REPORT OF THE THEATER ENGINEERING COMMITTEE*

Summary.—This is an account of the work of the several sub-committees of the Theater Engineering Committee during the past two years. The report of the Sub-Committee on Projection Practice embodies a preliminary study of safety factors in projection rooms, specifically with reference to the use of hand-operated fire extinguishers.

The report of the Sub-Committee on Theater Design includes a preliminary study of the basic shapes of theaters and advantageous seating zones, including a report on a study of these factors made in the Surrey Theater in New York.

A report of the Sub-Committee on Screen Brightness deals with proposed specifications for meters for measuring incident and reflected screen light in theaters, and the efforts of the Committee to encourage the manufacture of such instruments for the industry.

In a previous report of the Committee, published in the December, 1940, issue of the JOURNAL, announcement of the reorganization of the Theater Engineering Committee was first made. Originally, the Committee consisted of the two Sub-Committees on Projection Practice and Theater Design. Under the new arrangement, a third sub-committee took over the work dealing with screen brightness, leaving the Projection Practice Sub-Committee to concentrate its attention on projection problems proper.

The personnel of the Theater Engineering Committee, divided into the three sub-committees, is as follows:

THEATER ENGINEERING COMMITTEE

ALFRED N. GOLDSMITH, *Chairman*

Projection Practice Sub-Committee

H. RUBIN, *Chairman*

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T. C. BARROWS	M. GESSIN	J. H. LITTENBERG
H. D. BEHR	A. GOODMAN	E. R. MORIN
K. BRENKERT	H. GRIFFIN	J. R. PRATER
F. E. CAHILL, JR.	S. HARRIS	F. H. RICHARDSON
C. C. DASH	J. J. HOPKINS	J. J. SEFING

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Theater Design Sub-Committee

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Screen Brightness Sub-Committee

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Sub-Committee on Projection Practice

Working Committee on Fire Hazards.—A special subject before the Working Committee on Fire Hazards dealt with the question of including hand-operated fire extinguishers as part of the equipment of the motion picture projection room. The first step in the study was to send communications to various manufacturers of hand-operated fire extinguishers, stating the problem facing the Committee and asking specifically the following questions:

(*1*) What effect has your extinguisher on burning film, especially of the cellulose nitrate type?

(*2*) What damage to other equipment in the projection room might be incurred from the use of the extinguisher?

(*3*) What, if any, possibly toxic vapors are produced from the use of the extinguisher on burning cellulose nitrate film, and in what amounts?

In view of the inadequacy of information pertaining to these subjects, no definite answers to these questions were available either from the manufacturers of the equipment or from the information at the command of the Committee. However, the questions indicate some of the important data that should be obtained by the Committee aside from the question of establishing a policy with regard to the use of hand-operated extinguishers in projection rooms.

A reply received from Mr. R. M. O'Connell, Service Engineer of Underwriters Laboratories, Inc., Chicago, contains paragraphs of special interest to the Committee, since the thoughts expressed agree

strongly with the feelings of the Projection Practice Committee expressed frequently in previous reports and at many meetings of the Committee. These paragraphs follow:

We also attach a copy of the *Regulations of the NBFU for Nitrocellulose Motion Picture Film.* Section 19 of this pamphlet is intended to afford necessary safeguards for booths, including vents, shutters, and noncombustible construction. We may call your attention to the note following sub-paragraph J appearing on p. 22 of this pamphlet. This note recommends the installation of automatic sprinklers wherever practicable.

In our study of the subject we have come to believe that the fundamental purpose of the above Regulations is to afford protection to the other parts of the building and to the occupants rather than to suggest means of controlling any film fires which may actually occur within the projection room. As you know, such fires burn rapidly, give off intense heat, and great volumes of suffocating fumes and in our opinion ordinarily could not be controlled by hand-operated extinguishers of the usual type, even though it were possible for the occupants of the projection room to put such extinguishers into action and remain within the booth for any appreciable time following the start of a fire. As you know, nitrocellulose film is not dependent upon supplies of oxygen from the surrounding atmosphere. The entire intent of the Regulations therefore seems to be that the operator should try to get out of the room or booth as quickly as possible and hope that the booth itself was so constructed and ventilated that the film fire would burn out without extending into the building and without emitting a hazardous volume of fumes to the rest of the surroundings.

