

FIG. NO. 6.8.



FAN SHAPED AUDITORIUMS OFFERS UNIFORM SOUND DISTRIBUTION DUE TO NON PARALLEL WALLS.

FIG. NO. 6·9.



CIRCULAR OR ELLIPTICAL SHAPED AUDITORIUM OFFER NONUNIFORM DISTRIBUTION OF SOUND, CREATES ECHOES AND FOCUSSING EFFECTS.

FIG. NO. 6·10

most ideal because of (i) good sound distribution due to non-parallel walls (Fig.No.6.8 and 6.9), (ii) material assistance in obtaining a low value of c.ft./seat., (iii) aesthetics.

Circular and elliptically shaped plans of auditorium usually give rise to focussing effects (Fig.No.6.10), nonuniform distribution of sound and echoes. The focussing effects are more pronounced in elliptical plans. In both, elliptical and circular plans, the acoustical conditions can be improved by addition of diffusing surfaces.

Auditorium length greater than about 150 ft. should be avoided to avoid a noticeable delay in reaching of sound to persons in the rear of the theatre. It requires 1/7th second to travel 150 ft. The lack of synchronism between the sight and sound becomes quite annoying when the difference exceeds about 1/7 second.[6]

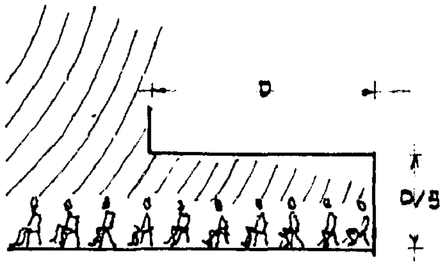
As far as ceiling height is concerned, from architectural point of view, it is governed (i) sight line requirements, (ii) obstructionless projection of picture on the screen, (iii) general appearance of the audience. From acoustical point of view, it is governed by (i) correct relationship between height and horizontal proportions, (ii) the optimum cubic ft. volume/ seat required.

As already mentioned that for the best acoustical performance, the volume of the auditorium should not exceed 150 c.ft./seat. Similarly, as a general rule, for auditorium plan with 1:1.4 ratio of width to length, the height should not exceed half of the width, while for 1:2 ratio, it should be less than 2/3rd of the width.(8)

In case of auditorium with balcony, the depth of the balcony recess should not exceed thrice the height of opening (fig.No.6.11) shallow depth and high opening of the balcony recesses usually offers a good design, as it permits the sound to flow readily into space under the balcony, (Fig.No.6.12). Good design also requires reverberation time in the balcony recess same as in the main part of the auditorium.

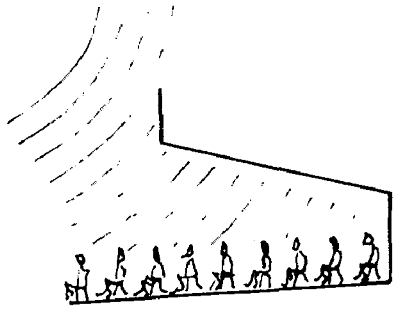
6.2.2.3 Internal Surface Shaping

(a) Side walls- They should reinforce the direct sound that reaches the rear part of the auditorium and should be treated so that the sound, they reflect to the audience, will not be delayed too long. In large auditoriums, the parts of side walls,



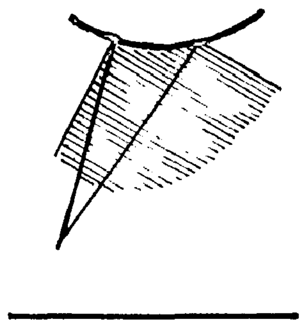
HEIGHT OF BALCONY RECESS SHOULD BE 1/5 OF BALCONY PROJECTION

FIG. NO. 6·11



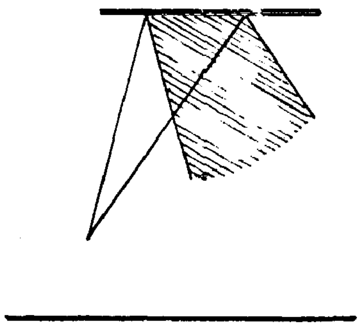
SLOPING BALCONY SOFFIT FACILITATES SOUND TO FLOW INTO SPACE UNDER BALCONY.

FIG. NO. 6·12



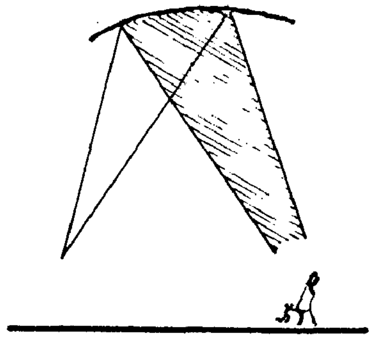
CONVEX SURFACE DISPERSES SOUND

FIG. NO. 6·13



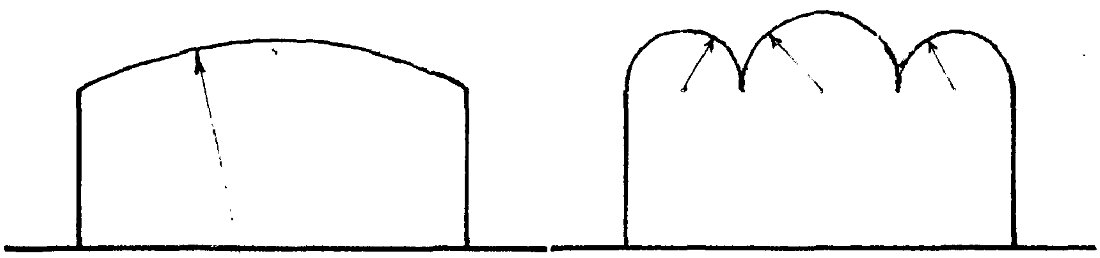
FLAT SURFACE DISPERSES SOUND

FIG. NO. 6·14



CONCAVE SURFACE CREATES THE FOCI

FIG. NO. 6·15.



THE RADIUS OF CURVATURE OF CEILING SURFACES SHOULD BE MORE THAN TWICE THE HEIGHT OF CEILING.

THE RADIUS OF CURVATURE OF CEILING SURFACES SHOULD BE LESS THAN HALF THE HEIGHT OF CEILING.

FIG. NO. 6·16.

PLATE NO. 17

suspected of causing echoes or unduly delayed reflections should be either made acoustically rough to diffuse the sound or should be covered with highly absorptive materials.

In auditorium with parallel walls, possibilities of flutter echoes are more. They can be avoided by (i) diverging, nonparallel or tilted walls, (ii) splayed walls. Diverging walls provides higher sound level at rear of auditorium by reflecting the sound, but these reflections must be controlled so that the path difference between direct and reflected sound will not exceed the limit which give rise to echoes, since it will further result in lack of 'intimacy'.

Similarly splaying prevents flutter and can contribute both to desirably directed reflections and diffusion of sound within the room. Minimum splay of 5/8" / running ft. will prevent flutter.(7) Curved surfaces facing to the loudspeaker should be avoided deliberately as they give rise to the focussing of sound on some part of the seating area.

(b) Rear Wall- Large concave rear walls should be avoided since they are responsible for troublesome echoes and delayed reflections. If these reflections are either from vertical or tilted wall, they should be treated with highly absorptive materials. In other words, the rear wall must be designed so that the delayed reflections from it are prevented from reaching the audience. This requirement usually necessitates the use of highly absorptive rear wall, therefore the portion of the wall above the wainscot (dado) should be treated with suitable absorptive materials. Auditoriums where tilting of rear wall is advisable to utilize the reflections from the rear wall, requires very much less absorptive material and it should be applied in patches and panels. The application of absorptive materials in the form of patches not only promotes diffusion but it also helps to support flutter echoes, hence they should be used skillfully.

(c) Wall Behind the Screen- The nature of treatment to wall behind the screen depends on the type of the sound system used and its position in relation to the screen. Farther the distance of speaker from the rear wall, the more drastic will be the treatment. Generally wall behind the screen should be treated with highly absorptive material. It prevents sound which is radiated from the back of the loudspeakers, from being reflected to the audience.

(d) Ceiling- It should provide the favourable reflections of sound especially for the rear seats. In some cases, the ceiling should also diffuse the sound. If the adequate means of diffusion are furnished by floor and wall, no additional diffusion is needed by ceiling. It may be utilized utmost for reflecting sound. Ceiling splays in the form of panels help in this regard (Fig.No.6.4). They should be oriented so as to reinforce the sound, reaching the rear parts of an auditorium. Similarly, splays between the ceiling and rear wall should be designed to reinforce the sound in the rear of the room and to prevent echoes from the rear wall.

Ceiling with concave surfaces such as domed, arched, barelled etc. should be avoided wherever possible, as they create the detrimental focussing effects. (fig.No.6.15). If they are required for special reason, the radius of curvature should be either atleast two times the ceiling height or less than half the ceiling height. (Fig.No.6.16). The most serious defects occurs when the radius of curvature of a ceiling surface is about equal to ceiling height.

Similarly, flat and convex surfaces have dispersive reflecting characteristics (Fig.No.6.13 and 6.14). However, to enhance the diffusion of reflected sound, it is advisable to break up the surfaces into the sunk panels. Coffered ceiling usually gives best results, but the sizes of the panels should be proportional to average wavelength of the sound.

In short, the areas along the wall and ceiling surfaces near screen, should provide reflections which help in obtaining vitality and naturalness to the presentation. Hence no sound absorbing material should be used in this area. Through the proper arrangement of the surfaces and planning of surface contours, the useful sound reflections can be controlled. Similarly, the reflections responsible for multiple echoes, sound concentration and the area of excessive or deficient loudness, can either be dispersed or directed to outside the limits of seating area, where they will be absorbed or dissipated. This control of reflection can be achieved by (i) full of partial surface tilts, (ii) surfaces with angular or broken contour of special design.

(c) Floor- The floor between the screen and the first row of seats should be highly absorptive to prevent sound from reaching the audience in the front seats by the reflections. Such reflections contribute to the loss of intimacy. They may be suppressed by covering the floor with heavy carpets.

Since the audience constitutes a highly absorptive surface, sound waves which graze it, are greatly weakened. Hence it is good design of auditorium from audio-visual point of view, to elevate the seats to allow free flow of direct sound from the source to auditor. A good sight-line can help in this respect. The first few rows can be on the same level, since they have a good line for both sight and sound. The higher the source is elevated, the farther back the level area can be extended.

When the ratio of length and width is 1:2, it is necessary to design the ceiling, side walls and the floor to minimise the weakening of the sound transmitted towards the rear seats. Sound propagated over an absorptive surfaces, such as audience or an acoustically treated ceiling, is greatly weakened. Hence, the floor should rise steeply towards the rear, and the loudspeakers and screen should be elevated.

(f) Balcony- The soffit of the balcony should slope downwards towards the rear and should not be treated with absorptive material. Similarly, the concave parapet of balcony give rise to echoes. By tilting the surface towards the floor or making it convex, it is possible to utilise the reflections to increase the sound level in the middle of auditorium. Otherwise, it should be treated with highly absorptive material or should have contours such that the reflection from it will be diffused and concentrated in small area.

In conclusion, the acoustical design of cinema auditorium should be based on a well established science of architectural acoustics. The principles and the procedures are derived from this science. If they are carefully followed in the designing and constructing of a theatre, there need not be any anxiety about the results. But it is only possible by the cooperation of architect and acoustic engineer.

6.3 Quieting and Noise Isolation.

Noise can be defined as undesirable sound. It is detrimental to the hearing of desired sound. Low tone noise is not objectionable as the high tone. It has been proved that the noise of frequency below. 500 cycles/second is tolerable noise; however it is very important to reduce the noise, both air borne and solid borne, in the auditorium for good hearing(9). Because high noise level requires the operation of the sound system at higher level and even though the audience does not realise that the sound level is higher than otherwise would be. It does not put them under a nervous tension, and if the noise is extremely high, the sound level has to be so much high to overcome the noise that it really becomes annoying.

Nevertheless, noise of certain levels is required to be maintained for acquiring acoustical privacy among the patrons. If it is very quiet, the the conversation at one corner can be easily heard at another corner. Therefore, to mask this conversation, certain amount of noise is required which is known as a 'Back-ground Noise'. The sound level of this noise should be below the audience noise i.e. 30 to 35 dbs.(3)

Noise reduction means shifting of objectionable sound from high to low frequency as well as its intensity, which can be done by (i) sound proofing of solid borne noise, such as noise due to shocks, vibrations of machinery, etc. (ii) sound insulation

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9. Rottinger, M., 'Applied Architectural Acoustics, (Brooklyn: Chemical Publishing Company), page No.230.

of air borne noise such as traffic noise, industrial noise, shouting etc. However, a noise survey is necessary before the construction of theatre to determine the noises in the surrounding area, because, it is observed that outdoor and traffic noises in some area of big cities reach 85 to 100 dbs.(10) Similarly projection of future noise nuisance should be taken into account.

There are various sources of noise, which affect the hearing condition of cinema auditorium. The remedies to overcome them are as follows:-

(1) Outside air borne noises due to traffic, industries and public activities etc. have a major impact on the cinema planning. These noises can be isolated by the special techniques of construction such as cavity wall construction, various types of surface treatment and use of sound absorbing materials in the construction etc.

Exits are the weak points which allow the sound transmission in the auditorium. Therefore, it is very essential to design the exits which will reduce the sound transmission.

(2) Noise from projection room and rewinding and generator rooms can be overcome by (i) the use

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10. Rossman, 'Acoustics and Architecture in Auditorium Design', Proceedings of Third International Congress on Acoustics, Stuttgart 1959, ed. Cremer, (London: Elsevier Publishing Co.), page, No.167C.

of quiet operating machines, (ii) treating the ceilings of these rooms, with noise absorbing, fire proof materials. If the ceiling is high, acoustical absorbing materials should be used on walls also. Similarly the projection and the viewing ports should be fitted with plane glasses.

(3) Air conditioning system poses the problem of both airborne noise and solid borne noise. Air borne noise is created due to air movement itself and the solid borne noise is caused by the vibrations being transmitted through the ducts. They can be minimised by,

(i) lowering the velocity of air,

(ii) installing low speed, quiet operating equipments for air conditioning system.

(iii) mounting the equipments on anti-vibration bases to prevent vibrations from being transmitted through the ducts. Such vibrations set-up very serious noises in some other part of the building also.

(4) Other noises created by the patron, in the surrounding areas of the auditorium, such as lobby,

lounges, rest-rooms and enterance hall etc., can be reduced by treating the ceilings of these spaces with noise absorbing materials.

(5) Finally, there is audience noise about which nothing can be done, except hope for a quiet audience.

6.3 Behaviour of Acoustical Materials

Sound absorbing materials are employed to reduce the reverberation time and to avoid distant reflections from walls, ceiling and other surfaces in an enclosure for improving hearing conditions. They are also employed for the reduction of noise in the enclosure. By an acoustical material, is usually meant a sound absorbing substance which is fastened in flat patches to the walls and ceiling of the auditorium. The principal function of acoustical materials is to absorb sound energy which originates within the room. Rarely they prevent transmission of sound energy from one room to another. Such transmission can be prevented by other techniques.

Architects and engineers are faced with the problems of selection of the materials to be used in the auditorium to secure the proper amount of sound absorption and choice of economical absorbent to quiet the noisy locations. Therefore, it is very essential that they must have accurate data on the behaviour of acoustical materials. Such data is made available by their manufacturers. However, the special uses to which the material is to be employed, will require more detailed information which can be obtained from the results of laboratory tests.

Different kinds of acoustical materials can be grouped as given below:-

(1) Prefabricated, e.g. tiles and panels,

(2) Prepared at the time of application e.g. acoustical plaster.

In prefabricated type, many varieties are available. A common type is the homogeneous porous absorbent consisting of wood fibers, or glass fibers or granulated materials held together with a suitable binder under pressure. Another common type is the porous material having a hard nonporous surface which is perforated so that the sound waves can pass into the porous region and be absorbed. The perforation might be regularly spaced slots or circular holes or irregular fissures. Some varieties are available in blanket form such as glass wool or rock wool. They are protected by a perforated surfacing of wood, metal or asbestos cement board. The principle advantage of the prefabricated acoustical material lies into the uniformity of the product which can be carefully controlled. There are relatively small variations in the absorption coefficient for particular type.

Amongst the cast in situ types, several acoustical plasters are available. Some consists of granulated organic substances which are mixed with the foaming agent and a suitable binder, and are to be applied to the surfaces to be treated with trowel. Other types consist of fiberous material such rock wool, asbestos etc. which are mixed with a binder and sprayed directly on the wall by means of spraying equipments. Acoustic plasters are generally difficult to handle and careful control must be exercised when they are applied. However, there are economic advantages in favour of plaster and sprayed-on materials.

Acoustical materials also can be classified according to the ways of sound absorption. A knowledge of mechanism of absorption is important, especially, if one is going to be faced with the problem of painting the material. Almost all sound absorbing materials are porous. Usually sound energy penetrates porous materials such that the friction of movement in the.

porous, converts some energy into heat. Some of the incident energy will be transmitted through the material, and some will be reflected from the incident surface. If sound strikes a thin flexible panel, some of the incident energy will be used to make the panel vibrate. The performance of an acoustical material is judged by its sound absorption coefficient, which depends on density of the material and frequency of sound. Low density absorptive panels have higher absorption coefficient at low frequency than at high frequency. Any acoustical material must absorb atleast 20%. of the incident sound energy.(3)

Various elements are important in the selection of an acoustic materials. Architects are interested in sound absorption and also concerned with light reflection, fire resistance, appearance, strength, durability and paintability. These all points are equally important. C.B.R.I. and other institutions have worked out sound absorption coefficients of different indigeneous and commonly used acoustical material. They are given in appendix 'B'.

Absorption of sound depends not only on the physical properties of material but also on the method of mounting the same. Air space between the absorbent and rigid wall on which it is mounted, enhances the absorption. But painting to the absorptive material affects the absorption quality of material. Excessive painting will clog the pores and prevent absorption of sound. Paint should be applied so long as the perforations and the fissures remain open. Painting of a porous material without large holes of fissures are more difficult. The paint must be applied as thinly as possible, preferably with the spray gun. If it is applied by brush, care must be taken to get a thin coat of paint without closing the pores of the matefial.

6.4 Sound Reproducing Equipments

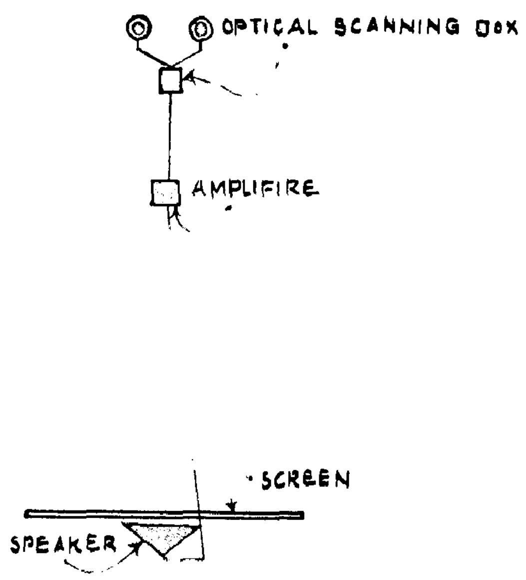
Equipments for sound reproduction have a major share in creating good auditory or acoustical environment. Efficient equipments will definitely offer good quality of performance. They are the outcome of technological development which has been done uptil now. Still, scientists are working for the refinement in the design to achieve maximum possible efficiency in reproduction of sound. The sound reproducing equipments are 1) Amplifier , 2) Film, 3) Speakers.

The basic requirement of reproduction of sound is that the amplifier should be able to give the adequate frequency output. The recorded sound is converted into electrical energy by scanning the film optically or magnetically and then amplified by the amplifier at desired frequency level. The number of the amplifiers depends upon the channel system to be adopted for reproduction of sound which is basically dependent upon the film to be presented. Today, films with upto seven channels recorded sound, are available. The sound is recorded either by optical method or by magnetic method. Magnetic sound is better than optical sound in many respects. The films with multichannels are primarily produced for three dimensional (stereophonic) sound effects.

Architecturally , detailed knowledge of amplifier and film is of less importance. But, some thought about the speakers is needed for architects, as they create some architectural problems such as placement of speakers and treating them in interior design scheme.

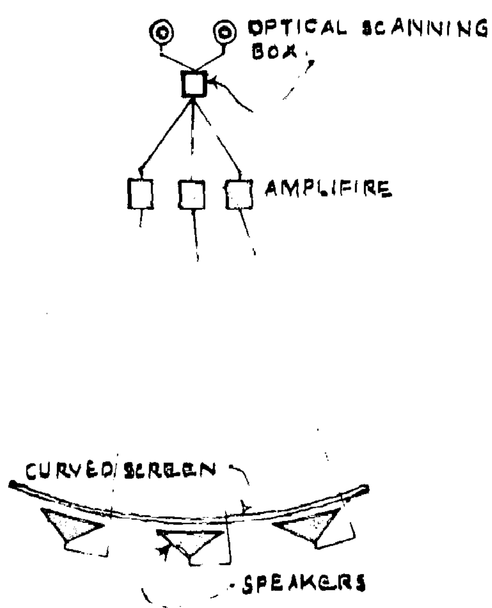
6.4.1 Loud Speakers

It is a device for converting electrical energy into acoustical signal energy in the air. It should preserve the essential character of this signal energy while converting it from electrical to acoustical form. The part of the speaker, which does



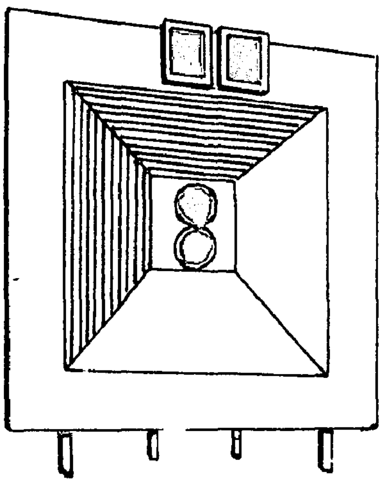
MONOCHANNEL SOUND
SYSTEM
(OPTICAL SOUND)

FIG. NO. G·17



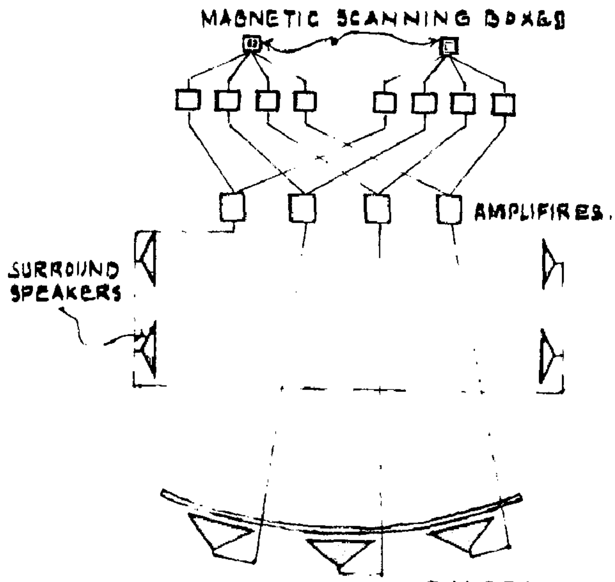
TRIPPLE CHANNEL SOUND
SYSTEM
(OPTICAL SOUND)

FIG. NO. G·18



A COMPLETE BACK-STAGE SPEAKER
ASSEMBLY PROVIDING FOR FULL COVERAGE
OF LOW AND HIGH SOUND FREQUENCIES.

FIG. NO. G·19



FOUR CHANNAL STEREO-
PHONIC SOUND SYSTEM
WITH MAGNETIC SOUND.

FIG. NO. G·20

PLATE NO. 18

this conversion, is called the motor[11]. The motor vibrates the diaphragm in front of it, that in turn vibrate the air in the immediate contact with it. The vibration results in slight pressure changes in the air above and below the atmospheric pressure. These pressure changes are transmitted in the air as sound wave.

Speakers are classified by the kind of the motor employed for the conversion of the energy. Common types are (1) magnetic armeture or 'Magnetic', (2) moving coil or 'dynamic'. Magnetic types are hornless and the diaphragm is made large enough to radiate the energy directly into the air. They offer low frequency sound and hence used in radios and televisions. Moving coil type speakers are with horn attached to relatively small diaphragm and meant for high frequency. The large (mouth) end of horn behaves as a large lightweight diaphram that radiates sound more efficiently than the small diaphragm. The horn gives efficiency, frequency response and directional property. Large horn offers low frequency whereas small horns offers high frequency sound. Both are to be provided in a complete assembly unit for full coverage of low and high sound frequencies. (Fig.6.19). Horn speakers can be made quite efficient, they are therefore,

11. Davis, Kaye, 'The Acoustics in Buildings (London: G.Bell and Sons.Ltd.) Page No.137.

primarily used where efficiency, high acoustic power output and small size is important.

The placement of speakers behind the screen should be well understood to achieve the desired effects of sound and adequate sound level to all seating positions. Theatre with small screen (35 mm. presentation) uses monochannel system for sound reproduction which needs only one high frequency speaker unit behind the screen (Fig.No.6.17). It should be installed in the centre at 1/2 to 2/3 height of the screen. In large auditorium, additional speakers may be placed on the wall to produce the required sound level at the rear seats. But the position and number of such speakers require lot of considerations, therefore it should be left to acoustics engineer.

In theatres with large curved screen, where the multichannel system is essential, three or five assembly units of high and low frequency loud speakers (Fig.No.6.18 and 6.20) of identical type and of approximately the same sensitivity should be installed. The centre to centre distance between them must be equal to 1/3 of the screen width and should be placed at 1/2 to 2/3 height of the screen. For good performance these units should be as close to the screen as possible. 16 to 30 surround speakers are to be installed upon the side walls of the theatre to produce music and special sound effects such as storm, earthquake, rains etc., which are intended to surround the audience. They must assure that, no part of audience hears the effects from a definite source and the uniform distribution. The selection of speakers should be such that they will reproduce the effect with reasonable fidelity.

In theatres with balcony, the surround speakers must be placed close to the audience seated at the sides, with adequate in number to provide the surround effects. These speakers are of low frequency but they produce the total output power to fill the auditorium. Speakers under balcony should be placed as high as practicable using enclosures with tilted fronts, and mounted in such a way that the sound from loudspeaker is directed to the underside of the balcony. In the theatres without balcony, surround speakers should be placed on side walls at the height of 15 to 20 ft. from the floor. Sometimes surround speakers are also installed on the ceiling for the special effects of thundering and raining, but they require separate channel (sound track) for such effects.

CHAPTER-7

VISUAL COMFORT ASPECT

7.0 General

The visual performance of the auditorium is vitally concerned with visual comfort. There is no doubt that one can see the movie without visual comfort, but the absence of it may affect to great extent on visual organ and may result in decreasing the popularity of cinema. Therefore, visual comfort aspects should be of primary importance in planning the auditorium. Since the visual task is primarily related to the visual organ of man, its range of response to visual task should be taken into account for the study of planning of auditorium. Physio-anotomical study of eye gives the guidelines in this regard.

It is obvious that the visual comfort is mainly dependent on the following factors

(i) Enclosure for performance,

(ii) Equipments to be used.

Their inter-relationship is shown in Chart No.3. Design of the enclosure can be made efficient by

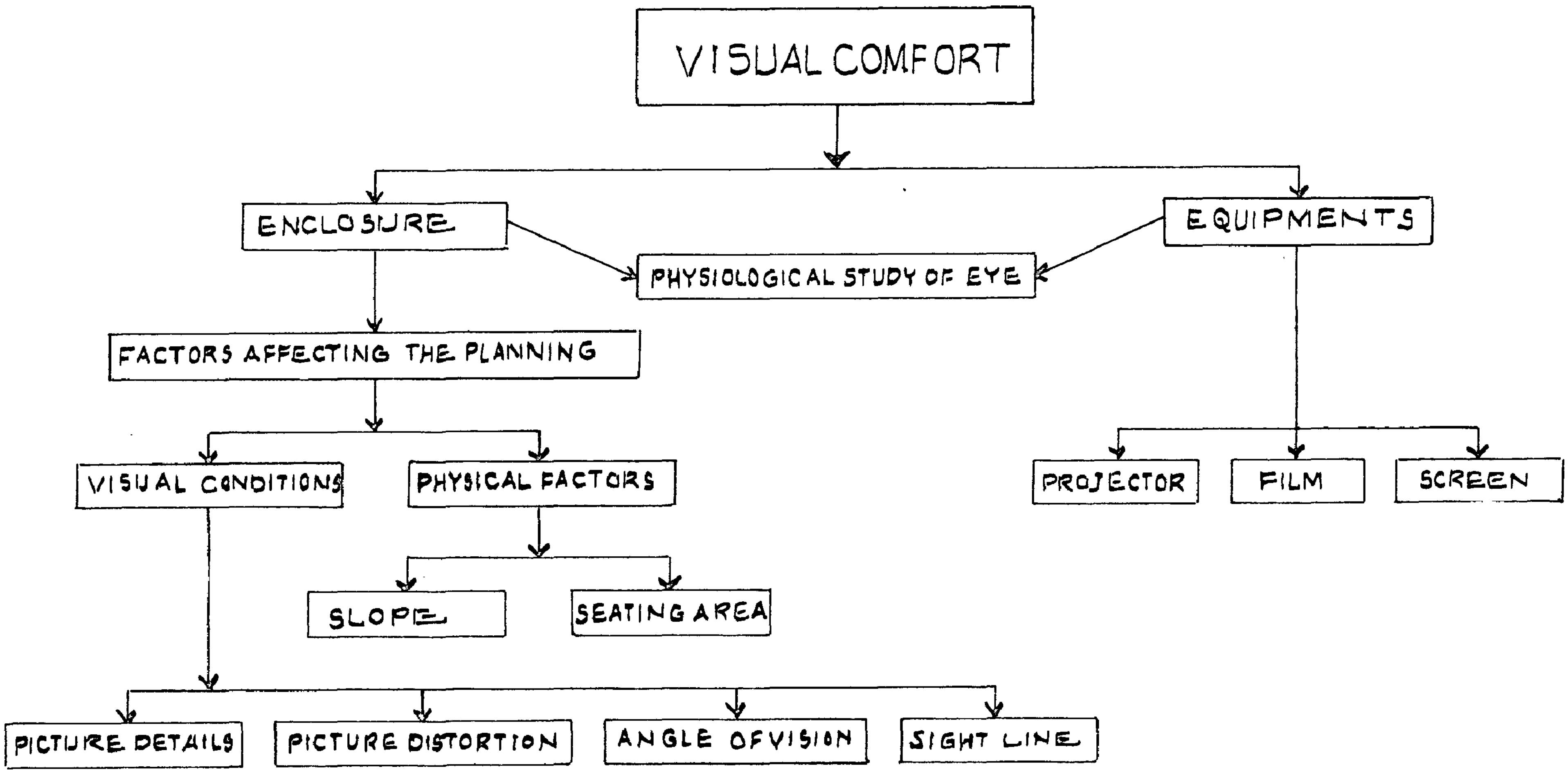


CHART NO. 3.

