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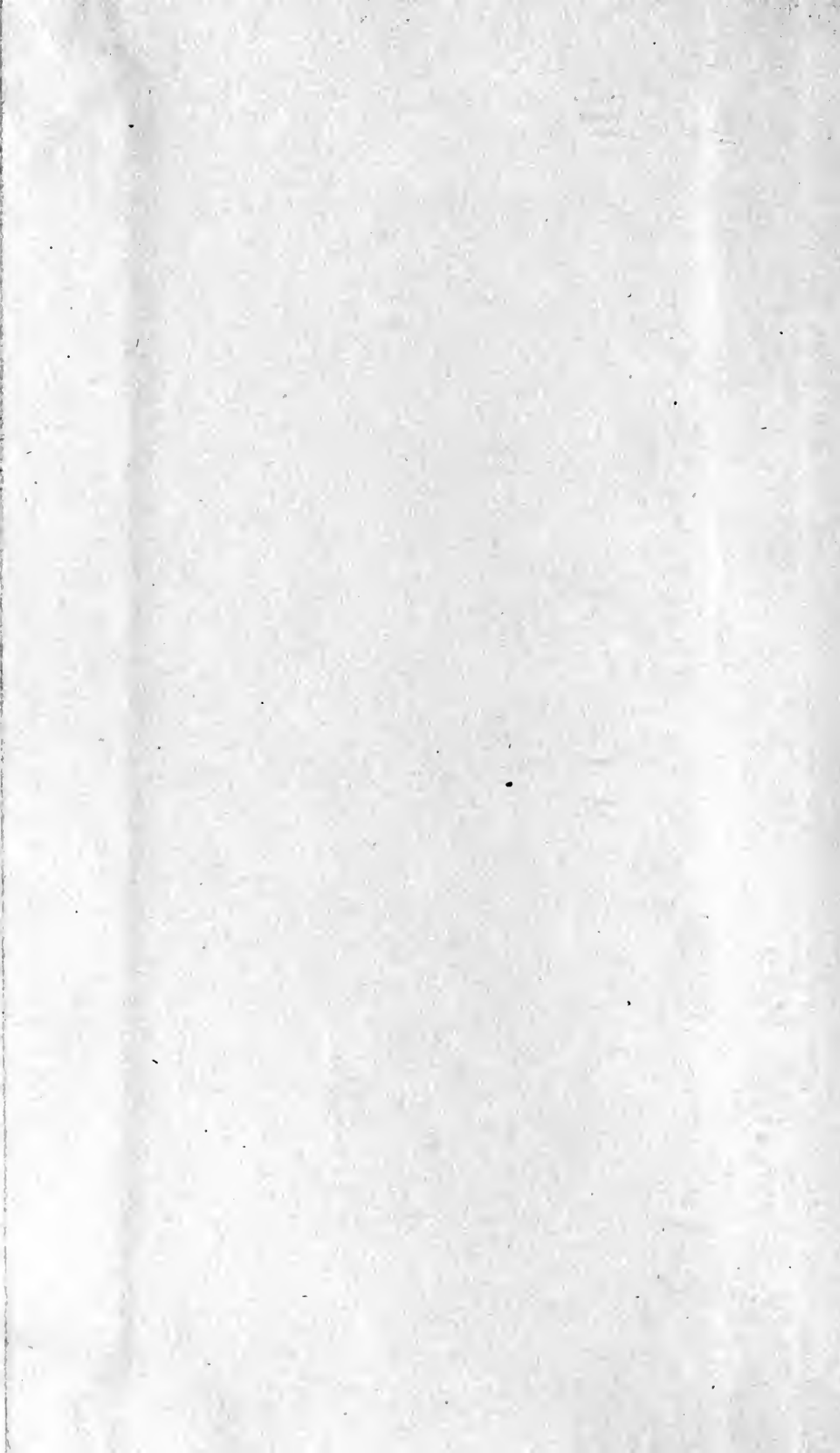
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# Journal of the

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# Report of the President\*

**T**HIS IS THE semiannual report of the president to the members of the Society of Motion Picture Engineers. It is a statement of activities subsequent to the report submitted at the 61st Semiannual Convention of the Society in Chicago and published in the July, 1947, issue of the JOURNAL.

The Society now has a new home—a four-room suite on the ninth floor of the Canadian Pacific Building, 342 Madison Avenue, New York 17, N. Y. The entrance room number is 912 and the telephone number is Murray Hill 2-2185. There is a big “WELCOME” mat out to all members and friends. We want you to become better acquainted with our staff and to use these facilities. They are yours as members of this organization.

We enjoyed our long tenancy at the Hotel Pennsylvania and were sorry to leave its many conveniences but we had outgrown our old quarters and the hotel could not give us more room.

Our staff has both changed and grown. Harry Smith, Jr., who served the Society during the war, has resigned to go into business for himself. Mr. Boyce Nemeck has now been promoted to executive secretary. As you will recall, he joined the Society as engineering secretary upon his release from the Army's Signal Corps Photographic Division. He is doing a grand job. He is assisted by the new staff engineer, Mr. Thomas F. Lo Giudice; the JOURNAL editor, Miss Helen Stote; and Miss Margaret C. Kelly, office manager. In our office staff we also have Miss Beatrice Melican, Mrs. Silvyia Morrow, Miss Dorothy Johnson, and Miss Helen Long. We are proud of this organization.

The Society membership has now reached a new high of 2760 members. The member's equity in the Society is \$99,314.30 as of October 1, 1947. The sustaining membership under the chairmanship of our past-president, Mr. Donald E. Hyndman, now includes 42 companies which have expressed their interest in our activities by contributing \$15,650.

\* Presented October 20, 1947, at the SMPE Convention in New York.



At the Chicago Convention I reported that the scope of the Society had been defined to include all phases of pictorial rendition of action whether it be from film, as in motion pictures, or from electronics, as in television. The Society's facilities and staff are now prepared to handle this great field of activity and to be of greater service to more people. I am sure that each of you knows at least one person who can both contribute and profit by being a member. This is not an open plea for new members, for it is our desire to retain the high standard of our membership. We do wish, however, to bring within the fold of our organization all people who should rightfully be associated with us.

We now have the Atlantic Coast Section in New York, the Midwest Section in Chicago, the Pacific Coast Section in Hollywood, and a Student Chapter at the University of Southern California in Los Angeles. Since it is a part of our duty to aid in the training program of young engineers, plans are under way for more Student Chapters at worthy institutions of higher learning.

Every major move that has been made by the Society has been made after careful consideration by the Board of Governors. As president of the Society and as chairman of the Board meetings, I call your attention to the fact that expansion entails increased responsibilities, financial and otherwise. As of this date our revenue, including sustaining membership, and our operating expense are about equal. We may show a deficit this year because of furnishing our new offices. Next year we should again show a 10 per cent or more excess of revenue over expense or we should curtail some of our activities. More members or more sustaining funds is, of course, the best answer.

The papers program for the 62nd Semiannual Convention, as for the 61st Convention in Chicago, was oversubscribed. We regret that convention time permitted the presentation of only those papers having greatest topical interest or the papers first to be submitted. It is our desire that our membership gain full advantage of all technical information through our JOURNAL and I want to encourage you to present more and more manuscripts for publication, even though time may not permit their presentation at conventions.

Few people realize that the JOURNAL OF THE SOCIETY OF MOTION PICTURE Engineers is the one and only up-to-date and authoritative technical publication covering all phases of PICTORIAL RENDITION OF ACTION. We are proud to announce that in our postwar recovery our September issue went to press in September and shortly you will

receive the JOURNAL of the month during the first week of the month.

Your engineering vice-president, Mr. John A. Maurer, has continued to do a colossal job. At the request of the American Standards Association and with the approval of the Board, the Society jointly with The Institute of Radio Engineers has undertaken a special assignment in standardization of sound recording, including film, disk, and magnetic methods. This can be of great aid to all manufacturers and users of recording equipment. We expect that our Society will be in the same important position in regard to all large-screen television.

The theaters and the producers as a group have been slow in heeding the warning of the engineers in regard to theater television but individually there has been an awakening. Several producing companies have now taken out licenses and several others will follow. Our efforts in this respect as presented in last year's report have not been in vain.

I can now predict with assurance the great success of this our 62nd Semiannual Convention and Theater Engineering Conference. The credit for this undertaking and its success goes to our ever-efficient convention vice-president, Mr. W. C. Kunzmann, the Atlantic Coast Section chairman, Mr. James Frank, Jr., and the many persons who have contributed so liberally of their time and effort.

Between the time of the April report and this report, your president has been appointed to the American National Film Committee of the United Nations for which your past-president, Mr. D. E. Hyndman, is acting as representative. Your president has also been appointed to the Motion Picture Committee of the American Heritage Foundation with which I am sure you are all familiar.

By action of the Board of Governors of the Society the 63rd Semiannual Convention is to be held at the Santa Monica Ambassador Hotel and Del Mar Beach Club, May 17 to 21, inclusive. This convention will be general in its scope. Please be among those present—we shall make it worth your while.

Respectfully submitted,

LOREN L. RYDER, *President*

# New York Motion Picture Production\*

By EDWARD C. MAGUIRE

CO-ORDINATOR OF THE MOTION PICTURE INDUSTRY OF THE CITY OF  
NEW YORK

THERE HAVE BEEN many news articles with reference to the problem of motion picture production in the City of New York, and many of them, I fear, used the language of the West Coast by reason of the extravagance of the adjectives used. Our approach has been a simple and a modest one. It is an approach that I think any people residing in any city, who have an interest generally in the welfare of that city, would take with reference to a business to which it feels it can contribute substantially. We do not envision lifting Hollywood from the West Coast and dropping it into New York City. That would be ridiculous and we realize and know that only too well. We do believe that we have many things here that this industry needs and we feel that the City of New York is entitled to and properly should be given a greater percentage of the production of pictures and that if the facilities, if our scenes, if our backgrounds, if that which we have to contribute are utilized by the industry, it will result not in bitter competition between the West Coast and New York City, or competition between any other center of production and New York City, but it will serve as a stimulant which will bring improvement to the motion picture industry.

Some of the problems with which we were confronted were these: For the past year and a half, many people have spoken to the Mayor with reference to bringing motion picture production or a greater percentage of it to the City of New York. It was only early in July that Mayor O'Dwyer decided the time had arrived when a special survey should be made of the needs of the industry and that it should include a study of the respects in which we of the City of New York had been remiss and failing to co-operate with the industry.

\* Presented October 20, 1947, at the SMPE Get-Together Convention Luncheon in New York.

We found that we had some shortcomings. We learned that by inviting the independent producers and the major companies to confer with us and requested their very sincere and direct comments and criticism of how we had been conducting ourselves. We found out this: Many of the laws, the rules, the regulations we had on the books in the City of New York gave no consideration to the needs of the motion picture industry. There had never been a study of what the needs of the industry were. We found that laws were on the books which were designed to cover electric construction in buildings, and, as motion picture production companies came to New York those laws were being applied to them.

There were many unreasonable restraints and restrictions involved in those laws. We found, too, that even with reference to the issuance of permits for the taking of outdoor scenes we were tied up in terrible red tape, that we were imposing unreasonable restrictions on the industry.

We have had that survey and as a result of it the Mayor has done two things: He has directed, first, that the study be continued and that we determine what would constitute a streamlined and reasonable set of rules to apply to motion picture production in the City of New York.

That is well on its way, and I hope and expect that within the next month or two at the most, we shall have a simplified code which can be readily understood and easily followed out by the industry.

We have not been content simply to wait for the passage of that time while this study and survey are being made. Late in August the Mayor established a Co-ordinating Office. I can say this to you now and if there be any inaccuracy in my statement I see enough of the people in New York here who have participated in the various conferences and who can tell you the respects in which my statements may be inaccurate. I say they are not.

Since late August, on the basis of the only complaint made by the industry—and we invited complaints in every respect—there has not been one picture company that has come to New York and sought to produce that has made a complaint with reference to the service that it is getting. Many of the people do not realize that this is a city of close to 8,000,000 people. It is a city where we have dozens and dozens of different departments and necessarily must have those departments.

Our Police Department naturally must stand on its own.

We have a Department of Housing and Buildings that is concerned with structures.

We have a Department of Public Works that operates most of our public buildings and our bridges.

We have a Department of Water Supply, Gas, and Electricity whose responsibility includes that of insuring proper wiring and servicing with reference to electricity.

We have a Department of Marine and Navigation that has jurisdiction over our docks and our ferries:

We have as a separate body the Triborough Bridge Authority which operates our tunnels and certain bridges. The Port Authority control many of our bridges.

We have the Board of Transportation for our subways.

Now, I admit that for a production manager to come to New York and try to break through that maze of jurisdictions would be a pretty difficult and trying task. It was because of their efforts in that direction, because of their lack of knowledge of the jurisdiction of the respective departments, that there had been confusion, there had been delay, and there had been red tape. This Co-ordinating Office has been set up. It is no longer necessary for the production manager to know the jurisdiction of the different departments.

At this time any production manager who wants to take scenes in the City of New York, has only to contact directly the office of the Co-ordinator. If in certain situations permits are required, those permits are procured for the unit by that central office.

We have worked the thing down to the point now where only a very short time is necessary to obtain clearance. As an example of it, one morning a major motion picture company called; they wanted to take certain pictures. It was just a telephone call. The thing was arranged for them within a half hour. They were taking scenes in connection with other pictures over the course of the past few weeks in New York. Those arrangements were made over the telephone, without the need of any permits, and when they got to the location of the scenes the police were there ready to protect them and afford them all that they required.

We can do that and are doing it, and I ask you to inquire of any company that has been shooting in the City of New York in the past two months, if they had a single cause for complaint. If they have, then the proper and fair thing for them to do is to state the complaint to us, because we are not sensitive and it is our only

purpose and design to cure the mistakes we have been making in the past.

On the other hand, we do need some co-operation from the industry. You know, a director cannot come into New York with the idea of making thirty or forty exterior scenes, come in, let us say, on a Saturday, expect to pick out his locations and scenes and then want to start shooting on Monday morning, because even he does not really know what scenes he wants after he just gives it a superficial study. I think that the industry cannot only save us trouble—and we are not bothered about it, we are willing to go through trouble—but can save money for the industry itself, if it will only do a little more and better planning in selecting its locations.

We ask for the co-operation of the industry. I say this: In the meetings that I have had with the industry representatives, I have received co-operation. The industry designated a committee of five that has been sitting with the various Commissioners and heads of different City Departments, telling those heads of the departments the needs of the industry. Out of that, as I said before, will come this very simplified and streamlined code. Out of this also will come a long-range and central co-ordinating office which will continue along the same lines that we have been following for the last two months.

We are going to say this to the industry in behalf of the Mayor and in behalf of the City Government: We think we have much that you need. We are only too happy to try to understand your problems and we want you to call upon us in any respect and on any thing, to help us study and solve your problems and in return we ask for a fair, reasonable share of the industry.

# New One-Strip Color-Separation Film in Motion Picture Production\*

BY H. C. HARSH AND J. S. FRIEDMAN

ANSCO, BINGHAMTON, N. Y.

*Summary*—A description is given of procedures to be used with the new Ansco Film Type 155—which is designed for making color-separation negatives. Equal gammas are obtained for the red, green, and blue filter exposures with the same developing time, making it possible to obtain the black-and-white separations as successive frames on a single strip of film and thus obviate much of the difficulty of registration. By varying the developing time or developer formula, it is possible to change the gamma over a range of 0.5 to 2.0 to suit the purpose for which the separations are intended, while still maintaining equal gradations for the different filter exposures.

The following are some of the applications for the film which are described: (1) to provide duplicates of Ansco Color originals for protection or (2) foreign release, (3) for special-effects and process photography in conjunction with Ansco Color motion picture films, and (4) for direct photography of animated cartoons which are to be printed in Ansco Color.

THE USE OF monopack color films such as Ansco Color Types 735 and 732 for the original exposure and the release printing stock in the production of motion pictures, poses certain problems in providing the intermediate duplicates or masters which are necessary for protection of the original, for foreign release, or special effects. Methods for making such duplicates using Ansco Color Type 132 have been described by Duerr and Harsh.<sup>1</sup> The present paper describes another method for making intermediate duplicates, utilizing a new black-and-white film designed especially for color separations.

The specific problem in motion picture color photography with monopack materials is the loss of color saturation when it is necessary to make second, third, or fourth generation duplicates to arrive at a release print as is often the case in black-and-white motion picture practice. Current use of monopack color processes such as Ansco Color has proved that a direct print from a color original gives color reproduction of satisfactory quality. The difficulty in making more than a first generation print is due to the absorption characteristics of the image dyes. Fig. 1 shows the spectrophotometric curves for the image dyes of Ansco Color Film in the proper proportion to give a gray density of one.

\* Presented October 21, 1946, at the SMPE Convention in Hollywood.



To achieve accurate color reproduction, the intermediate duplicates should have yellow, magenta, and cyan images that are the exact counterpart of those in the original. A glance at the absorption curves of the yellow, magenta, and cyan dyes shows that the cyan absorbs appreciable amounts of blue and green and that the magenta absorbs appreciable amounts of blue. These absorptions are undesirable and to the extent to which they take place they contribute to

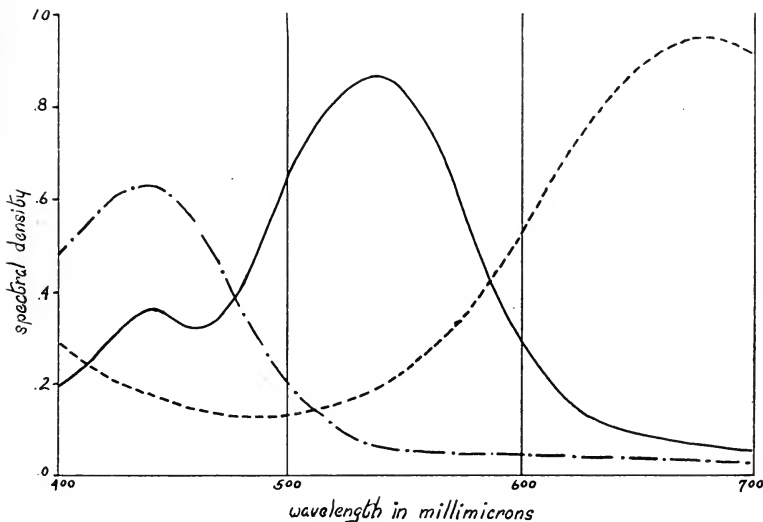


FIG. 1—Spectrophotometric curves of dyes in Ansco Color Type 735.

color degradation and poor color reproduction. From these curves it becomes evident that the blue component of the printing light will not only copy the yellow image in the transparency but also the magenta and cyan. Hence, the yellow image in a second generation print is no longer a true representation of the yellow in the original and the same is true for the magenta. If this is to be used for another intermediate from which release prints are to be made, further degradation of color will take place. The result is a loss of color brilliance which may not be acceptable to critical audiences. The difficulty is obviated if the intermediate duplicates are made in the form of black-and-white separations. By the use of sharp cutting filters it is possible to obtain accurate black-and-white records of the red, green, and blue densities as they are present in the original. These negatives

after being converted to black-and-white positives can be printed with identical or similar tricolor filters onto Ansco Color Type 732.

The idea of making separation negatives from monopack color originals is not new and has been applied in imbibition and other color printing processes for many years. However, a black-and-white film which is designed especially for this purpose has not been generally available and it has been found desirable to develop a new type of film to meet this requirement. The new film is tentatively designated as Ansco One-Strip Color-Separation Film, Type 155.

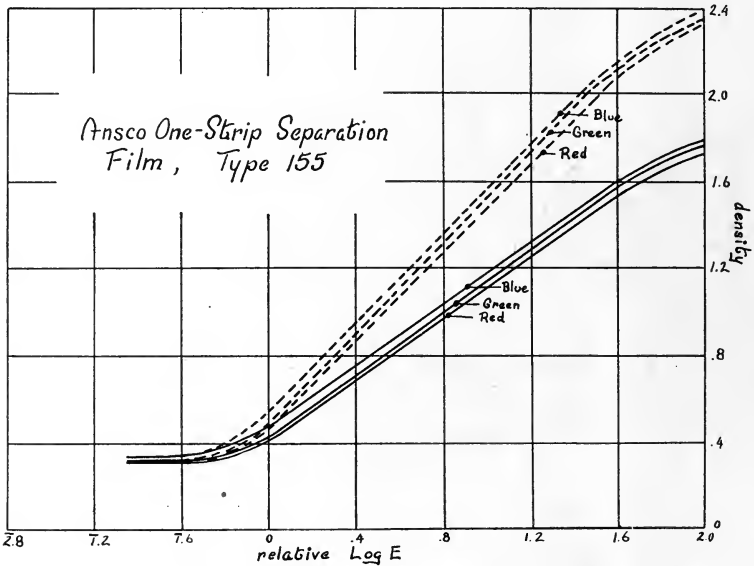


FIG. 2—Characteristic curves for Type 155.

Accurate registration of separation negatives is essential in motion pictures. The ideal solution would be a film base material with high dimensional stability, but such a base material which is suitable for photographic use has not yet been realized. This problem is solved in the new film by making the separations as successive frames on the same 35-mm strip so that any shrinkage or other changes or variations in physical properties of the film with handling and aging will remain the same for all three filter exposures. Hence, the term "one-strip color-separation film".

Equally important is the need for balance in the gradations of the three separations. In the past this has been achieved by giving the

different filter exposures differential development. Since the three separations are on the same strip of film in the new material it is essential that the same effective contrast for the blue, green, and red filter exposures be obtained when developed for the same length of time. This is the important feature of Type 155. The lower set of curves in Fig. 2 shows the characteristics for the red, green, and blue exposures when developed to a gamma of approximately 0.65. This is the desired value for separations from Ansco 735 Type originals. Where it is desirable to include the technique of color correction by masking, the separation film should be developed to an appreciably higher contrast. Therefore, the material must have a wide latitude of gradation. The upper set of curves in Fig. 2 shows the characteristics for a higher

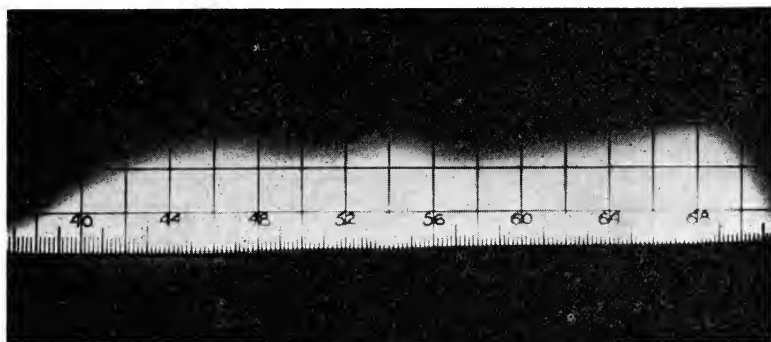


FIG. 3—Spectral Sensitivity of Type 155.

contrast and it is noticed that the curves still retain the same equal gammas with different filter exposures as obtained with the shorter developing time. The normal density differentiation of a Type 735 original is approximately 1.6. It is seen that this range is adequately covered in the straight-line portion of the  $H$  and  $D$  curves.

Another feature of this new film is the sensitization which is extended farther into the red than a normal panchromatic film. The spectral response of Type 155 is shown in Fig. 3. The reason for this is apparent when you refer to the spectrophotometric curves of Fig. 1. You will note that the cyan-dye image has a maximum absorption at 680 millimicrons which corresponds to the maximum of the red sensitivity of the film. This enables one to use an extremely sharp cutting filter such as the Wratten 70, the cutoff of which is well beyond the sensitivity range of a normal panchromatic film. The

use of the extended red sensitization in conjunction with the 70 filter gives a red filter separation that is for all practical purposes perfect, thereby achieving a considerable increase in saturation especially for the reds and those colors in which red plays a part.

The following will describe briefly the application of the film in the production of Ansco Color motion pictures. Fig. 4 shows graphically the steps involved. The scene is photographed on Type 735 film. This is then copied on Type 155 film using a printer equipped with

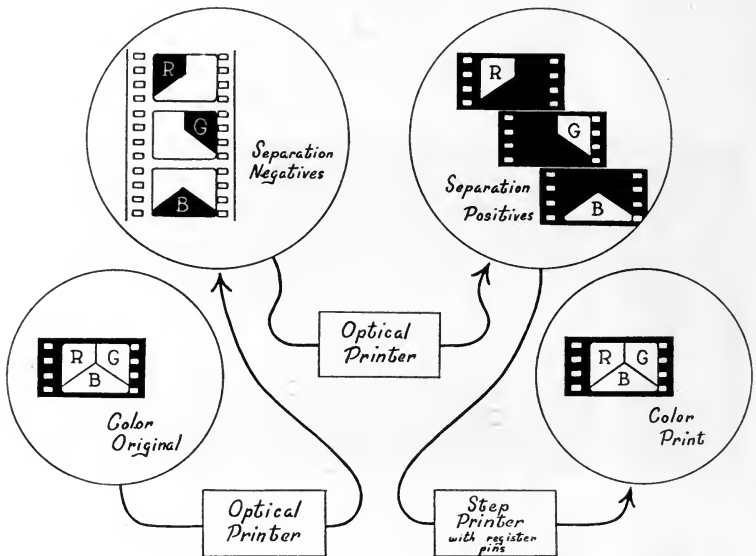


FIG. 4—Graphic representation of steps involved in using Type 155.

registration pins and capable of skip-frame printing. It will also be advantageous if the printer has a synchronized filter wheel so that the red, green, and blue filter exposures can be made on successive frames in one printing operation. However, the latter is not essential and the black-and-white film can be printed three times and still obtain the images successively by techniques well known in optical printing. At this stage, fades, lap dissolves, and other special effects can be included. The type 155 film is then developed to a gamma of approximately 0.5 to 0.6 in a buffered borax developer of the type used for variable-density sound film. The resultant film now is a conformed master containing all of the effects and with the color records as successive-black-and-white frames. It will serve as protection against damage

to the original color transparency since it is a good permanent record. The latter point is an important one since present-day color originals, if not stored under the proper conditions, may be subject to fading.

To convert the separation negatives to color prints they are first printed on standard black-and-white duplicating positive film on the same optical equipment as used for making the negatives. That is, the one-strip separation negatives are now converted into separation positives using three separate films. The final step is to print the separation positives onto the Type 732 Ansco Color printing film. This can be done in a standard contact step printer equipped with registration pins by printing the Type 732 film three times, each time using the appropriate separation positive and filter. It is also possible to make the black-and-white positives by contact from the negatives. In this case, release printing would have to be made on a skip-frame printer. In either case, the result is a release print which is equal to a direct print from the original in color reproduction.

Because of its unique feature of maintaining the same gamma for all three filter exposures over a wide range of gammas, Type 155 can also be applied to the direct photography of animated pictures or used for background projection and process photography. Those skilled in motion picture methods will immediately recognize other important uses of this new film in the production of color motion pictures.

#### REFERENCE

- (1) H. H. Duerr and H. C. Harsh, "Ansco Color for Professional Motion Pictures," *Jour. Soc. Mot. Pict. Eng.*, vol. 46, pp. 357-368; May, 1946.

#### DISCUSSION

MR. S. P. SOLOW: Could you tell us to what extent different colors produce different gammas on ordinary film?

MR. H. C. HARSH: Usually the blue separation is softer than the others, and requires about two minutes more development time to bring it into equal gradation. They vary on the red and green. One time the green might be a little different from the red and vice versa, depending on the film.

MR. HERBERT GRIFFIN: Suppose your color original does not have the same red, green, and blue printing contrast, then how do you proceed?

MR. HARSH: This film was designed especially for use with Ansco Color Type 735 which gives a balanced print on Type 732 printing film. We are using it only as an intermediate step. We want to retain the same gamma relation in our black-and-white dupes as we have in making a direct print. Ordinarily, in using a black-and-white separation film, you would proceed from a well-balanced original. In the case of a faulty original the development times for the black-and-white positive could be varied for correction without interfering with the one-strip negative.

# A New Variable-Area Recorder Optical System\*

BY J. L. PETTUS AND L. T. SACHTLEBEN

RCA VICTOR DIVISION, RADIO CORPORATION OF AMERICA, HOLLYWOOD, CALIF.

RCA VICTOR DIVISION, RADIO CORPORATION OF AMERICA, CAMDEN, NEW JERSEY

*Summary*—A new variable-area recording optical system is announced which incorporates refinements and improvements in design and arrangement that make for better performance and more convenient operation, maintenance, and servicing. Optical features include improvements in aperture condenser, aperture, and intermediate objective lens designs; in design and mounting of slit; in mounting of filter; in ground-noise-reduction shutter and phototube monitor; in design and mounting of monitoring optics and monitoring screen. The system incorporates features enabling the operator to record a negative or positive track at will; it utilizes a new low-distortion galvanometer previously announced before this Society. It has been expressly designed as a component part of a new de luxe recording machine, RCA Type PR-31, also previously announced before this Society.

## I. INTRODUCTION

FEATURES THAT have been under development by the Radio Corporation of America for nearly twenty years, as well as a number of recently developed improvements, have been incorporated into a variable-area recorder optical system of entirely new design. Numerous papers by Kreuzer,<sup>1</sup> Dimmick,<sup>2</sup> Hasbrouck, Baker and Batsel,<sup>3</sup> Kellogg,<sup>4</sup> and others have described the principles, construction, and use of the area optical system during the course of its development. The new optical system is especially designed to accompany the Type PR-31 de luxe 35-mm recorder (Fig. 1) recently described before the Society.<sup>5</sup> The optical system is shown mounted in the recorder in Fig. 2. Basic features of the variable-area optical system, such as incandescent lamp, electromagnetically driven mirror, and the shaped aperture whose image is moved across the slit by the mirror, are retained. Improvements in component parts and assemblies, and refinements in the arrangement and design of the general layout and accessory equipment, enhance performance and operating convenience, and make for economy in maintenance and servicing.

\* Presented April 24, 1947, at the SMPE Convention in Chicago.

### A. General Arrangement of the Optical System

As illustrated in Fig. 3, the general layout is roughly in the form of an L with the illuminating branch at right angles to the modulating branch. For reasons of geometry the two branches have been retained effectively at 30 degrees to each other, but the prism *E* folds the illuminating branch so that the over-all system has the general shape of an L. This arrangement permits an effective increase in the

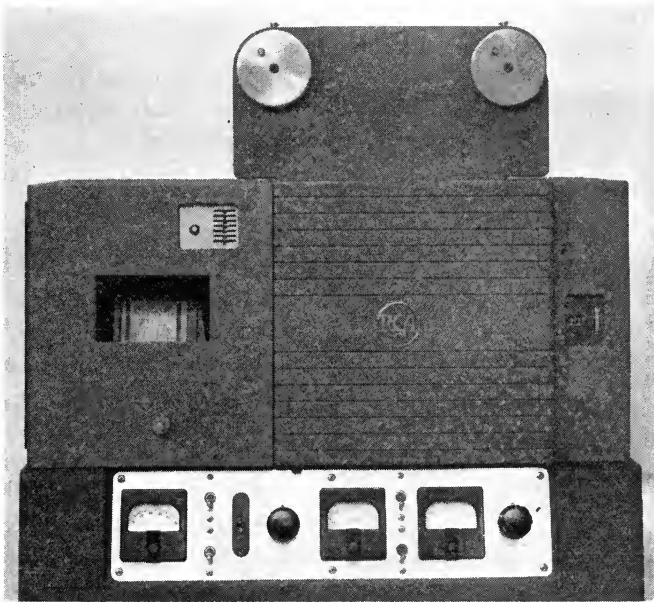


Fig. 1—View of Type PR-31 recorder, showing visual monitoring screen and light-meter plunger.

distance from lamp *A* to mirror *J*, of well over an inch without interference between the optical and recorder assemblies. It increases certain optical clearances that make possible new features to be described later. The new layout makes the lamp adjustments more accessible, and improves thermal isolation of the lamp from the modulating branch of the system.

### B. New Features of Arrangement and Design

The new optical system has the following specific features, some of which are consequent upon the new general arrangement described



above. Except where noted, they are all standard equipment.

1. Prefocused exposure lamp, adjustably mounted and thermally insulated from main base plate.

2. Two-element aperture condenser.

3. Compensated<sup>6</sup> apertures with azimuth adjustable by opposing screws.

4. Air-spaced intermediate objective lens.

5. Low-distortion galvanometer<sup>7</sup> with large protective window.

6. Large diameter slit condenser.

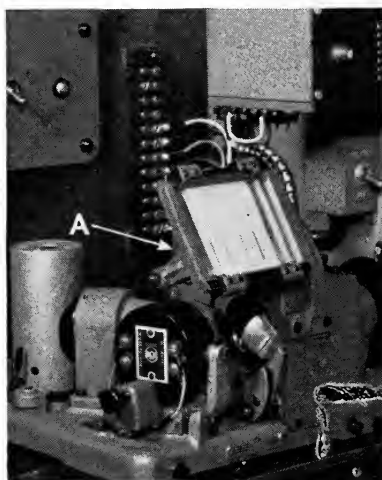


Fig. 2—Optical-system assembly mounted in Type PR-31 recorder. Phototube monitor assembly just visible at A behind visual monitor screen.

7. Slit of entirely new design with azimuth adjustable by opposing screws.

8. Single-vane, fully adjustable ground-noise-reduction shutter<sup>8</sup> for class A push-pull and duplex recording. (Auxiliary equipment, not standard.)

9. Reversible ultraviolet filter assembly, easily removable for cleaning.

10. Isolated focus adjustment for objective lens.

11. Top-mounted phototube monitoring system<sup>9</sup> with phototube in upright position to the rear. (Accessory equipment.)

12. Fixed optics for monitoring galvanometer, ground-noise-reduction shutter and lamp filament visually, by rear-screen,

line-of-sight projection, with monitoring screen mounted to the operating side of the system (Fig. 1).

13. Thumb-actuated, safety-locked light-meter control.

14. Aperture of entirely new design for recording positive or negative bilateral tracks at will.

15. Standard equipment provides for recording new double bilateral tracks designed to reproduce equally well in standard or push-pull sound heads.

16. Bias-type ground-noise reduction for bilateral recording.

17. Optical system adjustable to record at standard or other distances from either edge of film.

18. Unit subassembly construction employed throughout.

19. All objective housing assemblies premachined to mount phototube monitoring and ground-noise-reduction shutter assemblies when required.

20. All lenses and prisms coated to reduce reflection, except in visual monitoring and light-meter systems.

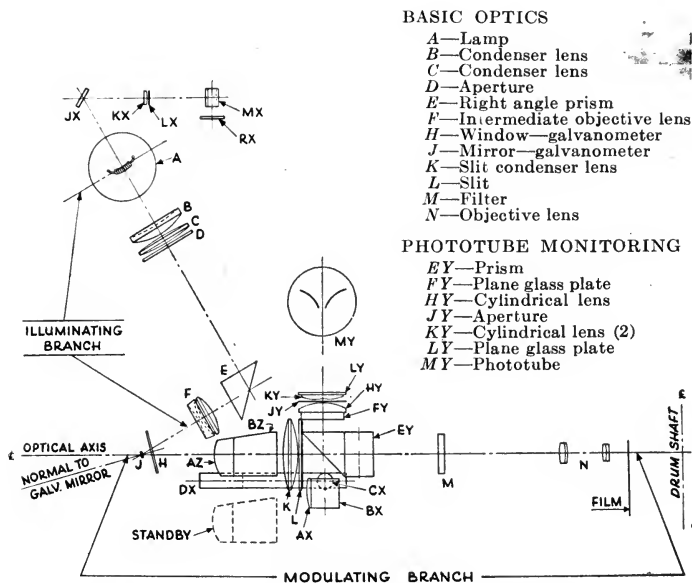


Fig. 3—Schematic plan view of the optical system.

## II. OPTICAL DESCRIPTION

### A. Component Optical Systems

The new system includes the following seven distinct component optical and electromagnetic systems; all are standard equipment except as indicated:

1. *The Basic Optical System:* This may be traced by referring to the schematic plan view of Fig. 3, and following the legend "Basic Optics" in the order of progression of the light from A through N.

2. *The Modulation Monitoring Optical System*: This may be traced by referring to the schematic front and side elevation views of Figs. 4 and 5, respectively, and following the legends "Modulation Monitoring" in the order of progression of the light from AX through FX.

3. *The Filament Monitoring Optical System*: This may be traced by referring to the schematic side elevation and plan views of Fig. 5, and following the legend "Filament Monitoring" in the order of progression of the light from JX through FX.

4. *Phototube Monitoring Optical System (Accessory Equipment)*:<sup>9</sup> This may be traced by referring to the schematic plan and front

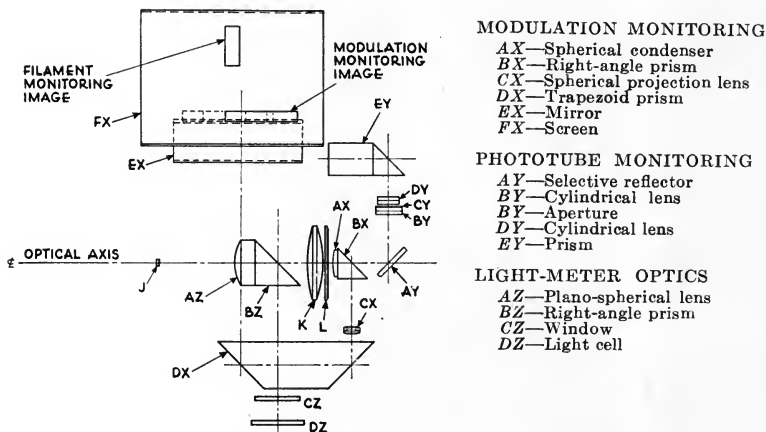


Fig. 4—Schematic front elevation of the optical system.

elevation views of Figs. 4 and 3, respectively, and following the legends "Phototube Monitoring" in the order of progression of the light from AY through EY, and from EY through MY.

5. *Light-Meter Optical System*: This may be traced by referring to the schematic front elevation view of Fig. 4, and following the legend "Light-Meter Optics" in the order of progression of the light from AZ through DZ.

6. *Low-distortion Galvanometer*:<sup>7</sup> This is a vibrating mirror type of light modulator, the mirror being shown at J in Fig. 3. The motor that drives the mirror is of the balanced-armature type and has unusually low distortion.

7. *Single-Vane Ground-Noise-Reduction Shutter (Auxiliary Equipment)*: This is a moving-armature type of motor<sup>3</sup> moving a suitably shaped metal vane up and down very close to slit<sup>8</sup> *L* of Fig. 4, and between it and lens *AX*. A description of its optical performance will be given in II,B,7 below.

### B. Features of the Component Optical Systems

1. *Basic Optical System*: In this optical system (Fig. 3) the filament of lamp *A* is imaged by condensers *B* and *C* and lens *F*, upon galvanometer mirror *J*. The filament image fills this mirror. The

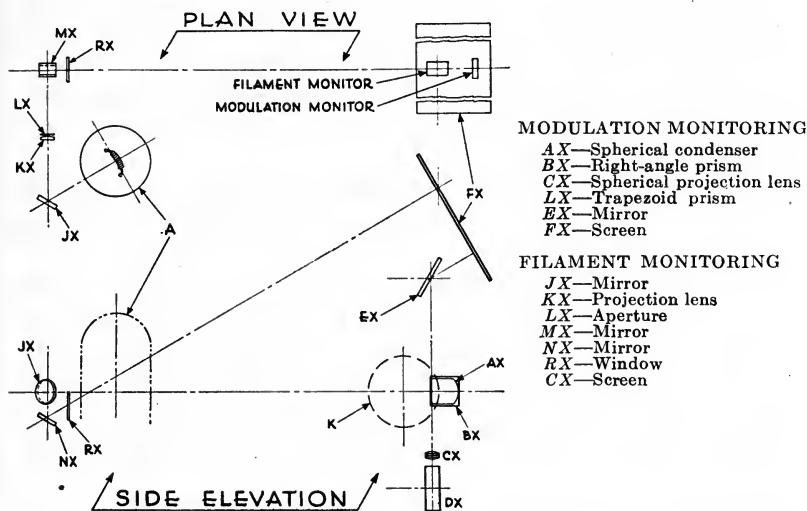


Fig. 5—Schematic side elevation and partial plan view of the optical system.

aperture *D* is imaged by lenses *F* and *K* upon slit *L*, where rotary vibration of *J* makes this image move across the slit to vary the length of its illuminated portions. Lens *K* produces an image of mirror *J* in objective lens *N*, and lens *N* images the slit *L* upon the sensitive film emulsion. Prism *E* folds the optical system into the L shape discussed above; window *H* protects the galvanometer motor from dust; and filter *M* controls the spectral distribution of the light that finally exposes the film.

The arrangement is essentially like that used in former systems of

this type, but includes a number of improvements. The double condenser *B* and *C* is especially designed to minimize spherical aberration in the image of the filament at the mirror *J*. The effect of this is to improve uniformity of illumination in the aperture image that illuminates the slit. The lens at *F* is an air-spaced crown and flint pair designed to flatten the aperture image at the slit and is an improvement upon the former cemented doublet lens in this respect. Lens *F* has been specifically designed for this application and full account has been taken of the effects of lens *K* upon the image. Lens *K* has been increased in size for easier cleaning.

The slit *L* is of entirely new design, and replaces the fabricated slit formerly used. The new slit is formed on glass by a special technique and embodies a number of desirable qualities that constitute an improvement over the old mechanical slits as follows:

(a) The slit is between glass plates where it cannot accumulate dirt. It can be readily cleaned by methods suitable for glass surfaces without damage to the slit.

(b) The slit edges are smooth, straight, and parallel, and its width is precisely controllable in manufacture. Its width cannot change after the slit is made.

(c) The layer forming the slit is only a few light wavelengths in thickness. It produces no vignetting as in mechanical slits where the metal edges forming the slit had to be about 0.003 inch thick to be practical. (In the mechanical slit, which was 0.0018 inch wide, the thickness of the metal edges was nearly twice the slit width.)

The slit azimuth is readily adjusted and secured by a pair of opposing screws.

The lamp *A*, in prefocused base with curved filament rated at 10.5 volts 7.8 amperes, is fully adjustable for location and height.

The apertures designed to be located at *D* are compensated<sup>6</sup> to neutralize the rotation effect in the aperture image, that results from the vibration axis of the mirror *J* making an oblique angle with the projection axis. This is accomplished by appropriately computing the angles of the cutting edges of the apertures, with the obliquity of the mirror *J* taken into account. Also, in each aperture there is at least one edge that is imaged approximately parallel to the slit. These edges are specially oriented with respect to the cutting edges so that, when their images are brought into coincidence and parallelism with the slit, the associated aperture is automatically in approximately the correct azimuth for proper operation of the system.

The filter  $M$  is readily removable for cleaning or replacement without disturbance to any adjustments, and the objective lens  $N$  moves independently of all other adjustments for focusing purposes.

Objective  $N$  produces a track of standard width, and a special objective to make a track that conforms to the wide standard is in course of design.

2. *Modulation Monitoring Optical System:* In this optical system (Figs. 4 and 5) a portion of the light arriving from the mirror  $J$  at the slit  $L$  passes through a window in the slit and enters the lens  $AX$ . It is then reflected downward by prism  $BX$  to lens  $CX$  in which there is formed an image of mirror  $J$ . The light is then doubly reflected by prism  $DX$  to mirror  $EX$  and thence to the screen  $FX$  where lens  $CX$  produces an image of the window in slit  $L$ . The monitoring aperture in  $D$  (Fig. 3) is imaged in this window, and the noise-reduction shutter, when used, is in a plane very close to the window. Thus motions of both mirror  $J$  and the shutter vane can be registered upon the monitoring screen. The precise operation of the visual monitoring light beam will be explained in connection with the description of the ground-noise-reduction shutter vane in II,B,7, below, and also in connection with the description of the action of the system when recording bilateral negatives and positives, in II,C,4, below.

All optical elements in the modulation monitoring optical system are fixed in position, and the projection lens  $CX$  is provided with a screw-driver adjustment for focusing.

The screen  $FX$  is translucent and the image projected upon it from the rear. It is tilted back at an angle of 30 degrees to the vertical to provide for more comfortable viewing; the light is projected upon the screen normally and in the line of vision to provide maximum observed image brightness for this type of projection, and to avoid keystone in the images. Built-in straight edges for drawing limit lines, and colored overmodulation indicators are provided. The screen deflections are five times as great as the deflections of the aperture image in the plane of the slit.

3. *Filament Monitoring Optical System:* In this optical system (Fig. 5) light is received by mirror  $JX$  from the concave side of the curved filament of lamp  $A$ , and reflected to lens  $KX$  which is provided with a small aperture  $LX$ . Thence it passes to mirrors  $MX$  and  $NX$  which reflect it to the back of screen  $FX$  where it is incident normally to the screen surface in the line of vision. The lens  $KX$  produces an image of the filament upon the screen. The axis of the filament

appears vertical on the screen and there is no keystoneing. The image is formed at a magnification of  $3.75 \times$  for comfortable viewing.

4. *Phototube Monitoring Optical System:* In this optical system (Figs. 3 and 4) a selective or dichroic reflector<sup>9</sup> *AY* between the slit *L* and objective *N* receives the light from the slit, reflecting the red vertically for monitoring purposes and transmitting the violet and ultraviolet to objective *N* and the film to expose the sound track. From reflector *AY* the red light passes through cylindrical lenses *BY* and *DY* which image the slit upon the beam-splitting cylinders *KY* after passage through prism *EY*. The light from one half of the slit is directed by lenses *HY* and one of the lenses *KY* to an image of the galvanometer mirror on one cathode of the RCA-920 push-pull phototube *MY*. Light from the other half of the slit is similarly directed to the other cathode. An appropriate switching arrangement in the circuit associated with the phototube permits audible monitoring of standard or push-pull recordings with the same monitoring optical system.

5. *Light-Meter Optical System:* In this optical system, Fig. 4, a simple lens *AZ* is cemented to the right-angled prism *BZ*; the combination converges and directs all the light from galvanometer mirror *J* upon photovoltaic cell *DZ* in the base of the optical system. The cell is protected by the dust window *CZ*. Except when metering the light, the lens and prism assembly is drawn aside by a spring to a stand-by position in which it is safety-locked to avoid accidental interruption of a recording by inadvertently pushing the light-meter optics into their operating position. The light-meter optics and actuating arm are mounted integral with the visual monitoring optical system. The actuating button is in the recorder housing and an adjustable member makes the meter operable with the optical system in position to record at standard or other distances from either edge of the film.

6. *Galvanometer:* The galvanometer is of new design. It has unusually low distortion,<sup>7</sup> and is equipped with a  $1/8 \times 1/10$ -inch rectangular mirror and large dust window for easy cleaning. A bias coil is provided for ground-noise reduction when bilateral tracks are to be recorded.

7. *Single-Vane Ground-Noise-Reduction Shutter:*<sup>8</sup> This unit is a necessary auxiliary to the recording of duplex and class A push-pull tracks for the production of which the bias-type ground-noise-reduction system is not applicable. Its action from the optical



standpoint is readily understood by referring to Fig. 6, which, from the galvanometer mirror, is a view of the slit  $S$  and monitoring window  $W$ , showing a superimposed image  $A$  of the class A push-pull aperture. It also shows in phantom the outlines of the ground-noise-reduction shutter vane  $V$  which is just behind the slit.  $M$  is the image of the monitoring aperture associated with the class A push-pull aperture. In action, images  $A$  and vane  $V$  move up and down transverse to the slit as indicated by the two-headed arrow. Two edges of the opening  $O$  in the shutter vane cross the slit at points equally spaced from its center and between which the vane does not cover the slit. The cutting edges of the images  $A$  also cross the slit at points equally spaced from its center; they are designed to intercept the slit at all points when moved up and down,

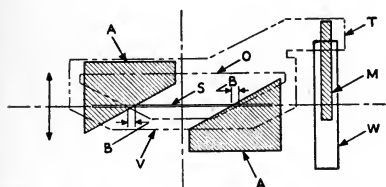


Fig. 6—Action of the single-vane ground-noise-reduction shutter.

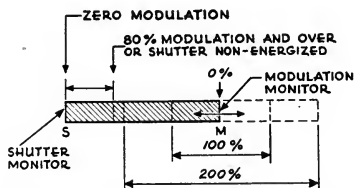


Fig. 7—Appearance of visual monitor when ground-noise-reduction shutter is employed.

save a neutral portion or septum at its center. The images  $A$  are shown in their stand-by position with cutting edges intercepting the slit at points midway between septum and ends. The vane  $V$  is raised to the position shown, by application of direct current to its motor,<sup>3</sup> until the portions  $B$  of the slit covered by images  $A$  and also uncovered by the vane  $V$  are sufficiently long to trace in the track bias lines that have the required width. As voice currents are applied to move images  $A$  up and down, the current holding vane  $V$  in this top position is automatically reduced, and the opening  $O$  assumes a lower position, as it opens the slit farther to accommodate the excursions of images  $A$ . When the voice currents cease, the vane  $V$  rises again and restores the narrow bias lines to the track to minimize ground noise.

A portion of the image  $M$ , as shown in Fig. 6, passes through window  $W$  in the slit plate, and of this a further small portion is intercepted by tab  $T$  appended to shutter vane  $V$ . The light that passes through  $W$  and is not intercepted by  $T$  reaches the monitor screen as

the image  $SM$  of Fig. 7, where  $S$  is the image of the lower edge of the tab  $T$  and  $M$  that of the image  $M$  of Fig. 6. Modulation and displacements of the shutter are indicated by independent motions of the ends  $M$  and  $S$ , respectively, of the image as shown in Fig. 7.

### C. Types of System Operation

Fig. 8 illustrates schematically the various types of recording apertures and slits that may be employed with the new optical system. Other types may also be used for producing special kinds of sound tracks, but those illustrated are designed to produce the tracks most commonly used.

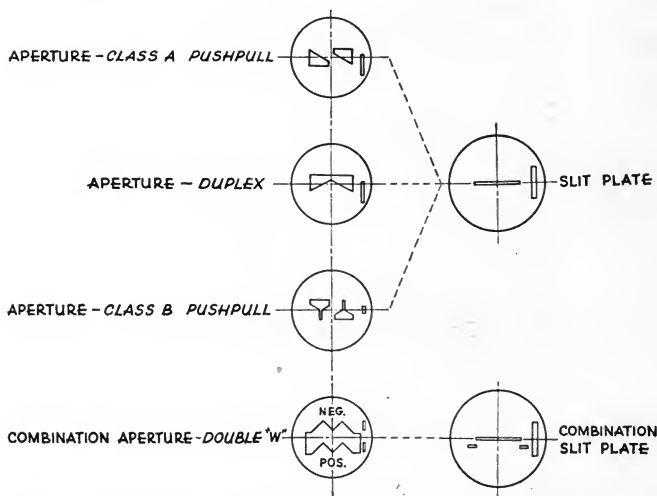


Fig. 8—Assortment of slits and apertures for recording negative and positive tracks.

1. *Class A Push-Pull Negative*: For this type of operation, the compensated<sup>6</sup> class A aperture and single slit of Fig. 8 are used. The noise-reduction shutter is required as auxiliary equipment, and the appearance of the monitoring beam on the screen is as shown in Fig. 7. The track produced is well known and has been discussed in past issues of the JOURNAL.<sup>10</sup> Its commercial application is of long standing.

2. *Duplex Negative*: For this type of operation, the compensated duplex aperture and single slit of Fig. 8 are used. The noise-reduction shutter is also required, and the visual monitoring image has the same

appearance and action as in class A push-pull operation (Fig. 7). There are many references to this type of track in the literature,<sup>3,10</sup> and it has long been in commercial use.

3. *Class B Push-Pull Negative*: For this type of operation, the compensated class B aperture and single slit of Fig. 8 are used. No ground-noise-reduction equipment whatsoever is required. The visual monitor indication is essentially the same as described for the type of operation to be discussed in the next subsection. This type of operation has been described in detail and has been in commercial use for many years.<sup>11,12</sup>

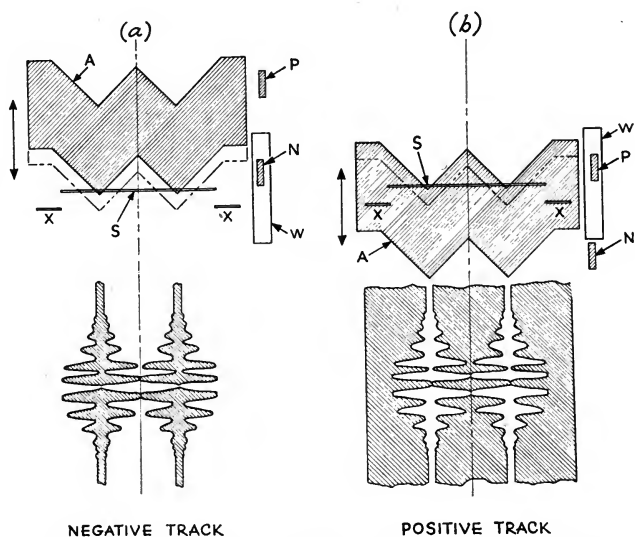


Fig. 9—Action of the double-W aperture and combination slit, in the production of both negative and positive master double bilateral tracks.

4. *Double Bilateral Negative or Positive Master*: In this type of operation, a special compensated combination aperture known as double-W and combination slit are used. These are illustrated schematically in Fig. 8. The drawing of Fig. 9 shows in detail how this aperture and slit co-operate to produce a negative or positive track at the will of the recordist. The shaded areas *A* represent the image of the double-W aperture, and areas *P* and *N* the images of the two monitoring apertures associated therewith. *S* is the recording slit in the plane of the aperture image, and *W* is the window in the slit plate

through which the monitoring beam passes to the monitoring optical system and screen. The two auxiliary slits *X* below the recording slit serve to expose the track to standard printed area width<sup>13</sup> when recording a positive master track.

In recording a negative track, the image *A* and slits *S* and *X* bear the relation illustrated in (a) of Fig. 9. The negative track appears as shown directly below, where the shaded areas correspond to the dense parts of the track. During modulation, the lower edge of *A* may drop to, and vibrate vertically about, mean positions as low as the limit indicated by the phantom line. This mean position is controlled by the bias current in the galvanometer<sup>7</sup> for noise-reduction purposes.

In recording a positive master track the image *A* and slits *S* and *X* bear the relation illustrated in (b) of the figure. The positive master track appears as shown directly below, where the shaded areas

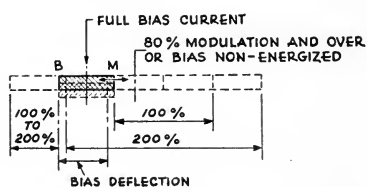


Fig. 10—Appearance of visual monitor when bias ground-noise reduction is employed with double-W aperture.

correspond to the dense parts of the track. During modulation the upper edge of *A* may drop to, and vibrate vertically about, mean positions as low as the limit indicated by the phantom line. This mean position is controlled by the bias current in the galvanometer for noise-reduction purposes.

The track produced is in two identical parts as indicated in Fig. 9, each being of the bilateral type,<sup>14</sup> hence the name double bilateral. The advantage of the double over the old single bilateral track is that it can be reproduced in push-pull type reproducers<sup>11</sup> without incurring distortion at low levels. In the case of the single bilateral track, distortion could be caused by the track center, where low modulations occur, riding a little off the center of the septum of the beam splitter. In the case of the double bilateral track, no interference between the track and the septum of the beam splitter can occur, except at full modulation, where its effect would not be so serious. The new track thus minimizes effects of track mislocation in reproduction.

The design of the combination aperture and slit allows 200 per cent amplitude to be impressed on the galvanometer before modulation of the auxiliary slits *X* will occur. This applies whether a negative or positive master is being recorded.

When negatives are being recorded the monitoring beam  $N$  of Fig. 9 is imaged on the screen, and when positive masters are being recorded the beam  $P$  is so imaged. In Fig. 10, the solid-hatched rectangle represents the beam on the monitoring screen when negatives are to be recorded. The monitoring apertures are staggered so that when positive masters are recorded, the beam falls lower on the screen to the position indicated by the dotted crosshatching. The end  $B$  of the rectangles indicates the ground-noise-reduction bias adjustment under stand-by conditions, and the end  $M$  moves as shown when modulated 100 and 200 per cent. During modulation the rectangle  $BM$  may move to the right, and vibrate horizontally about mean positions to the right of that shown. The amount of this displacement of the mean position is indicated by the range labeled "Bias Deflection". This action is controlled by the bias current in the galvanometer<sup>6</sup> for noise-reduction purposes.

5. *Standard Equipment:* The combination (or double-W) aperture is supplied with the optical system as standard equipment in response to a growing interest in directly recorded positive sound tracks. Such tracks<sup>8</sup> have been used in the recording of high-quality masters that are then re-recorded to disks without intervening steps involving quality losses in sound printers. These tracks are also used as black-and-white masters for the production of dye tracks on color prints that are produced by reversal.<sup>15</sup> It has been found that better color tracks result by working from a directly recorded positive master than from a positive master printed from an original negative.

In addition to a combination aperture and slit for negative or positive master recording, standard equipment also includes coated lenses and prisms throughout, except in the visual monitoring and light-meter systems.

6. *Wide-Track Recording:* A special objective lens is in course of design. It is interchangeable with lens  $N$  of Fig. 3, and will render the optical system capable of recording wide sound tracks in accordance with Academy Research Council Specification RC-5001.

### III. MECHANICAL DESCRIPTION

Recent studies have shown that a de luxe recording optical system must be highly flexible if it is to fulfill the requirements of the present-day art. As shown in Fig. 2, the general arrangement and design consist of a common base supporting several subassemblies, which

permits simplification of manufacturing and flexibility of construction. The over-all design has been made to harmonize with the construction of the RCA Type PR-31 de luxe film recorder<sup>5</sup> and these two devices combine to provide a unit capable of producing sound-film records of extremely high quality.

The design provides wide clearances for all component parts and the assembly is removably mounted on the recorder mechanism. When

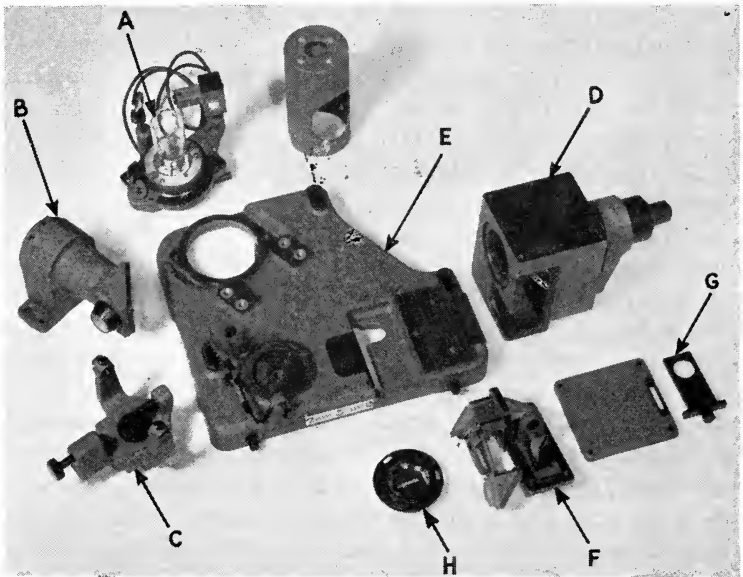


Fig. 11—Standard Type PR-31 recorder optical system, exploded into component subassemblies.

mounted in the Type PR-31 recorder (Fig. 1) the optical system is accessible for routine inspection through a wide hinged door, with complete accessibility afforded by easy removal of the entire optical system compartment housing, which is part of the recorder assembly.

Lightweight materials have been chosen in its construction wherever possible. All castings are made of an aluminum alloy heat-treated for maximum dimensional stability. Each part has been either anodized or nickel-plated to insure against corrosion and oxidation. In addition, an enamel finish has been applied to certain exposed surfaces. This finish serves to enhance appearance, and harmonizes

with the finish scheme of the Type PR-31 recorder. The selection of hardware permits the use of standard servicing tools, although the adjustable features have been carefully restricted to essential items.

#### A. Component Assemblies

Fig. 11 shows the various subassemblies detached from the main base, each such assembly being complete within itself. The various assemblies are described briefly as follows:

1. *Exposure Lamp Socket:* This assembly (Fig. 11A) permits the use of a curved filament prefocused lamp rated at 10.5 volts, 7.8 amperes, and operating at approximately 3200 degrees Kelvin. It is mounted to a standard self-locking socket equipped with a pressure-release key for easy removal of exhausted or defective lamps. A mica-glass composition insulator is placed between the socket and the assembly base for thermal isolation. The entire assembly is oriented on the main base casting with adjustments provided in both horizontal and vertical planes. The horizontal adjustment is semifixed while the vertical adjustment is made accessible to the operator by means of a slotted shaft for coin or screw-driver rotation. This rotation elevates the position of the lamp filament with respect to the optical axis. The adjustment is provided to compensate for variations in light center length tolerances for commercial lamps. A single-piece cover encloses the lamp yet provides adequate ventilation. Also attached to the socket assembly are the filament monitoring optics which indicate the position of the lamp filament relative to the optical axis as well as its configuration. In this assembly only three optical surfaces are exposed.

2. *Intermediate Objective Lens Assembly:* Adjacent to the lamp-socket assembly is a bracket (Fig. 11B) for housing the lamp condensers, recording apertures, 90-degree prism, and the intermediate objective lens. This bracket is mounted to the main base as an independent unit which is oriented and doweled in place. It may be removed for interchanging with other types of intermediate systems without alteration to the other components of the over-all optical system. Lenses *B* and *C* and aperture *D* of Fig. 3 are assembled in a single demountable cell and mounted in the bracket nearest the lamp. Two opposing screws are provided in the bracket for independent aperture azimuth adjustment. The entire cell may be removed and replaced in the bracket without readjustment by means of dowel-pin positioning. Opposite the condenser-aperture cell is located prism *E* of Fig.

3, mounted in a fixed position and accessible by a single cover plate. Adjacent to this prism are the two components of the intermediate objective lens  $F$  of Fig. 3 which are combined in a common cell and attached to the bracket in a fixed position. Neither the prism nor the objective lens requires adjustments beyond the factory alignment.

3. *Galvanometer Mounting:* A yoke arrangement (Fig. 11C) supports a low-distortion galvanometer.<sup>7</sup> All routine operational adjustments of the Type PR-31 recorder optical system are confined to this assembly. The adjustments for so-called "stand-by position" of the recording light beam are controlled by rotation of the bracket and galvanometer assembly about the point of intersection of the axis of the illuminating and modulating branches of the optical system. The yoke when attached to the main base plate (Fig. 11E) may be rotated on the vertical axis by adjustment of two opposing screws. The galvanometer tilt or adjustment on the horizontal axis for normal 50 per cent track exposure is accomplished by adjusting a large knurled screw extending from the rear of the bracket. The tilting screw likewise permits aligning the galvanometer for either negative or direct-positive recording by appropriately positioning the double-W recording aperture image superimposed upon the recording slit. Transfer from negative- to positive-type recording may be accomplished in matter of seconds. Spring tension is supplied to the tilting screw to insure stability of adjustment.

4. *Recording Slit, Monitoring, and Objective Lens Assembly:* Fig. 11D shows a housing for the slit condenser  $K$ , recording slit  $L$ , filter  $M$ , and final objective lens  $N$  (Fig. 3), as well as the various monitoring elements. This unit is mounted on the main base plate. Each of the aforementioned items of this assembly is an individual unit and will be described separately. Taken in order of the passage of light, the slit condenser lens  $K$  and the recording light slit  $L$  are mounted in a cell (Fig. 11H) providing a dust-tight enclosure of the inner surfaces of each element, while the exposed surfaces are made accessible for routine inspection. The slit condenser lens is held in the cell by a suitable spanner nut on the side nearest the galvanometer, while the slit, previously described in this paper, is retained on the opposite side of the cell. Slit azimuth adjustment is accomplished by means of opposing screws while positive locking is obtained by suitable screws extending through an outer flange of the cell into the housing. The cell is doweled in place and may be removed for inspection without loss of azimuth. Located beyond this assembly is a plate providing



a common mounting for all items of the visual monitoring system, except mirror *EX* and screen *FX* of Fig. 4. This assembly (Fig. 11*F*) may, by use of locating dowels, be readily removed and replaced without readjustment. Each optical element is positively positioned. When assembled in place, only one optical surface is exposed to open atmosphere. Also attached to this plate is the exposure-meter projection assembly which, when "triggered" into position, intercepts the recording light beam reflected from the galvanometer and projects the beam to a photovoltaic cell located in the base plate. The output of the photovoltaic cell is terminated at a meter located on the Type PR-31 recorder control panel. This device may be actuated through the

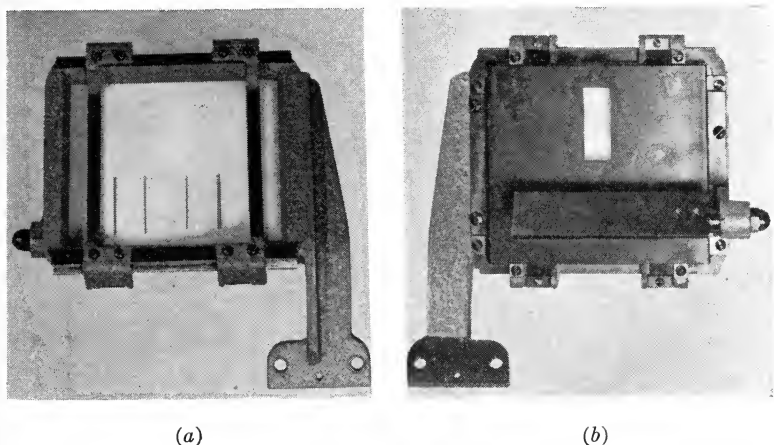


Fig. 12—Visual monitoring screen assembly showing mechanical construction.

closed recorder optical system compartment door by a nonlocking plunger mechanism (Fig. 1) or may be operated directly when the door is in open position. It is safety-locked in the nonoperating position to prevent accidental use during a recording operation. Towards the right from the monitoring assembly may be seen the ultraviolet filter and clear compensator *M* of Fig. 3, with both items mounted in a single holder (Fig. 11*G*). Selection of filter or compensator may be readily made by reversing the holder end for end on its supporting plate. To the extreme right of Fig. 11*D* is the final objective lens barrel, focusing nut, and objective lens *N* of Fig. 3. This assembly is mounted independently of all other optical elements and may be adjusted without disturbance to the remainder of the system.

Calibrations on the focus-adjusting nut provide for easy and accurate setting of the objective lens. It is divided into 25 equal divisions providing a 0.001-inch focal increment per division. The entire assembly is locked in place by a single pressure screw which does not disturb the lens position. A single cover plate totally encloses the housing, rendering it dust-tight. The phototube monitoring assembly, described above under II,B,4, replaces this cover plate when added as an accessory item.

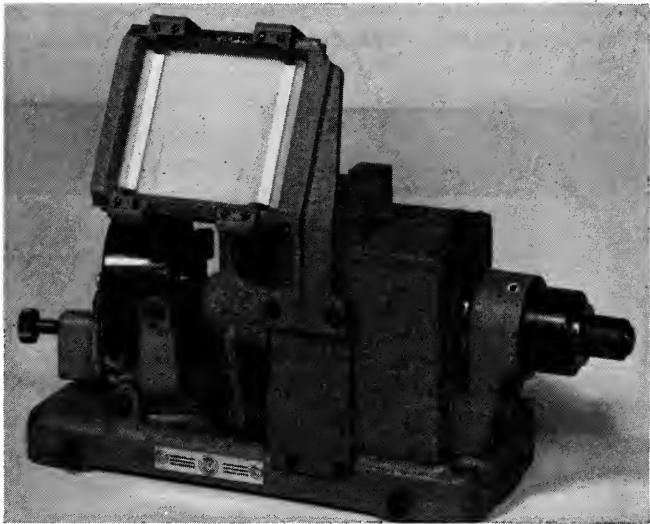


Fig. 13—Standard optical system assembly for the Type PR-31 recorder.