In our opinion the safety of booths can not be made dependent upon hand fire extinguishers. It would, of course, be well to have proper extinguishers close at hand outside of the booth in case a need for them should arise. You will observe in Section 14, Rule 144, of the National Board Regulations, a note which recommends small hose equipment and extinguishers except in film vaults. This is probably a reasonable recommendation, but we would not depend too much on extinguishers to handle film fires unless of the very smallest size and only if the extinguishers were brought into action quickly before very much film was involved. It is probably more true of films than of other combustibles that protection is to be sought in preventing fires rather than by provision for extinguishing them after they have once started.

The Chairman has obtained permission of Mr. O'Connell to quote these paragraphs in a report of the Committee.

Another question considered by the Committee was a possible inconsistency between Sections 144 and 218 of the *Regulations of the National Board of Fire Underwriters for Nitrocellulose Motion Picture Film* as recommended by the National Fire Protection Association and published by the National Board of Fire Underwriters as NBFU pamphlet No. 40.

Section 144 reads as follows:

Every room in which film is stored or handled, except film vaults, shall be provided with first aid fire appliances of types using water or water solutions. (Then follows a list of several extinguishers considered suitable.)

Section 218 reads as follows:

In the event of film fire in a projector or elsewhere in a projection or rewind room, the projectionist should immediately shut down the projection machine and arc lamps, operate the shutter release at the nearest point to him, turn on the auditorium lights, leave the projection room, and notify the manager of the theater or building.

It was pointed out that if the projectionist should leave the projection room in the event of a fire, there would be no point in having hand-operated extinguishers inside the projection room.

The Committee felt that a hand extinguisher might perhaps be of use in cases of small fires from sources other than film, but in turn it was pointed out that nothing that would be likely to burn was permitted in the projection rooms, according to the *Regulations*.

There is apparently no definite information concerning cases of fire where hand extinguishers have been used, and most of the information available with regard to film fires in the projection room and the extinction of such fires is incomplete and sometimes questionable.

The general consensus of the Committee may be summed up as follows:

(*1*) The Committee felt that no hand-operated extinguishers should be in the projection room.

(*2*) One or more hand extinguishers should be available immediately outside the door or doors of the projection room.

(*3*) The Committee still feels that in the event of film fire, the projectionist should immediately leave the projection room, so that Section 218 of the *Regulations* is to be regarded as satisfactory, but that Section 144 should either be omitted entirely or revised in accordance with Items 1 and 2.

Working Committee on Tools and Tolerances.—It is the conviction of the Projection Practice Sub-Committee that progress in the projection art requires that there be promptly made available, preferably by the projector manufacturers, information on exact methods and appropriate tools for measuring the wear of projector parts, data on the permissible maximum tolerable amount of wear of each part before required replacement, accurate methods of measuring such op-

erating values as film tension at the gate, and the corresponding convenient tools for measuring and adjusting such operating conditions.

The Sub-Committee points out that it has endeavored for a period of years to secure such information and tools, and at this time regards the lack of such material as detrimental to the advancement of projection and accordingly urges the early availability of such data and tools.

Sub-Committee on Theater Design

The Theater Design Sub-Committee is endeavoring to formulate plans for a series of surveys from which information may be derived which will indicate those zones of seating in the motion picture auditorium most preferred for comfortable viewing of the pictures. It is intended also to locate the zones of second, third, and even lesser choice for seating as selected by the audience after the more highly preferred areas are filled.

The Committee fully realized that there would be many significant factors which might change the pattern of the preferred zones; for example, the size and brightness of the picture might have a direct influence on the pattern. Also, the traffic lines into the auditorium and the placing of the aisle leading to the seats would be relevant factors. While it is realized that poor sightlines due to improperly pitched floors and uncomfortable chairs might influence the location of preferred seating zones, the Committee feels that it would be wise to place little stress on these last two factors because theaters having such conditions could and probably should be avoided for this survey work.