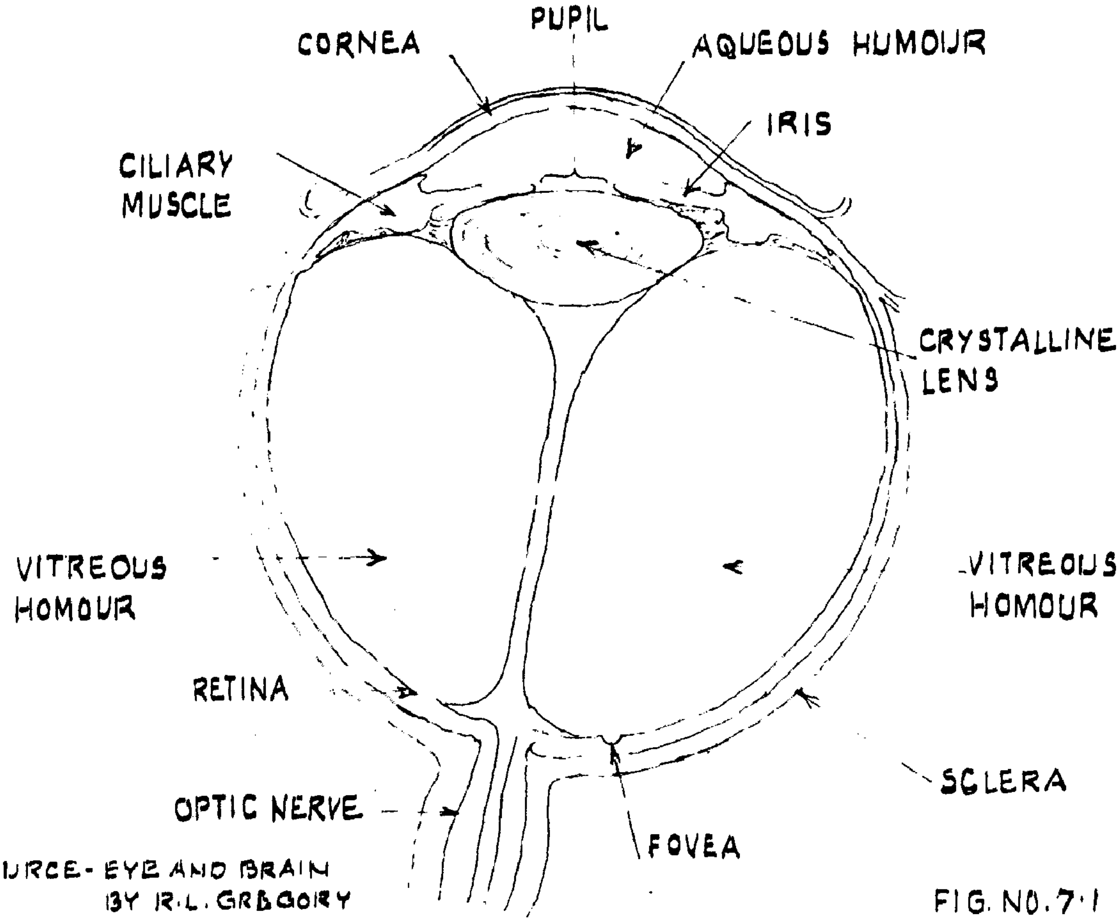
SCHEMATIC DIAGRAM FOR VISUAL COMFORT.

fulfilling the factors affecting the physical planning. The equipments have also dominant role in offering the visual comfort, rather to say, the very performance cannot be possible without them. In short, both good design of enclosure and equipments lead to achieve comfort which further results in good visual performance.

7.1 Physio-anatomical Study of Eye

Eye is the visual organ of man when it removed from the orbit of skull, it represents a roughly spherical organ, which is enclosed by a tough and opaque membrane called SCLERA. (Fig.No.7.1)[1] The front part of this membrane which is transparent and elliptical in shape, is called CORNEA or the window of the eye. It has smaller radius of curvature than rest of the eye sphere. Behind the cornea, there is eyeball known as IRIS which can move along the internal surface of the cornea. It has a hole in the centre to receive light. Immediately behind the Iris, a crystalline lens is fixed in the frame of CILIARY muscles, which controls the curvature of lens. The crystilline lens consists of an elastic, jelly like

1. 'Physiology of vision,' Physiological Hygiene, (Toronto: School of Physiological Hygiene), page.No.415



SOURCE- EYE AND BRAIN
BY R.L. GREGORY

FIG. NO. 7·1

A SIMPLIFIED CROSS-SECTION OF HUMAN EYE

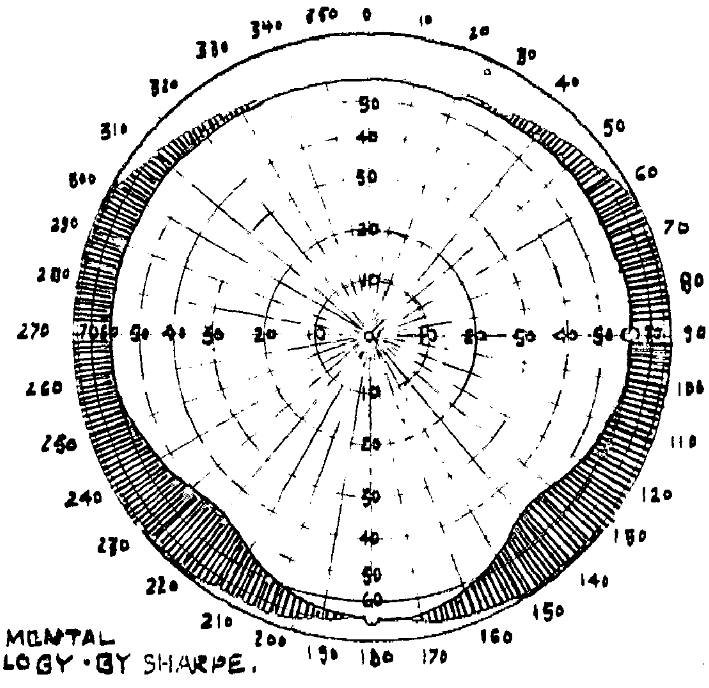


FIG. NO. 7·2

SOURCE- ENVIRONMENTAL TECHNOLOGY - BY SHARPE.

THE FIELD OF VISION, WITH SHADED AREA REPRESENTING THE PORTION SEEN BY THE LEFT AND RIGHT EYE RESPECTIVELY

PLATE NO. 20

substance having an index of refraction that increases gradually from outer to inner portion. The space between the crystalline lens and the cornea is called as ANTERIOR CHEMBER and is filled with clean liquid AQUEAOUS HOMOUR, and the space behind the crystaline lens is called as Posterior Chember and filled with clear, soft jelly like substance. VITREOUS HOMOUR.

The Cornea, the Aqueous Humour, the Crystalline lens and the Vitreous Humour form an optical system, which produced the real image of the external objects on internal posterior of sclera known as RETINA, which is composed of two distinctive type of cells, i.e. 1) RODS and 2) CONES. Rods and cones are connected by nerve fibers to the OPTIC NERVE which is directly connected to brain.(2)

The small central area of the retina contains largely cones and subtends an area of two degrees, which is called FOVEA. Objects are focused upon this area and most of our seeing and all discrimination of fine details result from this action. It is obvious that most of the objects, we see at, subtends an area larger than the fovea. In order to see them, the eye makes rapid movement similar to the scanning

2. Kinzey, Sharp, 'Environmental Technologies in Architecture', (New Jerse: Prentice Hall, Inc.) Page No.504.

of television tube, focusing all part of the object. Through a phenomenon of persistance of vision, the object is considered to be perceived in an instant. The retinal area outside fovea is called PARAFOVEA. Here, the rods are located, interspersed with cones which perceive objects indistinctly but are alert to brightness and motion.

The rays of light are first refracted by the cornea and then pass through the pupil of eyeball to the lens. The size of the pupil in the eyeball is automatically adjusted to the response of light. The rays are, then, brought by lens to focus on ratina, producing an inverted image. This lens is flexible optical instrument which can change its curvature with the help of ciliary muscles for focusing of near or distant objects upon the retina. When viewing objects beyond twenty feet from eye, the lens has the least curvature. This is called the distant vision and imposes the least strain upon the adjusting ciliary muscles. When viewing near objects, the lens becomes more convex due to contraction of the ciliary muscles.[3] The inverted image thus formed on the ratina, is converted into electrical impulses through photochemical action, by the rods and cones.

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3. Habell, Cox, 'Engineering Optics', (London: Sir Isaac Pitman and Sons, Ltd.), page No.244.

These electrical impulses are conveyed through nerve fibers to optic nerve, which, ultimately convey them to the brain. Thus the image produced by retina is transmitted to the brain.(4)

The eye receives radient energy outside the limit of visible band. ULTRAVIOLET rays from the sun is completely absorbed without damaging the eye structure. Manmade ultraviolet rays should always be considered dangerous and never viewed except through protective glasses. Infrared rays in small quantities can be absorbed but large quantity can not be screened out. If such radiation reaches the retina, there is danger of damage to, or even complete destruction of the rational cells which overlays almost all of the inner surface of the eye sphere.

The response to light is not identical in rods and cones. The cones operate at brightness level above 1/1000 of a foot lambert(2). Since the colour is perceived only by the cones, there is no colour perception at very low level of brightness and poor colour perception in dim lights

Although, retina is sensitive to radiation between approximately 4,000-7,000 angstows, it is not equally responsive to every wavelength within this range because it is developed under homogeneous

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4. Fincham, 'Optics', (London: Hatton Press Ltd.) page No.132.

radiation over entire luminosity band[2]. A sense of naturalness is possible only when all wavelengths are available. Monocromatic light in the 550 angstans region is the only value which improves the visual acuity for objects near absolute threshold of visibility[2].

When the eye focuses upon an object bringing the fovea into action, three characteristics of the object are important. They are, (i) size, (ii) contrast with background, (iii) brightness. The inter-relationship of these factors introduces a fourth character i.e. time. It takes time to be aware of the object to focus upon it, to transmit the stimulus to the brain and to understand it. All four factors are inter-related in complicated way, but a common denominator is brightness. Poor contrast of object with its background can be improved by increasing the brightness of the background. The speed of seeing can be increased or decreased by varying the brightness on the object. Of course, there is a definite upper limit to the speed of vision, but for any combination of object, size and contrast, improvement continues upto 1000 foot-lambert of brightness[2].

When the eye is fixed on some object a large area of the surroundings is also within the view, although details are not sharply clear. The angular dimensions of the binoculor field of vision is approximately 85° to each side and 50° above and below the central visual axis or line of sight[2].

7.2 Visual factors affecting the planning of Auditorium.

7.2.1 Visual Conditions

The most important factor in cinema auditorium planning is the visual comfort which can be achieved through the fulfilment of visual conditions. These conditions can be satisfied skillfully when the planner has got the detailed knowledge of the same. These are as follows:-

i) Visual acuity- (a) Screen size in relation to viewing distance,

(b) Contrast.

(c) Screen brightness.

ii) Sight line- (a) Obstruction of view by other spectators,

(b) Obstruction of view by fixed part of structure.

iii) Viewing angle- (a) Horizontal ,

(b) Vertical

(iv) Distortion of picture- (a) By viewing.
(b) By projection.

Considerable data on these visual conditions is available to solve the problem. However, more research in this field is needed to expose the important technical data, which will lead to minimise the number of substandard theatres.

7.2.1.1 Visual acuity (Picture Details)

It can be defined as a ability to discern the the details of the picture projected on screen. Viewing pattern is determined by fixing the visual standards, that enable each viewer to see the picture satisfactory. Those standards are primarily based on visual acuity.

As far as, screen size and maximum distance is concerned, it is also based on the visual acuity. To limit the maximum viewing distance, the viewer should not be required to discern the details smaller than 1" for every 32 ft. of viewing distance[5]. Detailed study suggests that the maximum viewing distance should

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5. Szoboo, William, 'Shadow, Screen, and Sight Lines', (Progressive Architecture, Nov.1966), ed. Rowan, page, No.163.

not be greater than twice the width of the screen for cinemascope projection (Fig.No.7.3), whereas, for 35 mm. projection, absolute maximum viewing distance is 4 to 5 times of the screen width.[6] Five times being advisible and four times being more ideal, confining the areas in which all the photographic details of importance can be discerned by the viewer. Where the large capacity is required, introduction of balcony is adviseable to avoid the excessive viewing distance that would otherwise increased.

Limiting of viewing distance is essential to maintain intimate relationship to spectator to screen action. Viewing distance, confined to limits set for proper visual acuity, would be the best guide for practical purposes to determine the maximum seating depth which would maintain the spectator's field of view.

Contrast value of the projected picture depends upon the magnification of film. Excessive magnification spreads the picture grains, which results in reducing the contrast value of the picture. With the result, the distinction between light and shade cannot be recognised due to blurtness

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6. Schlanger, Ben, 'Motion picture Theatre', (Time Saver Standards), New York: McGraw Hill Book Co., Ed.Callender, Page No.1101.

of the image. In 35 mm. projection, film graininess becomes visible from nearest seats and hence they are less acceptable, whereas in 70 mm. projection, they are desirable since film graininess is greatly reduced and those seats unable the viewers to experience the dramatic impact of picture dominance. In nutshell, it is highly preferable to reduce the rate of magnification to achieve good pictorial quality and it should not be more than 300 times for desirable screen image[7].

Not only the contrast value but also the brightness helps to visual acuity. It is primarily dependent on the projector lamp, which is usually selected to suit the larger image to be projected. The amount of light leaving the projection lens is called the luminous flux and expressed in lumen (lm) (Fig.No.7.4)[8]. Illumination on the screen is the function of area of screen, the distance between screen and the source of light and the reflectivity of the screen. Finally this illumination will vary with the viewing angle. This variation in the picture brightness should not exceed 3% of the total illumination. Minimum luminance of 5 ft. lambert

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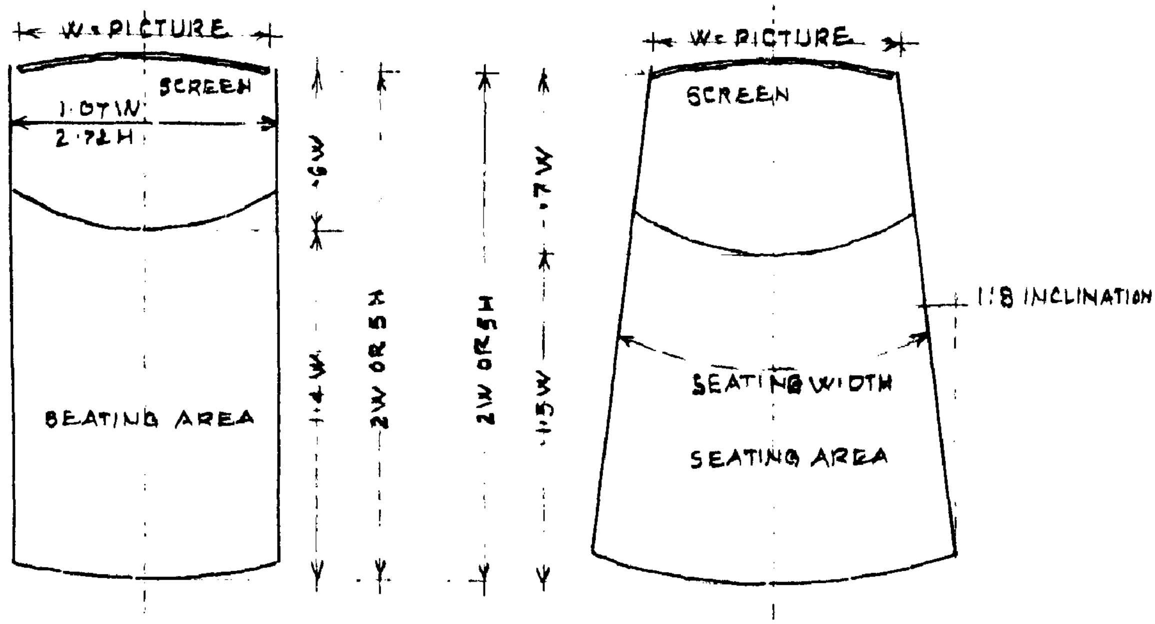
7. Worthington, Clifford, 'The Influence of Cinema on Contemporary Auditoria Design', (London: Sir, Isaac Pitman and Sons, Ltd.),page No.65.

8. Ramamrutham (ed.), 'Planning a Cinema', Part II, (Bombay: Philips India Ltd.), page No.15.



SEATING AREA PROPORTION IN RELATION
TO SCREEN WIDTH
FOR CINEMASCOPE

FIG. NO. 7.3

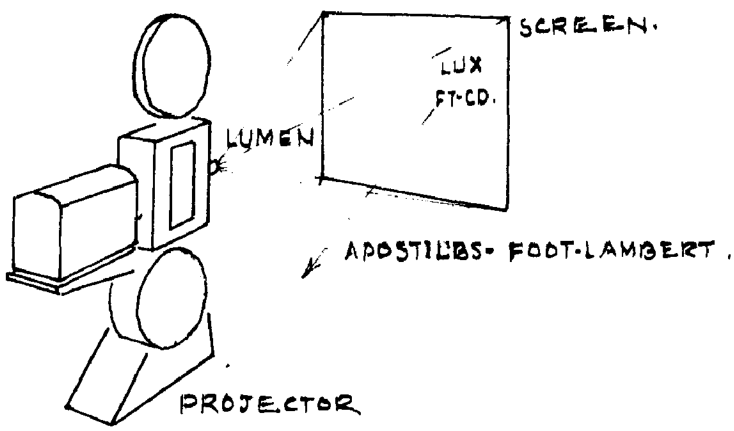


FIG. NO. 7.4.

and maximum of 10 ft. lambert should be provided for clear colour perception in any type of presentation.(8)

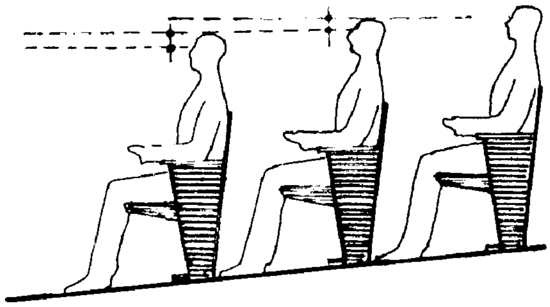
Film industry is working seriously to evolve the standards for basic factors such as print density, print contrast, projection light intensity and spectral quality, light distribution, screen brightness, screen size and reflectivity. This will definitely lead to good results.

7.2.1.2 Sight Line

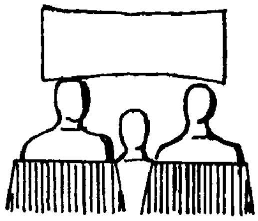
Obstruction of view by the patron sitting in the front, requires major consideration in obtaining the good sight lines. The condition for sight line is that the clearance should allow any seat occupant of anotomically average dimensions to see over the head of the spectator sitting the row ahead. This condition can be satisfied by

i) having a proper slope to the floor,
ii) proper seating arrangement,
iii) desirable location of the screen.

The vision, thus, obtained from he above conditions, is known as 'one row vision', (fig.No.7.5). Some theatres are designed on two or even on three row vision basis. In two row vision spectators have to

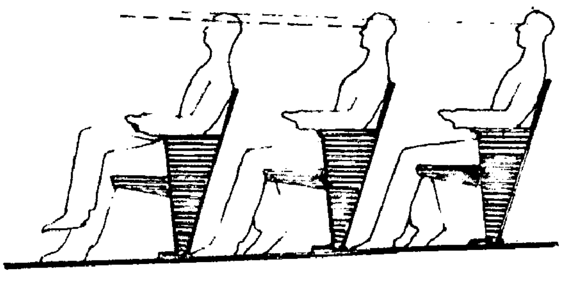


FIRST OR ONE ROW VISION

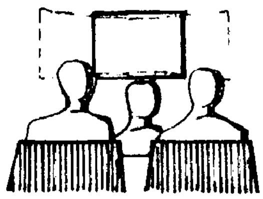


SPECTATOR CAN VIEW THE SCREEN OVER THE HEAD OF THE PATRON SEATING IN THE FRONT ROW OF HIM.

FIG. NO. 7.5



SECOND OR TWO ROW VISION



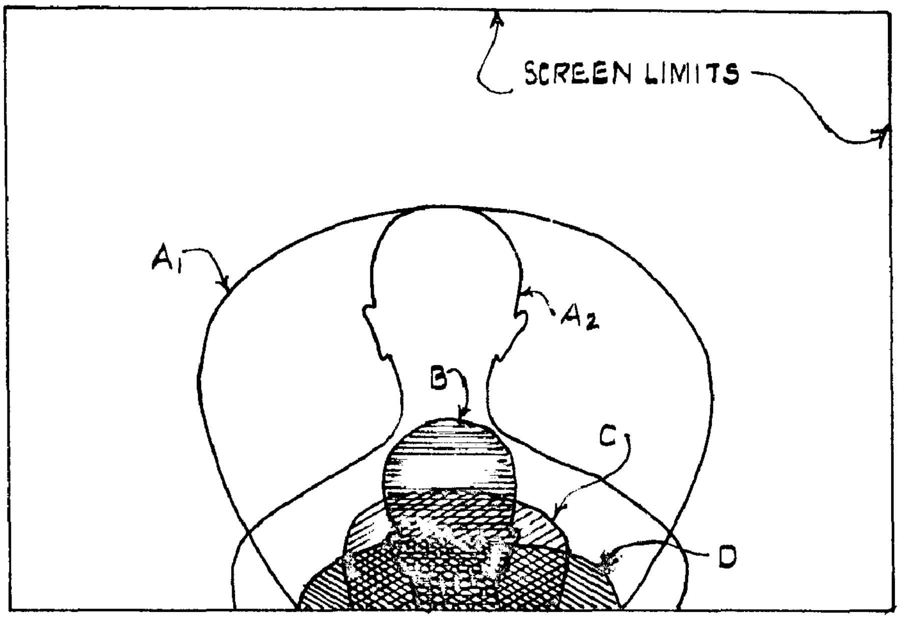
SPECTATOR HAS TO LOOK BETWEEN THE HEADS OF THOSE IN THE ROW IN FRONT OF THEM AND OVER THE HEADS OF THOSE IN ONE ROW AHEAD

FIG. NO. 7.6

look between the heads of those in the row in front of them, (Fig.No.7.6). It necessitates the uncomfortable adjustment of shifting obstacle in front, especially when the action images shift from one side of the screen to another. Three row vision does not provide desirable results.

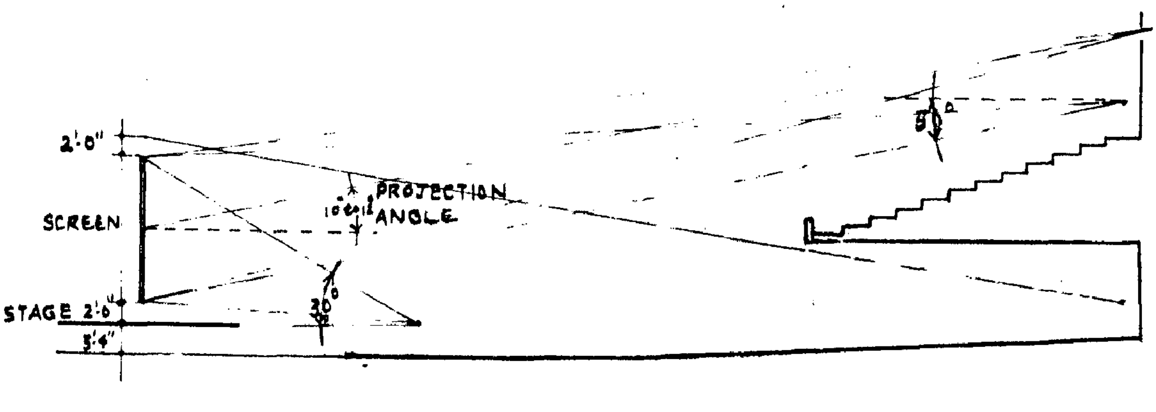
Staggered seating arrangement helps in reducing considerable amount of obstruction and excessive stiffness of the slope. Effective methods have been developed and successfully employed for staggering the seating to achieve the necessary amount of clearance of view between the heads of the preceding spectators. This is the notable development since it can be used in improving the sight lines by reseating the existing theatres. Floor slope for motion picture theatres would have become excessive if any attempt were to be made to gain vision over the heads of preceding spectators. The progress made in staggering seat design in conjunction with successful development of 'REVERSE FLOOR SLOPE', has developed a theatre, from which it is purely inspired by the function of viewing a motion picture. Moreover the sightline for the screen presents a flexibility in design.

Good sightlines and other conditions desirable for proper viewing can be obtained by adjusting the position of the screen from the floor. Excessive rising of screen offers completely unobstructed view but causes physical strain on the part of patron to see the upper part of screen,and this physical strain can be entirely eliminated by adopting a low position of the screen. In short, the position of the screen in the vertical sense should be such that it would permit the vision of its entire height without physical strain to see upward. It is, therefore necessary to determine the maximum tolerable amount of obstruction and maximum upward vertical angle of vision for efficient floor slope design and position of the screen. Figure No.7.7 shows the superimposed outlines of screen obstruction from various viewing angles. B,C, and D outlines shows the tolerable amount of obstruction. Although obstruction B is greater in height but less in area than D. Such obstruction is tolerable because important action of screen in these areas occures only for small percentage of time and it is not objectionable to see a clear view between the heads of preceding spectators. Maximum vertical angle of vision should be considered $\pm 30^{\circ}$ to the horizontal. (Fig. No.7.8).



AREA OF SCREEN OBSCURED FROM VARIOUS VIEWING ANGLES.

FIG. NO. 7.7



MAXIMUM VERTICAL VIEWING ANGLE FOR FRONT PATRON ON MAIN FLOOR AND THE LAST PATRON ON BALCONY.

FIG. NO. 7.8.

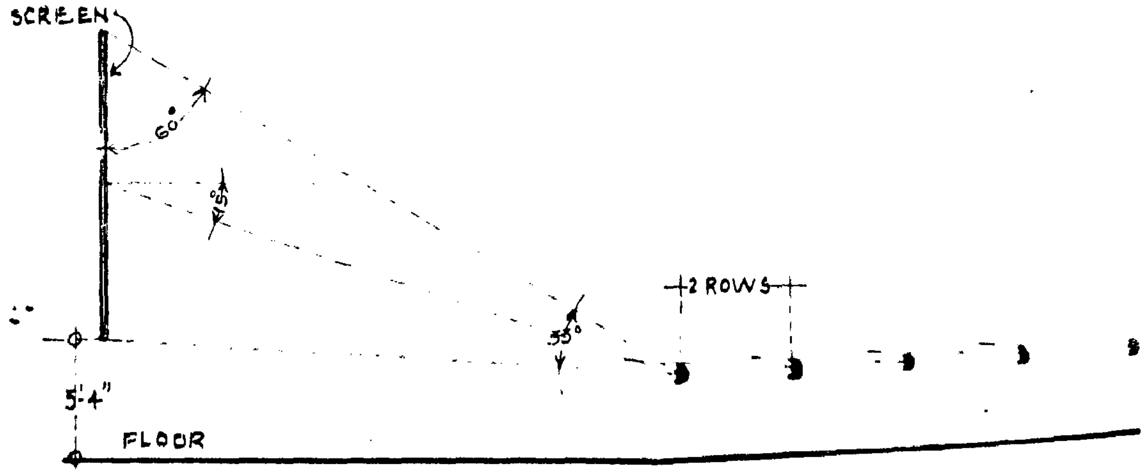
Obstruction of view by the fixed part of the structure such as balcony soffit, balcony railing etc. also requires considerations for good sightline. Each patron must be able to see a strip of 2 ft. at top and bottom of the screen for psychological reason.(6)

7.2.1.3 Viewing Angle

From comfort point of view, the quality of theatre design is very much affected by desirable angles of view upward and downward to the picture. Spectator on upper level seating should not experience excessive downward viewing and those seated on the main floor should not experience excessive upward viewing. The ideal design would present the largest percentage of seating positions for the entire theatre affording desirable vertical angles of view.