5. *Visual Monitoring Screen:* Fig. 12 shows the visual monitor screen assembly which is also attached to the objective housing assembly. The monitor screen receives the combined modulation and ground-noise-reduction monitor light beam as well as the projected image of the exposure-lamp filament. The assembly consists of a flashed opal-glass screen ground on the outer surface for ease of marking, a pair of movable straight edges, a pair of movable color filters, and a mirror for reflecting the modulation monitor beam to the screen. Reference lines indicating "stand-by" and 100 per cent limits for both modulation, and bias indications are established on the screen by positioning the straight edges to the respective positions of the light beam

and then marking the screen with either pencil or pen. After calibrating in this manner, the straight edges are moved to a position of approximately 200 per cent reference for both modulation and bias. At this latter position, a colored filter is brought into position from the rear side of the screen for both references. When the system is in operation at a level in excess of 100 per cent for either modulation or bias, a contrasting color indicates the presence of overshooting. This arrangement affords the recordist an easily visible indication of excessive level that does not require critical observation.

6. *Over-all Assembly of Standard Features:* Fig. 13 shows all the aforementioned items assembled in place. Attachment of the optical



Fig. 14—Phototube monitoring optical system and transformer assembly.

system to the recorder proper is accomplished with hold-down screws which permit the sound-track location on the film in the recorder to be controlled by two fine pitch lateral adjusting screws. A wide range of track positions is obtainable. The complete assembly weighs approximately  $8\frac{1}{2}$  pounds and measures  $8 \times 8 \times 11\frac{1}{2}$  inches over all. The outer surfaces are finished light amber gray metaluster enamel with polished black accessories.

### B. Accessory and Auxiliary Equipment

1. *Phototube Monitoring Assembly:* A phototube monitoring device as shown in Fig. 14, and described in section II,B,4 above may be installed as an accessory item. Mounting of this assembly is accomplished by interchanging it with the objective housing cover plate,

and without additional preparatory machining (Fig. 2). This assembly is also of unit construction except for the associated transformer and control network to which it is coupled by a single cable. A selector switch on the transformer assembly mounting plate is located within the recorder optical system compartment, and permits operation as either "standard" or "push-pull," depending upon the type of sound track being made.

2. *Ground-Noise-Reduction Shutter Assembly:* Fig. 15 shows the ground-noise-reduction shutter assembly. This is an auxiliary item required for recording class A push-pull or duplex tracks. This device is new in construction but retains the electromagnetic motor

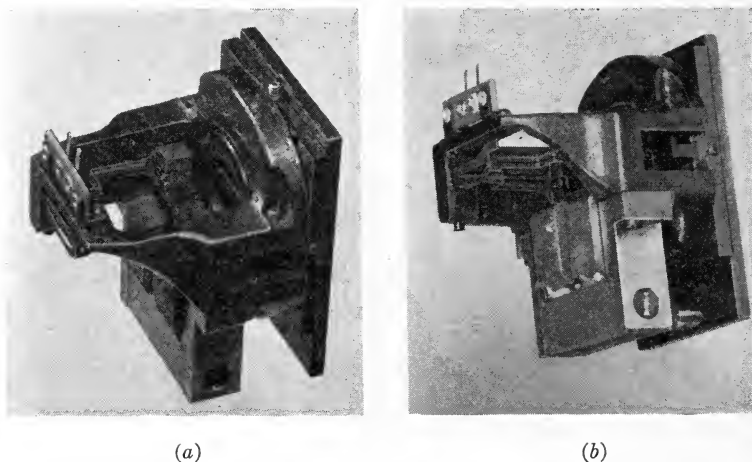


Fig. 15—Ground-noise-reduction shutter mechanism.

mechanism of earlier shutters.<sup>9</sup> The new design embodies the following features:

(a) A single vane insuring uniform masking of both ends of the slit; it is rigidly linked to a moving armature.

(b) Independent adjustment of the shutter vane in three planes by means of an interlocked cross-slide assembly.

(c) Moistureproof coils.

(d) Low hysteresis iron for pole-piece construction.

The entire unit is attached within the objective housing assembly and connected electrically to the over-all system by a single-pair conductor. All objective housing assemblies are premachined to mount shutters when required. Normal sensitivity of the shutter is in the

order of 20 milliamperes direct current and may be operated from all RCA ground-noise-reduction amplifiers that operate on the principle of increased output with decreased input. The over-all linearity of the shutter-vane travel extends well beyond the maximum deflection required to mask the recording slit adequately. The moving mechanism resonates at a frequency well above the highest that can appear in the output of the control amplifier. Optical monitoring of the shutter vane is accomplished by placing a small tab on one edge of the shutter vane to intercept a portion of the monitor light beam (section II,B,7). No change in monitoring optics is required when installing the shutter assembly in the standard optical system. The phototube monitor can also be used with systems employing this shutter, without additional modifications.

3. *Wide-Track Recording Objective Lens Assembly:* The wide-track objective lens assembly, which is in course of design, will be mechanically interchangeable with the lens that produces the normal or standard track as defined by ASA Z22.40-1946.

#### IV. CONCLUSION

The RCA variable-area optical system has undergone a long period of development, during which many changes in both principle and detail have steadily increased flexibility and quality of performance, with little change in basic form. Oftentimes improved features have had to take the form of attachments that functioned well, but were at a disadvantage from the standpoint of appearance, location, or operating convenience, because they had been added to a system not originally designed for them. The optical system described here combines previously established features and quality performance, with newly developed quality features in a new physical layout. The new arrangement is designed to combine optimum functional advantage and operating convenience with improved accessibility, adjustability, and interchangeability of all components as far as possible on an integral subassembly basis. There is also improved functional integration between the optical system and film mechanism, which together constitute the PR-31 recorder.

#### V. ACKNOWLEDGMENT

Grateful acknowledgment is tendered the many individuals, both within and without the RCA organization, whose thoughts, suggestions, and efforts contributed to the design and construction of this

optical system. Specific acknowledgment is made of the contribution of Messrs. W. V. Wolfe, A. C. Blaney, O. B. Gunby, M. E. Collins, E. W. Kellogg, G. L. Dimmick, C. E. Hittle, and the late J. L. Underhill.

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# Cathode-Ray-Oscillograph Images of Noise-Reduction Envelopes\*

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*Summary*—A method of using a standard cathode-ray oscillograph to present low-frequency or direct-current conditions is described. In the interest of sound on-film recording the paper describes how an electronic switch is used to generate repetitive pulses of audio signals as a second electronic switch is used to pick up the signals and the resulting noise-reduction-bias envelope and place them in reference positions on the oscillograph.

THE MOST ACCURATE method of measuring noise-reduction "envelopes" or direct-current pulses is (probably) the high-speed recording oscillograph. This instrument involves a delay before the graph may be developed and read and it lacks reference marks unless a dual unit is used. Graphs can be compared before and after adjustments but the changing results of an adjustment cannot be shown without considerable comparison and delay.

The use of two electronic switches of standard design, a cathode-ray oscillograph, a sine-wave audio oscillator, and an optional high-pass filter make possible the generation of ideal reference signals and presentation of both the reference signal and envelope on the oscillograph.

Fig. 1 shows a block schematic of the Western Electric Type RA-1124 Noise-Reduction Unit which was the "guinea pig" for this work. In typical operation the speech amplifier is bridged across the recording circuit. The signal is amplified, diode-rectified, and "shaped" by the low-pass filter of proper timing characteristic. The timing varies with use. Low-speed filters are used with single sound tracks and high-speed filters are normally used with push-pull sound tracks. The voltage output of the filter is used to modulate a 20-kilocycle oscillator output. The modulated 20-kilocycle is then amplified, rectified, and ripple-filtered to provide bias current for the light modulator. During silent intervals the bias current closes the modulator to a predetermined value. As speech is applied to the light modulator the bias is removed according to the "shape" of the timing filter.

\* Presented April 21, 1947, at the SMPE Convention in Chicago.

The clearance between the biased spacing of the modulator and signal peak is referred to as margin. If the bias spacing fails to provide sufficient clearance for the signal, particularly at the beginning of a speech signal, distortion or "clipping" of the signal peaks occurs.

A light-valve variable-density system was used with this work although a similar analysis may be made with any variable-area system.

In Fig. 2, when the signal is graphically applied to the lower ribbon of the light valve and the noise-reduction envelope to the upper ribbon, the functions of signal and noise reduction may be separated and more easily illustrated. The variable-area equivalent is the familiar unilateral sound track.

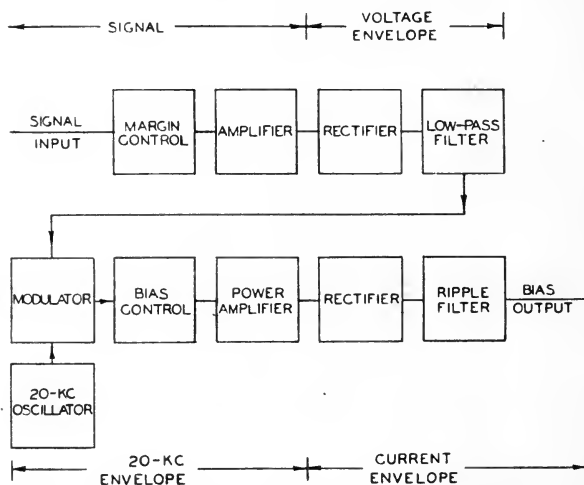


Fig. 1—Block schematic of RA-1124 noise-reduction unit.

The method used to place the signal and noise-reduction envelopes in their proper graphical relationship on the oscillograph screen makes use of this type of illustration.

Fig. 3 shows the test signal. The signal is a pulse of 700-cycle sine waves followed by a blank interval, another pulse, another blank interval, and so on. The pulse amplitude and rate are varied over desired limits. Each pulse, depending on length, amplitude, and repetition rate will, when connected to a properly adjusted noise-reduction system, generate a noise-reduction envelope whose "shape" will have a definite relationship to the pulse characteristic, as shown in Fig. 4.



Adjusted vertically and timed horizontally on the cathode-ray oscillograph the attack and decay times are shown graphically and may be read directly in milliseconds. The effect of margin on "clipping" is seen; that of "threshold" adjustment on margin may be determined.

The test circuit requires explanation. Fig. 5 shows a functional schematic and a typical pattern observed on the oscillograph. In practice a 700-cycle sine-wave signal is connected to both input *A* and input *B* of electronic switch No. 1. Practically, the switch is a double-throw switch switching from the output of attenuator *A* to the output of attenuator *B* at any adjustable square-wave frequency between

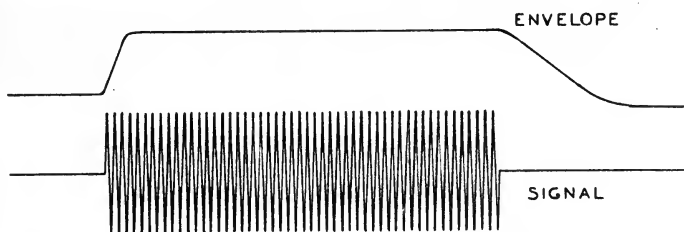


Fig. 2—Graph of test signal and noise-reduction envelope.

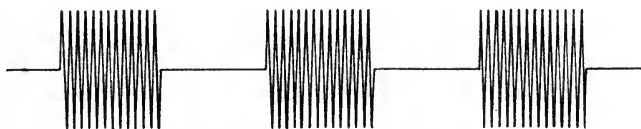


Fig. 3—Pulses of signal only.

2 and 3000 cycles per second. To illustrate: with the switching rate adjusted to 4 cycles per second, a signal on the output of attenuator *A* would be passed through the switch for one eighth of a second or 125 milliseconds. Then the switch changes to the output of attenuator *B*. The switch is disconnected from either attenuator for approximately one fortieth of a millisecond. The signal, if any, on the output of attenuator *B* is now passed through the switch for one eighth of a second or 125 milliseconds. The switch then transfers back to *A* in one fortieth of a millisecond and the signal *A* is passed for its interval, and so on.

With the attenuators adjusted to identical output levels an essentially steady signal appears on the output of switch No. 1 with a small transient every 125 milliseconds. This condition is used for line-up, bias, and margin adjustment.

After line-up the signal through *B* is completely attenuated and there appears from *A*, through the switch, the pulse of predetermined rate and amplitude. The oscillograph horizontal-sweep circuit is adjusted to synchronize with the pulse rate or submultiple of switch No. 1. Many amplifiers generate a low-frequency transient of varying amplitude when passing pulses or "blocks" of tone. To remove these from the pattern, a high-pass filter is used immediately before the light valve and noise-reduction circuit.

Examination will show the connections to the electronic switch No. 2. Input *C* is connected to the modulating signal and input *D* is connected to the noise-reduction leads, or light valve. For the test, the signal is *not* connected to the light-valve circuit. Only the noise-reduction envelope is applied to the valve. The oscillograph vertical

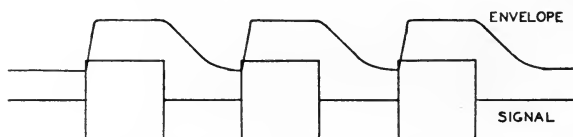


Fig. 4—Pulses of signal and noise-reduction envelope.

plates input is connected to the output of switch No. 2 which is adjusted to a 500-cycle switching rate. During the 1-millisecond interval when switch No. 2 is connected to *C* the signal on the output of attenuator *C* is passed through the switch and is seen on the oscillograph. Similarly, during the 1-millisecond interval when switch No. 2 is connected to *D*, the signal on the output of attenuator *D* is passed through the switch and is seen on the oscillograph. Normally, a useless jumble would be seen because the electrical axis of signal *C* is congruent with that of signal *D* and it is difficult to segregate the intermixed patterns. To make separation possible, a biasing supply is designed into the switch. Effectively it appears as a pair of variable voltages of opposite polarity placed in series with the output of each attenuator. These potentials, superimposed on the signals of each attenuator output, separate the signal from the noise-reduction envelope and the pattern shown is obtained. A low-frequency signal is shown for ease in illustration. By adjustment of these potentials and the attenuators *C* and *D*, the pattern on the oscillograph may be adjusted to illustrate any line-up condition of level and margin. Then the attenuator *A* may be adjusted to indicate the results of various signal levels, while the pulse rate of electronic switch No. 1 may be adjusted

to any multiple of the oscillograph sweep rate to show the effects of pulse rate.

The use of a 500-cycle switching rate on electronic switch No. 2 permits a short line of the envelope or signal pattern to appear every 2 milliseconds and for 1 millisecond's duration alternately on the upper (noise-reduction) and lower (signal) pattern. Faint vertical lines of one fortieth of a millisecond duration appear 1 millisecond apart. It is then possible to determine quickly and accurately the time constants.

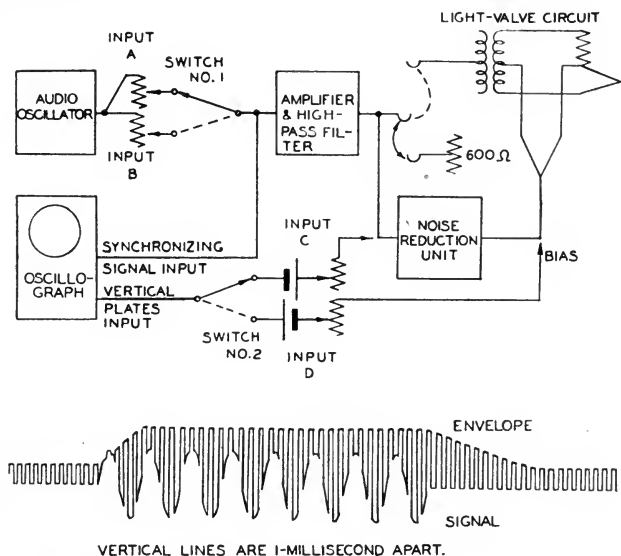


Fig. 5—Block schematic of electronic switches and recording system plus typical detailed pattern.

In Fig. 6, the upper patterns show a 700-cycle envelope of 125 milliseconds' duration and the resulting noise-reduction envelope. The 700-cycle signal is used to provide a signal near the center of the audio-frequency band whose interference with the 500-cycle switching rate would be random enough to show a "block" of signal rather than a distracting pattern.

The signal level, 6 decibels below unbiased overload, refers to a signal whose amplitude is 6 decibels below unbiased light-valve overload, or clash, of a light valve whose ribbons were normally spaced 1 one thousandth of an inch apart.

To set up this pattern a 4-cycle switching rate is used with the 700-

cycle signal. After margin adjustment with a steady signal the signal through attenuator *B* is eliminated. The signal measures 1 one thousandth of an inch peak to peak and on the lower ribbon would cause the ribbon to move one-half thousandth of an inch above and below its rest position. The noise-reduction ribbon at rest is spaced exactly 1 one thousandth of an inch from the signal ribbon at rest. Biased to 10-decibel noise reduction, this ribbon would position itself approximately 3 ten thousandths of an inch from the signal ribbon. When the signal is applied to the noise-reduction-bias cancellation

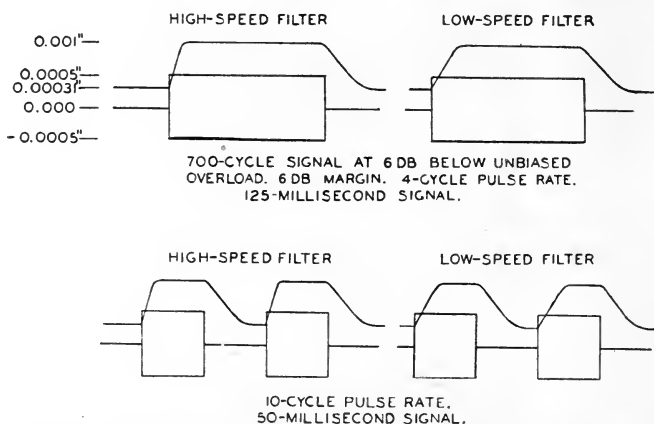


Fig. 6—Detail of 125-millisecond pulse and noise-reduction envelope. Also 50-millisecond patterns.

amplifier and rectifier the noise-reduction ribbon would, with a 6-decibel margin and a typical high-speed filter, move to 1 one thousandth of an inch from the signal ribbon in approximately 10 milliseconds. After the signal was removed from the noise-reduction unit, the ribbon would move again to the 3 ten thousandths of an inch spacing in approximately 30 milliseconds. In these filters of essentially constant "slope" the attack and decay-time ratings are those of 90 per cent voltage change. High- and low-speed filters usually differ only in attack interval. Observe the difference in the amount of "clipping" and accompanying distortion.

At the time these patterns were being traced the techniques of photographing cathode-ray-oscillograph images were not available to the author. However, the patterns have been traced from the oscillograph screen, and redrawn without French curves.

The lower patterns show the pulse rate increased to 10 cycles and each pulse shortened to 50 milliseconds' duration. The noise-reduction-to-signal ratio is the same as that for the 4-cycle rate because there is ample time for a complete noise-reduction cancellation and return cycle.

In Fig. 7, the upper 15-cycle patterns show the decay and attack curves beginning to overlap. The lower 20-cycle patterns show that, after the first pulse, clipping is not possible with either high- or low-speed filters. In Fig. 8, the upper patterns show how with short

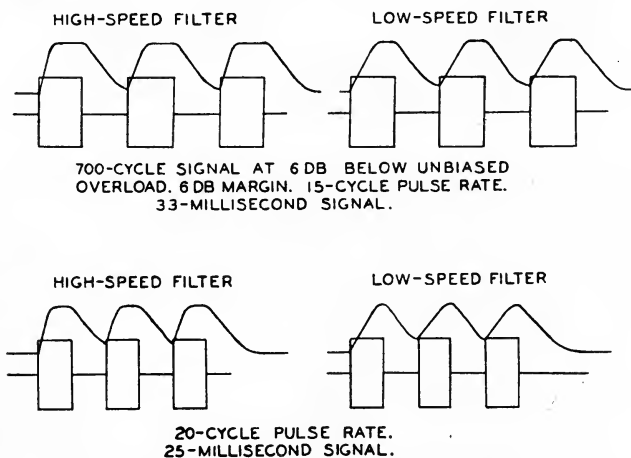


Fig. 7—33- and 25-millisecond patterns.

pulses, it may require a considerable time for the 6-decibel margin to be reached with the low-speed filter. If the pulses are very short, as in the lower figure, the 6-decibel margin may not be reached.

In generating the pulses used in these tests, the electronic switch No. 1 splits many cycles. The upper pattern of Fig. 9 is typical.

Observe the incomplete cycles at the start and termination of the pulse. These incomplete cycles contain many higher frequency transients and pulse-rate harmonics.

A 12-decibel equalizer is inserted in the line after the switch. The equalizer has a 10-decibel rise between 700 and 9000 cycles. The 700-cycle margin adjustment is remade and the lower pattern of Fig. 9 is obtained. The peak amplitudes of the equalized harmonics range up to 10 decibels above the 700-cycle normal.

In all subsequent patterns the pulse rate is 4 cycles and the pulse

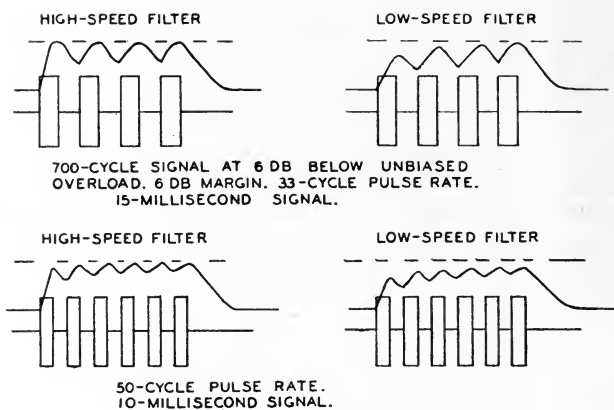


Fig. 8—15- and 10-millisecond patterns.

length 125 milliseconds. The signal and the noise-reduction envelopes are altered in vertical scale for ease in illustration.

Fig. 10 illustrates the effect of transient peaks in the signal or the noise-reduction envelope. The upper patterns are for the normal pulse. The lower patterns contain transients at the beginning and end of each pulse and are somewhat similar to many sounds encountered in speech and music. Contrary to some opinions, the peaks in the "front" of a modulation envelope do not cause the attack slope to become greatly exaggerated as most of the energy is used in charging the input capacitors of the filter; and the amplifier-rectifier stage preceding the filter does have some impedance. They do increase the slope slightly and may cause a slight overcancellation. A peak rising

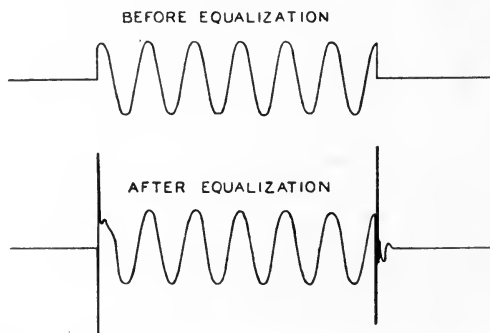


Fig. 9—Pattern with incomplete cycles equalized.

from a steady-state signal will cause a greater proportional disturbance than one at the beginning of a wave train.

In Fig. 11 and following graphs these effects are illustrated. Until the signal envelope is below threshold adjustment levels, the first peak is of lower amplitude than the peak at the end of each wave train. Threshold control requires a brief explanation. Normally any signal applied to the noise-reduction unit would start the cancellation process. By adjusting a fixed-delay bias on the grid of the modulator tube weak signals, whose amplitudes require no wider light-valve spacing, will not cause bias cancellation. Thus the average

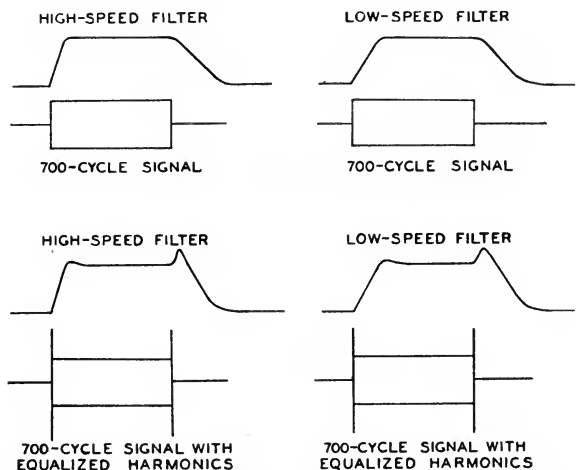


Fig. 10—Pattern showing envelope affected by transients.

spacing of the light valve remains less than it would be if no threshold were used. Consequently, less “breathing” of background noise is heard on reproduction of the film. The patterns are similar, except for attack slope, for both high- and low-speed filters.

In Fig. 11 a signal of 14 decibels below unbiased overload was used at a 4-cycle rate and 125-millisecond length. The margin was adjusted to 6 decibels at 6 decibels below unbiased overload. The threshold of cancellation action was varied from 25 to 16 decibels below unbiased overload. Note how threshold adjustment reduces noise-reduction envelope movement with low signal levels.

In the lower pattern the equalized pulse is used. Note that the first (attack) peak is of lower peak amplitude than the second peak.

As the threshold approaches the signal level, the cancellation is reduced and the first peak becomes similar to the second peak.

In Fig. 12 the flat pulse of 18 decibels below unbiased overload is used. Observe how with a 16 threshold adjustment no cancellation takes place. In the lower pattern the equalized pulse is used. As the threshold nears the signal level the peaks become symmetrical. In Fig. 13 the equalized pulse of 25 decibels below overload is used. The peaks cause no disturbance with the 16 threshold adjustment. In judging these results the use of threshold control and the disuse

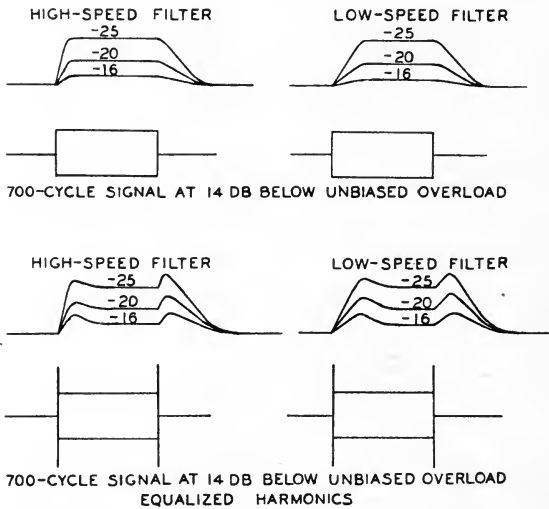


Fig. 11—Pattern, signal at 14 decibels below unbiased overload, showing effects of threshold.

of pre-equalization is indicated. However, this must be weighed against inherent noise reduction of pre- and postequalization and cancellation of noise-reduction disturbance in push-pull original recordings. The results indicate that clipping of staccato signals and sharp wave fronts may be greater than expected because the first peak does not contribute as much toward cancellation as might be desired.

The possibility of transients on the bias leads has been advanced. With some filter units, oscillograph patterns show a transient at the end of the decay interval. This varies with the type of filter, signal level into the margin amplifier, threshold adjustment, and so on.



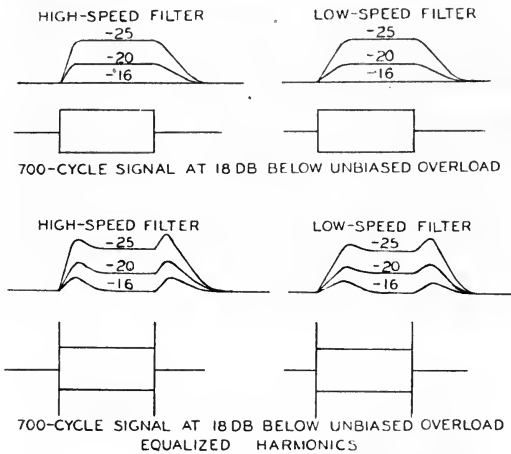


Fig. 12—Pattern, 18 decibels below unbiased overload, showing effects of threshold.

In Fig. 14, upper left, is a typical pattern obtained with the switch No. 2 input *D* across the speech rectifier output and with the timing filter removed. A typical unfiltered full-wave rectified pattern is seen. The upper right pattern is obtained with the input *D* across the speech-rectifier output with the filter in place. The slight attack slope is due to the time necessary to charge the input capacitor. The shape of the transient at the end of the decay slope varies with level, threshold adjustment, and individual filter unit over the limits shown.

The lower left pattern is obtained with the input *D* across the filter output. Greater slope is apparent on both the attack and decay. The transient changes in shape and seems delayed about 20 milliseconds. As previously explained, with this type of noise-reduction unit the output of the filter controls a modulator tube which in turn

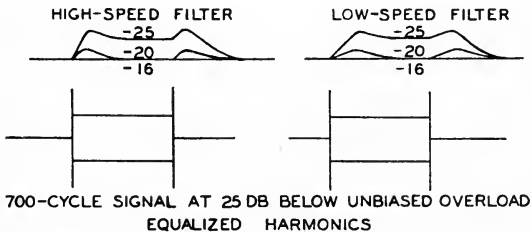


Fig. 13—Pattern, signal at 25 decibels below unbiased overload, showing effects of threshold.

modulates a 20-kilocycle signal which is later amplified, rectified, filtered, and applied to the light-valve circuit as bias. The lower right pattern is obtained with the input  $D$  across the bias leads. The slopes and transients are altered by the characteristic of the modulator tube.

Examination of all the components of the RA-1124 noise-reduction unit discloses no particular trouble or remedy. The transient is due to the controlled damping of the timing filter. It varies with individual filters and is most evident with the low-speed-type filter. It could be reduced by the retuning of the filter but this is usually involved. The amplitude of the transient is such that it, for about 30

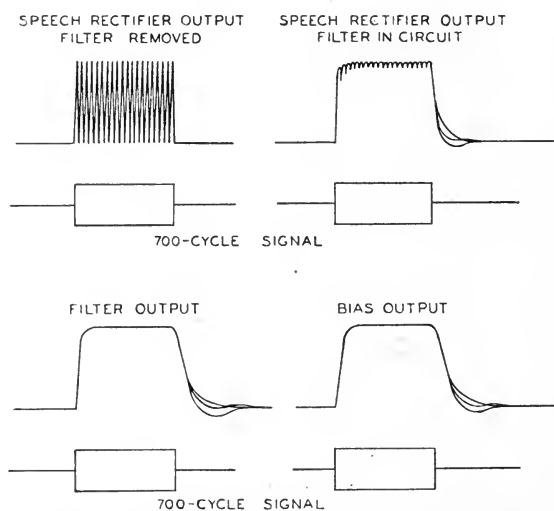


Fig. 14—Patterns showing transients in timing filter.

milliseconds, alters the noise reduction about 1 decibel. Practically, this can be ignored.

A poor tube in the margin amplifier caused the effects shown in Fig. 15. Overloading on positive peaks caused the bias and the plate voltage to change and the patterns shown resulted. The transient at the end of the envelope is caused by the low-frequency wave generated as the bias and plate voltage shifted back to normal after the signal was removed.

The oscillograph used may be of any average type. The tube may be of the  $P1$  phosphor medium-persistence type although the  $P7$  or  $P2$  long-persistence types would be desirable. Only one feature

should be stressed, that of a linear horizontal sweep at frequencies as low as 4 cycles per second. Because the oscillograph vertical amplifier receives its information at 500 cycles, and above, the usual difficulties of low-frequency or direct-current presentation are avoided.

This adaptation of electronic switches to the visual inspection of noise-reduction envelopes is one of the many utilizations of such equipment. Low-frequency and direct voltages may be read with high-frequency switching rates. The switch may be used to transfer the

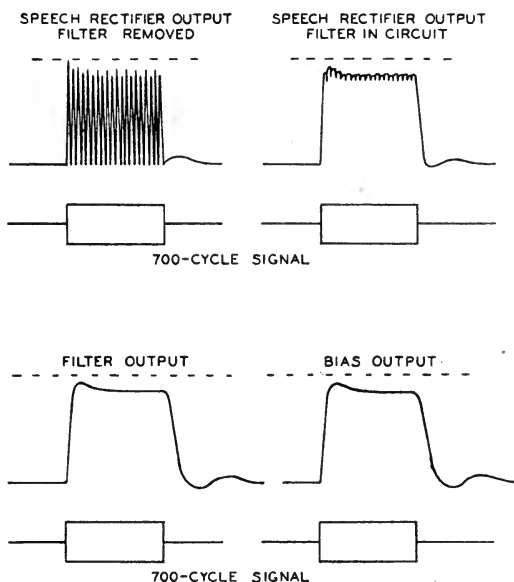


Fig. 15—Patterns showing transients generated in margin amplifier.

oscilloscope back and forth between the input and output of an amplifier, and after the patterns are adjusted to equal amplitude, by comparison check amplitude distortion, frequency characteristic, and phase distortion quickly. The switch used to time pulses or "blocks" of signal may be used to check time constants and "thumps" of compressors and expanders. A typical use is to send pulses of 700-cycle signal into a limiter amplifier and audibly adjust the balancing controls for minimum "thumps".

The switches of the author are homebuilt but are similar to devices available on the instrument market.\*

\* Allan B. DuMont Laboratories, Inc.

# A Motion Picture Film-Developing Machine\*

BY R. PAUL IRELAND

ENGINEERING DEVELOPMENT LABORATORY, CHICAGO, ILLINOIS

*Summary*—This paper describes a motion picture film developing machine which operates on a principle which has been used for a long time. It has been designed with the intention of providing convenience and flexibility of operating setup for various processes. Thyatron controls are used to provide uniform tension at the head and takeup, and to control speed of the main drive. Air agitation is provided.

THIS MACHINE is designed to fit the needs of both small and medium-sized motion picture laboratories. It is made in models for both 35-mm and 16-mm film, and to handle all processes in general use, at speeds of from thirty to one hundred feet per minute. It is of small size in relation to its capacity.

The basic principle of operation of this developing machine has been in use for many years and is not new. The general design of the machine will be described rather than a specific model. Fig. 1 is a photograph of one of the machines installed with the drying cabinet in the same room with the wet section; Fig. 2 is a schematic drawing.

The head assembly is made with two spindles, each holding a 2000-foot roll, either on reel or core. Film can feed into the machine from either spindle. In use, the two spindles permit one to be always ready, loaded with a new roll of film, to facilitate rapid splicing onto the preceding roll end. The film feeds from a roll into the elevator, which is kept at full-load position by means of a thyatron-controlled brake on the spindles.

Another electrically operated brake is located on a sprocket roller at the entrance to the elevator. When a feed roll is exhausted, this brake automatically stops feed into the elevator, leaving a loose end of slack film ahead of the elevator to be spliced onto the new roll. The pressing of a brake release button after a new roll is spliced on, causes the elevator to refill. An audible warning signal is provided on the head, which operates whenever a roll runs out or when the elevator starts to rise.

The drive is run by a thyatron-controlled motor. It operates by means of an endless chain, which engages a chain sprocket attached

\* Presented April 22, 1947, at the SMPE Convention in Chicago.

to the top roller shaft on each developing rack. Processing racks are held in place only by gravity, and may be removed individually, without tools. Wet end racks are interchangeable. They can be engaged with the drive at intervals of three inches along the length of the wet end of the machine.

The bottom-rack rollers are mounted on a free-floating shaft, which may be raised or lowered to decrease or increase the amount of film on a rack. The amount of film on a rack is indicated by a flag rod

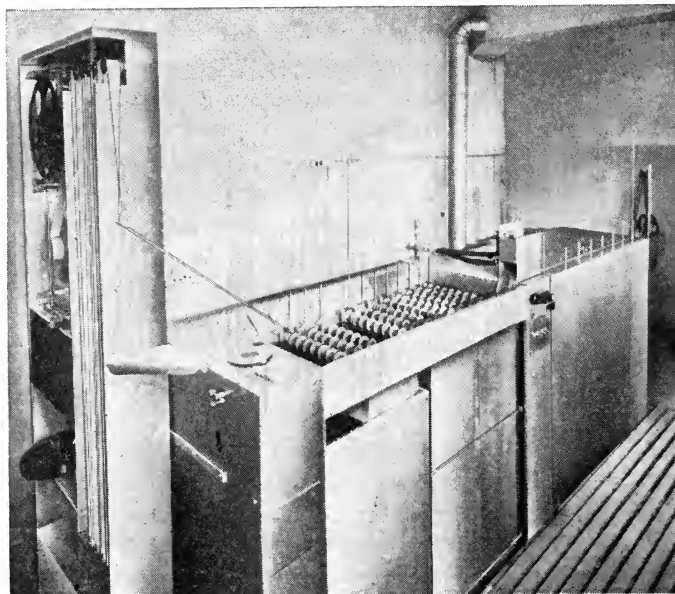


Fig. 1—Typical developing machine installation.

which raises or lowers corresponding to the amount of film on the rack. Tanks are all individually removable and are interchangeable. Any combination of tanks may be set up within limits of the machine frame size, to handle any desired process.

Air agitation is provided in all tanks, by means of a system similar to that described by Ives and Kunz.<sup>1</sup> The film passes through a cascade wash system, and thence through a pneumatic squeegee into the dry box. Drying is by high-velocity filtered air, with provision for dehydration and/or heating, if required. A cascade system is employed in drying. The dry box uses racks similar in design to

the wet-end racks. They are driven by a continuation of the same endless-chain drive which operates the wet end. Transparent plastic is used for the dry-box top, which may be opened to expose the drive and racks completely. All dry-box racks may be removed easily without tools, as they are held in place only by gravity. This facilitates the periodical cleaning of the dry box, and permits flexibility in drying time as racks may be cut in or out as desired.

The film passes from the final drying rack onto an elevator, enclosed in the dry box, which starts into operation when a reel is is

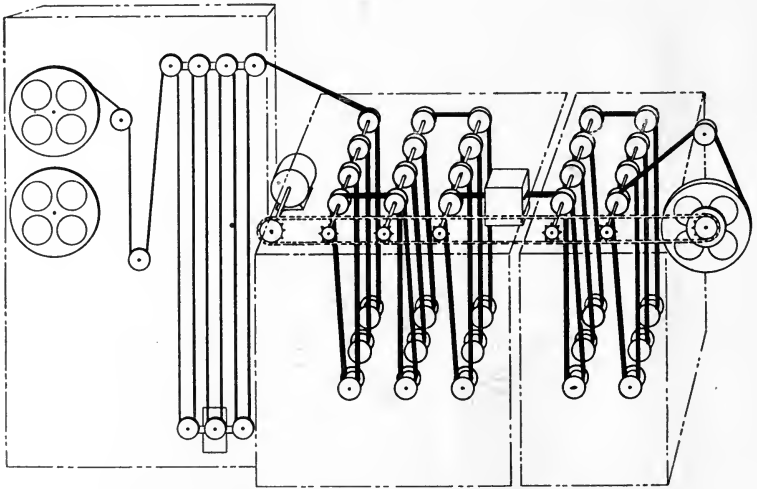


Fig. 2—Schematic diagram of developing machine.

removed from the take-off. This elevator holds sufficient film to allow the machine to operate while a new reel is being started.

On leaving the dry box, the film passes over a roller which can rotate in one direction only, preventing back-up of film into the dry box while the take-up reel is being changed.

#### THEORY OF OPERATION

The film path through the machine is over a series of racks similar to the one shown in Fig. 1. The top shaft is mechanically driven with a single sprocket roller on it next to the end where the film enters the rack. The other top rollers are free on the shaft. The bottom rollers are all free to rotate on a fixed shaft held by a carriage that can slide vertically in the rack frame.

Neglecting friction, the tension of the film is therefore equal to the weight of the bottom carriage divided by the number of strands of film supporting the carriage. However, friction of the rollers and of the film passing through the solutions upsets the equal distribution of the tension. This effect is minimized in the following way:

The retarding force produced by the bottom rollers is approximately compensated for by a driving force produced by the top rollers. The latter (the driving force) arises because the pitch diameter of the sprocket roller is smaller than that of the free rollers, and hence the shaft rotates faster than the rollers.

The frictional torque of a roller on a shaft depends upon the bearing surfaces, the diameter of the shaft, the load, the type of lubrication, and in most cases upon the relative angular velocity of the roller with respect to the shaft.

In order to balance the driving friction and the retarding friction, some of the above factors can be varied. The bottom-rack rollers have a smaller shaft than the top rollers, but the relative speed of the roller with respect to the shaft is less for the top rollers.

If the balance were perfect the sprockets would neither drive nor hold back the film. That the balance actually achieved is quite good, can be shown by a stroboscope or by running a length of unperforated film through the machine.

The bottom rollers have stationary washers between rollers to prevent them from locking together as a unit with static friction. This facilitates compensation for shrinkage or expansion, because each roller may rotate with a slightly different velocity.

The head elevator is similar in principle to the racks, except that none of the roller shafts is driven.

The friction brake on each feed-in roll spindle is actuated by an electromagnet controlled by a thyratron tube in such a way that the braking force on the feed-in spindle depends only upon the vertical position of the bottom rollers of the elevator. Since the weight on the bottom rollers remains constant at all times, the tension on the film remains constant and does not depend upon the diameter of the feed-in roll. The take-off operates in a similar way as it also is controlled by means of a thyratron and electromagnet to maintain uniform tension regardless of the change in size of the take-off roll.

#### REFERENCE

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# Television Remote Operations\*

BY A. H. BROLLY

TELEVISION STATION WBKB, CHICAGO, ILLINOIS

*Summary*—Remote operation implies the pickup of program matter outside the studio and station. Equipment and personnel in the field, in the station, and interconnecting are always involved in a "remote". Field operations usually require two cameras, preferably employing image-orthicon tubes. Studio or film images and sound can be dubbed in between field sequences, a procedure useful for commercial announcements. A relay receiver, a picture switching or mixing device, monitors, oscillograph, and audio-control equipment are required at the station for such operation. These combined facilities provide unsurpassed program possibilities.

REMOTE OPERATION is the term used by television broadcasters for the procedure of picking up program matter from points outside of their studios, transmitting, or relaying the image signals and sound into the station, and broadcasting them. It usually applies to intracity operation as distinguished from intercity or interstation relaying. The relay transmitting facilities are usually portable in this type of operation, while the receiver location is fixed.

By use of suitable remote facilities a station can broadcast a great variety of public-interest subjects at the instant of occurrence. In this way it fulfills a desire of the average individual that cannot be fulfilled by any other medium. Hence this type of broadcast has strong appeal and is extremely popular. The subject matter is usually of a nature that has been developed for visual as well as auditory appeal, the best example being sports, which can be broadcast without costly special staging for television. In view of these factors remote operations may well become the backbone of television programming and are, therefore, worthy of thorough development.

Another point not to be overlooked in the development of remote-operation techniques is their possible future application to theater reproduction. Any remote operation involves three main divisions: the field, the interconnecting facilities, and the station.

## FIELD OPERATIONS

Typical field operations require at least two cameras. Types employing the well-known image-orthicon tube are best adapted to the tasks, chiefly because of their remarkable light sensitivity. The

\* Presented April 22, 1947, at the SMPE Convention in Chicago.



broadcaster seldom has control over illumination of his subjects outside of his own premises, especially when working out of doors, where the incident illumination varies by a factor of 1 to 1000 from a cloudy winter day to summer sunshine. The level may sink to 2 or 3 foot-candles or less before a game is called on account of darkness. Indoor events such as boxing, water polo, and many others are frequently illuminated in a hit-or-miss manner that varies from as low as 15 foot-candles up to 500. These wide variations can be taken care of in image-orthicon equipment by lens diaphragms variable from  $f/1.9$  to  $f/22$ . Filters are sometimes added on sunny days out of doors, giving an added benefit in improved color response.

While image signals can be obtained with incident light as low as one foot-candle, the average image-orthicon tube requires about 50 to produce a signal sufficiently free of shot and thermal noise to be satisfactory for relaying and broadcasting. Noise is added in the relaying process and, while small in a good link, it cannot be neglected. Hence it is wise to have conditions as favorable as circumstances will permit at the source. Where light levels of less than 50 foot-candles are encountered indoors, and it is possible to supplement existing illuminants for the television pickup, it is desirable to do so. Artistic lighting is uncalled for in sports and many other events and simple overhead illumination is adequate. Lenses ranging in focal lengths from 2 to 24 inches are used on the cameras providing horizontal angles of view of 30 to about 2 degrees. This gives a great deal of latitude in placing cameras. For football they can be placed in press booths or even above the press booths. For boxing or wrestling the cameras can be placed anywhere from 20 feet away from the ring to 150 feet. Other events can be handled in proportion to their scope. Fig. 1 shows a typical setup.

Any television cameras, including the image-orthicon type, must have control equipment associated with them. This control equipment includes the synchronizing impulse and scanning source, usually referred to as the synchronizing generator. It also includes video and scanning amplifiers, monitors, oscilloscopes, and numerous controls on the camera action. All of these facilities are packaged in suitcase-sized units for convenient handling. However, some of them weigh 65 pounds or more. When combined with audio equipment, cables, spare-parts kits, and tool boxes, they add up to a dozen packages. It has been the practice of some operators to carry this equipment to a vantage point within a building, stadium, or arena.

In some instances this is necessary, but in the majority of cases it is not. Very satisfactory operation has been achieved in most cases at WBKB by maintaining this gear in the light truck by which it is taken to the site. The equipment is located in a semifixed state on an operating bench as may be seen in Fig. 2. Up to 350 feet of cable are used on each of two cameras to reach advantageous locations. In this way, only the camera cables, microphone wires, and cameras have to be carried into buildings; up and down ramps,



Fig. 1—Typical remote camera setup.

elevators, and stairs. This saves labor in setting up and avoids having extra help attached to a remote crew who would not have duties during operation.

The minimum crew for an operation in a location where preliminary work has been done consists of two cameramen, one field director, two operating technicians, and an electrician, in addition to an announcer and a spotter, if required. The field director and technicians usually operate in the truck. Under favorable circumstances they can set up and commence operations in less than one hour.

During operation one technician operates the controls on the camera apparatus; the other "rides gain" on the sound and looks after the relay transmitter. The electrician assists with setup and serves as relief operator and emergency repairman. The field director co-ordinates the cameramen's work, switches pictures, and acts as liaison with the main station director in case of switches back to the studio for commercial announcements.



Fig. 2—Technical operator's position in remote truck.

In cases of frequent broadcasts from the same location, such as baseball games during the season, it is worth while to locate equipment semipermanently in a broadcast booth convenient to camera locations and the announcer's position.

It is helpful, particularly in sports, to provide the announcer with a picture monitor. This should be connected to the output of the control equipment and can be fed by a small coaxial cable up to 1000 feet in length, perhaps more if needed. An ordinary table-model home receiver equipped with carrying handles and a cable connection into its video amplifier is convenient for this.

A useful piece of additional equipment maintained on tap for remote operations is a gas-engine generator. The complete two-camera television chain with relay transmitter and audio equipment requires a little over five kilowatts. A 10-kilowatt 60-cycle-per-second, 115-volt, single-phase alternator driven by a four-cylinder gas engine is mounted in a two-wheel trailer which can be towed behind the equipment truck to any location where public-utility services are not available. Its excess capacity over and above apparatus requirements is sometimes used for lights. Relays have been made from the apparatus truck while in motion by using this source of power.

Audio equipment in the field consists of a Western Electric Type 22D portable speech-input equipment with from one to three microphones. Dynamic microphones are used in many instances because of their sturdiness and insensitivity to wind or drafts. This is an important consideration out of doors. Low-impedance microphone circuits are favored for their freedom from pickup of electrical disturbances in cables which are frequently 200 or 300 feet long.

Considering the foregoing it will be apparent that rather extensive intercommunicating facilities are required in the field and between there and the parent station. Basically these consist of two circuits, a technical-order circuit and a program-cuing circuit. The first interconnects the cameramen with the technical operator and ties him in with the relay operator and the parent-station technical personnel. The other circuit interconnects the announcer and cameramen with the field director and through him with the parent-station program director. The field director can also monitor the program sound.

#### INTERCONNECTING OR RELAY FACILITIES

Two basic functions and two auxiliary functions are required of the interconnecting communications between the field and the parent station. To dispose of the simpler ones first, the technical-order circuit and the program-cue circuit are most conveniently connected back to the station by ordinary telephone lines run to a site convenient to the location of control equipment. When operation is from the truck the lines are terminated in a building at any point nearest to where it is to be parked. They are extended by temporary flexible leads to the truck when operating. For program sound the output of the speech amplifier is fed to a telephone program circuit

which is also terminated in a convenient spot with the order wires. The program sound is fed to this line at zero level, and it is usually equalized at the station end only. Telephone lines for these three functions are rented by the month for locations where remote broadcasts are done weekly or oftener.

The remaining interconnecting or relay function, perhaps the most important and the one posing the most problems, is that of getting the picture signal to the parent station. This must be accomplished for a frequency range of 60 cycles per second to 4 megacycles or more with good response to transient-wave shapes composed of frequencies in this range and with the least possible injection of noise or extraneous interfering signals.

The intracity relaying of video signals can be accomplished by telephone lines, coaxial cable, and very-high-frequency radio. Telephone lines of the ordinary type must be highly equalized at intervals of only one to one and one-half miles.<sup>1</sup> Apparatus for this service as well as coaxial lines or other special conductors have not been readily available in Chicago up to the date of this paper and the cost of such service is quoted at a high figure. Experience at Station WBKB, upon which this paper is based, has been confined to radio relaying. Line transmission undoubtedly has merits in freedom from noise and interference but for mobility and economy of operation, very-high-frequency radio-beam equipment cannot be surpassed. Even in the matter of first cost, based on present quotations, the radio-relay equipment offers a decided economy. Modern microwave apparatus employing frequency modulation can offer a bandwidth scarcely equaled by line equipment available and, for distances of a few miles, can probably equal line facilities in the matter of noise or interference.<sup>2</sup>

Station WBKB so far has not been able to enjoy the advantages of this up-to-the-minute type of equipment, yet it has established an enviable record of achievement in remote operations with less-elaborate equipment which is worthy of special mention.

Radio relaying in a large city like Chicago is somewhat akin to a short person viewing a motion picture in a crowded theater. Everywhere he sits someone's head is in the way. Very-high-frequency waves do not penetrate through buildings very well and the higher the frequency the more severe this limitation becomes. In Chicago the highest points for receiving relayed signals giving unobstructed paths from the greatest number of points do not happen to be at or even adjacent to the location of the station, so relay operation

by WBKB has been done best in two steps, requiring two sets of equipment. An important part of this equipment is installed as a repeater station atop one of the tallest buildings in the Chicago loop. The relationship of the remote operation to the parent-station facilities and the function of the repeater station are illustrated in Fig. 3.

The basic unit of relay equipment at WBKB is a 210-megacycle transmitter of 20 watts output, amplitude-modulated. Double-sideband transmission is used with a frequency response out to  $4\frac{1}{2}$  megacycles. This unit is carried with the mobile camera equipment and at most locations is operated in the truck. Its output is fed to antenna arrays of varying numbers of elements depending upon the distance over which the relay is to work. These antenna arrays are usually set up in advance of a broadcast and if repeated broadcasts are to be made from any location, one of them is left there. On a succeeding broadcast it is only necessary to drive the truck to the location and connect the antenna lead. Arrays of 20 half-wave dipoles having gains of about 14 decibels are used in most locations. With this transmitting and antenna equipment satisfactory relays have been conducted from points up to 15 miles distant from the station.

Reception on top of a tall building in the Chicago Loop is accomplished with an eight-element antenna, four of the elements being parasitic reflectors. The receiver is a superheterodyne with one radio-frequency stage, five intermediate-frequency stages, and one cathode output video stage. The output of this receiver is monitored with an oscilloscope and a television receiver before being coupled into the succeeding relay equipment. This is a 1300-megacycle, amplitude-modulated apparatus of about one watt output. Its antenna is a dipole with parabolic reflector. The beam is directed from the building, as shown in Fig. 4, to the building where the studios and transmitter are located. The distance is only about one-half mile. The circuit is very reliable, unaffected by weather conditions, and contributes a negligible amount of noise to the system.

Reception of this 1300-megacycle beam is accomplished with a half-wave dipole antenna and 60-degree corner reflector. The receiver employs a cavity-tuned oscillator, crystal mixer, and three stages of intermediate frequency. It has been found that the noise level at the output of the receiver, for a given signal input, depends very much upon the forward-to-inverse conductivity ratio of the crystal mixer. This ratio ranges from 3 to 1 up to 100 to 1 in various crystals as measured with low direct voltage. A high forward

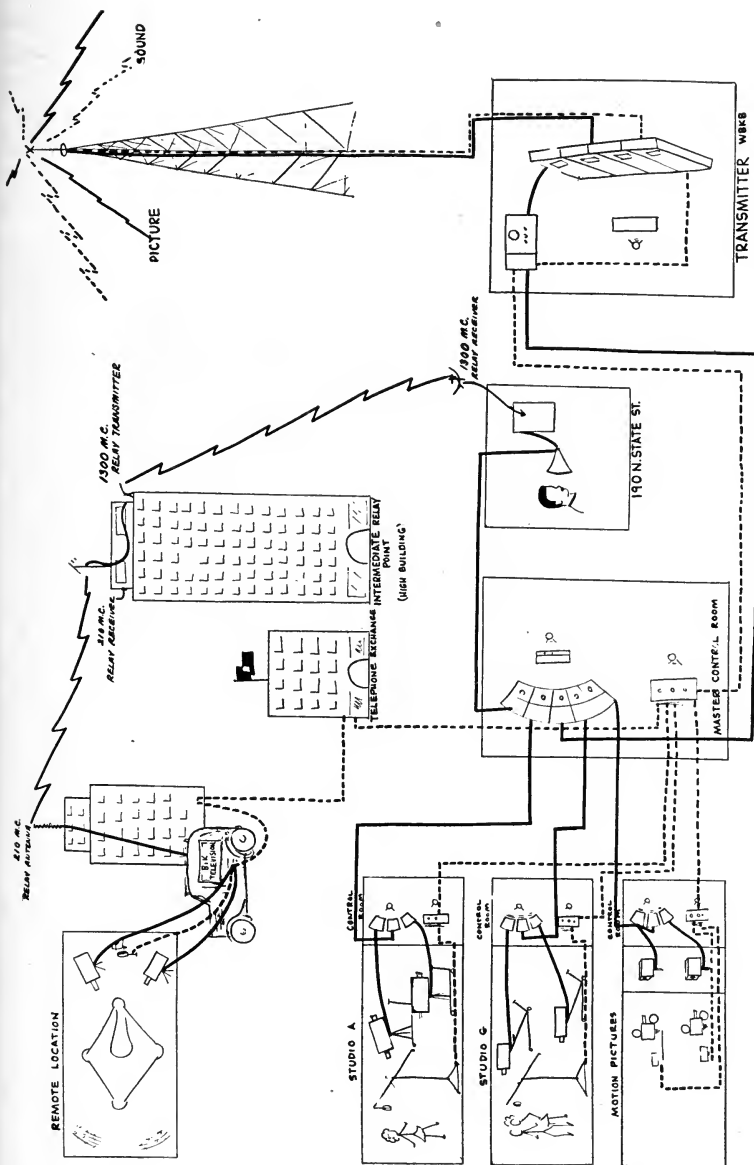


Fig. 3—Remote-operation facilities and their relation to the parent station.

conductivity and low inverse conductivity provides the highest signal-to-noise ratio. The output of the second detector of this receiver is a cathode output video stage feeding a 73-ohm coaxial line extending to the control room.

#### THE STATION OPERATION

Entering the station control room from a remote location are the three telephone lines and the one coaxial line from the relay receiver. The technical-order wire has taps leading to the repeater station and the relay receiver at the station building. It terminates on the desk of a technical operator in the control room. From there he is in touch



Fig. 4—1300-megacycle relay transmitting equipment at repeater station.

with other station personnel. Fig. 5 shows the master-control room at the station through which all the relay and communication circuits pass and are co-ordinated with station operations. The program-cue line terminates at the director's console in the control room. The director is in communication with other program personnel at the station and with the technical operator. The program line passes through an equalizer, an amplifier that makes up a loss of some 50 decibels in the lines and equalizer, and thence into a nemo circuit on the audio console. From this point it is supervised by an audio operator who is on hand to dub in commercial announcements or station breaks.

The coaxial line from the relay receiver terminates in a video console where it is under control of the video operator who also is on duty to dub in shots from the studio or film for commercials or station



breaks or to switch over to a succeeding program. On a remote program without too much studio or film pickup the technical operation can be handled by four technicians: the technical supervisor, the audio operator, the video operator, and the transmitter operator.

With the facilities described, WBKB has handled, by remote pickups, a range of subject matter which is fairly representative of the great possibilities open to television through this type of operation. Some of the subjects covered to date have been: baseball,

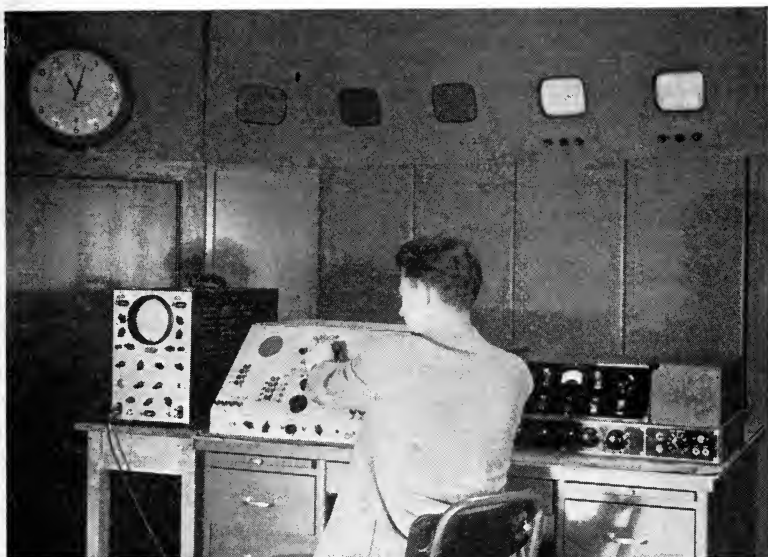


Fig. 5—Station master-control room, co-ordination point for remote and studio productions.

basketball, hockey, ice follies, boxing, wrestling, billiards, water polo, Museum of Science and Industry events, stock exhibitions, golf tournaments, football, a circus, and automobile racing. This list probably will be expanded manyfold in the months and years to come. It offers an engaging example of the horizons opened to the television receiver viewer through this remarkable medium, television remote operation.

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# Sound Motion Pictures for Passenger Trains\*

By JOHN G. BITEL

COMPREHENSIVE SERVICE CORPORATION, NEW YORK, N. Y.

*Summary*—This paper discusses the practicability of converting existing railway dining cars for the presentation of motion pictures as a medium for relaxation while still retaining the use of the car for restaurant service. Determining factors for selecting available 16-mm standard projection equipment are given, and problems presented by the moving train with respect to good screen results are outlined. Necessary modifications to standard equipment are described and details regarding a rigid demountable screen and an adequate loudspeaker system are given. The large power capacity of the car's battery system, in conjunction with the General Electric Amplidyne convertor, is used to operate the complete motion picture installation. The paper concludes with statements regarding the final results obtained, passenger comments received, and the general public reaction to the installation made for the Chesapeake and Ohio Railway.

THE POSTWAR plans of many industries have led the public to expect unique developments. In line with this thought, the Chesapeake and Ohio Railway Company decided, among other innovations, to present motion pictures as a form of relaxation to passengers on their de luxe passenger trains. The long backlog in the railroad-car building program has delayed the building of a special theater car. Instead, it was decided to convert existing dining cars for the dual purpose of showing full-length feature films and still retain the use of the car for restaurant service.

The 60-foot twin-unit diner car, *The George Washington*, was selected and brought to the Huntington, West Virginia shops for necessary modifications. A major change had to be made to the sixteen dining-car tables. Retracting-lever mounts fastened to the under side of the table tops enabled the tables to fold in a vertical position against the side walls, clearing the floor area for occupancy. A total of 343 square feet of floor area provided for fifty chairs and a two-foot aisle for through traffic. The remainder of the car space was utilized for housing air-conditioning equipment, food compartments, supply lockers, and a miniature projection room measuring 45 inches wide and 70 inches long. The air-conditioning system was piped to operate inside the projection booth, in addition to an air

\* Presented April 21, 1947, at the SMPE Convention in Chicago.

duct and exhaust for the lamphouses and comfort of the projectionist.

For continuous performance, dual 16-mm projectors were installed. Small booth dimensions made it necessary to select a left- and a right-hand type of projection equipment. This combination occupied a minimum of space and enabled the projectionist to be centrally located, facing the operating side of each projector. The type of equipment selected was the new RCA Model PG-201 and the Natco Model 3015. Professionally designed, both of these models lent

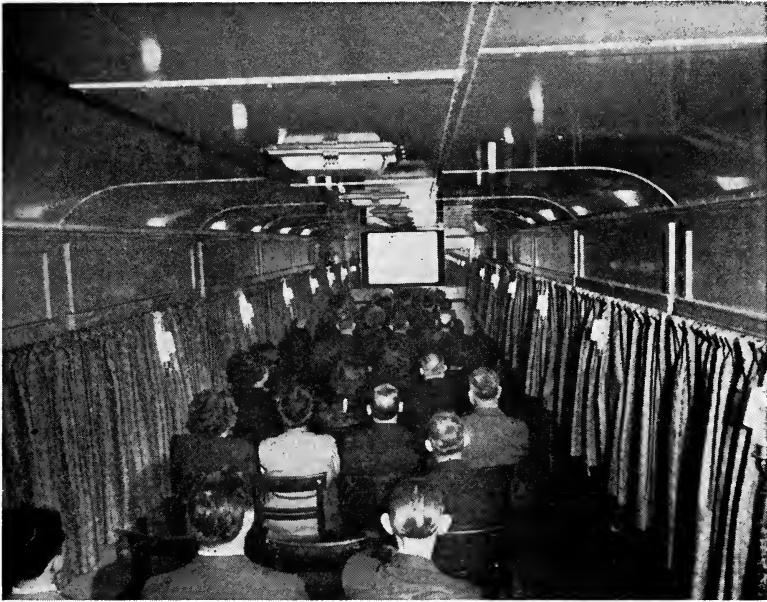


Fig. 1—General view of diner, showing passengers seated for presentation.

themselves suitably for this particular installation. Strictly alternating current in operation, the constant-speed motors maintain correct sound speed within 1 per cent even when line-voltage change is 10 per cent. The amplifier output level rated at +35 decibels proved ample for overcoming extraneous noise level of the train in motion. Shock-mounting the amplifiers in their respective machines was necessary to prevent damage to the tubes and components from car vibration.

The projector mechanisms had to be rigidly mounted on solid bases, which in turn were welded to the car frame for absolute rigidity. Steady screen performance was realized only when the above

precaution was observed—even when riding over rough areas of road bed. The same precautions had to be taken with the screen proper. Here the problem was twofold, for the screen had to be rigid and still be easily demountable. The picture size was determined to clear the heads of persons occupying the first row of seats. The height clearance of 55 inches for a seated person allowed for a screen image 41 inches by 55 inches. A four-inch lens with a throw of 48 feet gave the desired dimensions. Beaded screen fabric, cemented to a  $\frac{3}{4}$ -inch plywood backing, properly masked and equipped with snapping hardware, enabled quick mounting of the screen in its proper place. Two rod braces fitting into keyhole sockets lock the screen rigidly in position.

Finger-tip control of all switches, mounted in one unit between the two projectors, facilitates ease of operation of the equipment. Standard projection-room practice of change-over is accomplished with a change-over switch, which automatically applies a glow voltage to the projection lamp on the incoming machine when the motor switch is tripped on the first cue. Full voltage is applied by tripping the light change-over switch on the final cue, at the same time cutting off the lamp current on the outgoing machine. By adjusting proper glow voltage to the 750-watt projection lamps and operating within the time element of the two film change-over cues, a clean change-over of light is accomplished. Sound change-over is simultaneously accomplished by simply switching the outputs of the respective amplifiers and placing a dummy load across the outgoing machine.

Preliminary tests with the existing heavy layers of car insulation, previously installed in conjunction with the air-conditioning system, proved valuable in reducing the outside noise level to a negligible degree. Heavy drapes and carpeting served admirably in correcting the acoustic condition of the car. The narrow and long dimensions of the dining car presented a problem of good sound distribution. A beaming effect proved to be the answer. A two-way speaker system is used, although no dividing network is used. The RCA MI-6304 driver unit, coupled to the Altec-Lansing Model 808 multi-cellular horn, and a standard 10-inch permanent-magnet speaker make up the desired combination. The cone speaker simply supplies the tonal balance for the upper cellular unit, which beams the sound the full length of the car.

A 32-volt, direct-current 1000-ampere-hour battery, in conjunction with a 5-kilowatt General Electric Amplidyne inverter supplying

substantially constant 110-volt alternating current, constitutes the power system. The General Electric inverter, Model 5LY153A1, the Amplidyne Booster Inverter which is series-connected with the amplidyne that bucks or boosts the voltage supplied by the axle generator or battery to maintain constant alternating voltage and frequency on the output side of the inverter, is essential for correct sound speed operation of the projection equipment while the train is in motion or standing at a station. The unusually large capacity of the inverter serves well on peak loads, such as change-over periods, and for operating auxiliary equipment requiring 110 volts alternating current. The inverter is approximately 45 inches long by 16 inches in diameter and weighs 800 pounds. An adequate cradle support is built beneath the car structure to house the complete unit.

The final results were very gratifying, and met with warm reception from the general public. The inaugural run from Washington to Cincinnati was attended mostly by officials of the company, film critics, editors, and representatives of trade journals. Their reaction, comments, and reception were very glowing in their praise. As one observer stated, "It is a curious sensation at first, to watch a film and have the theater jostle gently. But the consciousness of motion soon fades. True, when the camera moves up for a scene, that action plus the forward motion of the train brings a feeling of accelerated speed, and when the camera backs away for a long shot, you may feel as if you're going in two directions at once, but most of us found the experience rather unique. The sound comes across with exceptional clarity. After a few moments, the movement of the train is forgotten and the story runs quite as smoothly as it does in your local theater."

Succeeding runs proved so popular with the passengers that five additional diners were converted, and a special tavern theater is now being built.

#### DISCUSSION

MR. WOODSON: Does the screen impede the passage of people through the car?

MR. W. R. ISOM: The people are seated to one side of the car and the passage aisle is on the other side. In that way people can pass without interfering with the showing of the film.

MR. DAWL: How many shows an evening are given?

MR. ISOM: The full length picture runs an hour and fifteen minutes, so I would imagine that they run it as long as there is an audience.

MR. DAWL: Was the voltage of the light taken from alternating- or direct-current side?

MR. ISOM: I assume it was taken off of the alternating-current side.

# Improved Film Splicer\*

By MICHAEL LESHING

TWENTIETH CENTURY-FOX FILM LABORATORY, HOLLYWOOD,  
CALIFORNIA

*Summary*—A waterproof tape splicer for the assembly of motion picture film prior to development is described and illustrated.

**I**N SEARCHING for improvement in film splicing which would reduce waste, increase durability and strength of splices, and be simple to accomplish under darkroom conditions, an improved film splicer was designed, constructed, and put into operation by the Twentieth

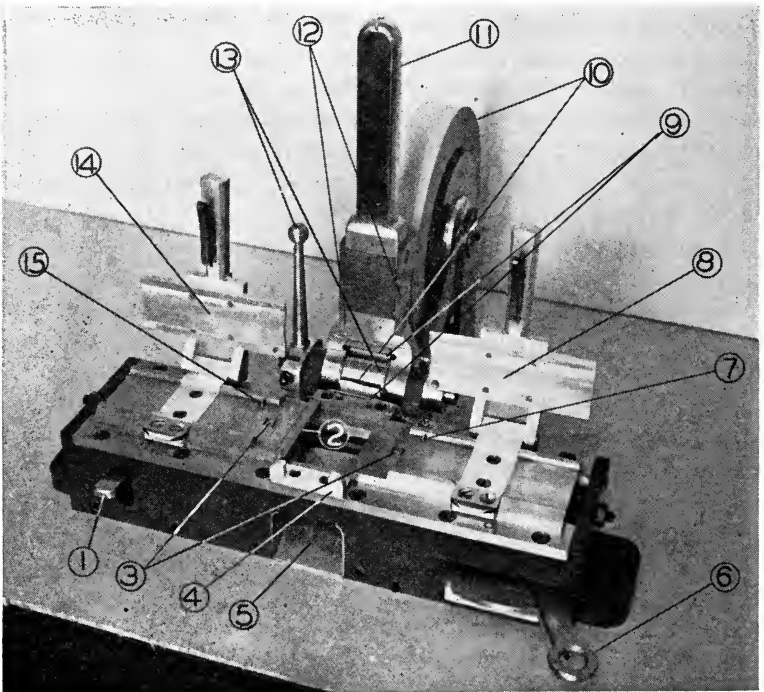


Fig. 1

\* Presented April 22, 1947, at the SMPE Convention in Chicago.

Century-Fox film laboratory. This splicing machine utilizes a durable waterproof cloth tape.