To arrive at any worthwhile conclusions, it is felt that it would be necessary to make surveys for auditoriums of varied basic shapes, such as the square shape, the extremely elongated rectangle, and in-between shapes. It would also be necessary to survey theaters of varied capacities, the 600, 900, 1200-seat capacities being recommended for the tests. It would be preferable if the size and brightness of the picture could be varied for a given seating pattern so that their influence could be more definitely observed.

The first survey was made in a theater under actual operating conditions. This type of survey can be made fairly accurate and gives a true picture of the preferred seating zones. The main difficulty, however, arises from the fact that it is necessary to have at

least one checker for approximately every 60 chairs in an auditorium. Each checker must have a chart in front of him indicating the chairs in his zone so that he can mark the chairs as they become occupied.

Still another method of checking the preferred seating zones was considered in which the audience would be brought to an auditorium chosen for test purposes, and, under different conditions be asked to seat themselves in accordance with their ideas of comfortable viewing positions. It is probably true that an unsuspecting audience would give more conclusive information but there are definite advantages in this latter type of survey. It would not be necessary to have large squads of checkers. It must be remembered that considerable travel and arranging of available time is involved in getting together a group of checkers to make a survey in theaters in actual operation. In the plan which involves the use of an audience chosen for the test purpose, the necessary changes in picture size and brightness could be made and their effect noted on the specific audience. It would also be possible to rope off designated seating areas in which the basic shape of the seating pattern could be varied to check on the influence of the basic shape. Of course, one major obstacle to this type of survey would be the difficulty of obtaining an auditorium equipped with the necessary chairs and projection equipment for the tests. The difficulty of obtaining a sufficiently large audience could be minimized by spacing the chairs farther apart in both directions than would be normal practice so to decrease the required number of viewers; for example, the normal audience of 600 could be tested with approximately 200 persons.

The Committee made an actual survey in the Surrey Theater in New York City. The theater was open for business and the tests were made starting at 6:45 P. M. and ending at 9 P. M. The theater has a capacity of 570 chairs; and in the hours indicated 453 people entered the theater to view the screen performances. The accompanying diagram indicates the plan of the theater, the position of the screen, and the like. The results of this survey are herewith given and the sub-committee may continue with a series of these surveys unless it is found that other more practicable methods can be used to arrive at the necessary results.

The survey shown in Fig. 1 was taken, as stated, at the Surrey Theater located in the Bronx, New York. Eleven members of the Sub-Committee entered the theater on a week-day evening at about 6:30 P. M. Each sub-committee man occupied a specified seat from which he could view an area of approximately 50 seats. The survey

started at 6:45 P. M. and terminated at 9 P. M., the evening period in which the major part of the audience was expected to arrive. The total period was divided into three periods: 6:45 P. M. to 7:30 P. M. for the first period; 7:30 P. M. to 8:15 P. M. for the second period; and 8:15 P. M. to 9 P. M. for the third period. Each man had a seating chart in front of him which enabled him to record those seats which were occupied in the first, second, and third periods.

Fig. 1 shows the seating diagram of the theater and black boxes of various sizes indicate in which period the chairs were occupied. Fig. 1 shows the different weights given to the black markings in accordance

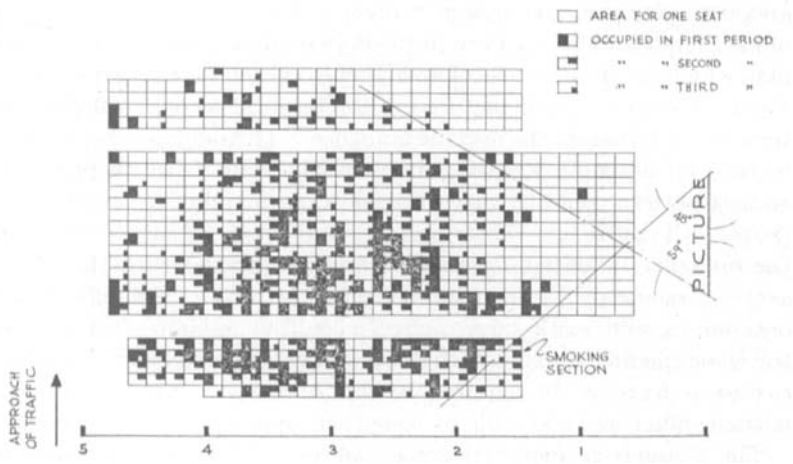

FIG. 1. Theater seating chart for determining preferred seating areas.