The vertical angle substended average screen, should not exceed 33° and the sight line from the front row to the centre of the screen should not be more than 15° above the horizontal for comfortable viewing (Fig.No.7.9)(9). The vertical viewing angle can be adjusted by (i) screen height,(ii) distance

9. Graft, Don, 'Data Sheets', (New York: Reinhold Publishing Corporation), page No.236.



SECTION

VERTICAL ANGLE OF VIEWING

FIG. NO. 7.9

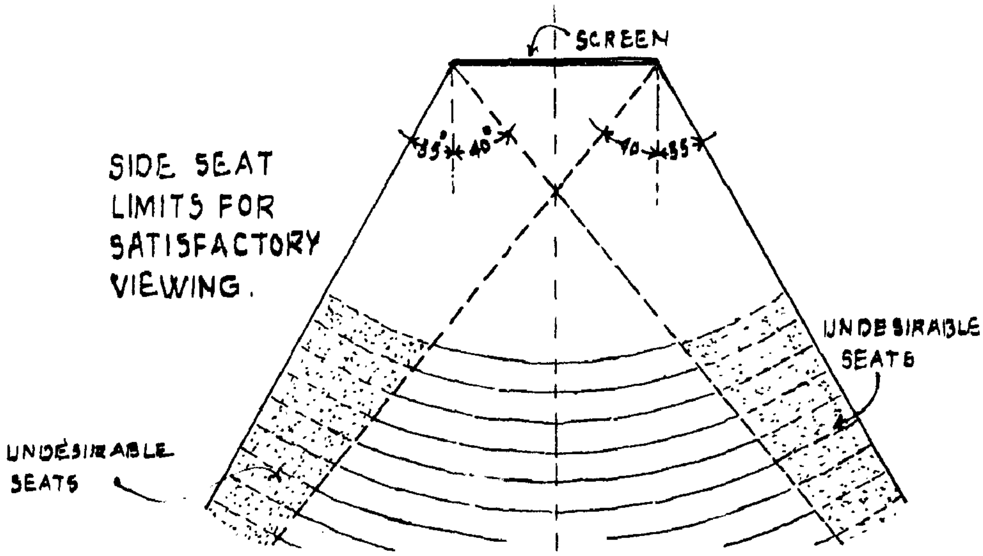
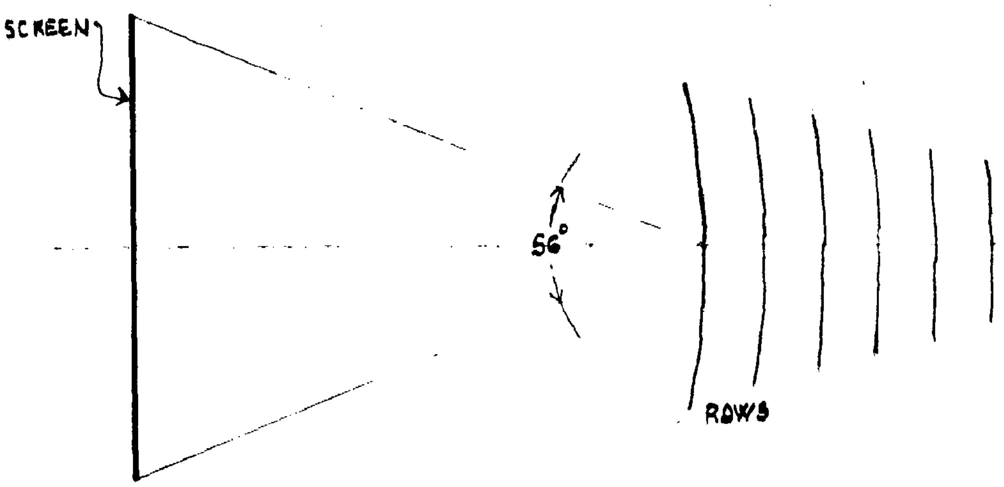


FIG. NO. 7.10.



PLAN

HORIZONTAL ANGLE OF VIEWIING

FIG. NO. 7.11

PLATE NO. 24

between the screen and the patron in first row, (iii) screen position.

Horizontal angle subtended to the screen should not exceed 56° which can be adjusted by (i) the width of the screen, (ii) distance between the screen and the patron in the first row, (Fig. No.7.11)[9]. Detailed study suggests to install a slightly cylindrical screen which will yield a larger acceptable viewing area.

7.2.1.4. Distortion of Picture

Distortion or deformation of picture is caused by (i) projection, (ii) viewing. Truest picture is obtainable in level projection, that is, where the angle of projection is at zero degrees to the horizontal. Projection angle is the angle formed with horizontal by a line, from the projection lens to the mid height of the projected picture (Fig.No.7.8). The problem of obtaining minimum projection angle is not difficult in situations where balcony is not under consideration, but in case of balcony, it should be kept as low as possible and should not exceed 10° or 12° to have tolerable distortion of picture, (Fig.No.7.8)[9]. Wide and curved screens required special attention to reduction of projection angle.

Extreme side seating positions are responsible for distorted view of screen image due to two dimensional characteristics of picture. Such seating positions from which the observer sees any part of the screen image to angle greater than 40°, have been found to destroy the illusion of reality(9). The usual side seat limit employed in motion picture theatre design has been a 35° line from the near edge of the screen (Fig.No.7.10). The hatched area indicates undesirable seat and this portion should be kept to an absolute minimum.

7.2.2 Physical factors

The visual conditions, as discussed above, should be the aim of architect to achieve the visual comfort for each patron. These conditions can be controlled by the following physical planning factors,

(i) Slope of floor,
(ii) Seating area.

7.2.2.1 Slope of floor

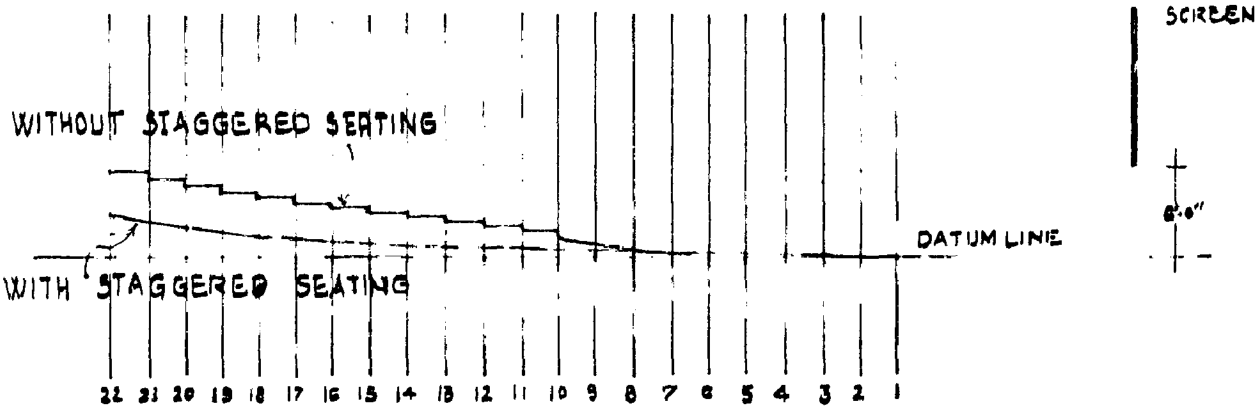
Primary function of slope is to eliminate the objectionable screen obstruction caused by patron seating in front of viewer, for good viewing conditions. The viewing conditions are mainly governed by the slope of the floor. Therefore, it is necessary to establish physical dimension of seated patron and the standards for the vision of the screen image for designing floor slope and upper level stopping.

The slope depends upon (i) position of screen, (ii) distance of first row of seats from screen, (iii) sight line clearance, (iv) type of seating arrangement. To preserve the illusion of reality, the screen must not be too high with respect to first row of spectators. Generally, the stage level has been taken as 3'-4" above the level of the first row of seats. The bottom of the screen image being 2'-0" above the stage. Therefore, a point, 5'-4" above the floor is the focus of all eyelines for determining the main floor (fig.No.7.9)[9].

The height of the screen image may be assumed equal to 1/3.5 of the distance from the screen image to last row of seats. 30° angle with the horizontal from the top of the screen will intersect the horizontal eyeline 3'-8" above the floor and will determine first row of seats. (Fig.No.7.9).

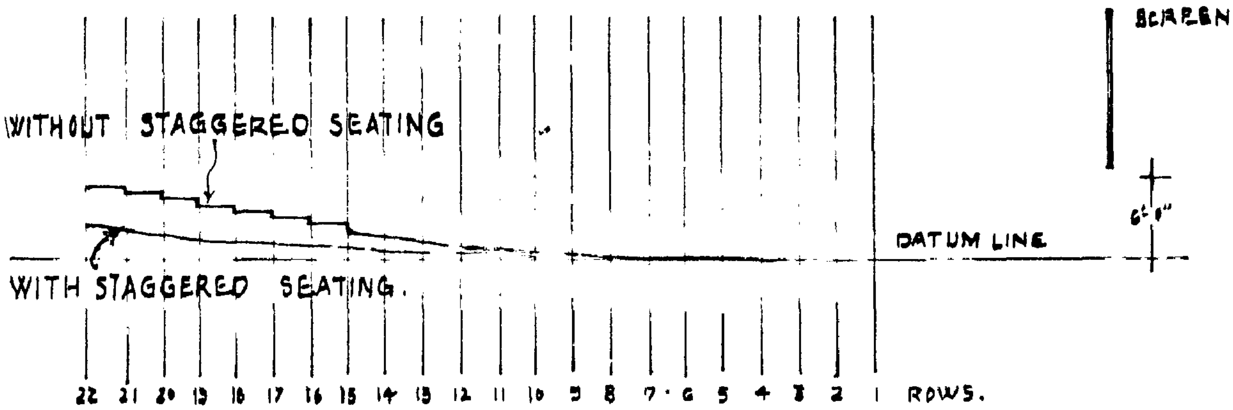
As already mentioned, that the conditions for sight line clearance should allow any seat occupant of anatomically average dimensions to see over the head of a spectator sitting in the row ahead. 5" clearance can be assumed safely for determining the slope. The vision , thus, obtained is called 'first row vision', which provides completely unobstructed view, but offers hazardous stiff slope, causing excessive height of auditorium which ultimately results in large volume (Fig.No.7.12). It also creates difficulty in providing access at upper level. In case of balcony, it will create excessive stepping which will result in poor seating positions in relation to screen. This excessive slope can be reduced to half by staggered seating arrangement.

Similarly, vision with conditions requiring spectators to look between the heads of those in the row in front of them and over the heads of one's, two rows in front, is known as 'second row vision'. It is not ideal as it necessitates uncomfortable adjustment of shifting obstacles in front. However, it is not acceptable as it permits milder slopes (Fig.No.7.13). It is made more acceptable by staggering the seats to permit the view between the heads of patron in the front row. It can be further improved by using the widest chairs which will offer the wider view between heads. Upward floor slopes by both, first row vision and second row vision, should start as far back from screen as possible, since slope greater than 9"



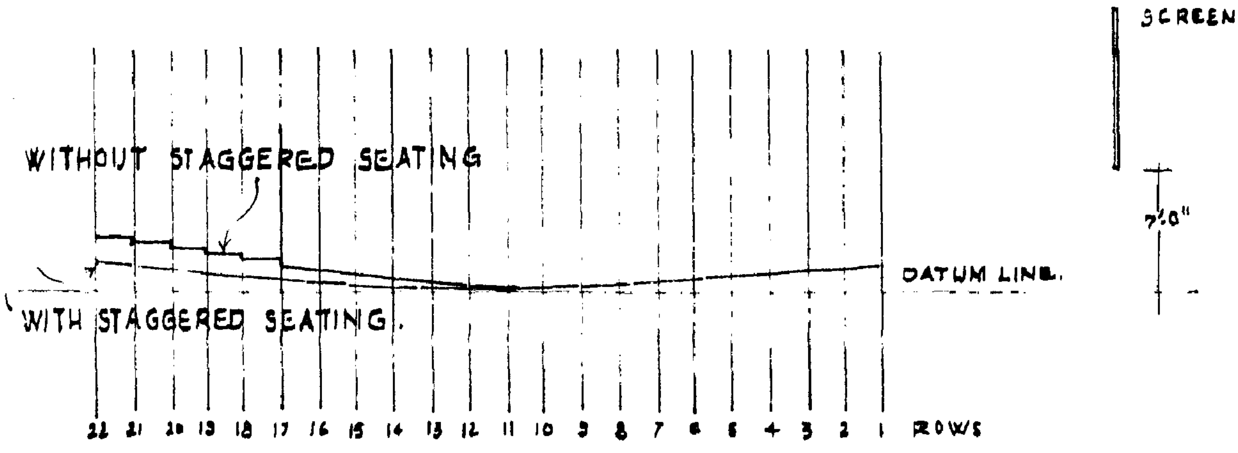
SINGLE SLOPE WITH ONE ROW VISION

FIG. NO. 7·12



SINGLE SLOPE WITH TWO ROW VISION

FIG NO. 7·13



DOUBLE SLOPE OR REVERSE FLOOR SLOPE

FIG NO. 7·14

between rows requires risers.

A combination of downward and upward slope is known as 'REVERSE FLOOR SLOPE'. It is adopted in conjunction with staggered seating due to which, it results in minimum departure from the horizontal (Fig.No.7.14). It provides the optimum downward viewing angles for balcony viewing positions and negligible increase in the upward viewing angle for the main floor seating positions.

In reverse floor slope, the floor is lower in relation to the level of the screen to appreciable amount only for the portion farthest from screen.This lowering of the floor does not create any annoying upward viewing because the distance from the screen, places the screen well within the normal range of vision. The balcony seating positions are also improved considerably. The relative flatness of main floor is a distinct improvement over the steep slopes. Another distinct improvement in reverse floor slope is the elimination of requirement for the intermediate steps in the balcony aisles. In case of upward slope the extra steps which is to be provided between the two platforms, causes hazard, since this step is shorter than the rest of the platform. But the reverse floor slope results in much less severe slope of balcony, therefore, there is no need for the extra steps between sitting platform. The obvious advantages of reverse floor slope over the traditional slopes made cinema to adopt it considerably throughout the world.

The rate of the slope for each successive row of seats and the location of the screen has to be determined carefully to achieve desirable results. As it has been explained that the screen should be so located that the downward viewing angle from balcony floor and upward viewing angle from main floor seats are balanced out to create the most comfortable angle to the greatest number of seats. In vertical plane, the ideal viewing angle is one that requires the least physical exertion to eye and neck muscles of the viewer. The ideal viewing angle would be zero degree, formed by the horizontal line from the viewer's eye to the centre of the screen.

Balcony slopes also requires major considerations for good visual conditions for upper level patrons. Steep slope in balcony causes excessive volume of auditorium and undesirable projection angle due to necessarily high position of projection booth and produces seating positions at height from which the screen image is distorted still further than the amount caused by the steep projection angle. This can be controlled by the proper design of auditorium floor. Therefore, a suitable solution for auditorium floor slope design is important before the design of balcony floor. There are no set rules for slope design. Each theatre must be studied and designed to meet the varying conditions of site, capacity, and the number of seating tires desired, etc.

7.2.2.2 Seating Area

The dimensions of seating area should be such that all spectators can see the picture under the most favourable conditions. In large cinema theatres, the distances of the first row and of the last row from the screen differs too much. With the result, a picture that is large enough for the patron int the front row, will be too small for the rear ones. Therefore, both the distances should be determined in conjunction with visual conditions.

The depth of the seating area is determined by fixing the viewing distance which depends upon the proper substended angles of the screen image. The size of image details depends upon the cinematography. Close-up shots offer more viewing distance than distant shots. But, normally, cinematography consists of large proportion of middle and distant shots, therefore, those should be taken into account and seating should be fixed in relationship to screen size, projected by these shots. After constant experimentation, it is proved that for the best results, no seat should be located at much greater distance from screen than two times the width and five times the height of cinemascope picture (fig.No.7.3)[10]. However distance of $2\frac{1}{2}$ times picture width or $6\frac{1}{4}$ times picture height is desirably accepted. Generally, 30 rows of seating is the maximum depth of cinema. However, for larger capacity, it may have upto 40 rows in which the obstruction problem is very acute.[7] Similarly the distance of front row from screen should not be less than half the width of cinemascope screen.

As far as, width of the seating area is concerned, it should not be greater than 1.07 times the width or 2.72 times the height of screen. In case of fan shape auditorium, the splay of outside limits of the seating, starting with edge of the screen, should not exceed 1 foot in 8 ft. on each side of the seating area[10]. Alternatively, the seats should be placed in the space bordered by the two lines drawn at an angle of maximum 100° to both sides of the screen (Fig.No.7.16)[9].

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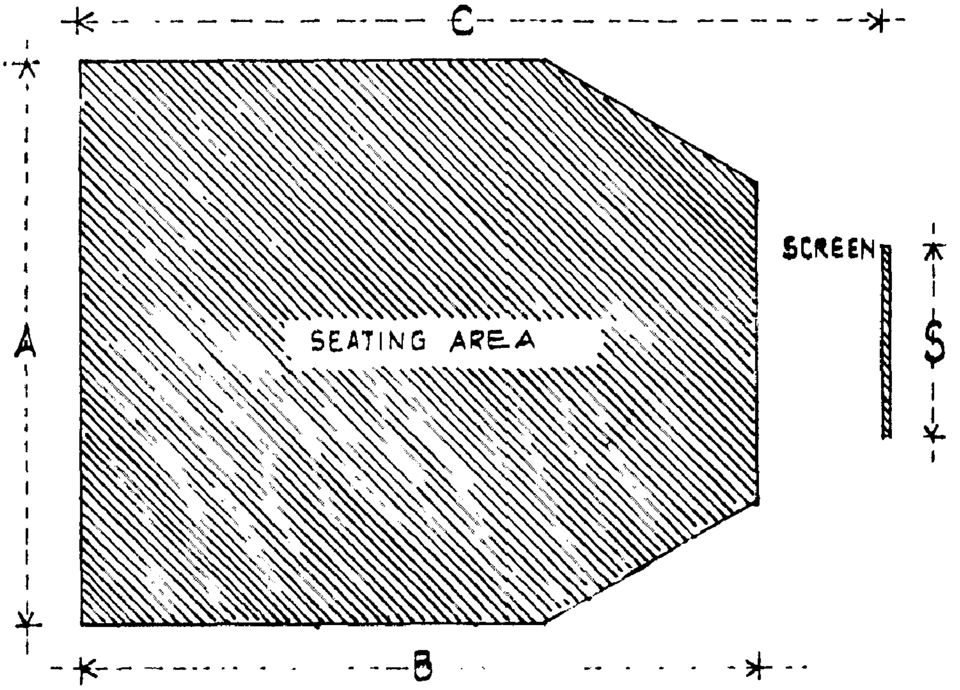
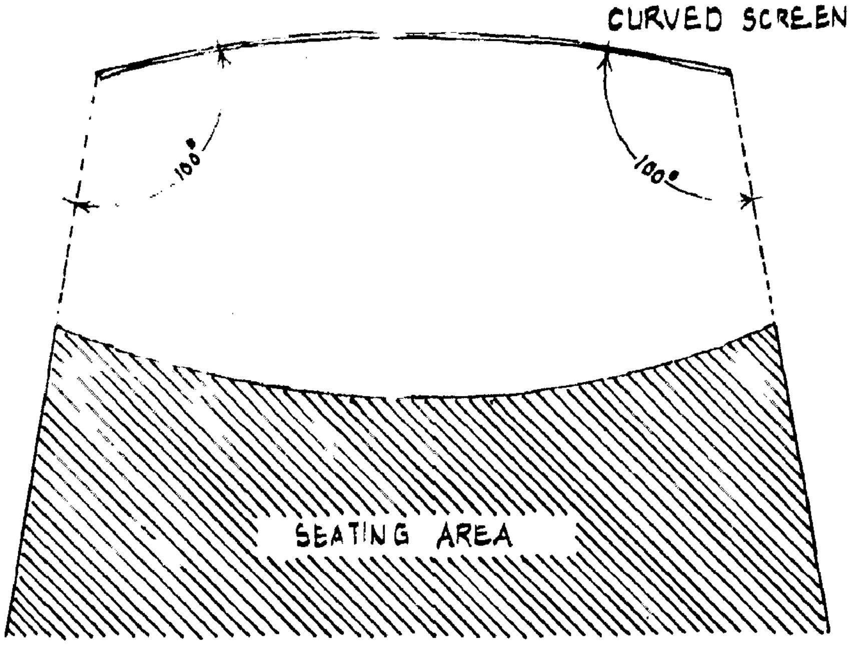
10. Schlanger, Ben, 'Motion Picture Theatre', (Motion Picture Theatre, Planning and Upkeep), New York: S.M.P.T.E.Inc., ed. Stote, page No.117.



RATIO OF SEATING AREA TO SCREEN WIDTH

FIG NO. 7.15



LIMITATION OF SIDE BOUNDRIES OF SEATING AREA

FIG. NO. 7.16

In case of 35 mm. projection, the following limits of seating area are recommended on the basis of survey conducted by Society of Motion Picture and Television Engineers, covering about 600 theatres in U.S.A. (Fig.No.7.15)[9]. These limits are expressed in ratios with the screen width,

(1) Screen to depth of the seating area,

(i) 1:4.65 minimum.

(ii) 1:5.2 average,

(iii) 1:5.85 maximum.

(2) Screen to width of the seating area,

(i) 1:2.5 minimum,

(ii) 1:3.0 average,

(iii) 1:3.5 maximum.

(3) Width to depth of the seating area,

(i) 1:5 minimum

(ii) 1:2 average

(iii) 1:2.35 maximum

7.3 Projection Equipments

Projection equipments play an important role and form the body of visual performance. The quality of performance is mainly dependent upon the efficiency of the equipments to be used. Research in this field, has resulted in the refinement in design of equipments which further improved projection quality. The projection equipment includes (i) projector, (ii) film, (iii) screen.

Different types of projectors are being produced in the country and abroad to cater the present need. The fundamental requirement of projection is that the lamp-house of the projector should be able to illuminate the screen at the desired brightness level and should have required aperture size. The standards for projected light and aperture has been made to facilitate the projection of films of standard sizes. The type of the projection depends upon the projection techniques to be adopted. These have been discussed already in Chapter No.2. They require different size of the films, which should have the required physical properties and quality of cinematography for good visual performance. Architects are not much concerned with projector and films but the consideration of screen which is visible to the audience seems to be important.

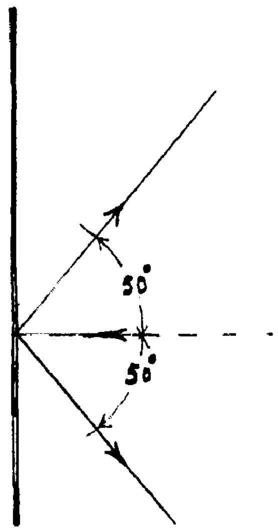
7.3.1 Screen

For the maximum effectiveness, the screen should occupy as nearly as possible the entire width of auditorium. This condition implies the parallel side walls as it accommodates the audience seat within the width of the picture area, which results in greater 'feeling of participation'. This is further enhanced by the proper position of screen, which has been discussed in the earlier text of this chapter.

There are various types of screens. Most of them are made up of plastic or cotton fibres. The selection of screen for better performance should be based on (i) reflectivity to distribute the incident light uniformly all over the seating area, (ii) porosity to allow the sound transmission from speakers placed behind the screen, (iii) transparency, if the rear projection is to be utilised, (iv) uniformity in appearance, (v) Ease in placement.

Modern projection requires more light than the former projection system, to obtain the same brightness of the picture. This can be achieved by, (i) using more powerful projection lamps, (ii) using the screen with high reflection coefficient, which reflects the light mainly towards the spectators. Directional (metallized or perlux or lenticular) screens fulfil both the conditions. Their reflection coefficient is twice than that of other screens and the amount of reflected light remain substantially constant upto an incident angle of 30° with respect to normal to the screen, (fig.No.7.17)[8]. They furnish more even distribution of reflection of light over the seating area and waste less reflected light on ceiling, walls and floors, consequently requiring less lamp-house amperage than would be indicated for normal screen. Nevertheless the new techniques require more light because the surface to be lighted is greater as compared to old screens. Directional screens obey the laws of mirrors. This implies that, for projection at a large angle, the screen should be tilted so as to obtain uniform light distribution all over the auditorium.

Directional or lenticular screens satisfy almost all requirements of ideal screen. They are made with a cotton base which is overlaid with the several coatings of plastic, surfaced with aluminium and accurately embossed with the fine detail pattern. The pattern is designed so that very little light is reflected to the walls, ceiling and floor, but within the theatre seating area, the distribution includes 30° above and below, and 50° to each side of normal to screen. It will be recognised that the theatre is adequately covered. By concentrating all of the incident light to the region of audience, a screen is obtained which is atleast twice as bright

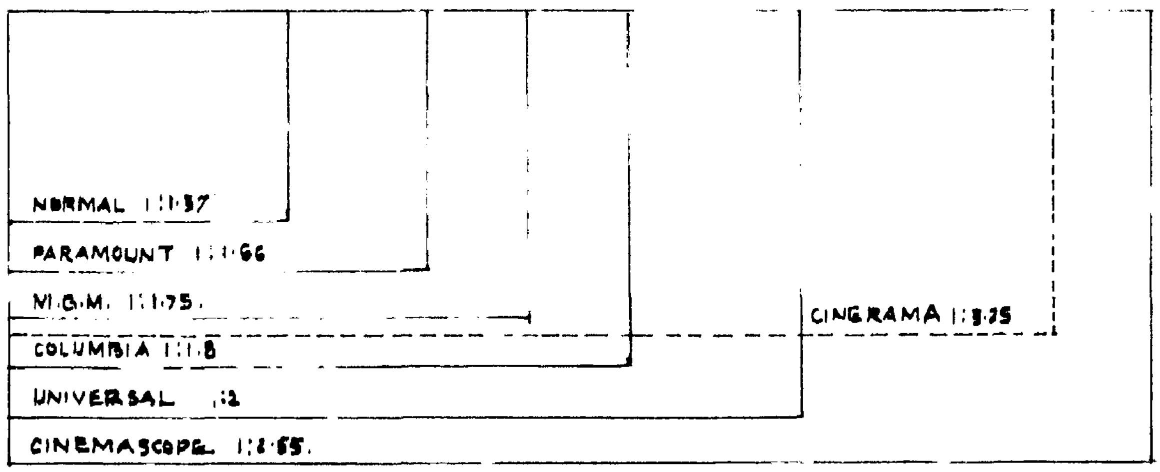


DIRECTIONAL SCREEN REFLECTS LIGHT BY 50° ON BOTH SIDES OF INCIDENT RAY.

FIG. NO. 7·17

CURVATURE IN DIRECTIONAL SCREEN REFLECTS LIGHT TOWORDS THE SPECTATORS

FIG. NO. 7·18



COMPARATIVE SIZES OF SCREENS USED IN VARIOUS TECHNIQUES OF PRESENTATION.

FIG. NO. 7·19.

PLATE NO. 27.

as usual screen for the same value of projector illumination. By the virtue of metallic surface the screen is excellent for 3-D polarised projection.

The sense of audience participation is much enhanced by curving the screen. The more the screen seems to surround the people, the greater is the effect. For curving the screen general rule is to use the projection distance as a radius of curvature. However, for accuracy, it can be obtained from the table given in Appendix 'C'.

The curved screen has the following advantages (i) The incident light reflected from the extreme sides of the wide screen will be diverted to the seating area, thereby increasing the picture brightness (Fig.No.7.18), (ii) There is less overall picture distortion for sides as well as head on viewing, (iii) picture contrast at the sides may improve.

Curved screen introduces difficulty of curvature in horizontal line of the image. This can be reduced by slightly tilting the screen. It should be recognised that when a curved screen is tilted the ends rise and due consideration must be given to sightlines, frame construction and masking. The picture masking or framing is generally provided for hidening the irregularities of edges of the projected picture. The common method for masking the picture ist to use the matte black surround. This is simplest and least expensive way to absorb the fuzzy edges of the projected picture. The masking may be in the form of a curtain or panel, that can be adjusted mechanically or manually. The average sizes of the screens and their aspect ratios differ from technique to technique. They are as follows: (Fig.No.7.13)

Type of film	Screen size
1. Normal 35 mm film.	18'-0"x25'-0"
2. 70 mm films for vista-vision and Todd-A.O.	25'-0'x50'-0"
3. 70 mm film -Cinemascope	
(a) magnetic sound	28'-0'x75'-0"
(b) optical sound	28'-0"x70'-0"
4. Other wide screen films	
(a) paramount	16'x6" x27'x0"
(b) MGM	18'-0" x38'-0"
(c) Columbia	23'-0" x42'- 0"
5. Cinerama-	23'-0" x68'-0"

CHAPTER-8

PHYSICAL COMFORT ASPECT

8.0 General

Audio-visual performance cannot be enjoyed without physical comfort, as it is an integral part of entertainment. Therefore, it is the designer's task to provide the physical comfort to each spectator in the auditorium. It can be possible through the knowledge of fundamentals of physical comfort, which includes

i) Physical environment,

ii) Seating comfort.

The affecting factors and their inter-relationship are shown in Chart No.4(Plate No.28).