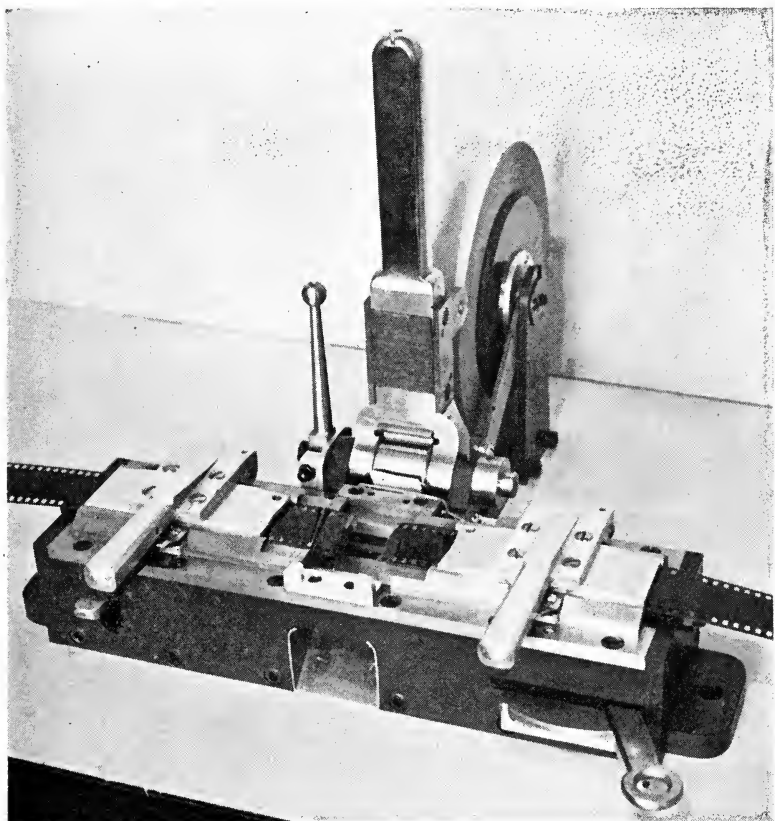


Fig. 2

Fig. 1 shows the splicer ready for operation. The various parts of the apparatus have been numbered, in this photograph only, for easy reference. In Fig. 2, the two ends of film to be spliced are placed in the film guides, properly positioned over the pins 7 and 15 with the ends hanging over the chute 5, and the clamps 8 and 14 are locked down holding the film firmly in position.

In Fig. 3, the lever *11* is pulled downward shearing the film ends at the cutting edges *2* and *12* and allowing the clippings to drop down through the chute *5*.

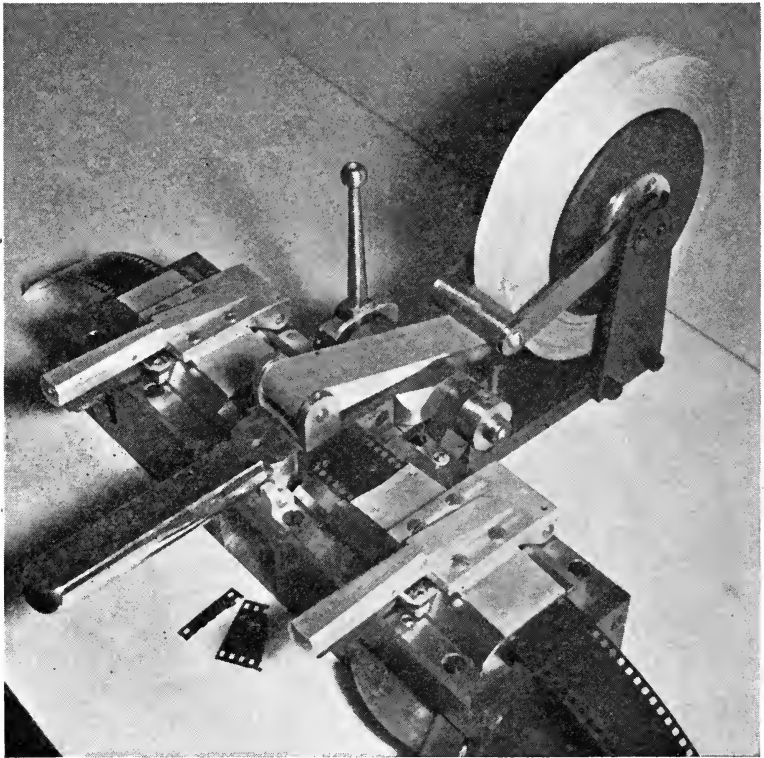


Fig. 3

In Fig. 4, the lever *11* is raised to its original position, the lever *6* is moved from right to left bringing the film-guide platforms and edges *2* together which gives a solid roof over chute *5* and by this movement of lever *6* the plungers *3* are automatically raised causing the film ends to be swung into a vertical position. The end *10* of



adhesive tape *10* is then pressed by finger against drum *13* and lever *13* is shoved forward rotating drum *13* slightly which brings sufficient tape forward so that it can be grasped more easily by the fingers and pulled forward across the platform as shown.

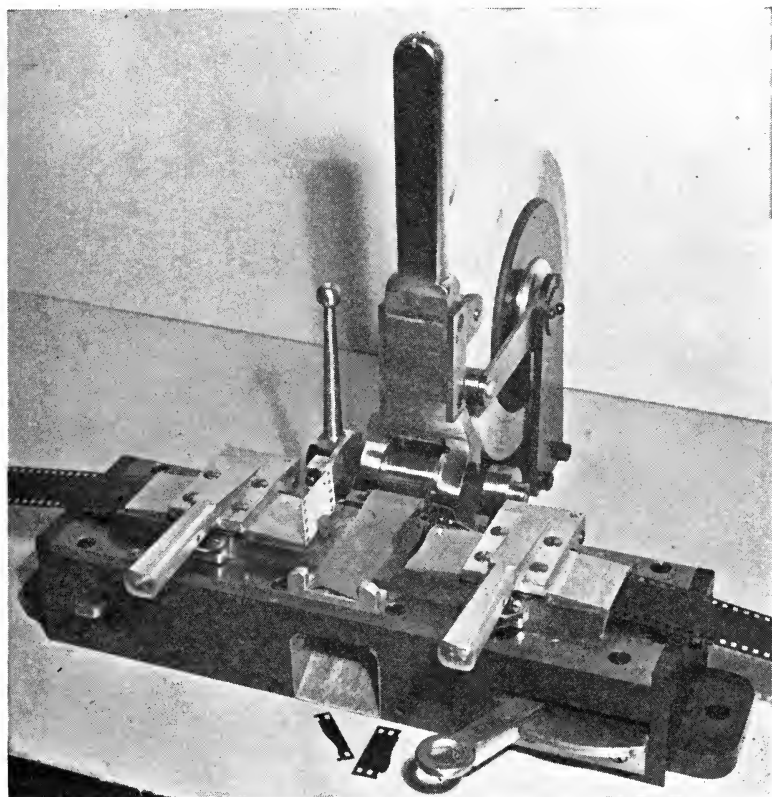


Fig. 4

In Fig. 5, lever *1* is pushed downward which releases the plungers *3*, allowing them to retract downward and the film ends to drop down on the tape. The end of the tape is then manually folded over the film as shown and lever *11* is pulled down forcing the cutting edges *9* to shear the tape.

In Fig. 6, the tape end just sheared is manually folded back across the film and lever 11 is brought down on the completed splice and pressure is applied to force good contact between the tape and the film. After clamps 8 and 14 are lifted the film can then be removed from the splicer.

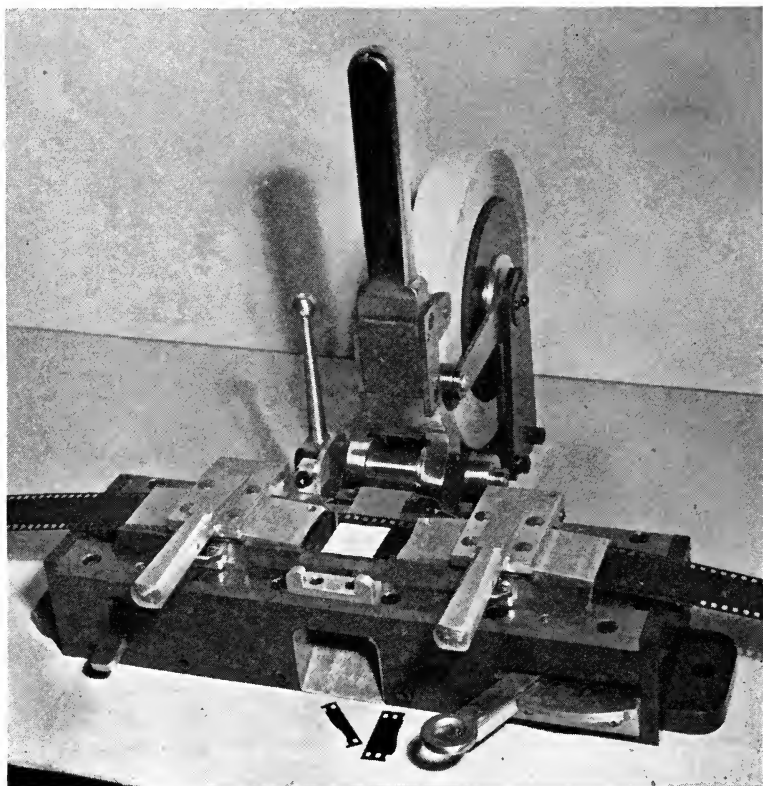


Fig. 5

With this type of splice the film under extreme tension will tear anywhere except at the splice. This splice itself will last for a long period of time under constant processing conditions.

## DISCUSSION

CHAIRMAN C. E. FILLMORE: How far along in the laboratory processes is this splicer used and where is it removed?

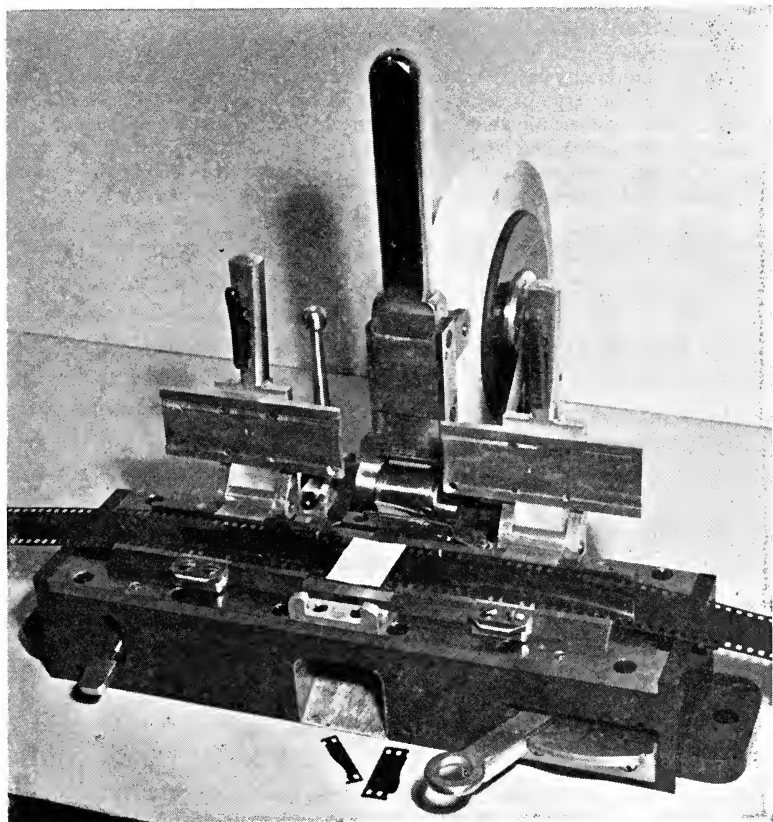


Fig. 6

MR. E. A. BERTRAM: This type of splicer is used on the friction-type developing machine, and the splice is made at the loading table and the film. After the splice is made at the loading table, it goes through the usual linear process and the developing machine is removed at the end of the take-off table and the rolls come out in individual sizes. If it is a 40-foot roll it would be split at that point, or a 1000-foot roll would be split at that point. It is nothing more than a method of attaching the two pieces together, perforating the film, and putting a piece of stickum over it and holding it so it will go through.

# A New Sound Slidefilm Projector\*

BY J. McWILLIAMS STONE

OPERADIO MANUFACTURING Co., ST. CHARLES, ILLINOIS

*Summary*—Sound slidefilm equipment is an audio-visual aid that is rapidly assuming its proper place in the fields of education, sales, and entertainment. This type of equipment fills in the gap between silent still pictures and sound-on-film moving pictures. The purpose of this paper is to describe the design and construction of the EXPLAINETTE "100", a sound slidefilm unit that has been built with a functional approach to the general application of such equipment.

THE ELECTRICAL components of the EXPLAINETTE "100" can be broken down into: (1) the sound-reproducing unit consisting of the phonograph pickup, the sound amplifier, and the loudspeaker; (2) the phonograph motor; and (3) the slidefilm projector.

The sound-reproducing unit consists of a crystal pickup feeding a small audio amplifier which in turn drives a 4- × 6-inch elliptical loudspeaker. The crystal pickup cartridge is a high-output unit that is fed into the grid of a beam-power output tube through an attenuating and equalizing network. The cartridge is mounted in a special arm so pivoted above the record that a 16-inch transcription can be played without tracking difficulty even though the arm measures only 7½ inches from pivot to needle.

The network between the pickup and the amplifier, besides giving control of volume, also is arranged to give a rising high-frequency response as the volume is increased. This was done on the premise that as the size of the audience increased and more volume was needed, an accentuation of the higher frequencies would improve intelligibility by overriding background noise and counteracting high-frequency absorption.

The amplifier is an alternating-direct-current model utilizing a 50B5 miniature output tube supplied with plate and screen voltage from a 35W4 half-wave rectifier. This selection of tubes was utilized because of their small size and also because of their ready availability for replacement in the field.

The 4- × 6-inch elliptical speaker used was carefully designed so

\* Presented April 21, 1947, at the SMPE Convention in Chicago.

that the proper cone and cone treatment were incorporated to assure clear sound in the speech-frequency range. All tests were conducted using the actual baffle in which production units are mounted so that the combination of baffle and speaker would do the job required.

The record-rotating medium selected for this unit is a sturdy yet light-in-weight phonograph motor rotating at  $33\frac{1}{3}$  revolutions per minute. It has a gear reduction that is fully enclosed with the gears running in an oil bath. The motor is fan-cooled and the fan besides cooling the phonograph motor also agitates the air in the amplifier housing. The motor is rubber-mounted to the phonograph plate and the turntable and record are completely separated from the motor by a rubber sleeve that acts as a combination drive washer and insulator. This combination reduces both rumble and feedback.

The projector for this equipment is a specially designed unit constructed so as to become an integral part of the machine. The light from the 100-watt T8-type projector bulb is collected by a three-lens condenser system and heat-ray filter to provide uniform illumination of the single-frame aperture.

The film as it passes through the aperture is held flat by aperture glasses. The rear plate of this pair of glasses is retractable and synchronized in motion with the film-advance sprocket and index mechanism. The objective lens is mounted in a barrel that is friction-retained for ease in bringing the picture in focus on the screen. The objective lens is a 3-inch focal-length lens and gives a brilliant picture on the self-contained screen for desk or table use and also at a distance of about 16 feet.

The film-advance sprocket is provided with a friction clutch so that when the advance knob is pressed in the indexing cam is released and the picture may be brought into frame in the aperture.

An elevating mechanism of the nut-and-screw type is provided to allow vertical positioning of the picture on the screen.



Fig. 1

The ventilation of the lamphouse is of the natural gravity type, but the flow of air is so directed that even after long periods of operation the film temperature in the aperture does not rise above 150 degrees Fahrenheit.

Contacts with users of slidefilm equipment and the answers to a questionnaire indicated that the one almost universal difficulty was that of threading of the film through the projector. Operators could



Fig. 2

not close the gate over the sprocket and keep the film in place until the gate was closed. The result was torn and punctured film and a frustrated operator while he fumbled through several attempts to get the film started properly through the aperture and over the sprocket.

The answer to this difficulty was the development of a hinged film guide over the sprocket. This guide can be swung back away from the sprocket, the film positioned over the sprocket and the guide placed against the film without any danger of the film getting out of place when the lens barrel is closed. This improvement eliminates the possibility of damaged film entirely and greatly simplifies the job of threading the projector.



ARTHUR SHELDON DICKINSON

**A** RTHUR SHELDON DICKINSON, 59, for twenty years Director of the Conservation Department of the Motion Picture Association, died Saturday, October 25, in Santa Monica, California, after a long illness.

Mr. Dickinson had retired last July, ending a career that began in 1912 in the states rights phase of the motion picture industry. He was connected with a number of motion picture companies in the following fifteen years before joining the Motion Picture Producers and Distributors of America, forerunner of the Motion Picture Association, in 1927. As Director of Conservation of the MPA, he handled technical matters for the motion picture industry, which included contacts with the Society of Motion Picture Engineers, National Film Carriers, Inc., National Fire Protection Association, and the National Board of Fire Underwriters. He devised a plan for film exchange fire inspection which established safety records for all major companies in the handling of motion picture films. This method of inspection gave to the motion picture industry one of the finest safety records of any major industry.

Mr. Dickinson was born in Chattanooga, Tennessee, in 1888, and studied engineering at the Georgia School of Technology. He was well equipped, therefore, to handle technical matters for the MPA and also to be a Fellow of the SMPE. He served for many years as a Member of the Board of Governors and also was formerly Financial Vice-President of the SMPE.

We shall remember him as one who was generous and tolerant toward his fellow man, and we shall remember his deliberate and slow delivery of counsel.

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## Sixty SEMIANNUAL



MR. JAMES  
FRANK, JR.,  
IN CHARGE  
OF LOCAL  
ARRANGEMENTS  
AND  
MR. WILLIAM  
C. KUNZMANN,  
CONVENTION  
VICE-PRESIDENT

**E**IGHT-HUNDRED members of the Society of Motion Picture Engineers and guests registered during the 62nd Semiannual Convention of the Society, which was held on October 20 to 24, 1947, at the Hotel Pennsylvania, in New York City. The Get-Together luncheon on Monday was attended by two hundred and twenty-five members and guests, and there were three hundred and twenty at the Wednesday night Banquet. President Ryder presided at both of these functions and introduced those seated at the Speakers' tables. Judge Edward C. Maguire, Co-ordinator of the Motion Picture Industry of the City of New York, was the guest speaker at the luncheon. At the Banquet, the Progress Medal was awarded to Dr. John G. Frayne; the first annual Samuel L. Warner Memorial Award was presented to Mr. John A. Maurer; the 1947 JOURNAL Award was given to Dr. Albert Rose; and thirteen Active members of the Society were elevated to the Fellow grade.

For the first time in the history of the Society, A Theater Engineering Session was a part of the general program. There were ten of these sessions and three technical sessions. Another innovation of this convention was the holding of an exhibit, at which there were thirty-five exhibitors. At the Television session and demonstration of large-screen television, over four hundred and fifty were in attendance.

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## Second CONVENTION

Mr. William C. Kunzmann, Convention Vice-President, and Mr. James Frank, Jr., were largely responsible for the great success of this Convention. Mr. Robert T. Kenworthy, who was in charge of the Exhibit; Mr. Gordon A. Chambers, who secured the many fine technical papers; Mr. Leonard Satz, who was responsible for the Theater Engineering papers; and the chairmen of all of the other Convention Committees worked hard to make this meeting such an outstanding success. Mr. Kunzmann, in addition to his many other activities, obtained passes to six of the first-run motion picture theaters in New York. Through the efforts of Mr. Harry B. Braun, an excellent public-address system was installed. Publicity was handled by Mr. Leonard Bidwell and Mr. Don C. Gillette most efficiently.

Theater owners, purchasing agents, and architects, who had not previously attended Conventions of the Society, were very much in evidence.

The papers presented at this meeting will be published in early issues of the JOURNAL. These have not as yet been scheduled, but it is anticipated that the first of them will appear in the February issue.



JUDGE  
EDWARD  
C. MAGUIRE,  
GUEST SPEAKER AT  
GET-TOGETHER  
LUNCHEON,  
AND  
PRESIDENT,  
LOREN L. RYDER

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## PROGRES



PRESIDENT  
RYDER  
PRESENTS  
PROGRESS  
MEDAL TO  
DR. J. G. FRAYNE

**A**T THE BANQUET held on October 22, 1947, during the 62nd Semiannual Convention of the Society, Dr. John G. Frayne was presented with the 1947 Progress Medal Award, given for outstanding achievement in motion picture technology. Dr. Frayne was chairman of the Progress Committee from 1932 to 1938; chairman of the Pacific Coast Section for 1941 and 1942; member of the Board of Governors for 1946 and 1947; and at present is chairman of the Sound Committee.

Born in Wexford, Ireland, in 1894, he received his early education in the Irish National School system. He was graduated from Ripon College in Wisconsin in 1917 and received a graduate scholarship at the University of Minnesota the same year. After serving in the Army during World War I and later as an engineer with the American Telephone and Telegraph Company, he returned to Minnesota where he received the Ph.D. degree in physics in 1922.

Dr. Frayne was a member of the faculty at the University of Minnesota, professor of physics at Antioch College, and a National Research Fellow at the California Institute of Technology. For the past eighteen years he has been with the Electrical Research Products Division of the Western Electric Company in Hollywood, where, at the present time, he is development supervisor.

Since 1932, Dr. Frayne has been the author or coauthor of twelve papers published in the JOURNAL, for one of which he received the 1940 SMPE JOURNAL Award.

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## MEDAL AWARD

Among Dr. Frayne's technical contributions, the following are outstanding:

Investigation of reproduced sound-film print noise as a function of negative and print density, in the development of variable-density noise reduction.

Original investigation of light valve, phototube, and printer gammas, and establishment of relationships for their optimum use.

Research in sensitometric control of variable-density sound tracks which evolved into adoption of dynamic gamma control in their exposure, processing, and reproduction. Accompanying this investigation and important in establishing the benefits to be derived from it was his intensive educational program among the studios and film laboratories.

Development of the RA-1100 Integrating Sphere Densitometer, which virtually is a primary standard in the industry.

Coauthor of the intermodulation method of testing and controlling processing and sound equipment which is now universally employed in control of variable-density recording.

Investigation of sprocket-hole modulation.

Studies and applications of light valves. Actively participated in the application of MGM four-ribbon light-valve push-pull development and, more recently, development of the current three-ribbon light-valve modulator.

Active supervision of development of sound-film movements which are now standard and outstanding in their simplicity and performance.

Development of a frequency-modulated control track for release prints.

Supervision and development of several improved recording and reproducing optical systems.

Contributions to the field of anticipated noise reduction.

Development and supervision of new variable-area light-valve-type modulators.

In addition to his technical achievements and the documenting of his work, Dr. Frayne has contributed in a broader sense by his sincere interest in the field of education and by his inspiration to his fellow engineers. An indication of the esteem in which he is held by the Society is given by the unanimous proposal that he be awarded the 1947 Progress Medal.



PROGRESS MEDAL AWARDED FOR ACHIEVEMENT IN MOTION PICTURE TECHNOLOGY

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## SAMUEL L. WARNE



MR. JOHN A.  
MAURER  
RECEIVES  
WARNER  
AWARD  
FROM  
PRESIDENT RYDER

**T**HE FIRST annual Samuel L. Warner Memorial Award, for the most outstanding work in the field of motion picture engineering, was presented to Mr. John A. Maurer during the Banquet held on October 22, 1947. This Award consists of a gold medal and an accompanying bronze replica, and it was established by the Warner brothers in memory of their brother, Samuel. It was fitting that the first recipient of this Award should be a farsighted pioneer in his field, in much the same way that Mr. Warner was in his. As Mr. Warner had faith in the value of the talking picture, so Mr. Maurer staked his judgment and his career on the usefulness of the 16-mm sound-recording medium.

One of the first engineers to appreciate the need for high quality in 16-mm sound recording and reproduction, Mr. Maurer has dedicated his career to furthering this objective. Not only has he promoted this cause by manufacturing equipment of his own design, but he has given unselfishly of his time and ability to assist in every way possible to improve 16-mm sound quality.

Mr. Maurer started his work by the design of the first precision 16-mm camera and sound-recording devices to reach the commercial market. In order to provide a specialized laboratory service to the users of 16-mm equipment, he collaborated in the establishment of a motion picture laboratory where 16-mm film could receive the necessary treatment to ensure excellence of results.

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## MEMORIAL AWARD

When, during the War, the Armed Services asked for the cooperation of the Society and that of the American Standards Association in the preparation of a large number of War Standards in the fields of both 35-mm and 16-mm motion pictures, Mr. Maurer was one of the first members of the Society to be drafted for this work. Throughout the War, he gave liberally of his time to this project, and his extensive background of experimental activity was the source of much useful information to the committees.

His outstanding contribution was the design and construction of special film-recording machines for the manufacture of 16-mm test films to complement the standards which he had helped to prepare. A series of test films was prepared to provide a means of testing any 16-mm sound equipment then or now in use. These films, which are available through the Society of Motion Picture Engineers and the Motion Picture Research Council, provide the tools whereby the engineers of the industry can test their equipment and evaluate their results.

Mr. Maurer was appointed to serve out an unexpired term as Engineering Vice-President in 1945, and was elected in 1946 to serve a two-year term in this same capacity. During his tenure of office, the work of the Standards Committee, for which he, as Engineering Vice-President, is responsible, has gone forward steadily.

The industry owes a debt of gratitude to Mr. Maurer, who has made available to it equipment, methods, processes, test films, and above all, an inspired leadership, to bring 16-mm sound films to the point where they compare favorably with the 35-mm films with which the industry leads the world.



SAMUEL L. WARNER MEMORIAL AWARD PRESENTED ANNUALLY FOR MOST OUTSTANDING WORK IN SOUND MOTION PICTURE ENGINEERING

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## JOURNAL AWARD 1947



PRESIDENT  
RYDER  
PRESENTS  
CERTIFICATE  
TO DR. ALBERT  
ROSE

FOR HIS PAPER on "A Unified Approach to the Performance of Photographic Film, Television Pickup Tubes, and the Human Eye," which was judged to be the most outstanding paper originally published in the JOURNAL during 1946, Dr. Albert Rose was presented the JOURNAL Award at the 62nd Semiannual Banquet.

Dr. Rose was graduated from Cornell University in 1931, and received his doctorate from there in 1935. That same year he accepted a position in the research laboratory of the electron-tube plant of the Radio Corporation of America in Harrison, N. J. The work at Harrison was dedicated to the development of a pickup tube that would provide greater light-sensitivity contrast and picture quality, and would require less space in the camera than the iconoscope. He conceived the idea for the orthicon camera tube, forerunner of the image-orthicon television picture tube which was developed by Dr. Rose in collaboration with other members of the RCA Laboratories staff. It was for his work on the image-orthicon tube that Dr. Rose received the 1946 Morris Liebmann Memorial Prize from The Institute of Radio Engineers.

In 1943 the image orthicon was turned over to the Army for use in guided missiles. Because of military security restrictions, it was not made available for commercial television until after the end of the war.

Dr. Rose is a member of the American Physical Society, The Institute of Radio Engineers, and Sigma Xi.

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# FELLOW AWARDS

## 1947

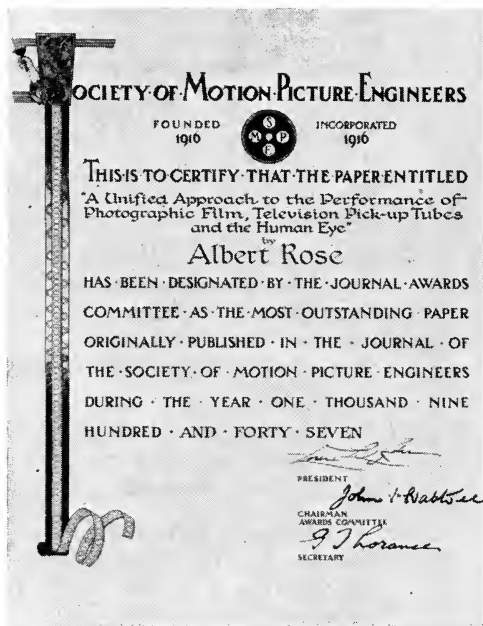
**T**HIRTEEN ACTIVE members of the Society of Motion Picture Engineers were elevated to the Fellow grade at the Banquet held on October 22, 1947. The names of the recipients and the citations are listed below.

F. E. ALTMAN, Eastman Kodak Company,  
“for original work in the field of optics of camera and projection lenses.”

A. C. BLANEY, RCA Victor,  
“who has done much of the research and development work on the problem of photographically recording sound on film.”

KARL BRENKERT, SR., Brenkert Light Projection Company,  
“for his work on the design, construction, and distribution of 35-mm projection lamps and projectors.”

CERTIFICATE  
AWARDED TO  
DR. ROSE FOR  
MOST OUTSTANDING  
PAPER  
PUBLISHED  
IN JOURNAL  
DURING 1946



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- P. E. BRIGANDI, RKO Radio Pictures,  
"who has been responsible for development  
work in sound recording.
- C. C. DASH, Eastman Kodak Company,  
"for the design and manufacture of motor-  
generator sets used extensively in the motion  
picture industry."
- A. J. HATCH, Strong Electric Corporation,  
"who has been responsible for development  
work on projection lamps."
- R. KINGSLAKE, Eastman Kodak Company,  
"for his work on the design of the camera and  
projection optics."
- R. G. LINDERMAN, Mole-Richardson Company,  
"who has been responsible for the design and  
construction of studio lighting equipment and  
is considered one of the top specialists in this  
field."
- R. H. TALBOT, Eastman Kodak Company,  
"who has been responsible for much research  
and development work on the physical be-  
haviorism of motion picture film and who has  
contributed several papers to the JOURNAL."
- M. G. TOWNSLEY, Bell and Howell Company,  
"who has contributed to the design and con-  
struction of 16-mm projection equipment, 35-  
mm printing equipment, cameras, and ac-  
cessories."
- FORDYCE TUTTLE, Eastman Kodak Company,  
"who has been responsible for the design and  
construction of 16-mm cameras and projec-  
tors and was in charge of highly specialized  
development of various types of equipment  
during the war."
- R. T. VAN NIMAN, Motiograph Corporation,  
"who has been responsible for the design of  
35-mm motion picture projectors."
- R. J. ZAVESKY, National Carbon Company,  
"for much of the development work on carbon-  
arc lighting and who has contributed many  
papers to the JOURNAL."
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# Society of Motion Picture Engineers

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JOSEPH A. DUBRAY

**J**OSEPH A. DUBRAY, who joined the Society of Motion Picture Engineers in 1928 and was elected a Fellow in 1934, resigned his membership in the Society early last year because of ill health. He also retired from Bell and Howell, with whom he had been associated since 1929, and has gone to live near Paris.

In 1898 he started experimenting with motion picture photography and in 1905 he became active in this field. During World War I he was associated with the Pathé Company in Paris where he did experimental work with moving pictures. After the war, he came to the United States where he was employed by several different motion picture companies before he resigned to do free-lance photography and to perfect the technical aspects of his work.

With the advent of sound motion pictures, Mr. Dubray joined the Bell and Howell company. He was placed in charge of the Hollywood office and later was sent to Europe to organize company interests in the motion picture industry there. Upon his return, he was in charge of the Professional Equipment Division of the company.

Mr. Dubray was very active in the affairs of the Society and served on the following committees: Admissions; ASA Sectional Committee on Motion Pictures, Z22; Historical and Museum; Journal Award; Laboratory Practice; Membership and Subscription; Papers; Progress; Standards and Nomenclature; and Standards. He was a Manager of the Pacific Coast Section in 1933; a Manager of the Midwest Section in 1939, and Chairman during 1940-1941.

Mr. Dubray was the author or coauthor of nine papers published in the *JOURNAL*, and made important contributions in the fields of printing and perforating.

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## PERSONAL

HENRY PHELPS GAGE



**H**ENRY PHELPS GAGE, vice-president of the Society of Motion Picture Engineers from 1927 through 1930, retired from active duty at the Corning Glass Works on July 1, 1947.

Dr. Gage was born on October 4, 1886, at Ithaca, New York. He was graduated from Cornell University in 1908 and received the Ph.D. degree in physics from there in 1911. His postgraduate years were devoted to the study of arc lamps and color problems. At this time he made some of the engineering experiments and researches recorded in "Optic Projection", published in 1914 and written in collaboration with his father, Simon Henry Gage. In this book, one chapter is devoted to the projection of motion pictures.

In 1911, Dr. Gage joined the Optical Laboratory of the Corning Glass Works, where he specialized in the design of pressed signal lenses and the development and standardization of signal colors for use by the railroads. These laboratory studies have since been enlarged to include some phases of illuminating engineering, as well as colored glasses for scientific, industrial, and theatrical purposes. Two of the products developed are the corrugated "CONZA" condenser for motion picture projection and the two "black-light" glasses. One of these, opaque to the visible and transparent to the ultraviolet, is used for spectacular scenic effects with fluorescent materials and also in some advanced types of sound recording. The other is opaque to visible rays and transparent to infrared or "heat rays". Both had important military applications.

Dr. Gage has presented nineteen papers before the Society of Motion Picture Engineers and other technical societies, and has published five in the *TRANSACTIONS* and the *JOURNAL* of the SMPE.

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## SOCIETY ANNOUNCEMENTS

### CONVENTION PAPERS

Preparations for the Spring Meeting of the Society which will be held at the Santa Monica Biltmore Hotel, May 17 to 21, inclusive, are now under way.

Authors desiring to submit papers for presentation at this meeting are requested to obtain Authors' Forms from the Vice-Chairman of the Papers Committee nearest them. The following are the names and addresses:

E. S. SEELEY 250 West 57 St. New York 19, N. Y.	R. T. VAN NIMAN 4431 West Lake St. Chicago 24, Illinois	N. L. SIMMONS 6706 Santa Monica Blvd. Hollywood 38, Calif.
	H. L. WALKER P. O. Drawer 279 Montreal, Que., Canada	

The Author's Form together with an abstract not exceeding 200 words should be submitted to *Mr. N. L. Simmons*, at the address above, not later than April 15, 1948. The abstract should be suitable for use in preparation of the program.

Two manuscript copies of the paper, at least one of them complete with illustrations, should be sent to *Mr. Simmons* not later than May 1, 1948.

In order that the preliminary program may be printed and distributed to the members not later than May 1, it is important that all abstracts and Authors' Forms for this meeting be received by April 15 for inclusion on the program.

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### MOTION PICTURE RESEARCH COUNCIL

The officers, Board of Directors and member companies of the newly reconstituted Motion Picture Research Council, which was described in the *JOURNAL* for October, 1947, are listed below.

#### Officers

Y. FRANK FREEMAN, Chairman of the Board  
THOMAS T. MOULTON, Vice-Chairman of the Board  
WALLACE V. WOLFE, President  
R. A. KLUNE, Vice-President  
WILLIAM F. KELLEY, Secretary-Treasurer

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#### Member Companies

Columbia	Paramount	Hal Roach
Samuel Goldwyn	Republic	20th Century-Fox
Metro-Goldwyn-Mayer	RKO-Radio	Universal-International
	Warner Brothers	

## MIDWEST SECTION MEETINGS

The September 11, 1947, meeting of the Midwest Section opened with the showing of a Kodachrome short as an example of a sound track made locally.

The first part of the program consisted of the reading by Robert E. Lewis of two papers: "Design and Operation of Trace Recording Camera", by Robert E. Lewis and Seichi Okubo, of the Armour Research Foundation; and "Use of G-3 Film Processing Tank", by Robert E. Lewis and Henry Froula, of the Armour Research Foundation.

The recording camera was analyzed in terms of a review of the problems rather than any novelty of design. It was recommended that high-intensity, blue phosphor tubes be used when possible.

Formulas for the use of the G-3 tank were distributed. There was a short discussion of the problems presented by the confinement of chemical activity.

The paper by Howard C. Hardy, "The Psychological and Physical Factors Behind Acoustical Design", dealt with basic considerations and their practical application. The use of a stethoscope or other probe was reviewed as a means of locating noise sources. A good discussion was had concerning gear noise, panel vibration, and dipole radiations.

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One hundred members and guests attended the October 9 regular monthly meeting of the Midwest Section held in the rooms of the Western Society of Engineers in Chicago. Lee de Forest, now associated with American Television Laboratories, Inc., of Chicago, presented an interesting historical discourse entitled "Early Days of Sound on Film". He outlined his early work in the optical recording of sound on film and mentioned the numerous difficulties which beset the pioneers in this field. Not the least of these was the one of convincing a too-complacent film industry that talking pictures would have a commercial future. Technical and artistic problems involved in recording and reproducing sound films were overcome, one by one, to the end that commercially acceptable sound films were publicly shown in New York theaters several years before the industry generally accepted the idea of having synchronized sound and music with its pictures. In the discussion following his talk, Dr. de Forest expressed doubt that television in theaters will be of any great importance, except for certain specialized events, because of programming difficulties, but stated that he feels that the future of the industry is already assured by the public acceptance of television as a home entertainment medium.

The second paper of the evening, "Producing Films for Schools", was presented by Ellsworth C. Dent, General Sales Manager of Coronet Instructional Films and Educational Director of *Coronet* magazine. Mr. Dent discussed in considerable detail the problems and procedures involved in making films which will convey the desired information in a manner both intelligible and acceptable to the student-age groups for which the films are intended. He stressed the value of color films in making the presentations more interesting and natural. At the conclusion of his talk, Mr. Dent exhibited a recently completed Coronet film, "Shy Guy", intended for showing to high-school-age groups, which treats the problem of students who do not know how to get along with other students, and effectively shows them how to go about improving their relations with others.

\* \* \* \* \*

On November 13, 1947, there was a meeting of the Midwest Section at the Ansco Laboratories in Chicago, Ill. Chairman A. Shapiro presided and introduced the newly elected officers of the Section for the coming year, and Haldon A. Leedy of the Armour Research Foundation presented a paper on "Magnetic Sound for 8-Mm Motion Pictures". Dr. Leedy gave a brief history of magnetic recording illustrating his talk with slides. One of these showed the relative space available for the sound record on 35-, 16-, and 8-mm film. The space available for 8-mm film is 0.030 inch wide and may be placed on either edge of the film. All film demonstrated used the area between the sprocket holes and the edge of the film.

An Ampro 8-mm projector, mounted on a base containing the amplifier and film-stabilization mechanism developed by Armour, was used in making demonstrations. A loop running in the projector was recorded and played back immediately on the same system. An 8-mm Kodachrome reduction print with recorded voice and musical background was presented, in which the music and the intelligibility of the voice were good.

Before the discussion, Chairman Shapiro warned that it would be a mistake to overemphasize the addition of soundheads to existing equipment, since 8-mm models should be redesigned completely. The discussion brought out the following points: 5000 cycles per second would be difficult to record and is not to be expected in the near future; three speeds are now being used for experimentation—16, 18, and 24 frames per second; the magnetic material is particles of iron oxide, about one micron in size, and especially heat-treated. The response of the system at 18 frames per second is flat from 100 cycles to about 2500 per second with sharp cutoff.

James Wassell of Ansco welcomed some 300 members of the Society and their guests to the Laboratory, and William Macomber, manager of the Laboratory, gave a brief description of its scope of operations. A short demonstration reel of Ansco Color 16-mm film was shown, and a tour of the Laboratory concluded the meeting.

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### Membership and Journal Subscriptions

Recently the Los Angeles Better Business Bureau informed President Ryder that an unauthorized group in the Hawaiian Islands was soliciting Christmas memberships in the Society of Motion Picture Engineers. The Bureau believes that these people are collecting initiation fees or membership dues which probably will not be forwarded to the Society.

Legitimate subscription agencies are authorized by the Society to accept Journal subscriptions and they will continue to handle these as in the past. However, no arrangements have been made for them to handle memberships.

All checks or money orders should be made payable to the Society of Motion Picture Engineers, Inc.

### Membership Directory

In the Spring of 1948 the Society of Motion Picture Engineers will publish a Membership Directory containing the names and addresses of all members. Questionnaire cards were enclosed with the dues bills sent to the membership early in January, and members were requested to return them without delay. If you have not sent in your card, please do so now.

1. Fill in the card promptly.
2. Return it with your dues bill and remittance.
3. Print or typewrite.
4. If you make any change in address or position after you have sent in your card, inform the SMPE immediately so that you may be correctly listed.

*The Editor*

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### Training-Film Research Project

Sponsored by the Navy Department, a research project is under way at Pennsylvania State College to increase the value of training films. The study is intended to develop principles of producing effective sound films that provide "complete" instruction in the shortest possible time.

Types and characteristics of training films already produced will be analyzed and evaluated. Appropriateness of subject matter in terms of its application to real situations will be studied. Individual response to sound-film training will also be investigated, to determine speed of learning and retention of memory.

Based on collected information and new research findings, a highly selected and specialized library and information center will be established. These services will be available for use of the Navy and other government departments.

The project at Penn State, under the direction of Dr. C. R. Carpenter, professor of psychology, will be conducted in close co-operation with other universities and government agencies engaged in similar work.

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### Library and Search Service

The American Library Service has announced that it specializes in books, periodicals, and other material relating to the motion picture industry. This organization provides a library and search service free of charge.

Through the libraries and research departments of motion picture studios, the American Academy of Motion Picture Arts and Sciences, the Library of Congress, and other sources, it locates and makes available scarce and out-of-print books and periodicals. Requests for single titles or complete collections should be addressed to American Library Service, 117 West 48 Street, New York 19, N. Y. They will also supply a listing of available scarce material, on request.

## CURRENT LITERATURE OF INTEREST TO THE MOTION PICTURE ENGINEER

The editors present for convenient reference a list of articles dealing with subjects cognate to motion picture engineering published in a number of selected journals. Photostatic or microfilm copies of articles in magazines that are available may be obtained from The Library of Congress, Washington, D. C., or from the New York Public Library, New York, N. Y., at prevailing rates.

### American Cinematographer

- 28, 10 (Oct., 1947)
- Future of Cinematography (p. 358)  
L. SHAMROY
- Historical Development of Sound  
Films. Pt. 4 (p. 362)  
E. I. SPONABLE
- The S.E.I. Exposure Meter (p. 370)
- Telefilm Sets 16-Mm Program for  
Production Distribution (p. 376)
- New Exposure Meter Developed by  
G. E. (p. 379)  
28, 11 (Nov., 1947)
- Mitchell Background Projector  
(p. 391)
- 30 Years of Technicolor (p. 392)  
W. R. GREENE
- The Men Behind the Mouse. Pt. 2.  
How Animated Cartoons are Made  
(p. 394) H. A. LIGHTMAN
- Motion Picture Art Direction  
(p. 396) H. HERMAN
- Historical Development of Sound  
Films. Pt. 5 (p. 398) E. I.  
SPONABLE
- The Cinema Workshop. 17. Sound  
Cutting and Recording (p. 400)  
C. LORING
- Blue Seal Cine Devices 35-Mm  
Sound Recorder (p. 404)
- Akers Professional Conversion for  
the 16-Mm Bolex Camera (p. 406)  
W. C. THOMPSON

### British Kinematography

- 11, 4 (Oct., 1947)
- Colour Modified Compact Source  
Lamps for Film and Television  
(p. 107) H. K. BOURNE and  
E. J. G. BEESON
- The Production of Cartoon Films  
(p. 117) D. HAND
- The British Tricolour Camera  
(p. 123) J. H. COOTE

### Electronics

- 20, 11 (Nov., 1947)
- Console for Dubbing (p. 142)

### International Photographer

- 19, 10 (Oct., 1947)
- What the Cameraman Means to Ad-  
vertising Photography (p. 8)  
G. M. HURRELL

### International Projectionist

- 22, 10 (Oct., 1947)
- B. & L.'s New 40-Inch Photographic  
Lens Stops 'Em (p. 18)
- Acoustics. Pt. II. Sound Level  
Meter (p. 22)
- New Cadmium-Mercury Lamp Bows  
in Studios (p. 23)  
22, 11 (Nov., 1947)

- Color Temperature: Origin and  
Meaning (p. 5) W. W. LOZIER
- The Production of Cartoon Films  
(p. 10) D. HAND
- Projection Data Charts. VII. Pro-  
jection Room Accessories Data  
(p. 12) R. A. MITCHELL
- British Screen Brightness Standards  
(p. 18)
- The Triatic Signal Tracer (p. 22)  
E. STANKO
- Why Acetate Film? (p. 25)  
R. MITCHELL

### RCA Review

- 8, 3 (Sept., 1947)
- Colorimetry in Television (p. 427)  
W. H. CHERRY
- Application of I.C.I. Color System to  
Development of All-Sulfide White  
Television Screen (p. 554)  
A. E. HARDY

### Radio News (General Interest Section)

- 38, 6 (Dec., 1947)
- The Recording and Reproduction of  
Sound. Pt. 10 (p. 48) O. READ



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# Theater Television— A General Analysis\*

By ALFRED N. GOLDSMITH

CONSULTING ENGINEER, NEW YORK, NEW YORK, PAST-PRESIDENT  
AND FELLOW OF THE SMPE

*Summary*—Excellent engineering progress has been made in the development of equipment and methods for the exhibition of television pictures in theaters. Considerable thought has been devoted to types of acceptable programs for theater television. However, the final design of commercial television equipment for theaters is not yet available, nor are proved and acceptable program methods as yet clearly defined.

Accordingly, theater television may be regarded at present as being, in some respects, in a partly developed state. Considering this situation, the following analysis is perforce a descriptive report, as of today. It contains as well some analytical discussions of possible future trends. But the data and conclusions are of necessity subject to revision as further progress in theater television brings forth new methods and offers greater capabilities in this highly interesting field.

## I. PICTURE SIZE AND VIEWING CONDITIONS

TELEVISION PICTURES in theaters will, initially at least, have the strong appeal of novelty. Accordingly, the screen pictures may be smaller than those shown from projected motion picture film in the same theater. Since, in any case, a screen having a specially desirable directional characteristic will be used, the problem of masking thus will be automatically solved by a screen change between motion picture presentations and television projection. The directional characteristics of the television screen will also be discussed below. Even if an intermediate-film process, as described below, is used, the presumably lesser detail or resolution of the television pictures will justify a smaller screen image than for motion picture projection.

Since motion pictures in most theaters range from  $9 \times 12$  feet to  $18 \times 24$  feet, television pictures may fall within the range of  $6 \times 8$  feet to  $15 \times 20$  feet. Ultimately, it may be found desirable and economical to use identical picture sizes for television and motion pictures, but at present this seems unnecessary.

The picture masking may be made slightly different for television. It is permissible to mask off more of the corners of the picture in

\* Presented October 21, 1947, at the SMPE Convention in New York.

television, a step which is justified since the television pictures may fall off in resolution more rapidly, toward the corners, than do the projected motion pictures.

The light which forms a projected television picture (without intermediate-film recording) is produced in a cathode-ray tube by special electrical methods. It is a costly form of illumination and should be conserved to the utmost and utilized efficiently. For this reason unusually high-speed television projection systems are used (of the so-called Schmidt-optics type) with speeds as high as  $f/0.6$  to  $f/0.8$ . Further, a screen is preferably used which will throw light only to those portions of the house which are occupied by the audience. After all, any of the precious light which is thrown to the ceiling or off to the side walls of the house is wasted. It might better be utilized by concentrating all light reflected by the screen in the localities occupied by the audience. The directional screens may, therefore, be specially suited to the design of the theater, giving a considerable central concentration in long, narrow houses and a wider horizontal spread in shallow and broad houses. Vertically, light will similarly be concentrated between the top balcony and the front of the orchestra. While directional screens have been used to some extent for motion picture projection, the television directional screens will likely be even more specially "tailored" to the particular theater.

In the front rows of some theaters, the line structure of the television image occasionally may be visible, particularly with imperfect interlacing. This is not a particularly serious defect, as has been shown by the satisfactory experience in this regard in receiving television broadcast pictures in the home. In any case, it is possible that slight residual optical aberrations may sufficiently soften television pictures so that the line structure is not noticeable in practice.

The television engineer and the exhibitor alike must strike a thoughtful balance between television picture size and the corresponding brightness. If the picture size is increased 50 per cent, the picture brightness will of course drop to less than 50 per cent. The motion picture field has experienced a continual urge toward larger and brighter pictures. In some theaters, brightness has been sacrificed for size, with much resulting inconvenience to the audience when finding its way in a too dimly illuminated house. For this reason, it is thought that television pictures may well sacrifice something of their size for the sake of acceptable brightness.

Picture weave was quite noticeable in the early days of the motion

picture but now it is not a serious factor unless badly worn film is used in decrepit projectors. In television, picture weave is rather unusual, and should not be noticeable under normal projection conditions.

If a large and less-bright television picture is adopted in a given theater, it may prove necessary to change the house lighting before going over to a television presentation. That is, the residual house lights may be dimmed further whenever television is about to be shown. As previously suggested, this is not a particularly desirable procedure since it imposes extra duties on the house staff, requires added control equipment for the lights, and may inconvenience the entering or leaving audience during the period of dimmed illumination. It is unlikely that this step will be necessary except perhaps in the early days of theater television in color where the problem of screen illumination is even more pressing because of certain technical and psychological factors.

## II. PICTURE BRIGHTNESS AND WHITENESS

As previously indicated, the picture brightness will depend to some extent on the skillful adaptation of the directional screen to the particular theater in which the picture is shown. Obviously, theater television will require close co-ordination between the television engineer, the architect, and the exhibitor. This, however, is a desirable state of affairs for motion picture exhibition as well.

Present-day motion pictures have a usual screen brightness of about 10 foot-lamberts. Television pictures, even in the early stages of the art, should show the same brightness or, preferably, 25 to 50 per cent higher brightness. This may require acceptance of a somewhat smaller picture in monochrome. For color presentations, picture size might require still further reduction in the early stages of that art.

Television pictures should show no marked falling off in brightness toward the edges and corners. The skillful optical design of the projection system has enabled meeting this requirement. Unfortunately some motion picture projectors have been so designed (or used) that the brightness at the center of the picture is undesirably higher than that at the edges of the picture. If an intermediate-film process is used for television presentations this factor will require consideration in connection with the suitability of the projector itself.

It is well known that defects in an optical system, namely the so-

called optical aberrations, result in a loss of contrast, or decrease in gradation range in the viewed picture. Whereas a "brilliant" or "sparkling" picture may have a gradation range between 50-to-1 and 200-to-1, a "flat" picture may have a range of only 10-to-1 or even 20-to-1.

Scattered light in an imperfectly designed projection system will contribute to lack of picture contrast. So, also, will certain halation effects in the television projection tube. These last have recently been overcome in large measure by the process of aluminizing the fluorescent surface.

However, special care should be taken in the design of television optics and the selection of television pictures to maintain an acceptable contrast in the projection picture. This will also require a certain amount of careful maintenance of the optical system to reduce undesired and parasitic reflections.

The "whiteness" of the television picture presents an interesting topic for opticians and colorimetric experts. At present no standard has been generally adopted to control the "whiteness" of either television or motion pictures. Indeed, change in the illuminant or arc-type in motion pictures gives rise to marked changes in the tint or "whiteness" of the projected picture.

Fortunately, the human eye easily adapts itself and regards most light tints, when sufficiently bright, as "white". Thus, after a moment or two, the eye will regard a light yellow, a light yellow-green, or a pale blue as "white".

Nevertheless, if there is any marked difference between the color of the projected motion picture and the color of the television picture, this may be detrimental to the audience reaction to one or the other of these. It would be well to keep television pictures and motion pictures in monochrome at approximately the same "white" tint. This tint may, however, vary for different theaters. If a rather yellowish arc is used in a theater having an old and yellowed screen, a blue-white television picture will show up that situation.

It would be quite appropriate for the Society of Motion Picture Engineers to study the standardization of "whiteness" for theater-television pictures. At a later date American Standards may be correspondingly developed.

### III. PICTURE RESOLUTION

The picture detail, or resolution, adopted for theater-television practice should be a reasonable compromise between extremely

high detail (and correspondingly high cost of specialized equipment and precise operation) on the one hand, and insufficient "story-telling" capabilities or undue softness of the pictures, on the other. If the subject matter is presented with sufficient clarity so that but few complaints, if any, are received from the theater audience when television pictures are displayed, it is certain that an acceptable value of picture resolution has been adopted.

Motion pictures in theaters have a theoretical resolution of between 1000 and 1500 "lines". (These are "television lines", and represent twice the resolution value expressed according to ordinary photographic or motion picture practice.) Television pictures usually will not require, in the early stages of commercial exploitation, as high detail as the motion picture itself. The 525-line pictures now broadcast probably will be acceptable. Appreciable improvement would result only from substantial increases such as going to approximately 800 or approximately 1200 lines. Such a change does not seem economically or otherwise justified at present.

There is room for good showmanship in television presentations in order to avoid any obvious or objectionable transition from the high resolution of motion pictures to the somewhat lower practicable resolution for television pictures. One way of handling this would be to produce a short film which would precede the television presentation. This film might state that the next part of the program would be television and point out some of the dramatic or other attractive aspects of the impending television performance. The film in question might start with material photographed as sharply as standard motion picture practice normally requires. During this film the resolution might be reduced gradually (preferably by diffusion means) until the resolution at the end of the film, just before the television presentation, was approximately the equal of that of the television picture, or even slightly less. Another short film or trailer might follow the television presentation, preceding the next motion picture. This film might be recorded with a "resolution transition" going from television resolution to motion picture resolution. Doubtless other methods of bridging the television-to-motion-picture transition can be devised.

There is one major argument in favor of using the current television-broadcast resolution value for theater presentations. If theaters are to be able to use broadcasts of transcendently important events which are broadcast by television (as may be desirable,

say at elections, conventions, certain sports events, and the like), it would be somewhat complicated for the theater to have to use 525-line television reproduction for such events and then to switch over to some other and higher number of lines for other television program material syndicated to the theater. Such a switch-over is by no means impossible, but it is an added complication, probably unjustified in the early stage of the art.

While the picture resolution will undoubtedly fall off toward the edges and corners, just as it does in motion picture reproduction, yet the change should not be obtrusively noticeable. This is not an unduly difficult requirement.

#### IV. PRESENT THEATER-TELEVISION METHODS

Two of the main methods for reproducing television programs on theater screens will be discussed briefly, together with a summary of their apparent present-day advantages and limitations.

(a) The first of these is cathode-ray-tube projection systems, usually using Schmidt optics or some high-speed projection-lens system.

Such a system has numerous advantages. It reproduces the program instantaneously as received, a factor of psychological importance. It is free from the cost of expendable materials, such as photographic film. Inasmuch as a high-power arc is not used, the cost of electric power probably will be lower in such a system. There is no processing cost for film involved in this process. Nor is there any possible loss in picture quality or resolution (nor, on the other hand, a possible improvement in adapting the gamma characteristics of the picture to the television system) as a result of photographic recording, processing, and projection. Gaps or jumps in the program, resulting from the time required for film processing, are absent. Accordingly, the program continuity or flow is more readily obtained.

The system has certain limitations including the following: High-speed optics generally require either that they be designed for a specific throw which is convenient in the theater or, alternatively, that the equipment be installed at the position required by the designed throw, even if that location be inconvenient. If television projectors are to be placed in the projection room, they will require additional space and may, therefore, lead to structural changes and building reinforcements. Further, television projectors are unlike motion picture projectors, and accordingly the theater staff will



require retraining to utilize such equipment. In addition, the optical and electrical systems in such projectors must be cleaned and inspected systematically to ensure effective operation, and according to methods not at present familiar to the theater staff. Since television projectors use optical and electrical equipment, as do motion picture projectors, it is conceivable that certain questions of jurisdiction will arise in labor circles. And, finally, when direct projection of television programs takes place, no film record exists and therefore there is no available means for repeating the program at some convenient, desirable, or prearranged time (except by retransmitting it from a film record or from a repeated live-talent performance at the point of program origination).

(b) According to the second method of theater television, the incoming program is reproduced on a bright cathode-ray tube, but the image is projected, not on the theater screen, but on motion picture film in a recording camera. The film is rapidly processed in special high-temperature rapid-flow processing systems and is then projected from the theater projectors (with or without modification of these projectors) according to the usual motion picture technique.

The advantages of such a system include the following. So far as projection is concerned it uses the normal and well-understood motion picture projector. It does not become necessary to train the projectionist on a new method of projection (although he or some other other worker will, of course, be required to understand how to use the television receiver, the recording camera, and the film-processing equipment). The picture which is projected readily can be as bright as that normally shown in the theater, of the same size, and of the usual color or "whiteness". Further, the entire television material can be rerun as desired for later shows and at any convenient time. Thus it fits into the motion picture program with considerable flexibility. Some thought will, nevertheless, be required in connection with abuse of this system in sports events, such as horse racing, where gambling is usual and picture delays may lead to certain abuses.

Among the limitations of the film-recording process for theater television are the following: There is, as stated, a slight delay (from a fraction of a minute to several minutes) between the actual time of occurrence of the program and its reproduction in the theater. Change-over from motion picture programs to television programs will require considerable dexterity in the use of the available projectors. If 16-mm film is used, with resultant lower cost, different

projectors will be needed. If 35-mm film is used, its cost will become a factor of some importance. Further, the expense of handling and processing the film must be considered. In this connection it should be remembered that undoubtedly only acetate-base film would be acceptable for theater recording of television programs.

Other limitations involve the need for liquids for processing, heaters, driers, winding and film-transport equipment, and other associated gear. Questions may arise as to jurisdiction between cameramen and projectionists in processes of this sort. The projection room may also present space and facilities problems in connection with the installation of the necessary supply of water, clean air, power supplies, and the like.

(c) Other processes are known for theater-television presentation. One of these is the so-called Eidophore method which, so far as is known, has not been demonstrated in the United States. This Swiss method is one of considerable novelty and ingenuity, but its performance under practical operating conditions is not known at this time.

#### V. POSSIBLE LOCATIONS OF PROJECTION EQUIPMENT

There will be discussed briefly the advantages and limitations of five possible locations of the television projection equipment in a theater. Assuming available space and facilities, the projection room itself seems at first to be the desired location, provided again that efficient television-projection systems can be built for the corresponding throw. If film recording is used, the projection problem probably presents few difficulties.

(a) A first possible location for the television-projection equipment is behind the translucent screen, with the picture projected on the screen toward the audience. One advantage of this system is that no space is required in any part of the theater other than back stage, nor need any structural modifications be made anywhere else in the theater (except as required for interconnecting wiring). If the projector were mounted at a height equal to that of the center of the screen, keystoneing will also be absent.

There are, however, certain limitations to this location. For one thing, the necessary space for the required throw simply may not be available backstage behind any feasible location of the translucent screen. It is unlikely that complete flexibility of design and placement will exist in present-day theaters. Further, projection of this type will require, in most instances, a very wide-angle projection lens

which will have a correspondingly low aperture or light-passing value. The cost of the elevated support for the projector (assuming no keystoneing), and the cost of the surrounding projection room, may be considerable. The efficiency of a translucent screen, even of a highly directional type, is generally considerably below that of an opaque screen. The out-of-the-way location of the television projector necessarily would require a duplicate operating staff except in the unlikely event that the entire television-projection equipment could be accurately and simply controlled remotely from the projection room. Such remote control, however, doubtless would be costly and less than simple.

(b) A second possible location for the projection equipment is either on or below the stage, or in the orchestra pit. In this case an opaque screen would be used with front projection.

The advantages of such a plan include the absence of need for any modifications of the house either in the orchestra, balcony, or projection room. Further, no seats need be removed from the house. It should be noted, however, that a rather special type of directional screen would be required for such a markedly oblique projection position.

Among the difficulties to be expected in this case may be mentioned the following: Space may not be available either below stage or in the orchestra pit. Rather extensive structural changes might be required if such a location were used. The projectors necessarily would employ wide-angle optical systems because of their nearness to the screen, and such equipment usually is inefficient in the production of bright pictures. Serious keystoneing might be anticipated and would require correction. Again a duplicate operating staff, or, alternatively, remote control of the projection equipment, would be needed.

(c) A third possible location for the television-projection equipment is somewhere in the central axis of the orchestra.

Such a location has the advantages of offering considerable flexibility in the selection of the precise place at which the television projector is installed. Thus, this system is extremely well adapted to provide whatever throw is optically preferred and economically desirable. Further, no space in the projection room is needed nor yet any changes in the projection-room equipment (beyond control and interconnection circuits for signaling, and the like). In addition to providing an adequate and selected throw, this location permits the ready use of a suitably directional opaque screen.

There are some limitations in a system of this sort. It requires that certain seats in the orchestra be removed to make way for the projection equipment. Persons located behind the projector may experience difficulty in viewing the television picture pleasantly. The intrusion of operated equipment in the orchestra to some extent interferes with the desired theatrical "illusion of reality". The costs of wiring and certain related costs may be considerable for such a location since most theaters have been designed without any consideration of such a possible future need for space and facilities in the center of the orchestra. There will be some keystoneing from projection at orchestra level and this, in turn, will require correction. Since the projector light beam emanates from a point in the orchestra it may be visible, particularly in houses where smoking is permitted or where dusty conditions prevail. This factor may not be noticeable in other cases. In this system there will also be required two operating staffs, one for motion pictures in the projection room and one for television in the orchestra television-projection location, again assuming that remote control of television projectors is not feasible on an everyday basis.

(d) A fourth conceivable location for the television-projection equipment is somewhere between the extreme front and the extreme back of the first or second balcony.

Such a system has certain advantages. It does permit considerable flexibility in the location of the equipment. It requires no added space or change in the projection room, excepting perhaps of minor nature. The important orchestral seats are left without any change or intrusion. As before, any desired type of opaque directional screen may be used.

Among the difficulties which might be anticipated for such a location are the following: Certain of the balcony seats must be removed and the view from certain other seats will be blocked (unless the television projectors are placed at the extreme back of one of the balconies). Undoubtedly strengthening of the balcony structure will be required in some instances; this may prove a costly and cumbersome undertaking. The added expense of special wiring and certain related costs will be involved for balcony locations. The picture throw will in general be a long one, and this may not fit in with the best designs for current television projectors of the direct type. As in all other balcony locations, keystone correction will be needed. Assuming personal operation of the television projectors,

two operating staffs will be needed or their equivalent, with proper co-ordination and intercommunication.

(e) A fifth and final possible location for television projectors is in the motion picture projection room itself.

Such a location offers certain obvious and attractive advantages. For one thing it concentrates all projection equipment, of whatever nature, in one room. Similarly all wiring and interconnection is in the same room. Only a single operating staff is needed, although this staff may be a larger one ultimately than would be required for motion picture projection alone. It is also simple to use film-recording systems for television presentation in the projection room itself since the film projectors are close at hand. Indeed, wherever film recording is used (that is, the intermediate-film television-projection system), the projection room offers major advantages as a location.

However, there are certain limitations to the projection-room location for television projection. The room size likely will require an increase, and this in turn will lead to considerable structural changes. The added weight of equipment will, in turn, demand other structural changes for strengthening the supporting members. Since a considerable added amount of electrical (or even film-processing) equipment will be placed in the projection room, care will be required to be certain that no novel physical or fire hazards are introduced. Unless the intermediate-film process is used for television, the long throw to the screen may not fit too well with presently available television-projection systems. And, as usual, keystone correction will be needed.

From all of the preceding it can be seen that the desirable location in the case of any particular theater depends on whether the intermediate-film process or the direct-projection process is used for theater television and also upon the dimensions and physical construction of the particular theater and its projection room. Obviously no general prescription can be used which will be guaranteed to bring perfect health to television in every theater.

## VI. SOUND-REPRODUCTION METHODS

As a matter of economy, convenience, and availability of staff training, it is probably best at this time to produce the sound accompanying television programs directly from the motion picture amplifiers and stage loudspeakers. In effect, this amounts to introducing the received sound into the circuits associated with the sound-track output of the motion picture projector.

However, it may prove desirable to modify the frequency characteristic of the reproducing system when television programs are reproduced in order to secure the most natural and desirable quality of reproduction.

Since change-overs from motion pictures to television and back again may become increasingly frequent, it will be necessary to have a simple and errorproof change-over system, presumably suitably interlocked with the picture change-over system from motion pictures to television and back again.

#### VII. COLOR-TELEVISION METHODS AND PROBLEMS

Large-screen color television has been demonstrated successfully. It is natural to inquire concerning the practicability of theater color television at this time.

There are certain considerations that indicate that color television in theaters should be introduced after considerable experience has been gained in monochrome theater television and after further developments in color television have been carried out successfully.

It must be remembered that, because of the use of color filters, color television requires considerably more light from the original projection tube or tubes or, alternatively, the acceptance of a smaller picture for identical brightness. While certain ingenious technical expedients enable this factor partly to be overcome, yet it is sure that the light-producing efficiency of color-television equipment is unlikely to equal, or even closely approach that of monochrome television equipment.

Further, color television requires considerably more elaborate and costly apparatus. The radio or cable channels for program syndication must transmit a far wider block of frequencies for color television than for monochrome, with correspondingly increased first cost and maintenance charges, or rentals as the case may be. Color-television equipment is also more complicated than monochrome equipment and may require skilled handling and maintenance.

In live-talent presentations, more studio illumination is required (or alternatively, a far more sensitive camera tube). In addition, careful consideration must be given to the color of the costumes, sets, make-up, and the like. All of these factors correspond to increased expenditure of time and funds.

In the case of programs taken from film, similar difficulties arise. Color film is a precise product which, at this time at least, is in relatively short supply. Indeed, it is not known whether the existing or

projected color-film manufacturing facilities would be capable of meeting the requirements of the television broadcast field were color television to be generally adopted. This condition may persist for many years, since the successful manufacture of color film is a difficult art of high precision.

Color film is also far slower than monochrome film. This, in turn, would restrict the range of time and subjects which could be recorded for television purposes.

In the theater itself, the intermediate-film process for television-program projection would require the availability of color film which would be of sufficient sensitiveness to enable photographing the incoming program in color, together with the capability of high-speed processing in the theater. So far as is known, color film which can be processed at high speed for such theater purposes is something for future accomplishment rather than present commercial availability.

While the preceding considerations indicate that color television is not available for practical and commercial theater purposes at this time, and that exhibitors necessarily will confine their television presentations to monochrome, yet it should be mentioned that color television does offer attractive possibilities in the future. It can readily be agreed that color presentations are, in general, superior artistically and dramatically to black-and-white presentations. It is therefore hoped that, within the next decade or two, color television also may find its place in theaters.

### VIII. COST FACTORS

The major cost factors which must be considered by the exhibitor entering the field of theater television include the following. Some of these factors are major; others are relatively small.

The first factor to be considered by the exhibitor is the making of a systematic survey of his theater and a study of appropriate methods of introducing television into that theater. It would be a major error, in a new field of this sort, for an exhibitor to enter theater television uninformed as to its general characteristics and without data as to the most suitable way in which television equipment can be installed and operated in his own theater. Such surveys can be conducted by trained technical and program men who have been active in television.

Following a survey, the exhibitor presumably will place an order for appropriate television equipment. The various results of this

analysis or survey will indicate the general nature of the equipment which he may select. Clearly, a small theater in a town of medium size will probably find a different solution advisable from a large theater in a great city.

Following the selection of equipment, it becomes necessary to install such equipment in neat and reliable fashion. This is handled in much the same way as the sound motion picture equipment.

Once installed, the equipment will require a certain amount of maintenance and servicing. This can be arranged with appropriate agencies or representatives of the equipment manufacturer. It is believed that modern television equipment for theaters will require only a reasonable amount of maintenance.

Regardless of the type of television equipment which has been selected, the theater staff will require training in its daily use. The staff must further acquire skill in smoothly changing over from motion pictures to television and back again. The size of the staff which can handle both motion picture and television programs will require analysis, and perhaps some negotiation.

The exhibitor of necessity must find an available source of television programs. He can hardly depend upon television broadcasting for that purpose because of certain restrictions and also because the theater owner, in general, will desire exclusivity of use of his program materials in his own neighborhood.

The programs to be shown by television may in part consist of film material which is sent from a central transmitting station to a group of subscribing theaters. The cost of such a service will of course depend upon the cost of the program and the cost of carrying it to each individual theater in flawless shape.

Another portion of the television program in theaters may consist of live-talent presentations. Here again is a cost factor which will depend upon quality of the talent and performance, and the cost of carrying the program to each theater.

The total cost of a program is, therefore, the sum of at least two elements, namely, the program cost itself, and that of carrying the program to the theater (that is, of syndicating it). It is possible that these elements will be combined into a single charge for the delivery of the program at the theater, in much the same way in which films carry a charge which includes actual delivery.