with the period when the occupancy occurred. Greater weight was given to the earlier periods so that a visual picture could be obtained of the preferred seating locations. It also assumed, of course, that the chair locations occupied in the earliest period would indicate the highest preference.

In this particular theater the facts that the approach of traffic was from one side rather than from the usual center approach, and that the smoking section was placed to one side threw the weight of preferred seats to one side, as the chart indicates. The picture size in this theater was 12 ft 7 in. × 17 ft 5 in. and the screen illumination was a little above the average in intensity. The picture size was larger than the average size to be expected for the maximum viewing

distance of this theater. The maximum viewing distance was 4.85 × the picture width. In accordance with a previous survey made by this Committee, the average picture size in relation to the maximum viewing distance was found to be the maximum viewing distance divided by 5.2. It is not assumed at this time that this single survey could by any means give conclusive information as to preferred seating arrangements. It would be necessary to make approximately a dozen or more of these surveys under different conditions as already suggested in this report. However, it is interesting to note some of the disclosures made by this survey. These are as follows:

(*1*) That seating locations in an area near the picture starting with the picture and ending with a distance approximately $1\frac{1}{2}$ times the picture width away from the picture, are resorted to only very infrequently.

(*2*) That the preferred viewing distances from the picture are found in an area located at distances beginning at approximately twice the picture width and ending at approximately four times the picture width. Fig. 1 is marked with a scale at the bottom to show the relation of viewing distances to the picture width. Each unit marked on the scale is equal to the picture width.

(*3*) That seats located in an area too far to one side of the picture, or such as may be located outside an angle of approximately 60° in relation to the picture surface as shown on the chart, are not occupied any sooner than the two seats heretofore mentioned in the front sections, when other seats are available.

Conditions in this particular theater did not permit any worthwhile observations to be made as to what could be considered as useful seating areas at more remote distances from the picture.

Sub-Committee on Screen Brightness

As reported at the last Convention of the Society, the Sub-Committee formulated provisional specifications for illumination meters and brightness meters and was placing these before instrument manufacturers to determine the feasibility of having them made available. It is proposed to review the results of this investigation in this report. Before doing so, however, it seems desirable to summarize briefly the preliminary conclusions and opinions of the Sub-Committee on which the provisional specifications were based.

The Sub-Committee has felt that instruments for merely measuring total flux in the beam from the projector, or average brightness of

the screen, would be inadequate and that the instruments should be of such a character as to permit determinations of uniformity of illumination and brightness. This introduces no serious problems so far as illumination meters are concerned, but it does mean that, in the case of the proposed brightness meter, the instrument must be designed so that it "sees" only a limited area of the screen at a time. It was also agreed that, if the brightness determinations are to represent a true measure of what the audience sees, the measurements should be made from the seating area and include the extreme seat positions.

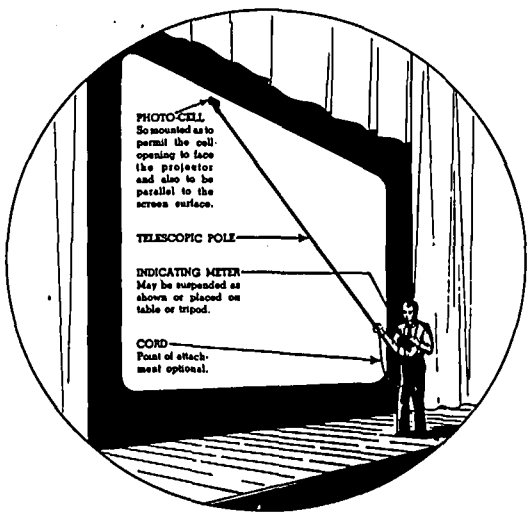

FIG. 2. Suggestion for possible form and use of illumination meter.