8.1 Physical Environment-

It deals with the conditioning of the atmosphere within the enclosure. Temperature, ventilation and humidity are the primary physical environmental conditions which can be mainly controlled by the mechanical equipments. The general accepted standards for these conditions are 25.5° to 27°C temperature, 50% to 60% relative humidity,

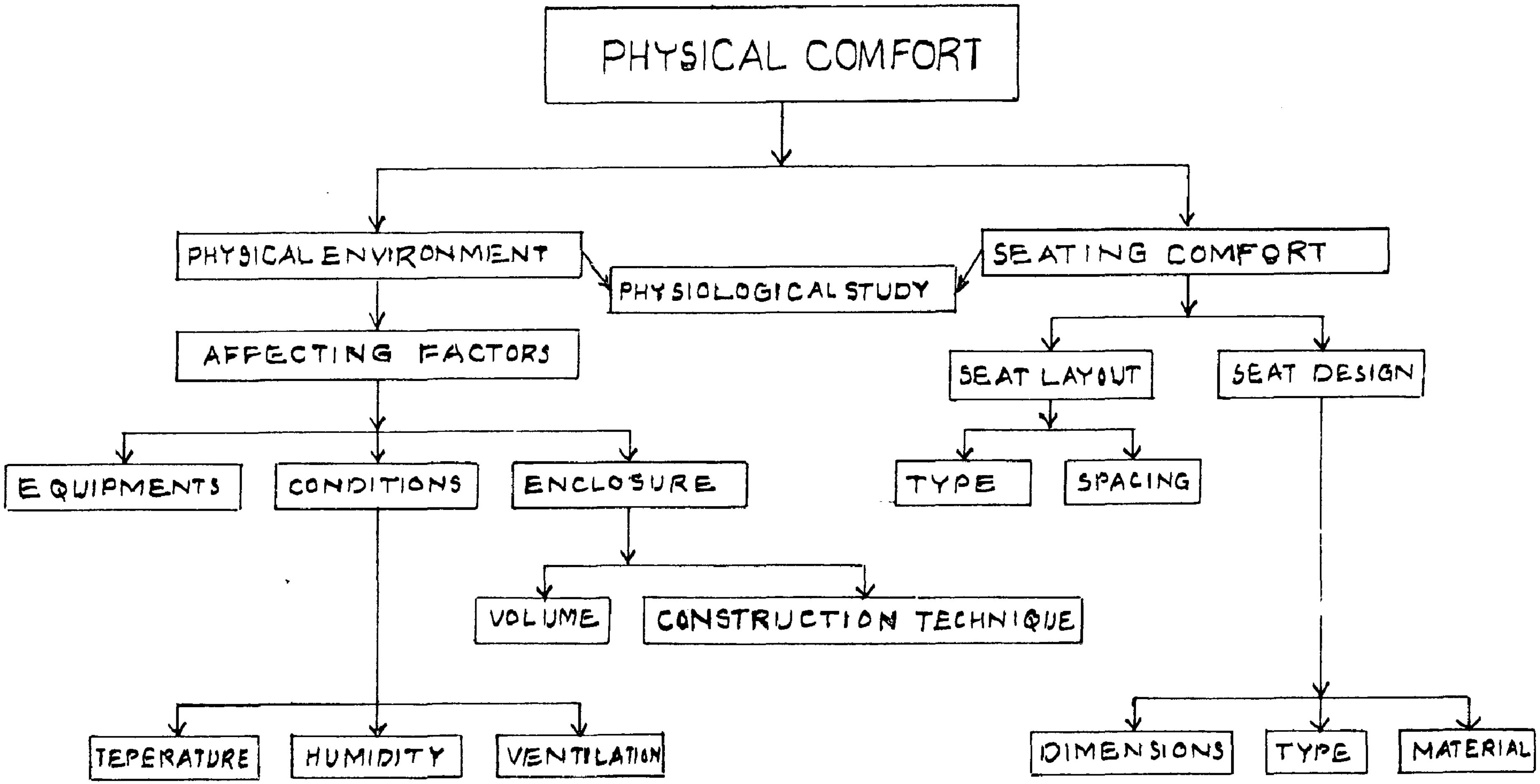


CHART NO. 4. SCHEMATIC DIAGRAM FOR PHYSICAL COMFORT.

35 to 50 ft/min. air movement and 3 to 4 air changes within the seating area.[1] The temperature difference inside and outside temperature should not be more than 12°C, as higher temperature difference cannot be adopted by the human body.[2] These conditions should be extended to every seat in the theatre which can be achieved through proper distribution of air.

The inside temperature can be better maintained by the various construction techniques such as cavity wall, surface treatment for thermal insulation, false ceiling etc. But the air changes are affected by the volume of the enclosure for which the standards are discussed. Except these, the environmental conditions do not have significant effects on physical planning factors and so, are beyond the scope of this study.

8.2 Seating Comfort-

Comfort in seating depends upon (1) indiviual

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1. 'Physical Environment', ASHRAE Guide and data book-1962, New York: American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc.) Page No.445.

2. Alexa, Felix, 'Seating Arrangements, Sight Lines and Seating design', Motion Picture Theatre, ed. Stote, (New York: Society of Motion Picture Engineers), page. No.65.

seat design , (ii) layout design. Proper attention to these factors provide good seating conditions.

8.2.1 Seat Design

8.2.1.1 Ideal requirements-

Comfort, safety and durability are the basic requirements of the seat, which can be obtained through efficient design. Comfortable seat can be achieved by perfect posture, which is brought about through the proper relationship of back-rest to the seat and by the use of deep spring cushion and/or foam rubber cushions in seats and the proper padding at the back. It should be sturdy enough to bear the load of users without damaging any part of it. It should offer trouble-free service during its life. In addition to above, the following points should be taken into account in seat design.

(i) There should be ease in operation with least amount of efforts on the part of occupant of the seat.

(ii) It should have no obstruction in its understructure, that will, in any way, hinder cleaning under the seat.

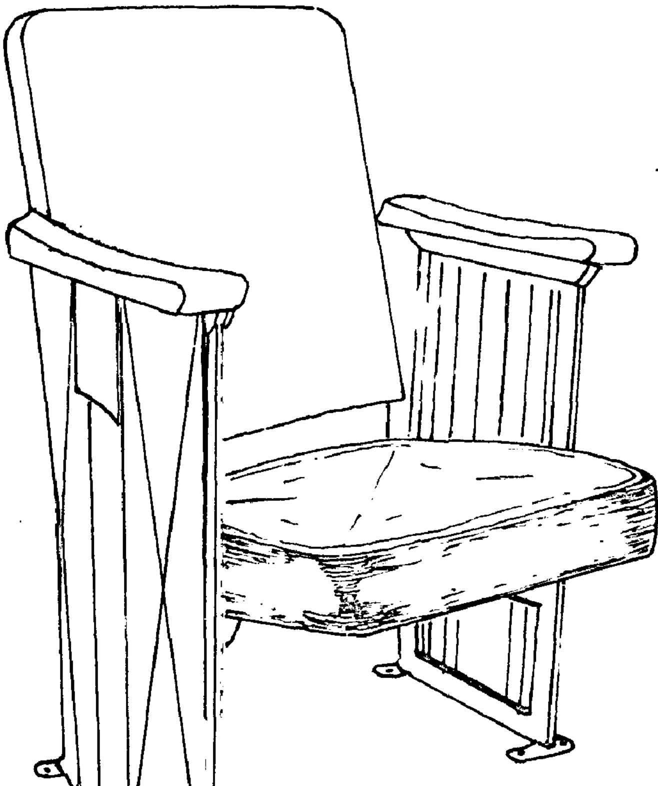
(iii) The design should be flexible enough to facilitate the replacement of seat.

(iv) It should also offer the ease in replacement of upholstry part without the need of specialised machanics for upholstring purposes.

(v) In case of push back seats, it should be equipped with an automatic push-back devices that automatically retracts the seat when the occupant stands up to leave. This devices should retract the seat slowly without bumping or jarring the mechanism. Similarly, it should be embodied with seat lifting devices which lifts the seat to an angle of approximately 40^{o}(2). This leaves it in position so that the occupant can sit down without the necessity of holding the seat. Seating with retracted as well as raised seats, leaves the space between rows free of any obstruction which is a big safety factor in case of emergency and also eliminates the necessity of rising the seat when cleaning under the seat.

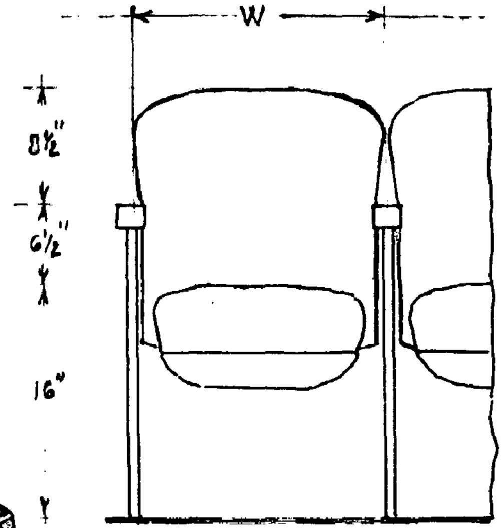
8.2.1.2 Types of Seats

Seats can be categorized according to their functions. Presently, manufacturers are producing mainly two types of seats, i.e. (i) fixed type, (ii) push-back type. The fixed type can be further subdivided into (a) Tip-up and (b) Two-ford tip-up In the former, the seat can be tipped up and back is fixed at an certain angle (fig.No.8.3-A), whereas

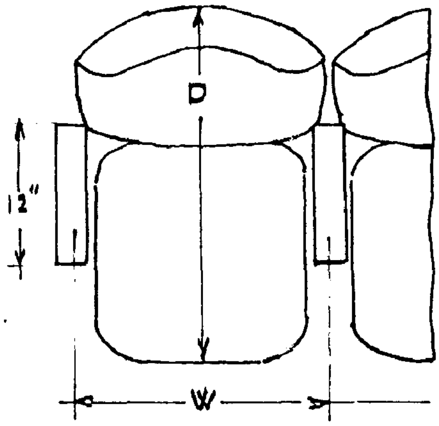


ISOMATRIC VIEW OF TIP-UP SEAT.

FIG. NO. 8.1



ELEVATION

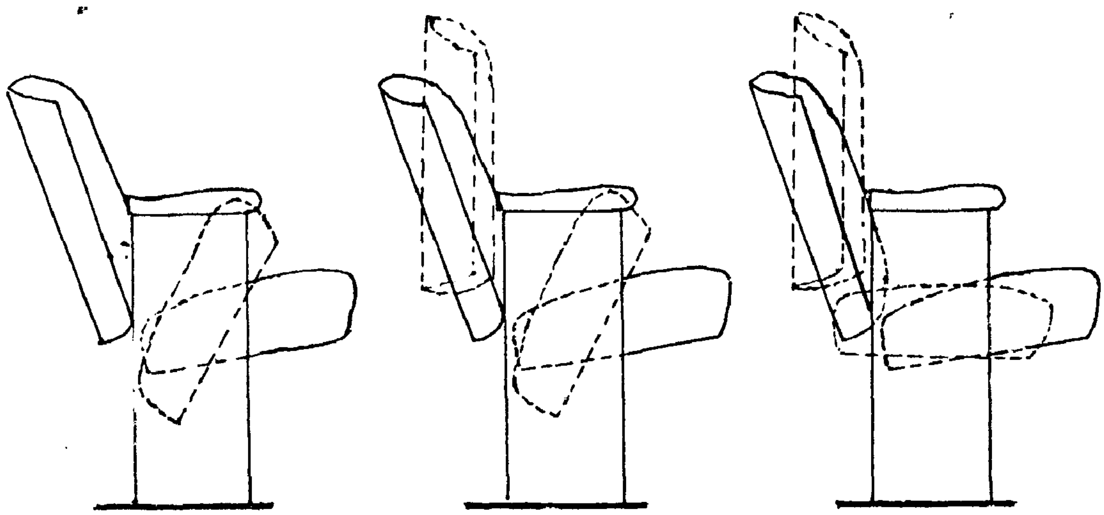


PLAN.

FIG. NO. 8.2

SIZES AVAILABLE

W	18"	19"	20"	21"
D	26⅞"	27¼"	27⅝"	28"



TIP-UP SEAT A | TWOFORD TIP-UP SEAT B | PUSH-BACK SEAT C

TYPES OF SEATS.

FIG. NO. 8.3.

PLATE NO. 29

in the later type, the back can also be adjusted (Fig.8.3-B).The tipping of seat and the movement of back is possible with the help of mechanical devices. Both the types, when unoccupied, provide wider passage between the rows to pass the patron easily and also in case of emergency.

Recently, push back type seats are in practice, in which the back as well as seat is retractable and can be pushed backward or foreward according to the convenience of patron (Fig.No.8.3-C). It provides more passing room than in the fixed seats with the same spacing. It is therefore in the interest of theatre-owner as this gives maximum number of seats and still gives more comfort than fixed type.

8.2.1.3 Material used for construction

Generally pressed street sheet, fabricated frames or cast iron frames of various designs are extensively used for seats as they offer adequate durability and troublefree service. The back and the seat is made out of steel sheet, anadized aluminium sheet, teak wood planks and plywood are very common and they are padded with upholstry materials. For luxurious seats, arms are also upholstered. Coir, cotton, foam rubber etc. are common materials for upholstring the seats. Even the springs are also added for extra-ordinary comfortable seats. Covering material such as Jute, Nowar, Hessin cloth and Rexine cloth etc. are in practice. Rexine is more popular as it is available in all shades, more sanitary than fabrics and do not receive dust.

8.8.1.4 Dimensions of Seat-

It is the most important factor in seat designing. The dimensions which affect the design are as follows:-

(i) Height of seat from floor,

(ii) Depth of seat,

(iii) Width of seat,

(iv) Back height,

(v) Distance between the arms,

(vi) Arm height from seat.

The average dimensions are given in the Fig.No.8.2.

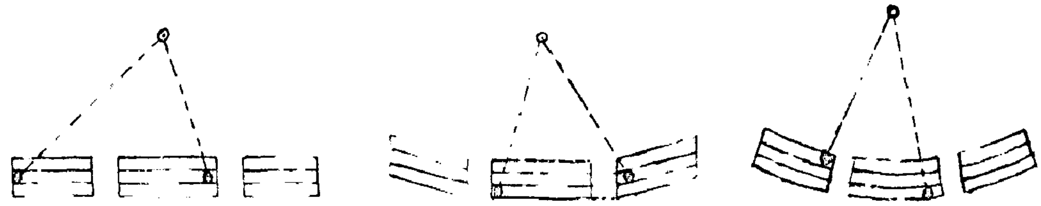
8.2.2 Layout-Design

8.2.2.1 Type

The layout of seats is mainly affected by overall shape of the hall which itself suggest the seating layout. (Fig. No.8.6) and the types of rows to be adopted. There are three types of rows i.e. (i) straight, (ii) straight in middle and scanted at sides, (iii) curved (fig.No.8.5). Straight rows have the greatest disadvantages as they are uncomfortable for spectators at sides and creates unequal stresses on seat and back. Straight in middle and scanted at sides have the same defects though not to the same degree.

Curved rows are the most comfortable from ease of vision and safety point of view. Minimum radius for curved rows due to seating construction is 20 ft.[3] Centre for radius of rows and centre for screen need not be same, although when possible, it offers an ideal case. When the rows are curved a slope of auditorium floor should be with a compound curve to prevent tilted side seating. Gangways may be straight or curved or parallel or radial. They should run at right angles to the row of seats as it eliminates waste of space.

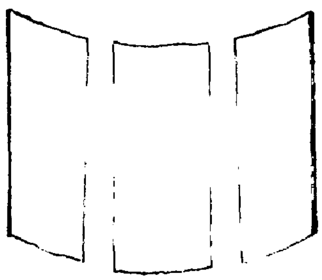
In any type of rows, seats can be arranged either back to back or staggered. Back to back seating arrangement necessitates the greater slope to floor to get the sight line over the head of spectator seated in front. But the staggered arrangement



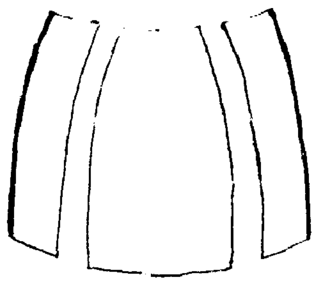
STRAIGHT ROWS — STRAIGHT IN MIDDLE AND SCANTED AT SIDES — CURVED ROW

TYPES OF ROWS

FIG. NO. 8.5



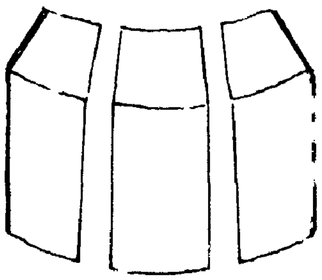
STRAIGHT



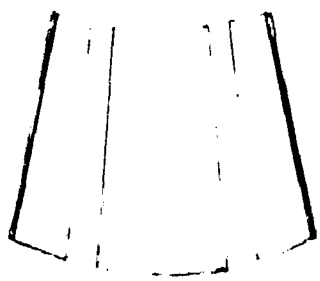
CURVED

COMMON TYPES OF SEATING AREA LAYOUS.

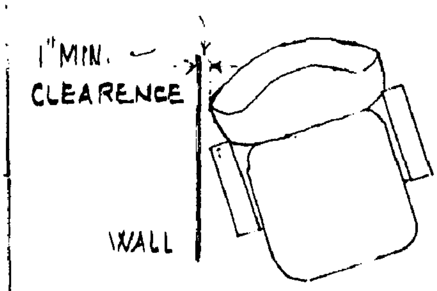
FIG. NO. 8.6



COUMPOUND

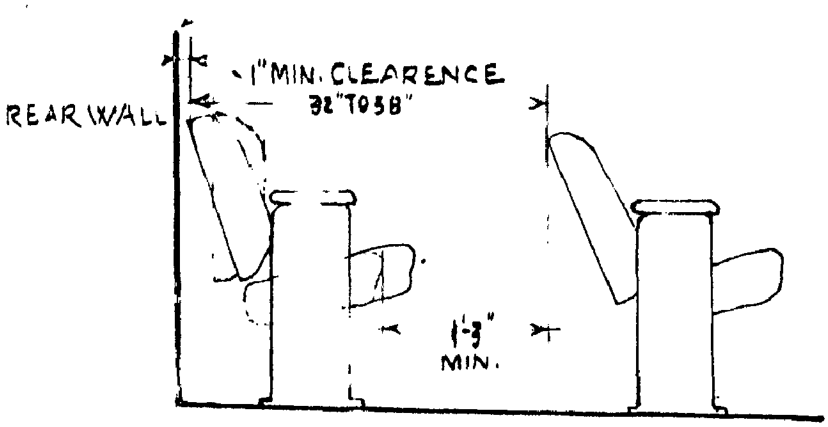


FAN



CLEARENCE BETWEEN WALL AND CHAIR

FIG. NO. 8.7



SPACING BETWEEN THE ROWS.

FIG. NO. 8.8

provides the sight line between the heads of spectators in front row, which ultimately results in comparatively less slope.

8.2.2.2 Spacing

Back to back seat measurement varies from 32" to 38" .As already stated that pushback seats require less spacing as it can be pushed backward and provide wider pass-way to spectator, whereas fixed type requires slightly more spacing . This measurement varies with the overall dimensions of seat. However, the passing room should be 1'-3" minimum to pass the spectator with less body contact (Fig.No.8.8)[4]. The clearance between the seat back and rear wall (or side wall should be atleast 1" to prevent the seat as well as wall from damaging by rubbing (Fig.No.9.7 and 8.8).

8.2.3 Anthropometric and Physio-anotomical Study for Comfortable Seating

Design of comfortable seat is mainly based on the dimensions of seat. If the dimensions are achieved

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4. India, Indian Standards, 'Byelaws for Construction of Cinema Buildings," (Delhi; Indian Standards Institution) IS:4878, page No.34

A - UNDERSIDE OF THIGH TO FLOOR

B - BUTTOCK TO BACK OF CALF

C - SEAT WIDTH

D - SHOLDER TO SEAT HEIGH

F - ELBOW WIDTH

G - ELBOW TO SEAT HEIGHT

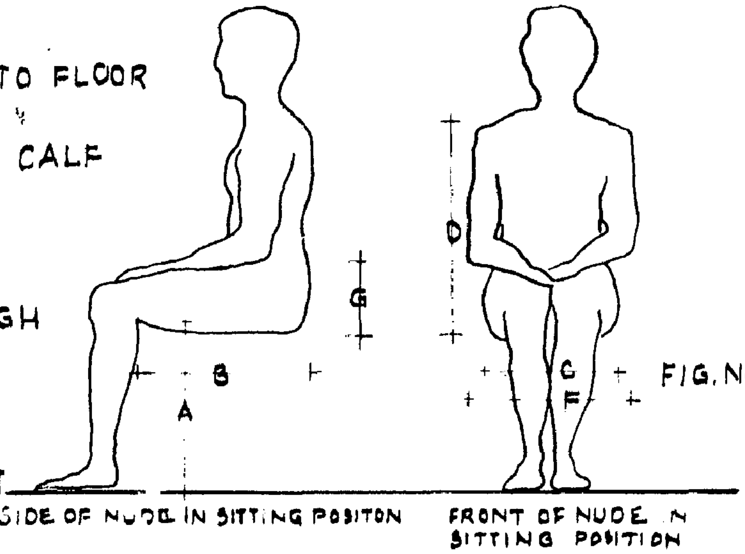
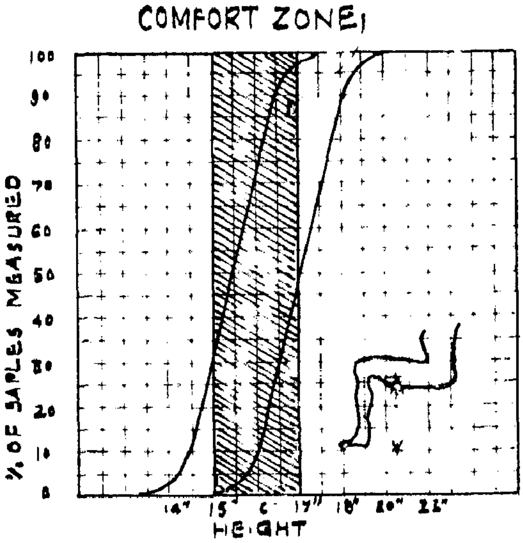


FIG. NO. 8·9

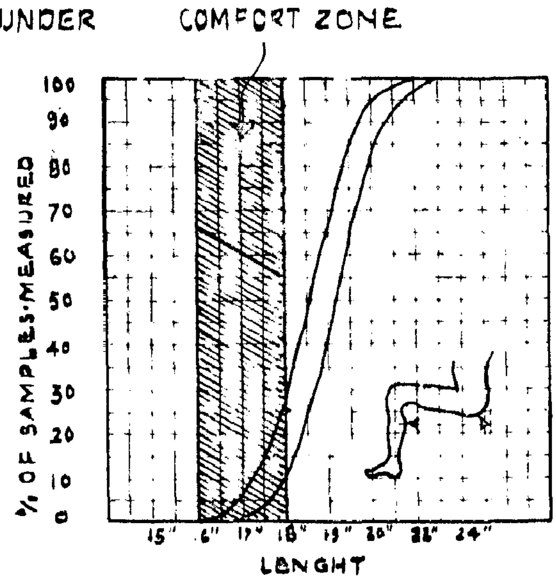
DIMENSIONAL STUDY OF NUDE BY FURNITURE DEVELOPMENTE COUNCIL, BRITAIN.



PHYSIOLOGICAL STUDY OF COMFORTABLE SEATING BY DR. AKERBLOM FROM STOCKHOLM.

GRAPH. NO. 6

PERCENTILE GRAPH SHOWING LENGHT OF LOWER LEG FROM FLOOR TO UNDER SIDE OF THIGH



PHYSIOLOGICAL STUDY OF COMFORTABLE SEATING BY DR. AKERBLOM FROM STOCKHOLM.

GRAPH. NO. 7

PERCENTILE GRAPH SHOWING LENGHT OF THIGH FROM CALF TO BACK REST. OF CHAIR

SOURCE - ARCHITECTURAL DESIGN AUG. 1951.

on correct basis, seat will offer maximum comfort in seating to the majority of audience. An average human dimensions and physiological study of comfortable seating can help in this regard.

For average human dimensions, an anthropometric study of the population is required (Fig.No.8,9). It is clear that human dimensions vary with the height of the person, which depends upon the age and race of the person. Therefore, age group and ethinic group of the population has to be considered in designing the seat.

In Britain, FURNITURE DEVELOPMENT COUNCIL undertook an anthropometric survey and worked out the dimensions in seating position for the both sexes between the age group of 18 to 40 years[5]. The dimensions arrived from the study are given in Appendix 'D'. Here it is worth to mention only maximum and minimum dimensions (Table No.1). In India, no significant work has been done on these lines, therefore we do not have any data for seat design and hence author has conducted the survey of random samples to work out the maximum and minimum dimensions for the same age group, which are given in Table No.2 (Plate No.32).

5. O'Donovan, Brigid, 'Seating Dimensions-Theory and Practice', Architectural Design, March,1961, page No.31.

HUMAN MEASUREMENTS IN SEATING POSITION TAKEN BY FURNITURE DEVELOPMENT COUNCIL BRITAIN.

SYMBOL	DIMENSIONS	MEN		WOMEN	
		MIN.	MAX	MIN.	MAX.
H	HEIGHT IN STANDING POSITION	68"	71½"	59"	67½"
A	UNDERSIDE OF THIGH TO FL.	15¼"	17¾"	14¼"	16¾"
B	BUTTOCK TO BACK OF CALF	17"	20½"	16½"	20"
C	SEAT WIDTH	12¼"	15¼"	13¼"	16¼"
D	SHOLDER TO SEAT HT.	21"	25"	17¼"	28¼"
F	ELBOW WIDTH	14¾"	19¾"	10¾"	18¼"
G	ELBOW TO SEAT HT.	7"	10½"	6¼"	9¾"

SOURCE- ARCHITECTURAL DESIGN.
MARCH, 1961.

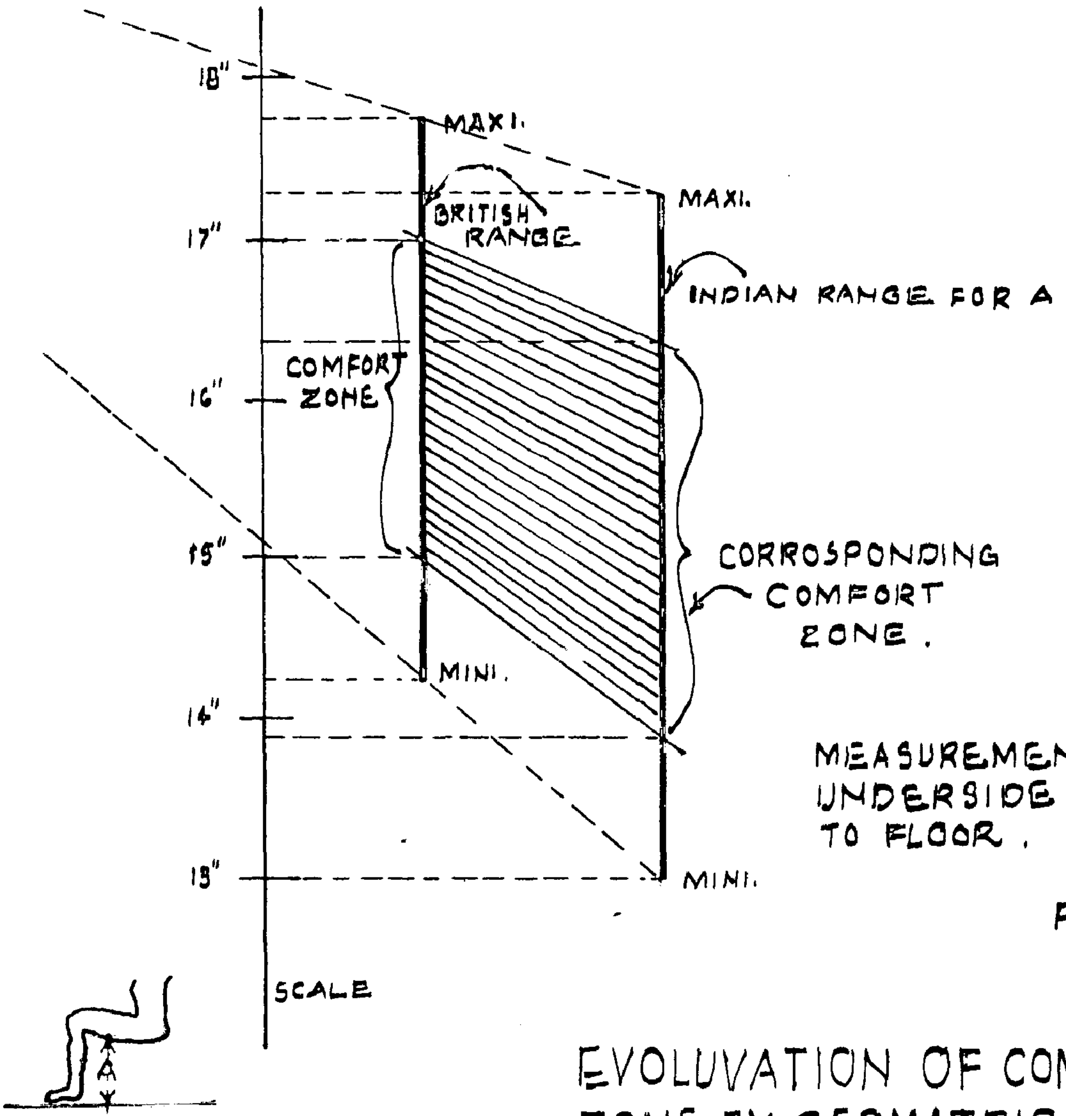
TABLE NO. 1.

SYMBOL	DIMENSIONS	MEN		WOMEN	
		MIN.	MAX.	MIN.	MAX.
H	HEIGHT IN STANDING POSITION	60"	70"	55"	65 ✡
A	UNDERSIDE OF THIGH TO FL.	14½"	17¼"	13"	16"
B	BUTTOCK TO BACK OF CALF	16"	20"	15"	19"
C	SEAT WIDTH	11¼"	14¾"	12¼"	16"
D	SEAT TO SHOLDER HT.	19¾"	24¼"	15¾"	22"
F	ELBOW WIDTH	13¼"	19"	10¾"	16¾"
G	SEAT TO ELBOW HT.	6"	10"	5"	8¾"

HUMAN DIMENSIONS IN SEATING POSITION TAKEN BY AUTHOR IN RANDOM SAMPLE SURVEY

✡ SOURCE- REPORT ON THE 42nd MEETING OF THE NUTRITION ADVISORY COMITTEE, HYDRABAD. 1960- INDIAN COUNCIL OF MEDICAL RESEARCH.