It is clear that the greater the number of theaters which can use a given program at a particular time, the less may be the program cost



per theater, and also the less may be the cost of carrying the program to the theater. Manifestly, if one thousand theaters seating an average of one thousand persons each utilize a television program simultaneously, the cost would be far less per theater (or per member of the audience) than if a small number of theaters of limited seating capacity were to carry the program at a given time. Here again we encounter the overwhelming advantages of large-scale syndication which, accordingly, presents a major problem, and also an opportunity to the theater-television field.

As against the factors of expense just listed (which might include special advertising of the television programs, adaptation of operations to the insertion of television, and the like), there is the pleasant factor that box-office returns may be increased substantially because of the television presentations in the theater. In fact, theater income may be increased for at least two significant reasons. In the first place, a program containing attractive television material as well as motion pictures may command a higher admission price than a motion picture program alone. In the second place, if the house is more nearly filled for each performance because of the "pulling power" of television programs, the total number of persons entering the theater per day will be correspondingly increased. Only experience will show the extent to which these factors operate in practice under various conditions. Undoubtedly the size and type of theater, its location, the nature of the audience, the availability of competitive syndication facilities, and the like will determine the increase in theater revenue resulting from television and, accordingly, the appropriate scale or investment in television by the exhibitor as well as the program-originating agency.

#### IX. PROGRAMMING PROBLEMS AND POSSIBILITIES

The problems of programming in theater television are, strictly speaking, not all outright engineering problems. They are, however, so closely tied in with the engineering techniques and apparatus that it is appropriate briefly to refer to them at this point.

It is of course evident that theater-television programs must fit into the schedule of motion picture presentations without awkward gaps or abrupt and undesirable changes of mood or subject matter. Accordingly, program planners will face the problem of fitting television and motion picture material into each complete show in such fashion as to form a unified and interesting performance.

However, when events of supreme importance occur, constituting "transcendental news events", it may be necessary to throw all everyday rules into the discard. In such an instance good showmanship might even involve interrupting everyday material to make way for something that is unique and of possibly tragic interest to the entire audience. It is to be hoped, for many reasons, that such events will not break into normal theater operations too frequently.

A number of types of television programs suitable for theater presentation are fairly obvious of acceptance. Thus, news events will have real interest. So will sports events, or crucial parts of such sports events. It will be quite a problem to fit the best parts of a baseball or football game, for example, into a theater presentation. The top events in a circus, or rodeo, being capable of prescheduling on an accurate basis, afford more flexibility and therefore more readily usable material.

Live-talent shorts may be of real interest, particularly if the actors in them or the subject matter are related to the motion picture program in the same theaters. In that case, a live-talent presentation might even function as a "supertrailer" for the motion picture feature.

Short subjects, comedy subjects, and "black-outs" all seem susceptible of development for theater-television purposes.

There are some legal matters that will require attention either by the exhibitor or by the organization that supplies him with television programs by whatever syndication means may be used. Undoubtedly copyrights will exist on the picture and sound (or speech) of practically every presentation, except news events. The rights of the copyright owners in music will require attention. Patent rights may be involved in equipment and circuits. And there may even be some rather interesting legal questions in connection with so-called "violation of the right to privacy" in such States as will not permit the public display of photographs of living persons or episodes in their lives without their previous permission. It may be mentioned that some States do not recognize this right to privacy while others do, thus complicating the situation in connection with the national syndication of news events.

#### X. METHODS OF URBAN PROGRAM SYNDICATION TO THEATERS

In a key city, there are usually theater chains controlling a considerable number of theaters, smaller theater groups, and individual

theaters not affiliated with any larger group. When television programs become available for syndication, methods will be required to sort out these various theaters in accordance with their television needs. Obviously the extremely large groups of major theaters might be able to afford their own television programs, syndicated exclusively to them and perhaps to a limited number of relatively noncompetitive independent theaters. Smaller groups of theaters likely will have to form a coalition among themselves, and with the probable addition of some independent theaters, to build up a group justifying a special syndication service.

Each group of theaters, which has its own television programs and syndicates them to its members, necessarily will require central studios for live-talent production and a central projection room for film transmissions. However, several such syndicating agencies might readily rent (or own) studio space in a single building or group of buildings devoted to theater-television program production.

On the physical side, the actual syndication of programs can be by one of the following methods:

The simplest method, though perhaps not the most economical, involves the use of specially quiet telephone lines which are equalized to the extent necessary for excellent picture transmission and which have repeater stations sufficiently close together to prevent the intrusion of "noise" into the picture. This system has the advantage of utilizing facilities which may be available but it does require some changes in wiring at the telephone exchanges and the addition of considerable amplifying and equalizing equipment. The sound channel naturally presents no problem being practically identical with a high-quality standard broadcast circuit.

Another method is to run a coaxial cable to the group of theaters which are to be served. Such cables also require repeaters and equalizers but are more specifically adapted to picture transmission. Both the cable and the telephone-line methods of syndication have the advantage of being strictly private which, from the theater viewpoint, is of course desirable.

Another method which may well be quite economical is the use of highly directional or narrow radio beams to carry the program for syndication. The advantages of such a system may be economic, both as to first cost and maintenance. If the beam is sufficiently narrow, is operated on a special frequency, and perhaps has some "secrecy" element in it, unauthorized pickup of the program may be

avoided as a practical proposition. It would be odd if, in the new theater-television art, we again encountered the old-fashioned motion picture "bicycling" of early days. If radio syndication is used, as described, it will be necessary that the government allocate, through the Federal Communications Commission, the necessary channels to enable such operation. Other physical problems will arise. Thus, some theaters might be shielded from the central transmission station and would then require an intermediate automatic radio-relay station located off to one side to avoid obstruction of the signal by the obstacle. Again, some theaters may find themselves in an "electrically noisy" location (that is, with much electrical interference with reception). If so, highly directional receiving antennas, shielding, or other expedients may prove necessary.

If radio syndication is used, a heavy-duty television receiver will be necessary in the theater to handle the picked-up program and to transfer it, by projection, to the screen. If wire or cable syndication is used, probably somewhat simpler receivers will be feasible.

#### XI. METHODS OF NATIONAL SYNDICATION

As has been suggested, the more widely distributed the individual television program, the more economic the operation. This would indicate that large-scale television-program producers will build up national syndication facilities of one sort or another. It cannot be stressed too strongly that quality of performances and economy of operation (in terms of program cost per member of the audience) depend considerably on national syndication).

The principal types of interconnection of cities (and theaters) for national syndication are by coaxial cable or by radio-relay systems. A coaxial cable is really a hollow conducting pipe with an insulated central conductor running through it. A radio-relay system is a series of "booster" stations each of which picks up the incoming signal, amplifies it in one way or another, and sends it along in strengthened form to the next "booster" station. This is a greatly oversimplified description in each case but sufficiently indicates the nature of the connection.

In each case cities not lying directly on the network will require side-line or "spur" feeders to carry the program to them. Sometimes this may be a rather costly procedure as, for example, in the far Northwest.

The economics of national syndication will depend, of course, upon

the number of cities (and theaters) served by each national theater-television network. If a sufficiently large number of theaters (and members of the audience) are served by a network, the cost per member of the audience may be quite reasonable.

Another factor in determining the practicability of a national theater-television network will be the number of hours per day that it may be in actual use. Once an elaborate cable or radio network is established, it is troublesome either to tear it down for other uses or even to switch it over to other uses from time to time. For reasons connected with good showmanship, such a network, in many instances, must be continuously in "readiness to serve". For this reason it probably will tax the showmanship and inventive ability of the television-program groups to keep national and even urban-syndication facilities in use to the desired extent.

If radio facilities are used for syndication, it will again be necessary to assign appropriate frequencies for their operation, such authorization coming from the Federal Communications Commission.

A number of other problems will arise in connection with national syndication. For one thing, there is a three-hour difference between Pacific Time and Eastern Time. It may prove necessary to divide the country into time zones and to utilize syndication primarily within one (or two adjacent) time zones. Alternatively, recorded programs may be repeated one, two, or three hours later as desired.

Although national syndication offers the best promise of markedly reducing the cost of television programs per member of the audience and therefore of improving theater-television program quality, it probably will be a delayed achievement because it is, after all, an extremely large-scale and costly operation involving substantial capital investment and operating costs.

## XII. FUTURE TRENDS IN THEATER TELEVISION

In the early days of theater television, the extreme novelty and mystery of such programs will attract the audience on a curiosity basis, if nothing else. It would be easy enough today to fill theaters, for a while, with audiences eager to see large-screen television of any reasonably acceptable technical quality, and almost irrespective of the nature of the program.

Yet it will not be long before theater audiences will come to regard television programs in the theater as just another sort of picture in motion, though not a motion picture. After all, the picture will

appear on the screen with its accompanying sound in much the same way as do the film presentations. When that day comes, television programs will be accepted mainly on their intrinsic quality. That is, the originality and dramatic or comic interest of the program will determine audience acceptability.

Accordingly, those who produce television programs for theater use must, through ingenuity and good showmanship, discover those things which television can do particularly rapidly, convincingly, with human appeal, and with convenience. Only in this way can television programs assume a position of importance beside motion picture material in the theater.

As previously stated, news and sports events, and happenings of major importance will afford certain program material. But personal and live-talent presentation of a special nature will possibly be of considerable interest. Television programs will always depend for their appeal, in part at least, on "immediacy" (also referred to as "instantaneity" or "simultaneity"). Television is particularly capable in the realm of permitting events to unfold, so to speak. That is, wherever the outcome is unknown and unknowable, television can present material of peculiarly appealing human interest. For this reason, it is likely that the techniques of theater television and of motion pictures in theaters will run along parallel rather than converging paths. And it is well that each should remain a different and distinctive type of theater entertainment.

It is certain that other, as yet undisclosed and amazingly attractive, technical and program possibilities exist in the theater-television field. The engineers and showmen of the future are indeed offered a major opportunity to develop a new and important art.

### XIII. PROPOSED PROCEDURE FOR EXHIBITORS

Exhibitors might naturally inquire what, at this time, would be a suitable procedure for them so that they may be prepared advantageously to enter the theater-television field and may take all such steps as shall make likely their success in that field.

The present owners of theaters will be well advised to insist that their group representatives study the field of theater television, through committees or otherwise, and report back to the theater owners. It would be well if the theater owners were periodically to receive bulletins or reports descriptive of the technical, commercial, and program status of theater television. Since the individual

theater owner will be unable to accumulate such information in his available time, the task should, as indicated, be delegated to exhibitor organizations.

Present theater owners would also do well to install television-broadcast receivers in their homes or in their private offices in the theater. They should systematically follow local television-broadcast programs so that they may see how that art is developing. Some of the television programs may be, in the exhibitor's opinion, "good theater", others may not. By becoming acquainted with television in this fashion, the theater owner will have a better idea of what can be accomplished with television and may develop his own thoughts and proposals as to future and desirable types of programs for theater television.

The exhibitor should also keep in touch with the technical societies, and notably the Society of Motion Picture Engineers, so that he may receive copies of any pertinent reports, or papers appearing in the *JOURNAL OF THE SMPE*. He should also follow the development of theater television in the trade press and should as well subscribe to the magazines dealing with television itself along broadcast lines. In this way he will know more about program structure, commercial problems, and the general development of television.

Even more concretely, the present exhibitor should study the possible television installations in his own theater. On the basis of the material in the present analysis, he should keep in touch with manufacturers of theater-television equipment and in due course, secure their advice and estimates on installation of suitable equipment whenever they have announced publicly the availability of such apparatus. This, however, may not be for several years. Before doing this, however, it would be well for the exhibitor to confer with a competent architect acquainted with theater design so that any installation problems may be analytically considered. Only in this fashion can the exhibitor know what he is doing and how to do it with least expenditure and with maximum results.

The exhibitor should also keep in close touch with those groups which plan to offer television programs in his vicinity. In this way he will know when such programs will be available and at approximately what cost. He will also be in a position to study the most efficient ways of introducing them into the motion picture program in his theater and will be prepared to devise a box-office schedule which will yield corresponding returns.

Persons who plan to enter the motion picture and television-theater field as owners should carry out a similar program to that just mentioned. They should affiliate themselves with well-informed groups who will render informational reports on the status and trends in theater television. In view of the complexities of theater design, and of recent important advances in that field, the prospective owner should be certain that his engineer and architect are alike well qualified. In this connection it must be stressed that the design of a theater for both motion pictures and television requires excellent engineering guidance both from the consulting engineer dealing with the theater owner and from the manufacturer of the equipment in question. Only with such information will the theater owner be likely to secure from his architect designs which will prove practical and economical in operation. In this connection it may be mentioned that, considering the possible rapid rate of the development of both motion pictures and television in theaters, the design of future theaters should be far more flexible than in the past. Time limitations forbid mentioning the various details that are here involved.

In summary, all exhibitors, present and future, should study, discuss, and understand television equipment, operations, programs, and economics. They should keep in touch with sources of dependable information in these fields and should endeavor to draw their own conclusions systematically as the art develops.

#### XIV. FUNCTIONS OF THE SMPE IN THEATER TELEVISION

The Society of Motion Picture Engineers, as the leading technical group in the world in the motion picture field, is under the obligation of studying theater television, of assisting in its development, and of disseminating useful technical and operating information to all who may be benefited by such data. The Society is interested in the video-audio arts, and theater television is an important addition to that group. Further, the utilization of film in theater television clearly brings it within the professional purview of the Society. It may be mentioned, as a fortunate and encouraging circumstance, that the relationships between the Society and The Institute of Radio Engineers, its sister organization, have been and remain cordial and co-operative. The Institute has been vigorously active in the development of basic television methods involved, as these are, in the communications and electronics field. In view of this, it is desirable, and to be expected that the Society of Motion Picture Engineers and The



Institute of Radio Engineers will closely co-operate from time to time in standardization problems and in all other matters which will be mutually beneficial.

Returning to the functions of the Society, it should arrange for the presentation before its membership and exhibitors of papers on theater television and, in fact, on the use of film or photographic methods in the television field. It should arrange for the preparation of appropriate recommended practices in the field of theater television, these later to become generally accepted standards. In such activities it should collaborate with its sister societies. It should at all times endeavor to raise the level of performance of television and film equipment utilized for public-exhibition purposes in theaters and should widely disseminate accumulated information in its fields.

It is also normal that the Society should represent the motion picture industry in its technical aspects, and in particular in relation to standards, channels, or facilities required for the syndication of theater-television programs, and all related matters. To that effect, it should secure industry opinion and thereafter represent that opinion before the Federal Communications Commission. It should continue its representation on the Radio Technical Planning Board and thus ensure a condition wherein the viewpoint and needs of the motion picture field are at all times clearly stated to the public, the professional world, and the government, and are clearly set forth in the publications or reports of the Society.

In conclusion, it is pleasant to pay tribute to the Society of Motion Picture Engineers. From its earliest days the Society has been interested in the video field and, later, in the video-audio field. It has made many and basic contributions to that field. The motion picture industry is greatly indebted to the Society for having laid the firm technical foundation on which that industry has grown to great achievement and enthusiastic public acceptance.

Whatever the Society has done in the past may be regarded as a promise of its like accomplishment in the future. Indeed, the Society has the encouraging prospect of remaining both a technical leader within the motion picture industry, and one of the major assets of that industry. It is hoped and anticipated that the Society will carry forward with equal success, in the field of theater television, the constructive activities which it has carried out in the sister art of the motion picture.

## DISCUSSION

CHAIRMAN D. E. HYNDMAN: I observe a number of representatives of film manufacturers in the audience, who will be very much interested in the commercialization of color television, either small or large, for a purely ulterior motive.

MR. W. H. OFFENHAUSER, JR.: To those of us who have seen radio grow, have seen sound films grow, and hope to see television grow in whatever form, history does repeat itself, and there was one portion of Dr. Goldsmith's talk that specifically brought this to mind. That was the little section about high-speed processing in the projection room.

As I remember, we discarded crystals in order to eliminate them and their uncertainties, and brought in vacuum tubes. As the art developed, we went into what we call plumbing, a little later on, and back to crystals.

It seems that when we look back over the history of motion pictures, we have done something quite similar there. In the very early stages of motion pictures, we had no developing machines and, accordingly, the processing laboratory or the studio stage was either in the studio or very close to it, merely because the number of square feet available in a studio of the early days was very small. However, we thought we made a tremendous advance when we took out the developing machine. Originally, we operated that by hand, and then we drove it with a motor, and we removed it far from the studio, relatively speaking, in terms of time. We now come along with a proposal quite like the crystal. We are going to put it back into the studio again.

DR. ALFRED N. GOLDSMITH: Mr. Offenhauser seems to be correct. The fact is that the radio field has gone through an extremely interesting cycle of historical repetition. Hertz was the earliest worker in the field, and he used microwaves. The microwaves were then decided to be useless for practical purposes, and much longer waves were used. We have recently gone back to the microwaves, and maybe, in a second cycle, we shall find longer waves useful again in new ways!

The fact is that history does, to some extent, repeat itself, and that one often does find new uses for old things. Thus, the high-speed local processing machine, of which some clever examples recently have been devised, has come back into its own; it has even been flying around and operating in an airplane.

MR. JAMES FINN: Do you suggest the feasibility of interpolating television clips into motion picture programs as presently constituted? I should think that that would take a great deal of chest-puffing on the part of an art that is already sorely pressed to revolve a 10<sup>1</sup>/<sub>2</sub>-hour program schedule daily for network stuff.

Programming today is one of the major problems in television. The technicians have far surpassed them. When the Federal Communications Commission issued its order for ten hours daily, there was great consternation. The television adherents now come and say, "We will not only put on television programs on a network scale for the swollen budgets of Lux, Rinso, and similar concerns—they being the only people with enough money to do the job—but we will give you supplementary lines to keep the motion picture theater in business."

This is quite apart from the structural facilities of existing theaters, which you as an outstanding engineer will agree offer some pretty severe problems for the installation of television equipment.

DR. GOLDSMITH: I should like to separate the answer to your question into

two parts. In the first place, I have not heard that the existing television broadcasters have any intention of providing programs for theaters. That is, when I spoke of transmitting programs to a theater, I meant transmission by the owners of the theater or by a special theater group. If the XYZ theater, for example, in Chicago wanted theater television, it would get it in all likelihood from central studios and central transmitters owned by the XYZ company, and not, as a contrary procedure, from television broadcasting Station WPQR. Only in the rarest instances if, for example, the President of the United States were speaking or some tragic disaster had just occurred, might the theaters pick up a broadcast program and show it in the theaters.

So that, as the second point, there would be no systematic correlation or interconnection so far as presently can be seen between television broadcasting, which goes to the homes of all, and theater television, which is a form of "narrowcasting", and is sent only to a specific group of theaters within the control of the corresponding company that owns the studio and transmitters.

MR. FINN: If it should be a delayed program by so much as an hour, then it is simply a delayed newsreel. What will be the difference whether we put it on film? Moreover, with feature pictures today running anywhere from 75 to 120 minutes, it is going to take close scheduling.

I am talking now about the interpolation of spot tele-events into the motion picture program as presently constituted. That is one.

Second, suppose that we do expand and assert ourselves and we make use of this new art. What is going to happen during a period of transition? Shall we break into the feature? What would the tele-industry have to offer to us in the nature of a feature attraction that we today cannot obtain better from film?

DR. GOLDSMITH: It is not thought that news events would necessarily come to the theaters with any delay. If an event were happening, let us say, in Washington or Detroit, it would be picked up by the television cameras, nationally syndicated, and sent to all theaters desiring to use it. So that there would be no delay so far as we now know. If the event in question happened to be, let us say, something like the Kentucky Derby, naturally, it would be scheduled at the time the Kentucky Derby took place.

So that, to answer your first question, I do not see any delay necessarily involved in theater presentation of news events, provided one knows when the news event is going to happen. When something happens that is unforeseen, the theaters may not be able to use it immediately, because they are momentarily in the midst of the presentation of something else. That is entirely conceivable. However, the news event may be so serious and important that they will nevertheless stop their regular performance and show it. Let us assume, for example, that some major disaster occurred in some great city of the United States, either by accident or by the design of others. If that disaster occurred, I believe there would be few theater exhibitors in this country that would not stop any usual performance to show such an event to the people, for one thing, for national reasons of interest.

The other point mentioned is this: What shall be done about interruptions to 75- to 120-minute feature films? How shall the exhibitor break in or interpolate? I believe that only the skilled exhibitors and program planners could answer such a question, or work out a suitable method.

However, it is thought that there is nothing sacred about performances having lengths of 75 to 125 minutes. So that it may well be that in the future there will be some feature films with intervening shorter films between them, thus offering a new type of program. Presumably someone will find the way to work out such procedures.

MR. FINN: If I had a very good television set in my home, why should I patronize the Gem Theater on the corner?

DR. GOLDSMITH: The programs which will be seen on television receivers in the home are not the programs the audience will see in the theater. In the home there generally will be seen commercially sponsored programs of a certain range and type of construction with which the public is slowly becoming familiar. They are excellent and appealing programs, but they are not the sort of program which will be found in the theater.

If, for example, a great star and the actor who plays opposite her or him were to appear in a "television trailer", as it may be called, preceding a feature film in the theaters, and to be seen only in the theaters (because it was transmitted on a nonpublic frequency), the home audience would know nothing of it. To see such a television-theater program, it is necessary to go to the theater and to pay the admission price. And it is entirely right and proper that that should be the case.

MR. MCKEE: We finance little exhibitors who build theaters, 600 seats. Their average business is 1200 to 1500 a week. Sixty per cent of all the theaters over the country have less than 500 seats. Of that 60 per cent, one half of them have less than 300 seats. There are only about 11 per cent over the country that have over 2000 seats. That is the motion picture.

We are ready now to build theaters. We are starting one out on Long Island within ten days. Television has us a little disturbed. A 600-seat house with land costs \$200,000 today, which is a large sum of money. Our banks are very much disturbed about television. So we studied television the last four or five years, and what it is going to cost us in the theater.

Today, 50 cents of every dollar taken in these small theaters goes for overhead, without the cost of the film. So we started to experiment with television. We find that the television machine is going to cost us about \$25,000. We find that we may have to pay a royalty per seat to the manufacturer of the television. We find that we have to pay for the show coming in. We have to pay for the show. We have to pay ASCAP. We don't know what Mr. Petrillo is going to ask.

So, on a 500-seat house, averaging a net of 50 cents, if we charge a dollar and fill that house right to the end, which would bring in \$500 to us, and if tried to amortize some of the equipment, the show would cost us about \$2000 for one night. That is the case in which we use a theater and we use television as a side line.

We have been talking it over with our architect. If we are going to go into television, we are going to reverse the situation. We are going to build a television theater, and we will run film as a side line, because if we follow all that you have said tonight, the cost of operating the theater, the cost of changing a theater, fixing the lights, possibly putting the projection machine back of the screen or putting it halfway down the aisle and eliminating some seats, and all the other things that have been said, it would be impossible to stay in business.

If we build a television theater in the cheapest form, it is going to cost \$150,000.

If we try to amortize that all the way through, we shall have to charge about \$3 admission, for a 500- or 600-seat house. We are trying to find out from where we are going to get the business. The only thing may be a prize fight at ten o'clock. If we put it in our regular theater, we shall have to change the entire audience before that, and then we have to charge double admission for prize fights.

There is no afternoon business. The average small theater over the country in the matinee business does not do \$8, or \$9, or \$10. In some of the big houses they do not even do \$50. If we are going to have any matinee business, what are we going to run in the theater when we use television? We cannot use baseball. Maybe we shall use home economics. We do not know; but if we are going to charge a dollar admission in the afternoon for women to come in and see how to cook or bake a pie, we are not going to get the money. We cannot even get them in there to see a good picture and charge thirty cents in the afternoon, for regular theater programs. If we are going to charge them for television and have most of the show in film and a little of it is going to be a live show, and have the costs coming in, we shall all go broke.

If you say we are going to have co-operative ideas and coaxial cable and a half-dozen things in which a group of exhibitors are going to combine together there and show, if you have had any experience with exhibitors you will know that it either ends up with just two running the business or it ceases to exist.

So we can see television only from one viewpoint, and that is a separate television show, and just try to get an RFC or an FHA loan on that.

DR. GOLDSMITH: Mr. McKee's points seem extremely well taken, and they emphasize two things: First, as I have pointed out, the television solution for the type of theater he is talking about may be a type of television equipment which is not now available, methods not yet discussed, and the like. The solution in each case depends largely on the sort of theater, and therefore the solution in each case may be different. It may well be that for the small theater, a large television program syndication group and more emphasis on television would be required.

The paper which I presented was addressed primarily to the larger theaters, where major and fundamental operations will remain on film, at least for quite a time into the future. However, the important point that I wish to stress in connection with Mr. McKee's remarks is that obviously there has been accomplished exactly what was desired; namely, to point out that the exhibitors themselves have to tackle this problem and solve it. The engineers cannot give showmen the answers. If the exhibitors tell the engineers what they want and can afford to pay for, and how they want to use it, the engineers will find the answer or tell the exhibitors that they cannot. They will probably find the answer; they usually have.

However, the one thing that was particularly desired was to stimulate people into thinking out the answers to the showmanship problems. This audience certainly is indebted to Mr. McKee for what he has said in that connection, because he is clearly thinking his way through the problem; and if others will do the same, we may be confident that it is going to be solved.

# New Developments in Mercury Lamps for Studio Lighting\*

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*Summary*—Development work on mercury lamps in England progressed at an accelerated rate during the past eight years in connection with war projects. The result of this work has been new types of such lamps in which the source shape has been modified, the source brightness increased, and the color quality improved so much as to suggest important advantages for motion picture and television studio lighting if economic factors permit their use.

In this paper the author summarizes and analyzes data made available to him from research laboratories in England.

THIS IS A report and an appraisal of the results of extensive development work in England on mercury sources undertaken first for military purposes and subsequently continued with a view to motion picture and television studio lighting. The primary objective was to overcome the defects of previously available mercury sources.

Light sources and lighting have always been subjects of major importance to the motion picture and television industries. While mercury lamps of the forms and characteristics heretofore available have not been acceptable for use in the modern motion picture studio, certain inherent features of such sources have long been recognized as desirable attributes in these lighting fields. These have included:

1. Relatively high efficiency in conversion of electrical energy into light.
2. Relatively low heat radiation.
3. Long life.
4. Silent operation.
5. Cleanliness.

Their usefulness in these particular lighting fields has been limited for the following reasons:

1. The shape and dimensions of the source did not lend themselves to effective use in appropriate types of lighting equipment.

\* Presented September 30, 1947, at a meeting of the Pacific Coast Section of the Society of Motion Picture Engineers in Hollywood.

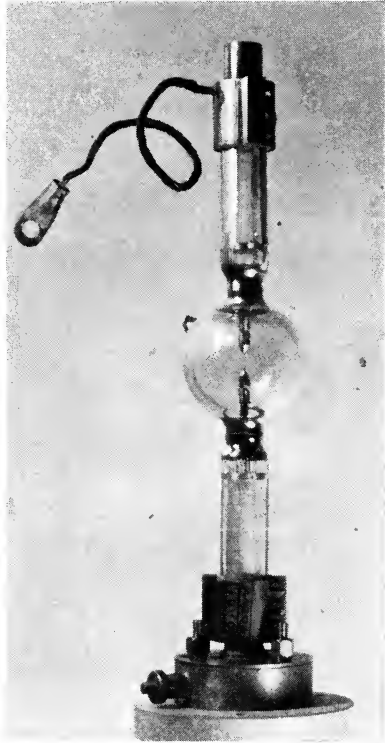
2. The starting and operating voltages exceeded the voltages generally available in the studios and the lamps were not designed for operation on direct current.

3. The "warm-up" time of a cold lamp and the restarting time of a hot lamp were excessive.

4. The maximum wattage was limited to a value, entirely too low to serve many of the lighting needs of the motion picture studio.

5. The color quality of the light produced was not suited to color photography and, in fact, was not so good as desired for black-and-white photography.

We, in America, are indebted to the British lamp manufacturers for the tremendous strides which have been made toward the solution of these difficulties. Development work on such sources in England proceeded at an accelerated pace during the war in connection with projects sponsored by the British Admiralty while the development facilities of American manufacturers were assigned to other projects. Data included in this paper have been supplied by the British-Thomson-Houston Co., Ltd., and more particularly by H. K. Bourne, MSc., M.I.E.E., F.R.P.S., of the Research Laboratory of that company.



*Photo Courtesy of British-Thomson-Houston Co., Ltd.*

Fig. 1—Developmental 10,000-watt "compact-source" mercury lamp and holder.

#### DESCRIPTION OF BRITISH LAMPS

The new type of mercury lamp, Fig. 1, is conspicuously different in appearance from the types previously available. The lamp consists of a quartz bulb, approximately spherical in shape, containing near

its center two relatively massive tungsten electrodes with dome or chisel-shaped ends. These electrodes are spaced from a few to perhaps 10 millimeters apart. Thus, instead of the familiar long slender source characteristics of mercury lamps in general, the new design results in a source of light which is approximately spherical in shape. The advantages of this form are apparent not only in the types of equipment used for motion picture and television studio lighting but for projection purposes<sup>1-3</sup> as well.

Such lamps have been made in various ratings between 100 and 20,000 watts although in some ratings the lamps are still in a developmental form.

A single-ended construction has also been developed, Fig. 2.

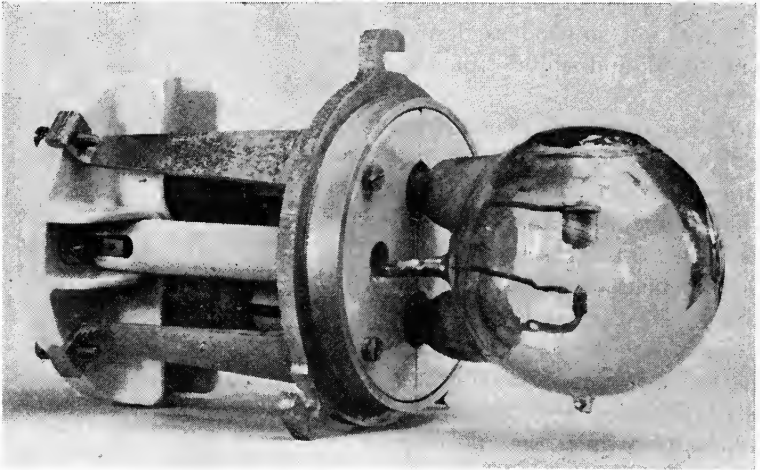


Photo Courtesy of British-Thomson-Houston Co., Ltd.  
Fig. 2—Single-ended construction of "compact-source" lamp.

#### SOURCE BRIGHTNESS

It is a well-known fact that high source brightness is a prerequisite of virtually all light sources used for studio lighting; only thus can the requisite optical control of sufficient amounts of light be achieved. It is quite proper, therefore, to examine the British development from this standpoint first of all. There are two general methods available for obtaining high source brightness. The first of these is exemplified by the water-cooled mercury lamp<sup>4, 5</sup> of the H-6 type available in this country since 1938. This type of lamp, consuming 1000 watts, has a source length of approximately 1 inch (2.5 centimeters) and has a



maximum brightness of 30,000 candle power per square centimeter. Destruction of the quartz at the high loading of the small quartz tube is prevented by the cooling effect of a stream of water flowing rapidly over the surface. The high light output of 65,000 lumens from this 1000-watt lamp and the small amount of heat radiation are important advantages, but as the source is long and very narrow, special optical

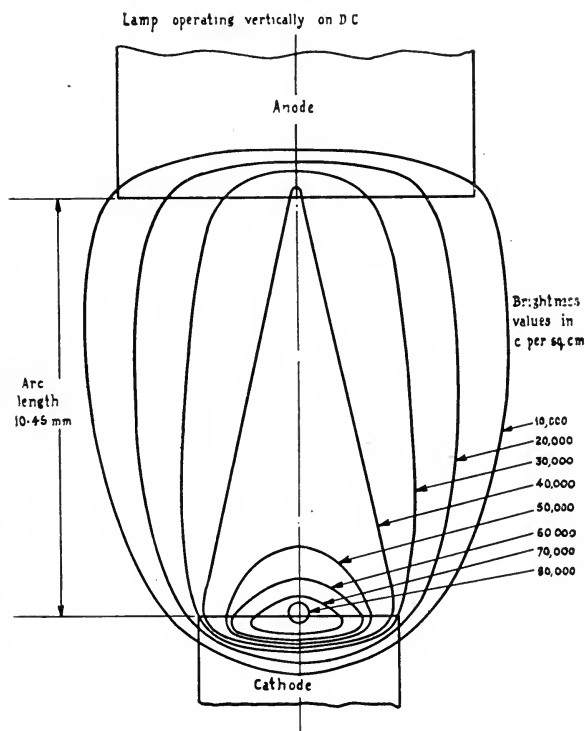


Fig. 3—Brightness distribution in the arc of a 5000-watt "compact-source" lamp.

systems are generally required for efficient light collection. Again, for many applications the relatively short life and the necessity for using water cooling detracts from the other good features of this source.

The second method of increasing the brightness of the mercury-vapor source has been developed very fully in Great Britain by several lamp manufacturers. In such lamps, generally known in England as "compact-source" lamps, the high brightness is a result of the reduced electrode spacing previously described. At the same time, the quartz

bulb is designed with a surface area sufficiently great to prevent overheating, but small enough to ensure a relatively high operating pressure. No forced cooling is required as natural convection cooling and surface area limit the temperature of the surface of the bulb. The high concentration of energy in the arc column results in maximum brightness values of approximately 100,000 candle power per square centimeter. Developmental lamps are reported to have given values which are higher than those attained in the high-intensity carbon arcs.<sup>6</sup> Fig. 3 shows the brightness distribution for a 5000-watt lamp of this type.

#### LUMINOUS EFFICIENCY AND LIFE

The luminous efficiency of the "compact-source" lamp depends on the lamp wattage but is normally between 45 and 55 lumens per watt. The light output falls gradually to about 75 per cent of its initial value at the end of life, owing to blackening of the bulb. The average life of 250-, 500-, and 1000-watt lamps in service is generally about 500 hours.

#### ELECTRICAL CHARACTERISTICS

The arc of the "compact-source" lamp will strike immediately when a potential of more than 200 volts alternating current or 275 volts direct current is applied to the terminals. More important, however, it may also be established at lower voltages (115 volts, for example) if ionized by either a Tesla coil or a momentary high-voltage impulse. Like all arcs, however, the electrodes would be destroyed if this voltage were maintained at the electrodes once the arc is established. Therefore, a ballasting impedance (if the supply is alternating current) or a ballasting resistance must be used in series with the arc to limit the lamp current. Since a resistance ballast must be used on the direct-current systems available in motion picture studios the over-all power requirements of such operation are indicated in Table I.

TABLE I  
TOTAL POWER CONSUMPTION OF "COMPACT-SOURCE" MERCURY LAMPS ON  
DIRECT-CURRENT SUPPLIES

Lamp watts	250	500	1000	2500	5000	10,000	20,000
Lamp current, amperes	4	8	15	37	75	150	150
115-volt direct-current supply ballast resistance, ohms	11.2	5.6	3	1.2	0.6	0.3	.....
Total watts	460	920	1720	4250	8620	17,200	.....
230-volt direct-current supply ballast resistance, ohms	40	20	10.7	4.3	2.15	1.06	0.63
Total watts	920	1840	3440	8500	17,240	34,400	34,400

## WARM-UP AND RESTART TIME

The "compact-source" mercury lamps are subject to the same criticism of slow start and restart time that applies to almost all other mercury sources. The time required to reach full output and proper color after being first turned on is of the order of 5 to 10 minutes, Fig. 4. Similarly if the electrical supply is interrupted when the lamp

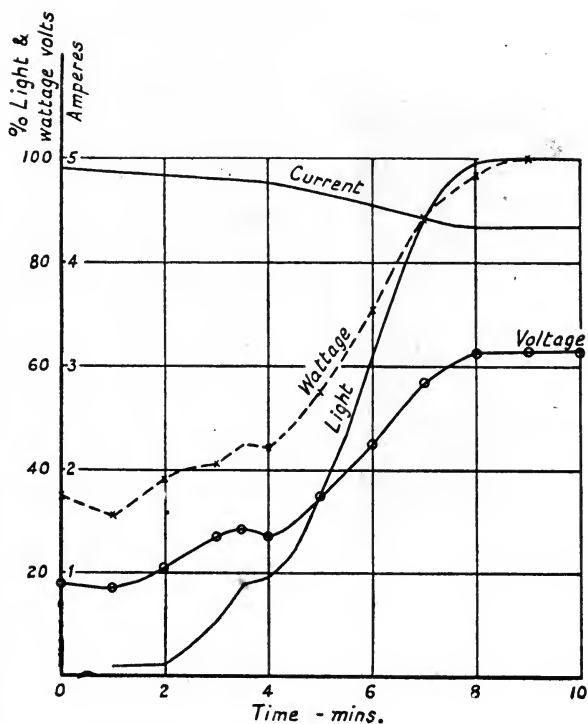


Fig. 4—Warm-up characteristics of a low-wattage mercury lamp. Higher-wattage types require substantially the same warm-up time.

is operating it will not restart normally for perhaps 5 to 15 minutes, after which the warm-up cycle may be repeated.

In some applications where the lamp is in continuous operation these delay times are not important but there are other cases where such delays represent a serious disadvantage. For example, in motion picture studio illumination it is often difficult to forecast the

exact number of lamps which will be required as the cameraman often calls for additional units to be switched on at short notice, and delays of some minutes obviously cannot be tolerated. It has therefore been necessary to devise practical methods of avoiding this difficulty.

There are two ways by which the delay time can be minimized or avoided.<sup>7</sup> In the first of these the lamp may be warmed up some time before the light will be required. The current in it is then reduced to 10 to 15 per cent of its full load value and a lagged cover is placed around the bulb both to obscure the light and to conserve the heat in

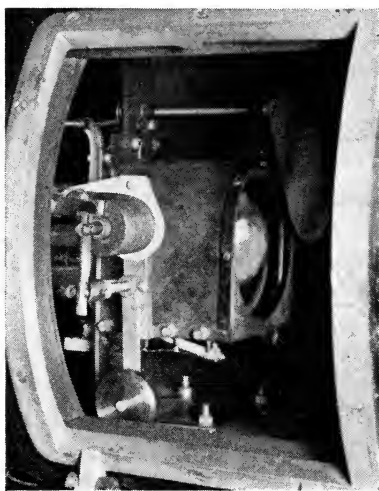


Photo Courtesy of British-Thomson-Houston Co., Ltd.

Fig. 5—Developmental assembly of mercury lamp in "simmering" housing to conserve heat for quick restart at full output.

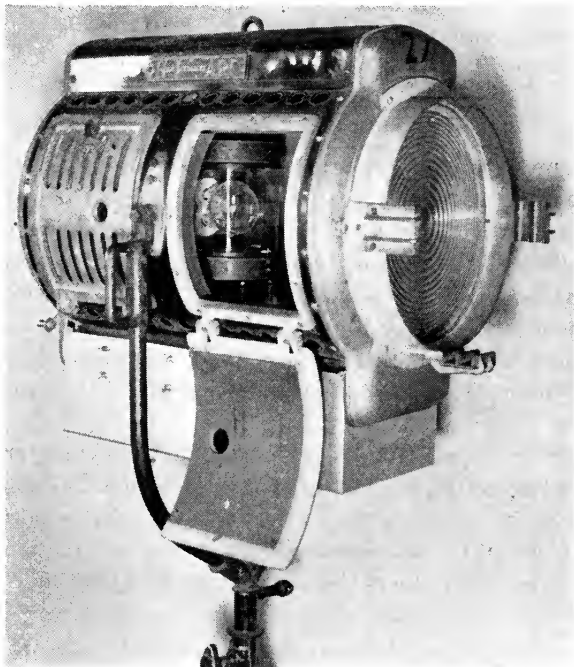
the lamp, Fig. 5. With this cover in place, the "simmering" current is sufficient to maintain complete vaporization of the mercury and full light output may be obtained instantaneously by opening the cover and simultaneously increasing the current to its normal value. The life of the lamp is reported to be scarcely affected by simmering as at the low simmering wattage apparently no deterioration of the lamp takes place. The current is reduced to the simmering value by inserting an additional resistance in series with the lamp. This resistor may be located inside the simmering cover so that the additional heat dissipation from it helps to maintain the tempera-

ture of the bulb and so improves the over-all efficiency of operation.

In the second method, the lamp is mounted inside a glass-walled oven, Fig. 6, which is maintained by heaters at a temperature sufficient to vaporize the mercury in the lamp completely. The arc may be ignited instantaneously by applying a high-voltage impulse either across the main electrodes in the lamp or between an auxiliary electrode and the adjacent cathode. In the latter case a momentary voltage of around 15 kilovolts is generally sufficient to insure reliable reignition of the arc. Without the auxiliary electrode an ionizing

potential of 30 to 50 kilovolts will be necessary. Full light output can be obtained whenever it is required and even if the supply is interrupted or has been switched off inadvertently, the arc can be reignited immediately.

If desired these two methods may be combined by using the high-voltage impulse method of arc reignition with a lamp which has been



*Photo Courtesy of British-Thomson-Houston Co., Ltd.*

Fig. 6—Developmental housing for mercury lamp to pre-heat lamp for quick start by ionizing pulse.

simmering to cater for the condition where a simmering lamp has been extinguished and from which light is again required immediately. By applying these methods the light from a "compact-source" lamp may be obtained virtually instantaneously whenever it is needed. The only remaining delay is the initial period of 10 to 15 minutes needed for a cold lamp to warm up in the first instance. If all the lamps likely to be required are warmed up initially then delay times become of no practical importance.

### STROBOSCOPIC EFFECT

When mercury lamps are operated on alternating current the light output varies in proportion to the cyclic variations of the current.<sup>4</sup> Therefore, if such lamps are used for motion picture photography or projection, the frequency of the alternating current must be some multiple of the frame frequency, or direct current must be employed. Since the same problem exists with carbon arcs and since direct current is already available for such sources the latter procedure is the more convenient.

### STABILITY OF OPERATION

A photographic light source must operate steadily and produce a constant light output and these conditions appear to be fulfilled admirably by the "compact-source" lamp. Reasonable fluctuations in supply voltage produce only comparatively small changes in the characteristics of "compact-source" lamps. Such variations have no appreciable effect on lamp life or on the color of the radiation while the considerable effect of supply-voltage variation on both these characteristics in the case of an incandescent filament lamp is only too well known.

The effect of supply-voltage variation on the characteristics of a 250-watt "compact-source" lamp operating from a 230-volt supply is shown in Fig. 7. In the case of a 5-kilowatt mercury-cadmium lamp operating from a 115-volt direct-current supply a reduction in supply voltage of 1 per cent reduces the light output by 3 per cent.

### OPERATING POSITION

In a "compact-source" lamp a stream of hot vapor, generally known as the "arc flame", rises above the arc because of the action of convection currents in the bulb. When the lamp is operated with the arc vertical, this arc flame is dispersed by the upper electrode and is thereby prevented from playing on the quartz bulb. If the lamp is tilted, however, the flame will impinge on the quartz and will cause overheating which may lead to premature failure of the lamp. This arc flame consists of ionized vapor and may therefore be deflected by a magnetic field. It is thus necessary to employ a magnetic deflector with "compact-source" lamps to prevent the arc flame from playing on the quartz when the lamps are tilted out of the vertical position. A mechanism has been developed for studio spot-

lights which brings the magnetic field into play automatically as soon as the lamp is tilted so that operation at any angle may be achieved.

### SAFETY

Very little actual experience is available at this time to permit authoritative statements on the subject of safety. However, certain general observations are possible and should be mentioned here.

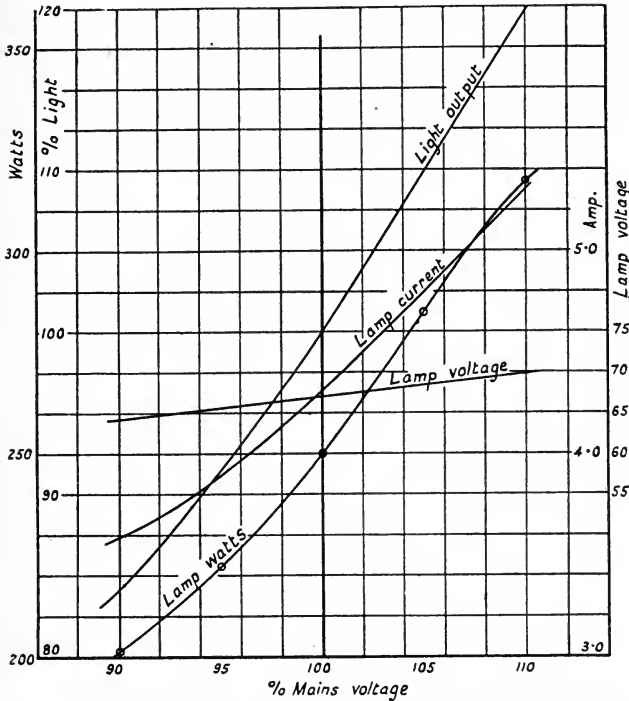


Fig. 7—Effect of variations in supply voltage on a typical mercury lamp on resistance ballast.

Mercury lamps emit radiations in that portion of the ultraviolet spectrum which can cause sunburn or conjunctivitis. These radiations are absorbed and rendered harmless by the outer bulb which is used with most such sources. Since such an outer envelope is not used with the mercury lamps described here it follows that they must be enclosed in housing providing the same degree of protection that prevails for carbon arcs.

It would also seem that the use of a protective housing serves a second important purpose. Very little is known at this time of the mechanical strength of the quartz bulb used. We do know, however, that the internal pressure of the mercury vapor within the bulb is high when the lamp is at normal operating pressure and that, therefore, the hazards of bulb failure must be considered.

### COLOR QUALITY

Unlike tungsten-filament lamps or carbon arcs, the light from a mercury lamp is emitted at specific wavelengths in the spectrum, and these wavelengths are always present whenever mercury is used. The unfortunate difficulty with mercury arcs has been that these radiations do not occur at the proper wavelengths and in the proper

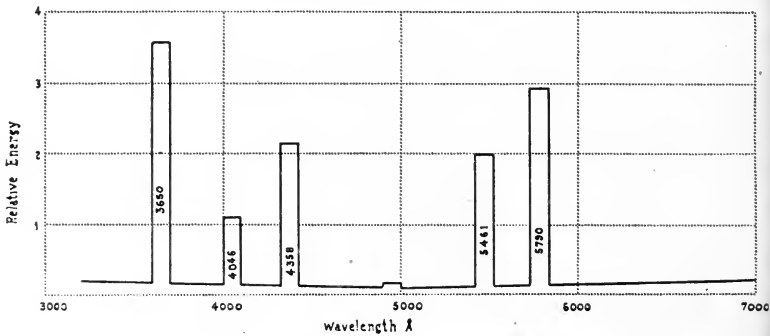


Fig. 8—Spectral distribution of radiation from a 5000-watt "compact-source" mercury lamp.

relative amounts to produce good color rendering when used to expose color film. A serious deficiency in the red region of the spectrum has been particularly apparent.

Some improvement in color quality is achieved by the same two methods that produce high source brightness. In such cases, the radiation comes from wavelength *bands* of appreciable width and centering at the specific wavelengths characteristic of mercury and, even more important, these radiations are supplemented by a lower intensity radiation with a continuous spectrum, including the red region, Fig. 8. This improvement, however, is still insufficient to satisfy the requirements of any color film.

Certain other metallic vapors have been added to mercury to increase red radiation and to fill in the gap in the mercury spectrum in



the blue-green region (about 5000 angstroms). The number of metals available for this purpose is, however, limited for several reasons. The most satisfactory results were obtained several years ago, both here and abroad, by the introduction of cadmium and/or zinc which produce not only a generous amount of red radiation but also radiation in the blue-green region. However, at that time the developments did not appear promising due to the fact that there was some loss in luminous efficiency.

Recent studies by the British lamp manufacturers now indicate that, when cadmium is introduced in the "compact-source" types of 1000 watts or more, not only is there considerable improvement in

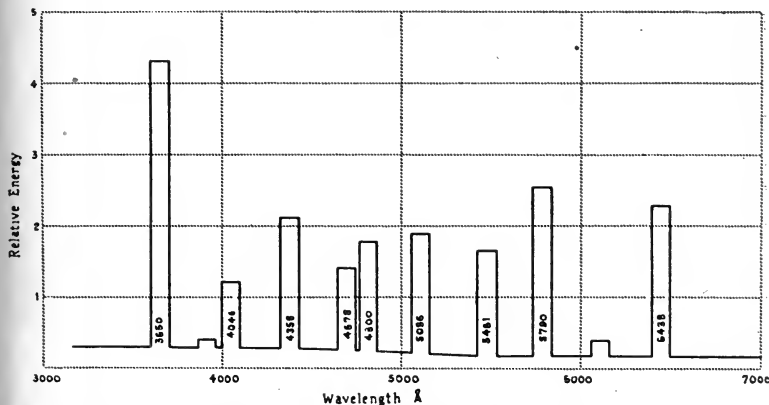


Fig. 9—Spectral distribution of radiation after cadmium has been added to the mercury lamp of Fig. 4.

color but that it is achieved at a loss in efficiency of only about 5 per cent. A comparison of Figs. 8 and 9 indicates the important magnitude of the improvement. Tests described later indicate that the color quality of the light from high-power mercury-cadmium lamps is suitable for use in connection with modern processes of color photography.

#### PHOTOGRAPHIC PROPERTIES

Light sources used for photographic purposes must also be judged in terms of their photographic "speed" and the faithfulness with which they and the film can record the visible colors either on a gray scale with the proper luminosities or in color. Some such tests have been

made in England but they are not sufficiently complete to provide a basis for a conclusive statement.

Mercury lamps without cadmium have been used to expose a variety of photographic materials ranging from panchromatic film to bromide paper, and increases in "speed" relative to an equal amount of tungsten-filament illumination were found which ranged from 10 to 690 per cent, respectively. When compared on the basis of equal over-all watts on alternating current, gains in speed ranging from more than two times to about 14 times are reported. This agrees with our own experience in testing other types of mercury lamps.

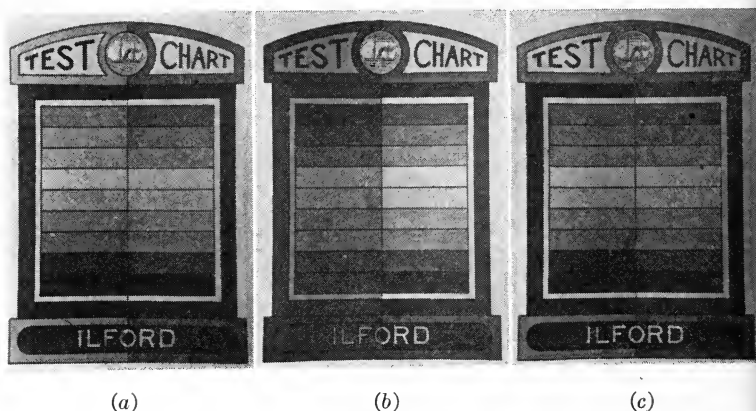


Fig. 10—Ilford color charts photographed on panchromatic film when illuminated by (a) tungsten filament lamps, (b) mercury lamps, and (c) mercury-cadmium lamps. The left-hand side of the charts include colors of the spectrum ranging from red at the top to violet at the bottom. The right-hand side consists of neutral panels in shades to match the visual luminosity of the adjacent color.

Color rendering also agrees with our own observations. Mercury produces excessive exposure on panchromatic film in the blue and violet portions of the spectrum and insufficient exposure in the red. The reverse condition is, of course, observed with tungsten-filament sources. On the other hand, the same type of test using a mercury-cadmium "compact-source" lamp shows a much more favorable balance of grays in terms of luminosity, Fig. 10.

Photographs of color charts illuminated with 5-kilowatt mercury-cadmium "compact-source" lamps have also been made in Technicolor and other color photographic processes and some excellent results have been obtained. Practical tests show that there is little

difference between the color rendering given by these lamps and by either the high-intensity carbon arcs or properly filtered tungsten now being used to expose Technicolor film. Again with Kodachrome, Dufay-color, and Ansco Color, the color reproduction appears to be good. These remarks must not, however, be taken to mean that this is the official view of the various color-film manufacturers.

#### APPLICATIONS IN MOTION PICTURES AND TELEVISION

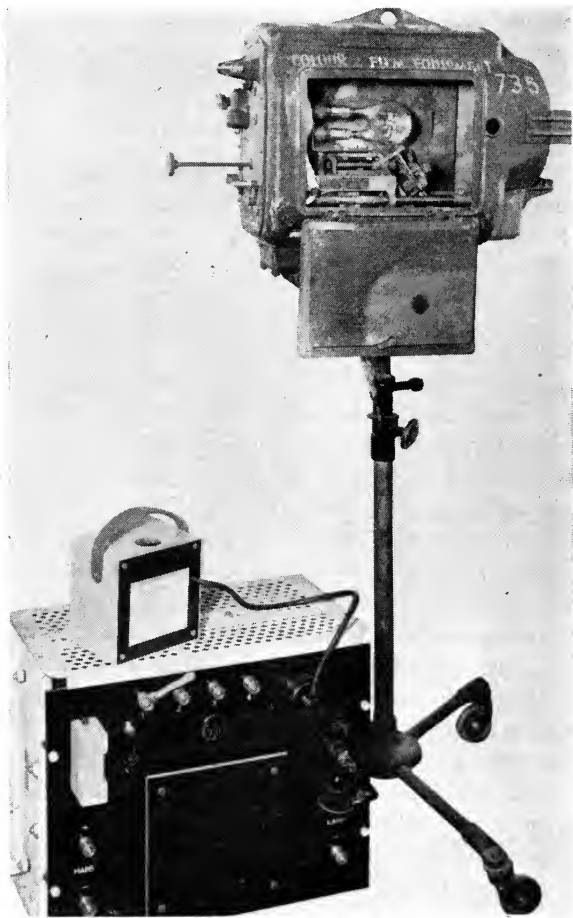
Engineers in the field of motion pictures and television can readily point to many applications for sources having the characteristics described. It may be of interest to know something of the uses for which these sources have been tried in England. H. K. Bourne reports:

##### *“Studio Lighting*

“The first experiments with the studio compact-source lamp were made by F. V. Hauser, Messrs. Technicolor, and the writer at Denham and Pinewood Studios in 1945, on which occasion photographs of color charts were taken in Technicolor using a 5-kilowatt compact-source mercury-cadmium lamp in a converted MR.65 spotlight housing.<sup>7</sup> The comparison with high-intensity carbon-arc illumination was so good that tests on a larger scale were organized. These were made in November, 1945, when some small sets were illuminated alternately with seven spotlights fitted with these lamps and with a similar number of MR.65 high-intensity arcs. Short films were taken in Technicolor under the two forms of illumination and it was difficult to differentiate between them. The color reproduction was regarded as being very satisfactory by the film studio engineers. These experimental films were shown at the Illuminating Engineering Society's Convention in London in May, 1946, to a large audience among whom they aroused considerable interest and surprise.

“Since that time further tests have been made and the lamps have been used with complete success in the black-and-white film production, ‘The Crowthers of Bankdam,’ by Archibald Nettlefold Studios. The first experimental unit to be used in a studio was a converted MR.65 spotlight fitted with a 5-kilowatt mercury-cadmium lamp illustrated in Fig. 11. In subsequent tests MR.90 housings fitted with an oven for maintaining the lamp temperature and an auxiliary circuit to provide instantaneous arc reignition were used. (See Fig. 6.) A housing in which the lamp is mounted inside a simmering cover which

opens automatically as the current is raised to its full value is illustrated in Fig. 5. In this photograph the simmering cover is shown in



*Photo Courtesy of British-Thomson-Houston Co., Ltd.*

Fig. 11—Development 5-kilowatt "compact-source" lamp in converted fresnel-lens spot.

the open position. The magnetic deflector is also visible on the side of the simmering oven. While experiments made so far have been carried out chiefly with spotlights, the lamps are equally well adapted for application to 'broads' and units of this type are also being built

and tested. The lamps have created a most favorable impression among the studio engineers who welcome the stability of operation, the complete absence of noise and smoke, the lack of attention, and the reduced heating effect. A comparatively large number of units is shortly to be installed at Pinewood Studios for use in forthcoming film productions.

"The compact-source lamp has also proved to be most effective for television studio lighting. These lamps have already been used by the British Broadcasting Corporation at Alexandra Palace television station where they were first employed for lighting a feature program entitled 'Picture Page' in August, 1946. The advantages of the lamp for television lighting are the considerable reduction in heating, particularly as compared with incandescent filament lamps, an improvement in picture quality due to absence of "mush" owing to reduced infrared radiation, and a spectral-radiation distribution, which, in combination with the sensitivity curve of the television camera, gives an excellent color rendering in monochrome.

#### *Film Printing*

"Another important application of compact-source lamps is in film-printing machines. Recently some new fine-grain emulsions with a relatively low sensitivity have been introduced and it has been necessary to reduce the speed of the printing machine to secure an adequate exposure. The high brightness of the source and the high actinic value of the radiation from the compact-source lamp enable a considerable gain in printing speed to be realized. A disadvantage is that the light output cannot be controlled over a wide range by variation of lamp current so that these lamps are normally only fitted to machines having aperture control. A 250-watt lamp, which has been used very successfully in Great Britain for film printing, has enabled printing speeds to be maintained or even increased in spite of slower emulsions. As in the case of both studio illumination and in film projection, direct-current operation is essential in order to avoid the stroboscopic effect which would cause variations in exposure if the lamp were operated from an alternating-current supply."

#### CONCLUSIONS

It is difficult to speculate as to the future possibilities of "compact-source" lamps, but it seems inevitable that they will play a prominent part in the motion picture and television industries in the years to

come. It would appear that all of the major technical difficulties which have restricted the use of mercury-vapor lamps in studios have either been overcome or means are now available for doing so.

Of course this new development brings with it new problems. For example, everything at this time indicates a much higher unit cost of light source than has been previously considered by the studios. On the other hand, the relatively long life which seems possible, the high output per source, and the simplicity of operation may still result in advantages, economic and otherwise, which will compare favorably with other illuminants.

It is expected that intensive development work now in progress here and with which the author is associated, will provide an early opportunity for a comprehensive study in American studios. It must be understood, however, that the results reported here apply to lamps made largely by hand by skilled quartz workers. In order to make such lamps economically practicable here, designs adapted at least in part to production methods are indicated. It therefore follows that such lamps may bear little resemblance to the types illustrated in this report.

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# Acoustical Factors in the Design of Motion Picture Equipment\*

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*Summary*—No simple solution for the reduction of mechanical noise of motion picture equipment can be expected. Acoustic designing depends on fundamental analysis of the phenomena which cause the undesired disturbance. The psychology of hearing points out the importance of lowering the frequencies. The importance of measuring the spectrum of the noise is emphasized in order to find a clue to the treatment. A distinction is made between sound-energy sources and sound-radiating sources. A discussion of these and the coupling between them is made. Reduction of noise comes about by means of (1) lessening the force from the energy source, (2) reducing coupling, (3) increasing the mechanical impedance, and (4) lowering the radiation impedance. Reducing the coupling appears to have the best potentialities. A brief discussion is also made of measuring techniques.

## I. INTRODUCTION

SEVERAL REQUESTS for information on the silencing of motion picture equipment have come to the Armour Research Foundation. The literature on the subject is very meager. For instance, not a single paper on this subject has been presented before the Society of Motion Picture Engineers. Very little work has been done at the Armour Research Foundation on this particular kind of equipment, but the previous experience of this organization in quieting other devices has led to a general formularization of a method of attacking these problems which may be of interest.

One general conclusion has been obtained from the queries of the engineers which are confronted with these problems. The experimenter is generally not at a loss in getting answers once the problem is understood; the chief difficulty has been in not knowing what questions to ask. The purpose of this paper will be, therefore, to discuss the psychological and physical factors of acoustical design with particular application to motion picture equipment. It will become apparent that acoustical design is not a matter for hasty improvization after the complete mechanical layout is finished, nor is there any

\* Presented October 22, 1947, at the SMPE Convention in New York.

general cure-all which will reduce the noise. Consistent progress can best be obtained by fundamental analysis of the phenomena which cause the disturbance and by keeping these factors in mind throughout the design stage.

## II. PSYCHOLOGICAL FACTORS

Of importance to the acoustical designer of any device is some fundamental knowledge of the psychology of hearing. Fig. 1 shows the Fletcher-Munson curves<sup>1</sup> for the loudness contours of the human

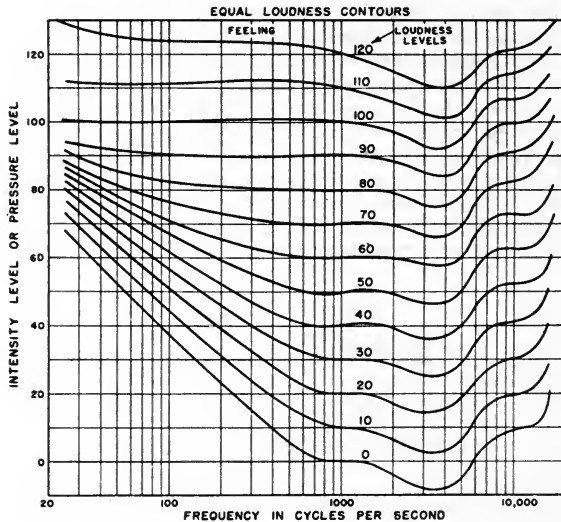


Fig. 1—Loudness contours of the human ear. Sound can be reduced in loudness by either lowering the intensity or the frequency.

ear. For reference, conversational level is about 70 decibels between 100 and 5000 cycles per second, and the average noise level of a home motion picture projector is about 50 decibels. Notice that the curves are crowded at lower frequencies and lower intensities. In this region the loudness can be reduced either by lessening the intensity or lowering the frequency.

In addition to the fact that the lower frequencies are less loud is the fact that they are less annoying. Data taken at Harvard University<sup>2</sup> show that the higher frequencies (10,000 cycles per second) are more annoying by 10 decibels than the lowest frequencies, the



curve rising more rapidly above 1000 cycles per second, which emphasizes the importance of lowering the frequency.

A very important consideration is the effect of the background noise in masking the sound of the device. It is necessary to know the noise background to be expected in order to know the design goal which is desired. Fig. 2 gives the results of measurements by Bell Telephone Laboratories of the noise in the average home.<sup>3</sup> The average level is 43 decibels, and about the same level exists in the average motion picture theater.<sup>4</sup> The noise per cycle is given in

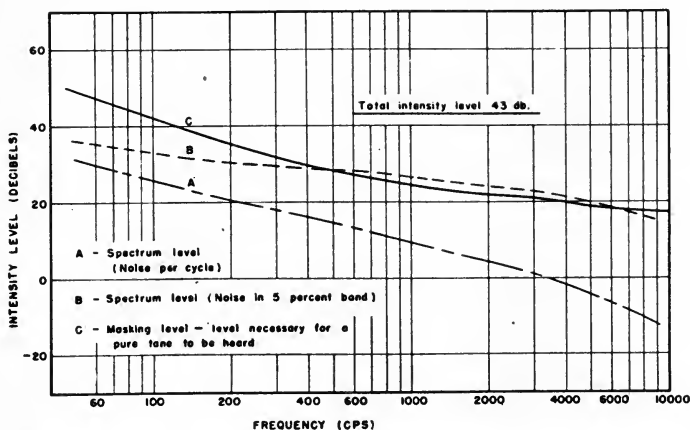


Fig. 2—Bell Telephone curves of the noise in the average home. The noise per cycle is given in curve A; curve B is the noise spectrum as measured on a meter having 5 per cent bandwidth. Curve C is the level of pure tone necessary to be heard against this background spectrum.

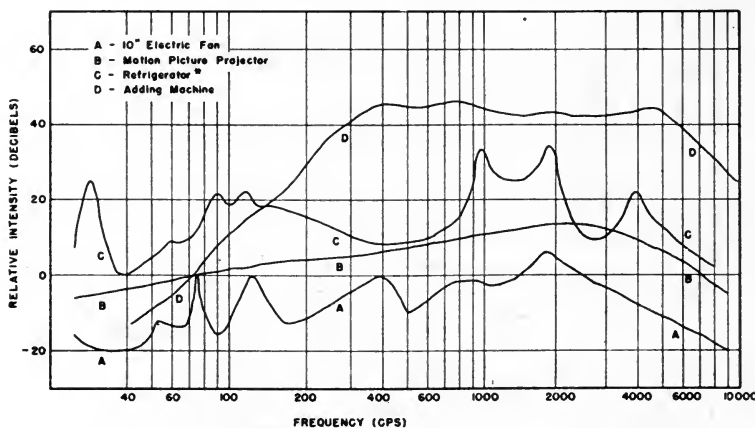
curve A. Curve B is the noise as it would be received on an instrument which has a bandwidth of 5 per cent of the center frequency, the effective bandwidth of the average sound analyzer. Curve C is the level of pure tone necessary to be heard against the background noise of the home. The fact that high frequencies are more noticeable against the background noise is another reason for eliminating them.

To summarize: Low-frequency noise sources are less objectionable than high frequencies because (1) the sounds are less loud, (2) they are less annoying, and (3) they are more likely to be masked by the ambient noise. Of interest, therefore, is the noise spectrum of a typical home motion picture projector, which is shown in Fig. 3, along with comparative spectra of other devices. It will be noticed that

the over-all output of the projector has a rising frequency characteristic with a peak at about 3000 cycles. This type of spectrum is particularly undesirable in that it is practically ideal for masking speech or music, and is quite noticeable in the quiet passages of reproduced sound. Considerable improvement, more than would appear from intensity measurements, would be obtained by materially reducing the noise radiated above 300 cycles per second.

### III. PHYSICAL FACTORS

In determining the physical factors which influence noise production, a distinction should be made between energy sources and radia-



\* From General Radio Co. Bulletin 30 - June, 1937

Fig. 3—Spectra of some common industrial products. Of special interest is curve *B*, the motion picture projector. The high-frequency components in the noise are particularly undesirable.

tion sources. As an example, consider the production of sound by a violin, which has more analogies to a movie projector than would be supposed. The sound radiated from the strings of a violin is extremely small compared to that radiated from the body of the violin although the amplitude of the latter is very small compared to the violin string. In this case, the action of the bow on the string is the source of energy, the string is a secondary source which is coupled finally by the string supports to the body of the violin which is the radiating surface. The resonant internal cavity of the violin is another secondary source which is coupled to other parts of the system and to the air through the *f* holes. These openings are also radiating sources.

In a movie projector the gear noise cannot be radiated very efficiently from the gear teeth, whose contact provides the energy source. The vibration is coupled to other parts of the projector through the bearings and other mechanical links. The larger areas provide the radiating sources. Air cavities become other secondary sources which emit sound through the various openings in the instrument. Air-cavity sources are particularly important in the fan and motor radiation.

The elements of the system can be generalized to be somewhat as in Fig. 4. Attention should be drawn particularly to the coupling between the various elements.

The problem is how to reduce the amount of sound radiated. It is first necessary to discover the actual sound-radiating sources and their coupling to the energy sources. For identification of the locality of the radiation source, the stethoscope is a very useful instrument. In

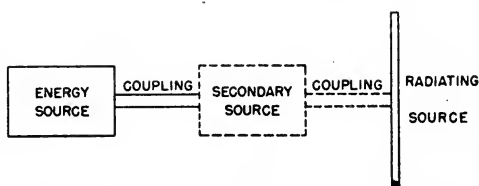


Fig. 4—Elements in an acoustic radiating system. The sound can be reduced in any of the elements. Of particular interest in motion picture equipment is the coupling.

a particular projector, the following were found to be the most noticeable radiating sources: the gear-lens-housing assembly, the openings in the motor housing, the openings in the fan housing, and some parts of the over-all housing. Of particular interest is the radiation from the table on which the projector sat. This radiation was rather large unless felt or soft rubber pads isolated the projector.

There are just four general methods by which the sound can be reduced:

1. Lessen the force from the sound-energy source.
2. Reduce the coupling to secondary sources and finally to the radiation source.
3. Increase the mechanical impedance of the vibrating parts.
4. Decrease the radiation resistance of the radiating source.

The mechanical impedance and radiation resistance will be defined

below. Items 1, 2, and 3 above control the amplitude of the radiating source. The efficiency of the coupling to the air is controlled by 4. It is believed that not all of these factors are considered in the usual survey of the problem. For instance, a gear-noise problem which cannot be solved at the energy source, where a great amount of attention is usually placed, can possibly be alleviated by consideration of the other factors.