Data presented by the Projection Practice Committee in 1938 indicate a minimum angle subtended by the screen of approximately 8 degrees. Therefore, the "angle of view" of the brightness meter should preferably be not more than 2 degrees if a reasonable indication of brightness uniformity is to be obtained from the most distant seats.

If possible, the use of "visual" types of instruments should be avoided because of the difficulty of matching brightness fields with color differences present. The use of photoelectric cells of either the photoemissive or photovoltaic types corrected to eye sensitivity was recommended.

Since measurements of illumination at a variety of points on the screen area are required to obtain a reasonably accurate average value, the illumination meter should be separate from the photocell and connected to it by a suitable length of conductor. Similarly, means should be provided to hold the cell at any point on the screen area without resorting to the use of ladders or other cumbersome equipment.

Since measurements of brightness at a variety of areas on the screen were proposed, at least the "viewing" part of the brightness meter should be swivel mounted on a suitable support, or tripod, and means provided for aiming at specific points on the screen. Also, the aiming device, or "view finder," should probably indicate specifically the field included by the instrument.

To clarify the several points summarized here and included in the letter circulated to instrument manufacturers, two sketches were prepared to illustrate the proposed use of the meters (Figs. 2 and 3). The letter also included a tabulation of the provisional specifications (Table I).

TABLE I

Provisional Specifications for Illumination and Brightness Meters

	Illumination Meter	Brightness Meter
Useful Range of Instruments	0.2–50 ft-candles	0.5–30 ft-lamberts (or 4–30)
Accuracy of Measured Values	±5%	±5%
Reproducibility of Measured Values	±3%	±3%
Max. Screen Area or Angle to be Included by Instruments	1 sq ft	3° (preferably 2°)
Maximum Price	$50	$50

The Sub-Committee's choice of readable brightness values from 0.5 to 30 ft-lamberts was included provisionally to permit measurement of the brightness of the peripheral field should that area be illuminated. The alternative range of values from 4 to 30 ft-lamberts was included if it should be found impracticable to obtain an instrument capable of reading 0.5 ft-lambert.

The values for the illumination meter of from 0.2 to 50 ft-candles were chosen in recognition of the requirement in some states of minimum ambient levels of illumination in theater auditoriums, and

because of the numerous other illumination measurements for which such an instrument could be used in theaters.

The letter to instrument manufacturers also included a request to consider the practicability of an inexpensive amplifier for increasing the sensitivity of brightness meters employing photocells. Since the frequency of the light on a motion picture screen is 48 cycles per second, it was felt that perhaps a 48-cycle amplifier, with a null method of indication, might have advantages.

The general letter outlining the problem and the provisional specifications was sent to 30 instrument manufacturers. Replies were

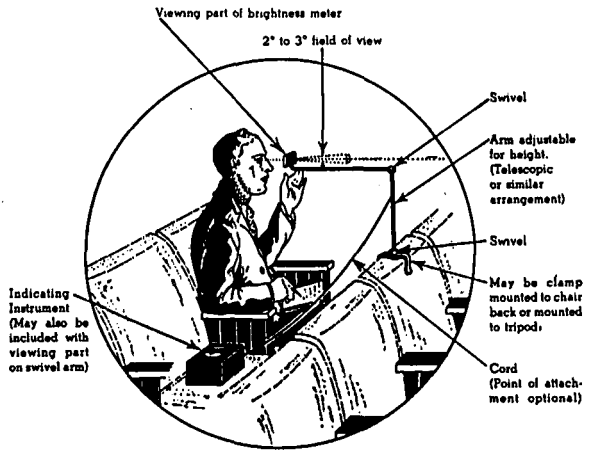

FIG. 3. Suggestion for possible form and use of brightness meter.

received from 20 of these companies. Twelve of them expressed either no interest in the subject or an inability to take action at the present time. The remainder expressed a willingness to coöperate and several submitted helpful suggestions and criticisms. As a result, the Sub-Committee first of all revised the tentative specifications for accuracy and reproducibility of measured results from 5 to 15 per cent and from 3 to 5 per cent.