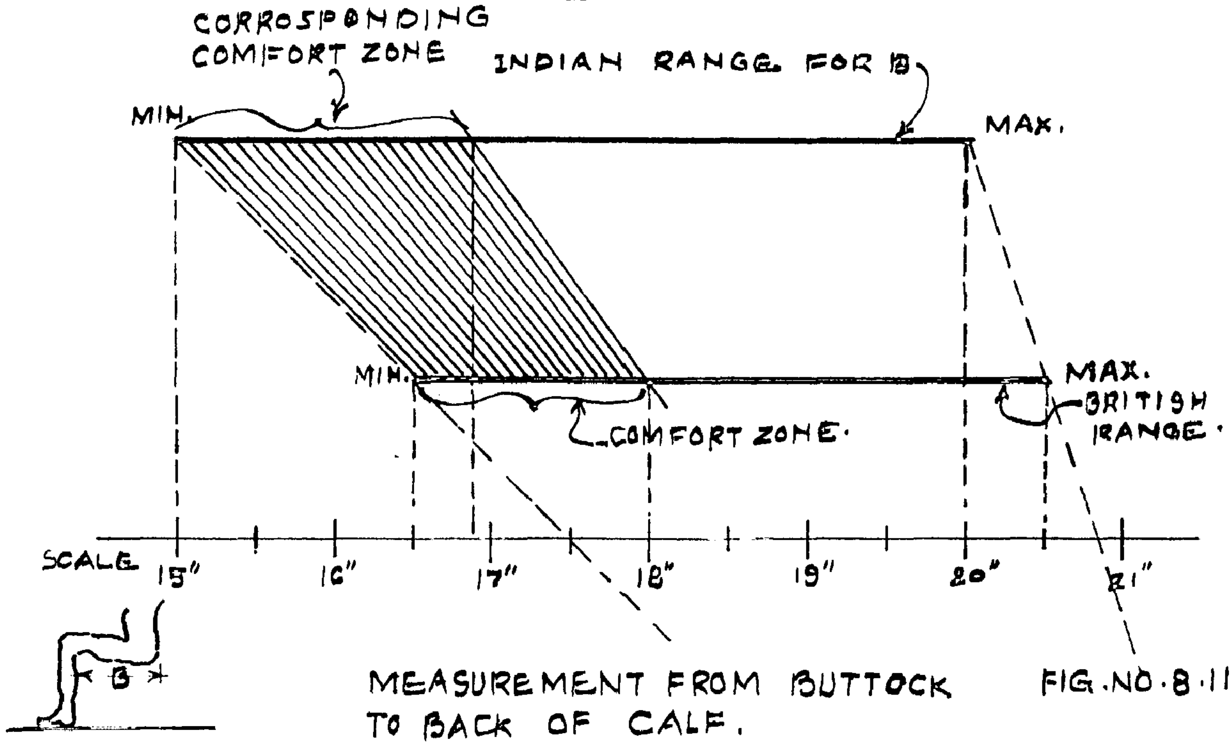
TABLE NO. 2.



MEASUREMENT FROM UNDERSIDE OF THIGH TO FLOOR.

FIG. NO. 8.10

EVOLUVATION OF COMFORT ZONE BY GEOMATRICAL METHOD



MEASUREMENT FROM BUTTOCK TO BACK OF CALF.

FIG. NO. 8.11

PLATE NO. 55

Generally, people remarks that the seat is too soft, too hard, too resilient, not resilient enough, too deep, too narrow and so on. It is found that many people feel comfort in low seat than in high one. Several investigators have also recommended lower seat after studying the physiology of comfortable seat, but unfortunately their recommendations are framed in vague manner and do not provide data for designer to evolve a standard dimensions of seat.[6]. Hence there is a need of mathodical study to evolve the principle of restful seating.

Dr. Bengot Akerblome from Stockholm has worked in this directions for his thesis on 'SEATING AND STANDING POSTURES[6]". He studied the basic resting positions and checked the relaxation of muscles by electro-measurements of the activity of muscles. The conclusions from his study is of great importance to the furniture designers. The details seat consideration concerns.

(i) Seat height from floor,

(ii) Seat depth,

(iii) Slope of the seat to the horizontal,

(iv) Angle of the back rest to seat,

(v) Seat width,

(vi) Arm width.

(vii) Back height,

(viii) Height of arms from seat.

According to Dr.Akerblom, first four measures are affected by the physiology of comfortable seating, whereas last four do not have any effect. Therefore, physiological study relating to first four measures is important.

8.2.3.1 Seat Height From Floor

It is expected that one should be able to change his position in the seat to avoid getting unnecessarily tired over long period, because however good a resting position may be, it will be exhausting in long time. This means that the seat should be low enough to unable the thighs to be lifted off the front edge of the seat and the legs either folded stretched out. Many people feel tiredness in the legs when sitting on high seats. The 'X'-ray photograph taken by Dr.Akerblom shows that when thighs are fully supported without the possibility of lifting them from seat, the soft muscles get compressed to less than a quarter. This is the reason of feeling tiredness on high seats. Similarly it is observed that generally people sit on the front edge of the high seat to relieve the pressure on thigh because the thighs are not well adopted for supporting the weight of the upper part of the body, when its own weight is on seat[6]. In this position the back-rest is beyond the reach and has to remain unsupported. To avoid or to relieve the pressure on thighs, the seat must be so low that the thighs should be able to hang freely or rest gently on the seat. The dimension that is useful in deciding what height a seat should, is that from the floor to underside of thighs. For this measurements, Dr.Akerblom prepared a percentile graph from survey and recommended the comfort zone (15" to 17") for majority of the population of both sexes (graph No.6). This comfort zone can be transferred on Indian range by geometrical method to evolve the corresponding comfort zone (Fig.No.8.10).

8.2.3.2. Depth of the Seat

To ensure that the back should be fully supported by back-rest of the seat, the depth of the seat should not exceed the measurement from buttock to back of the calf. Dr.Akerblom's study shows that the depth of seat should not be less than 16" and more than 18" for the comfort maximum population (Graph No.7). Also this comfort zone

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6. Bullivent, Durgan, 'The Design of Comfortable Chairs', Architectural Design, Dec.1951, Page No.36.

can be transferred on Indian range by geometrical method to evolve the corresponding comfort zone (Fig.No.8.11).

8.2.3.3 The Slope of the Seat-

A flat seat causes a tendency to slide forward preventing the back from being supported (Fig.No.8.13). A seat which slopes backward minimises this tendency and helps the back to be held against the back-rest, because it resists the tendency of pelvis to change its position and do not produce the slumped position (Fig.No.8.12)[6]. Dr. Akerblom suggests 5° to 8° angle of the seat to the horizontal for comfortable seat.

8.2.3.4 Angle of Seat to Back-rest

A detailed study of curve of spine in various position is done by Dr. J.J.KEEGAN from Omaha and he found the position of maximum relaxation occurs when angle between trunk and thigh is 135° (Fig.No. 8.15 and 8.16)[7]. This angle is required merely for complete relaxation, hence it is adopted in semi-reclining chairs. Any reduction in this angle

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7. Bullivant, Durgan, 'The Design of Comfortable Chairs', Architectural Design 1954, page No.25.

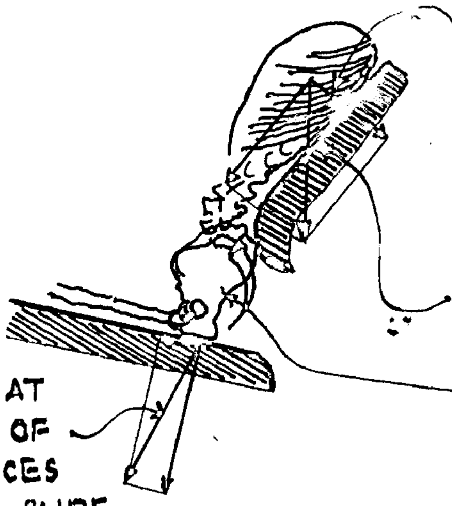


FIG.NO. 8·12

SEATING POSITION IN INCLINED SEAT AND BACK-REST

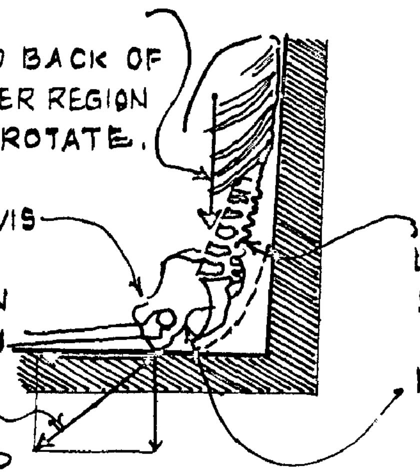


FIG.NO. 8·13.

SEATING POSITION IN STRAIGHT SEAT AND BACK-REST.

PHYSIOLOGICAL STUDY OF COMFORTABLE SEATING.

SOURCE - ARCHITECTURAL DESIGN 1951, AUG.

PLATE NO.34

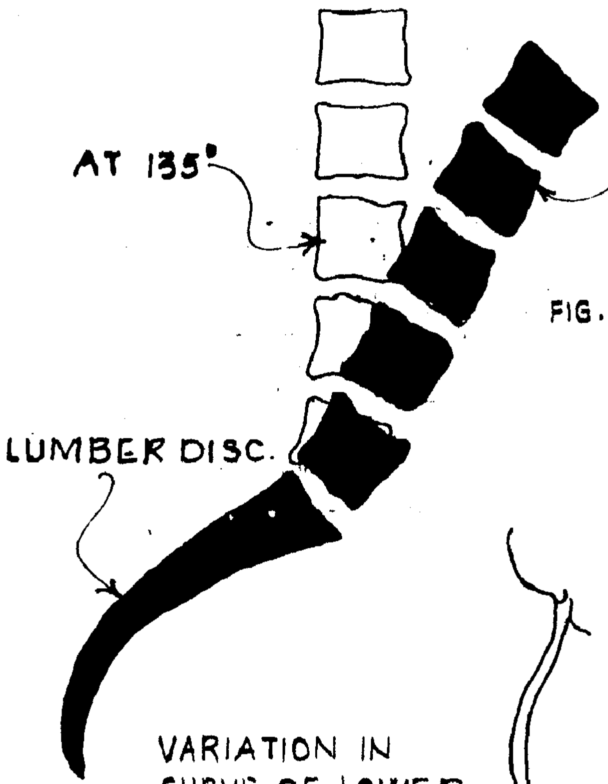


FIG. NO. 8.14

VARIATION IN CURVE OF LOWER SPINE AT 90° AND 135° ANGLE OF SEATING POSITION

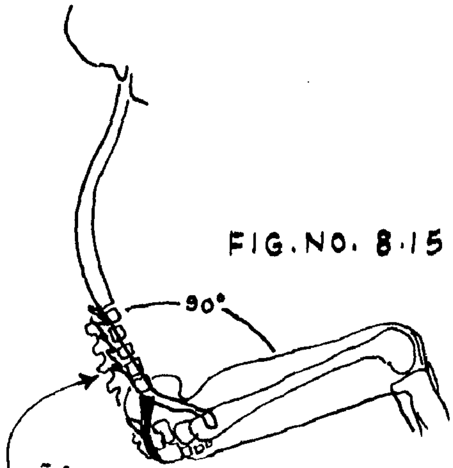


FIG. NO. 8.15

POSITION OF LOWER SPINE AT 90° ANGLE OF TRUNK WITH THIGH

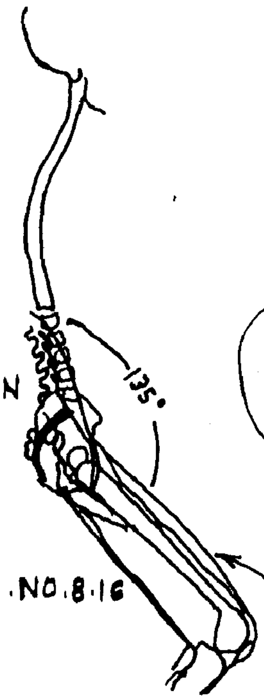
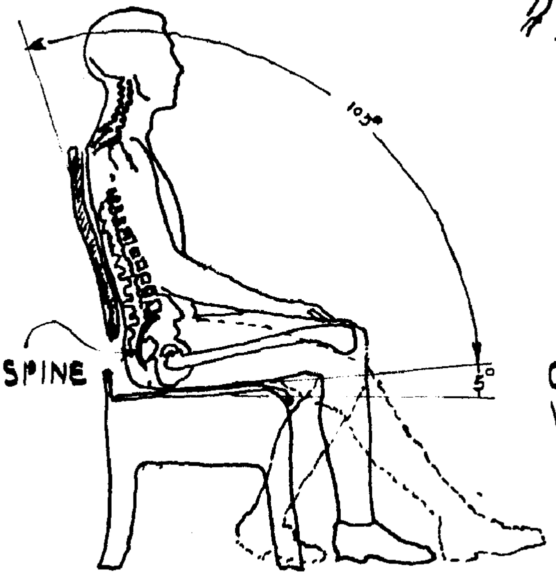


FIG. NO. 8.16

POSITION OF LOWER SPINE AT 135° ANGLE OF TRUNK WITH THIGH



LOWER SPINE

COMFORTABLE SEATING POSITION WITH MINIMUM ANGLE OF 105°.

FIG. NO. 8.17

PHYSIOLOGICAL STUDY OF COMFORTABLE SEATING.

SOURCE - ARCHITECTURAL DESIGN 1954, AUG.

increases the strain on the lower lumber disc. (Fig.No.8.14). After careful study, Dr. Keegon recommended the minimum angle of 105° between trunk and thighs (Fig.No.8.17).

CHAPTER-9

S A F E T Y

9.0 General

Safety is one of the most important functional requirements of auditorium being a public place. It has to go hand in hand with the comfort to satisfy the function of audio-visual performance. Proper consideration for safety in planning will minimise the possibility of losses or damages to life and structure. The safety can be taken care of under the following heads (Chart No.5),

(i) Structural safety,

(ii) Fire safety.

4.1 Structural Safety

The structure of auditorium should be sound enough to resist the dead and live loads, seismic forces and other external forces such as wind pressure, impacts, vibrations, temperature effects, shrinkage etc. In any case, the stresses in the materials used in the construction should not exceed the permissible limits as laid in the relevant Indian Standards.

The main structural elements to be designed

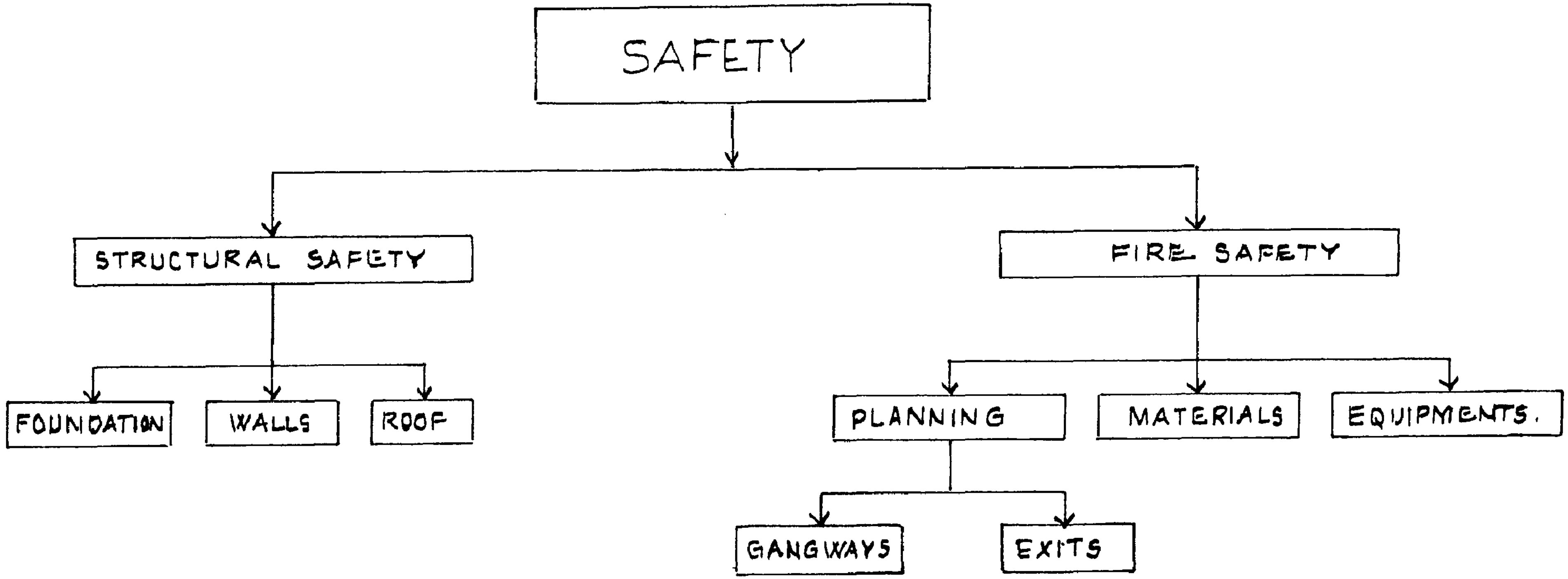


CHART NO. 5. SCHEMATIC DIAGRAM FOR SAFETY

PLATE NO. 36.

for structural safety are (i) foundation, (ii) walls, (iii) structural element for roofing, and broad performance standards are given below.

9.1.1 Foundation

The foundation of the structure is to be designed and constructed to sustain the dead of the building and superimpose loads, and to transmit the loads and to distribute them over the soil in such a manner that pressure brought to bear on soil by these loads should not exceed the safe bearing capacity of soil.

9.1.2 Walls

The strength of load bearing walls, depends upon number of factors, such as the thickness of wall, quality of bricks, mortar, method of bonding unsupported height and length, eccentricity in loading. The position and amount of openings in the wall, the location of longitudinal and cross wall and combination of various external loads to which the walls are subjected. In case of frame structure, the strength of framework depends on the size of the members (beams and columns), quality of concrete and reinforcement. The walls or frameow designed taking into account the various factors mentioned above, such that the stresses in the walls or framework do not exceed the safe permissible limits laid down in IS:1905-1961[1].

9.1.3 Structural Elements for Roofing

Trusses, beams (prestressed), folded plates, shells and cables etc. come under the structural elements for roofing. Trusses are more common as they are economical and have got various advantages over others, such as (i) easy to construct, (ii) facilitates the false ceiling of desired design, (iii) provides attic space for airconditioning ducting and fixtures for illumination, (iv) can cover desirable span etc.

Folded plates and prestressed beams are rearly used as a structural elements as they are expensive. Shells also are not suitable for roofing from acoustical point of view and should be avoided as far as possible. However, they can be employed for special architectural reasons, but it requires expensive acoustical treatment.Moreover, it does not facilitate the fitting of any fixtures.

From fire safety point of view, cable roof is found the best. It has various advantages over rest of the roofing systems. It also provides columfree

1. India, Indian Standards, 'Code of Practice for Structural Safety of Building: Loading Standards', (Delhi: Indian Standards Institution),IS:1905-1961', page No.12.

space without any intermediate support. In fact, cable roof is the most economical for larger spans, but as it has not been yet introduced in our building industry, it will be somewhat expensive.

The design of above mentioned structural elements is in the purview of the structural engineer, however, it should be according to relevant Indian Standard Code of Practice.

9.2 Fire Safety

Fire safety of cinema building should be considered from the following two aspects of the fire hazard and the precaution shall accordingly be provided against the same.

(i) Possibility of loss or damage to life, referred to as personal hazard,

(ii) Possibility of fire occurring and spreading in the building itself, referred to as internal hazard.

Cinemas, even though their combustible content may be low, are considered to present a high internal hazard primarily because of the large number of people and the extent of personal hazards is naturally of paramount importance and requires the provisions of liberally designed and safe fireproof exits or escapes to the auditorium and gangways within it. Internal hazard concerns damage or destruction of building and influences directly personal hazard. The internal hazard is directly related to the fire load which in turn enables the building to be graded when considered along with the duration of the fire.

Cinema houses are graded as an occupancies of low fire load as the fire load does not exceed 275,000 $KCal/m^2$ of net floor area of any compartment, or an average of 550,000 $KCal/m^2$ on limited isolated areas.[2]

As far as fire safety of auditorium is concerned, it can be ensured through ,

(i) Physical planning,

(ii) Elimination of combustible materials in the construction,

(iii) Fire fighting equipments.

Here, only first aspect is considered in detail.

9.2.1 Physical Planning

Proper planning can help in minimising the personal hazard therefore primary consideration to physical planning must be given. The planning factors

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2. India, Indian Standards, 'Byelaws for Construction of Cinema buildings', (Delhi : Indian Standards Institution) IS: 4878-1968. Page No.44.

affecting the personal hazard, are (i) aisles or gangways , (ii) exits.

9.2.1.1 Gangways or Ailes

Primarily they are to be provided for circulation within the auditorium and to facilitate safe and speedy egress of occupants in case of emergency. The width of gangway is directly related to the number of persons using it or amount of seating area it has to serve. Indian Standards Institution suggests the following minimum requirements for gangways from both, fire safety and circulation point of view.(2)

(i) Clear aisles not less than 1.2m in width should be formed at right angles to the line of seating in such number and manner that no seat shall be more than 3.8 m away from an aisle, measured in the line of seating. Under the conditions where all these aisles do not directly meet the exit doors, cross aisles should be provided parallel to the line of seating so as to provide direct access to the exit, provided that not more one cross aisle for every 10 rows should be required. The width of cross aisles shall be 1m minimum.

(ii) Where possible, gradients or inclined planes shall be used instead of steps but no gradient or inclined plane should be steeper than 1 in 10.

(iii) If the steps have to be inserted in a gangway or passage, there should be not less than three steps at any one place. The treads should not be less than 30 cms. and risers not less than 15 cm.

(iv) All gangways and treads of steps should be maintained with nonslippery surfaces and should be kept well illuminated.

(v) Druggets mattings and floor covering if provided in gangways should be securely fastened to the floor.

(vi) Exits and the gangways and passages leading to exit should be kept clear of any obstruction.

9.2.1.2 Exits

Exits are to be provided to ensure safe evacuation or escape of occupants in case of fire or other emergency. The size and the number depends upon the number of the occupants. It has been proved by experimentation that 45 persons require 53 cm. unit width of exit to pass in one minute and the audience must be able to leave the auditorium in $2\frac{1}{2}$ minutes; however the minimum number of exits to be provided under statutory regulations is as follows[3]:-

Number of persons	Number of exits
1 to 60	1
61 to 600	2
601 to 1000	3
1001 to 1400	4
1401 to 1700	5

The location of exit in relation to seating area and gangways is equally important. The maximum distances from seat to exit should be as follows.[3]

Structure	Maximum distance in metres
Wholly fire resistant	30 m.
30 minutes fire resistance	20 m.
Lessthan 30 minutes fire resistance.	15 m.

Faulty exit design, obstructions in the path ways to exits, inadequate exit size and lack of any indication for finding the exit are the factors

3. Fairweather, Leslie, 'AJ Metric Handbook' (London: The Architectural Press Ltd), page No.12.1.

which may lead to confusion and panic in emergency and many lives which could otherwise be saved, may be lost in a stampede. In order to minimise such personal hazard, exits should be conformed to the following requirements as prescribed by Indian Standards Institution.[2]

(i) All buildings and particularly buildings having more than one story height should be with liberally designed safe fire-resistant exit or escapes.

(ii) The exits should be so placed that they are always immediately accessible and each is capable of taking all the persons on the floor, as alternative escape routes may be rendered unusable and/or unsafe due to fire.

(iii) There should be one exit from every tier, floor or gallery for every 250 persons accommodated or part thereof, provided that from every upper floor or gallery, there shall not be less than two exits.

(iv) Escape route should be well ventilated, as person using the escapes are likely to be overcome by smoke and/or fume which may enter from the floor.

(v) Where fire resisting door are employed as 'cut-offs' or fire breaks, they shall be maintained in good working order, free from any obstruction so that, they may be readily opened to allow quick escape of any person or persons, trapped in that section of the building, and also, when necessary, prompt rescue work can be expeditiously carried out.

(vi) Every exit should provide a clear opening space of not less than 1.5m in width. All exit doors through which the public has to pass, should be available for exit during the whole time the public are in the building and during such time the door should not be locked or bolted but kept closed provided an attendent is placed in charge of each such door, whose duty shall be to throw open the door in case of emergency.

(vii) All exits should be clearly indicated by word 'EXIT' in block letters 175 mm. high and shall be so displayed as to be clearly visible in the light as well as in the dark.

(viii) No door which is required as exit should be less than 1.5 m in clear width and not less than 2.1 m in clear height. The clear width should be measured between the frame of a door.

(ix) All exits should open outwards and shall flush with outside of the walls or should be fitted, so that when open, they do not obstruct any gangway, passage, corridor, stairways or landing.

9.2.2 Materials and Construction

The elimination of use of combustible materials in the auditorium construction minimises the spread of fire. So the selection of materials for acoustical treatment to walls, ceiling and floor should be such that it will ensure the fire safety, satisfy the acoustical requirements and give appearance for the desired interior design scheme.

False ceiling, either for sound affects or air conditioning or other similar purpose, should be so constructed as to prevent either total or early collapse in the event of fire, so that the persons underneath are not fatally trapped before they have time to reach the exits. To provide easy access for fire fighting apparatus, cat walk of suitable materials should be provided.

Floors are required to withstand the effects of fire for the full period stated for the particular grading and their design and construction should be of such a standard that shall obviate any replacement partial or otherwise.

Construction for acoustical treatment and interior design purposes should be such that it will prevent the early collapse at the time of fire so that persons passing along walls will not get injured.

9.2.3 Equipments

In this respect Indian Standards Institutions has worked out the precautionary measures and requirements for fire fighting equipments in the cinema building. They are as follows[2]

(i) First aid fire fighting equipments should be provided according to IS:2217 -1963*, and should be inspected periodically by appropriate authority.

(ii) They should be distributed over the building in such a manner so as to readily available in case of fire in any part of the building and should be maintained in proper working order as specified in IS:2190-1962**

(iii) The premises of cinema should be so arranged as to be in communication with the nearest fire station by means of a telephone.

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* Recommendations for providing first-aid fire fighting arrangement in public buildings.

** Code of Practice for selection, installations and maintenance of portable first aid fire appliances.

(iv) One soda acid/gas propelled water type fire extinguisher of a pattern approved by competent authority and supply of not less than 25 litres of water per 10 sq.m.of floor area should be stored inside auditorium in the following manner.

One third of supply or 250 litres whichever is greater stored in buckets conforming to IS:2546-1963* of 10 litre capacity each and the balance stored in tanks or cisterns or buckets of any capacity so arranged as to be easily accessible to the satisfaction of competent authority. Buckets should have round bottom and handles. They shall be painted red with the word 'FIRE', printed on them in large block letters in local vernacular.

(v) One gallon size CTC or CO_2 extinguisher for the electrical risk on the stage, and one soda acid fire extinguisher for stage draperies etc. should be provided.

(vi) All the extinguishers and buckets in the auditorium shall be located in a manner so as not to obstruct the passage or aisles to reduce their width in any way.

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*Specification for galvanised mild steel fire buckets.

PART III

CHAPTER-10

FINDINGS OF SURVEY OF CINEMA THEATRES

10.0 General

The broad outlines of various factors of planning the cinema have been dealt already. Amongst them, technical factors which includes the functional requirements of the cinema auditorium have also been discussed in the earlier chapters. To formulate the standards for physical planning factors for facilitating the planning of cinema auditorium as a whole, the basis of basic study and the practice in vogue have been considered logical. Basic study provides a definite framework for standards and it is to be perfected by compromising it with the practice. Survey is an efficient device to find out the prevailing conditions of cinema theatres. Therefore a survey was conducted by the author with an objective to arrive at the recommendations of the planning standard. Delhi has chosen for the simple reason that it has old as well as latest cinema theatres with varying capacity which is assumed as a pivotal point of the study. Another survey was conducted to investigate the optimum capacity of theatre on economic return basis. The proforma of both surveys are given in Appendix 'B'.

Delhi is having theatres with the capacity ranging from 500 to 1100 seats. Theatres with capacity of more than 800 seats are recently constructed and with capacity less than 800 seats, are mostly old and were constructed before 1950. The theatres taken for survey study, are as follows.