It is well to know the relation between some of these quantities. The amplitude of an object is given by the expression

$$A = \frac{F}{2\pi fZ},$$

where  $F$  is the force applied,  $f$  the frequency, and  $Z$  the mechanical impedance. In the simplest case,  $Z$  is given by

$$Z = \sqrt{R^2 + \left(2\pi fM - \frac{K}{2\pi f}\right)^2},$$

where  $R$  is the mechanical resistance of damping,  $M$  the effective mass of the vibrating object, and  $K$  the effective stiffness. If the first term is the largest, the motion is called resistance-controlled. Similarly, there are mass-controlled and stiffness controlled vibrations, the former being the more usual except for the very lowest frequencies. Notice that at one particular frequency  $f_0$ , the mass and stiffness terms are equal

$$2\pi f_0 M = \frac{K}{2\pi f_0},$$

$$f_0 = \frac{1}{2\pi} \sqrt{\frac{K}{M}},$$

and resonance occurs. At this point, the impedance is a minimum and the amplitude a maximum. The fact that there are no sharp peaks in the spectrum of the motion picture projector shown indicates that the radiation surfaces are either resistance-controlled or that there are so many peaks that the individual ones are obscured in the overall response.

The radiation resistance is the factor that determines how well the radiating source is coupled to the air. Obviously, a large surface is more efficient than a small one in moving the air. The large amount of mathematics necessary to discuss this subject explicitly is not needed here. It suffices to say that for approximately round or square surfaces, all parts of which are moving in phase, and whose

dimensions are small compared to a wavelength,\* the radiation resistance is proportional to the *square* of the area and to the square of the frequency. For objects whose surfaces are not so evenly dimensioned, the radiation increases less abruptly with area and frequency. Two separated areas are less efficient than one of the same total area.

The radiation resistance can also be reduced by removing baffles and changing the sound source from a simple one to a dipole source. An analogy can be made to a loudspeaker with and without a baffle. The output may be increased 20 or more decibels at lower frequencies by a baffle. Partial or total enclosure of the radiating source will also reduce the radiation, provided that the enclosed cavity does not resonate and the enclosure does not act as a baffle.

#### IV. REDUCTION OF COUPLING

Whether these physical facts can be applied to the improvement of the noise conditions of motion picture projectors will depend a great deal on the ingenuity of the engineers who work with the problem. The best method of attacking this particular problem appears to be to reduce the coupling between energy sources and radiating sources. The immediate goal is to reduce the transmission of high-frequency energy. Essentially what is needed is a low-pass filter between the energy sources and the radiation sources. The situation is very analogous to the power supplies in electronic circuits. Direct current is desired without alternating ripple. In some parts of the motion picture projector continuous motion or motion repeated at very low frequency (say 24 times a second) is needed without the high-frequency components. If the higher frequencies, particularly those above 200 cycles, could be rapidly attenuated, the situation would be greatly improved.

The electrical circuit for a low-pass filter is shown in the upper part of Fig. 5. There may be as many sections as desired. The cutoff frequency for such a filter is

$$f_c = \frac{1}{\pi} \sqrt{\frac{1}{LC}}$$

If there is unappreciable resistance in the circuit elements, there will be no drop in voltage across the filter.

Similarly, an ideal mechanical filter would be arranged as shown in the lower part of Fig. 5. The cutoff frequency for this filter would be

\* Wavelength at 100 cycles, 11 feet; 1000 cycles, 1.1 feet.

$$f_c = \frac{1}{\pi} \sqrt{\frac{K}{M}}$$

If there is very small damping in the mechanical elements, there will be no appreciable loss of force across the mechanical filter.

Of course, nothing so ideal as the above can be expected. It has only been drawn to illustrate the method of attack. To reduce the transmission, or rather to reduce the frequency above which attenuation is great, the moving parts should be as massive as possible and the

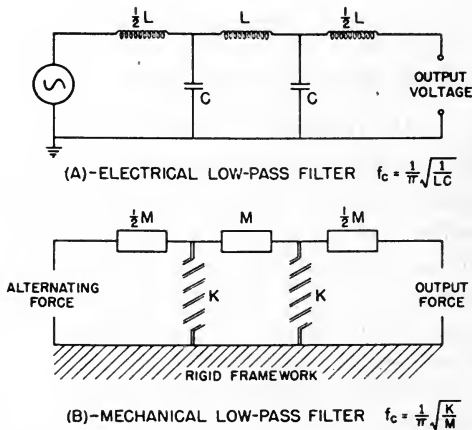


Fig. 5—Acoustical analogy between an electrical and a mechanical filter. In order to reduce coupling, the mass should be as large as possible and the stiffness of bearings, and so forth, as low as possible.

stiffness of the supports as small as possible. The use of rubber vibration isolators is an example of the application of this principle in a simple one-section filter. In the motion picture projector the coupling of the gears and motor to the frame should be accomplished with a less stiff support. Coupling by means of belts is one way that less stiffness can be accomplished. It should be emphasized, however, that it is necessary to hold the lens and film rigid with respect to the frame and lamp mounting to eliminate low-frequency vibration which would cause the projection to "shimmy".

Addition of mass is usually objected to, but it should be emphasized that this need only apply to the small moving parts coupling the motion. With additional mass, no additional force should be

required to obtain the same steady-state motion, but the action will begin and stop at a slower rate.

### V. MEASUREMENT TECHNIQUES

There are many sources of sound in a motion picture projector and each should be isolated and studied separately, beginning with the loudest or the one contributing most to the higher-frequency spectrum. This may mean building of separate drive systems for some studies. The most versatile way to examine the phenomena is to analyze the spectrum of each source; in fact, this is sometimes the best

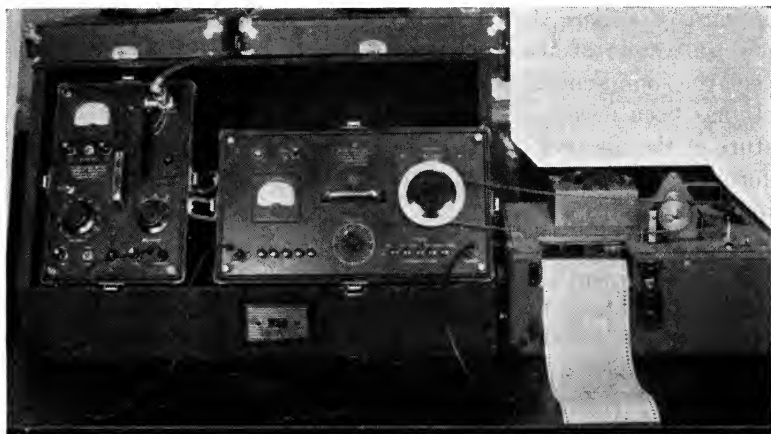


Fig. 6—Measuring setup for determining the noise spectrum of mechanical devices. At the left is a sound-level meter which is coupled to a sound analyzer. The data can be automatically recorded on the level recorder at the right, the motor of the recorder providing the drive for the dial of the sound analyzer.

way to determine the source itself. Instead of trying to find an operation which changes the *intensity of the sound*, it is often easier to find something which changes the *frequency*. This points out the source of difficulty and perhaps even the cure for the trouble.

Fig. 6 shows an experimental setup for measuring frequency spectra. On the left is a sound-level meter which is electrically coupled to a sound analyzer. Readings can be taken point to point, but a more convenient system is to record the data on a level recorder, such as is shown at the right. The motor of the level recorder drives the analyzer frequency dial.

The Armour Research Foundation has also found that it is very

useful to make a record of the objectionable sound on a magnetic recorder. The instrument is used more or less as an "acoustical notebook" on which comparisons can be made of changes over a considerable period of time. It is also convenient for presenting the results to executives, supervisors, and customers.

## VI. CONCLUSION

This survey has been presented only as an introduction to the subject of noise in motion picture projectors. An attempt has been made to analyze the problem and to discuss both the psychological and the physical factors involved. It is important in the present apparatus to reduce the energy in the high frequencies. Potentially the best system of attack appears to be to reduce the coupling between the sound-energy sources and the radiating sources.

It has been necessary to generalize in many cases because of the nature of the discussion. However, it is hoped that enough specific information has been supplied to provide a basis for productive experimentation.

## ACKNOWLEDGMENT

Acknowledgment is made to Mr. R. T. Van Niman and Mr. R. E. Lewis of the Society for stimulating discussions of the subject.

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## DISCUSSION

CAPTAIN A. G. D. WEST: Have you developed a device which gives you an instantaneous view of a spectrum, a spectrum of music or a spectrum of noise as distinct from the point-to-point device which you showed on the screen?

DR. HOWARD C. HARDY: Every acoustical engineer would like to have such a device. Such things have been made in very elaborate form that take up something like a space of ten to twenty feet on the side of the laboratory wall.

The difficulty in acoustics is that you have to cover about eight octaves. Devices in radio, which have been used to sweep a band of frequencies, cover about one octave. No device like that has ever been developed that is very satisfactory for portable use.



# A Modern Sound-Reinforcement System for Theaters\*

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*Summary*—Theaters using “live” talent shows usually require a sound-reinforcement system to enable patrons to hear as well as to see the entire show. This paper describes a system recently installed in the Roxy Theater in New York City, which incorporates many unique features to permit satisfactory handling of any stage presentation, however complex. Among these features are a control console of unusual design, equipped with mixers and volume controls of a new type, and a method of effecting stereophonic reproduction.

## HISTORY

THEATERS, actors, and public entertainment in general have undergone considerable change since the advent of the silent motion picture. Prior to that time, theaters, with the exception of concert halls, were comparatively small, well damped acoustically, and of such shape that the majority of patrons could hear and follow the dialog of well-trained actors. The actors themselves, knowing that they had to rely on themselves to be heard, devoted much time to the cultivation of a good speaking voice. The relationship between actor and audience was close and intimate. Concert halls were somewhat larger and well suited for musical programs but not for types of entertainment that relied on the speaking voice. With the coming of the motion picture several other types of theaters evolved. One was the small auditorium used for motion pictures exclusively; another the medium-sized combination picture and vaudeville theater; the third, the large theater, featuring first-run pictures accompanied by a musical program and vaudeville. The combination theater, while somewhat larger than so-called legitimate theaters, was yet not too large for use by well-trained actors, while the large theater was.

In the meanwhile, facilities for magnifying the human voice were evolved and made commercially available. However, they were, for understandable reasons, not immediately accepted for use in theaters.

\* Presented October 24, 1947, at the SMPE Convention in New York.

Then in 1926 the motion picture acquired a voice, an entirely new art developed, and theater exhibitors became acutely aware of a new and potent entertainment medium. Coincidentally, interest was aroused in reinforcing sound from live talent. In general, technical developments in connection with the production and reproduction of sound pictures grew at a rapid pace resulting in a nearly perfect product, whereas those concerned with sound reinforcement did not.

#### CURRENT STAGE PRODUCTIONS

While these developments were in progress, theater programs changed. Vaudeville became practically extinct, combination theaters adopting a straight picture policy. Today only the larger theaters feature stage shows, usually built around a so-called name band. Stage arrangements are commonly used whereon the orchestra or name band is grouped upstage so as to form a general background for other stage activity. Such arrangements have eye appeal and conform with modern stage-setting design which caters to the eye rather than the ear, but they present acute operating difficulties, detract materially from the efficiency of the sound system, and necessitate expansion of pickup facilities. The difficulties occur because of undesired pickup of high-volume instruments, such as brasses located upstage, by microphones in use downstage. This detracts from the efficiency of the sound system in that the louder orchestra instruments which do not require reinforcement tend to be overemphasized. The additional pickup facilities are required to enable the audience to hear pianos and string instruments which, without reinforcement, would not be heard in the auditorium from their upstage location.

It may be stated safely that today a sound-reinforcement system is required to so produce a stage show that all patrons may hear as well as see the entire show and to maintain intimacy between performers and audience.

#### IDEALS AND LIMITATIONS

Since many patrons are enabled to hear the performers directly as well as by reinforced reproduction, it is imperative that the original and its reproduction be identical except in intensity. This means that the sound-reinforcement system must be of the highest quality, capable of faithfully reproducing the original and at the same time magnify it as required.

Ideally, an auditor should not be conscious of the fact that a sound-

reinforcement system is in use. This ideal is extremely difficult to attain for reasons governed by the physical aspects of the auditorium and the relationship between microphone and loudspeaker. Good illusion dictates that sound should appear to come from its source, but here the source is a performer who works into a microphone. It is obviously not practicable to place a loudspeaker so as to attain perfect illusion in this situation because acoustic coupling between microphone and loudspeaker would be maximum and the amount of amplification that could be used without acoustic feedback would be valueless.

In any auditorium the efficiency of a sound-reinforcement system is maximum when the coupling between microphone and loudspeaker is minimum; i. e., more amplification can be used without regenerative disturbances and pickup over a greater distance effected when microphones are located at a distance from and in back of the loudspeaker system. Pickup from a reasonable distance is desirable since it permits performers more freedom of action, keeps system power demands at a minimum, prevents overloads at any point in the system, and generally results in better quality than can be obtained if the pickup distance is restricted.

For these reasons a modern loudspeaker system usually cannot be placed on the stage. It could be suspended from the proscenium arch but such mounting, while efficient if low enough, is unsightly and not generally used. It is therefore necessary to mount loudspeaker systems in front of the proscenium at each side of the stage opening, preferably as far out into the auditorium as possible and in such manner that they may be concealed. Such an arrangement necessitates cross flaring of horns to cover the auditorium but permits maximum amplification to be used resulting in pickup from a reasonable distance, this pickup distance decreasing as the microphone is moved downstage in the direction of the audience.

#### THE ROXY THEATER

The Roxy Theater in New York City has an auditorium of more than 1,500,000 net cubic feet, being roughly 185 feet wide, 150 feet long and 85 feet high, seating approximately 6000. It has a mezzanine and a large balcony. It operates on a policy of showing first-run pictures and presenting elaborate "In-Person" stage shows, during which the sound-picture screen and horn system are flown and full use is made of a rather large stage. It employs a staff orchestra that

plays on a movable "band-car" located upstage. An organ is also used and while the Roxy is equipped with one of the finest, its chambers have been sealed in under the stage as a result of a former stage enlargement. It is therefore necessary to pick up and reproduce the organ music by means of the sound-reinforcement system. The operating policy also requires that the projection department be enabled on certain occasions to use the sound-reinforcement horn system for the reproduction of sound on film. In order to meet the current requirements of the production department and to anticipate their future needs, the sound-reinforcement system described herein, the third installed during the twenty-year history of the Roxy, was specifically designed not only to meet their present requirements, but at the same time to provide them with the very best and most flexible system of its kind in existence. To accomplish this it was determined that a total of 32 microphone circuits for stage pickup and four for organ pickup would adequately meet any likely demand. Accordingly a 36-circuit system, using high-level mixing, with dual driver and power amplifiers, having a combined audio output of 150 watts, feeding a separate horn system on each side of the proscenium, was decided upon. Such a system would also provide rehearsal facilities without disturbing those set up for a current show. It was also decided that the system should be entirely self-sufficient, fully protected by emergency features, flexible in control, and be provided with adequate test facilities to assure optimum performance.

To provide stereophonic reproduction a manual stereophonic control was decided upon, to be used in connection with a special amplifier-horn selector switch, which would not only enable selection between paralleled and stereophonic operation of main amplifiers to be made, but would also serve as an emergency measure in the event of failure of one of the dual amplifier channels. Limiting amplifiers for use as drivers were also considered but discarded in favor of manual control. A block schematic of the installed system is shown in Fig. 1.

#### AMPLIFIERS AND POWER-SUPPLY UNITS

Forty-two Type A-420, two type A-126, two type A-287-F, and one type A-323-A Altec Lansing amplifiers are installed. The A-420 is a low-impedance, low-level, high-gain preamplifier, having a normal gain of 42 decibels. The A-126 is a low-impedance, high-gain power amplifier having a maximum gain of 90 decibels and a power output of 15 watts. The A-287-F is a 75-watt power amplifier with a gain of 15



equalizers have been adjusted for optimum results in this theater, the high-frequency droop starting at 5000 cycles per second. Thirty-six of the type A-420 amplifiers are used as preamplifiers, four as booster amplifiers, and two as utility spares, one serving as a low-level monitor. These booster amplifiers feed the A-126 and A-287-F amplifiers used as drivers and power amplifiers, respectively, through adequate control facilities. The A-323-A is used as a monitor amplifier.

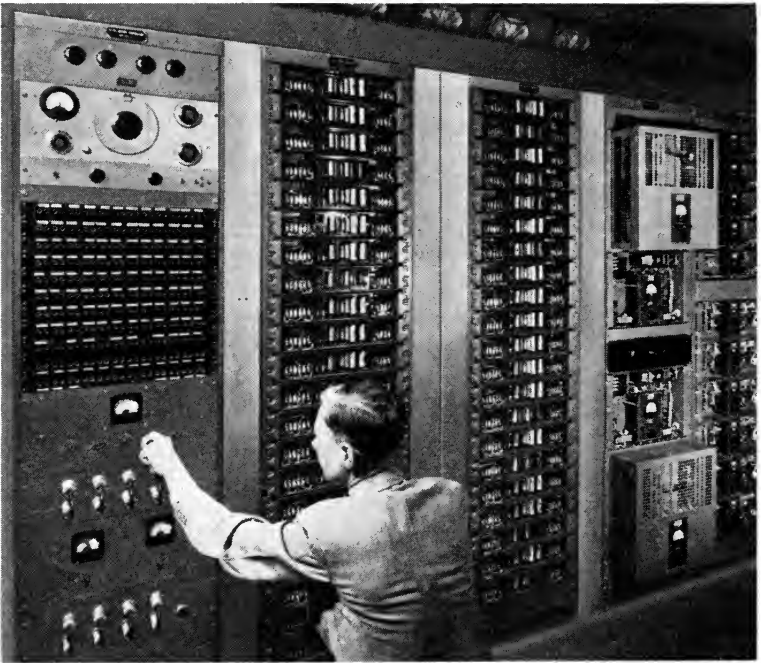


Fig. 2

In the interest of an over-all low noise level, the filaments of all but spare A-420 amplifiers are operated from direct-current filament-supply units, and the plate supply is obtained from regulated direct-current plate-supply units, Altec Lansing Types E-18 and P-509, respectively. Five of each type are installed. Four of each supply ten A-420 amplifiers through heavy-duty patch cords and plugs. The fifth units of each type serve as spares, but are instantly available for use through power-patching cords. The filaments of the spare A-420

amplifiers are energized by alternating current from two separate P-509 units. All preamplifiers and booster amplifiers are arranged so that they can be removed readily from the circuit or from their rack without disturbing any wiring, wiring to amplifiers being terminated in suitable jacks mounted on the rear cover plates of metal raceways located on each side of preamplifier racks. Connections to amplifiers are through flexible cords and plugs, the cords on the two spare amplifiers being long enough to reach any location on their racks. Fig. 2 shows the amplifiers and power-supply units.

### CONSOLE

The number of circuits and other features decided upon would result in a console of unwieldy proportions and difficult to operate if controls of conventional design were used. Therefore a special console design had to be evolved, which was made possible through the co-operation of the Daven Company. Their type 600-T attenuators having sliders actuated by a lever operated in an approximate straight line were selected for all circuits except stereophonic control and organ mixing, since they offered the utmost in close grouping and ease of operation of the various controls. The special stereophonic attenuator is of conventional physical design as are the organ mixing controls; the latter being rack-mounted, since only initial adjustments are required. The completed console is semicircular in shape, 5 feet 8 inches wide at its widest point and 30 inches deep. It contains four eight-circuit mixing panels, each with a submaster volume control; a console master volume control; a master organ control; and a stereophonic volume control. In addition it contains a jack panel for monitoring each individual microphone circuit; a heavy-duty, five-position selector switch, operated in a gear-shift fashion as amplifier output-horn input selector; a monitor horn control switch; two volume indicators (VU meters) and associated meter multipliers; and a push-button pilot-light assembly for control of a heavy-duty impulse-type relay in the horn circuit to enable the projection department to use the sound-reinforcement systems horn facilities for sound pictures when required.

The connections made through the amplifier-output horn-input selector switch are as follows: In the No. 1 position, amplifier and horn systems are connected in parallel. In position No. 2, each amplifier system is terminated in a suitable load resistor and the horn systems are disconnected. In position No. 3, additional horns are

connected to amplifier and horn systems, all in parallel. In position No. 4, each amplifier system is connected to one horn system. Position No. 5 is neutral and not used. Position No. 4 is the normal operating position and since the stereophonic volume control is in the input circuits of the system amplifiers, manually controlled stereophonic reproduction is possible. While position No. 1 may be used for normal operation, it serves as an emergency protective measure in case of failure of one of the main amplifiers. Position No. 2 is provided for system tests. Position No. 3 is intended for organ reproduction only.



Fig. 3

All instruments are mounted so that they may be removed readily for inspection and service, twist-to-lock-type mounting screws being used throughout, and each individual piece of equipment is connected to its section's terminal strip by means of flexible cables. The installed control console is shown in Fig. 3.

#### MIXING CIRCUIT

Console mixing is at 250 ohms with controls arranged in groups of eight; T networks are used with outputs connected in parallel and



series resistors are used to maintain circuit impedance. The sub-master volume controls form a four-circuit mixer of similar design and feeds the console master volume control. The organ mixer, mounted

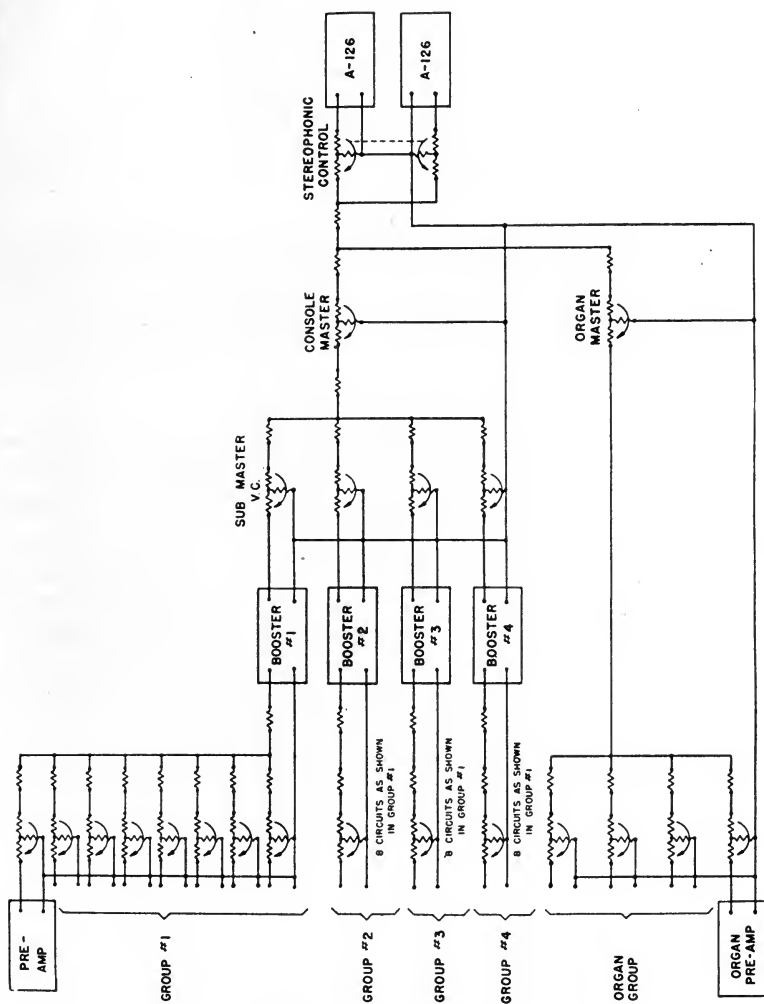


Fig. 4

on the rack, is a four-circuit, 500- to 250-ohm version of the same arrangement and feeds the organ master volume control which is located on the console. The paralleled outputs of these two masters feed the stereophonic volume control which has one input and two

outputs. Each output is connected to a driver and power amplifier and the stereophonic volume control varies the voltage to these "channels" at a ratio determined by its setting. When centered, a three-decibel insertion loss is introduced into each channel and equal voltages are fed to both. Varying the control knob to right or left varies the signal level in the two amplifier systems. As used, moving the control knob to the right reduces the volume from the horn system on that side, and vice versa. The control is in 17 discrete steps of attenuation, providing no change in total acoustic power from the two horn systems but altering the ratio of power in the two in a realistic manner.

On the console, all controls are so arranged that those most frequently used are immediately in front of the operator. All so-called stage microphones are controlled from the center sections; orchestra and footlight microphones are controlled from left and right sections, respectively.

#### CONTROL-ROOM LOCATION

In order to obtain the very best results from the new system it was deemed essential that the control console and associated equipment be so located that its operator would react as would one of the audience, and that he have sole and complete control of all the facilities at his command. Experience has shown that space above balconies or in unused side loges were to be avoided. Various locations in the lower balcony, in the mezzanine and on the orchestra floor were considered, but an oblong space adjacent to the rear cross aisle on the left side of the orchestra floor was chosen as being best suited for monitoring purposes. The floor in this space has been raised and a partial wall erected separating all of the control room, except the space above the console from the auditorium proper. While the console actually forms a lower part of this separating wall, it has been mounted so as to protrude somewhat into the auditorium. The control operator is therefore effectively a part of the audience and can accurately determine the auditorium sound level. He is 45 feet to the left of the center line of the auditorium and 145 feet from the center of the footlights and, from a seated position, has a full and unobstructed view of the entire stage. During nonoperating periods, the space from console to ceiling is closed by means of two three-section hinged glass panels. All facilities are controlled from this room and all sound-reinforcement system equipment except microphones and loudspeakers are contained therein.

## PATCH PANEL, MICROPHONE CIRCUITS

Fifty pairs of shielded wires, of which 13 are spares, run in two separate conduits, connect the control room with a main junction box located under the stage. Thirty-six of these pairs are connected to preamplifier inputs and have been wired to 52 microphone receptacles, strategically located so as to permit use of relatively short microphone cables, thereby facilitating the handling of microphones. The wire shielding is insulated and in each case carried through from microphone to amplifier. At the control room end, 36 of these pairs are connected through multiple, normal-through jacks to their respective preamplifiers. Other normal-through jacks connect the preamplifier outputs to their associated volume (mixer) controls on the console. By the use of patch cords, which are provided, any microphone can be connected to any preamplifier although during normal operation none is required.

## STAGE, MICROPHONE FACILITIES

Of the 36 preamplifier input circuits, four are for organ pickup exclusively and are terminated in the organ chamber. The other 32 circuits are for general sound-reinforcement pickup; 16 circuits are terminated on the stage, eight in the orchestra pit and eight in the footlights. In order that the orchestra or portions thereof may be picked up whether located on the stage as at present, or in the pit, parallels of these circuits are also available at microphone receptacles on the stage. Parallels of the footlight circuits are likewise available on the stage. It is of course intended that these circuits be picked up in either of the two locations but not at both simultaneously. Dust-caps are provided for all unused microphone receptacles. In addition to the above facilities, the eight orchestra circuits have been extended to a new location tentatively contemplated for the orchestra. These, too, will be parallels when connected and placed in service.

The method of handling the so-called "phantom" microphones which are mounted on elevators and remotely controlled to disappear into the stage may be of interest. The flexible microphone cables are short and wired permanently to outlets under the stage adjacent to the microphone raise-lower mechanism. From that point the wiring is in conduit to outlet boxes adjacent to the microphones' normal amplifier input receptacles on the stage, and the microphone leads are terminated in short cables and plugs which protrude from their outlet boxes. Normally these plugs are inserted in their amplifier input

receptacles; however, by removing these microphone plugs their amplifier circuits are available for any other use. While four phantom microphones are available, only one is regularly used, the others serve for special stage arrangements. Through connections, microphone to amplifier, would have left three circuits idle and unavailable.

### HORN SYSTEM

One Altec Lansing horn system is concealed in the grillework in front of the proscenium wall on each side of the stage opening. Since the proscenium opening is 70 feet wide, the horn systems are roughly 80 feet apart and of necessity cross-flared. Each system consists of two 2 by 5 multicellular high-frequency horns with one type 288 high-frequency unit each; two folded-type low-frequency horns with one type 515 low-frequency unit each; and one 800-cycle, 180-degree dividing network. The low-frequency horns are laid on their sides, one on top of the other. One high-frequency horn is mounted below and one on top of the low-frequency horns. The center line of the horn systems is approximately 20 feet above the orchestra floor. Each horn system is separately wired to the control-room console and additional conductors are wired to suitable outlets for future use with additional organ reinforcing horns.

### MONITORING FACILITIES

While the control operator normally is expected to determine quality and auditorium volume from his point of vantage in the auditorium, complete monitoring facilities are at his disposal. A type A-323-A amplifier is provided for use with a monitor speaker, and one of the spare A-420 amplifiers for use with a headset as a low-level monitor. The jack strip on the console permits these test amplifiers to be connected to any one of the 32 volume controls that are mounted on the console without disturbing a program that is being reinforced. In addition, a key on the console connects a monitor speaker across the output of either amplifier system. This key normally is open and intended to be used only during such time that the equipment is not in use.

Monitoring facilities for the stage manager and organist are provided by means of loudspeakers, for the orchestra leader and pianist by means of hearing-aid-type headsets, volume controls, and matching transformers. These are bridged across one of the horn systems. These facilities are necessary since without them, reproduction from

the sound-reinforcement system cannot be heard on the stage well enough to pick out cues.

#### TEST FACILITIES

A high-grade audio-frequency oscillator, containing a suitable attenuator and impedance selector, is wired to a pair of jacks. By means of a patch cord the oscillator signal may be fed into any channel for test purposes. This feature, together with the special amplifier-horn-selector switch on the console, which in the test position places a dummy load and a volume indicator across both power amplifiers, permits complete tests to be precisely and speedily made on the entire system.

In addition, two special metering panels having suitable selector switches permit the filament and plate voltages to each group of pre-amplifiers, and the plate current of each individual preamplifier to be checked.

#### PROJECTION-ROOM LINK

Since on occasions, particularly just prior to closing, exit music is reproduced by the projection-room equipment from sound on film while the sound-picture horn system is flown, arrangements were provided to connect the projection room equipment to the sound-reinforcement systems speakers. This is done by means of a six-pole, double-throw, heavy-duty, impulse-type relay, located in the control room and controlled from push buttons with appropriate signal lights in the projection room and at the console.

#### CONCLUSION

The installed system has fully met all expectations. The quality of reproduction is good, the noise level low, and the system has ample power. It is flexible and extremely easy to operate. The system is entirely complete and all facilities are under the sole and direct control of its operator. The location chosen for the control room, console, and associated equipment has been found eminently satisfactory and probably is the best possible under any condition. While it is not anticipated that any one show will require a total of 36 individual microphones, the system is believed capable of meeting any current or possible future demand of an alert production department.

# An Improved Intermodulation Measuring System\*

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*Summary*—This paper describes a new intermodulation analyzer of improved design and also a two-signal generator for use with the analyzer. The equipment is intended for measuring distortion in audio-frequency systems by means of paired signals which may be selected in several combinations from 40 to 12,000 cycles per second. This equipment has been found to be particularly useful in determining optimum processing conditions for variable-density recording but is also useful in any field where audio frequencies are employed.

THE INTERMODULATION method of measuring nonlinear distortion in audio-frequency systems has been in successful use for nearly ten years. Numerous papers have been published discussing the method together with the relative advantages and disadvantages as compared with the better-known harmonic-analyzing technique.<sup>1-5</sup> This paper describes a new intermodulation analyzer having a number of refinements and features which make it particularly valuable for precise measurement work. Also described is a companion instrument in the form of a signal generator which is used to provide a source of paired frequencies by means of which intermodulation can be measured.

Although the intermodulation method has been found useful in broadcast, public-address, and allied fields, it has proved of greatest value in variable-density sound-film recording. In this field the measurements have seemed to correlate more closely with observed distortion in speech and music than have measurements by other methods.

Reliable intermodulation measurements may be made in the presence of considerable noise since the latter is excluded by filters to a greater degree than is the case with the usual total harmonic-

\* Presented October 24, 1947, at the SMPE Convention in New York.

measuring methods. The intermodulation method also makes possible distortion measurements at the higher frequencies in systems having limited bandwidth which is not possible at all with the harmonic method. For example, most sound-film recording systems have little response above 8000 cycles so that measurements of harmonics for fundamental frequencies above 5000 cycles is meaningless. But intermodulation tests with the combination 100 and 7000 cycles will readily show up the type of high-frequency distortion which may have serious effects on sound quality. A further advantage of the intermodulation system is in the provision of a phase detector which gives a direct indication as to whether the distortion is occurring at the



Fig. 1—Intermodulation analyzer.

“toe” or “shoulder” region of the transfer characteristic or both. In the case of variable-density sound film the phase detector indicates whether the compression is occurring in the light or dark region of the film-transmission characteristic, when properly calibrated.

#### INTERMODULATION ANALYZER

A new intermodulation analyzer unit designed for rack mounting is shown in Fig. 1. A cabinet is supplied for the unit where desired. The instrument is approximately  $19 \times 9 \times 8$  inches in size and weighs 32 pounds.

The operation of the RA-1257 Intermodulation Analyzer is based on the theoretical considerations presented in an earlier paper,<sup>1</sup> and may be summarized as follows, using the block diagram, Fig. 2, as a

reference. An input signal (from the device under test) consisting of mixed high and low frequency is applied to the input of the analyzer. The low frequency is between 40 and 150 cycles per second; the high frequency is 2000 cycles per second or between 7000 and 12,000 cycles per second. The amplitude ratio of low frequency to high frequency is generally 4:1 (i.e., low frequency 12 decibels greater than high frequency) although this ratio is not mandatory. The effect of changing this amplitude ratio is to vary the relationships between distortion measured by the intermodulation method and distortion measured by any other method. For example, with 12 decibels difference between high- and low-frequency amplitudes, distortion measured by the intermodulation method is approximately four times that which would be measured by harmonic analysis although the ratio will vary with the nature of the distortion; if the difference in amplitude is reduced to 6 decibels distortion measured by the intermodulation method will be approximately 2.7 times that measured by harmonic analysis.

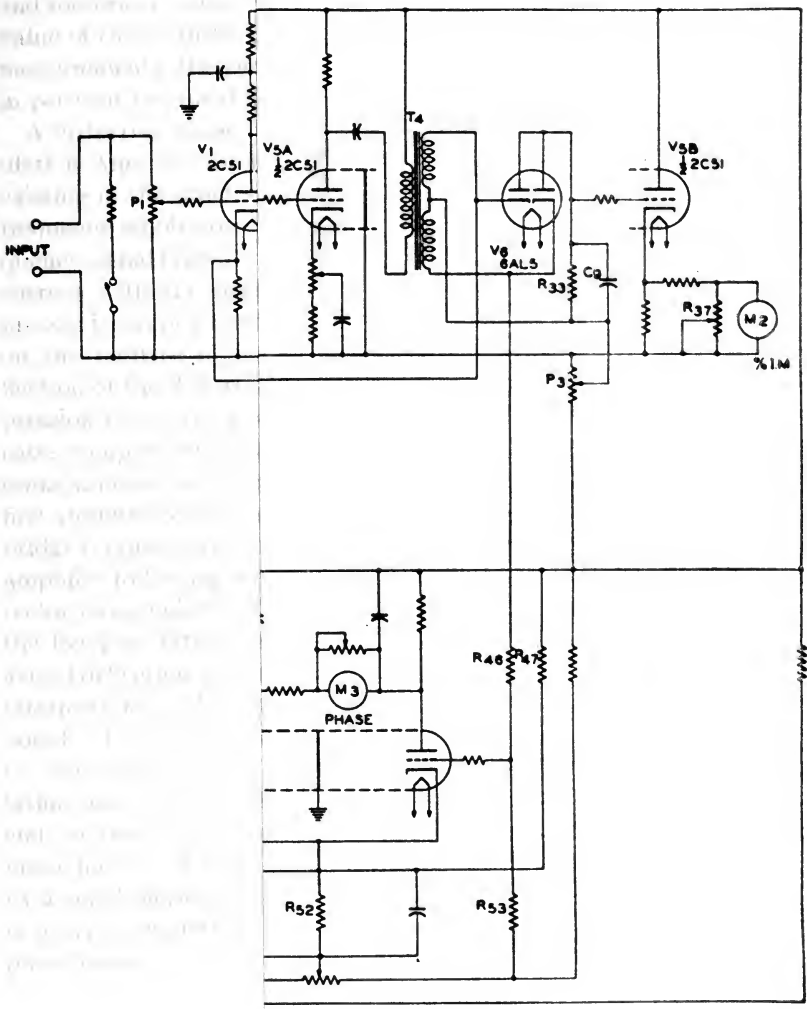
Distortion in the input signal consists of amplitude modulation of the high-frequency component at the low-frequency rate (or multiple thereof); i.e., the amplitude of the high-frequency component will vary as the low-frequency component makes one complete cycle if the transfer characteristic over which the low frequency swings is non-linear. This variation is not necessarily sinusoidal in nature but may have any wave shape depending on the transfer characteristic of the device under test. The percentage of intermodulation as used here is defined as the per cent amplitude modulation of the high-frequency signal. No standard definitions of terms used in this field have yet been formulated by authorized groups.

After being amplified the input is passed through a filter to eliminate the low-frequency component. Either of two filters may be selected; for a 2000-cycle-per-second high-frequency signal, a 1500- to 2500-cycle-per-second band-pass filter is used; for high-frequency signals between 7000 and 12,000 cycles per second, a 6500-cycle-per-second high-pass filter is used. The resulting high-frequency component is then amplified and rectified.

The output of the rectifier is a series of half sine-wave pulses of the high frequency with a low-frequency envelope. This envelope is a replica of the intermodulation in the input signal. The average output of the rectifier is adjusted in operation to a reference value of 4 volts by the use of an input attenuator. The voltage of the low-frequency envelope is measured by amplifying, rectifying, and applying



VOL. CONTROL — AMPLIFIER — RECTIFIER — VAC TUBE VOLTMETER



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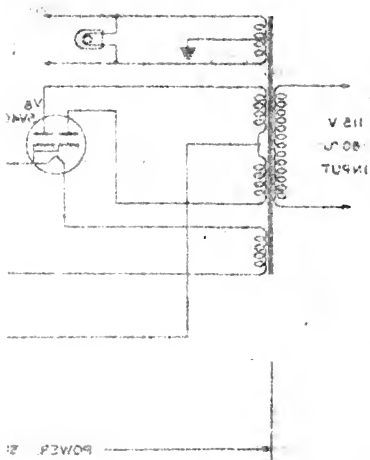
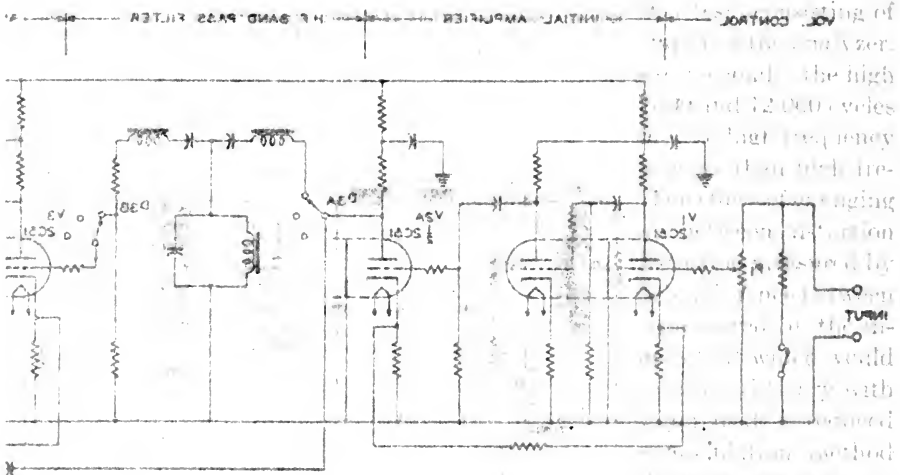


Fig. 3 - C-11

of grid-leak biasing of the 6X4 tube. The high frequency transformer has a primary of 2000 turns and a secondary of 1000 turns. The secondary is connected to a load through a 500K resistor. The circuit is labeled 'POWER'.

it to a vacuum-tube voltmeter. The time constant of this voltmeter (0.1 second) is such that its response is intermediate between the peak and root-mean-square values of the applied signal. Since the average value of the rectifier output will be adjusted to the same value for all measurements, the vacuum-tube voltmeter can be calibrated directly in per cent intermodulation.

A distortion phase detector is provided on the RA-1257 Intermodulation Analyzer for measuring the relative phase of the distortion existing in the input signal. This meter indicates whether the high-frequency amplitude concurrent with the positive peak of the low-frequency signal is greater or less than the high-frequency amplitude concurrent with the negative peak of the low-frequency signal. Expressed in simpler terms, it indicates whether compression is occurring on the positive or negative half of the low-frequency signal. Deflection of the distortion phase meter to the right indicates that compression is occurring on the positive half; deflection to the left indicates compression on the negative half. Referring to the block diagram, a phase detector receives a portion of the input signal from the first amplifier on one arm of a bridge circuit and on a second arm of the bridge is impressed a voltage of unknown phase from the output of the amplifier following the low-pass filter. The output of the phase detector has a polarity dependent upon the phase of the voltage out of the low-pass filter relative to the low-frequency input signal. The actual deflection of the phase-detector meter is related to the per cent intermodulation but ordinarily only the direction of the deflection is noted. If the distortion is all on one end of the transfer characteristic, the deflection will be proportional to the amount of intermodulation, but in either direction. If the distortion is equally on both ends of the transfer characteristic, there will be no deflection of the phase meter. A large per cent intermodulation reading accompanied by a small phase-meter reading therefore indicates that the distortion is nearly symmetrical with unbalance to the side indicated by the phase meter.

#### ANALYZER CIRCUIT

The various circuits and features included in this unit are described with reference to Figs. 2 and 3. Provision is made for terminating the input either in 600 ohms or in an impedance of approximately 1 megohm.

The input control consists of a continuously variable potentiometer

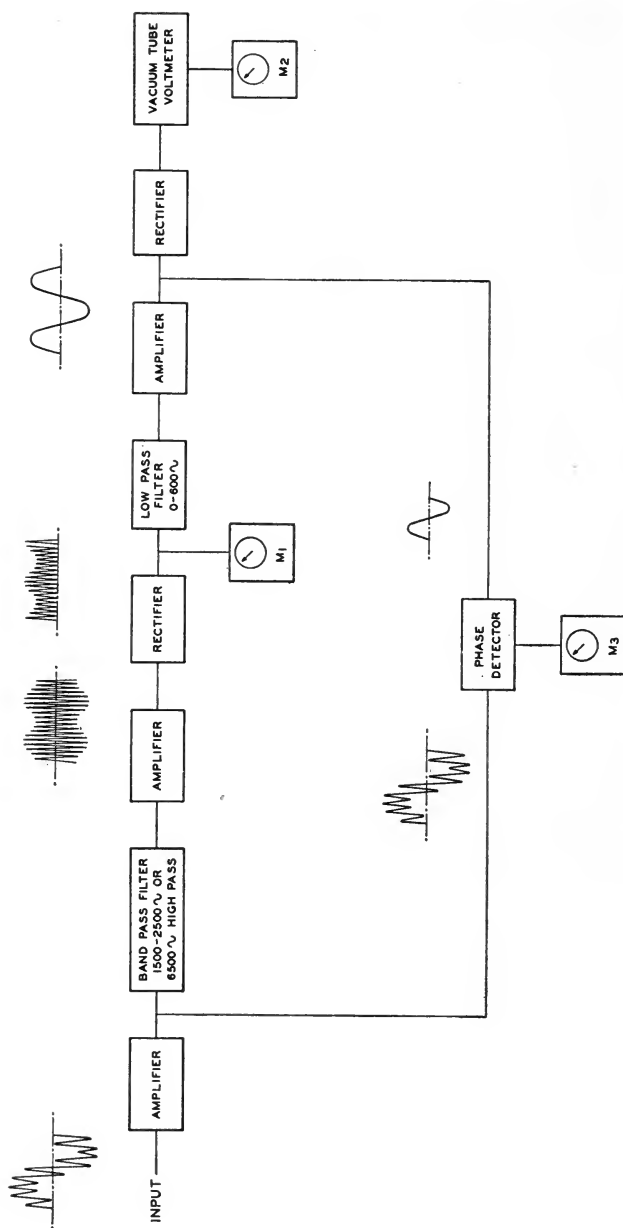


Fig. 3—Block diagram of intermodulation analyzer.

$P_1$ , with 26 decibels of range and three fixed values of attenuation of 0, 20, and 40 decibels as selected by a switch on the front panel labeled INPUT ATTEN.

The initial amplifier consists of three triode stages, the two halves of  $V_1$ , a 2C51/396A and one half of  $V_2$ , also a 2C51/396A with a large amount of feedback. The plate load of the third stage is a filter which may be either a 1500- to 2500-cycle band-pass filter or a 6500-cycle high-pass filter as selected by the FILTER-SELECTOR switch on the front panel.

The amplifier following the high-frequency filter consists of two halves of  $V_3$ , a 2C51/396A dual triode. The output of this amplifier is a high-frequency signal, amplitude-modulated at a low-frequency rate. The amount of modulation is dependent on the amount of intermodulation contained in the input signal.

The output of the high-frequency amplifier is rectified by the 6AL5 double-diode  $V_4$  and the high-frequency component rejected by the following low-pass filter which has an attenuation of more than 60 decibels for all frequencies above 1500 cycles. The terminating resistor for this filter is  $R_{25}$ . There will be developed across this resistor a positive direct voltage with a low-frequency voltage superimposed on it. The amplitude of the low-frequency voltage at this point is dependent on the amount of intermodulation in the input signal. The average value of the current flowing through  $R_{25}$  is a measure of the amplitude of the high-frequency input signal and is indicated on the input meter  $M_1$ , with the FILTER-SELECTOR switch  $D_3$  in either the 2000- or 7000-cycle position. In operation the input attenuator is adjusted to give a voltage of approximately 4.0 volts direct current out of the low-pass filter when the input meter reads 100 per cent.

The direct-current component existing at the output of the low-pass filter is blocked by capacitor  $C_7$ , and the low-frequency component impressed on the primary of transformer  $T_3$ . The secondary of  $T_3$  is connected to a variable attenuator  $D_4$ , which provides for full-scale sensitivities on the per cent intermodulation meter of 5 per cent, 15 per cent, 50 per cent, 100 per cent, and OFF.

The output of the attenuator is fed into an amplifier (one section of  $V_5$ , a 2C51/396A dual triode) whose voltage gain is adjustable by means of variable cathode feedback used as a calibration adjustment.

The output of the low-frequency amplifier is rectified by the 6AL5 double diode  $V_6$ , used as a full-wave rectifier. The diode load consists of  $R_{33}$  and  $C_9$ , which combination has a time constant of 0.1 second.

The polarity of voltage developed is such as to make the grid of the following tube negative with respect to ground.

The voltage developed across  $R_{33}$  is applied to the grid of a triode (one half of  $V_5$ , a 2C51/396A) which is used as a vacuum-tube voltmeter, in connection with meter  $M_2$ , which is a high-speed response meter with zero current at the right extreme of movement. It is calibrated directly in per cent intermodulation with two scales, 0-5 and 0-15. With no input to the vacuum-tube voltmeter, but with plate voltage applied, the cathode voltage of  $V_{5B}$  and the value of  $R_{37}$  are adjusted so that  $M_2$  will read 0 per cent intermodulation. The cathode voltage of  $V_{5B}$  is adjusted by the ZERO-ADJUST control  $P_3$ , on the front panel; this control applies a small amount of positive direct voltage to the grid, thus increasing the plate current and cathode voltage. In order to accommodate possible extremes of vacuum-tube characteristics the meter-sensitivity control  $R_{37}$  is also included. As noted in the previous paragraph the polarity of the direct voltage developed by  $V_4$  is such as to make the  $V_{5B}$  grid more negative as the amount of intermodulation increases. The plate current and cathode voltage of  $V_{5B}$  therefore decrease as intermodulation increases, causing the pointer of  $M_2$  to move to the right. This type of indication i.e., increased signal level operating in the direction of vacuum-tube cutoff, has the advantage that it is impossible to damage the indicating meter due to high values of input.

The phase detector, consisting of a 2C51/396A dual triode  $V_7$  and associated circuits, compares the phase relationship existing between the intermodulation envelope at the output of the low-pass filter and the low-frequency signal at the input to the analyzer. The operation of this comparison circuit is as follows: Both halves of  $V_7$  are biased to cutoff by applying a positive voltage (obtained from the voltage divider  $R_{47}$  and  $R_{52}$ ) to their cathodes which are paralleled. Also applied to the cathodes is an amplified sample of the analyzer input voltage obtained from the plate of  $V_{2A}$  and further amplified by  $V_{2B}$ . This causes a series of half sine-wave pulses to flow through each half of  $V_7$ , which in turn results in a decrease in the average plate voltage of both halves of  $V_7$ .

The two grids of  $V_7$  are excited with voltages 180 degrees out of phase with each other obtained from the secondary of  $T_4$  through the voltage dividers  $R_{41}$ ,  $R_{51}$  and  $R_{46}$ ,  $R_{53}$ . Application of these two voltages will cause the average plate voltage of one half of  $V_7$  to increase and the average plate voltage of the other half of  $V_7$  to decrease. The

difference between the two plate voltages will be a function of the product of the amplitude of the voltage from  $T_4$  and its phase difference with respect to the input voltage. This phase difference will in most cases be either 0 or 180 degrees, corresponding to compression on either the positive or negative half of the input signal.

The difference in voltage between the two plates of  $V_7$  is measured by the zero-center meter  $M_3$ . Calibration of  $M_3$  is in arbitrary units with 100 divisions in either direction from center. Deflection to the right is labeled LIGHT and deflection to the left is labeled DARK. It is assumed that in operation the input signal will be poled so that compression on the light end of the film characteristic will cause deflection to the left and compression on the dark end of the film characteristic



Fig. 4—Intermodulation signal generator.

will cause deflection to the right. As a matter of absolute reference, compression on the positive half of the low-frequency input causes deflection to the right, compression on the negative half of the low-frequency input causes deflection to the left.

A conventional power supply is used with gas-tube regulators so that the only external supply required is 115 volts, 50 or 60 cycles alternating current.

#### SIGNAL-GENERATOR UNIT

Fig. 4 shows the appearance of a new signal-generator unit to work with the intermodulation analyzer previously described. This unit is normally supplied for rack mounting but may also be furnished in a cabinet. It is approximately  $19 \times 7 \times 8$  inches in size and weighs about 30 pounds.

The function of the RA-1258 Intermodulation Signal Generator is to add two frequencies without appreciable amplitude modulation of one frequency by the other. This summed voltage is then passed through any device which is to be tested and the amount of intermodulation in the output from the device under test is measured by the RA-1257 Intermodulation Analyzer or similar device.

In the RA-1258 unit the two frequencies are generated and separately amplified to the desired level. The two frequencies are then combined in a hybrid coil after the high frequency has been attenuated by the required amplitude ratio between the two frequencies. A range of output levels between +23 and -44 decibels maximum is obtainable, at 600 ohms output impedance. This range of output is sufficient for testing most studio equipment without the use of additional amplification.

The two frequencies may be designated as the low-frequency and high-frequency signals. The low frequencies provided by this unit are 40, 60, 100, and 150 cycles per second; the high frequencies are 1000, 2000, 7000, and 12,000 cycles. In addition, provision is made for connecting an external signal source to either signal channel in order that any frequency combination may be realized. General operating practice has been for the ratio of low-frequency amplitude to high-frequency amplitude to be 4:1. However, in order to permit the possibility of changing this ratio, four fixed ratios are built in, selected by means of a front-panel switch. These are 1:1, 2:1, 4:1, and 10:1, the last for use in calibration tests.

In addition to the above combinations of frequencies for use in intermodulation-distortion measurements, an output signal is provided for use in calibrating the RA-1257 Intermodulation Analyzer. This is a signal of 2000 cycles combined with a signal of 1900 cycles, the amplitude ratio between the two being 10:1. This results in a voltage wave containing 10 per cent amplitude modulation and as such can be used for calibration purposes.

Setup adjustments of the two oscillators are made as follows: Each of the two oscillators is set to the frequency desired. The ratio switch is set to the amplitude ratio required. Then the signal-selector switch is set to the low-frequency position. The low-frequency-signal amplitude control is then adjusted to produce a convenient reading on the VOLUME INDICATOR, say midscale. The signal-selector switch is then turned to the high-frequency position and the similar adjustment made, setting to the same volume-indicator reading as before, which



automatically will give the amplitude ratio previously set up. The signal-selector switch may then be turned to the most clockwise position which mixes the two signals and connects them to the output terminals.

### SIGNAL-GENERATOR CIRCUIT

The operation of the signal generator will be made clear by reference to Figs. 5 and 6. Two separate oscillators each consisting of a 2C51/396A dual triode ( $V_1$  and  $V_5$ ) are used in a resistance-capacitance-tuned oscillator circuit. Negative feedback for each oscillat-

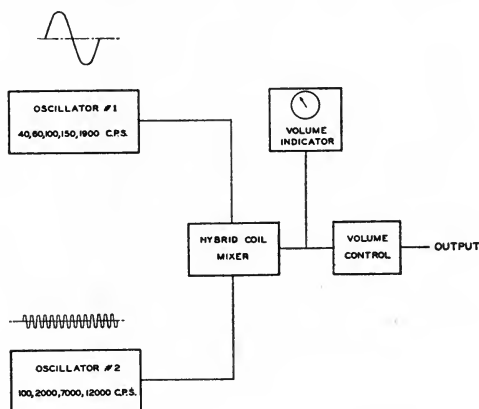


Fig. 5—Block diagram of intermodulation signal generator.

tor is provided by the voltage divider  $R_5$  or  $R_{47}$ , and the thermistor ( $R_{V1}$  or  $R_{V2}$ ) operating on one cathode of  $V_1$  or  $V_5$ . The action of the thermistor is to stabilize the oscillator output against variations which would result from changes in gain. The output of each oscillator is impressed on a three-stage amplifier, the final stage being push-pull for both cases.

The outputs of the high-frequency amplifier and the low-frequency amplifier are combined in the hybrid coil  $T_3$ . The high-frequency output of  $T_2$  is attenuated by the bridged-T attenuators connected between  $T_2$  and  $T_3$  by the switches  $D_7$  and  $D_3$ ; attenuations of 0, 6, 12, and 20 decibels are provided in the four positions of  $D_7$ . The use of the hybrid coil for combining the two frequencies results in a minimum of intermodulation between the two frequencies by

isolating the two amplifiers from each other. For most combinations of frequencies and at low outputs the intermodulation is less than 0.2 per cent.

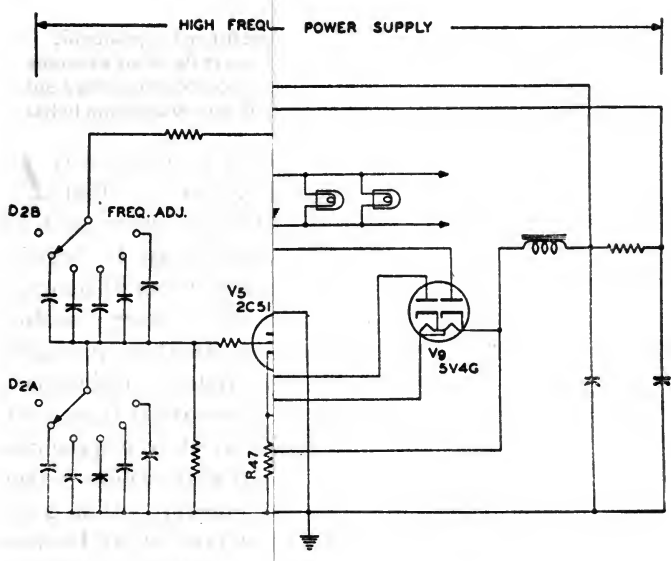
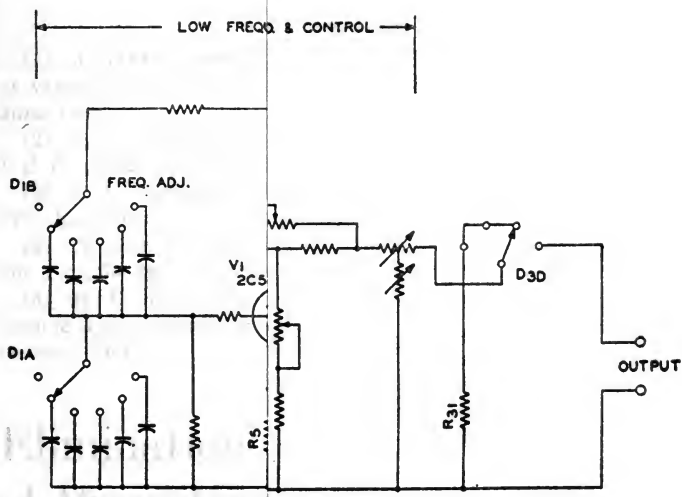
The output of the hybrid coil  $T_3$  is connected through two attenuators to the output terminals or to an internal terminating resistor  $R_{31}$ , the selection being made by the OUTPUT-SELECTOR switch  $D_3$ . The two attenuators are capable of continuous adjustment from 0 to 40 decibels. An output meter is connected directly across the output of  $T_3$ . The output from the unit is thus the value read on the output meter less the sum of the attenuations shown on the two attenuators, providing 600 ohms is connected across the output terminals.

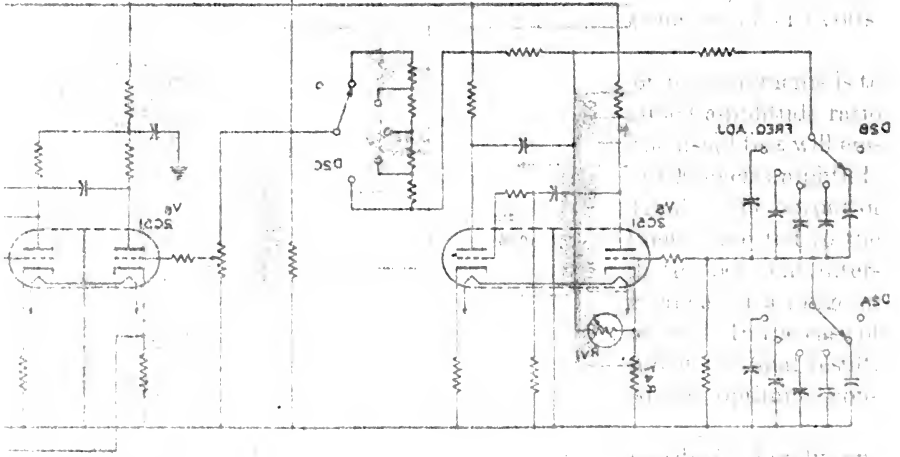
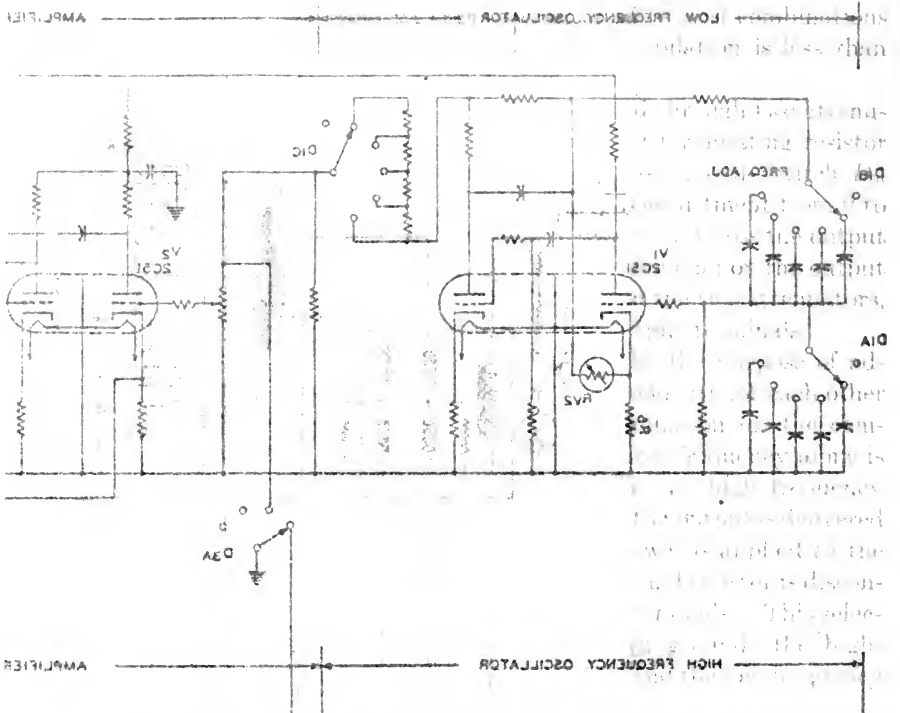
The output selector switch  $D_3$  is provided for the purpose of adjusting the outputs of the two amplifiers independently of each other and providing either internal or external termination for the combined frequencies. In the first position, the low frequency alone is applied to the output; in the second position the high frequency only; in the third position both are applied but the output is delivered to the internal terminating resistor, and no power is applied to the output terminals; in the fourth position the internal resistor is disconnected and the signal is applied to the output terminals. This selection is made by the switch section  $D_{3A}$ , which grounds the high-frequency oscillator output in the first position and the low-frequency oscillator output in the second position.

The unit has its own power supply requiring the use of 115 volts, 50- or 60-cycle alternating-current input.

The usual procedure in making intermodulation measurements is to send paired frequencies adjusted to a predetermined amplitude ratio into the device undergoing test. For example, the usual test will employ 100 cycles added to 2000 cycles and having a 100-cycle amplitude 12 decibels higher than that of the 2000-cycle signal. The output of the device, suitably amplified if necessary, is then connected to the RA-1257 Intermodulation Analyzer from which the per cent intermodulation can be read. Usually, readings are taken for a range of output levels near the region wherein overload occurs. In the case of film recording, where several factors generally affect the final result, families of curves are frequently plotted so that the optimum conditions can be more readily determined.

The intermodulation measuring equipment described is highly sensitive, yet stable and reliable as well as easily portable. It should be a useful tool in many fields of audio-frequency measurement.





... circuit diagram ...

## REFERENCES

- (1) J. G. Frayne and R. R. Scoville, "Analysis and measurement of distortion of variable-density recording," *J. Soc. Mot. Pict. Eng.*, vol. 31, pp. 648-672; June, 1939.
- (2) J. K. Hilliard, "Distortion test by the intermodulation method," *Proc. I. R. E.*, vol. 29, pp. 614-620; December 1941.
- (3) J. K. Hilliard, "Intermodulation testing," *Electronics*, vol. 19, pp. 123-127; July, 1946.
- (4) Norman C. Pickering, "Measuring audio intermodulation," *Elec. Ind.*, vol. 5, pp. 56-58; June, 1946.
- (5) H. E. Roys, "Intermodulation distortion analysis as applied to disk recording and reproducing equipment," *Proc. I. R. E.*, vol. 35, pp. 1149-1152; October, 1947.

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## Elimination of the Fire Hazard of Projectors Using Nitrate Film\*

BY LLOYD MANNON

PRESIDENT, CONTROL ENGINEERING CORPORATION, SAN FRANCISCO,  
CALIFORNIA

*Summary*—An automatic safety sprocket is described, together with adapters to fit all types of 35-mm projectors. The conditions which cause the safety sprocket to operate to prevent a fire are discussed as well as a detailed analysis of how fires can be prevented in projectors.

A FIRE within a projector is caused either by mechanical or film failure. Any device which is to protect nitrate film from combustion must respond automatically when either of these failures occurs. A speed-sensitive device which is actuated by the film will respond to any mechanical failure. It will also respond to any film failure. Such a device is the automatic safety sprocket, which is a standard 16-tooth feed sprocket, with a built-in speed-sensitive mechanism, rotated by the film as it passes through the projector. Because it is driven by the film and is speed-sensitive, anything that can happen to the projector or film affects it. Fig. 1 shows the automatic safety sprocket mounted in a Model K Motiograph. The drag of the sprocket on the film is negligible, tension in the film, created by the loop, is sufficient to hold the film against sprocket and cause it to rotate.

\* Presented April 21, 1947, at the SMPE Convention in Chicago.

In igniting nitrate film, time and temperature are equal factors. The longer film is exposed to a certain temperature, the more likely the film is to ignite. A particular sample of nitrate film withstood 150 degrees centigrade (302 degrees Fahrenheit) for 330 seconds, and withstood 180 degrees centigrade (356 degrees Fahrenheit) for 45 seconds, so there is a definite time lapse after heat is applied to nitrate film before combustion. In an investigation of the temperatures at the picture aperture, no temperatures were found that did not pro-

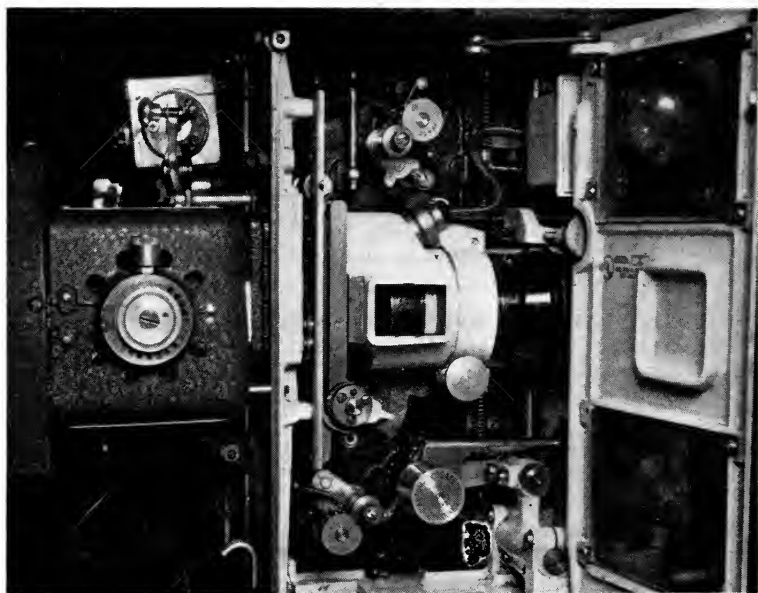


Fig. 1

vide a time lapse. By taking advantage of this time lapse and applying a device such as the automatic safety sprocket to the projector, accidental projector fires can be eliminated. The mechanism within the safety sprocket acts within  $\frac{1}{60}$  of a second after its response to any failure. The speed with which this sprocket responds to a failure depends on the type of failure. For example: The response to the loss of the lower loop is  $\frac{1}{12}$  of a second, whereas the maximum time that can elapse before response to any kind of failure is  $\frac{5}{12}$  of a second. This occurs in the event of the parting of a splice or the tearing of the film just below the picture aperture. These times

apply to the safety sprockets being installed in the projector as an accessory. However, should the safety sprocket be incorporated in the design of the projector, the maximum time can be reduced to  $\frac{3}{12}$  of a second.

The speed-sensitive mechanism within the sprocket actuates a standard microswitch, normally closed and connected to the closing coil of a dowser. Any electrically operated dowser can be used, but for economical reasons use of the change-over dowser is most practical.

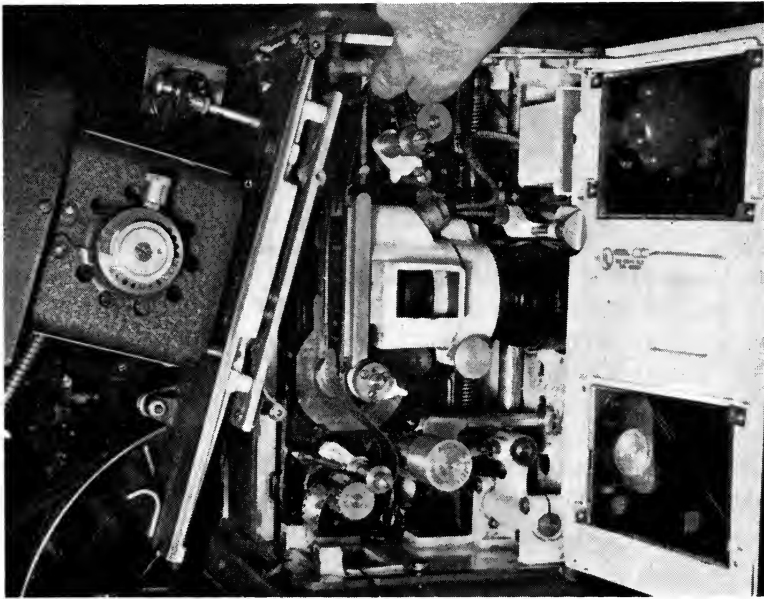


Fig. 2

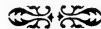
How soon the automatic safety sprocket reacts to a film failure that can cause a fire, depends on how close the safety sprocket is located to the picture aperture in the projector. To insure correct location the sprocket is provided on an adapter bracket for each type of projector. Installation is easy and simple. In placing the safety sprocket as close to the picture aperture as possible, it is only necessary to allow three frames of film between the intermittent sprocket and the safety sprocket to stabilize the film as it passes over the safety sprocket. Mounted in this position the lower loop is formed to ride on the safety sprocket and rotate it at 360 revolutions per minute.