As anticipated, the attainment of a satisfactory illumination meter seems to present no serious problems. However, the design of the desired type of brightness appears considerably more difficult and the Sub-Committee feels that it should devote its attention to that problem until a practicable design has been found.

Subsequent calculations by members of the Sub-Committee indicate the magnitude of the brightness meter problem. Assuming the use of a collector lens which would also serve to limit the field of view of an instrument employing a photoelectric cell, the illumination at the lens with 4 ft-lamberts on the screen in the 2-degree angle would be 1×10^{-3} ft-candle at any distance from the screen.

A photovoltaic cell corrected to eye sensitivity and used as proposed would have an output of the order of one or two thousandths of a microampere under these conditions. Such currents are too low to read on any convenient, rugged form of instrument and, therefore, the Sub-Committee is extremely doubtful of the practicability of using such cells, unless the tentative specifications are radically altered at the expense of many features now considered to be eminently desirable.

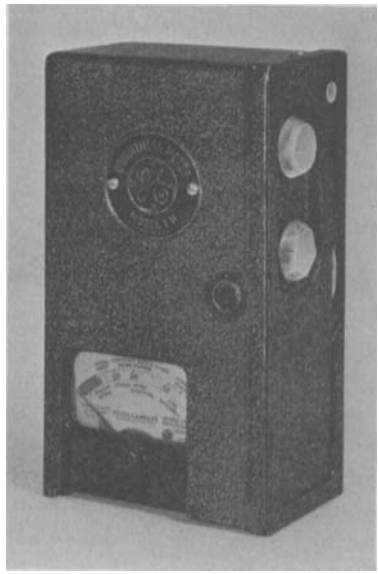

FIG. 4. A simple brightness meter employing a light-meter for the indicating instrument.

The use of the photoemissive type of photoelectric cell presents many difficulties. Under the conditions previously described, an output from the cell of the order of 2×10^{-5} microampere seems likely. While so low an output does not necessarily represent an insurmountable obstacle, it should be evident from the foregoing data that the design of a suitable brightness meter employing either type of photocell would require a considerable amount of development work.

An interchange of ideas between the Sub-Committee and those instrument manufacturers interested in a photocell type of brightness meter continues. In the meantime, however, the Sub-Committee is reconsidering visual types of brightness meters, since one such instrument is already available (Fig. 4) at a price close to the figure considered to be acceptable.

One objection to a visual type of instrument has been the difficulty

of matching fields of brightness when a color difference is present. This can be minimized through the use of color-matching filters. This leaves, then, only the inconvenience of taking a number of readings to average out errors of individual readings, and the fact that such instruments are less convenient to use.

As a further possibility, the Sub-Committee has under consideration a photographic type of brightness meter. Such an instrument would function as a camera with a lens of fairly long focal length, and probably small aperture, that could be used to photograph the illuminated screen from any seat position. Exposures would probably be long—perhaps in the range of ten to twenty seconds.

The camera and film in itself could not be considered as an absolute brightness measuring device; an auxiliary piece of equipment to calibrate the camera and film at the time of its use would be essential. In its simplest form, this auxiliary device might consist of a box containing a lamp illuminating a series of targets to definite brightness levels. This panel box would have to be photographed either when the screen is photographed, or soon before or after, and both images would have to be developed together. The process of evaluating screen brightness and brightness distribution would involve simply comparison of target and screen image density distribution.

There are certain difficulties in the design of such an apparatus. The color response of the film would have to be matched by filters to that of the eye. Precautions to avoid scattered light in the camera would have to be taken. Some convenient means of matching target and screen-image densities would have to be devised. At best the apparatus involved would be cumbersome.

On the other hand, such a device would result in a convenient form of permanent record of test results. In addition, the simplest form of operating instructions would suffice and it is beleived that the specifications of accuracy, angle, range, and price could be conveniently met.