Name of Cinema	Capacity
1. Excelsior	500 (old)
2. Radhu	600 (old)
3. Novelty	700 (old) Renovated
4. Sudarshan	800 (old) Renovated
5. Plaza	875 (old) Renovated
6. Sapna	1000 (new)
7. Vishal	1000 (new)
8. Shiela	1000 (new)
9. Amba	1020 (new)
10. Chanakya	1085 (new)

This survey was done to investigate the prevailing conditions of the planning factors by studying the functional requirements of the cinema auditorium. The findings of the survey are given in Table No.3. (Plate No.37) , and the general observations and reasoning are as follows:

COMFORT / SAFETY

Name of Cinema	Capacity: Main Floor	Capacity: Balcony	Capacity: Total	Auditory Comfort – Shape: Form	Shape: Ratio	Volume: C.ft per person	Visual Comfort – Slope: Type of slope	Screen height from floor	Max. departure from horizontal (M. floor)	Rise in balcony tiers	Type of seating arrangement	No. of rows: Main floor	No. of rows: Balcony	Seating area – Maximum dist. from screen: 35mm	Max. dist.: 70mm	Minimum dist. from screen: 35mm	Min. dist.: 70mm	Width: 35mm	Width: 70mm
EXCELSIOR	500	-	500	RECTANGULAR	1:2	200 C.FT.	UPWORD	5'-3"	2'-5"	-	NOT STAGGERED	25	0	4W	-	1W	-	2.5W	-
RADHU	600	-	600	RECTANGULAR	1:1.75	225 C.FT.	UPWORD	5'-3"	2'-2"	-	NOT STAGGERED	27	0	6W	-	1W	-	3W	-
NOVELTY	625	75	700	RECTANGULAR	1:1.6	250 C.FT.	UPWORD	5'-6"	2'-0"	10"	NOT STAGGERED	28	7	4.5W	-	1W	-	2.7W	-
SUDARSHAN	650	150	800	RECTANGULAR	1:1.5	225 C.FT.	UPWORD	5'-6"	2'-0"	9"	STAGGERED	24	7	5W	-	1W	-	2.6W	-
PLAZA	625	250	875	RECTANGULAR	1:1.4	265 C.FT.	UPWORD	5'-6"	1'-5"	11"	STAGGERED	22	8	-	1.5W	-	.5W	-	1.15W
SAPNA	750	250	1000	RECTANGULAR	1:1.7	275 C.FT.	REVERSE	7'-6"	0'-9"	13"	STAGGERED	25	9	-	1.6W	-	.5W	-	1.07W
VISHAL	750	250	1000	RECTANGULAR	1:1.8	270 C.FT.	REVERSE	7'-5"	0'-9"	13"	STAGGERED	21	10	-	2W	-	.5W	-	1.09W
SHIELA	660	340	1000	RECTANGULAR	1:1.8	285 C.FT.	REVERSE	7'-0"	1'-1"	13"	NOT STAGGERED	23	11	-	1.7W	-	.5W	-	1.1W
AMBA	750	270	1020	WEDGE	1:1.8 / 1:1.65	280 C.FT.	REVERSE	7'-6"	1'-3"	15"	STAGGERED	26	11	-	2W	-	.5W	-	1.05W
CHANAKYA	735	350	1085	WEDGE	1:1.7 / 1:1.6	300 C.FT.	REVERSE	7'-9"	1'-6"	10"	STAGGERED	24	9	-	1.7W	-	.5W	-	1.1W

Name of Cinema	Physical Comfort – Environmental – Volume: Air changes per hour	Seating – Seat: Type of seat	Seat ht. from floor	Seat depth	Seat width	Back-rest height	Arm distance	Arm height from seat	Layout: Type of rows	Layout: Spacing	Area: Net seating area/person	Circulation area/person	Total area/person	Ratio of seating to circulation area	Fire Safety – Exit: Clear opening per 100 persons	Gangways – Longitudinal: Length of seating	Longitudinal: Width of gangway	Cross: Length of seating	Cross: Width of gangway
EXCELSIOR	2.50	FIXED	18"	17"	17"	18"	18"	6½"	STRAIGHT	34"	4.15 S.FT.	2.1 S.FT.	6.35 S.FT.	1:0.65	4.5 FT.	13 FT.	3'-6"	[illegible]	3'-6"
RADHU	2.00	FIXED	17"	17½"	17"	18"	18½"	6½"	STRAIGHT	34"	4.5 S.FT.	2.4 S.FT.	6.9 S.FT.	1:0.7	4.8 FT.	16 FT.	3'-6"	10 FT.	3'-6"
NOVELTY	1.95	TIP-UP	17½"	17"	17"	18½"	19"	7"	STRAIGHT	32"	4.1 S.FT.	2.0 S.FT.	6.1 S.FT.	1:0.6	5.25 FT.	18 FT.	3'-9"	16 FT.	4'-0"
SUDARSHAN	2.00	TIP-UP	16"	18"	18"	19½"	19"	7½"	STRAIGHT	32"	4.0 S.FT.	2.5 S.FT.	6.6 S.FT.	1:0.6	5.5	22 FT.	3'-9"	18 FT.	4'-4"
PLAZA	1.90	PUSHBACK	16"	19"	17"	19"	20	8"	STRAIGHT	34"	4.25 S.FT.	3.85 S.FT.	8.1 S.FT.	1:0.7	5.8 FT.	20 FT.	4'-0"	23 FT.	4'-5"
SAPNA	1.85	PUSHBACK	16½"	18"	18"	20"	19"	7½"	CURVED	36"	4.6 S.FT.	4.25 S.FT.	8.8 S.FT.	1:0.8	5.6 FT.	21 FT.	4'-6"	24 FT.	4'-9"
VISHAL	1.85	PUSHBACK	16"	17½"	18"	20"	20"	8"	CURVED	36"	4.5 S.FT.	3.9 S.FT.	8.4 S.FT.	1:0.75	5.7 FT.	22 FT.	5'-6"	23 FT.	5'-6"
SHIELA	1.80	PUSHBACK	16½"	18½"	18½"	21"	21"	8"	CURVED	38"	4.3 S.FT.	3.85 S.FT.	8.15 S.FT.	1:0.7	5.9 FT.	25 FT.	5'-0"	22 FT.	4'1"
AMBA	1.80	PUSHBACK	17"	18"	18"	20"	21"	8½"	STRAIGHT	39"	4.9 S.FT.	3.45 S.FT.	8.3 S.FT.	1:0.8	6.0 FT.	30 FT.	5'-6"	25 FT.	6'-0"
CHANAKYA	1.75	PUSHBACK	15"	18"	19	21"	20"	7½"	STRAIGHT	36"	4.75 S.FT.	3.9 S.FT.	8.65 S.FT.	1:0.75	6.25 FT.	27 FT.	5'-0"	30 FT.	5'-0"

TABLE NO. 8

COMPUTATION OF THE FINDINGS OF SURVEY OF TEN CINEMA THEATRES OF DELHI

PLATE NO.

10.1 Study of Comforts in Theatres.

10.1.1 Auditory Comfort-

Especially, new theatres are carefully designed from acoustical point of view and the equipments installed, are efficient , whereas old theatres lack in this respect, but most of them are improved by acoustical treatment. Therefore there is considerable amount of difference in the auditory performance of old and new theatres. However, in general, almost all theatres offers desirable sound distribution, optimum reverberation time and echofree seating areas.

10.1.1.1 Shape

Most of the theatres are rectangular in shape. Rarely fanshape is employed, inspite of the fact that it is good from seeing, hearing and architectural point of view. Rectangular shape of auditoriums has the reflecting panels at side walls upto the front half of the auditorium for the uniform distribution of the sound at rear seats.

10.1.1.2 Volume

It is found varying with the capacity from 200 to 300 c.ft./person (see table), which is much more above the desirable range to maintain the optimum reverberation time. This is mainly due to the visual and architectural problems such as unobstructed projection of picture, sightline to each spectator and proportion of hall. This increased volume of auditorium resulted in elaborate acoustical surface treatment.

10.1.1.3 Surface Treatment

The location of reflecting surfaces is found to be influenced by the form of the hall whereas the location and the amount of absorbing surfaces is found influenced by volume and position of the speakers. The common materials used for sound absorbing are straw board, jute board, glass wool, rock wool etc. They are designed with due consideration of interior design, but some of the recently built theatres are richly treated merely for aesthetics in addition to the functional (acoustical) requirements.

10.1.2 Visual Comfort

The visual conditions studied are (i) sightline, (ii) picture acuity, (iii) picture distortion, (iv) angle of viewing. New theatres offer the best visual performance whereas old theatres are deficiating as they do not fulfil some of the visual conditions.

10.1.2.1 Slope

It is found that recently constructed theatres have been planned with proper attention to the sight line condition. Most of them are having reverse floor slope which has been proved successful in providing unobstructed view of the projected pictures. Desirable amount of departure from horizontal have been achieved by staggered seating arrangement (See Table), which reduced the balcony slope, thereby decreasing the projection angle due to comparatively lower position of projection booth. This helped in getting the minimum distortion in projected picture. Some of the old theatres are having slope without staggered seating arrangement which created uncomfortable floor slope to get the clear sight line. This has been found workable to some extent, because, as there is no balcony due to less capacity, the question of picture distortion due to large projection angle, does not arise. Moreover, some theatres are having desirable upward slope without staggered arrangement but they do not provide clear sight line due to the obstruction of the spectator seated in front row. With the result the spectator has to move to his right or left to see the clear picture through the distance between the heads of two spectators seated in the front row.

10.1.2.2 Seating Area

Almost all theatres fulfil the remaining visual conditions i.e. picture acuity, picture distortion and viewing angles. Seating area is to be demarcated by fixing the maximum and minimum viewing distances between the screen and the patron, and the width of the seating area. These distances can be expressed in terms of the width of the screen and are mentioned in the table under reference of seating area. There are set-up standards achieved by equipment manufacturers, for deciding the seating area. It is found that they are regarded for visual comfort in theatres under study.

10.1.3. Physical Comfort

It includes, (i) environmental comfort, (ii) seating comfort, which have been achieved by air conditioning and push back seats respectively, in the modern theatres, whereas, in old theatres it is maintained by simple mechanical ventilation or cooling system and fixed type of seats respectively.

10.1.3.1 Environmental Comfort

Construction techniques and the volume are the only physical planning factors which could influence the environmental conditions. Survey shows that the construction techniqués vary from place to place to meet their individual problems of thermal insulation, and the volume is found offering 1.75 to 2.5 air changes/hour which are not within the limits (3 to 4 air changes/hour) recommended by cinematograph rules and ASHRE GUIDE.(1)

10.1.3.2 Seating Comfort

Seat design and its layout are the effecting factors in the seating comfort. There are numerous designs with different dimensions, type (push-back and fixed) and materials. The type and the material for the seat construction differed according to client's requirements and the designer's choice. Dimensions have been found varying, leading to discomfort in old theatres. As we do not have any

1. 'Physical Environment', ASHRAE Guide and data book-1962, New York: American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc.) page No.445.

standard for seat dimensions, manufacturers are producing seat of different sizes according to the requirements of their clients.

Seat layout with straight rows, straight in middle and scanted at sides rows, and circular rows have been found with spacing from 32" to 38" back to back.

The abové mentioned seat dimensions and their spacing required the net floor area from 4 to 5 sq.ft./ person and the circulation area from 2.1 to 3.9 sq.ft./person. The ratio of net seating area to circulation area found ranging from 1:0.5 to 1:0.75. New theatres offer the gross area of 7 to 8 sq.ft. whereas old one varies from 6.0 sq.ft. to 7 sq.ft.

10.2 Safety

It includes (i) structural safety, and (ii) fire safety. Structural safety is beyond the scope of the survey study. However, for fire safety the following measures have been investigated:-

i) planning,

ii) elimination of use of combustible materials,

iii) equipment for fire fighting.

Survey investigation shows that the materials are employed according to the designer's choice to meet the requirements of interior design and acoustics of the hall, and the equipments for fire fighting are installed according to the requirements of the local authority. But the planning which includes exits and gangways vary with the capacity of the auditoria.

10.2.1 Exits

Exit opening from 7'x4' to 7'x7' have been provided in most of the theatres. The number and size of the exits varies with the capacity. Clear exit opening for per 100 persons is found varying from 4.5 ft. to 6.25 ft. (running) for per 100 persons with the capacity 300 to 1100 seats. Other requirements of exits to ensure the fire safety which are suggested by cinematograph regulations, have been followed strictly by almost all theatres.

10.2.2 Gangways

The width of gangways is found varying from 3'-6" to 6'-0". The longitudinal gangways are located after 7 to 15 seats whereas cross gangways are located after 6 to 10 rows of seats.

10.3 Capacity

Optimisation of Capacity

For the evolution of the optimum capacity, auther has conducted the survey of cinema theatres of varying capacity as a case study of Delhi. General observations show that there is a acute shortage of cinema facility needed for a metropolis like Delhi. In Delhi, at present, there are 48 theatres which offers the total capacity of 35191 seats and the total population of Delhi is 4044338 according to 1971 census report. The ratio of seat to population comes to 1:115 whereas UNESCO has suggested this ratio as 1:50 , on the basis of social survey conducted in various countries(2). Taking this ratio as an international standards, Delhi requires 45696 additional seats to satisfy the present need. It means that there is a shortage of ~~45~~ theatres of 1000 seats capacity.

It is very easy to calculate the shortage of seats, but allocation of this shortage requires considerations of technical and economical bindings. Technically small theatres are more perfect for exhibiting the films and theatres with seating capacity over 1250 seats is not advisible

2. Zha, 'Atmac 70', (Calcutta: Calcutta Publication Co.), page No.60.

from visual as well as auditory conditions point of view. Economically, capacity should be such that it will offer the maximum returns out of the owner's investment. Capacities of 500 and less, are uneconomical as their initial and operating costs are higher as compared to returns. Cinema having capacity more than 1000 seats are more costly to erect as they require additional subsidiary requirements such as provision of elaborate mechanical equipments, additional toilet facility, exits to allow free passages for the patrons to leave the house, excessive circulation area, and car parking which requires ample space etc. It ultimately results in larger investment and running costs, and comparatively lesser profit. Therefore, there is a need of optimisation of capacity and the criteria for that should be the returns from cinema, which depend upon the following factors:-

1. Situation of cinema,
2. Proximity of other cinema,
3. Transportation facilities,
4. Density of catchment area,
5. Socio-economic pattern of catchment area,
6. Good design layout of interior,
7. Type of machinery and equipments used,

8. Type of presentation,
9. Amenities like push back seats, car parking etc.
10. Quality of film shown,
11. Management techniques,
12. Capacity.

It is very difficult to workout the optimum capacity of theatre as there are a number of variables. So, for simplification, the author has assumed all variables, except capacity, constant and the variation in the income with respect to capacity has been surveyed. The results are given as follows.

Name of Cinema	Capacity (seats)	Net income per seat per week in paise.
Defence	300	20
Laxmi	400	75
Excelsior	500	150
Radhu	600	250
Novelty	700	325
Sudarshan	800	375
Plaza	875	495
Sapna	1000	375
Amba	1020	370
Chanakya	1085	355

PART-IV

CHAPTER NO.11

EVOLUTION OF PLANNING STANDARDS

11.0 General

Standardisation of planning factors has a dominant role in the design process which ultimately leads to saving in resources, time and energy, and simplifies the design process. Keeping in view the importance of standards, it is essential that the standards should be formulated on correct and logical basis. The study of the past practice and theoretical knowledge provides reasonable basis for evolution of standards for a particular purpose. Standards based on such a system will help the architect to use them for their individual problems without depending on foreign standards. This need has been felt by Indian Standards Institution, which took initiative and formulated BYELAWS FOR CONSTRUCTION OF CINEMA BUILDING (IS: 4878). However, these bye-laws did not adequately consider the planning factors dealt in this study. Based on the basic study and the conclusions of survey of ten cinema theatres of Delhi, the standards for the following planning factors have been evolved.

11.1 Volume

To decide the volume of the auditorium, the following considerations have been taken into account.

i) Architectural,

ii) Physiological, and

iii) Acoustical.

Volume can be controlled by the height of the auditorium. Architecturally, the height-width ratio should be within 1:1.5 to 1:2 for better proportion which should also facilitate the projection of the picture and sight line to each patron.(1) These two factors should be taken into account before deciding the height of the hall. However, it should not be less than 20 ft.(2)

Physiologically, man needs air of 7.5 c.ft. per minute for his respiration in sitting position and 3 to 4 air changes/hour due to vitiation of air by body odours and sweating(3). These conditions demand 112 c.ft. to 150 c.ft. volume/person (Graph No.8 on Plate No.38).

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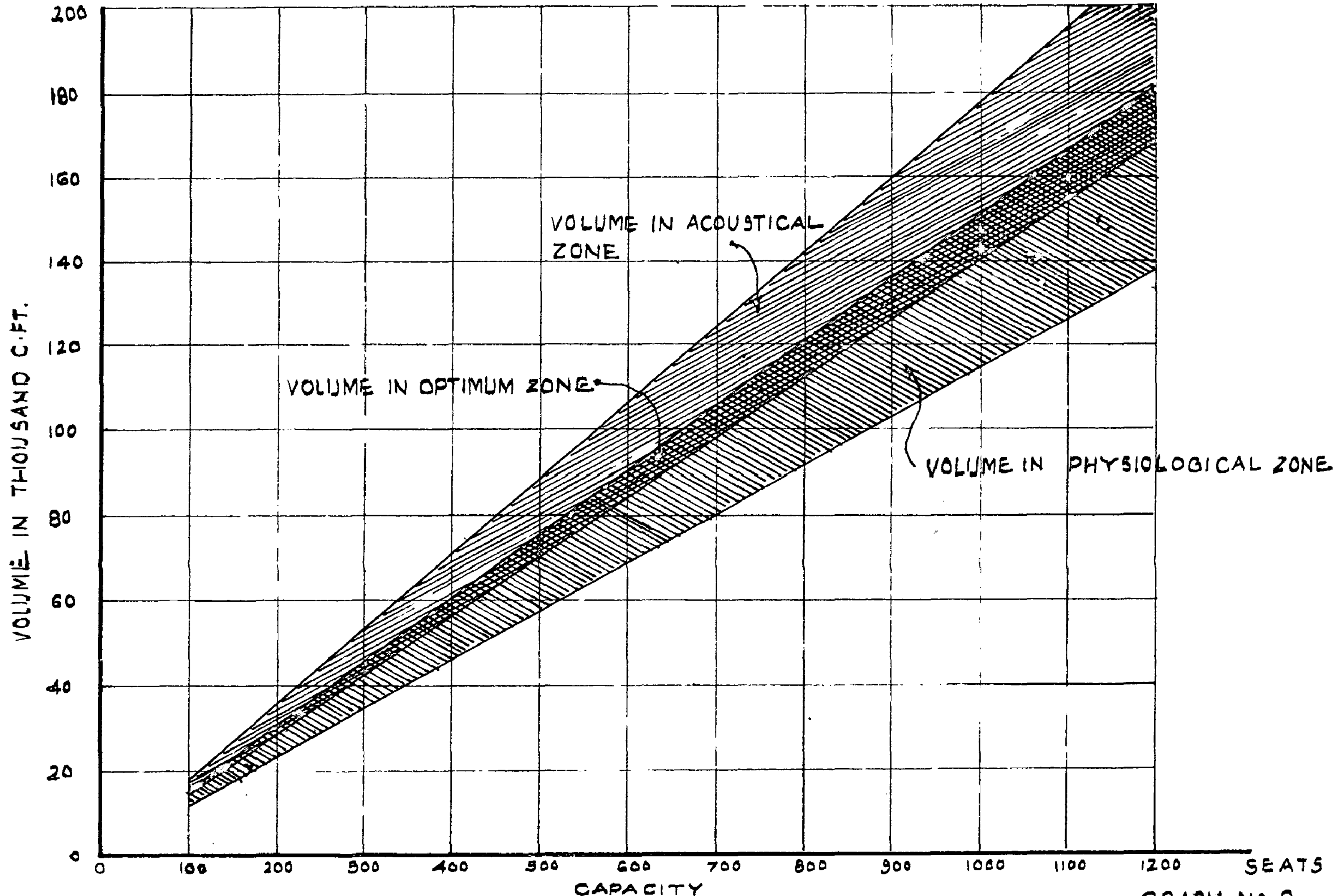
1. Callender 'Time Saver Standandards'.
2. IS: 4878- 'Byelaws for Construction of Cinema Buildings'.
3. ASHRAE GUIDE-1962.



GRAPH. NO. 8.

OPTIMISATION OF VOLUME FOR CINEMA AUDITORIUM.

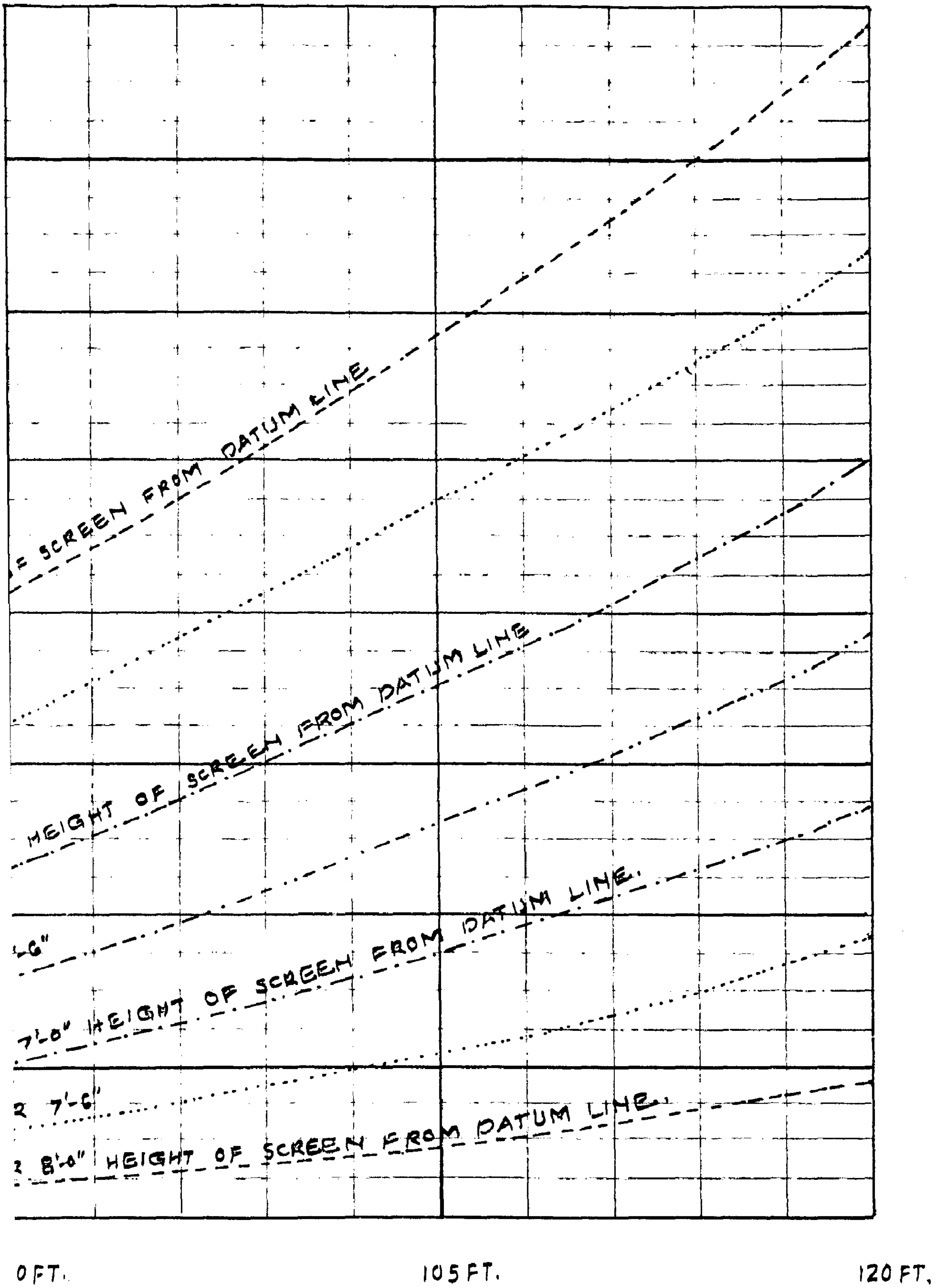
PLATE NO. 80.

Acoustically, it should range from 140 c.ft. to 175 c.ft./person as per IS: 2516[4]. It is, therefore, concluded that 140 c.ft. to 150 c.ft. is the optimum range of volume which compromises, both, acoustical and physiological requirements.

11.2 Slope

The contours of cinema auditorium floor should provide clear sightline to each patron and the departure of floor from the horizontal should be minimum as far as possible. From economy in construction point of view. The characteristics of slope depends upon the height of the bottom edge of screen from datum line and the depth of the seating area. From basic study and survey, it has been pointed out that lower screen height from datum line, offers lesser departure from horizontal in front seating area, than in rear seating area; whereas higher screen height from datum line, offers more departure from horizontal in front seating area, than in rear seating area. So, to find out the amount of variation in departure from horizontal, with respect to height of the screen from datum line, author has prepared a graph, which also provides

4. IS:2516- 'Code of Practice for acoustical Design of Auditorium and Conference Halls'.



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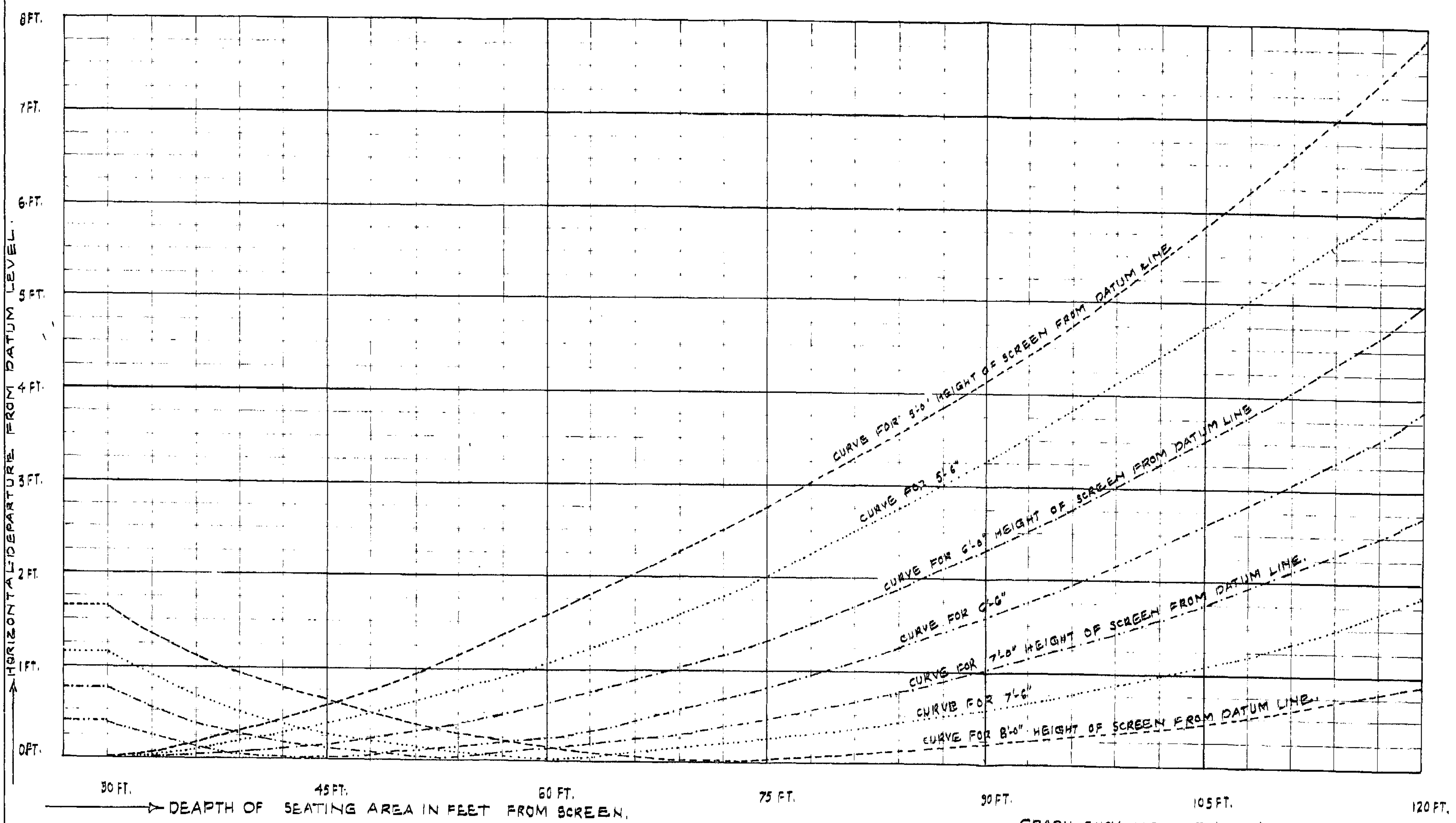
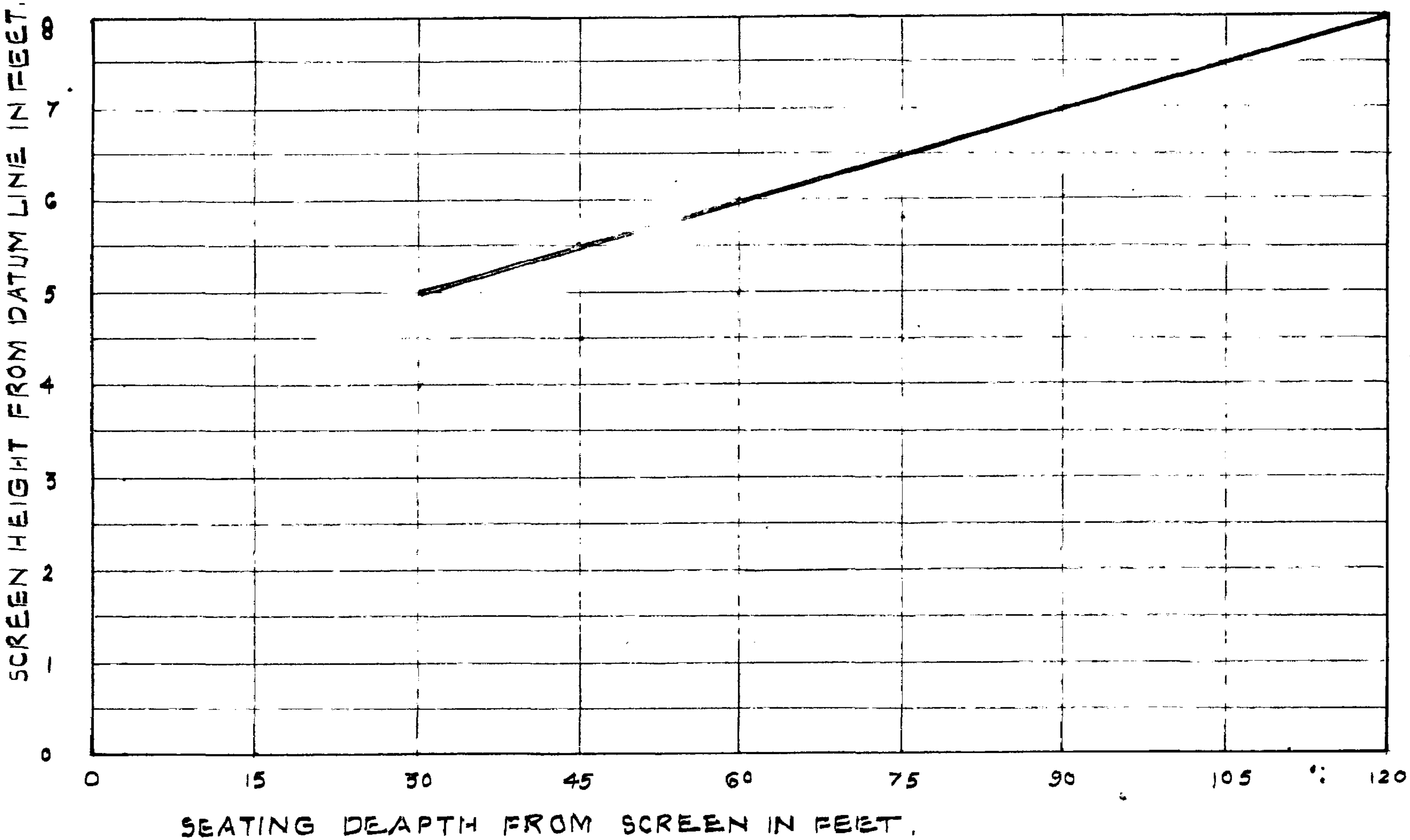
GRAPH SHOWING THE ELEVATIONS OF FLOOR SLOPE FOR VARYING HEIGHTS OF SCREEN WITH RESPECT TO DEAPTH OF SEATING AREA - GRAPH NO. 9.