The speed-sensitive mechanism can be set to act at any predetermined speed. In practice, satisfactory results are obtained by setting it to operate at a ten per cent drop in speed.

Many projector fires have been caused by the failure of the dowers between the film and light source to be in closed position when the light is on. By making the circuit for the lamp the controlling circuit this is eliminated. Closing the switch for the lamp excites the closing coil and closes the dowser, should it be open, holding it closed until the projector is running in a safe and normal manner. Likewise, the danger of prematurely opening the dowser is prevented. When the lamp is not lit, the safety sprocket has no effect on the projector, run-downs, and tests, and there will be no interference with the opening and the closing of the dowser. A further safety feature of the safety sprocket is control of the projector motor. This provides protection from greater damage to the film in the event of a film failure, and further damage to the projector should a bearing freeze up.

Fig. 2 shows the results of failure of the intermittent to move the film down the aperture plate. The size of the lower loop has decreased, the film has left the automatic safety sprocket, causing the mechanism within the sprocket to operate and close the dowser. Traveling at 90 feet per minute, the film left the sprocket approximately three frames or  $\frac{3}{24}$  of a second after the intermittent failed to move the film.

The foregoing is a new approach to motion picture projection and achieves the elimination of accidental projector fires.





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# 63rd Semiannual Convention

Santa Monica, California  
Santa Monica Ambassador Hotel

May 17-21, 1947  
Del Mar Beach Club

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## ● PAPERS PROGRAM

The Convention will open on Monday, May 17, with the Annual Business Session at 11:00 a.m., followed by the Get-Together Luncheon at the Del Mar Beach Club.

The program is shaping up nicely and the Papers Committee urges authors to submit Authors Forms and Abstracts to Mr. N. L. Simmons as soon as possible, and in any event not later than April 15th. Forms may be obtained from

E. S. Seeley	R. T. Van Niman	N. L. Simmons
250 W. 57 St.	4431 W. Lake St.	6706 Santa Monica Blvd.
New York 19, N. Y.	Chicago 24, Ill.	Hollywood 38, Calif.
	H. L. Walker	
	P. O. Drawer 279	
	Montreal, Que., Canada	

There will be nine Technical Sessions with papers on related subjects scheduled for presentation as a group. Color will be a topic of major interest, because a number of such papers have already been scheduled for sessions late in the week. One of these sessions is to be sponsored by the Inter-Society Color Council, and if present plans materialize will be followed by an open forum on the general subject of color in a variety of applications.

## ● RESERVATIONS

Requests for accommodations at either the Santa Monica Ambassador Hotel or the Del Mar Beach Club should be sent to Watson Jones, Chairman of the Housing Committee at The Radio Corporation of America, 1016 N. Sycamore Ave., Hollywood 38, California. W. C. Kunzmann, Convention Vice-President, points out that Santa Monica is twenty miles from Los Angeles and ten miles from Hollywood, so that members who do not expect to have their cars available should plan to stay at Santa Monica. Single rooms will be \$5.00 to \$6.00; double rooms \$7.00 to \$9.00; parlor suites at \$17.50. The Hotel Miramar in Santa Monica, about five blocks from the Convention, will have rooms or bungalows available.

## ● DINNER DANCE AND COCKTAIL HOUR

The 63rd Semiannual Dinner Dance is scheduled for 8:30 p.m. on Wednesday, May 19, in the Magnolia Room of the Ambassador Hotel and will be preceded by a Cocktail Hour in the Rouge Room.

## ● LADIES ACTIVITIES

The Ladies Committee is planning an interesting entertainment program for those ladies who attend.

## ● MOTION PICTURES

During the Convention, three theater circuits, Fox West Coast, Hollywood Pantanges, Paramount, and Warners, will extend courtesy passes to all registered members and their guests, for seven theaters in Hollywood and Santa Monica.

## ● RECREATION

In addition to special entertainment provided for the Convention, the Santa Monica area offers ocean fishing, bathing, golf, tennis, and horseback riding.

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## Society Announcements

### New Society Officers

Society Officers, Governors, and Section Officers who were elected in 1947 and took office officially on January 1, 1948, were listed in the January issue of the JOURNAL. So that new members may know who and where they are and thus become better acquainted, I am introducing them here.

LOREN L. RYDER, *President*

#### ENGINEERING VICE-PRESIDENT

John A. Maurer was re-elected for another two-year term, having served as Engineering Vice-President since January 1, 1945. He was appointed to that office by the Board of Governors to fill the vacancy created when D. E. Hyndman was elevated to the Presidency. He was then formally elected in 1946 and has continued as one of the Society's most enthusiastic members, guiding our engineering activities with a calm, steady hand. The work for which he is primarily responsible expanded during the war and after to such an extent that the Board of Governors in January, 1946, employed a full-time, paid Engineering Secretary on recommendation of the President and Engineering Vice-President to handle engineering correspondence and help administer engineering committee projects. The continuity of thought and administration provided by Mr. Maurer's re-election will prove to be a valuable asset to the industry and Society membership. Mr. Maurer was awarded the 1947 Samuel L. Warner Memorial Award for his many valuable contributions to the professionalization of 16-mm motion pictures. He is President of J. A. Maurer, Inc., and can be reached at 37-01 31st Street, Long Island City, New York.

#### FINANCIAL VICE-PRESIDENT

James Frank, Jr., newly elected Financial Vice-President, has served on Society committees and the Board of Governors continuously since 1937, when he became Secretary of the Society. In 1947 he planned and supervised the Theater Engineering and Exhibit phases of the 62nd Semiannual Convention, which made it without question the most successful venture of its kind in Society history. Largely through his efforts the exhibitors, theater architects, and equipment manufacturers were informed of the Society's interest in the engineering aspects of theater design, construction, and maintenance. In turn, the Society will now be able to assess the things of this field more completely in the planning of future engineering work, as well as future convention programs. Until recently Mr. Frank was the New York Branch Manager of National Theater Supply, 356 West 44th Street, New York 18, New York.

#### TREASURER

Ralph B. Austrian joins the Board of Governors for the first time this year as Treasurer, but is by no means a newcomer to the Society. He joined in 1935 and has served on numerous committees during the intervening years. His major interest has been in the application of motion pictures to television, and we always

think of him as an enthusiastic pioneer in this field, both in his previous associations as President of RKO Television, Inc., and now as an executive with the Foote, Cone and Belding Advertising Agency, 270 Park Avenue, New York 17, New York.

#### GOVERNORS

Alan W. Cook is now beginning his second two-year term as Governor of the Society and has a record of ten years of active participation in Society work, particularly engineering committees. He can be reached at Ansco, Binghamton, New York.

Lloyd T. Goldsmith became a member of the Board of Governors for the first time this year after a career of distinguished service to the motion picture industry and the Military Photographic Services. During the war he served as Director of the Army's Photographic Engineering Laboratory and, in addition, was Chairman of Z52, the War Committee on Photography, which, more than any other single factor, was responsible for developing the industry's vigorous interest in wartime Standards and in programs of quality improvement that followed. His address is Warner Bros. Pictures, Inc., Burbank, California.

Paul J. Larsen has been a member of the Board of Governors for many years and this year begins another two-year term in the office of Governor. As Chairman of the Society's Television Projection Practice Committee, Mr. Larsen's name has become synonymous with theater television because of his excellent work in the preparation and presentation in 1945 and 1946 of statements before the Federal Communications Commission requesting frequency allocations for theater television use. The purpose of his appearance before the FCC was to prevent the imminent reallocation of frequencies in the radio spectrum from excluding their use by the motion picture industry for theater television at some future date, if the industry felt at that time that such a development was desirable. Mr. Larsen has recently terminated his previous association with the Department of the Navy at Johns Hopkins University and is now Associate Director, Los Alamos Laboratory, University of California, Albuquerque, New Mexico.

Gordon E. Sawyer has been a member of the Pacific Coast Board of Managers and has been most active in the affairs of the Society for many years. He is also a member of the Motion Picture Research Council and has aided in the co-ordinated activity of the Research Council and the Society. Mr. Sawyer is Director of Recording at the Samuel Goldwyn Studios in Hollywood, California.

#### Atlantic Coast Section

William H. Rivers, Chairman, assumed that office and thus became an *ex-officio* member of the Board of Governors on January 1 of this year. Together with the Board of Managers, he has planned an interesting program of Section Meetings for the current year. Mr. Rivers served in the Army Signal Corps during the war and then rejoined the Motion Picture Film Department of the Eastman Kodak Company, Room 626, 342 Madison Avenue, New York 17, New York.

Edward Schmidt, Secretary-Treasurer, has been interested in the work of the SMPE for some time and this year holds his first Society office. He is with the Photo Products Department of the E. I. du Pont de Nemours and Co., Inc., 350 Fifth Avenue, New York 1, New York.

### Midwest Section

R. T. Van Niman, Chairman and *ex-officio* member of the Board of Governors, is experienced in Midwest Section affairs. The major part of organizing the Papers Program for the Society's 61st Semiannual Convention in Chicago in May, 1947, was done very capably by Mr. Van Niman, and his enthusiastic interest in the SMPE will fit him well for his new job. He may be reached at Motiograph, 4431 W. Lake Street, Chicago 24, Illinois.

George W. Colburn, Secretary-Treasurer, is well known to many members of the Society in the Chicago area and beyond. This year he holds his first Society office. He is President of George Colburn Laboratory, Inc., 164 N. Wacker Drive, Chicago 6, Illinois.

### Pacific Coast Section

Sidney P. Solow, Chairman, has been active in West Coast Section activities for years, having been on the Board of Managers previously and a member of several committees. He is now an *ex-officio* member of the Board of Governors, and in addition, is Chairman of the Local Arrangements Committee for the 63rd Semiannual Convention to be held in Santa Monica, California, May 17-21, 1948. He is with Consolidated Film Industries, Inc., 959 Seward Street, Hollywood, California.

G. R. Crane, Secretary-Treasurer, is one of the younger, more active participants in Pacific Coast Society affairs, having served on several committees and gained recognition from his associates. He is with the Hollywood Office of Electrical Research Products Division of Western Electric Company, 6601 Romaine Street, Hollywood 38, California.

### Student Chapter

(University of Southern California)

Thomas Gavey, Chairman, is a graduate student at the University of Southern California in the Cinema Department. He not only has been active in the formation of the Student Chapter at the University but also for some time has been an active student member of the Society. Mr. Gavey's address is 1046 North Ridgewood Place, Los Angeles.

John Barnwell, Secretary-Treasurer, is a graduate student in the Cinema Department at the University of Southern California and along with Mr. Gavey was instrumental in the solicitation of student memberships for the establishment of a chapter at the University. Mr. Barnwell's address is Cinema Department, University of Southern California, University Park, Los Angeles, California.

## 1948 Nominations

The 1948 Nominating Committee, as appointed by the President of the Society, was confirmed by the Board of Governors at its January meeting. The members are:

E. ALLAN WILLIFORD, *Chairman*  
40 Charles Street  
Binghamton, New York

JAMES FRANK, JR.  
18 Cameron Pl.  
New Rochelle, N. Y.

L. T. GOLDSMITH  
Warner Bros. Pictures, Inc.  
Sound Department  
Burbank, California

EMERY HUSE  
Eastman Kodak Company  
6706 Santa Monica Blvd.  
Hollywood, California

PAUL J. LARSEN  
Los Alamos Laboratory  
University of California  
Albuquerque, New Mexico

J. K. HILLIARD  
2237 Mandeville Canyon Road  
Los Angeles 24, California

E. W. KELLOGG  
RCA Victor Division  
Radio Corporation of America  
Engineering Products Department 10-4  
Camden, New Jersey

K. F. MORGAN  
Electrical Research Products Division  
6601 Romaine  
Los Angeles, Calif.

M. G. TOWNSLEY  
7100 McCormick Road  
Chicago 45, Illinois

All voting members of the Society who wish to submit recommendations for candidates to be considered by the Committee as possible nominees, are requested to correspond directly with the Chairman or any of the members of the Nominating Committee. Active, Fellow, or Honorary Members are authorized to make these suggestions which must be in the hands of the Committee prior to May 1, 1948.

There will be ten vacancies on the Board of Governors as of January 1, 1949, which must be filled. Those members of the Board whose terms of office expire are:

President.....	LOREN L. RYDER	Governor.....	JOHN W. BOYLE
Executive Vice-			
President.....	EARL I. SPONABLE	Governor.....	ROBERT M. CORBIN
Editorial Vice-			
President.....	CLYDE R. KEITH	Governor.....	CHARLES R. DAILY
Convention Vice-			
President.....	WILLIAM C. KUNZMANN	Governor.....	DAVID B. JOY
Secretary.....	G. TOEL LORANCE	Governor.....	HOLLIS W. MOYSE

The recommendations of the Nominating Committee will be submitted to the Board of Governors for approval at the July meeting. The ballots will then be prepared and mailed to the voting members of the Society forty days prior to the Annual Meeting of the Society which is always the opening business session of the Fall Convention. This year it falls on Monday, October 25, and the Convention will be held at the Statler Hotel in Washington, D. C.

E. ALLAN WILLIFORD, *Chairman*, Nominating Committee

### **Atlantic Coast Section**

The engineering data on the new RCA 16-mm recording channel were presented to the Atlantic Coast Section at its January 21 meeting by Everett Miller, RCA's technical supervisor in New York. The recording system, as a whole, was described in general, and a paper was read, dealing with the film recorder in particular. A 16-mm print of the Academy test reel was run to permit listeners to hear something standard and of known quality on the RCA reproducing system. Thereafter, various samples of films recorded on the new 16-mm recorder were presented. These samples were used to show the relationships between prints made from a negative, and direct positives processed for optimum image. There were also comparisons made between prints made from negatives, and Kodachrome prints made from direct positives. There was exhibited at the meeting the new RCA 16-mm film phonograph. Mr. Miller presented some engineering data and discussed the performance of this device. Thereafter, the meeting was opened for general discussion.

### **ASA Appoints Vice-Admiral Hussey as Administrative Head**

Vice-Admiral George F. Hussey, Jr., United States Navy (retired), wartime Chief of the Navy's Bureau of Ordnance, recently joined the staff of the American Standards Association, and on January 1 assumed the duties of administrative head of that organization. Mr. Cyril Ainsworth, who for a number of years has been in charge of the technical activities of the ASA, will serve with Vice-Admiral Hussey as director of operations of the ASA staff.

In accepting the appointment, Admiral Hussey will take over the administrative responsibilities from Dr. P. G. Agnew, one of the world's foremost authorities on standardization. Dr. Agnew has served the ASA as secretary and head of the staff for the past 28 years, and will continue his service to the organization as Consultant.

As head of the Bureau of Ordnance, Admiral Hussey was responsible for its co-operation with industry and with other government departments on standards of mutual concern. In his new capacity, he will assist in co-ordinating the joint efforts of the interested bodies in many phases of standardization.

At present, almost four hundred projects are being carried on under ASA procedures, and the Association expects to increase its activities, under Admiral Hussey and Mr. Ainsworth, to approximately three times the volume of the largest prewar year.

### Inter-Society Color Council

Members of the Society of Motion Picture Engineers have been cordially invited to attend the 17th Annual Meeting of the Inter-Society Color Council which will be held at the Hotel Pennsylvania in New York City on March 2 and 3, 1948. Since the Society is one of the fourteen member bodies of the Council, it is hoped that as many of our members who are able will attend this meeting.

A copy of the final program notice may be obtained by writing to: WALTER C. GRANVILLE, Chairman, Program Committee, Container Corporation of America, 38 South Dearborn St., Chicago 3, Illinois.

The preliminary program is given below.

#### Tuesday, March 2, 1948—Conference Room 2

9:30 A.M. REGISTRATION

10:00 A.M. DISCUSSION SESSION. Reports from subcommittees studying problems on which the Council is currently working:

- Problem 2. Color Names. (Revision) D. B. Judd, Ch.  
 6. Survey of Color Terms. S. M. Newhall, Ch.  
 7. Survey of Color Specifications. W. C. Granville, Ch.  
 10. Color Aptitude Test. F. L. Dimmick and C. E. Foss, Co-Ch.  
 11. Color Blindness Studies. D. B. Judd and LeGrand Hardy, Co-Ch.  
 12. Illuminating and Viewing Conditions in the Colorimetry of Reflecting Materials, D. B. Judd, Ch.  
 13. The Illuminant in Textile Color Matching. D. Nickerson, Ch.  
 14. Single Number Specifications for Transparent Standards. R. H. Osborn, Ch.

2:00 P.M. DISCUSSION SESSION (Continued)

3:30 P.M. BUSINESS SESSION

#### Wednesday, March 3, 1948—Manhattan Room

9:30 A.M. COLOR CO-ORDINATION IN INDUSTRY. Discussed by members of the Inter-Society Color Council.

COLOR CO-ORDINATION FOR A HOUSING PROJECT. Isay A. Balinkin, University of Cincinnati, Cincinnati, Ohio

In the spring of 1946 a project was established at the University of Cincinnati Research Foundation to develop a co-ordinated color scheme for prefabricated houses. The color scheme was developed with the aid of a mechanical color space, a model of which will be shown and discussed.

COLOR CO-ORDINATION FOR HUMAN EFFICIENCY AND SAFETY. Faber Birren, New York, N. Y.

Functional color offers one of the newest and most gratifying fields of endeavor. Because of its importance to industrial relations and human welfare, the benefits should be vastly extended. The application of this idea to industrial plants will be discussed.

**THE HOME FURNISHINGS STYLE COUNCIL PLANS.** Elizabeth Burris-Meyer, New York, N. Y.

This Council was formed to select a group of colors to serve as the basis for color correlation in all branches of the home furnishings industry.

**COLOR ENGINEERING—A DOMINANT FACTOR IN HUMAN RELATIONS.** N. Creston Dons, Libby-Owens-Ford, Toledo, Ohio

Color research, aimed at combating worker eyestrain in the manufacture of precision glass, resulted in the development and standardization of the "daylight" principle of maintenance painting in all Libby-Owens-Ford plants. A program of color engineering was inaugurated to improve working conditions, create better industrial relations, and surround the worker with an environment which makes for better public relations between him, his fellow workers, and his neighbors. Color engineering thus becomes the catalyst which bonds several harmonious conditions into one condition which we may learn to know as "Human Relations".

2:00 P.M. **APPLICATION OF MODERN COLORIMETRY TO PLASTICS.** George Ingle, Monsanto Chemical Company, Springfield, Massachusetts

Color laboratories for large manufacturers of colored plastics develop thousands of color matches each year. Too often their efforts seem directed to prove the infinity of color in plastics. But far short of this is a minimum number of colors which will satisfy most requirements. To find this number most quickly and economically, it is helpful to file color matches by their color. A three-dimensional file based on colorimetric specifications of the International Commission on Illumination is proving useful in this work. Properly organized, it can show quickly an array of the colors already developed, one of which may serve a new requirement.

**COLOR CO-ORDINATION IN MAIL ORDER AND RETAIL MERCHANDISE.** Lucille Knoche, Chicago, Illinois

A study of merchandise color co-ordination for Montgomery Ward and Company was made in the fashion and home furnishing fields. The problem was approached through consumer surveys on color preferences in various lines, analyses of color sales for past years and a belief in the creation of multiple sales through color co-ordination of related lines. The results and applications of these surveys will be presented.

**THE 1947 FRAZER-MANHATTAN.** Carl Spencer, Detroit, Michigan

Requirements of color co-ordination and scope of materials involved in Frazer-Manhattan car styling as built in mass-production quantities will be discussed. Practical methods established in maintaining color control in the production of Frazer-Manhattan cars include control of viewing conditions, spinning-disk analysis and Munsell specifications. In order to allow maximum creative development, color-effect analysis is used to supplement basic color specifications.



COLOR CO-ORDINATION IN VARIETY MERCHANDISE. Helen D. Taylor, Philadelphia, Pennsylvania

The color plan for W. T. Grant Company will be described and its application by the sources of supply, by the buying staff, and by the retail stores will be presented.

### **International Commission on Illumination, Colorimetry, and Artificial Daylight**

For those members of the Society of Motion Picture Engineers who have a fundamental interest in the science of colorimetry as well as in the current programs for developing international agreement on colorimetry standards, specifications, and terminology, the following introduction and condensed questionnaire are presented here.

The Society is a member body of the Inter-Society Color Council and has the following delegates to represent the motion picture industry's interests in this important field:

R. M. EVANS, *Chairman*

J. A. BALL

L. E. CLARKE

F. T. BOWDITCH

A. M. GUNDELINGER

M. R. BOYER

H. C. HARSH

The Inter-Society Council, as its name implies, serves to correlate the views, attitudes, and recommendations of all interested groups as individuals in this country for the use of the United States National Committee of the International Commission on Illumination.

THE EDITOR

The International Commission on Illumination (I.C.I.) is planning to resume its activities interrupted by the war. The last meeting was at Scheveningen, Holland, in 1939. The next one is scheduled for Paris in July, 1948.

The I.C.I. operates through national committees of the respective member countries comprising the Commission, and through numerous technical committees covering a wide variety of subjects in photometry and lighting. Each national committee sets up a technical committee for each subject in which it is sufficiently interested. For each of these subjects the I.C.I. assigns the Secretariat to some one country. Each national committee selects the personnel of its technical committees.

For Technical Committee No. 7, Colorimetry and Artificial Daylight, the Secretariat was assigned to the United States and the U. S. National Committee appointed the following committee:

K. S. GIBSON, *Chairman*

D. B. JUDD

D. L. MACADAM

M. LUCKIESH

P. MOON

One of the duties of the secretariat committee is to obtain information on the assigned subject from the various countries and to prepare recommendations or summaries for the next meeting of the I.C.I. Dr. Gibson, chairman of the committee, would appreciate receiving any available information on the subjects as soon as possible.

The committee desires to summarize American opinion on colorimetry and artificial daylight as well as foreign opinion. The subject of color is of increasing interest to motion picture engineers, and the secretariat committee will be very glad to receive comments on the questionnaire.

Copies of the complete questionnaire are available for distribution to anyone who wishes to assist the American Technical Committee to formulate American opinion by sending in comments. Address requests to Dr. K. S. Gibson, Chairman, U. S. Technical Committee No. 7 of the I.C.I., National Bureau of Standards, Washington 25, D. C.

### 1. *Proposed Standard Illuminant E*

At the tenth session of the I.C.I. at Scheveningen in 1939 it was recommended that the national committees study the advantages which the use of standard illuminant *E* would present as a substitute for standards illuminants *B* and *C*, to represent a generally satisfactory artificial daylight, and to serve as a common basis whenever it is necessary to characterize the color of an object for the purpose of international comparisons.

A. The proposed new illuminant *E* ( $x = y = z = 0.3333$ ) is realized by combining I.C.I. illuminant *A* (2848 degrees Kelvin) with a specified Davis-Gibson filter, in a manner similar to the realization of illuminants *B* and *C*. Many in the United States are opposed to the substitution of the proposed illuminant *E* for standard illuminant *C* in the colorimetry of nonself-luminous objects.

Do you favor or disfavor the adoption of a new standard illuminant *E* for the colorimetry of nonself-luminous objects?

B. In the colorimetry of light sources there appears to be some advantage in the use of the point ( $x_w = y_w = z_w = 0.3333$ ) representing the equi-energy source as the achromatic point for the determination of dominant wavelength and purity.

Do you favor the adoption of illuminant *E* for the achromatic point in the colorimetry of light sources, or would you prefer that the hypothetical equi-energy source be used for this purpose?

### 2. *Colorimetric Purity*

(A second recommendation of the 1939 session of the I.C.I. relates to a definition of colorimetric purity. The present questionnaire asks for comments on a suggested revision of this definition. The suggested revision uses the spectrum locus and the purple boundary of the mixture diagram for unit colorimetric purity. It uses two achromatic points. For self-luminous bodies the point representing the proposed standard illuminants *E* ( $x = y = z = 1/3$ ) is suggested; and for light reflected from objects the point representing the illuminant is suggested. Since the chromatic and achromatic components are to be evaluated in terms of luminance this definition agrees with that given in the OSA colorimetry report, *J. Opt. Soc. Amer.*, vol. 34, p. 669; 1944.)

### 3. *Standard Observer*

Do you have any scientific evidence or practical experiences that indicate that the standard observer fails to represent normal observers satisfactorily?

#### 4. *Standard Illuminants*

A. In view of the possible influence of ultraviolet irradiation on the colors of fluorescent samples, do you believe that the definition of standard illuminants *A*, *B*, and *C* should be made more precise in regard to the ultraviolet?

B. In view of the growing use of fluorescent materials and of light sources that are rich in ultraviolet energy, do you believe that an additional standard illuminant different from illuminants *A*, *B*, and *C*, by having relatively more ultraviolet energy, should be established?

#### 5. *Illuminant for Color Matching*

For commercial color matching, is it your practice to use chiefly (*a*) one or other of the standard illuminants *A*, *B*, or *C*, (*b*) some other combination of filter with an incandescent lamp, (*c*) some fluorescent lamp, (*d*) some phase of natural daylight, or (*e*) some other light source?

#### 6. *Specification of Color-Rendering Properties*

Has any recognized method been developed to indicate the degree to which artificial daylight produces a rendering of object colors in conformity to that produced by one of the standard illuminants?

#### 7. *Color Discrimination*

The various National Committees are requested to supply such data on discriminability of various colors and on ways of distorting the *XYZ* lattice to yield approximately uniform color scales as have been obtained since 1939. These data will be summarized by the U. S. Committee for consideration at the 1948 meeting.

#### 8. *Color Terminology*

It is recognized by the U. S. Committee that discussion of color terms at the 1948 meetings of the I.C.I. might have the very desirable result that divergent usage in the various nations would be reduced, or even eliminated for some color concepts. To keep the discussion within reasonable bounds, however, it is proposed to limit discussion to the nine psychophysical and five psychological concepts defined below: (There follow definitions of the psychophysical terms: color, luminance, directional luminous reflectance, dominant wavelength, complementary wavelength, purity, chromaticity, tristimulus values, and chromaticity co-ordinates; and of the psychological terms: brightness, lightness, hue, saturation, and chromaticness. Comments on the definitions and on the terms used for the concepts are requested.)

# Society of Motion Picture Engineers

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# Wartime Naval Photography of the Electronic Image\*

BY FRANCIS X. CLASBY AND ROBERT A. KOCH

UNITED STATES NAVAL PHOTOGRAPHIC CENTER, ANACOSTIA, D. C.

*Summary*—In order to train new radar operators quickly and to teach experienced operators how to utilize the newer types of radar prior to installation, the United States Naval Photographic Science Laboratory undertook the investigation of cathode-ray-tube motion picture photography on a production basis. Its methods, as described here, form the basis for the present United States Navy advances in this type of photography.

**D**URING the early days of World War II, radar was becoming widely accepted and depended upon by the United States Fleet. In combat, unit commanders realized that radar was a powerful ally, and from their experiences and reports, a definite need became evident to institute a training program for personnel. This program was designed both to train new radar operators quickly and to teach experienced operators how to utilize the newer types of radar prior to installation.

The great bottleneck lay in instructing sizable personnel to interpret successfully the wide variety of signals appearing on such equipment and to keep operators abreast of the enemy's newest methods of jamming radar and confusing radar patterns. Obviously, it was not always practicable or possible to demonstrate to students through actual operations the many signals and conditions which could and probably would be encountered. No lecture, pamphlet, or book can show, for instance, how to "read through" enemy jamming, yet still determine the range, bearing, and target angle of attacking aircraft; this task is accomplished easily and effectively only through the medium of motion pictures (Fig. 1).

Accordingly, the United States Naval Photographic Science Laboratory undertook the investigation of the virtually unexplored field of cathode-ray-tube motion picture photography on a production basis; the results, photographed under actual operating conditions, were intended for incorporation in United States Naval training films.

\* Presented October 24, 1946, at the SMPE Convention in Hollywood; Burbank session.

The methods as described herein were evolved during the war for wartime utilization and form the basis for present United States Naval advances in cathode-ray photography (Fig. 2).

A study of the cathode-ray tube to be photographed is a critical part of the photographic procedure, and should be aimed at selecting a tube of maximum illumination output. Cathode-ray tubes, new and of the same make, may vary widely in brilliancy, a variation of 60 per cent being not uncommon. The optimum tube of the group is selected and is used throughout the production unless its brilliance falls off substantially. It may be interesting to note that a given

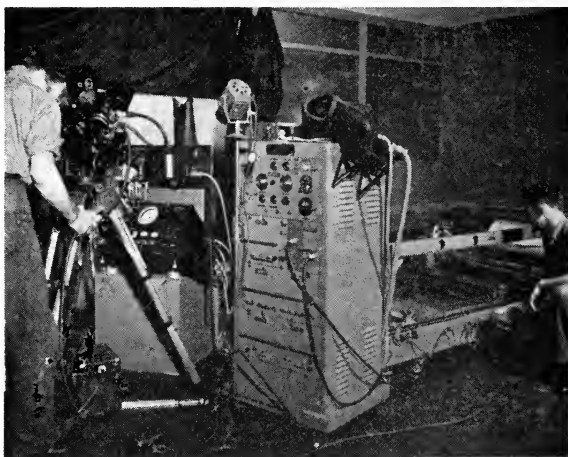


Fig. 1—Photographing the radar scope.

tube when activated in two sets of the same make may give entirely different photographic results because of inherent variations of the equipment.

The adjustments controlling tube intensity and focus are of the utmost importance from the viewpoint of the cameraman. The optimum point of signal intensity for photographic purposes requires some defining. In general, an operator views his radar scope with tube-illumination levels (gain) at a comparatively low point because of the increased contrast to the human eye. As tube intensity is increased and complete fluorescence of the scope is obtained, the signals are so diminished in contrast that the operator can no longer distinguish them. The optimum photographic point has been determined to lie just under the point where returning signals are slightly



discernible to the operator through the fairly luminous scope. When this optimum photographic point has been determined by test, its future determination must remain dependent upon the cameraman's eye. Merely marking the original control settings does not necessarily assure the same intensity from day to day. It has proved impractical to meter tubes either electrically or photoelectrically.

To the eye, a cathode-ray-tube fluoroscope assumes its greatest brilliance when viewed in surrounding darkness. It is quite natural

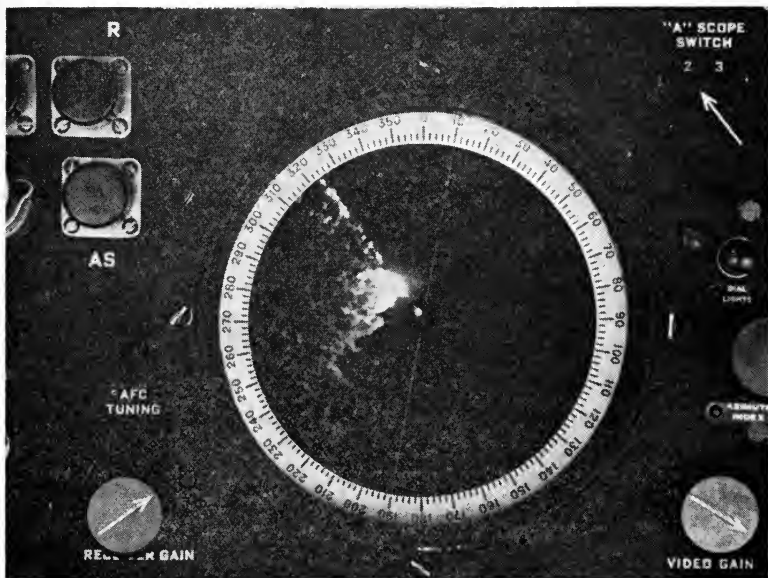


Fig. 2—A typical plan-position-indicator radar scope.

to assume that, because of the contrast noted by the eye, photography should be carried out under similar conditions. Repeated experiments and tests have shown that this assumption is incorrect. It was found that if a certain measured amount of light is projected or reflected on the face of the tube, the quality of the photographed image is considerably improved. The resulting increase in image density caused by the incident light on the tube face can be explained in part on the basis of threshold exposure; if the light used approximates that required to create a threshold exposure for the particular emulsion used and the processing to be applied, the additional exposure produced from the luminous tube is moved farther up the toe of the

sensitometric curve toward the straight line and usable region. Thus, *a small, measured amount of incident light* ("threshold" light) *on the face of the tube is one of the most critical and important factors in radar motion picture photography.*

In general, one or two heavily diffused lights are placed some distance from the tube face in such a position that unwanted shadow, hot spots, and reflections are avoided. The light may be projected directly on the tube face or bounced from a soft reflector. In any case, it is essential that the light be soft, even, and flat. The intensity of the threshold light may be controlled by diffusion, distance, or rheostat, and may be measured by means of the No. 603 Weston meter. Depending upon emulsion speed, lens aperture, tube intensity, future processing, camera speed, and the horizontal and vertical angular incidence of the light itself, the intensity may range from  $\frac{1}{4}$  to  $1\frac{1}{2}$  foot-candles, and possibly may even slightly exceed that range. The threshold light must be the *only* outside source of illumination, and should be high in ultraviolet.

Cathode-ray tubes are usually covered with colored plastic filters, which are removed during photography. If range lines or other indicating lines are desired on the tube face, a new cover of thin, clear plastic with the appropriate markings may be used.

Few concrete and unqualified statements can be made concerning camera speeds. It was generally desirable to stay as close to 24 frames per second as possible. At times, it may be possible to photograph at slightly lower speed and accordingly greater exposure if screen-speed distortion does not preclude its use. In some instances, the frequency of short persistent tubes is such as to produce harmonics with the camera shutter resulting in either partial or complete loss of exposure. It is absolutely necessary that the camera shutter turn at such speed as to prevent harmonics. Determining whether or not a serious harmonic exists may be done mathematically, employing a relationship between tube frequency, shutter opening in degrees, and shutter speed, or by straightforward visual means. If "blackouts" do not occur when watched through the camera's focusing eyepiece with the camera in operation (unloaded), and if signals appear normal and undistorted, there is no harmonic. In most cases, if the camera speed is slightly lowered, harmonics, noted at normal speed, will disappear.

If it appears impossible either to underspeed the camera without causing serious distortion, to change tube frequency, or have the nega-

tive double or otherwise optically printed, one course is open: the use of a larger shutter opening. A thorough study was made, and after a survey of all available cameras it was determined that an Akeley Standard 35-mm camera was most readily adaptable to this change. Gerald J. Badgley of the Naval Photographic Science Laboratory was successful in rebuilding an Akeley Standard to obtain a shutter opening of 291 degrees in comparison to the usual 170 degree shutter opening. This represented an increase of 121 degrees or approximately 71 per cent increase in exposure. Spatial and linear

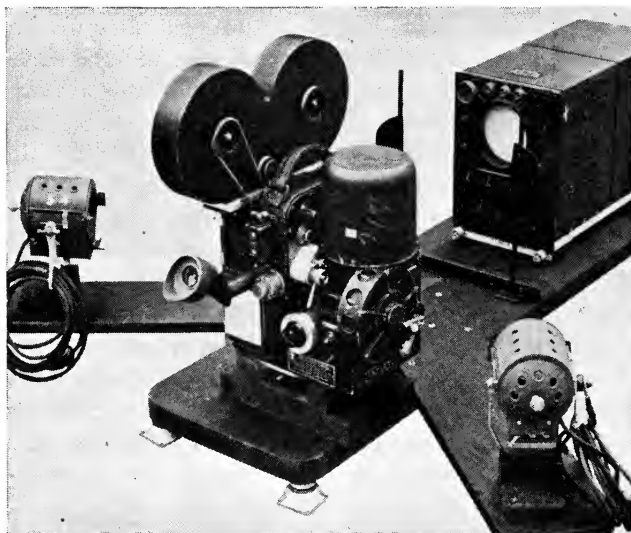


Fig. 3—Lighting and camera setup for photographing a cathode-ray tube using an Akeley single-system 35-mm camera.

distortions are occasionally noted, however, in the use of such shutter openings (Fig.3). In general, the standard precision movement 35-mm motion picture cameras, such as the Mitchell or the Bell and Howell, can be used to photograph the great majority of radar scopes.

Fifty-millimeter Zeiss Sonar lenses with maximum aperture of  $f/1.5$  were generally used in the cameras. Under some conditions, a 75-mm Zeiss Biotar lens proved useful. Almost invariably, the lenses were operated at full aperture. While any good lens of  $f/1.5$  or better is satisfactory, it should be remembered that the lenses of some manufacturers are overrated, based on transmission. The lenses were later coated with magnesium-fluoride coatings applied to

all surfaces. Transmission was thereby increased approximately 18 per cent, and definite results were observed in increased shadow detail and increased over-all sharpness of the signal images. Persistence of the signal image was improved, with diminution of flares and ghosts usually encountered when photographing a source of incident light such as a cathode-ray tube. The coatings were not of the usual commercial type, but were specially applied by the Optical Section, Navy Yard, Washington, D. C.

The possible effectiveness of filters was given extensive testing, and their use appeared to be inadvisable, having the major disadvantage of reducing exposure. The desired feature of a filter was to reduce the contrast between an overbright trace line and the signal. Experience has shown that no filters currently available are sufficiently sharp cutting to hold down the trace and transmit the signal.

In nearly every case, panchromatic film with a Weston rating of 50, such as Plus-X, was the preferred emulsion, irrespective of fluoroscope screen color. It reacted to the necessary type of processing better than any faster emulsion. Films of higher-speed ratings were also successful but had a proportional increase in graininess. When extreme speed was necessary, Eastman Fluorographic was used, although pronounced grain and subsequent loss in quality were evident. Theoretically, it would appear desirable to adopt an emulsion high in green and blue sensitivity to meet the color of most cathode-ray tubes; however, this consideration does not seem to be as critical as originally supposed. If a choice in the color of fluorescence is possible, that most closely approaching white is desirable.

Machine processing of the negatives was used exclusively. In most large production processing laboratories, only two developers are available, positive and negative. It was hardly possible under wartime conditions to reserve one entire machine for special developing solutions. If the photographic techniques are geared to the available development, with suitable adjustments in development time and selection of printer light, special developing solutions are not considered necessary. Tests with developers not adapted to machine processing did not show any gains commensurate with their disadvantages. Test results pointed markedly to the superiority of the positive-type developer for processing radar-scope negatives.

In most cases, positive-type development of 8 to 12 minutes offers a negative which will print near the middle of the scale. Increased development appears to result only in increased over-all fog. Forced

development in a standard negative-type developer did not yield comparably desirable results. Fig. 4 shows a sensitometric comparison between a comparatively fast emulsion and Plus-X in both negative and positive developer at various developer times. It may be noted that Plus-X reacted more desirably than any other fast emulsion tested. It may also be noted that the positive-type development brought about the desired advantages of increased gamma, apparent emulsion speed, and a heavier eleventh (star) step density, without undue increase in fog (Figs. 4 and 5).

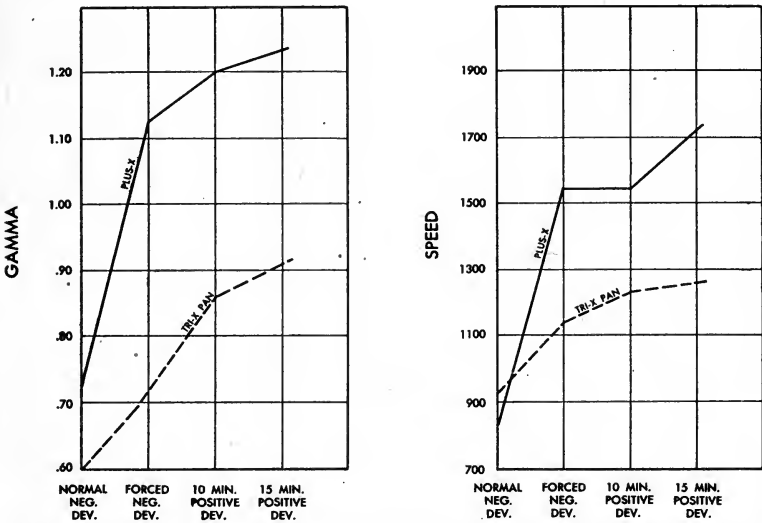


Fig. 4—Effect of development on gamma and effective speed for Plus-X and Tri-X panchromatic film.

The critical nature of radar-scope photography demands that both the tests and the entire production be carried on with film stock of the same emulsion number. Different emulsion numbers may yield slightly different results even when handled identically. When work is only slightly above the film threshold point, such small differences may produce drastically different results.

As an interesting side light to the problem of cathode-ray-tube photography, both hypersensitization and intensification for large-scale processes were attempted, and some interesting results were to be noted. In general, the mercury-vapor treatment of stock will increase film speed approximately one stop. The treatment of

substantial production footage presents many problems, however. Such factors as the influence of the treatment on various emulsions, the age of the film, differing intervals between photography and treatment remain to be answered. It was felt that the many variables which are to be encountered in hypersensitization did not allow its use on large-scale production footage. To date, no radar-scope photography has required its use. Brief experiments indicate that intensification probably holds more promise to produce better negatives than hypersensitization. In some cases, highly complicated photography of

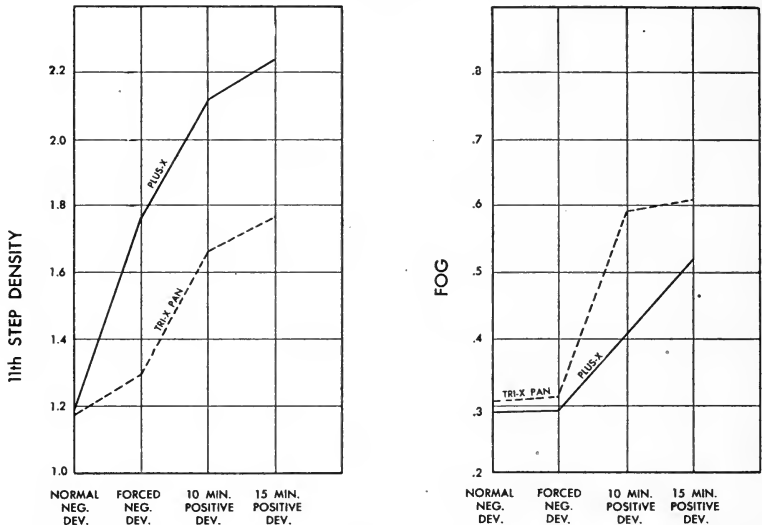


Fig. 5—Effect of development on eleventh-step density and fog for Plus-X and Tri-X panchromatic film.

the cathode-ray-tube signals were best presented by animation or a combination of animation and photography. For explanatory purposes in training films, animated signals offered the greatest clarity because they can be made uncomplicated by noise and secondary signals which frequently appear on an actual scope.

The methods and equipment described in this paper are not necessarily the ultimate in perfection, but they were the most satisfactory solution to the production motion picture photography of cathode-ray-tube signals during the war. It is emphasized that some tubes and signals pose no photographic difficulties; however, the cases where simple photography is possible should not be taken as the criterion for use in the many complicated cases.

It is the experience of the United States Naval Photographic Service that there is no secret magic involved in the satisfactory photography of cathode-ray tubes. Success is dependent upon the exacting application of the best photographic practices and the correlation of all standard photographic principles, plus some knowledge of the electronics involved. The postwar fields of cathode-ray photography are unlimited, and the basic principles as described herein doubtless will be used in the everincreasing use of photography in the fields of radar, loran, and television.

#### ACKNOWLEDGMENT

The authors wish to acknowledge and thank the following men whose foresight and photographic skill were responsible for the successful completion of radar motion picture photography, and whose meticulous data and reports were invaluable in the preparation of this paper: Lieutenant Commander Donald Hooper, Lieutenant George C. Maloney, Lieutenant Carlton G. Murray, Lieutenant Winston Hoke, and Chief Specialist L. Riley, all of the United States Naval Reserve.

#### DISCUSSION

MR. JOHN CRABTREE: What is the effect of this supplementary exposure on the front of the screen image? Does it not lower the brightness of the contrast, although it gives you effectively more speed?

LIEUT. WINSTON HOKE: I would not say that it increased the over-all contrast of the image, but it did pick up those very faint images, the faintest of which were our most serious problem. One point not covered in the paper was the various sweep speeds which were available on radar scopes. In almost all cases, we had sufficient photographic brightness. Our problem in that connection was one of timing, but we got down to the first and second and third sweep speeds, and each switch reduced the brilliancy about one tenth. We had a serious problem in the second and third speed. The foglight technique was rather striking on our tests in that, on occasion, in starting the camera the operator was blocking the light, and when his shadow cleared the face of the scope, the signal seemed to spring out with the foglight as it fell. I cannot say that it had any effect on the over-all gamma. It certainly did not tend to shorten the image.

The approach to the problem as presented in the paper is a little more formal than that which was actually accomplished. We were there with our two hands and the few cameras available, and the problem came through of photographing initially with the loran scope. It developed on tests we not only had a particular problem, but one of serious exposure in the second and third sweep speeds. I am not sure about the third, but I believe there were at least two, maybe three. We did not attempt to go too far into basic research in the problem, since there was not time. It was simply a case of using known techniques and squeezing the most out of them that we could under wartime conditions. The co-operation

and very close attention given to us by Wilson Leake, who was in charge of processing, very greatly aided this work. It was decided in conference with Mr. Leake that we would not try to advance too far into special developers, because his facilities were limited, and if we could get a possible solution with developers that were currently in production use, we could handle our photography on a production basis. As the ultimate goal, I am sure this work will be surpassed, or has been now; but it is an interesting story of what could be done or was done by squeezing the most effect we could get from forced development and from the use of the foglight or threshold exposure.

MR. HARRY R. LUBCKE: Why were your lights incandescent? Were they provided with filters? What was the nature of the exposing lights?

LIEUT. HOKE: The lights were incandescent.

MR. BOYLE: In the later stages of the war I was out at 20th Air Force and we had problems involving much the same as you did, only they were all airborne problems, that of taking the photographic image off of the airborne radar on B-29's and the problem there was to fly B-29's reconnaissance missions over Japan and over a planned route and make photographs of the scope and bring them back and brief whole groups from the basis of that reconnaissance flight. However, we had quite a bit of difficulty, and I am interested to find out from you whether this idea of yours was applied actually in operations with Navy airborne equipment. It seems rather large and bulky as shown here, and I just wondered whether you were using that for operational briefing.

LIEUT. HOKE: We had cameras mounted in the aircraft on all of the airborne equipment which was sent to us for photographic purposes. The nature of our work there was in connection with getting training-film problems on the screen, and I regret I do not have the reference here as to plane types, or radar types that we photographed, but we did fly in torpedo bombers. I took quite a jaunt in a PBM over the Atlantic, and on the trip we did not use the bulky equipment that you see. We did, however, use a full-sized motion picture camera. One of the cameras would carry the bulk of our work. It had about a 230-degree shutter that was used on the major part of our loran photography. It permitted us to use a photographing speed of approximately 17 pictures per second. Assuming you have a radar sweep speed of 25 cycles, if you tried to photograph that with a 170-degree camera reduced to approximately 12 pictures per second, and speeded up the action two to one, which is quite noticeable on the screen, it therefore decreases its training value. If you can squeeze it to 230, you can get close to 18 pictures per second and the eye and mind are much more willing to accept 18 pictures per second speed for training purposes. We later found one scope with a speed of, I believe, 10 cycles per second. That one was difficult. That was with the standard Akeley where we managed to get the 291-degree shutter, and by photographing at approximately eight pictures per second, and double-printing each frame, we achieved a screen result of 16 pictures per second, which retained its training-screen value. But exposure was a very serious problem to us in this work, and the threshold light was an astonishing aid. I hardly believed the results I saw. That is the photographic problem that caused us to request the Research Developing Department to find us a hypersensitizing aid. Roy Deering, who was then in charge of that department, succeeded in doubling the speed of the film by his mercury treatments. However, it was rather awkward to use in any quantity, and since the pressure was not too great, we did not actually use it to any large extent.



# High-Speed Motion Pictures with Synchronized Multiflash Lighting\*

By R. A. ANDERSON AND W. T. WHELAN

NAVAL ORDNANCE LABORATORY, WHITE OAK, MARYLAND

*Summary*—Equipment to synchronize a high-intensity flashlamp with a high-speed motion picture camera has been designed and built. The camera was a 16-mm, rotating-prism type and synchronization was accomplished by a brush-type contactor built into the camera. The electrical signal from the contactor was sent through a pulse-forming circuit to a trigger tube in the flashlamp circuit. The film speed was 1800 frames per second and the duration of each flash was about one microsecond. Resolving-power tests made by photographing a one-foot disk revolving at 1500 revolutions per minute showed the marked superiority of flash-lighting over continuous light at these speeds. The resolving power measured for a rapidly moving object was doubled by the use of multiflash lighting, and, even in the case of a stationary object, a 25 per cent increase was obtained.

## INTRODUCTION

IN ORDER TO obtain maximum effectiveness in the photography of fast-moving objects, exposure time must be kept to a minimum. This is particularly true in the recording of high-speed motion pictures where both the object and film are in motion. The motion of the film may be partially compensated by the use of a rotating-prism-type shutter† which deflects the image so that it follows the motion of the film, thus reducing the blurring caused by longer exposure time. For very high speeds, however, it is desirable to employ multiflash lighting and rely on the extremely brief duration of the flashes for timing exposures.<sup>1</sup> This paper describes the results obtained when a simple, multiflash lighting unit was synchronized with a high-speed motion picture camera.

## ADVANTAGES OF MULTIFLASH LIGHTING

In addition to permitting increased definition in high-speed motion pictures, the brief flash durations obtained with multiflash lighting result in an increase in efficiency over incandescent lighting as regards the utilization of available light output. For instance, if, when using

\* Presented October 21, 1947, at the SMPE Convention in New York.

† Commercially available cameras using a rotating-prism-type shutter are the Eastman High-Speed Camera, Type III, and the Western Electric "Fastax".

incandescent lighting, the exposure time per frame is one fifth the time required for each frame to pass the camera lens,\* then four fifths of the light energy required is wasted. With multiflash lighting, the camera shutter is open during the total duration of the flash and no light energy is cut off by the shutter. This results in an increase of efficiency by a factor of five. A second advantage of multiflash lighting lies in the spectral distribution of its light output.<sup>2</sup> The light emitted by an argon- or xenon-filled flashtube lies mainly in the blue-violet region of the spectrum where high-speed photographic emulsions are most sensitive. With incandescent lighting, the major part of the energy radiated lies in the red and infrared end of the spectrum and this is obviously inefficient for high-speed photographic work.

#### CAMERA AND SYNCHRONIZING SIGNAL

In order to use multiflash lighting for motion pictures, some system of synchronizing the flashes with the camera speed is required so that the frames will be spaced properly on the films. It was considered desirable to design synchronization equipment for use with a rotating-prism-type camera so that this camera might be employed with multiflash lighting when fine detail was required, but might also be used with a simple incandescent light source. The synchronization was accomplished by producing a signal, through a contactor on the camera, and sending this signal to the grid of a control tube. The control tube in turn operates the flashlamp.

The performance of the Eastman Type III rotating-prism camera had proved to be so satisfactory with incandescent lighting that it was chosen for the adaptation of synchronization. Because of variation in the speed of the camera during the run, it was necessary to provide for synchronization over a range of frequencies. While an average speed of 1750 frames per second was sought, the actual camera speed during the usable portion of its run varied from 1600 to 1900 frames per second. Synchronization was made available over a range of speeds from 1500 to 2000 frames per second. A contactor, consisting of nine radially located steel bars set into the side of a bakelite disk, was attached to the motor shaft of the camera as shown in Fig. 1. A brush was used to make contact with one of the steel bars each time the prism moved to its wide-open position.

\* Instruction booklets indicate that these are the relative times obtained with the Eastman Type III Camera.

Fig. 2(A) shows the idealized contactor signal which would result from a sharp, clean, make-and-break contact between the contactor bar and brush. Oscillographic examination of the contactor signal, however, showed this signal to be quite ragged because of vibration of the component parts of the contactor, and inductive and electrostatic interference from the driving motor. Voltage spikes of an amplitude comparable to the desired signal voltage occurred at random, preventing synchronization of the system. Fig. 2(B) shows a sketch of the signal actually obtained. To remedy this condition, the inte-

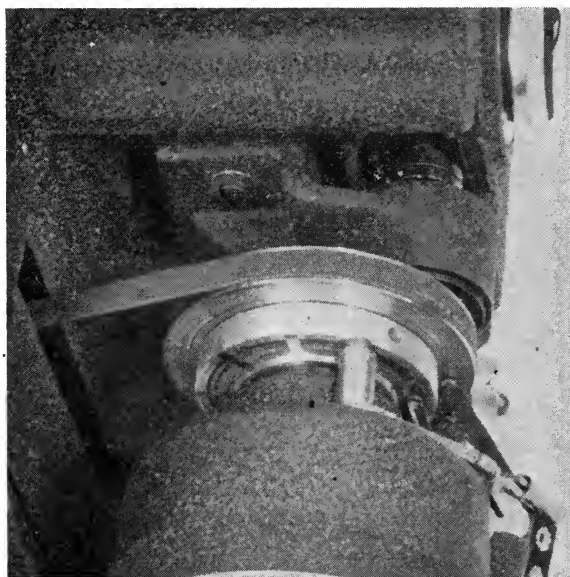


Fig. 1—Details of contactor mounted on motor shaft of camera showing nine radially located steel bars and brush.

grating filter shown in Fig. 3 was added to the contactor circuit. A capacitor  $C_1$  charges through resistor  $R_1$  during the make period of the contactor and discharges through resistor  $R_2$  during the break. The resultant output signal is of the form sketched in Fig. 2(C). After the charge and discharge time-constants of the circuit were properly adjusted for the desired camera speed, the contactor signal was found to be entirely satisfactory for more than fifty consecutive shots.

The output signal from the contactor is fed directly to a pulse generator which shapes the signal and increases its magnitude. The pulse

generator is of the multivibrator type, having an output of 150 volts with a variable pulse width, and is readily synchronized with an input signal. A quick check may be made of the signal by putting ear-phones across the output of the pulse generator and starting the camera. If the apparatus is functioning properly, a musical note of rising

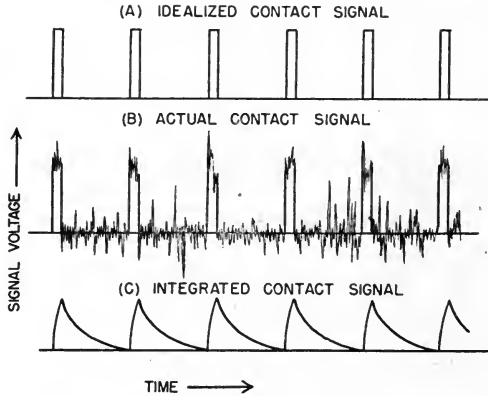


Fig. 2—Sketches of ideal and actual contactor signals.

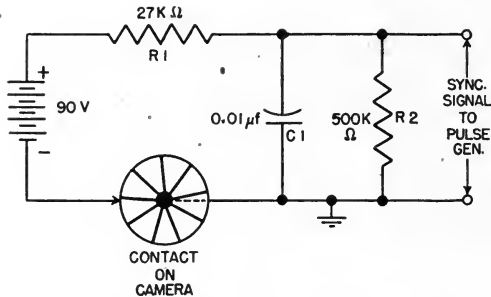


Fig. 3—Integrating filter circuit added to contactor circuit.

pitch will be heard as the camera approaches operating speed. If the synchronization is faulty, the note is unmusical except for short, disconnected bursts, and this condition can be corrected without the necessity of taking pictures.

#### FLASHTUBE CIRCUIT

The conventional flashtube circuit, shown in Fig. 4, was used. A storage capacitor of one-tenth microfarad is charged to approximately

8000 volts and discharged through the flashtube and a 4-C-35 hydrogen thyatron. The capacitor is charged between flashes through the charging choke connected to a high-voltage power supply. Flash durations of about one microsecond are obtained with this circuit. The 4-C-35 hydrogen thyatron performs reliably in this circuit, requiring a minimum pulse of at least 150 volts from a source whose internal impedance is 1000 ohms or less. This thyatron proved to be capable of withstanding this intermittent heavy loading over long periods of time.

#### SEQUENCE OF EVENTS

The life of flashtubes can be considerably prolonged by limiting the duration of the flash burst so that the large amounts of power expended in the tube do not cause blackening of its walls caused by

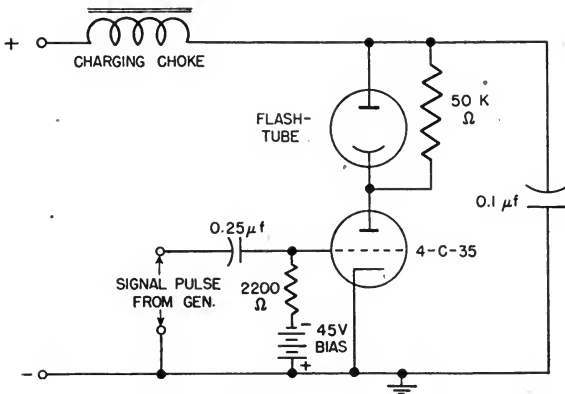


Fig. 4—Flashtube circuit.

sputtering of the electrode materials onto the walls. To restrict the total number of flashes for any one test run, the electronic equipment shown in Fig. 5 was introduced. The camera is started first and gradually increases its speed. During this interval the camera contactor is delivering signals to the pulse generator. However, the pulse generator has been modified for use in this circuit so that it does not respond to these premature signals. This is accomplished by negatively biasing the output amplifier tube of the pulse generator well beyond the cutoff value. Thus no further action takes place during the acceleration period of the camera. A microswitch built into the camera is set to close after a predetermined number of feet of film has run through,

thus providing an easily adjustable delay period during which the camera accelerates. The closing of this switch initiates the action to be photographed. At the same time, an interval timing switch is tripped and removes, for a preset interval, the negative bias on the output tube of the pulse generator. During this interval, the burst of flashes takes place.

#### PHOTOGRAPHIC TEST

Tests were made of the photographic performance of the Eastman camera, both with flash and incandescent lighting, by taking motion pictures simultaneously of moving and stationary resolving-power charts. The moving charts were mounted near the rim of a rapidly revolving disk. The three pictures on the left of Fig. 6 are enlarge-

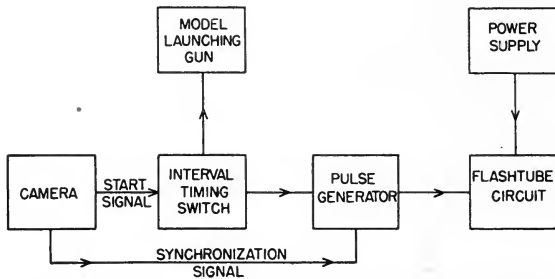
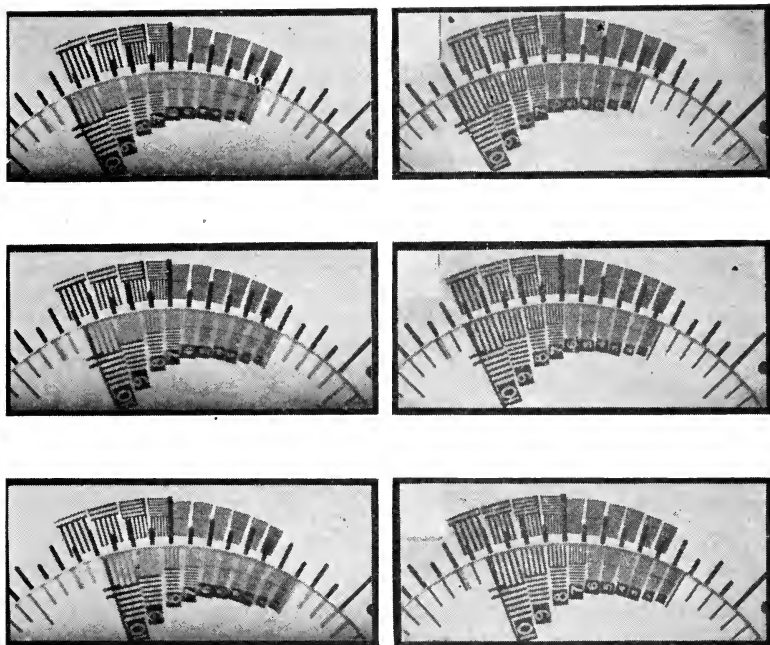


Fig. 5—Block diagram showing camera and multiflash equipment.

ments of consecutive frames of a film taken with incandescent lighting, while the other three were taken with flash lighting. Each picture shows two sets of resolving-power grids numbered from one to ten; the set on the disk rotates at 1500 revolutions per minute with a peripheral speed of 78.6 feet per second, while the outer set is stationary. The pictures were made at a camera distance of eight feet, with a Kodak Anastigmat, 102-mm,  $f/2.7$  lens. Optimum exposure in each case had been determined by experience; the lens was used at  $f/6.5$  for incandescent and at  $f/5.6$  for multiflash lighting. No changes were made in the focus of the camera, position of the camera, or position of the resolving-power grids between tests. Super-XX film was used and was developed as a negative in D-72 developer, diluted one to one.

The numbers of lines per inch and per millimeter *on the film* were calculated for the various resolving-power grids and are listed in

Table I. The films indicated resolving powers for the stationary grids of 1020 lines per inch (40 lines per millimeter) with flash lighting, and 815 lines per inch (33 lines per millimeter) with incandescent lighting. For the rotating disk, the resolving power with incandescent lighting was 356 lines per inch (14 lines per millimeter) while multiflash lighting gave 815 lines per inch (33 lines per millimeter). Thus



(A) Incandescent Lighting.

(B) Multiflash Lighting.

Fig. 6—Enlargements of resolving-power photographs with multiflash and incandescent lighting. In all the pictures the outer arc is stationary while the inner arc rotates at 1500 revolutions per minute.

the resolving power was more than doubled by the use of multiflash lighting in this test. Obviously these results do not represent the exact limits of the resolving power in each case since the resolving-power grids represent only ten arbitrarily selected steps between 170 and 1400 lines per inch or between  $6\frac{2}{3}$  and 56 lines per millimeter. No intermediate determinations of resolving power were made between these steps.

The resolving powers obtained seem quite reasonable when the limits imposed by exposure time and the resolving power of the film are considered. A resolving power of 1020 lines per inch (40 lines per millimeter) obtained with multiflash lighting and stationary grids is about that to be expected of Super-XX film with D-72 development. The lower resolving power which was found with stationary grids when incandescent lighting was employed can be attributed to blurring caused by the relative motion between the film and image during the longer exposure time. The multiflash-lighting data obtained with moving grids show a decrease in resolving power when compared to the stationary grids. This decrease is believed to be exaggerated by

TABLE I  
LINES PER INCH AND PER MILLIMETER ON THE FILM FOR THE RESOLVING-POWER GRIDS

Grid Number	Lines per Inch	Lines per Millimeter
1	1400	56
2	1020	40
3	815	33
4	687	27
5	612	24
6	508	20
7	356	14
8	254	10
9	203	8
10	170	$6\frac{2}{3}$

the lack of intermediate readings between 815 and 1020 lines per inch (33 and 40 lines per millimeter). With incandescent lighting and moving grids, the resolving power dropped to 356 lines per inch (14 lines per millimeter). This can be entirely accounted for by the motion of the object during the exposure time of approximately 110 microseconds.

#### ACKNOWLEDGMENT

The authors wish to acknowledge the assistance given by Dr. J. H. McMillen, Dr. A. May, Mr. D. J. Milano, and other members of the Hydrodynamics Subdivision.

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## DISCUSSION

COMMANDER KENNETH SHAFTAN: Did you remove the prism with the Eastman high-speed camera?

MR. ROBERT A. ANDERSON: No. We timed our flash measurements to occur when the shutter was in its wide-open position, that is, when the surface of the glass plate is perpendicular to the optical-center line.

COMMANDER SHAFTAN: It seems to me that the resolution would increase tremendously by elimination of that quarter-inch glass plate through which you shoot.

MR. ANDERSON: We intend to try using the camera with the prism in place at still higher speeds. In such pictures, the action of the prism might be of noticeable value in synchronizing the motion of the film and image during exposure time.

COMMANDER SHAFTAN: The General Radio Company in Cambridge, Massachusetts, has a motion picture camera in conjunction with multiflash equipment. They get a resolution approximating about 70 lines per millimeter. I note that yours runs approximately 40 at its best with the multiflash system, and I think it is probably not due to image displacement but to the prism. Usually that prism does not promote very good resolution, particularly in your flash-duration period, in giving you an extending exposure, but also giving you a displacement of the image due to the rotation of the prism itself.

MR. ANDERSON: I am not familiar with what type of film or development was used in the test with the General Radio camera. As I stated, our film was Super-XX and we used D-72 developer.

# Electronic Flashtube Illumination for Specialized Motion Picture Photography\*

BY HENRY M. LESTER  
NEW YORK 17, NEW YORK

*Summary*—This paper presents a discussion of the possibilities of utilizing electronic flashtubes in synchronization with standard motion picture cameras at normal and moderately high exposure rates. The results of experimental tests are described, and are followed by descriptions of two units, the Cine-Strobe-Light and the Universal Strobe-Light intended for use in this manner. Associated lighting equipment is shown, and results obtained, together with side effects, are discussed.

IN A PAPER presented before the Society of Motion Picture Engineers,<sup>1</sup> Carlson gave a preliminary appraisal of flashtubes from the point of view of motion picture studio photographers. He discussed the basic principles of repetitive flashing circuits; and the problems involved in the studio use of flashtube illumination, including the psychological effect of a flickering light source on the performer, and the electrical effects of large power discharges in proximity to sound-recording circuits. While no final conclusion could be drawn from these tests, the economic factors entering into them being unexplored, the paper did indicate that the results obtainable with conventional motion picture cameras established the possibility of such use in the future.

It must be kept in mind that the flashtube was originally designed for motion picture photography, with shutterless high-speed cameras using a continuously moving film. Only later was it adapted to use with still cameras, and in this latter field gained wide acceptance by photographers in general. To some extent, the problem of using flashtubes with the conventional motion picture camera was a more involved one. No difficulty was anticipated in synchronizing the light flashes with the camera shutter: this could easily be accomplished with one of several conventional circuits.

\* Presented before the Rochester Section, Technical Division, Photographic Society of America, December 3, 1947.

But the energy-storage principle used in most single-flash power packs gives a misleading impression of the power requirements of flashtube circuits. When 10 to 30 seconds are available to recharge a capacitor, power drain from the line is trifling. When the recharging must be accomplished in  $1/24$  to  $1/64$  of a second, power requirements mount by leaps and bounds.

A further problem is that of tube heating. Flashtubes are not designed to radiate much heat: in fact, this is one of the favorable factors which impelled their use in the examples to follow. On single flashes, the heat generated is dissipated completely in the interval between flashes. Repetitive flashing imposes a different requirement, and there was doubt that the conventional flashtube could stand up under such conditions.

Experience with flashtubes used with the high-speed motion picture camera was not of much assistance in this connection. Such tubes were specially designed for that service, and, in addition, a high-speed camera exposes its entire roll of film in a matter of seconds. With conventional motion picture cameras, continuous runs of as long as three minutes might be required.

However, it appeared to the present writer that these difficulties were not insurmountable, and that the electronic flashtube would provide an unusually valuable light source for certain specialized types of cinemography. The high intensity of the light, its short duration, and the low heat radiation were all advantages worth considering against the aforementioned difficulties.