READY RECKONER FOR FLOOR SLOPE DESIGN

GRAPH SHOWING THE ELEVATIONS OF FLOOR SLOPE FOR VARYING HEIGHTS OF SCREEN WITH RESPECT TO DEAPTH OF SEATING AREA - GRAPH NO. 9.

PLATE NO. 39



OPTIMUM SCREEN HEIGHT W.R.T. SEATING DEAPTH. GRAPH NO. 10.

PLATE NO. 40

ready reckoner for floor slope design (Graph No.9 in Plate No.39). From this analytical study of various curves of floor slopes, optimum screen heights with respect to seating depths have been investigated and plotted in Graph No.10 (Plate No.40). It gives optimum screen height which will offer optimum departure from horizontal and clear sightline to each patron in the auditorium.

11.3 Seat

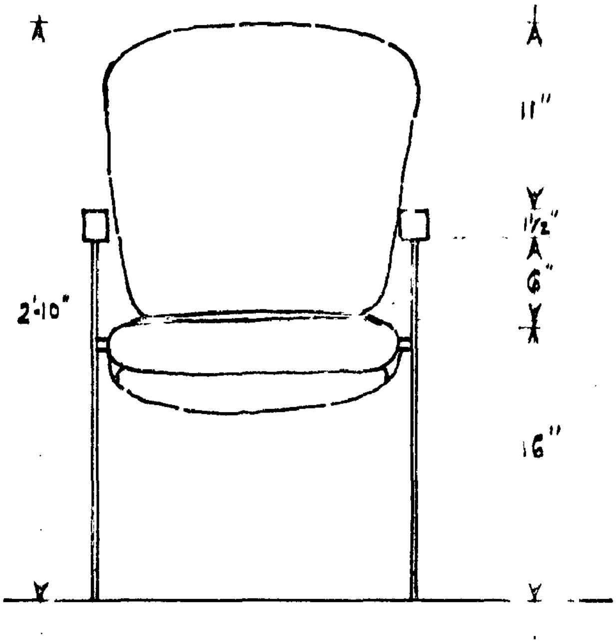
The standards for seat dimensions have been worked out after studying the anthropometric and physiological study of comfortable seating with the prevailing conditions. They are mentioned under the following heads. (also in Fig.No.11.1).

(i) Seat Height from the Floor

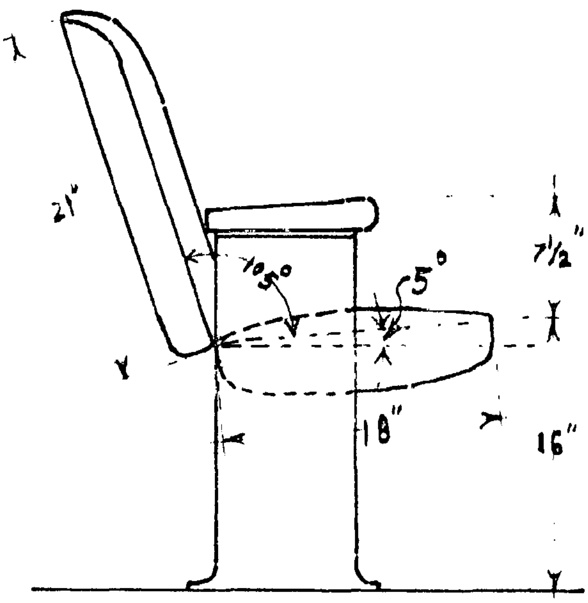
16" seat height from floor should be adopted as it compromises the range for comfortable seating (Fig.No.8.10) and prevailing practice.

(ii) Depth of Seat

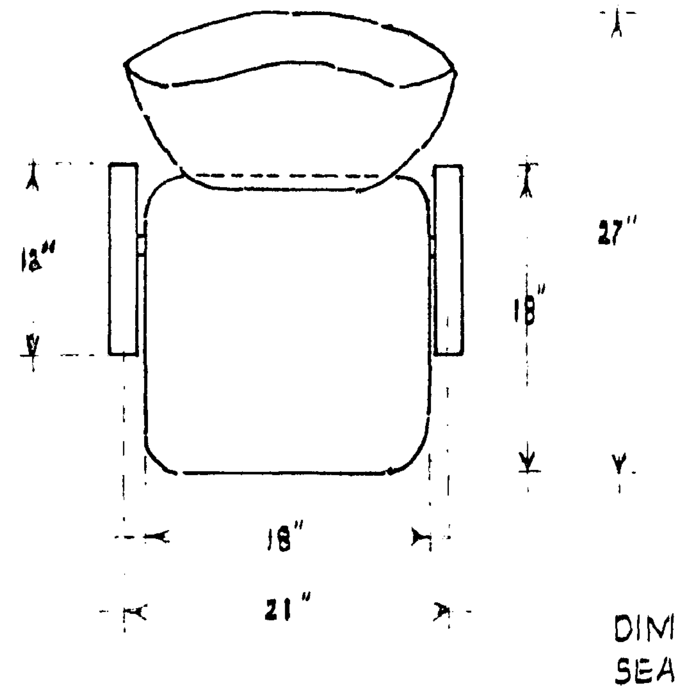
It should be 18". Though, it does not fall in the comfort zone (Fig.No.8.11) , it will not create possibility of resting thighs on seat at alternative positions, thereby will decrease tiredness due to compression of thigh muscles, because it is observed



FRONT ELEVATION



SIDE ELEVATION



DIMENSIONS OF SEAT.

PLAN OF RECOMMONDED SEAT.

FIG. NO. 11.1.

PLATE NO. 41

that people leave a gap of $1\frac{1}{2}$" to 2" between buttock and back rest.

(iii) The Slope of the Seat

5° to 8° to the horizontal is the comfort range for seat slope. (Fig.No.8.12)[5]. 5° is found more optimum to resist the tendency of sliding forward.

(iv) Angle of Seat to Back Rest

Physiological study suggests the maximum and minimum values of trunk-thigh angle. They are 135° and 105° respectively[(5)]. 120° is the average value for the balance relaxation. But from the visual comfort point of view, the axis of trunk should be parallel to the screen, which is always at 90° to the horizontal. Therefore to compromise the physical and visual comfort, the mean of these values is taken. It worked out 105°.

(v) Back Height

The mean value of maximum and minimum shoulder measurement, with 1" additional to compromise prevailing conditions, comes to 21". It supports the optimum part of the back which takes care of the spinal column.

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5. Bullivant, Durgan, " The Design of Comfortable Chairs," Architectural Design Dec, 1951 and Aug. 1954.

(vi) Seat Width

Maximum human dimension is accepted, keeping 2" allowable clearance for clothes and swivelling of face in all direction. It measures 18" in width.

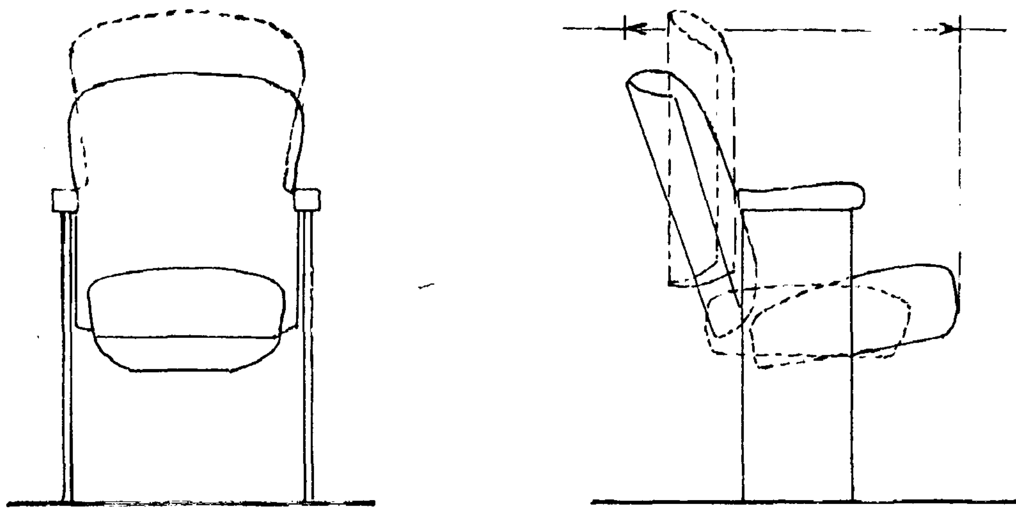
(vii) Arm Width

It necessitates similar consideration as seat width. Hence 20" which is the maximum dimension of arm width with 1" clearance for movement of arms should be provided.

(viii) Arm Height from Seat

$7\frac{1}{2}$" is the average value which will provide the comfort to maximum patrons.

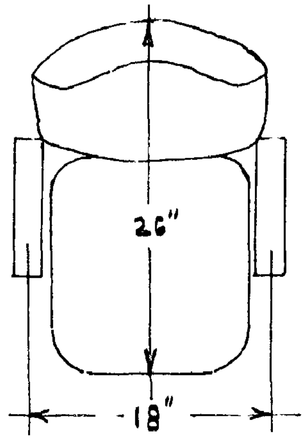
The above evolved standard dimensions for seat, are for bare seat. For additional comfort, it should be upholstered with spongy upholstry material, which necessitates the modifications in standard dimensions. The designer will have to derive his own dimensions which will retain the standard dimensions after application of upholstry materials. This modification in the standard dimensions, depends upon the physical properties of materials used for upholstry. Moreover, there cannot be standardisation in materials to reserve the freedom of designer in selection of materials, but he should be conscious enough to



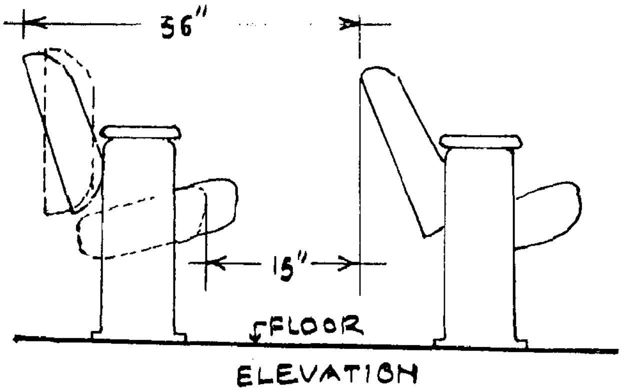
ELEVATION

FIG. NO. 11.2

SIDE ELEVATION



PLAN OF
STANDARD SEAT



SPECING BETWEEN ROWS.

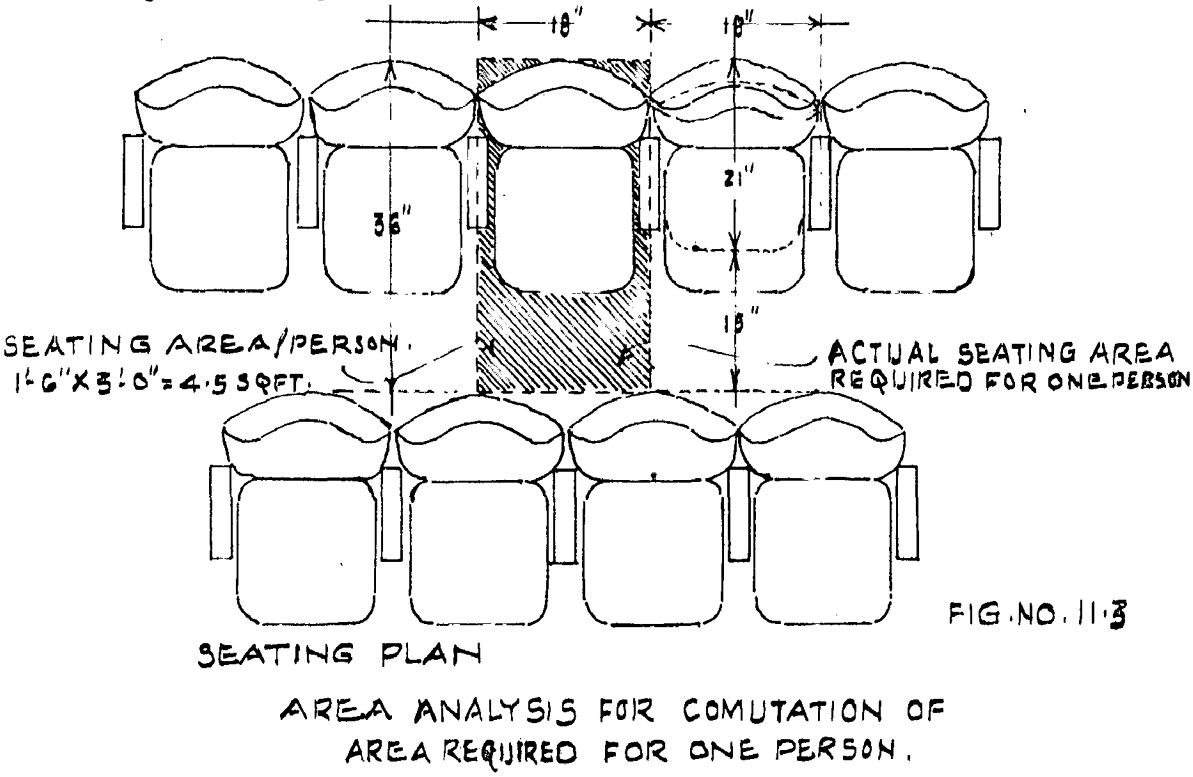


FIG. NO. 11.3

SEATING PLAN

AREA ANALYSIS FOR COMUTATION OF
AREA REQUIRED FOR ONE PERSON.

achieve the standard dimensions after upholstring the seat.

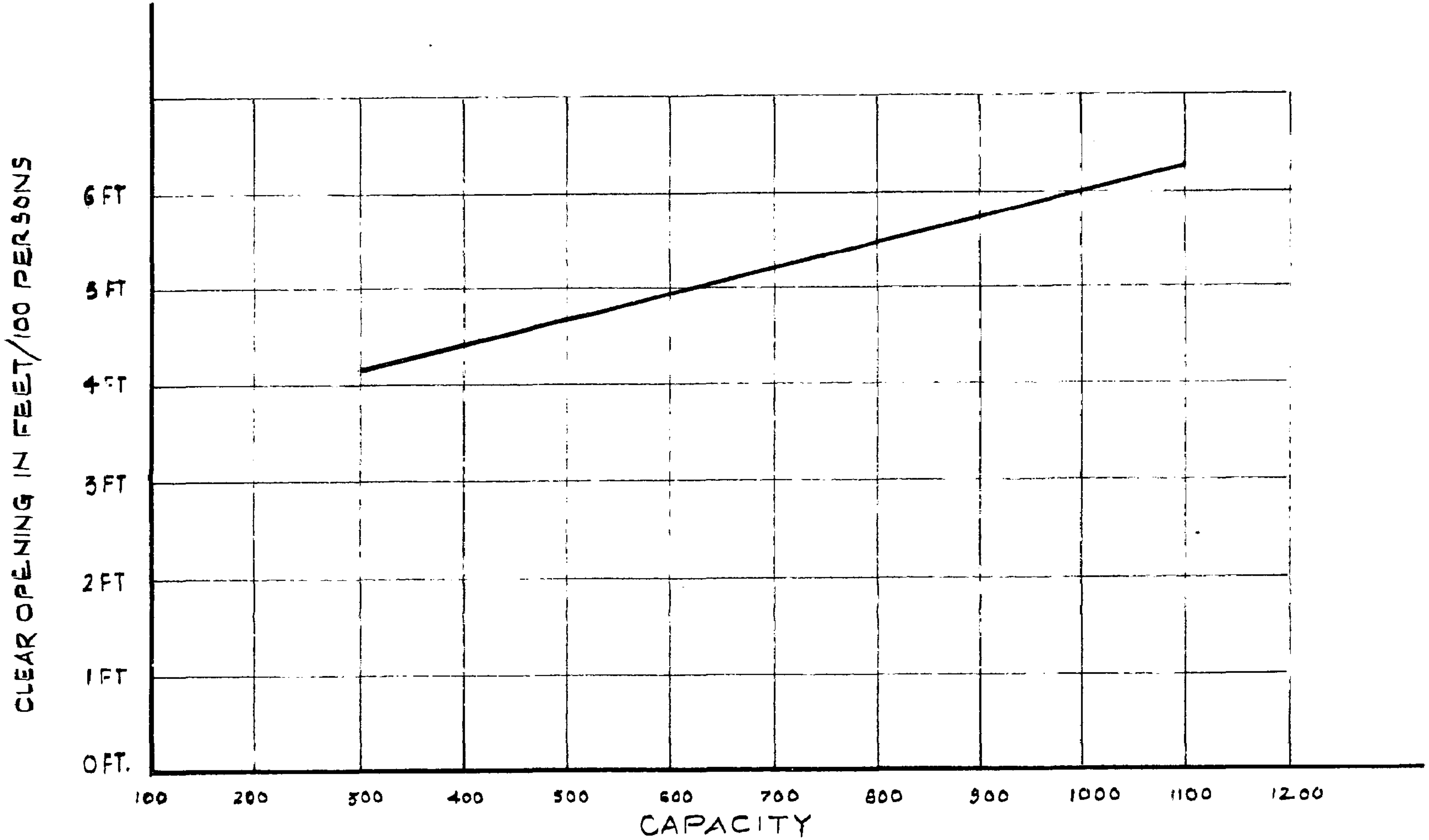
11.4 Area

Theoretically, actual seating area depends upon the overall dimensions (Fig.No.11.2) of comfortable seat and intervening space between the rows of seat to facilitate the passing of patron with minimum body contact (Fig.No.11.3). Taking overall seat dimensions from standards mentioned above and 1'-3" intervening space according to IS:4878[(2)], the space dimensions for a person, measures 3'-0"x 1'-6" which comes to 4.5 sq.ft. It also coincides the average values in the prevailing conditions and the range suggested by ISI. in IS:2516[(4)].

The circulation area has been calculated from the ratio of seating area to circulation area. Survey results show that the ratio of 1:0.55 is optimum, which gives the circulation area 2.5 sq.ft./ person. Therefore, the gross area which includes the actual seating area and circulation area, worked out 7 sq.ft./person.

11.5 Exits

For working out the number and sizes of the exits, a graph has been prepared by the author,



GRAPH SHOWING VARIATION IN CLEAR OPENING IN FEET/100 PERSONS.

GRAPH. NO. 11.

PLATE NO. 43

INCREASE (IN INCHES) PER ROW/SEAT OF SEATING AREA.

SEAT SPACING BACK TO BACK	FACTOR FOR CENTRTAL GANGWAY	FACTOR FOR SIDE GANGWAY
32"	1·3	·65
34"	1·4	·70
36"	1·5	·75
38"	1·6	·80

NOTE- PROPER FACTOR X NO. OF ROW = TOTAL INCREASE IN INCHES. ADD TO 4'-0" MINI. GANGWAY WIDTH.

TABLE NO 4

SEAT WIDTH ARM TO ARM	FACTOR FOR CROSS GANGWAY
18"	1·5
19"	1·58
20"	1·66
21"	1·75

NOTE- PROPER FACTOR X NO OF SEATS = TOTAL INCREASE IN INCHES. ADD TO 3'-3" MINI. CROSS-GANGWAY WIDTH.

TABLE NO. 5.

CHART FOR COMPUTATION OF GANGWAY OR AISLE WIDTH

PLATE NO. 44

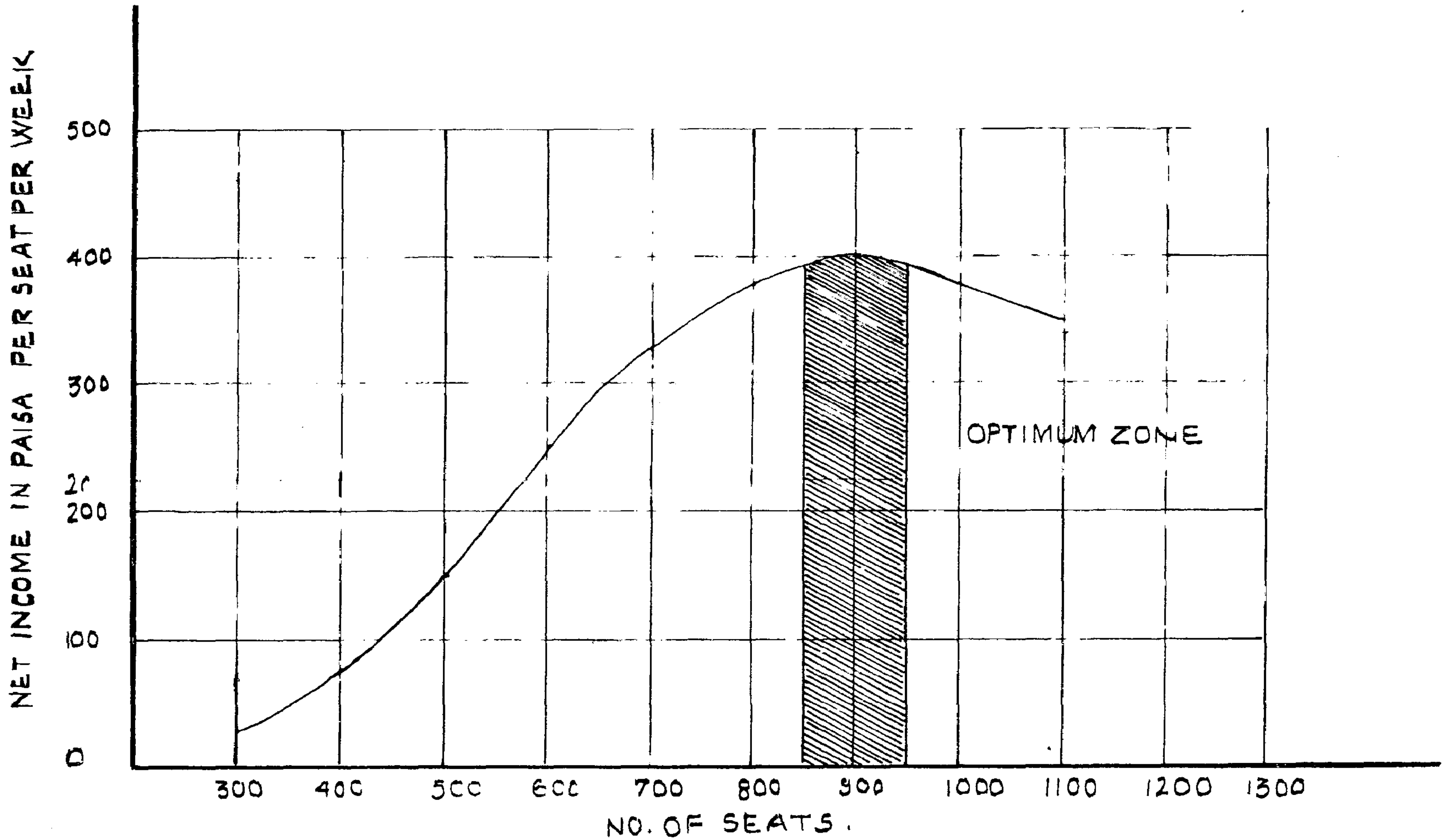
which takes care of the requirements of fire safety and physical requirement such as additional exits which are required for the egress of patrons after the end of the performance (Graph No.11 on Plate No.43.) Because 40%. to 60%. of the total exit have to be closed at the end of the previous performance.

11.6 Gangways

The width of gangway should vary with number of the persons using it or the seating area it has to serve. In other words there should be some relationship between the width of gangway and the length of seating area, it has to serve. This relation has been expressed by the author in table No.4 and 5 (Plate No.44), from which the width of the longitudinal and cross gangway can be calculated by adding the total increase/row or seat to the minimum width of the gangways. Minimum with 4'-0" for longitudinal gangways and 3'-3" for cross gangways have been suggested by ISI in IS: 4878[2].

11.7 Capacity

The economic returns have been assumed as a criterion for deciding the optimum capacity and a



GRAPH SHOWING THE VARIATION IN NET INCOME PER SEAT PER WEEK.

GRAPH. NO.12

PLATE NO. 45

graph has been plotted to investigate the characteristic of variations in income or returns of cinemas with varying capacity from 300 to 1085 seats (Graph No.12 on Plate No.45). The figures are obtained in survey. From the curve, it is concluded that the theatres with the capacity between 850 to 950 seats can be assumed as an optimum capacity for Delhi city.

PART - V

CHAPTER -12

RECOMMENDATIONS AND CONCLUSIONS

12.0 General

Considering the progress made by the audio-visual facility, its patronisation by various societies and potentials, it has in future with respect to its values in recreation, education, business and mass communication, this study has been carried out by the author. Especially the recreational value of audio-visual facility has been increased remarkably. With the results, the number of new cinema theatres are rapidly coming up in present stage of development. They are based on few cinematography byo-laws formulated since long. As already mentioned that recent efforts to bring them to date have been made, but it is felt that some of the vital areas still have not been considered and this study focuses such areas for consideration. At the same time, in some areas, attempts are made to suggest new standards. Table No.6, (Plate No.46) shows the work done on planning standards for cinema

FUNCTIONAL REQUIREMENTS.			PLANNING FACTORS	STANDARDS		
				FORMULATED BY AUTHOR	ANALYSED AND RECOMMANDED	NOT CALLED FOR.
COMFORT	AUDITORY		SHAPE			
			VOLUME			
			SURFACE TREATMENT			
	VISUAL		SLOPE			
			SEATING AREA			
	PHYSICAL	ENVIRONMENT	CONSTRUCTION TECHNIQUES FOR THERMAL INSULATION			
		SEATING	SEAT			
			LAY-OUT			
			AREA			
SAFETY	FIRE SAFTEY.		EXIT			
			GANGWAY			
OPTIMUM			CAPACITY			

CHART SHOWING THE WORK DONE ON PLANNING STANDARDS FOR CINEMA AUDITORIUM.

TABLE NO. 6.

CAPACITY			AREA	VOLUME	SEATING	OPTIMUM SLOPE		EXIT IN RUNNING FT. (TOTAL)
TOTAL	MAIN FLOOR	BALCONY			DEAPTH	TOTAL RISE.	SCREEN HEIGHT	
500	500	0	3500 S.FT.	75000 C.FT	16 ROWS	1'-0"	6'-9"	23.5 FT.
750	575	175	5250 S.FT.	110000 C.FT.	20 ROWS	1'-0"	7'-0"	40 FT.
1000	750	250	7000 S.FT.	145000 C.FT.	25 ROWS	1'-1½"	7'-3"	60 FT.
1250	925	325	8750 S.FT.	180000 C.FT.	26 ROWS	1'-3"	7'-6"	83.5 FT

VARIATION IN PLANNING FACTORS
WITH RESPECT TO CAPACITY

TABLE NO. 7.

PLATE NO. 47.

auditorium by the author. During the deliberation of this work, consideration of basic study, cinematograph regulations laid by the old institutions, existing standards as formulated by ISI and the standards in vogue have been taken into account. Keeping in view the functional requirements i.e. comfort and safety, the following recommendations for planning factors have been made, and the variations in the planning factors with respect to certain capacities have been shown in Table No.7 (Plate No.47).

12.1 Recommendations

12.1.1 For Auditory Comfort

12.1.1.1 Shape-

The rectangular shape of hall with length-width ratio 1:0.6 and wedge (fan) shape of hall with length with ratios 1:0.6, and 1:0.8 should be adopted for cinema presentation (Fig.No.12.1 and 12.2). Wedge shape should be prefered as it offers good auditory as well as visual conditions.

12.1.1.2 Volume

The volume of auditorium should be within the range of 140 c.ft. to 150 c.ft./person. It

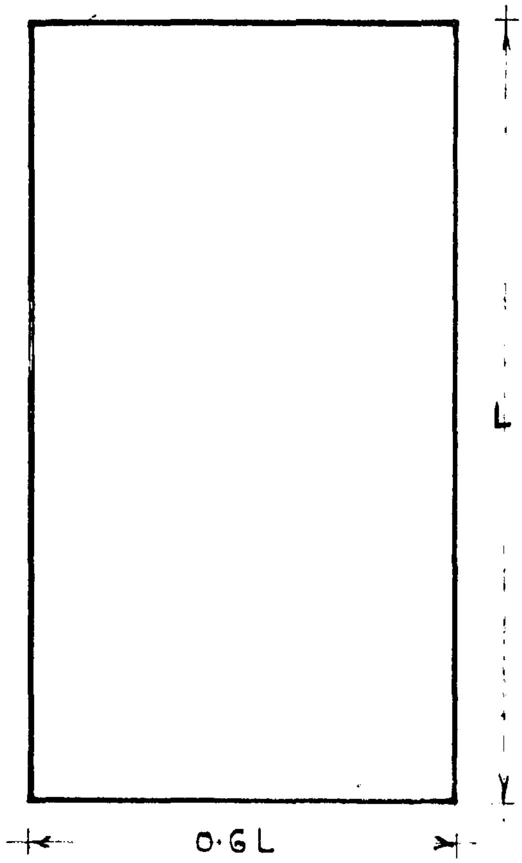
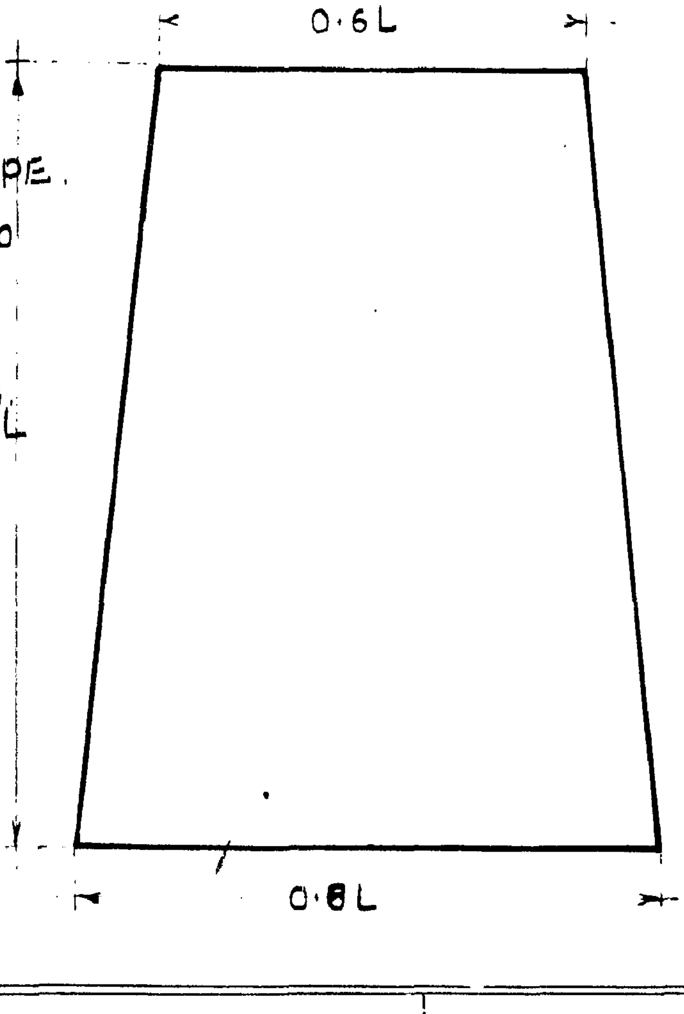


FIG. NO. 12·1

RECTANGULAR SHAPE

ROOM RATIO
1 : 0·6
LENGTH : WIDTH



WEDGE SHAPE.