### BASIC THEORY

It is not the function of this paper to explain more than the fundamentals of flashtube power packs and the design of associated equipment. These, and the characteristics of flashtube illumination from the photographic point of view, have been covered at length by Murphy and Edgerton,<sup>2</sup> Carlson and Pritchard,<sup>3</sup> Edgerton,<sup>4</sup> and others. Basic circuits and components, and design factors for their use, have been discussed by Edgerton, Germeshausen, and Grier,<sup>5</sup> and by Carroll.<sup>6</sup>

Basically, all electronic flash illuminators follow the elementary circuit shown in Fig. 1. The main capacitor is charged to a voltage somewhat below the self-discharging (or breakdown) point of the flashtube, by the main voltage source through the limiting resistor  $R$ . A similar circuit is used in the primary of the trigger transformer  $T_1$ .

which is designed to apply a pulse of approximately 15,000 volts to an external electrode on the flashtube. The application of this pulse ionizes the gas filling of the flashtube, lowering its resistance and causing the capacitor to discharge through the tube. This discharge, lasting from  $1/1,000$  to  $1/30,000$  of a second, results in the emission of a very intense flash of light. Because of the short time of the discharge, the instantaneous power values are very large, sometimes running as high as a million watts and more. This accounts for the very large light outputs resulting.

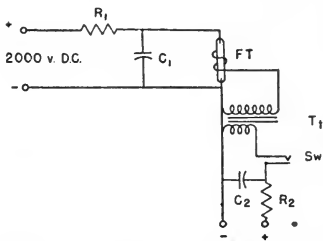


Fig. 1—Basic circuit of an electronic flash illuminator.

The capacitor is charged through a limiting resistor  $R$ , previously mentioned. This resistor serves two functions. First, it limits the charging current drawn by the capacitor at the beginning of each cycle to a safe value for the power supply. Second, it prevents the flashtube from drawing current directly from the power source, which would result in a continuous-glow discharge, damage to the tube,

and overloading of the power supply.

At extremely rapid repetition rates, the value of this charging resistor  $R$  necessarily must be small to permit substantially complete recharging of the main capacitor between flashes. Under the circumstances, considerable danger of sustained-glow discharges (or "hold-over") exists. Deionization of the flashtube must then be accomplished by other means, such as inductance added to the circuit to reduce the voltage at the end of the flash to zero. Mercury switch-tubes such as the General Electric Capacitron are also used to aid in stopping the current flow at the end of a flash. The relation and action of these parts will be discussed at greater length in connection with the Cine-Strobe-Light.

The present paper will discuss two special purpose power supplies for flashtube operation, and associated equipment for scientific motion picture photography. The first of these, the Cine-Strobe-Light, was designed for entomological photography on a macroscopic basis. It is strictly a single purpose unit, its design taking into account not only photographic problems, but also safety factors and the necessity for its use by untrained personnel.

The second unit, the Universal Strobe-Light, is intended for use by

the author's own staff: it is adaptable to a wide range of specialized photographic purposes, and was designed for rapid circuit changes and maximum versatility. This involved eliminating certain safety factors which would have impeded immediate change of various circuit components. Other safety factors have been introduced in their stead, so that any part of the unit may be handled within a matter of seconds after power has been shut off.

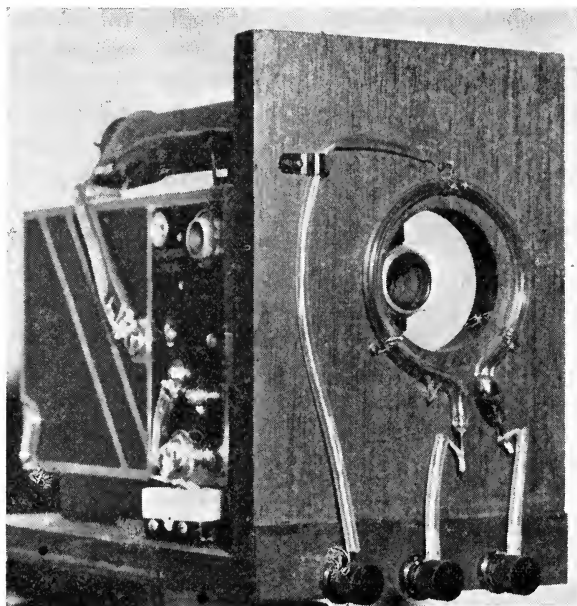


Fig. 2—Mockup of camera support, commutator (simulated by wiper operating microswitch), and FT-429 flash-tube without reflector.

### THE CINE-STROBE-LIGHT

#### *Preliminary*

The design and construction of the Cine-Strobe-Light was the result of a request from a Western entomologist for a lighting unit which would permit macroscopic cinephotography of insects without excessive heat. Illumination levels had to be high enough to permit exposure on Kodachrome film, at frame frequencies from 16 to 64 exposures per second, and to permit use of lens apertures small enough for adequate depth of field at these close ranges. Because of the close

working distance, the light unit proper had to be very small; to avoid equipment shadows, it was required to work as close as possible to the lens axis.

These requirements indicated that incandescent or arc illumination would not be practical, both on the ground of bulk and because of heat problems. While heat-absorbing cells and special glasses and filters are available, their use changes the color composition of the light to an undesirable degree. This unit was to be used by personnel who were not photographers; it was felt undesirable to present them with the problem of compensating the color of the light source by filters or other means.

The possibility of using flashtubes in connection with a cine camera had been under consideration for some time before this problem came up; it appeared to present the possibility of a solution in this case. Radiant heat from the flash appears to be favorably low, the flash itself is intense, yet well diffused, and the color temperature of the light from a xenon-filled flashtube is almost exactly correct for use with daylight-type color films.

Fortunately, there was available at the time, the General Electric Type FT-429 flashtube, a quartz ring  $2\frac{3}{4}$  inches in diameter. It appeared that such a tube, surrounding the lens, would provide adequate coverage of the fields to be photographed, and would have a very desirable shadowless quality.

For a preliminary test, a simple wooden stand was made, and painted dead black. One of these tubes was mounted on the front, surrounding a hole in the board. A standard 16-mm motion picture camera was mounted to the base of this unit, with its lens pointed through the hole. (See Fig. 2.) A simple wiper was fastened to the crank shaft of the camera, in such position that it would operate a microswitch at the open point of the shutter at each exposure. (Fig. 3.)

This setup was connected to a small power pack, similar to the portable units sold for use with still cameras. Since this pack took several seconds to recharge, even with small capacitors, it was not possible to run the camera at normal speeds; however, a series of single-frame exposures was made to determine the power required for optimum exposure levels at the lens apertures to be used.

The results of these tests indicated the possibility of securing adequate exposure under the required conditions, with between 12 and 14 microfarads of capacitor working at between 1800 and 2000 volts.

However, the problem of recharging a capacitor of that size in  $1/64$  of a second dictated the reduction of the final capacitance to 6 microfarads, raising the circuit voltage to restore the power level to the same total amount.\*

However, another factor entered at this point, and made it unnecessary to raise the voltage all the way to the point of doubling the power output (this would have been 2800 volts). In preliminary tests, the front of the board on which the flashtube was mounted was painted flat black, so that only the actual illumination from the tube itself was being used. The addition of a highly efficient reflector increased the light level at the subject plane to a degree which necessitated raising the voltage only to 2300 volts with 6 microfarads, to secure the same light as 12 to 14 microfarads at 1800 to 2000 volts without reflector.

This reflector was designed by a member of our own staff as a parabolic toroid (or paraboloidal semitorus . . . we have been unable to agree on just what the final shape is called). In effect it is a trough of parabolic cross section, bent into a circle to follow the tube. Mounting clips for the tube hold it quite accurately at the focus of the parabola. (See Fig. 4.) The reflector itself is spun from aluminum sheet and finished inside with matte Alzak; many favorable comments have been received on the unusually smooth light distribution and high efficiency of this unit.

At this point, all the basic design factors were known, except the important one. Would the FT-429 operate under such loading conditions? Basically, the FT-429 is intended for single flashes at widely spaced intervals, and is rated at 400 watt-seconds per flash. Our

\* Since the power (and light output) is given by the expression  $J = \frac{1}{2}CE^2$ , large increases in power can be obtained more easily by increasing voltage rather than capacitance.



Fig. 3—Contactor built onto one-frame-per-turn shaft of camera, operates microswitch to close trigger circuit of flashtube.

individual flash loading was far below this point: 6 microfarads at 2300 volts is actually not over 10 watt-seconds.

But we were figuring on flashing at rates up to 64 frames per second; this is a continuous loading of 1024 watts, or more than  $2\frac{1}{2}$  times the rating of the tube. Even at 24 frames per second, the load was nearly 400 watts; while this was the design loading of the lamp, it was based on intermittent flashing with plenty of cooling time between flashes. It was questionable whether the tube would stand up under such rigorous treatment.



Fig. 4—Toroidal-parabolic reflector with FT-429 tube flashing. Note even reflection and light distribution.

Even if it would do so, there was another unknown: how long would it last? Little is known of the actual life of flashtubes: they are nominally rated at 10,000 flashes. At 64 frames per second, this would give a \$28.00 tube a total life of 3 minutes, and even at 24 frames per second, hardly more than 7 minutes.

At this point, the problem was moved to Boston. Dr. Edgerton and Mr. Wyckoff, of the Massachusetts Institute of Technology, assembled a bread-board mockup of the power supply, with a motor-driven commutator simulating the camera. A single FT-429 was operated at the desired loading, and at 24 flashes per second, in 3-minute bursts, simulating 100-foot rolls of 16-mm film. At the end of five such bursts, the tube was still operative, though its electrodes had practically evaporated, and the tube was blackened to a degree severely limiting its light output.

The tube electrodes had reached white heat at the end of each burst, and the tube itself was far too hot to touch. Nonetheless, the radiant heat at a distance of a few inches was negligible. It was thought, therefore, that if such tube life could be obtained under the most unfavorable conditions, even greater life could be expected if the bursts were held to a few seconds each, the normal procedure for motion picture photography. Later this was borne out in practice.





Similarly, plate (or high-voltage) and filament circuits are fed from separate power transformers. In this way, all filaments can be preheated before use, and the pack can remain in operative condition between shots, with no high-voltage present until actually needed.

The high voltage is fed to the flashtube through a Capacitron which acts as a switch. In this way, even with the high-voltage transformer energized, there is no high voltage present in the tube wiring or terminals except while the tube actually is flashing. In addition to this switching function, the Capacitron also serves to aid in deionizing the



Fig. 6—Front of Cine-Strobe-Light power pack, showing switches, plugs, and pilot lights. All are marked to correspond with the circuit diagram; all are different in size and shape to prevent any possibility of misconnections.

flashtube and prevents holdovers or glow discharges. This is accomplished in connection with the third rectifier tube and an inductance, in a manner which will be explained later.

As can be seen from the circuit diagram, there are a number of external connections to be made. These are done with plugs, all of which differ from each other both in number and spacing of prongs, so that it is impossible to put any plug in the wrong socket, or to insert it in the correct socket the wrong way. (See Figs. 6 and 7.)

A compact, well-insulated commutator was designed and built to fit the single-frame crank shaft of the camera. (Not shown here.) It was essential that this place the minimum drag on the shaft as the

gearing at this point is high in ratio to the rest of the camera and a small load on this shaft will slow down the camera seriously. Since little current is carried by the commutator points, they were made small in area for minimum frictional effect, a spherical tip being used on the brush, and the commutator contact itself being a bar of bronze, flush with the surface of the commutator rotor. The commutator connects with plug  $P_2$  on the power pack: this outlet, of course, could also be used for a still-camera shutter or a free-running commutator for multi-exposure (or stroboscopic) uses.

$P_1$  is the main input plug for the 115-volt, alternating-current line. It is connected to the main switch  $S_1$  with thermostatic overload trip  $F_1$ . The filament and trigger circuits are separately fused  $F_2$  and the yellow-green pilot light  $L_1$  indicates when these circuits are in operation.

Power from the main switch also goes to the high-voltage circuit, through a relay  $S_3$ , which is operated by means of an external switch plugged into  $P_3$ . The relay coil is energized through  $S_2$  which is a safety switch, so placed that it is automatically opened if any of the covers or panels of the power pack are removed. Thus no high-voltage circuit can be energized unless the pack is completely enclosed and all covers in place. A red pilot light  $L_2$  indicates that the high-voltage circuit is energized.

From the safety standpoint, therefore, triple protection is afforded:

1. High voltage cannot be turned on unless all covers and panels are in place.
2. The switch carries only the relay-coil current, and must be held depressed.

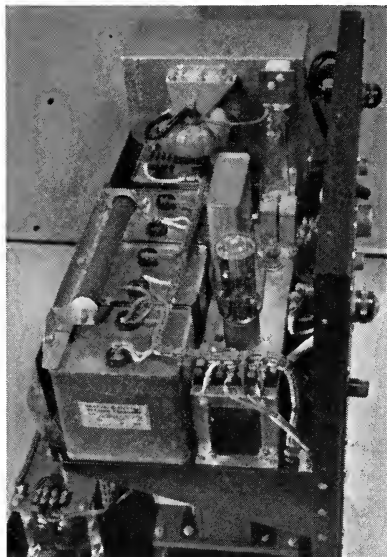


Fig. 7—Top view of Cine-Strobe-Light power pack, showing control circuit, including 5R4GY rectifier in foreground and OA5 triggertube (the small tube directly behind it). Three filter capacitors in foreground; main flash capacitor in the rear, under the reactance (or choke) in the Capacitron circuit. Capacitron tube partly visible behind the control chassis.

3. A red warning light glows whenever high-voltage circuits are in operation.

In addition, because of the use of the Capacitron tube, there will still be no high-voltage present at the lamp terminals until the camera contacts close, and then only during the actual flash of the lamp. Separation of the high-voltage and the filament circuits also permits preheating of the rectifier tubes before plate voltage is applied. This is important, since mercury-vapor rectifier tubes are used, and the mercury must be vaporized fully before operation.

The primary of the high-voltage transformer is fed through a variable autotransformer, providing adjustment for line-voltage conditions and also making it possible to increase the secondary voltage if additional light output is required. The output of this power transformer is rectified by two 866-A mercury-vapor rectifiers in a full-wave circuit. These tubes were chosen because of their large power-handling capacity and low internal voltage drop: the loss in the tube is 15 volts regardless of load.

To provide good voltage regulation, reduce line surges, and decrease the load on the rectifier circuit and power transformer, the direct-current output is filtered by choke  $T_6$  and capacitor  $C_1$  of 84 microfarads. This filter provides the greater part of the charging supply of the heavy current demand at the beginning of each charging cycle immediately after a flash takes place.

For safety reasons, this filter is bridged by resistors totaling 100,000 ohms which bleed off the charge when the power is shut off. The output of the filter is fed through choke  $T_7$  to the main flash capacitor  $C_2$  which as previously mentioned, is 6 microfarads. This also has a protective bleeder of 4.5 megohms, which will drain it to a safe level in about 30 seconds, after power is removed.

Power from the capacitor  $C_2$  is fed to the flashtube through the Capacitron or mercury switch tube and choke  $T_9$  which act to drop the voltage to zero at the end of each flash. Since the circuit contains both inductance and capacitance, any tendency it may have to develop oscillations is damped out by the third mercury-vapor rectifier tube  $V_{1c}$ , another 866-A, which prevents reversal of the current flow.

The trigger circuit is completely separate from the power circuit; it has its own power transformer  $T_5$  and its own rectifier  $V_2$ , this latter being a high-vacuum type 5R4GY connected as a half-wave rectifier. Its output is smoothed by filter capacitor  $C_3$ , and charges capacitor  $C_5$  to approximately 800 volts.

$V_3$  is the triggertube, type OA5, which serves as a switch to discharge  $C_5$  through the primary of the trigger coil  $T_8$ . It is operated by the camera commutator, which merely shorts out grid resistor  $R_6$ . A network of resistors  $R_4$ ,  $R_5$ , and  $R_7$ , and capacitor  $C_4$  is placed in the grid circuit to assure that each contact of the commutator results in only a single pulse being applied to the grid of the tube, avoiding the possibility of double tripping.

Resistors  $R_8$  and  $R_9$  apply voltage to the "keep-alive" grid of the triggertube. This grid maintains a small amount of ionization in the tube at all times and stabilizes its tripping time.

The triggertube acts in the same manner as a simple switch, discharging capacitor  $C_5$  through the primary of the trigger coil  $T_8$ . This coil, or transformer, applies a 15,000-volt charge to an external electrode or band placed around the neck of the Capacitron. Since the Capacitron and the flashtube are effectively in series, the ionizing voltage acts on both simultaneously, and the flash takes place.

The cable connecting the flashtube to the pack is a coaxial type with polyethylene insulation: it carries both flashing power and the trigger pulse. For this reason, an optimum length and diameter exist for this cable. If the cable is too long or too small in diameter, it will have excessive distributed capacitance, which will tend to damp out the trigger pulse and make flashing erratic. With a cable of correct dimensions, resistor  $R_3$  aids in neutralizing this effect by putting a small charge on the cable.

The flashtube and reflector are mounted on a metal box which serves as terminal housing, avoiding exposed high-voltage connections. Both box and reflector are grounded for additional protection.

### Operation

With the constants given, the unit has an exposure-guide number of 100 (in *inches*) for Kodachrome Daylight Type with CC-15 filter, and 300 (in *inches*) for black-and-white reversal film having a Weston rating of 100 to daylight. Thus at 9 inches from the subject, the exposure will be  $f/11$  for color film and  $f/33$  for black and white. (See Fig. 8.)

The exposure time is about  $1/20,000$  of a second; therefore, it should appear that film exposure should be substantially independent of camera speed. This would be true, but for the fact that at higher frame frequencies, the capacitor does not recharge quite completely. Hence it has been found necessary to increase the exposure somewhat

at higher camera speeds. The effect is far less than with normal lighting, however, being about one half stop extra at the maximum speed of the camera (64 frames per second).

The power demand of the unit varies, of course, with the flashing rate; it has a total current drain of about 23 amperes at 115 volts when running at the maximum rate of 64 frames per second. The power drain is roughly in proportion to the camera speed at other settings, but a fixed amount of current is used for filament and control

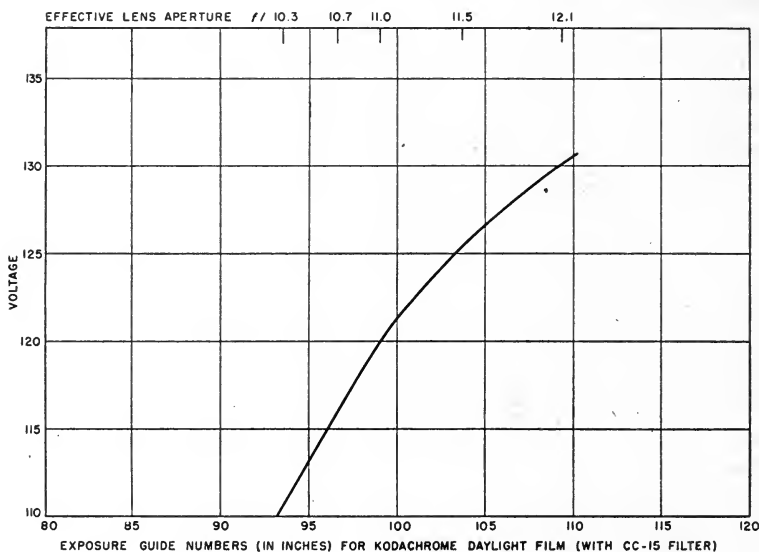


Fig. 8—With the Cine-Strobe-Light, having limited voltage variation, the graph gives exposure-guide numbers *in inches* for varying primary voltages. Capacitance being fixed, only one curve is needed for each film type, and this unit was to be used exclusively with Kodachrome film, daylight type.

circuits so that the total drain does not drop as rapidly as expected (See Fig. 9.)

Incidental effects are few, but in some cases, significant. Some ozone is generated by the discharge around the flashtube and the Capacitron. The quantity is negligible, and no precautions need be taken.\*

\* EDITOR'S NOTE: Ozone is considered to be very toxic in rather small concentrations. See Henderson and Haggard, "Noxious Gasses," American Chemical Society monograph, 1927. (No effect has been noted from the small amounts emitted by equipment of this type.)

A more important effect is the large quantity of ultraviolet radiation emitted by the flashtube. Since the FT-429 is of quartz construction, the ultraviolet output is much higher than that of ordinary flashtubes, and far greater than that emitted by incandescent or arc sources. This does not seem to bother the insects being photographed (according to authorities of the American Museum of Natural History, some flies are actually attracted by ultraviolet).

From the operator's standpoint, a good pair of high-quality sunglasses, such as Bausch and Lomb "Ray-Ban" or American Optical Company "Calobar" appears to afford adequate protection.

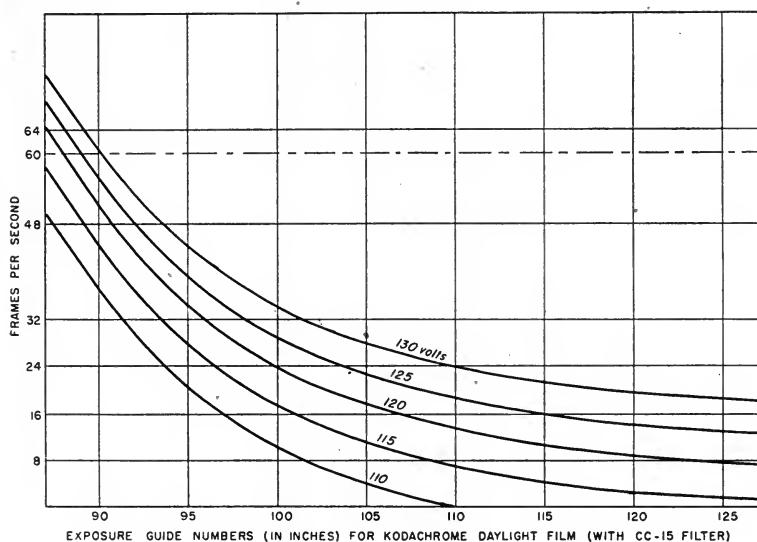


Fig. 9

Motion pictures taken with this unit show the expected stroboscopic effects on subjects in repetitive motion, such as wheels or dripping water. Slow, random motions appear on the screen with quite satisfactory smoothness of motion; rapid random motions appear erratic. The individual frames, as might be expected, show no motion blur whatever, and may be of especial benefit when individual frame enlargements are desired for study.

The expected flatness of illumination resulting from a light source surrounding the lens did not materialize. A remarkable degree of modeling actually is obtained, probably because of the closeness of the

source, which results in large inverse-square-law effects at short distances. Some of the excellent quality obtained may also be due to the property which strobe light seems to have, of retaining high-light detail, even in fully exposed areas. Nonetheless, the light is shadowless in the best sense of the word.

Electrically, the unit operated as expected. Only one unusual effect was found. In a conventional flashtube, the terminal supporting the barium "getter" pellet is usually considered the negative or cathode end of the tube. However, it appeared that some (but not all) tubes would operate with the polarity reversed. The only untoward result of reversed polarity appeared to be more rapid blackening of the tube.

After the pack was constructed and undergoing tests, the General Electric Company was induced to make several minor changes in the FT-429 flashtube which was still in an experimental stage so far as they were concerned. In collaboration with one camera manufacturer who plans to use this tube in a future product, agreement was reached on a wider and "squarer" spacing of the external connections, and larger internal electrodes. The former increases the safety factor, especially in damp weather, and permits the design of a better terminal box. The latter change seems to make flashing more reliable, and definitely adds to the life of the tube.

#### THE UNIVERSAL STROBE-LIGHT

The Cine-Strobe-Light was tested over a long period before delivery to the client. (See Fig. 10.) Its use indicated a number of possibilities in other fields of photography, provided the design were modified to allow greater flexibility. The design points chosen were as follows:

1. It should be possible to change capacitors very rapidly so that optimum power could be used for any purpose.
2. Variable voltage was desirable for finer control of light output, exposure, and charging time.
3. The triggering unit should be independent of the power pack, so that it could be used with still or motion picture cameras, or operated independently as a stroboscopic illuminator.
4. It should be usable with a variety of flashtubes, for special lighting problems.
5. Since the unit would be operated only by skilled personnel, some of the more elementary safety features, such as screwed-on panels



and door switches, should be omitted because of the necessity for making frequent circuit changes. However, to facilitate the making of such changes in safety, bleeder relays must be supplied to drain all voltage off the capacitors within a few seconds of cutting off the power.

In the light of these considerations, it was decided that the power pack would contain only transformers, rectifiers, and control components. All capacitors are external and plug in through a high-voltage coaxial connection. Triggering is also external and connects

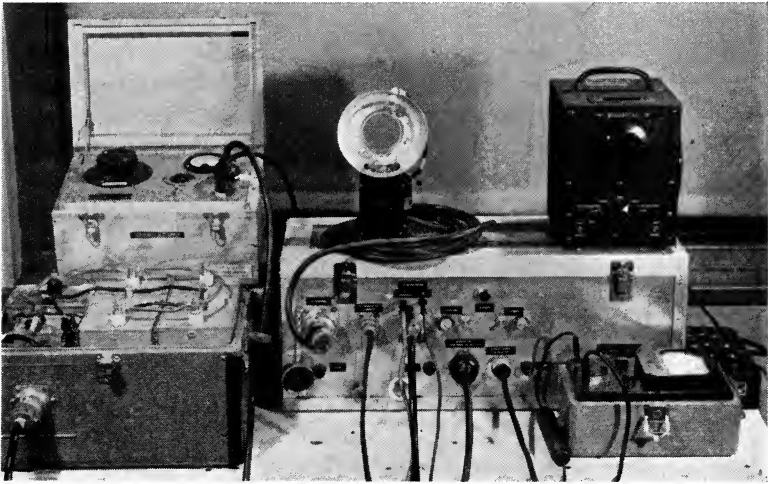


Fig. 10—Universal Strobe-Light. Capacitor bank lower left. Variac controlling primary voltage to power pack, top left. Main power pack with FT-429 flashtube assembly and Strobotac, top right. Weston Model 779 voltmeter and televerter used as kilovolt meter for measuring terminal voltage, lower right.

through a plug into the lamp circuit. All connections are made to plugs on the face of the power pack; thus it also serves as a central terminal box and switchboard.

The power pack, therefore, was wired according to the schematic diagram (Fig. 11).  $T_1$  is a General Radio Corporation Variac providing control of the input voltage to the high-voltage transformer. This latter is rated at 4000 volts output from an input line of 117 volts.  $T_3$  is the filament-heating transformer and is separately connected so that all filaments secure their correct voltage and current regardless of the voltage input to the power transformer. The use of

separate transformers also permits preheating of the mercury-vapor rectifier tubes, Type 866-A, as in the Cine-Strobe-Light.

No filtering is used in this pack; instead a charging resistor  $R_1$  was chosen to permit sufficiently rapid charging up to 64 frames per second with not over 6 microfarads of capacitor. Larger capacitors can be charged at a slower rate. The capacitance of the unit is sufficient to charge 135 microfarads at rates approaching 1 flash per second.

However, in this extreme case, charging of the capacitor is not complete: this is compensated by the Variac in the primary of the power transformer. If the time constant of the capacitor-resistor combination in use indicates that only 80 per cent of full charge can be reached

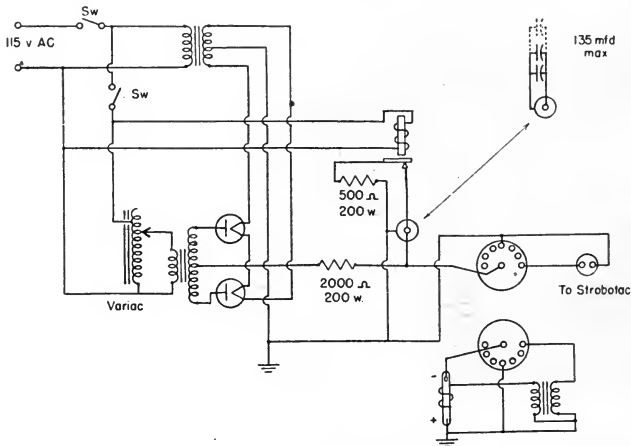


Fig. 11—Schematic circuit of the Universal Strobe-Light.

in the time given, and 2000 volts is required at the flashtube, then the secondary voltage of the transformer is set to 2500 volts and the capacitor will just be reaching the 2000-volt level as the flash takes place.

Pin jacks are provided in parallel with the capacitor plug for the insertion of plugs connecting to a Weston Model 779 voltmeter and Televerter. This meter and attachment have a combined range of 0 to 5000 volts at 20,000 ohms per volt; on the 5000-volt scale the resistance in the circuit is 100 megohms and the drain on the capacitors is negligible (about  $1/50$  of a milliampere). The meter, when plugged in, indicates the actual voltage being delivered to the flashtube, rather than the charging voltage from the transformer. Since the light output is proportional to the *square* of the voltage, errors in voltage are

more serious, exposurewise, than changes in capacitance, and the use of a voltmeter is insurance of correct exposure.

No Capacitron is used in this unit, and the trigger transformer is mounted directly to the flashtube housing. In this way the leads carrying the 15,000-volt pulse are kept down to a few inches in length and the capacitance of the cable is of minor importance. A twin coaxial cable is used, the central wire carrying the flashing voltage; the inner shield carries the primary pulse to the trigger coil and the outer shield is grounded and acts as common return for both circuits.

The trigger plug accepts any type of switching device provided it supplies its own pulse current. A simple trigger circuit similar to Fig. 12, might be used. However, such a unit could only be used where the switch contacts can carry considerable current, and there is always danger of double tripping.

For this reason a trigger circuit such as that in the Cine-Strobe-Light would be preferable. A ready-made triggering unit was found in the General Radio Corporation

"Strobotac". This instrument contains all the elements of the previously shown triggertube circuit, and has its own self-contained power supply. In addition, it also contains timing

circuits so that it can be set to flash at any desired frequency from 1 flash per second up to 240 flashes per second. The internal timing circuit may be disconnected and an external switch contactor, such as the camera commutator used with the Cine-Strobe-Light, may be used to operate the Strobotac.

The Strobotac uses the Sylvania 1D21 tube both as a light source and triggertube. Its output is quite sufficient to operate the trigger transformer at its optimum level, for a 15,000-volt output pulse.

The internal timing circuit of the Strobotac is instantly adjustable by means of a calibrated dial to any desired speed of flashing; thus it can be used in connection with a still camera for multiple-exposure stroboscopic photography. With cine cameras it may, as mentioned, be operated by a commutator. Or it may simply be used as a trigger circuit for single flashing with a still camera.

#### *Exposure Determination*

The Universal Strobe-Light was designed, as mentioned, to be used with a variety of flashtubes, a few of which are described below. In

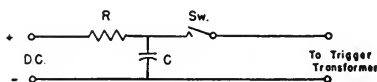


Fig. 12—Circuit for triggering flashtubes.

addition, the unit has a fully variable power output, attained by control of voltage and choice of capacitance. Under the circumstances, determination of the required exposure, if done in the manner already explained in connection with the Cine-Strobe-Light, would require several volumes of graphs.

A mathematical solution to the problem appeared preferable to a graphical one. Edgerton<sup>4</sup> has pointed out that the light output of a flashtube is a function of the applied voltage, the capacitance, and the tube efficiency (which is conditioned by the gas-filling pressure and other manufacturing factors).

Photographers using flash illumination are accustomed to using a flash-guide number for determining exposure. This number is the product of the *f*-stop and the lamp-to-subject distance. Thus if one factor, such as the distance is known, the *f*-stop is found by dividing the flash-guide number by the distance.

Edgerton<sup>4</sup> has shown that the flash-guide number (*Df*) can be calculated for flashtubes by the following formula:

$$Df = K \sqrt{\frac{nCE^2M}{2}}$$

where *Df* = the guide number  
*K* = film speed/development constant  
*n* = efficiency of flashtube in lumens per watt  
*C* = capacitance in microfarads  
*E* = voltage in kilovolts  
*M* = efficiency of reflector

This formula, then, contains all the necessary factors for determination of an exposure-guide number. The only factor which must be determined empirically is the film-speed/development factor *K*; reference should be made to the original paper<sup>4</sup> for the method. A table of *K* factors for most popular films is given in that paper, as well.

The determination of flash-guide numbers with the above formula, while simple, is somewhat tedious, and certain simplifying assumptions can be made. For example, most flashtubes have an efficiency in the vicinity of 35 lumens per watt; this figure can then be considered a constant. Similarly, the average well-made reflector increases the light intensity in the center of the field by a factor of 10 over the bare-bulb value.

Making these two assumptions reduces the formula to the form

$$Df = K \sqrt{175CE^2}$$

where *Df* is the required guide number, *D* being in feet. For low power

loadings and close-up photography, the factor 12 may be included:

$$Df = 12K \sqrt{175CE^2}$$

in which case  $D$  is measured in *inches*.

The value of  $K$  for a few typical cases is as follows:

Super-XX for thin negatives.....	0.7
Super-XX for fully exposed negatives.....	0.35
Kodachrome, daylight type (35-mm and Bantam)*.....	0.11
Kodachrome, professional film, daylight type*.....	0.076
Ektachrome, daylight type**.....	0.076

\* With Eastman Color Compensating Filter, CC15.

\*\* With Eastman Color Compensating Filter, CC33.

By the use of the formula, with capacitance known, and voltage read on the meter mentioned, an exposure-guide number can be calculated for any desired setup. In many cases, no tests at all are required; the few remaining require only slight modification of the  $Df$  factor after tests have been made.

#### *Flashtube Mountings for the Universal Strobe-Light*

The principal feature of the Universal Strobe-Light being its flexibility, it is necessarily designed for use with a wide variety of flashtubes. Some of those used with this unit are the FT-503, 403, 429, 220, 214, 210 as well as some experimental types. Special mountings have been built for each type of tube for use with associated equipment. (See Fig. 13.)

A variety of flashtube mountings has been built for use with the Universal Strobe-Light. One is a ring tube, FT-429 with housing and reflector, as supplied with the Cine-Strobe-Light. This is designed for close-up work with both cine and still cameras. A second unit consists of a simple housing containing an FT-220 flashtube with integral sealed-beam reflector. For still greater light output, an FT-403 or FT-503 is used. These last two tubes have provisions for inserting a small incandescent lamp through a hole in the base, so that light effects can be studied before flashing.

The most specialized light unit so far built consists of a ring tube FT-429 within a reflector. This unit was designed for low-power photomicrography of opaque objects. The FT-429 delivers adequate illumination for color photomicrography on Kodachrome or Ektachrome film, daylight type. This unit was of special value in the photography of certain chemical crystals which had so low a melting point

as to be completely ruined by heat from conventional microscope light sources. (See Figs. 14 and 15.)

Flashtube illumination has proved to be of great value in time-lapse cinephotography. One such setup included the FT-429 ring tube, a specially designed camera motor designed to make one revolution and stop each time a relay was energized, and also operating a

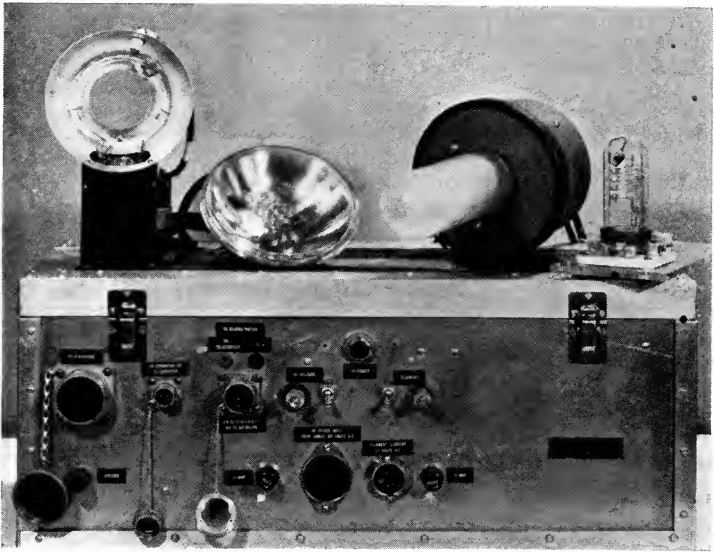


Fig. 13—Universal Strobe-Light power pack with some of the flashtubes it operates. Left to right: FT-429, FT-220 (sealed beam), FT-503 (similar to FT-403, but with quartz helix preferred for multiple flashing), FT-214. Though these lamps vary in shape, size, and possible application, their light output is based on the same formula:

$$Df = K \sqrt{\frac{nCE^2M}{2}}$$

microswitch at the shutter-open point of the camera cycle. The camera motor was controlled by a Kodak interval timer, and its contactor, in turn, operated the Strobotac, which flashed the tube.

The same setup has been used with flashtubes such as the FT-403 and as much as 135 microfarads of capacitance. The unit was permitted to run unattended for a period of 6 days, to make a picture of the growth and decay of a rosebud. Because of the short duration and absence of heat from the separate flashes (at 2-minute intervals) the entire sequence was photographed in a darkened room. This

avoided the movements and variation in growth of a flower subjected to alternate periods of daylight and darkness.

Other time-lapse sequences required variations in time from 1 exposure per second to 1 exposure every 5 minutes. A short preliminary run with the voltmeter connected was all that was needed to set the capacitor voltage at the desired point for correct exposure.

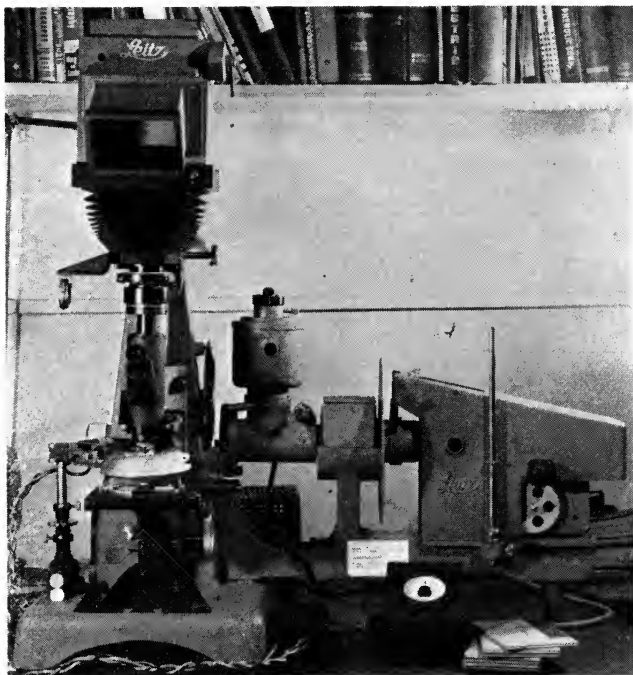


Fig. 14—A specially designed housing supporting the FT-429 flashtube with trigger coil in separate box, as used on a photomicrographic outfit for low-power photomicrography of subjects sensitive to radiated heat. A similar setup is currently used for cinephotomicrography of living organisms.

#### CONCLUSIONS

It would appear that electronic flashtubes hold a great deal of promise as light sources for motion picture photography. Particularly in scientific and research photography, where a cool, highly intense light source of great uniformity is required for the photography of limited areas, the flashtube appears to be the immediate solution of the problem.

On the other hand, it is apparent from the size and bulk as well as the power drain of the units shown here, which were designed for small area coverage only, that units for studio motion picture photography may have only limited application. In addition, the flicker of the light, and its high ultraviolet output, appear to restrict the possibility of its use with actors.

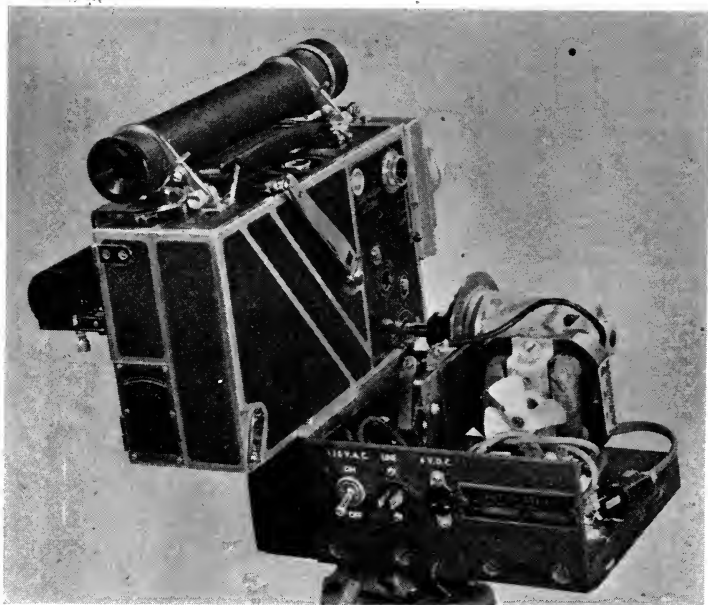


Fig. 15—An electric-motor drive for intermittent operation of motion picture camera employed in time-lapse photography. Operating at frequencies starting at one frame per second, it can be employed for any other frequencies in conjunction with a proper timer. Each revolution of the camera shaft operates a microswitch at the open-shutter point of the camera cycle. This, in turn, triggers the flashtube.

The Cine-Strobe-Light, for example, weighed over 350 pounds, drew  $2\frac{1}{2}$  kilowatts, and had a light output just sufficient for an area measured in inches.

On the other hand, the flicker problem is a psychological one only. The uniformity of exposure on the film was far beyond the expected; this applies equally to normal speed cinephotography with a camera running 24 frames per second or faster, and to time-lapse work, with an appreciable interval between exposures. In some cases, especially



that of time-lapse photography, the evenness of exposure actually appears better than similar pictures taken with incandescent light: this would appear to be due to the fact that minor variations in camera speed, or loose shutter gears can have no effect on the exposure. Some motion flicker (or discontinuity) does occur with rapidly moving subjects, but this has no relation to exposure, and exposure flicker is totally absent.

Two units designed for cinephotography in research have been presented in this paper; it is expected that they will be the forerunners of others as photographers and research workers appreciate the advantages of flashtube illumination. The Universal Strobe-Light, as shown here, is still to be considered an experimental unit, for exploratory purposes. Preliminary results obtained through its use indicate, at least, the direction in which the design of a universally useful, professional electronic flashtube power pack should tend.

Certainly, the application of a voltmeter to such a power unit, and the calculation of exposure-guide numbers from its readings and the capacitance in the circuit, could be carried to a logical conclusion. It is expected that future versions of such equipment could include built-in meters, calibrated directly in exposure factors or guide numbers.

This would be possible in most cases, only in a unit containing internally all of the elements now used in accessory form. Thus a Universal Strobe-Light should have:

1. Voltage flexibility: Attained by a built-in variable voltage transformer, and controlled with a built-in voltmeter.
2. Flexible capacitance values: When and if switches are available which can handle the enormous surge of current at the high voltages used, all capacitors might be internal, and switched in or out in even increments.
3. Variable charging rate: The use of a number of different charging resistors through switches, to attain an optimum charging rate for any desired capacitance, to avoid excessive line drain.

With these factors all controllable from the panel of the unit, calibration charts reading directly in flash-guide numbers would make the use of the system no more complicated than the handling of ordinary flashlamps in the studio.

Again, it must be emphasized, these are possibilities only. To the author, they appear both practicable and possible. Other photographers may prefer a different solution to their particular problems.

The element of importance, it seems, is that the basic flexibility of electronic flashtube illumination, provides scope for as many individual methods of working as there are photographers using the process.

#### ACKNOWLEDGMENTS

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# Synthetic Sound on Film\*

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*Summary*—An analysis of both hand-drawn and machine-made sound tracks is presented together with methods.

Of fundamental importance is the fact that synthetic sound tracks for the first time enable a composer to hear his composition as written rather than through artists' interpretation.

Three basic methods are presented: (1) hand drawing directly on the film, (2) frame-by-frame photography of drawings and patterns, and (3) mechanical generation by machines, such as the harmonic integrator, which are coupled to a variable-area or -density modulator registering on the film.

## INTRODUCTION

THE SUBJECT of synthetic sound on film is indeed an interesting one, so much so that it is not difficult to start a lively conversation on the subject. Perhaps this condition is due more to the elementary nature of present-day thought on synthetic sound than anything else in particular, or perhaps it is the attraction of a new musical instrument. But whatever the attraction, the present stages of development are so vague and crude that many improvements on the processes herein described are readily conceivable. A discussion of the subject therefore becomes more a statement of the present stage of general development than a discussion of a small increment of improvement on a particular aspect of the problem.

In presenting the possibilities of synthetic sound on film as well as a few simple accomplishments, it is hoped that a basis for further development will be established. The present state of the art apparently is such that the production of a sound track to any particular score is only remotely possible. This is due largely to the fantastic labor required in the animation of sound and the difficulties entailed by transients, attack and decay, and similar problems.

\* Presented October 21, 1947, at the SMPE Convention in New York.

### I. POSSIBILITIES OF SYNTHETIC SOUND ON FILM

In a survey of the limits of motion picture literary and esthetic possibilities, one finds the usual efforts diverging into further development of the traditional problems of mechanics, light, and sound reproduction. An effort to develop new areas in a literary way seems promised by the use of animated sound; roughly, it is to the sound track what animation is to picture reproduction.

The animated or generated sound-on-film of synthetic sound might well be defined as the placing on photosensitive film of images which produce systematic sounds by reproduction in the accepted motion picture manner, this new type sound being not necessarily a reproduction of known sounds or previously recorded sounds or related phenomenon. The simplest means of sound animation is that of drawing the sound directly on the film. Another process to produce this type sound is the frame-by-frame exposure of drawings of sound waves, changed, arranged, and drawn in such a manner as to control tonal quality, pitch, and amplitude.

The production of synthetic sound on film is to be differentiated from the "Voder" process of Bell Laboratories, as demonstrated at prewar World Fairs, in that the film process has, in effect, a "memory" and does not of necessity require manufacture of the sound at the same rate as that of the reproduction and, therefore, allows time for more complex processes and arrangements. The chief advantage in this use for film is the opportunity afforded for continuous playback; the disadvantage, the lack of completely instantaneous playback.

The synthetic sound on film is to be differentiated from the Hammond Organ, Novachord, and the radio-piano, in much the same way as the "Voder". The film process is also capable of recording non-continuous and nonuniform tones and notes such as occur in percussion. Also, it is capable of producing various types of tone-quality shift of a continuous nature through the playing of the note, as is exhibited in the solo Theremin. The film process is not necessarily dependent on the dexterity of a player artist and, therefore, allows more thought and choice to be exercised for each passing second. Obviously, the film process due to its memory and amount of time available in "recording" is not limited to one keyboard but may handle all types of sound.

Immediately the question of the relation of synthetic sound on film to magnetic recording raises the question of the literary end or purpose. The immediate playback allowable via magnetic recording

is an advantage, though not a complete one, as tones and rough combinations of tones may be played back immediately prior to chemical development or processing by a refinement of some other synthetic sound-recording systems. Duplication and re-recording in synchronism of separate magnetic recordings with picture do not allow repair of broken picture film and appear clumsy in this relation, necessitating the use of direct magnetic sound on film. It seems in order to point out the existence of the problem of recording magnetically with the material running at less than playback speed, as required for synthetic-sound systems.

It is obvious that with adequate development of the technique required, standard musical score and human voices may be synthesized on film by the aforementioned processes. Also, it is obvious that percussion instruments, various new instrument effects, and unnatural speech can be produced all too easily. As a tool of the composer it enables him to fix, in his mind as well as on film, and arrange his composition with a completeness as to tone, timing, and amplitude better than is possible with existing musical notation, without the economic cost of the reproducing musicians and their varying interpretations. It is probable that at the present, no other method approaches the theoretical possibilities of this method as a tool for a composer.

Production of sound films by this synthetic process should also allow experimentation and research into the nature of sound relations. Also by this process, test films might well be synthesized avoiding conventional recording errors, though, of course, introducing troubles of another nature.

Without much imagination it can be seen that an offshoot of the basic process should allow the production of better matched and cued fades and mixes. This should allow greater liberty in editing. In all probability, as in the case of picture animation, it will be some time before synthetic sound develops any worth-while literary and esthetic qualities further advanced than this type of engineering discussion. Nevertheless, for the enjoyment in itself, the authors have found experiments and discussions concerning synthetic sound an adequate enjoyment to justify the effort.

## II. HAND-ANIMATED SOUND

A variable-area sound track readily suggests its duplication and modification by hand for one or a dozen reasons. A simple scribble

in the sound-track area will make a noise, the challenge being the production of controlled tones of a pleasant nature.

In order to produce such a sound film without resorting to costly equipment, it is necessary to resort to the direct production of the sound track without the use of the photographic process or embossing or similar methods. The complete equipment requirements for the hand animation of sound film are one drawing pen, one bottle of India ink, clear film, and a film holder.

The production of controlled pitch may be accomplished by the use of the sprocket holes for the basic reference as to wavelength. Thus, one, two, or four lines per sprocket hole will, on running, demonstrate that the four is an octave higher than the two, which is also an octave

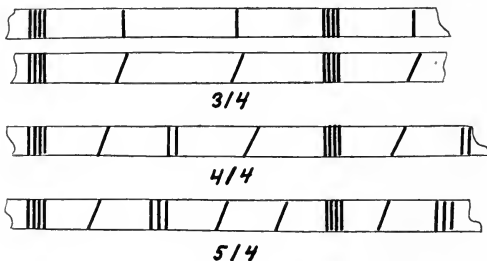


Fig. 1—The placing of marks along the sound track enables the control of rhythm. By rotation of the azimuth, a mark may be softened, though the same effect may be achieved by the change of inks, stroke length, and other factors.

higher than one. Such a process may be expanded such that, for example, five notes each an octave apart may be produced. If three strokes, instead of two or four, are made to the sprocket hole, the result will be a musical interval of a fifth above the bottom note. By six or twelve strokes and so on, a crude musical may be produced.

By spacing marks along the sound track and repeating the spacing again and again, it is possible to produce percussive effects and rhythms. (See Fig. 1.) By the construction of loops of film with sample rhythms, a continuous rhythm is possible, enabling repeated study of a drawing without the labor of redrawing successively.

Several methods of control of the volume of the drawn tones are possible. By the use of blue writing ink in place of black India ink, a definitely quieter sound will result, depending on the color sensitivity of the reproducing photocell surface. Thus, by the use of colored inks, it is possible to draw a passage which will reproduce

differently according to the color response of the system. This may be accomplished in a laboratory by means of a variable color source such as a monochromator or more simply by the use of color filters. This type of tone control is to be differentiated from an electrical tone control in that it is possible to control the volume of each sound, and, thus, knock out a "green" tone, for instance, by insertion of a green filter, while leaving the "red" tones at full modulation. Thus, the animator may play back and choose the relative intensity of several tones by the choice of color filters in much the same manner that a director of an orchestra directs sections of string and wind.

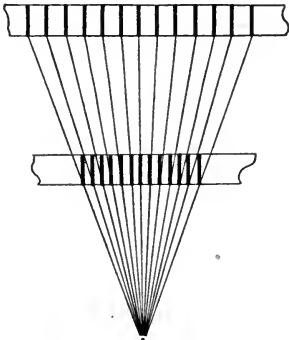


Fig. 2—Low "do" and high "do" are drawn as spaced strokes. The basic fan pattern shows the derivation of the spacings.

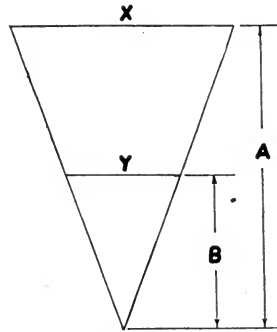


Fig. 3—The geometry of the basic pattern  $A/B = X/Y$ , wherein  $X$  is the pitch spacing of the higher note;  $Y$  is the pitch spacing of the lower note;  $A$  and  $B$  are the distances corresponding to  $X$  and  $Y$ , respectively.

If instead of a variable color of ink, a range of ink bottles of various gray densities is used, a stroke of black ink would produce a loud note; a dip in middle gray, a medium note; and the use of the palest of the inks, pianissimo. This is a fairly satisfactory system, though with transparent ink it is difficult to prevent some strokes from being heavier than others, which results in undesirable irregularity. Variation of modulation is also possible by varying the amplitude of the stroke, as is obvious. Therefore, it is possible to combine variable-area and variable-density methods for a most convenient system: black ink for 100 per cent, 75 per cent, 50 per cent, and 25 per cent modulation and lighter inks for less than 25 per cent. With this range of volumes and the pitch systems described above, the sound

tracks of the abstract films "Scherzo" and "Loops" were made in New York in 1939 for the Museum of Non-Objective Paintings.

Further improvement of the methods used is possible by the use of a diagram or guide which may be placed under the film so that the hand work is made to fit the spaces of the pitch selected. Such a

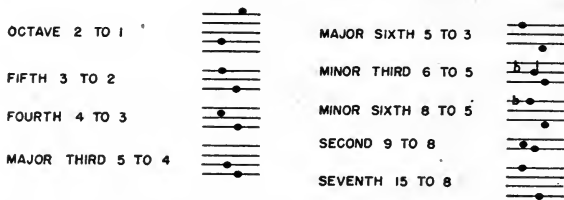


Fig. 4—The basis for the fan diagram of Fig. 5, a diatonic scale (just temperament).

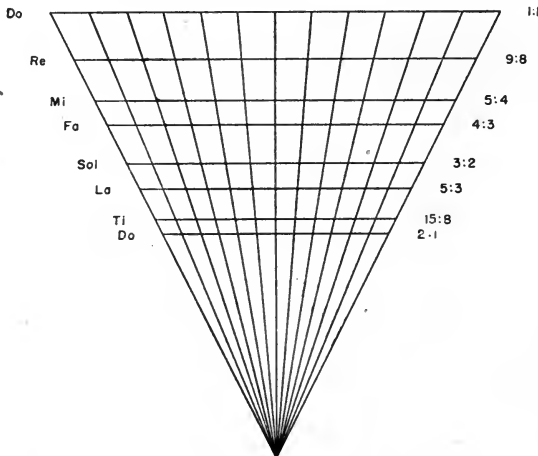


Fig. 5—A basic fan diagram showing the pitch spacings for the diatonic scale (just temperament).

chart or pattern may be viewed by transmitted light, though use by reflected light is not impossible. This same method may be used to repeat a passage by laying the master under the raw stock and hand-copying the master track.

A basic diagram is shown in Fig. 2 wherein low "do" is drawn as 30 equally spaced strokes, high "do" also as 30 equally spaced strokes at one half the distance. This is based on  $A/B = x/y$  of Fig. 3. On the assumption that musical intervals have the following ratios (Fig. 4); a diagram was built which represented the diatonic scale



(just temperament), Fig. 5. A section of sound track, Fig. 6, was drawn with a stroke for each one on the horizontal lines of the diagram. When played, this gives a clearly intoned diatonic scale. As this includes the interval of the semitone, there appears to be no reason why one could not draw a chromatic scale as well.

As the simplest ratios were used in the above diagrams, the scale that resulted was in just temperament. This is rather troublesome

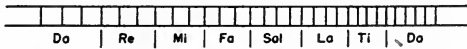


Fig. 6—A sound track showing a climbing scale.

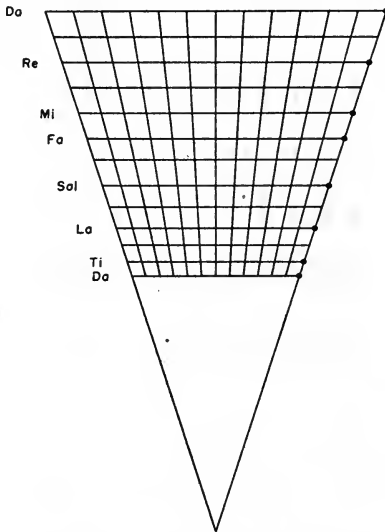


Fig. 7—A basic fan diagram for an equally tempered scale. Comparison between this fan diagram and that for the diatonic shows the differences quite clearly.

for any great use of chromatic passages or key modulation. Therefore, an equally tempered scale was produced, Fig. 7.

The development of quarter tones is possible but is an even greater amount of work. With five chromatic octaves of pitches and about ten degrees of volume, the remaining quality requiring control is the tone or wave form itself. For example, all the tracks of Fig. 8 have the same pitch, but different qualities of sound. To create a definite

timbre, it is necessary to make each stroke the same in shape, as the slightest variation from stroke to stroke tends to create an undesirable noise.

As a minute change in the shape of the stroke creates a radically different timbre, there is a definite problem as the drawing is done on an extremely small scale. The accuracy of visual observation by itself is not adequate, but when combined with the much greater precision of the hand and fingers, one can execute extremely fine changes of pressure and location, so that if strokes are made in rapid succession one beside the other, the hand develops a kind of muscular memory. Only if the hand moves or lifts away to dip into a bottle of ink is the muscular memory broken, such that it is impossible to make the same shape of stroke. By experimenting in

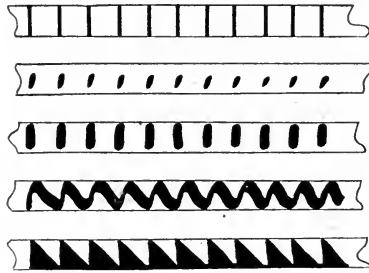


Fig. 8—All the tracks shown are of the same pitch, though they exhibit different qualities of sound.

a trial-and-error way with different types of pens and brushes, as well as ways of holding them, one can discover a number of different timbres, which when the muscular memory is trained may be reproduced on film at will.

As observed previously, a piece of photographically recorded sound track (variable-area) provides the temptation for hand imitation. To date, efforts at hand imitation have shown that it is an utterly hopeless method of arriving at any kind of synthetic sound. The photographically recorded track is far too complex and subtle to yield to the hand method. This is probably due to the combination of phase relations, transients, room acoustics, and other factors which yield more readily to synthesis by precise mechanical means which can produce pure sine waves and any number of harmonics as well as square and saw-tooth curves.

The more fruitful method for experimentation in the medium of

hand-drawn sound is that of building entirely new types of sounds which are the results of the shapes which a pen and brush can draw easily.

It should be pointed out, however, that it is not so much as a source of new timbres, but as a method of controlling rhythm and meter that this method of making sound is important. In remembering that one second of time is represented by about  $1\frac{1}{2}$  feet of 35-mm film, it is easy to see how complete a control of the time dimension there is. A sound can be plotted to at least the nearest 200th of a second if desired. This is much finer precision than it at first appears; it means that one can space sound metrically with a precision beyond most other ways of making music and considerably beyond the musical-notation system. Very intricate rhythm can be evolved by simple geometric spacing along the sound track. One rhythm can be set against others contrapuntally. Complex rhythms can be made to reproduce much faster than it is possible to perform by the human hand on any instrument; a rhythm can be expanded to last over many seconds, or contracted into a space of  $\frac{1}{20}$  of a second (or to the limit of human appreciation, which is about 30 notes per second). Rhythms can be inverted by simply running the sound track backwards, or drawing the same metrical spacing in reverse.

Loops of film, the ratios of whose lengths are carefully planned, can be played together to create constantly creeping rhythms which repeat themselves at very long intervals of time.

The contrapuntal use of rhythms can be made in two ways:

*If the rhythms are spacious*, they can all be drawn on one track.

*If complex*, they are best drawn on two or more separate, but parallel, tracks which are then synchronized and recorded in the usual way onto one track.

The re-recording of several tracks together opens up a veritable vista of possibilities, such as rhythms staggered against themselves, reversed, inverted, and the like, and gives over-all control of the volume of each strand of rhythm. No microphone, no recording apparatus, or studio! The normal complicated technical processes of making a sound track have been reduced to surprising simplicity of a drawing, and a one-man operation. This worthy goal has many virtues, as the personnel needed to make a film, and the accumulation of their decisions, gives the film a shape very different from what it would have been if the director or originating artist produced the film single-handed.

The present state of motion picture engineering is such that from the viewpoint of the individual artist, the traditional cinema is a cumbersome means of expression with so much mechanical gadgetry and technical processes intervening between the artist's original conception and the finished product, that it is difficult to finish up with one resembling the other. In discarding the traditional microphone and studio equipment, it becomes possible to make at least one branch of cinematic art a simple and arousing form of artistic expression.

As the inherent restrictions or limitations of hand-made sound tracks as a medium are severe, it seems in order to point out that they bear the same relationships to the usual technique of the cinema, as mosaics do to oil painting. Therefore, it would seem that restrictions are no more a reason for uninteresting work than they are in mosaics; in fact, the peculiarities can often prove a very great advantage.

In the preceding discussion it has been assumed that the hand-work was done directly on the sound track of a 35-mm film. The same can be done on 16-mm film directly, but it is not recommended under any circumstances as it passes the limits of unaided manual skill. In order to attain more controlled wave form, or tonal quality, it is possible to go to larger tracks than 35-mm and reduce in re-recording onto the release medium. The sound may be drawn directly on the film or drawn on cards or paper strips and transferred to the film. Such methods, though more complicated, offer some attraction and are described in the following sections.

### III. METHOD PROBLEMS OF SYNTHETIC SOUND ON FILM BY MECHANICAL MEANS

The standard sound-on-film recording means, as currently accepted, may be adapted to recording synthetic sound purely by the connection to the proper electrical circuits. The disadvantage in this adaption is, that at the speed of reproduction, it is not possible to initiate adequate control of recording to realize the benefits of the synthetic-film-recording methods. For this reason, it seems desirable to use methods more specialized and adaptable to the purposes of synthetic-sound problems. This moves more closely toward the conventional concept of animation.

The basic and simplest mechanical method consists of frame-by-frame exposure of the film in a standard animation camera employing a special aperture exposing only the proper lengths of sound track per exposure. This method by virtue of the pull-down tolerances,

shrinkages, and like difficulties, has inherent 24-cycle modulation caused by overlap or gap at the end of each exposure. This is the major problem of this method and can never be eliminated completely without complexities worse than the evil. Partial elimination of this difficulty was accomplished by the author by staggering the edge of the exposed frame and thereby utilizing the azimuth error as a bloop to soften the square-wave form. With care this solution will operate sufficiently so that common reproduction systems are not disturbed enough to upset the reproduction, but for the critical, the solution is not acceptable. The unwary should be cautioned optically to center the lens system used in this method, as resolution affects the frequency response and will also introduce 24-cycle modulation in bad cases. For continuous sustained notes, the camera may be run continuously. It may also be rewound to enable multiple exposure for choir and synthetic-reverberation effects. Various types of masks are effective in this system for noise reduction and other purposes, such as the separate exposure of separate tracks within the scanning areas.

In order to eliminate 24-cycle modulation, the frequency may be demultiplied by exposing multiple lengths of frame simultaneously; not necessarily the same length each shot, though usually so. This does not eliminate square-wave and saw-tooth trouble but lowers their frequency and effectiveness. For some types of composition this will reduce the labor, and therefore, it seems advisable to consider the possibility of a variable-frame-length camera, much on the order of some microfilm equipment.

In order to eliminate absolutely 24-cycle modulation, or multiples, continuous exposure of the film is necessary, whether by methods similar to optical reduction printers or scanning systems. The reproduction system possesses the advantage of being able to use directly, cards, drawings, and paper tapes intended for use on the animation setup, without change. The problems of gear modulation and other speed differentials are ever-present and constitute a hazard in this method, not to mention the problems of correctly operating and spacing and arranging the cards being reproduced, to avoid shift in pitch, loss due to azimuth error, and irregular rhythm. The continuous process will probably work best with two operators, though the authors have no experience in this line. Continuous camera design is also capable of operating directly coupled to a harmonic integrator or equivalent in synchronism, controlled by the

operator as to wave form, amplitude, rhythm, and other musical and speech components.

#### IV. GENERATION OF SYNTHETIC SOUND ON FILM BY MACHINE

As previously mentioned, a continuous camera directly coupled to a curve-generating or scanning system is sufficient to produce all forms of synthetic sound provided the control is proper, adequate, and understood. The best approach from the mathematical standpoint is that of synthesizing basically the wave form by a succession of sine-wave generators coupled in proper phase, with their frequency set for proper harmonics as well as amplitude, and integrated to produce the over-all envelope. By continuously varying the amplitude and frequencies, the wave form can be put through its paces, and if as demonstrated by Michelson and Stratton, with 80 elements, anything from a square wave to simple sine curve can be generated on the harmonic integraph.\* Needless to say, though basically simple, the mathematical concept of the harmonic integraph requires conversion from standard musical score, speech, and voice-tone notation and the like in order to be practical.\*\*

If it is desired to generate synthetically a wave form already known to exist and if photographed or available as a standing wave on an oscilloscope, application of harmonic analysis will produce the necessary constants to set the harmonic integrator.

By means of curves generated by the harmonic integraph or similar machines (Fig. 9), as well as by hand, it is also possible to photograph frame by frame and produce a synthetic sound track.

It is also possible to retouch, re-edit, and mask, existing sound tracks for special purposes. Several unsystematic trials have been made using miscellaneous material, such as human faces, photographed on the sound track by Moholy-Nagy which are closely related to the early block-image methods of the Russian experiments. The difficulty with the card or tape method lies in the large size of the image required for high-frequency response, unless the card is used only to supply setting data for the generator; in the same manner, the length of a complete cycle of a percussion instrument is excessively cumbersome.

\* Brother to the tide-prediction machine, well-known mathematical machine.

\*\* As far back as 1900 music research developed the practice of recording wave form analyzed as to character by means of a card giving the constants of the equation of the wave.

It is obvious that by means of standard accepted methods, electrical generation of wave patterns can produce the same result as the more mechanical harmonic integraph. The clumsy situation which exists with electrical wave-form generations is due to the necessity for recording at a slower speed than reproduced in order to be able to control the components accurately. Loss of the advantage of synthetic sound on film is likely to occur with electrical wave-form

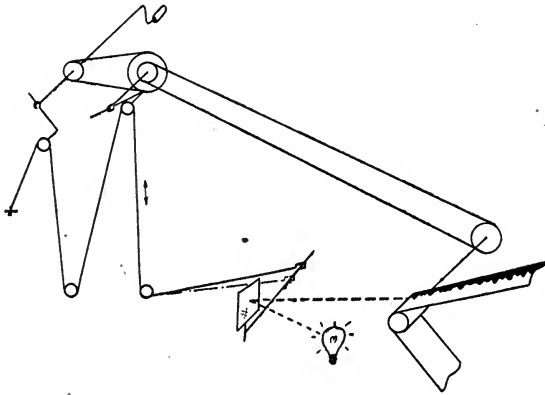


Fig. 9—The harmonic integraph is to be differentiated from the analyzer in that the latter reduces known tones to the basic components whereas the integraph synthesizes these basic components into an integrated and recorded wave form. Shown schematically is a very simple generator consisting of a drive on two crank eccentrics in harmonic relation (shown out of phase). The output of the cranks is added by the pulleys on the string which in turn operates the recording system driven interlocked with the crank drive. The strength of each harmonic is regulated by the leverage on the recording mirror. A basic weakness in this type of machine is the virtual impossibility of any transient effects.

generation because of the difficulty in obtaining duplicates of unsustained notes such as percussion and transitory phenomenon.

### *General Problems*

The general problems of picture animation apply to those of sound animation, namely, system, accuracy, and perseverance. The elimination of paper shrinkage and warp is a necessary prerequisite to photography of the frame-by-frame method of sound. Calibration and

measurement of all components involved is taken for granted, though it may well be the major amount of labor.\*

The maintenance of pitch and tonal relationships is inherently one of measurement. Alignment and placing of cards and tapes can and do exercise too great an influence for normal consideration, and should be solved very carefully before extensive efforts are laid out. The azimuth error introduced in hand drawings and cocked cards must be eliminated to control results.

Musical notation as currently used does not specify tones, nor timing, nor decibel level precisely enough that artistic interpretation is not necessary for acceptable transcription. In conversations with composers, it was found that a more precise notation or addition to present notations is required, human inertia being the chief barrier. Musical notation will not adequately handle unsung speech and sound effects and therefore, it is obvious that the mathematical notation system previously referred to in connection with the harmonic integrator, though lengthy, has of necessity some place in the system.

The choice of tone, namely, composite wave pattern may be expedited by the use of a card catalogue either indexing general patterns by work description or by loops to be run to hear the tone. Doubtless, the gadgeteer can devise punch-card systems to set the harmonic integrator automatically and thereby mechanize the labor, though it seems advisable that synthetic-sound systems eventually should be conceived and constructed in such a manner that initial capital investment is small enough to enable those who are of moderate financial status, and students of musical composition to have the opportunity to study more directly.\*\*

At this point, it seems rational to predict that frame-by-frame animation is a logical beginning point for experimentation, and that the cheapest forms of equipment should be supplied to fill this order. Driven continuous equipment seems to be the other possible beginner's stage, especially in consideration of the length required for complete recording of transients, percussion, and the equivalent. The addition, at a later date, to the beginning equipment of the continuous type may be made by substituting a scanning system driven

\* Optical distortion and magnification, lines-per-millimeter resolution, stray light or fog, and curvature of field, all should be known or measured, likewise unsteadiness.