ROOM RATIO
1 : 0·6
1 : 0·8
LENGTH : WIDTHS.

FIG. NO. 12·2

satisfies both, acoustical as well as physiological requirements. Graph No.8 (Plate No.38) offers the ready reckoner for volume with respect to capacity. The height of the auditorium should be such that it will satisfy the architectural problems such as sightline, unobstructed projection and proportion of hall etc. However, it should not be less than 20 ft.

12.1.1.3 Surface Treatment

There cannot be any standardisation regarding the surface treatment, as the acoustical and interior design requirements differ from one situation to another. However, the selection of material should be in accordance with the fire safety.

12.1.2 For Visual Comfort

12.1.2.1 Slope

The graphs have been evolved by the author, which gives ready reckoner for departure of floor from horizontal and optimum heights of the screen from datum line with respect to seating depths (Plate No.39 and 40). However, for certain capacities, optimum slope data has been given in Table No.7.

12.1.2.2 Seating Area

For deciding the seating area, the following limits which take care of the cinematograph rules and the conditions imposed by the cinema equipment manufacturers, should be adopted.

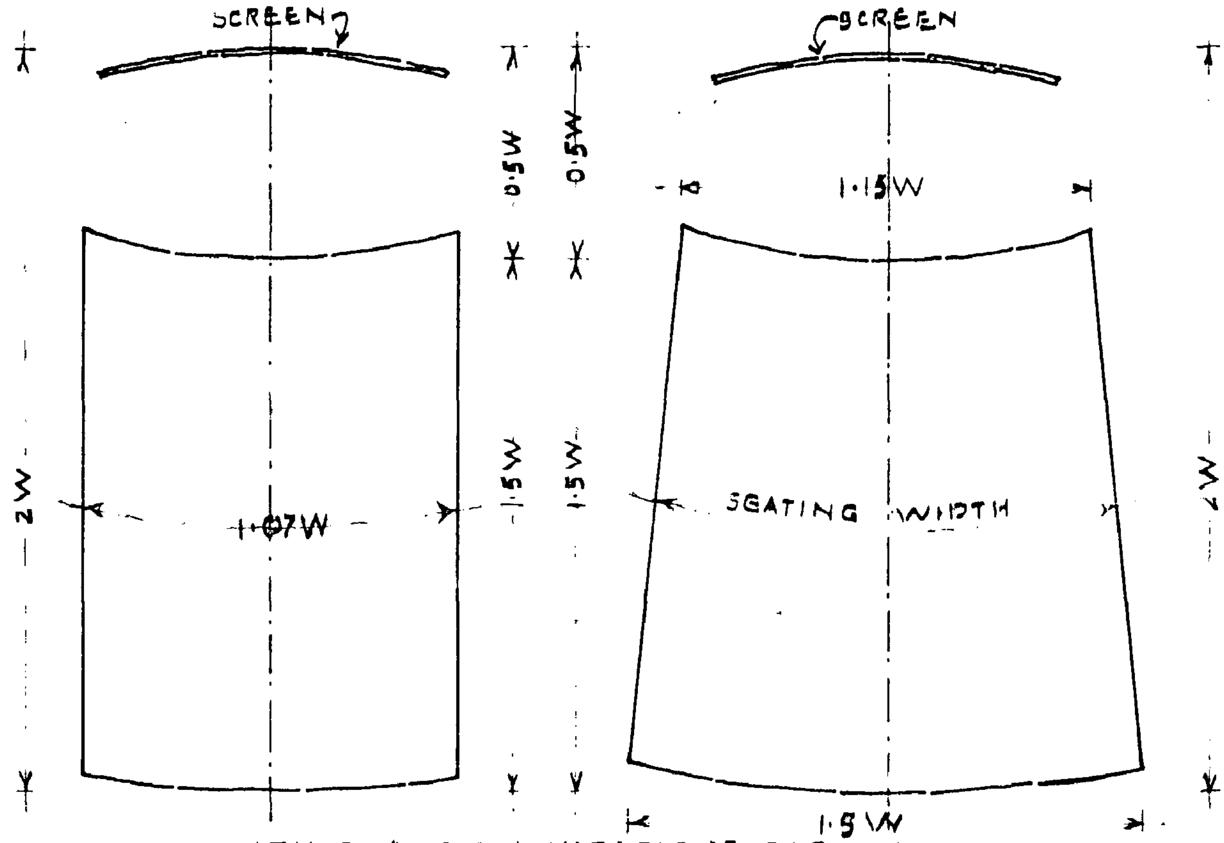
For 35 mm presentation, the maximum viewing distance should not be more 2W of the screen and the minimum distance should not be less than 1W of the screen. The width of the seating area should not be more than 3W for rectangular shape and 5.25W (major width) for width wedge shape (Fig.No.12.4).

For 70 mm presentation, the maximum viewing distance should not be more than 2W and minimum viewing distance should not be less than 0.5W of the screen. The width of the seating area should not be more than 1.15W for rectangular shape and 1.5 W (major width) for wedge shape (Fig.No.12.3).

12.1.3 For Physical Comfort

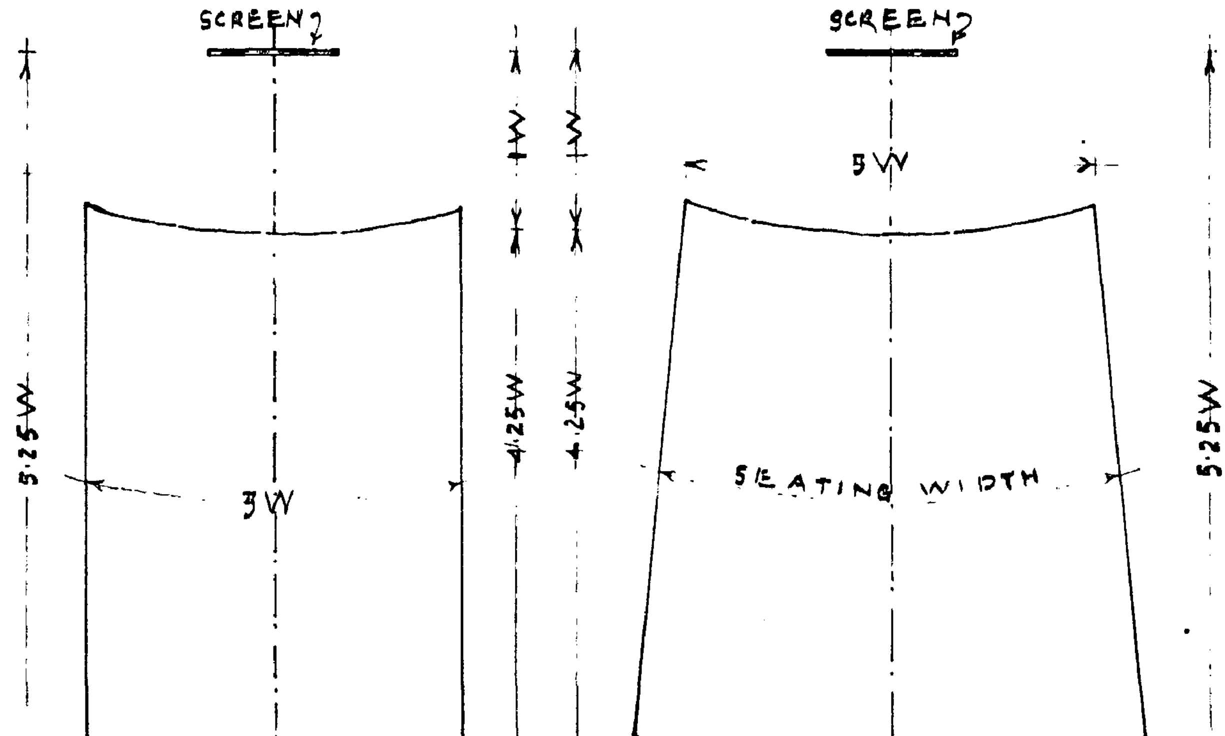
12.1.3.1 Construction Techniques for Thermal Insulation

Thermal insulation problems differ from situation to situation. Therefore, standards regarding to this respect cannot be called for. However, they should be solved through cavity wall construction,



SEATING AREA LIMITATIONS FOR 70MM PROJECTION

FIG. NO.12.3



SEATING AREA LIMITATIONS FOR 35MM PROJECTION.

FIG. NO. 12.4.

PLATE NO. 42

external and internal surface treatment, false ceiling etc.

12.1.3.2 Seat Design

The standards for seat dimensions arrived at, are as follows (Fig.No.11.1 on Plate No.41).

(i)	Seat height from floor	... 16"
(ii)	Depth of the seat	... 18"
(iii)	The slope of the seat	... 5°
(iv)	Angle of seat to back rest	... 105°
(v)	The back height	... 21"
(vi)	Seat width	... 18"
(vii)	Arm width	... 21"
(viii)	Arm height from seat	... $7\frac{1}{2}$"

The seat design should be such that it will retain the above recommended dimensions after upholstering the seat.

12.1.3.3 Seat Layout Design

The seat spacing of 36" back to back is considered optimum which provides an adequate intervening space (1'-3") between rows, and the seats should be arranged staggered in curved rows which offers physical as well as visual comfort.

12.1.3.4 Area

The gross area which includes the actual seating area and circulation area should be 7 sq.ft./ person.

12.1.4 For Fire Safety

12.1.4.1 Exits

The size and the number of the exits should be worked out from the graph developed by the author and their locations in relation to seating area and gangways should be in accordance with the byelaws prepared by ISI (Graph No.11 on Plate No.43). However, the minimum clear opening of exit should not be less than 4'-0".

12.1.4.2 Gangways

The widths of gangways should be calculated from the Table No.4 and 5 (Plate No.44) developed by author and their location in the seating areas should be in accordance with the byelaws prepared by ISI. Minimum width of 4'-0" for longitudinal gangways and 3'-3" for cross gangways should be taken.

12.1.5 For Optimum Capacity

The capacity of the theatres proposed in future, should be within the range of 850 to 950 seats, which will offer the maximum economic returns out of the enterpreneur's investment.

12.2 Conclusions

In the light of the study presented in this dissertation, the recommendations arrived at, for the standards for physical planning to achieve auditory, visual and physical comforts, and fire safety, deserve implimentations in the cinematography rules, ISI Standards and text or reference books on design standards. If this is done, a great stride forward is possible in quick and efficient planning of the cinema theatres which provides recreation to some and education to others, expands business, informs people about happenings in the world and also serves as a social entity.

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APPENDIX -A

Findings of survey of 2000 persons representing 2000 families, selected at random from Nainital, Meerut and Delhi to analyse the composition of cinema audience and their proportion.

FREQUENCY OF CINEMA GOING

Table I. Analysis by sex

Results on the basis of sex	Percentage of cinema goers.	Percentage of whole samples
Women	49%.	38%.
Men	51%.	62%.

Table II. Analysis by age

Results on the basis of age group	Percentage of cinema goers	Percentage of whole samples
12 to 17 yrs.	10%.	7%.
18 to 30 yrs.	35%.	25%.
31 to 40 yrs.	23%.	15%.
41 to 45 yrs.	12%.	15%.
46 to 65 yrs.	19%.	23%.
over 65 yrs.	1%.	15%.

Table III- Analysis by marital status

Results on marital basis	Percentage of cinema goers	Percentage of whole samples
Married	41%.	80%.
Single*	59%.	20%.

* Single person consists unmarried, widows and divorced.

Table IV- Analysis by economic groups

Results on economic basis	Percentage of cinema goers	Percentage of whole samples
1. Lower group Rs.30 to 150 p.m.	60%.	60%.
2. Middle group Rs.151 to Rs. 500 p.m.	29%.	20%.
3. Higher group Rs.500/- p.m. and onwards	9%.	10%.
4. Unclassified.	2%.	10%.

Ref. Dr. Rikhab Jain, 'Economic Aspects of Film Industry', Ph.D. Thesis, Page No.22.

APPENDIX "B-1"

Sound Absorption Coefficient of Acoustical Materials

Sl. No.	Material	Manufacturer	Thickness inches (cms)	Density lb/cu. ft. (kg/cu.m)	Absorption coefficients at 500 c/s	Mounting (a)
1.	Scrim mat fibreglass	The Bombay Co. Pte. Ltd. Bombay	1.0(2.5)	5.00 (80.0)	0.85	With rigid backing (Mounting No.1)
2.	-do-	-do-	2.0(5.0)	"	0.99	-do-
3.	-do-	-do-	2.0(5.0)	"	0.99	With rigid backing and a perforated hard board facing (10% open area)
4.	-do-	-do-	1.0(2.5)	"	0.99	-do-
5.	Sitatex-perforated 1600 (Standard)	Plywood Products Sitapur U.P.	0.75(1.9)	-	0.52	With rigid backing (Mounting No.1)
6.	-do-	-do-	0.50(1.3)	"	0.30	-do-
7.	Sitatex-perforated Random (Standard)	-do-	0.75(1.9)	-	0.56	-do-
8.	-do-	-do-	0.50(1.3)	-	0.34	-do-
9.	Uniformly perforated Jolly-Board (each Unit 2'x2')	Anil Hard boards, Bombay	0.50(1.27)	18.61 (300.0)	0.55	-do-
10.	Randomly perforated Jolly-Board (each Unit 2'x2')	-do-	0.50(1.27)	"	0.52	-do-
11.	Fibrosil	Indian Rockwood Co. (Pvt) Ltd. Delhi	1.00(2.5)	6.00 (98.00)	0.74	-do-

Ref. Building Digest, No.39, 'Sound Absorbing Materials and their Utility in Acoustics and Noise Control', (Roorkee: Central Building Research Institute), page No.4.

APPENDIX 'B-2'

Sound Absorption Coefficients of General Building Materials and Furnishings.

S.No.	Materials	Coefficient 500 cycles/second
1.	Ordinary Wall and Ceiling Surfaces	
	(a) Open windows	1.0
	(b) Brick, marble, glass, ordinary plaster etc.	0.01-0.03
	(c) Varnished wood	0.03-0.08
	(d) Wood panelling on studs	0.1-0.2
	(e) Porous breeze blocks, unplastered	0.4
	(f) Fire Board panelling	0.2-0.3
	(g) Curtain, cretonne	0.15
	(h) Curtains, medium weight	0.2-0.4
	(i) Curtains, heavy in folds	0.5-1.0
2.	Floor Coverings	
	(a) Wood floor	0.03-0.08
	(b) Linoleum,rubber carpet	0.1
	(c) Carpet	0.15
	(d) Carpet, heavy pile on thick underfelt	0.3-0.5
	(e) Audience as ordinarily seated.	0.96
3.	Special absorbants	
	(a) Acoustic Plaster and Tiles	0.2-0.35
	(b) Felt with muslin cover,distempered and perforated	0.75
	(c) Fiber board tiles, perforated or slotted.	0.5-0.05
	(d) Slag wool, wood wool, loose felts etc.1"thick.	0.55-0.8
4.	Individual Objects	
	(a)Wood seats for auditoria/seat	0.1-0.2
	(b) Upholstered seats per seat	1.0-2.0
	(c) Upholstered chair/chair	3.0
	(d) Audience/ person	4.7

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Ref. Stote(ed.) "Acoustical Materials', Motion Picture Theatre,Planning and Upkeep, S.M.P.T.E. New York, U.S.A.

APPENDIX - 'C'

SCREEN WIDTHS (ARC OF PICTURE) AND RISE OF ARC (DEPTH OR CURVE) WHEN PICTURE WIDTH AND PROJECTION THROW ARE KNOWN
PROJECTION THROW

Chord of Picture Width

r	60		70		80		90		100		110		120		130		140		150		160		170		180		190		200	
C	A	R	A	R	A	R	A	R	A	R	A	R	A	R	A	R	A	R	A	R	A	R	A	R	A	R	A	R	A	R
24	24.2	1.2	24.1	1.0	24.1	0.9	24.1	0.8	24.1	0.7	24.1	0.7	24.1	0.6																
26	26.2	1.4	26.2	1.2	26.1	1.1	26.1	1.0	26.1	0.9	26.1	0.8	26.1	0.7	26.1	0.6														
28	28.3	1.6	28.2	1.3	28.1	1.2	28.1	1.1	28.1	1.0	28.1	0.9	28.1	0.8	28.1	0.7	28.1	0.6												
30	30.3	1.9	30.2	1.6	30.2	1.4	30.1	1.3	30.1	1.2	30.1	1.0	30.1	0.9	30.1	0.8	30.1	0.8	30.1	0.7										
32	32.4	2.2	32.3	1.9	32.2	1.6	32.2	1.5	32.1	1.4	32.1	1.2	32.1	1.1	32.1	1.0	32.1	0.9	32.1	0.8	32.1	0.8								
34	34.5	2.5	34.4	2.1	34.3	1.8	34.2	1.7	34.1	1.5	34.1	1.4	34.1	1.2	34.1	1.1	34.1	1.0	34.1	0.9	34.1	0.9	34.1	0.8						
36	36.6	2.8	36.4	2.3	36.3	2.0	36.3	1.9	36.2	1.7	36.2	1.8	36.1	1.4	36.1	1.3	36.1	1.2	36.1	1.1	36.1	1.0	36.1	1.0	36.1	0.9				
38	38.7	3.1	38.5	2.6	38.4	2.5	38.3	2.1	38.2	1.9	38.2	1.7	38.2	1.5	38.1	1.4	38.1	1.3	38.1	1.2	38.1	1.1	38.1	1.0	38.1	0.9	38.1	0.9		
40	40.8	3.4	40.6	2.9	40.4	2.5	40.4	2.3	40.3	2.1	40.2	1.9	40.2	1.7	40.2	1.6	40.1	1.5	40.1	1.4	40.1	1.3	40.1	1.2	40.1	1.1	40.1	1.0	40	
42	42.9	3.8	42.7	3.2	42.5	2.8	42.4	2.5	42.3	2.3	42.3	2.1	42.2	1.8	42.2	1.7	42.2	1.6	42.1	1.5	42.1	1.4	42.1	1.3	42.1	1.2	42.1	1.1	42.	
44	45.1	4.2	44.8	3.5	44.6	3.1	44.5	2.8	44.4	2.6	44.3	2.3	44.2	2.0	44.2	1.9	44.2	1.7	44.2	1.6	44.1	1.5	44.1	1.4	44.1	1.3	44.1	1.2	44.	
46	47.2	4.6	46.9	3.9	46.7	3.4	46.6	3.0	46.4	2.7	46.4	2.4	46.3	2.2	46.2	2.1	46.2	1.9	46.2	1.8	46.2	1.7	46.2	1.6	46.1	1.5	46.1	1.4	461	
48	49.4	5.0	49.1	4.3	48.8	3.7	48.7	3.3	48.5	3.0	48.4	2.7	48.3	2.4	48.3	2.2	48.2	2.0	48.2	1.9	48.2	1.8	48.2	1.7	48.2	1.6	48.1	1.5	48.	
50	51.6	5.5	51.2	4.7	50.9	4.0	50.8	3.6	50.6	3.3	50.5	2.9	50.4	2.6	50.3	2.5	50.3	2.3	50.2	2.1	50.2	2.0	50.2	1.9	50.2	1.8	50.2	1.7		
52	53.8	5.9	53.4	5.1	53.0	4.3	52.9	4.0	52.7	3.6	52.5	3.3	52.4	2.9	52.4	2.7	52.3	2.5	52.3	2.3	52.2	2.1	52.2	2.0	52.2	1.9	52.2	1.8	52.	
54			55.6	5.5	55.1	4.7	54.9	4.3	54.7	3.5	54.6	3.5	54.5	3.1	54.4	2.9	54.3	2.7	54.3	2.5	54.3	2.3	54.3	2.2	54.2	2.0	54.2	1.9	542	
56			57.7	5.9	57.2	5.1	57.0	4.6	56.8	3.6	56.5	3.6	56.5	3.3	56.5	3.1	56.4	2.9	56.3	2.7	56.3	2.5	56.3	2.3	56.3	2.2	56.2	2.1	56.	
58			59.9	6.4	59.3	5.4	59.1	5.1	58.9	4.7	58.7	4.2	58.6	3.6	58.5	3.3	58.4	3.1	58.4	2.9	58.3	2.6	58.3	2.5	58.3	2.3	58.3	2.2	58.	
60			62.1	6.9	61.5	5.8	61.3	5.3	61.0	4.8	60.8	4.3	60.6	3.8	60.6	3.6	60.5	3.3	60.4	3.0	60.4	2.8	60.3	2.7	60.3	2.5	60.3	2.4	60.	
62			64.3	7.4	63.7	6.2	63.4	5.7	63.1	5.2	62.9	4.6	62.7	4.1	60.6	3.8	60.5	3.5	62.5	3.3	62.4	3.0	62.4	2.9	62.4	2.7	62.3	2.6	66	
64					65.8	6.7	65.5	6.1	65.2	5.6	65.0	5.0	64.8	4.4	64.4	4.1	64.6	3.8	64.5	3.5	64.5	3.2	64.4	3.1	64.4	2.9	64.3	2.8	64.	
66					68.0	7.1	67.7	6.5	67.4	5.8	67.1	5.2	66.9	4.6	66.8	4.3	66.7	4.0	66.6	3.7	66.5	3.5	66.4	3.3	66.4	3.1	66.2	2.9	66.	
68					70.2	7.6	69.8	6.9	69.5	6.2	69.2	5.6	68.9	4.9	68.8	4.6	68.7	4.3	68.6	4.0	68.5	3.7	68.5	3.5	68.4	3.3	68.4	3.1	68.	
70					72.4	8.0	72.0	7.3	71.6	6.6	71.3	5.9	71.0	5.2	70.9	8.9	70.8	4.6	70.7	4.2	70.6	3.9	70.5	3.7	70.5	3.5	70.4	3.4	70.	
72							74.2	7.7	73.7	6.9	73.4	6.2	73.1	5.5	73.0	5.2	72.9	4.8	72.7	4.5	72.6	4.1	72.6	3.9	72.5	3.7	72.4	3.4	72.	
74							76.5	8.2	75.9	7.4	75.5	6.6	75.3	5.9	75.3	5.5	74.9	5.0	74.8	4.7	74.7	4.4	74.7	4.2	74.6	3.9	74.5	3.7	74.	

where C = Chord, r = Radius, A = arc length R = rise

Note:- These figures may be used for screen or frame, the inside dimension of the frame being a minimum 12 inches greater than the screen.

Ref. E.H.McFarland, 'The Cinema and the new techniques', (The Construction department of 'Twentieth Century-Fox Film Corporation', U.S.A.), page No.19

APPENDIX -'D'

Estimated Nude Measurements of British Population Between the Ages of 18 and 40, taken by Furniture Development Council, Britain

	MEN					WOMEN				
	5%.	25%.	50%.	75%.	95%.	5%.	25%.	50%.	75%.	95%.
Stature	63'	65½"	69¼"	69"	71½"	59"	61½"	63¼"	65"	67½"
1. Underside of thigh from floor	15¼"	16"	16½"	17"	17¾"	14¼"	15"	15½"	16"	16¾"
2. Buttock back to calf	17"	18"	18¾"	19½"	20½"	16½"	17½"	18¼"	19"	20"
3. Seat width	12¼	13¼	13¾	14¼	15¼	13¼	14¼	14¾	15¼	16¼
4. Elbow width	14¾	16¼	17¼	18¼	19¾	13¼	14¾	15¾	16¾	18¼
5. Elbow height from seat	7	8	8¾	9½	10½	6¼	7¼	8	8¾	9¾
6. Shoulder height from seat	21	22¼	23	23¾	25	17¼	20½	21¼	22	23¼

Ref. Brigid, O'Donvan, 'Seating Dimensions- Theory and Practice', (Architectural Design, March, 1961), page, 31.

APPENDIX - "E" -1"

PROFORMA FOR SURVEY NO.1

M.N.KHANTE
M.Arch.II,
Department of Architecture,
University of Roorkee,
Roorkee, U.P.

THESIS PROJECT - PLANNING CRITERIA FOR AUDIO-VISUAL FACILITY WITH SPECIAL REFERENCE TO CINEMA AUDITORIUM

CASE STUDY - AUDITORY, VISUAL AND PHYSICAL COMFORTS, AND SAFETY ASPECTS OF CINEMA AUDITORIUM BETWEEN CAPACITY RANGE OF 500 to 1100 SEATS

SAMPLE NO.............

1. Name of Cinema ......
2. Name of interviewer ...... Shri ....
3. Date of Interview

QUESTIONNAIRE

GENERAL

1. Name of Cinema ....
2. Location ....
3. Grade ....
4. Capacity (Total) .... on main floor ....
   on balcony ....
5. Year of construction ....

(A) For Auditory Comfort ....

(i) Experience of auditory performance from different positions,

(a) Shape.

(i) Form of Auditorium ....

(ii) Length-width ratio ....

(iii) Height-width ratio ....

(b) Volume

(i) Length of auditorium ....

(ii) Width ....

(iii) Height (Average) ....

(c) Surface Treatment

(i) Location of sound absorption surfaces ....

(ii) Location of sound reflecting surfaces ....

(iii) Materials used for sound absorption and reflection. ....

(iv) Type of sound system adopted ....

(v) No. of speakers ....

(vi) Position of speakers ....

(vii) Type of speakers ....

(B) For Visual Comfort ....

(i) Experience of visual performance from different positions.

(a) Slope

(i) height of the bottom edge of the screen from datum line ....

(ii) Type of Slope ......

(iii) Maximum departure of floor from horizontal in front and rear seating areas ......

(iv) maximum rise in two rows on balcony ......

(b) Seating area

(i) Maximum viewing distance ......

(ii) Minimum viewing distance ......

(iii) Width of the seating area ......

(iv) Horizontal and vertical angle of viewing for the patron in front row ......

(v) Distance between the screen and the projector lens ......

(vi) Projection angle ......

(vii) Type of presentation adopted ......

(viii) Screen size ......

(ix) Type of screen ......

(C) For Physical Comfort

(i) Experience of physical performance from different positions

(C-1) For Environmental Comfort

(a) Construction techniques for thermal insulation ....

(i) Construction technique adopted for thermal insulation ......

(b) Volume -

(i) Air-changes/hour ....

(ii) Type of air conditioning system adopted ....

(C-2) For Seating Comoft

(a) Seat Design .....

(i) Dimensions of seat .....

(ii) Materials used for upholstring the seat .....

(iii) Type of seat (fixed or push back) .....

(b) Layout design.

(i) No. of seats in one row .....

(ii) Back to back distance between rows .....

(iii) Physical design of seating arrangement (staggered or back to back) .....

(iv) Type of rows (straight or radial) .....

(v) If radial, radius of curvature .....

(vi) Number of rows on main floor .....

on balcony .....

and Total .....

(c) Area

(i) Actual seat seating area .....

(ii) Circulation area .....

(iii) Ratio of actual seating area to circulation area .....

(D) For the Safety

(a) Exits-

(i) Number of exits .....

(ii) Size of exits ....

(iii) Location with respect to seating areas and gangways ....

(b) Gangways

(i) Width of longitudinal gangway ....

(ii) Width of cross gangway ....

(iii) Number of rows served by longitudinal gangway ....

(iv) Number of seats served by cross gangway ....

APPENDIX " E-2"

PROFORMA FOR SURVEY NO.2

From

M.N.Khante, M.Arch.II,
Department of Architecture,
University of Roorkee,
Roorkee. U.P.

To

The Manager,
__________ Cinema,
____
______ .

Dated ,1972

Respected Sir,

I, the undersigned , a student of Master of Architecture, am working on 'PLANNING CRITERIA FOR CINEMA AUDITORIUM' as my thesis project for the degree of M.Arch. at Roorkee University. I need some information about your cinema to work out the conclusions. I assure you that the information supplied by you, will be treated as 'Confidential Matter' and will be used exclusively for academic purposes.

Your help in this connection will be the contribution to my project work.

Thanking you,

Yours faithfully

(M.N.KHANTE)

AIM of the enquiry is to work out the weekly income from one seat:

QUESTIONNAIRE:

1. Name of Cinema-

2. No. of shows/day- On Sundays/holidays ....

3. Classification of seats-

4. Rates excluding entertainment taxes-

5. Weekly average vacancies in percentage-

6. Income from show-cases, slides, preview theatre etc./week.

OUTGOINGS

1. Total staff salary/weekly/monthly.

2. Electric energy bill/weekly/monthly.

3. Municipal taxes, weekly/monthly/yearly.

4. Municipal charges for neon-signs and other licence feesetc./weekly/monthly-

5. Stationery/printing and miscelaneous expenses weekly/monthly/yearly-

6. Repairs and maintenance of (a) Building, (b) Machine (c) Plant equipment, (d) Furniture/yearly-

7. Sinking funds-/yearly,

8. Insurance premium/weekly/monthly/yearly

Note: If it is not possible to supply above information, please let me know the net average weekly income from a seatand capacity of the cinema.