\*\* Re-recording seems advisable for various types of tracks to allow freedom in synthesizing.



by a harmonic integraph which may always be removed, for direct photography of already drawn patterns. The addition of punch-card control to the integraph is such that composition would become card-shuffling and film-changing with the exception of unsystematic patterns still requiring direct photography from tapes. In this respect, it seems probable that the animation of sound will not reach the laborious stage of picture animation, what with the repetition of passages and the possibility of recording partial passages consecutively by means of masks allowing separate exposure of separate tracks side by side within the scanning area.

Without the maintenance of maximum flexibility, that is, the ability to record a very wide variety of types of sound, it is possible to conceive that the whole concept of synthetic sound on film becomes limited and serves no better purpose than present-day electronic organs, and the like. The advantage of the system is not necessarily only the introduction of new sounds but also that of assistance to the composer in assurance that his score will be heard as composed and not rearranged beyond recognition. This we do not conceive as technical unemployment for the musician, but rather an assurance that proper rendition will be appreciated. It is probable that many synthetic-sound compositions may never be heard publicly, but used rather as training and prompting in the rendition of difficult passages of a standard score. As a supplementary device to standard musical training, a synthetic-sound installation should enable a student of music to hear his own work as "played" by symphony, chamber, or "boogie", according to his choice in generating the original film.

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# Industrial Control Applied to the Projection Room\*

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**Summary**—An improved method of adapting industrial control to picture and sound projection is described. Master-control stations located below the booth viewing ports place push buttons at the projectionist's fingertips. These remotely operate the various apparatus in sequence as selected. An integrating intercommunication unit provides reliable contact between projection booth and auditorium.

**T**HE MOTION PICTURE studio projection room, even today, is handicapped by some of the early practices established during the transition from silent to sound motion pictures. As an example,

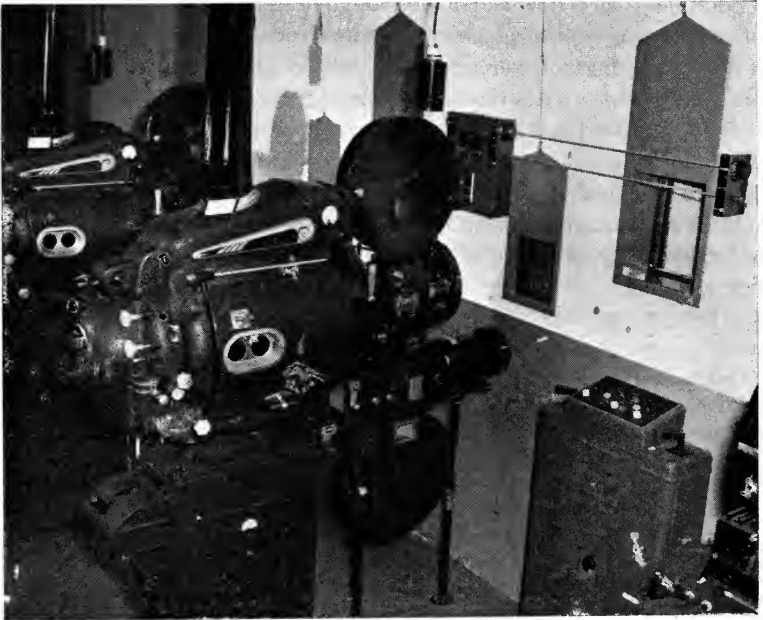


Fig. 1—Completed projection room.

\* Presented October 22, 1947, at the SMPE Convention in New York.

criticism may be directed at the lack of uniformity in regard to control. In many instances, the location and arrangement of controls have made good operation exceedingly difficult. In the studios, projectionists are expected to operate with equal skill in any of the various booths. Standardization, then, is desirable.

Careful planning in the design and placement of essential control apparatus provides improved programming. In addition to the generally accepted good engineering practices, an analysis of operational functions indicated the necessity of



Fig. 2—Master-control console.

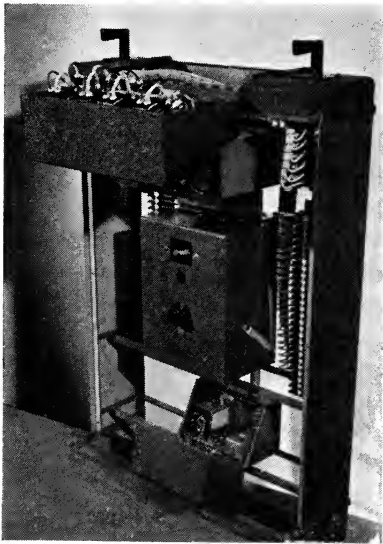


Fig. 3—Master-control console open for inspection.

including (1) centralized remote-control stations, designed and located to provide smooth, rapid utility; (2) flexibility of apparatus in relation to maintenance and routine testing; and (3) a satisfactory method of communication between the auditorium or theater and projection booth, permitting the operator to receive or impart instructions without handling an instrument.

The projection room shown in Fig. 1 was recently placed in service at the West Coast Studios of Paramount Pictures, Inc. The ceiling as well as the front wall is treated with acoustical tile to the trim line. The lower section is covered

with sectional, removable sheet-metal panels. These cover plates are an excellent fire wall and provide access to conduit junction boxes and raceways. This room was equipped with four soundheads, two associated with the projectors and the other two for sound-track reproduction only. Conventional mixing facilities may be remoted to the review room for preview or editing rehearsal if desired.

Adjacent and to the right of each projector is located a master-

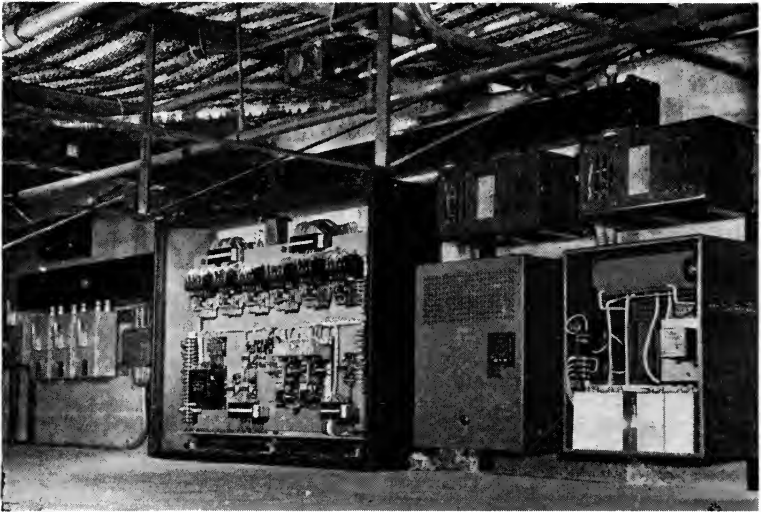


Fig. 4—Remote-operated equipment.

control station as shown in Fig. 2. Duplicate control facilities are available from the two operating positions. These units are located directly below the viewing port, conveniently placing the essential controls at the projectionist's finger tips. Grouped in sequence on the sloping surfaces of these units are transparent plastic push buttons. These buttons are illuminated when operated in the "on" position.

Fig. 3 shows one of the master consoles with the front cover removed and the control unit opened for inspection. Machine selection, distributor selection, the starting and stopping of interlock motors, the douser, signal, and annunciator gear as well as house lights are controlled from this station. The house-light contactor may be used to control saturable reactors and additional sequence

relays affording automatic dimming of lights in the auditorium, the opening of the screen curtains, and other desirable effects.

Suspended below are the preamplifier, postequalizer, and associated filter. The amplifier is isolated from the console frame to prevent vibration that might cause microphonics. Above this amplifier is located a compartment for headphones and tools, dubbed by its

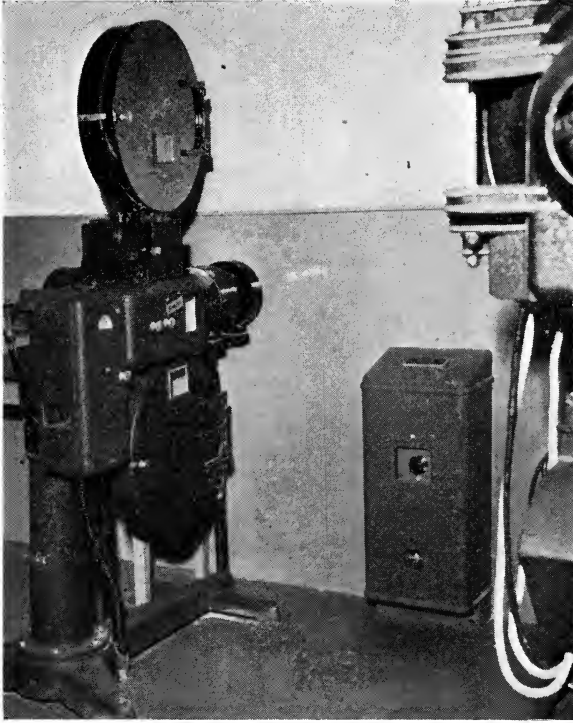


Fig. 5—Small console.

users as the "glove" compartment. The accessibility of the various components in relation to replacement and ease of testing received careful consideration.

The relays, contactors, lamp rectifiers, and associated power equipment controlled by these stations are located under the floor of the booth. Fig. 4 illustrates a portion of the remote-operated installations. Each relay and contactor is individually shock-mounted. These components are mounted on a base plate which in turn is shock-

mounted. With the sound- and dustproofed cover in place, no contribution is made to the aural noise level. This grouping of control relays and contractors is of great value in regard to maintenance. A meter and a few jumpers permit the rapid analysis of the various circuit functions.

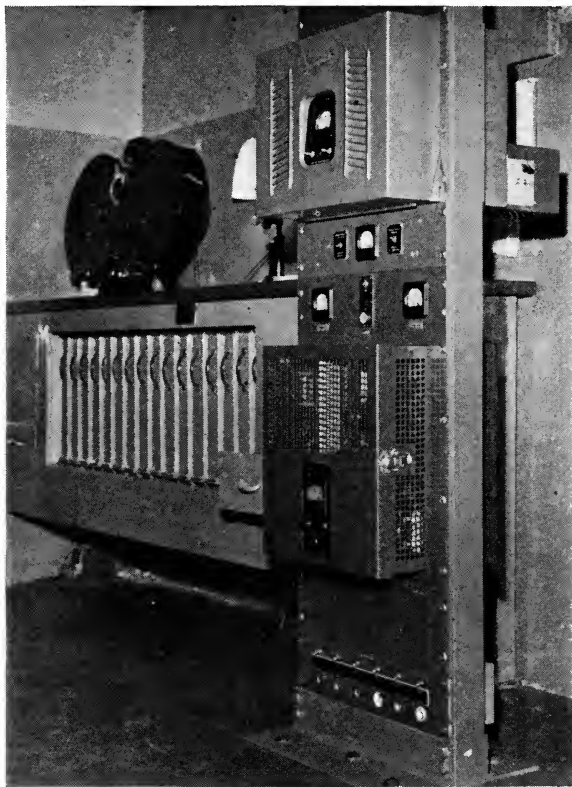


Fig. 6—Amplifier rack and test panel.

One of the small consoles associated with the sound (dummy) projectors may be seen in Fig. 5. These units house preamplifiers, postequalizers, and associated filters. The push buttons on the top of the enclosures are multiples of the booth to auditorium signal system.

The main amplifier, power amplifier and associated time delay, booth monitor amplifier, and the regulated power supply for the

remote preamplifiers as well as the test and lineup equipment are mounted in the rack shown in Fig. 6. This equipment, in addition to the regulated exciter-lamp power supplies, is energized at the touch of a push button located on the control panel. A "ready" light signals the completion of the plate time-delay cycle.

Communication between the review room and the booth was designed to relieve the operator of any manual operation that might detract from his duties. On the desk in the review room is located a conventional desk handset. When it is removed from its cradle, the booth monitoring is automatically heavily attenuated and a signal light alerts the projectionist. By the pressing of a button on the handset, the operator may be instructed by the executives or editors using the room. As the button is released, the booth operator may reply. Returning the handset to the cradle normals the projection-booth monitoring level and disconnects the signal light. The projectionist establishes contact with the review room by pressing a button that flashes an indicator on the review-room desk. Should this signal go unnoticed, a second button is available for sounding a warning buzzer.

The operating ease with which this improved equipment performs indicates a growing acceptance of simplified automatic controls wherever applicable throughout both studio and theaters.

## Review of SMPE Work on Screen Brightness

THE QUESTION of screen brightness became one of paramount importance shortly after the advent of sound motion pictures at the time processing control was being greatly improved and the industry was becoming uncomfortably aware of the complicated relations between print density, contrast, screen size, brightness, reflectivity, and auditorium illumination as related to audience viewing comfort. Numerous papers and committee reports published in the JOURNAL since 1931 have contributed greatly to the industry's understanding of the problem and represent most of the accumulated knowledge of the subject. This information was consulted prior to adoption of the present standard screen brightness level of 10 foot-lamberts which was approved by the American Standards Association as American Standard Z22.39 in May, 1944. For all the fine work done up to now however, the present American Standard is the only specific recommendation to have evolved but had the war not interrupted the Screen-Brightness Committee's program, undoubtedly much more would have been accomplished, particularly in both screen illumination and screen-brightness measurement.

The industry is attempting seriously to define audience viewing comfort in a positive way, so that at least a few of the many basic variables can be specified and, where possible, standardized. Among the factors that it seems desirable to specify are print density, print contrast, projection-light intensity and spectral quality, light distribution, screen brightness, and auditorium illumination. In addition, these are factors over which there is a reasonably precise degree of control and it is convenient that they lend themselves readily to measurement and that scientific language has provided the necessary nomenclature as well as accompanying units of measure. Therefore, specifying these factors is relatively simple when compared with defining the many intangibles that characterize visual enjoyment of motion pictures.

Since it is possible to make definite observations, record what is observed, and also to control several elements of the system, almost any given set of viewing conditions can be reproduced later for further study or investigation. It was for this reason that the committee



decided to consider only these controllable elements in the present program, which has been restricted in scope in order to hold the demands on the part of individual committee members to a minimum and to establish goals that the committee might reach in some reasonable period of time.

The three following items make up the Screen-Brightness Committee's long-range program. The first is the one with which the committee is currently occupied.

1. Determine present theater practice for screen illumination, screen reflectivity, and screen brightness.
2. Evaluate present use of projection equipment and screens from the standpoint of over-all efficiency.
3. From the data and experience gained in the above work, prepare specifications for intensity and brightness-measuring instruments; outline a standard procedure to be used in making these measurements and then establish a new standard for screen-brightness level, specifying desirable levels of auditorium illumination, brightness distribution, and so forth.

In order to determine present practice in a reliable way, the committee feels it is necessary first to agree on particular measuring instruments and the procedure for their use; then make measurements in enough of the country's 19,000 theaters for the results to be conclusive.

The following brief specifications for illumination and brightness-measuring instruments, prepared in 1942, were then the committee's recommendations and are quoted here with a word of explanation, from the January, 1942, JOURNAL.

TABLE I  
PROVISIONAL SPECIFICATIONS FOR ILLUMINATION AND BRIGHTNESS METERS

	Illumination Meter	Brightness Meter
Useful range of instruments	0.2-50 foot-candles	0.5-30 foot-lamberts (or 4-30)
Accuracy of measured values	$\pm 5\%$	$\pm 5\%$
Reproducibility of measured values	$\pm 3\%$	$\pm 3\%$
Maximum screen area or angle to be included by instruments	1 sq ft	3° (preferably 2°)
Maximum price	\$50	\$50

“... readable brightness values from 0.5 to 30 foot-lamberts (were) 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 foot-lamberts was included, if it should be found impracticable to obtain an instrument capable of reading 0.5 foot-lambert.

“The values for the illumination meter of from 0.2 to 50 foot-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.”

Commercially available illumination instruments that have suitable sensitivity and spectral characteristics for measuring light incident on the screen could be used in a survey at the present time, with some modifications, but brightness meters are a more serious problem. The MacBêth Illuminometer and Luckiesh-Taylor visual comparison instruments are well known but are difficult to use for theater-screen work because color differences in the comparison field make the apparent brightness match so much a function of the observer's individual eye sensitivity that two observers rarely read the same values without recalibration of the instrument. Correlation of results is not easy, even in the hands of experienced operators, so the previous committee recommended that a photoelectric type of instrument with the proper spectral and sensitivity characteristics be developed for the brightness phase of the survey because the results would be practically independent of human error. The present committee concurs and is now considering tentative specifications for a combination brightness-and-illumination instrument.

A combination photoelectric instrument to read such extremely low brightness levels will require a long time for development, so the committee felt it undesirable to wait and further delay its work, because the need for the survey information is so urgent. Therefore, to get things started, the first item on the agenda was divided into several parts, in order that more than one phase of the work might proceed concurrently.

1. Conduct a preliminary survey to prove practicability of procedures and value of results. (This has been done and is the subject of the report of the Screen-Brightness Committee which follows this introduction.)

2. Develop new brightness meters. (New instruments are now in the process of development and will be described in a following issue of the JOURNAL.)
3. Prepare a simplified survey procedure. (The Committee's current recommended procedure is described in the Report of the Committee.)
4. Conduct a complete theater survey using new instruments and the approved procedures that have grown out of the preliminary survey.

Several questions which merit further consideration but are of such a nature that they must be held for a later date, were published in a Screen-Brightness Committee report on page 127, of the August, 1936, JOURNAL. In addition to those mentioned above, they are substantially as follows:

1. What correlation is there between best print contrast and screen brightness?
2. What effect does the brightness standard have upon the standard of release-print quality? Shall release prints of different contrasts be made available to theaters operating at different screen-brightness levels?
3. Is high-light density, average density, shadow density, density of the area of principal interest, or a combination of these factors the thing that determines preferred brightness?
4. What possibilities are there for improvement in projection optics, pull-down efficiency, and source brilliance?
5. What is the effect of color of the light source, color of the screen, and color of the print upon the desired brightness?
6. What proportion of moving picture goers see pictures on screens greater than 20 feet, 25 feet, 30 feet? Statistical data on theater sizes, screen sizes, projection equipment, and attendance figures are needed by the Committee. A complete paper of this kind would be valuable also in connection with other problems confronting the Society.
7. What factors determine screen width? Would it not be better, for instance, to use a 25-foot screen at 9 foot-lamberts than a 30-foot screen at 7 foot-lamberts? The data of visual acuity tell us that the picture detail visible at great viewing distances should not suffer.
8. What is the effect of auditorium illumination upon the required brightness level?

9. What is the effect of the visual angle or the screen size upon this value?

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Recommends that previously proposed screen illumination test film not be used.
- (3). "Report of the projection screen-brightness committee," *J. Soc. Mot. Pict. Eng.*, vol. 2, p. 127; August, 1936.  
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Relation of object size, contrast, illumination intensity, and visual exposure time in the study of human vision, with numerous references.
- (7). F. K. Moss and M. Luckiesh, "The motion picture screen as a lighting problem," *J. Soc. Mot. Pict. Eng.*, vol. 26, p. 578; May, 1936.  
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Measurements of the spectral-energy distribution of light on the screen.
- (9). O. Reeb, "A consideration of the screen-brightness problem," *J. Soc. Mot. Pict. Eng.*, vol. 5, p. 485; May, 1939.  
Report of a German survey recommending an interim screen brightness standard of 8' foot-lamberts and proposes further theater surveys.

(10). R. P. Teele, "Photometry and brightness measurements," *J. Soc. Mot. Pict. Eng.*, vol. 26, p. 554; May, 1936.

General data on screen brightness.

(11). C. M. Tuttle, "Density measurements of release prints," *J. Soc. Mot. Pict. Eng.*, vol. 26, p. 548; May, 1936.

Light-transmittance characteristics of release prints and their significance as related to the study of screen illumination.

(12). C. M. Tuttle, B. C. Hiatt, and B. O'Brien, "An experimental investigation of projection screen brightness," *J. Soc. Mot. Pict. Eng.*, vol. 26, p. 505; May, 1936.

Average observer's choice of screen brightness and contrast between picture and screen border.

(13). A. T. Williams and W. F. Little, "Résumé of methods of determining screen brightness and reflectance," *J. Soc. Mot. Pict. Eng.*, vol. 26, p. 570; May, 1936.

Importance of auditorium illumination and screen brightness, and methods of measuring both brightness and reflectance.

(14). S. K. Wolf, "An analysis of theater and screen-illumination data," *J. Soc. Mot. Pict. Eng.*, vol. 26, p. 532; May, 1936.

Review and summary of theater and screen-illumination data previously published, with a valuable list of references.

(15). R. J. Zavesky, C. J. Gertiser, and W. W. Lozier, "Screen illumination with carbon-arc motion picture projection systems," *J. Soc. Mot. Pict. Eng.*, vol. 48, p. 73; January, 1947.

Present-day carbon-arc projection systems and the amount of light they project are described with curves for determining illumination intensities on various sizes of screens. Reference is made to the applicable American Standard on Screen Brightness.

BOYCE NEMEC  
*Executive Secretary*

# Report of Screen-Brightness Committee\*

THE COMMITTEE has actively embarked on a preliminary survey of a number of representative theaters to determine practical methods for measuring brightness and illumination of motion picture screens. Equipment and test procedures immediately available were used to expedite the initial task of investigating in a few theaters proper measuring techniques, and of determining present brightness and intensity levels in theaters.

The immediate purpose of the committee's program is to gain enough experience concerning specific test procedures to be able to recommend techniques to be used in a more complete survey aimed at obtaining basic information regarding screen illumination and brightness practice in the entire industry. With information available on test methods and present theater practice, it will be possible for the industry and the committee to utilize theater equipment most effectively to achieve desirable standards of brightness.

This progress report deals specifically with the preliminary survey limited to eighteen theaters in the East and Middle West. The committee was very much pleased with the active co-operation afforded by the projectionists, the theater managers, and all other groups connected with the theater survey.

Acknowledgment is due also to the Bell and Howell, Eastman Kodak, General Electric, and National Carbon Companies for supplying the necessary equipment for conducting the survey.

## DETERMINATION OF DATA

It was the decision of the committee that in order to obtain complete data for over-all usefulness, it would be necessary to measure the light intensity on the screen, the brightness of the screen, and to record some of the physical dimensions of the theater affecting projection, and some of the details regarding projection equipment.

The measurement of screen illumination was made with each projector separately, with operation entirely normal except for the absence of film. The light intensity was measured at various points on the screen to determine the distribution of the intensity over the

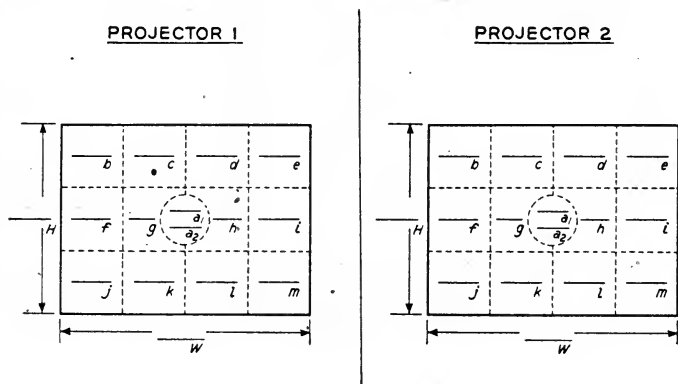
\* Presented October 22, 1947, at the SMPE Convention in New York.

surface and also to be able to compute the total lumens incident on the screen. Two different methods of doing this were employed. The one involved a division of the screen area into twelve equal areas.

SCREEN BRIGHTNESS SURVEY

SCREEN LIGHT INTENSITY

(PRELIMINARY "CONTROL" PROCEDURE)



READ INTENSITY ON THE SCREEN IN FOOT-CANDLES AT "a<sub>1</sub>" FIRST, THEN "b" THRU "m" IN SEQUENCE, CONCLUDING WITH "a<sub>2</sub>" AT THE CENTER TO CHECK INTENSITY CHANGES. POINTS "b", "c", "d", ETC., ARE IN THE CENTER OF THEIR DOTTED AREAS.

SCREEN AREA

AREA IN SQUARE FEET =  $H \times W$  (1)

SCREEN LUMEN CALCULATION

AVERAGE INTENSITY =  $\frac{\text{TOTAL } \Delta \text{ THRU } m}{12}$  (2)

SCREEN LUMENS = (1)  $\times$  (2)

SCREEN AREA

AREA IN SQUARE FEET =  $H \times W$  (1)

SCREEN LUMEN CALCULATION

AVERAGE INTENSITY =  $\frac{\text{TOTAL } \Delta \text{ THRU } m}{12}$  (2)

SCREEN LUMENS = (1)  $\times$  (2)

Fig. 1—Sample data sheet for determining screen illumination by the 12-point method.

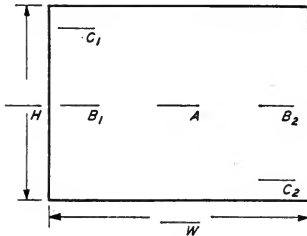
with the light intensity being measured at the center of each one of these zones. Fig. 1 describes this 12-point method and shows the form of the data sheet used to record the measurements. The other method consisted in measuring the light intensity at the center of the screen, at the upper left- and lower right-hand corners, and at the

SCREEN BRIGHTNESS COMMITTEE  
THEATER SURVEY

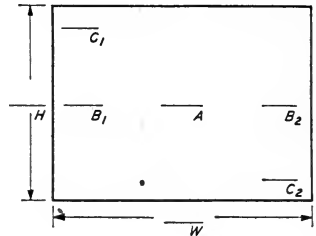
THEATER \_\_\_\_\_  
ADDRESS \_\_\_\_\_  
\_\_\_\_\_  
\_\_\_\_\_

DATE \_\_\_\_\_  
REPORTED BY \_\_\_\_\_

PROJECTOR 1



PROJECTOR 2



READ INTENSITY ON THE SCREEN IN FOOT-CANDLES AT THE FIVE POSITIONS INDICATED. "C<sub>1</sub>" AND "C<sub>2</sub>" ARE LOCATED  $\frac{1}{20}$  OF H FROM EDGES AND  $\frac{1}{20}$  OF W FROM SIDES. "B<sub>1</sub>" AND "B<sub>2</sub>" ARE ON THE HORIZONTAL CENTER AND  $\frac{1}{20}$  OF W FROM SIDES. "A" IS IN THE EXACT CENTER.

SCREEN AREA  
\* AREA IN SQUARE FEET =  $H \times W =$  (1)

SCREEN LIGHT INTENSITY AND DISTRIBUTION  
RATIO  $\frac{B_1 + B_2}{2} \times \frac{I}{A} =$   
RATIO  $\frac{C_1 + C_2}{2} \times \frac{I}{A} =$

SCREEN LUMEN CALCULATION  
 $A \times 2 =$   
 $B_1 + B_2 =$   
 $\frac{C_1 + C_2}{2} =$   
TOTAL = \_\_\_\_\_  
WEIGHTED AVG. =  $\frac{\text{TOTAL}}{5} =$  (2)  
SCREEN LUMENS = (1) x (2) = \*

SCREEN AREA  
AREA IN SQUARE FEET =  $H \times W =$  (1)

SCREEN LIGHT INTENSITY AND DISTRIBUTION  
RATIO  $\frac{B_1 + B_2}{2} \times \frac{I}{A} =$   
RATIO  $\frac{C_1 + C_2}{2} \times \frac{I}{A} =$

SCREEN LUMEN CALCULATION  
 $A \times 2 =$   
 $B_1 + B_2 =$   
 $\frac{C_1 + C_2}{2} =$   
TOTAL = \_\_\_\_\_  
WEIGHTED AVG. =  $\frac{\text{TOTAL}}{5} =$  (2)  
SCREEN LUMENS = (1) x (2) =

Fig. 2—Sample data sheet for determining screen illumination by the 5-point method.

right and left edges midway between the top and bottom of the screen. The 5-point method is illustrated in Fig. 2. The committee decided to use two methods in this preliminary survey to determine whether the method of 12 equal areas could be supplanted with no loss in accuracy by a quicker 5-, rather than 12-point measurement.



## SCREEN BRIGHTNESS SURVEY

SCREEN BRIGHTNESS

(MEASURED FROM AUDITORIUM SEATING POSITIONS)

<u>PROJECTOR 1</u>	<u>PROJECTOR 2</u>	
① $C_1$ _____	① $C_1$ _____	POSITION ① CENTER, $\frac{3}{2}$ SCREEN WIDTHS BACK FROM SCREEN ② LEFT FRONT CORNER SEAT ③ FIRST ROW CENTER ④ BALCONY TOP ROW CENTER  READ BRIGHTNESS AT 3 PLACES ON THE SCREEN FROM AUDITORIUM POSITIONS 1, 2 AND 3, BUT ONLY THE CENTER FROM POSITION 4
$A$ _____	$A$ _____	
$C_2$ _____	$C_2$ _____	
② $C_1$ _____	② $C_1$ _____	
$A$ _____	$A$ _____	
$C_2$ _____	$C_2$ _____	
③ $C_1$ _____	③ $C_1$ _____	
$A$ _____	$A$ _____	
$C_2$ _____	$C_2$ _____	
④ $A$ _____	④ $A$ _____	

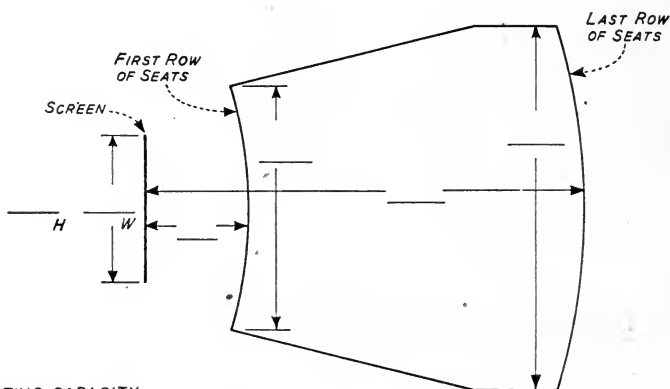
Fig. 3—Sample data sheet showing location of points for brightness measurement.

The equipment used to determine screen-light intensity consisted of a Weston "Photronic" cell corrected for eye sensitivity, and a microammeter, with the cell and meter calibrated in foot-candles. The cell was placed parallel to the screen facing the projector and the determination of incident foot-candles was made from the meter calibration at the various spots discussed and illustrated on the data

sheets. A telescoping pole capable of being extended 20 feet was used to advantage to raise the cell to the proper position on the screen. A tripod mounting equipped with casters facilitated the movement of the telescoping pole across the theater stage.

### SCREEN BRIGHTNESS SURVEY

#### AUDITORIUM DATA



1. SEATING CAPACITY \_\_\_\_\_
2. HOW MANY BALCONIES \_\_\_\_\_

#### PROJECTION DATA

- |   |          |                           |          |
|---|----------|---------------------------|----------|
| 1. DISTANCE FROM APERTURE TO CENTER OF SCREEN | _____    | 9. TYPE OF SHUTTER        | _____    |
| 2. PROJECTION ANGLE                           | _____    | (a) DEGREE OPENING        | _____    |
| 3. ARC LAMP TYPE                              | _____    | 10. DRAFT GLASS TYPE      | _____    |
| 4. POSITIVE CARBON                            | _____    | 11. HEAT FILTER TYPE      | _____    |
| 5. NEGATIVE CARBON                            | _____    | 12. PROJECTION PORT GLASS | YES - NO |
| 6. ARC AMPERES                                | _____    | 13. TYPE OF POWER SUPPLY  | _____    |
| 7. ARC VOLTS                                  | _____    | (a) RATING IN AMPERES     | _____    |
| 8. PROJECTION LENS                            | _____    | (b) RATING IN VOLTS       | _____    |
| (a) $f/$ NUMBER                               | _____    | (c) OPERATING VOLTAGE     | _____    |
| (b) FOCAL LENGTH                              | _____    |                           |          |
| (c) SURFACE COATED                            | YES - NO |                           |          |

Fig. 4—Sample data sheet for recording theater data.

Screen brightness was determined at the time screen-intensity measurements were being made. The brightness measurements were made at the center of the screen and at the upper left- and lower right-hand corners from four positions in the theater. The four positions as shown on the data sheet reproduced in Fig. 3 were in the

center of the theater  $3\frac{1}{2}$  screen widths back of the screen, in the center of the first row of seats, the extreme left seat in the first row, and the seat in the middle of the row farthest away from the screen in the highest balcony, if there was one. A Luckiesh-Taylor meter was employed to determine the screen brightness. Since only visual types of meters were immediately available the committee decided to utilize this type in the survey to permit concrete data to be obtained without too much delay. However, it is the intent of the committee to stimulate the development of physical brightness-measuring meters since it is felt that the visual type is not generally satisfactory because of the difficulty due to color differences in the photometer field.

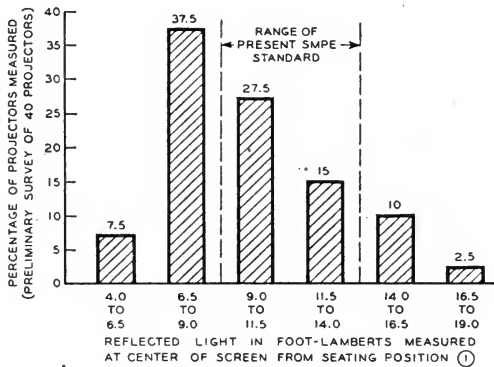


Fig. 5—Range of screen brightness obtained in the survey.

Among the more important theater characteristics which were measured and noted were the screen width and height, the seating plan with relation to the screen, that is, the distance from the screen to first and last rows, the width of the theater at the first and the last row, and the seating capacity. Data on projection equipment were also obtained and these included among other things the projection throw, projection angle, the type of lens, shutter, arc, and power supply. The data sheet used is illustrated in Fig. 4.

#### DISCUSSION OF DATA

The results obtained in the preliminary survey of the 18 theaters were representative of houses having screens in the range from 12 feet to 31 feet wide with seating capacities from 300 to 6200 seats and with

projection throws from 65 to 207 feet at projection angles from 5 to 24 degrees.

It was of particular interest to the committee to compare the results obtained on screen brightness with the 9- to 14-foot-lambert standard now in effect. After the brightness data were analyzed, one fact stood out. Approximately 50 per cent of the theaters had a screen brightness at or below the minimum recommended value. The data are summarized in Fig. 5 where there is plotted the percentages of the projectors—there were 40 projectors in the 18 theaters—which resulted in screen brightnesses in the indicated ranges. Only 12.5 per cent (5 projectors) exceeded the recommended maximum.

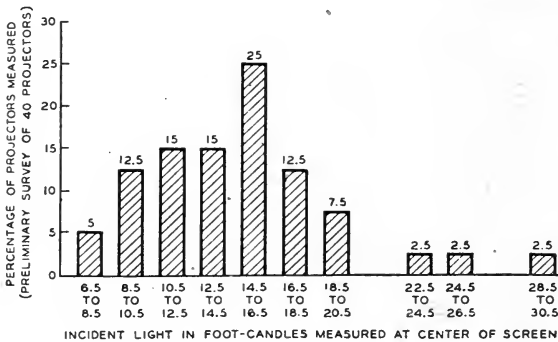


Fig. 6—Range of foot-candles incident intensity obtained in the survey.

Of interest to the committee also, was the light-intensity distribution over the screen and the total lumens on the screen. The foot-candle intensity at the center of the screen in these 18 theaters, varied from a minimum of 7 to a maximum of 30. The range of incident foot-candle intensities is shown in Fig. 6. Approximately one half of the projectors gave from 10.5 to 16.5 foot-candles.

An analysis of the distribution of light intensity over the screen showed that about two thirds of the projectors provided 50 to 75 per cent as much light at the sides as at the center. One projector provided only one third as much light at the side as at the center and in three cases the ratio was over 90 per cent. The ratio of corner-to-center light generally fell in the range 45 to 65 per cent, although in one case it was as low as 25 per cent and at the other extreme ran as high as 75 per cent.

TABLE I  
COMPARISON—5- VERSUS 12-POINT METHOD TO DETERMINE SCREEN LUMENS

Theater Number	1	2	3	4	5	6	7	8
Projector	1 2	1 2	1 2	1 2	1 2	1 2	1 2	1 2
Screen lumens, 5-pt	1630	3040	3250	3000	4340	2910	2340	1510
Screen lumens, 12-pt	1750	3240	4150	3160	3820	2150	2100	1480
Ratio, 5-pt to 12-pt	0.95	0.94	0.78	0.95	1.13	1.35	1.11	1.02
Theater Number	9	10	11	12	13	14	15	16
Projector	1 2	1 2	1 2	1 2	1 2	1 2	1 2	1 2
Screen lumens, 5-pt	2360	3950	3810	4840	3180	1765	2500	2950
Screen lumens, 12-pt	1660	3620	4200	5000	3460	1650	2300	2660
Ratio, 5-pt to 12-pt	1.06	1.09	0.91	0.97	0.92	1.07	1.09	1.10

Average ratio for all tests 1.002

The total luminous flux falling on the screens was calculated using both the 12-point and 5-point methods. The data are summarized in Table I. The results show no significant difference between the two methods, the average ratio of all results being 1.00. Because of this finding and the fact that the 5-point method is faster and simpler, the committee is inclined toward its use.

Estimates were also made of the screen lumens expected to be available on the basis of our knowledge of the equipment in use in each theater and the measurements recently published<sup>1</sup> on expected output of various types of projection systems. Generally, it was found that the screen lumens obtained fell below the expected values.

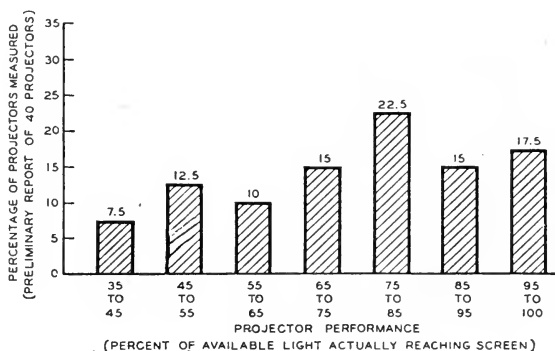


Fig. 7—Ratio of screen lumens observed in survey to that estimated available from laboratory measurements<sup>1</sup> on same type equipment.

The ratio of the screen lumens actually obtained to the expected values are shown in Fig. 7. Seventeen and one half per cent of the projectors obtained practically all the light to be expected from their equipment. On the other end of the scale, 7.5 were obtaining only 35 to 45 per cent of that estimated obtainable. About half of the cases resulted in from 35 to 75 per cent of the expected light while the other half obtained between 75 per cent and all of the light available. The reason for these deficiencies were not determined. However, it is felt that proper search would lead to corrections to minimize these differences.

With data available on light intensity on the center of the screen and brightness at the center, it was possible to calculate reflectivity for the matte screens encountered in the 18 theaters. The results are

shown in Fig. 8. The general average level of the reflectivity of the screens was approximately 70 per cent. Accurate reflectivity figures in individual cases were limited by difficulties in obtaining good visual-brightness values with the visual-brightness meter. This undoubtedly is partly responsible for the extremely high values of reflectivity in two theaters and possibly some of the low values, though in this case, deterioration is visualized as the major factor.

#### FURTHER PLANS OF THE COMMITTEE

It is recognized, of course, that the results obtained in a preliminary survey of 18 theaters are not conclusive evidence of the experience to be found in the approximately 19,000 theaters in the country.

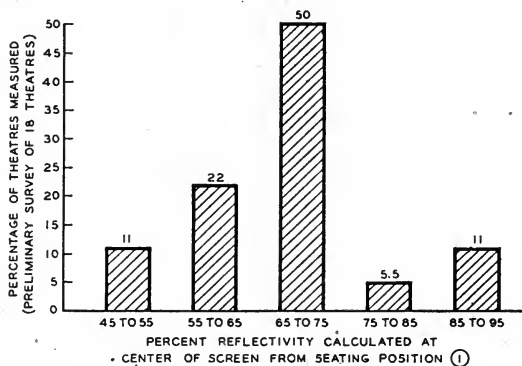


Fig. 8—Range of screen reflectivities obtained in the survey.

Therefore, this progress report is only indicative rather than conclusive and must be followed by a more thorough examination on rather sound statistical grounds before any conclusions can be drawn regarding the average brightness and illumination figures representative of motion picture practice today. Neither can the committee make definite recommendations yet concerning the technique to be used, particularly in the determination of screen brightness. The committee believes now that a truly successful and most useful brightness meter for motion picture survey usage should be a physical measuring device rather than a visual photometer. At least two manufacturers are engaged in the development of such instruments and the committee will examine these units to determine their practicability for the task involved.

Although definite plans have not yet been formulated, it is the hope and intent of the committee that this work be continued more extensively to arrive at the objectives of specifying equipment and test methods for accurately measuring brightness and illumination on the screen and of determining present practice in the theaters. It is believed the industry will then be in a proper position to make the most effective utilization of available equipment and to maintain screen lighting in line with recommended practice.

#### SCREEN-BRIGHTNESS COMMITTEE

	E. R. GEIB, <i>Chairman</i>	
HERBERT BARNETT	W. W. LOZIER	C. R. UNDERHILL
F. E. CARLSON	*V. A. SILARD	H. E. WHITE
SYLVAN HARRIS	*M. H. STEVENS	A. T. WILLIAMS
W. F. LITTLE	C. M. TUTTLE	R. J. ZAVESKY

\*Advisory members.

#### REFERENCE

(1) R. J. Zavesky, C. J. Gertiser, and W. W. Lozier, "Screen illumination with carbon-arc motion picture projection systems," *J. Soc. Mot. Pict. Eng.*, vol. 48, p. 73; January, 1947.

#### DISCUSSION

MR. HENRY GREENSPOON: Has the Committee established what would be a desirable screen brightness for theaters?

MR. R. J. ZAVESKY: The present standard is 9 to 14 foot-lamberts as measured at the center of the screen, with the projector running but with no film in the gate. Whether that standard will be changed I am not prepared to say.

MR. ABE KESSLER: As I understand, all the concerns that sell equipment—motors, generators, rectifiers, projectors—are not equipped to advise a man who is going to build a theater and who comes to the supply houses for advice. They are not equipped to advise him just what to get for a different throw considering the size of the house, and other matters.

Why should they not be supplied with proper information? They should know the right type of equipment to sell.

MR. ZAVESKY: By finding out the present practice in theaters, by proper measuring instruments, and by knowing what each piece of equipment will deliver, it will be a natural evolution that that sort of thing will occur: the equipment in the theater will be matched to meet the standards set up by the SMPE.

MR. RONALD BINGHAM: Knowledge of the surrounding brightness is very important in interpreting the data such as you have given. Is there any intent on the part of the Committee to gather data on the screen-brightness level, excluding projected light?

MR. ZAVESKY: That is part of the longer-range objective of the committee, but it has not been a part of the immediate program. The initial phases are



aimed mainly at determining what methods and equipment should be used to measure brightness and illumination and to determine what is the present practice. Some of those other things we all hope will come along a little later in the program.

MR. MATTHEW J. KEEHAN: I assume that during the course of your survey you did not visit any studios. Do you intend to do so?

MR. ZAVESKY: Not at the present moment. The main intent is to determine the practice in motion picture theaters.

MR. JOHN FERGUSON: There was one point on which I was not exactly clear. You mentioned that 50 per cent of the theaters were getting 75 per cent of the available light. Do you mean that there were misadjustments in the equipment or do you mean that the equipment was rated at a higher rating than the theater actually was using?

MR. ZAVESKY: Data have been published in the JOURNAL indicating the total quantity of light that could be expected from various combinations of arcs and optical systems. Those data were taken into consideration along with the exact projection equipment in the theater, and the ratio of that which could be expected to that which was actually measured was shown in Fig. 7. The committee did not investigate why that difference occurred.

MR. BEN SCHLANGER: The factor of the screen itself and the light coming from it represent additional items that are elusive. I wonder if this report will include that eventually? One is the age of the screen; two, the location of the screen, the atmospheric condition; three, the polar characteristic of the screen.

Unless we investigate all of these things, the changing factor of what you are getting off that screen is amazing. Unless we add those data we do not know what actually is getting to the people's eyes.

MR. ZAVESKY: The age of the screen with its condition was not specifically investigated. The committee went into the theater and measured what the condition was at the moment. Whether it was a new screen or an old, a dirty screen or a clean screen was not taken into consideration.

With reference to the condition of the atmosphere: Since all these measurements were made without any people in the house I suppose we could assume that the atmospheric conditions were best.

We expected to consider the polar characteristic and we still hope that the information that we have will show that. You will recall the slide on which was shown where and how the brightness was measured. The brightness reading was taken at the center of the screen and at the upper left- and lower right-hand corners, from four extreme positions in the theater.

When we have sufficient information available from a more intensive survey, all of those data can be analyzed to tell what is the polar characteristic of the screen. While the indications are not definite, yet they tend to show that the screens all were matte and had a fairly uniform reflectivity within the angles encountered in the particular theaters surveyed.

MR. SCHLANGER: What brightness is best for different density conditions of film or what lambert will produce the best contrast value for discerning image detail? The light values alone will not give us the ultimate answer unless we have tests made with actual film strips.

MR. ZAVESKY: That point is realized by the committee, but the committee

chose to consider first things first. One of the basic unknowns was the present value. Once that is determined, our activity can be enlarged to include such very pertinent questions as you have raised.

MR. SCHLANGER: Will not that affect the recommended foot-lambert measurement?

MR. ZAVESKY: It probably will if it is demonstrated by proper tests that the standards should be changed. Right now the standards are 9 to 14 foot-lamberts.

MR. GEORGE LEWIN: Could you give us a little more detail as to the type of instrument with which you measured the brightness?

MR. ZAVESKY: That was a Luckiesh-Taylor visual photometer.

MR. LEWIN: I am not familiar with that. Can you tell definitely what part of the screen you are looking at when you look through the instrument? Is it a focused image?

MR. ZAVESKY: You can use either a view finder—which we did in some instances—or by locating on the screen at the same time some one is measuring illumination with a photronic cell, it is possible to tell where you are on the screen and knowing the angle of acceptance of the instrument and the distance you are, you can tell what portion of the screen you are actually measuring when you are measuring brightness.

MR. LEWIN: I assume, then, you did not use the Weston instrument that is available to a limited extent right now?

MR. ZAVESKY: For measuring brightness?

MR. LEWIN: Yes.

MR. ZAVESKY: I am not familiar with that one.

MR. LEWIN: It is a foot-lambert meter which has been put out on a small scale.

MR. N. D. GOLDEN: Based upon your findings that you projected on the screen there, the wide variance of percentages that you have found as conditions exist in different theaters, would you not come to the conclusion that possibly a great deal of the fault is based upon the poor quality or outmoded use of the screens and possibly the projection equipment used in the theaters that you measured?

MR. ZAVESKY: I do not think the Committee has done enough to take any stand at all on that, Mr. Golden.

MR. GOLDEN: Because of the wide variance in your percentages found—in some cases your results were of a higher degree and in a great many cases they were of low degree—you can, therefore, come to but one conclusion: Either the screens were old, dirty, and outmoded, or the light sources projected from the projection room were not adequate.

MR. ZAVESKY: Certainly if you are investigating the basic reasons for those things which were discovered, you have two factors to consider: what light is projected to the screen and what is reflected. So that on a very broad generalization the reasons why the brightness was not up or why the light intensity was not what it might have been have to be attributed to one or the other. That was not determined in this survey.

MR. GOLDEN: I quite understand that, but I think it would be the object of your Committee to find out whether or not the equipment in use in the theaters of the country, screens, projection equipment, light sources, and everything involved needs replacing and can very well stand it.

MR. ZAVESKY: Your suggestion will certainly be given consideration by the committee, Mr. Golden.

MR. JOHN H. KURLANDER: One of the items measured there was the projection distance. I noticed that the projection distance was measured from the aperture to the screen. Now I have always considered that the projection distance was measured from the front surface of the lens nearest the screen to the screen itself. The projection lens constitutes the last light source in the train. It is true that the screen there is rather small. However, inasmuch as the foot-candles on the screen are determined absolutely by the brightness of the lens and the lens area, the effective lens area—and that varies inversely as the square of the distance—that discrepancy becomes somewhat larger. Why was the distance chosen as being from the aperture to the screen?

MR. ZAVESKY: It is more a question of saying that it was from the aperture to the screen rather than a specific measurement. The determination of that distance was made by measuring from the screen to the point in the theater on a parallel under which we estimated the projector to be, and then calculating from the projection angle what the actual distance was.

I am quite sure that those figures are not accurate to better than 6 inches, but even considering the shortest throw, a 65-foot throw, an error of plus or minus 6 inches, will be not more than 1 per cent.

MR. KURLANDER: I brought that up merely for the sake of accuracy because the projection distance is actually measured from the last lens in the system, and that is the projection lens to the screen.

The second point is with regard to the relatively low values of reflection factors for these screens. Was that reflection factor determined on the basis of an integrated effect over an appreciable area of the screen which took into account the screen perforations or was that intended to represent the coefficient of reflection of the screen surface itself, that is, the reflecting efficiency of the screen surface?

MR. ZAVESKY: That was determined by taking the ratio of the brightness measured at the center of the screen to the light intensity at the center of the screen. The brightness-measuring instrument probably did not include more than an area of 1 to 2 square feet. It certainly took into consideration if there were holes in the screen as it existed in the theater at the center.

MR. KURLANDER: It was an integrated effect?

MR. ZAVESKY: For a small area at the center of the screen.

MR. KURLANDER: There again the actual coefficient of the reflection of the screen surface would be higher than is shown.

MR. ZAVESKY: You mean of the unperforated screen?

MR. KURLANDER: That is right.

MR. ZAVESKY: I expect it would be.

# Report of ASA Committee on Standards for Motion Pictures, Z22

**D**URING THE YEAR 1947, fourteen American Standards on motion pictures were approved. Of these, the following three were reaffirmed from previous Z22 standards with only editorial changes:

- Z22.10-1947 Emulsion Position in Projector for Direct Front Projection of 16-Millimeter Silent Motion Picture Film
- Z22.16-1947 Emulsion and Sound-Record Positions in Projector for Direct Front Projection of 16-Millimeter Sound Motion Picture Film
- Z22.22-1947 Emulsion Position in Projector for Direct Front Projection of 8-Millimeter Silent Motion Picture Film

Although the two 16-millimeter emulsion-position standards (Z22.10 and Z22.16) were unanimously reaffirmed with only editorial changes, reconsideration was subsequently requested by Mr. K. F. Abeel, representing the General Electric Company. Since several other members who had voted for reaffirmation joined Mr. Abeel in asking for reconsideration, the chairman appointed the following subcommittee to prepare a further analysis of 16-millimeter photographing and printing practices for consideration of the entire Committee: A. W. Cook, *chairman*, K. F. Abeel, M. C. Batsel, O. Sandvik, and E. Schmidt.

The four following standards were reconsidered and modified in their methods of dimensioning, to be more useful in actual practice:

- Z22.5 Cutting and Perforating Dimensions for 16-Millimeter Silent Motion Picture Negative and Positive Raw Stock
- Z22.12 Cutting and Perforating Dimensions for 16-Millimeter Sound Motion Picture Negative and Positive Raw Stock
- Z22.17 Cutting and Perforating Dimensions for 8-Millimeter Motion Picture Negative and Positive Raw Stock
- Z22.36 Cutting and Perforating Dimensions for 35-Millimeter Motion Picture Positive Raw Stock

The principal changes in the above standards consisted in showing dimensions as measured from the edges of sprocket holes rather than from center lines.

In reviewing the 35-Millimeter Projector-Sprocket Specification, it was found desirable to make a further study of the sprocket diameter, which had been standard since 1930. In the reapproved edition, Z22.35-1947, 16-Tooth 35-Millimeter Motion Picture Projector

Sprockets, this dimension has been changed to 0.943 inch (from 0.945 inch) to reduce film wear.

The Standard for Photographic Density Z22.27 was revised to take advantage of the more detailed standard developed for Still Photography Z38.2.5-1946.

Two new standards on camera and projector apertures were based on corresponding Z52 War Standards:

- Z22.59-1947 Photographing Aperture of 35-Millimeter Sound Motion Picture Cameras
- Z22.58-1947 Picture-Projection Aperture of 35-Millimeter Sound Motion Picture Projectors

Film-Nomenclature Standard Z22.56-1947 and 16-Millimeter Buzz-Track Test Film Z22.57-1947 were also taken from Z52 War Standards without change. The new standard Z22.55-1947, 35-Millimeter Sound Motion Picture Release Prints, is essentially a statement of current American practice in the preparation of 35-millimeter motion picture film in 2000-foot lengths for distribution to theaters.

Shortly after the Screen-Size Standard Z22.29-1946 was adopted, the objection was raised that it was not clear as to whether or not the dimensions included the entire screen or only the useful area. Consequently the Chairman asked the Motion Picture Research Council to make a proposal for revision which would clarify this point.

The following nine proposed standards on 35-millimeter test films were prepared by the Motion Picture Research Council and submitted by letter ballot to members of the Z22 Committee:

- Z22.60 Theater Sound Test Film for 35-Millimeter Motion Picture Sound-Reproducing Systems
- Z22.61 Service-Type Sound-Focusing Test Film for 35-Millimeter Motion Picture Sound Reproducers
- Z22.62 Laboratory-Type Sound-Focusing Test Film for 35-Millimeter Motion Picture Sound Reproducers
- Z22.63 Service-Type Multifrequency Test Film for 35-Millimeter Motion Picture Sound Reproducers
- Z22.64 Laboratory-Type Multifrequency Test Film for 35-Millimeter Motion Picture Sound Reproducers
- Z22.65 Service-Type Scanning-Beam Uniformity Test Film for 35-Millimeter Motion Picture Sound Reproducers
- Z22.66 Laboratory-Type Scanning-Beam Uniformity Test Film for 35-Millimeter Motion Picture Sound Reproducers
- Z22.67 1000-Cycle Balancing Test Film for 35-Millimeter Motion Picture Sound Reproducers

Z22.68 Buzz-Track Test Film for 35-Millimeter Motion Picture Sound Reproducers

Each of these proposals covers a test film which is now in general use.

Two proposed standards for dimensions of 200-mil push-pull sound tracks were also submitted by the Motion Picture Research Council. Since these proposals did not include tolerances, the Chairman appointed the following Committee to prepare revised proposals conforming to other sound track standards: G. R. Crane, *chairman*, M. C. Batsel, W. F. Kelly, L. L. Ryder, and W. C. Miller.

The following 15 standards were referred to the Society of Motion Picture Engineers for revision on November 5, 1945:

- Z22.7-1941 Camera Aperture for 16-Millimeter Silent Motion Picture Film
- Z22.8-1941 Projector Aperture for 16-Millimeter Silent Motion Picture Film
- Z22.13-1941 Camera Aperture for 16-Millimeter Sound Motion Picture Film
- Z22.14-1941 Projector Aperture for 16-Millimeter Sound Motion Picture Film
- Z22.19-1941 Camera Aperture for 8-Millimeter Silent Motion Picture Film
- Z22.20-1941 Projector Aperture for 8-Millimeter Silent Motion Picture Film
- Z22.34-1930 Cutting and Perforating Negative and Positive Raw Stock for 35-Millimeter Motion Picture Film
- Z22.4-1941 Projection Reels for 35-Millimeter Motion Picture Film
- Z22.11-1941 Projection Reels for 16-Millimeter Motion Picture Film
- Z22.23-1941 Projection Reels for 8-Millimeter Silent Motion Picture Film
- Z22.26-1941 Sensitometry for Motion Picture Film
- Z22.24-1941 Film Splices Negative and Positive for 16-Millimeter Silent Motion Picture Film
- Z22.25-1941 Film Splices Negative and Positive for 16-Millimeter Sound Motion Picture Film
- Z22.6-1941 Projector Sprockets for 16-Millimeter Motion Picture Film
- Z22.18-1941 8-Tooth Projector Sprockets for 8-Millimeter Motion Picture Film

It is hoped that the Society will submit recommendations for revision of these standards at an early date.

At the request of Eastman Kodak Company, War Standards Z52.51-1946 Base Point for Distance Scales 16-Millimeter Cameras and Z52.50-1946 Lens-Registration Distance 16-Millimeter Cameras were referred to the Society of Motion Picture Engineers on February 4, 1947, for recommendations for American Standards.

Fader Setting Instructions Z22.32-1941 was unanimously withdrawn since the practice described is no longer followed.

The attention of the Committee was drawn to the apparent omission of silent pictures from the Scope as originally adopted. Since this was, of course, unintentional the following revision of the Scope was proposed and adopted:

The formulation of definitions, dimensional standards, methods of test and rating, and performance characteristics of materials and devices used in silent and sound motion picture photography and in sound recording, processing, and reproduction in connection therewith.

The revised Scope has been submitted to the International Standards Organization for its approval as the Scope for the international project. In this connection it will be recalled that the American Standards Association has been designated as the Secretariat of Motion Picture Standards for the ISO. All ASA standards on motion pictures will be submitted to the ISO for consideration.

The chairman wishes to express his appreciation for the active cooperation of the Society of Motion Picture Engineers, Motion Picture Research Council, and members of the Z22 Committee.

C. R. KEITH  
*Chairman*

ALFRED N. GOLDSMITH, *Honorary Chairman*  
W. H. DEACY, JR., *Secretary*

Acoustical Society of America.....	F. L. HOPPER
American Society of Cinematographers.....	JOSEPH RUTTENBERG
AnSCO Division of General Aniline and Film Corporation.....	ALAN W. COOK
ASA Sectional Committee on Standardization in the Field of Photography, Z38.....	L. A. JONES
Bausch and Lomb Optical Company.....	K. PESTRECOV
(Alternate).....	L. V. FOSTER
Bell and Howell Company.....	M. G. TOWNSLEY
The Calvin Company.....	LLOYD THOMPSON
(Alternate).....	F. O. CALVIN
De Luxe Laboratories.....	E. A. BERTRAM
(Alternate).....	F. G. GRIGNON
E. I. du Pont de Nemours and Company.....	J. E. SCHMIDT
Eastman Kodak Company.....	O. SANDVIK
(Alternate).....	M. E. RUSSELL
Illuminating Engineering Society.....	RALPH E. FARNHAM
International Projector Corporation.....	H. BARNETT
J. A. Maurer, Inc.....	J. A. MAURER
(Alternate).....	R. C. HOLSLAG
Mitchell Camera Corporation.....	G. A. MITCHELL
Motion Picture Association of America.....	J. B. McCULLOUGH
	F. W. DUVALL
	DAVID PALFREYMAN

National Bureau of Standards.....	RAYMOND DAVIS
National Carbon Company.....	D. B. JOY
(Alternate).....	F. T. BOWDITCH
General Electric Company.....	K. F. ABEEL
Optical Society of America.....	A. C. HARDY
Photographic Society of America.....	ALLEN STIMSON
(Alternate).....	WILLIAM YALE
Radio Corporation of America, RCA Victor	
Division.....	M. C. BATSEL
(Alternate).....	R. O. DREW
Motion Picture Research Council.....	FARCIOT EDOUART
	W. F. KELLEY
	WESLEY C. MILLER
Society of Motion Picture Engineers.....	F. T. BOWDITCH
	E. K. CARVER
	C. R. KEITH
(Alternate).....	D. F. LYMAN
Technicolor Motion Picture Corporation....	JOHN R. CLARK, JR.
United States Navy Department.....	E. S. COBB
	LT. J. HENRY McMURRAY
United States War Department, Army Air	
Forces.....	C. B. KRUMM
(Alternate).....	R. D. FULLERTON
United States War Department, Medical	
Corps.....	CAPTAIN J. Q. CONROY
United States War Department, Signal	
Corps.....	BERNARD S. LEE
(Alternate).....	E. P. SUTHERLAND
Western Electric Company.....	G. R. CRANE
Member-at-Large.....	ALFRED N. GOLDSMITH



SMPE—American Standards  
Binder



## American Standards on Motion Pictures

This is a review of all current American Standards in the Z22 series and others of interest to the motion picture industry that have been approved and published by the American Standards Association.

SINCE THE SMPE, the Motion Picture Research Council, and the American Standards Association began active work on their enlarged motion picture standards program in January, 1946, 40 pertinent motion picture standards have been approved and published. They have all been considered by engineering committees of the Society at some time in the history of their development, and were recommended for adoption by the SMPE Standards Committee. Some are revisions of previous issues that were recently brought up to date, others are modifications of Z52 War Standards that the motion picture industry requested be carried over in permanent form, while one is a Z38 Photography Standard that is referred to here because it is of importance to motion pictures.

All 40 standards are available in  $8\frac{1}{2} \times 11$ -inch format, punched to fit the standard three-ring binder. These standards are published also in the JOURNAL for the information of members, as soon after ASA approval as possible. Usually a report accompanies the new standard giving the history of its development, with a statement of the reasons for adopting certain dimensions or methods of presentation where these things might not be readily apparent.

The issues of the JOURNAL for April and September, 1946, August and December, 1947, and the current issue carry 39 of the 40 standards listed below, the other being the Z38 Standard that is described but will not be published.

All persons who purchased the SMPE American Standards Binder shown on page 278, from the Society, are notified each time new standards are approved so that they may keep their records always up to date. The name and address of the original purchaser are kept on a stencil by the Society, making notification automatic, where the original purchaser still has his binder. However, many binders have since changed hands without a change of stencil, so undoubtedly a number of incomplete records are now in use. If you are not certain that you have all 40, be sure to check what you do have against this list.

The last of these notices, which was mailed out in October, 1947, listed the 14 standards in the following list that are followed by an asterisk. If they are missing from your set, please notify Boyce Nemeec, *Executive Secretary*, so that your name and correct address can be placed on the list for future notices. There is no charge for this service, but there is a charge for the standards, which are available in sets only from the Society, or as individual copies from the American Standards Association, 70 East 45th Street, New York 17, N. Y. The last group of 14 standards may be purchased from the Society for \$2.30, representing a substantial saving over the single copy price.

The Society also has a small stock of complete sets of 40 standards with binders available for \$7.40, when mailed to an address in the United States, or for \$7.90 when mailed to a foreign country. Your order automatically will put your name on the mailing list, so be certain to show the correct name and address of the person who will use the standards, and not just the name of your company or purchasing agent.

- Z22.2-1946 Emulsion and Sound-Record Positions in Camera for 35-Millimeter Sound Film
- Z22.3-1946 Emulsion and Sound-Record Positions in Projector for 35-Millimeter Sound Film
- Z22.5-1947\* Cutting and Perforating Dimensions for 16-Millimeter Silent Negative and Positive Raw Stock
- Z22.9-1946 Emulsion Position in Camera for 16-Millimeter Silent Film
- Z22.10-1947\* Emulsion Position in Projector for 16-Millimeter Silent Film
- Z22.12-1947\* Cutting and Perforating Dimensions for 16-Millimeter Sound Negative and Positive Raw Stock
- Z22.15-1946 Emulsion and Sound-Record Positions in, Camera for 16-Millimeter Sound Film
- Z22.16-1947\* Emulsion and Sound-Record Positions in Projector for 16-Millimeter Sound Film
- Z22.17-1947\* Cutting and Perforating Dimensions for 8-Millimeter Negative and Positive Raw Stock
- Z22.21-1946 Emulsion Position in Camera for 8-Millimeter Silent Film
- Z22.22-1947\* Emulsion Position in Projector for 8-Millimeter Silent Film
- Z22.27-1947\* Method of Determining Transmission Density of Films  
(includes Z38.2.5-1946 Diffuse Transmission Density)
- Z22.28-1946 Dimensions for Projection Rooms and Lenses for Theaters
- Z22.29-1946 Dimensions for Theater Projection Screens
- Z22.31-1946 Definition for Safety Film
- Z22.35-1947\* Dimensions for 16-Tooth 35-Millimeter Projector Sprockets
- Z22.36-1947\* Cutting and Perforating Dimensions for 35-Millimeter Positive Raw Stock
- Z22.37-1944 Raw-Stock Cores for 35-Millimeter Film

- Z22.38-1944 Raw-Stock Cores for 16-Millimeter Film
- Z22.39-1944 Screen Brightness for 35-Millimeter Motion Pictures
- Z22.40-1946 Sound Records and Scanning Area of 35-Millimeter Sound Prints
- Z22.41-1946 Sound Records and Scanning Area of 16-Millimeter Sound Prints
- Z22.42-1946 Specifications for Sound-Focusing Test Films for 16-Millimeter Sound-Projection Equipment
- Z22.43-1946 Specifications for 3000-Cycle Flutter Test Film for 16-Millimeter Sound Projectors
- Z22.44-1946 Specifications for Multifrequency Test Film for Field-Testing 16-Millimeter Sound-Projection Equipment
- Z22.45-1946 Specifications for 400-Cycle Signal-Level Test Film for 16-Millimeter Sound-Projection Equipment
- Z22.46-1946 16-Millimeter Positive Aperture Dimensions and Image Size for Positive Prints Made from 35-Millimeter Negatives
- Z22.47-1946 Negative Aperture Dimensions and Image Size for 16-Millimeter Duplicate Negatives Made from 35-Millimeter Positive Prints
- Z22.48-1946 Printer-Aperture Dimensions for Contact Printing 16-Millimeter Positive Prints from 16-Millimeter Negatives
- Z22.49-1946 Printer-Aperture Dimensions for Contact-Printing 16-Millimeter Reversal and Color-Reversal Duplicate Prints
- Z22.50-1946 Reel Spindles for 16-Millimeter Projectors
- Z22.51-1946 Method of Making Intermodulation Tests on Variable-Density 16-Millimeter Sound Prints
- Z22.52-1946 Method of Making Cross-Modulation Tests on Variable-Area 16-Millimeter Sound Prints
- Z22.53-1946 Method of Determining Resolving Power of 16-Millimeter Projector Lenses
- Z22.54-1946 Method of Determining Freedom from Travel Ghost in 16-Millimeter Sound Projectors
- Z22.55-1947\* 35-Millimeter Sound Motion Picture Release Prints in Standard 2000-Foot Lengths
- Z22.56-1947\* Nomenclature for Motion Picture Film Used in Studios and Processing Laboratories
- Z22.58-1947\* Picture-Projection Aperture of 35-Millimeter Sound Projectors
- Z22.59-1947\* Photographing Aperture of 35-Millimeter Sound Cameras
- Z38.3.1-1943\* Definition of Safety Photographic Film

There is no standard numbered Z22.1, and Z22.32 has been canceled, leaving eighteen intervening yet to come and of these,

Z22.57-1947 Specifications for 16-Millimeter Buzz Track Test Film

will appear in a later issue of the JOURNAL with a review of its recent past history.

The remaining seventeen standards are in various stages of development, in Committees of the Society, the Motion Picture Research Council, or in Subcommittees of Z22, the ASA Committee on Motion Pictures.

# Five Recent American Standards on Motion Pictures

The Standards shown or described here are the last five of a series of forty American Standards of interest to motion picture engineers that are listed in a short review article beginning on page 279 of this issue.

## Density of Motion Picture Films

THE AMERICAN STANDARD Z22.27-1947, a revised version of a similar standard that appeared on page 245 of the JOURNAL for March, 1941, indicates that the motion picture industry has adopted the diffuse visual and printing density standards defined in another American Standard, Z38.2.5-1946, Diffuse Transmission Density. Prepared by the ASA Committee on Photography, with concurrence from the SMPE Standards Subcommittee on Sensitometry and Density, the Z38 document is an excellent treatise on the subject. Apparatus and procedures for evaluating the diffuse transmission density of photographic materials by integrating-sphere, opal-glass, and contact-printing methods are described. Outline diagrams of several types of instruments accompany each description, making it easy to visualize their fundamental differences as well as physical arrangement and operation.

With this standard it becomes practicable to calibrate a number of photographic samples to use as reference specimens for calibrating ordinary densitometers.

In general-only densitometers which conform to the conditions specified are capable of giving accurate readings of American Standard diffuse visual or printing density for all types of photographic materials. However, many simple densitometers give readings on different materials with sufficient accuracy for most practical work.

If a nonconforming densitometer is to be used in connection with a given type of photographic material, it may be calibrated from reference samples composed of the same material. In this way any type of densitometer can be calibrated to read "American Standard diffuse visual or diffuse printing density" on any single type of photographic material, to a degree of accuracy commensurate with the stability and reproducibility of the instrument itself.

American Standard  
**Method of Determining Transmission  
Density of Motion Picture Films**

**ASA**  
*Reg. U. S. Pat. Off.*  
**Z22.27-1947**  
Revision of  
**Z22.27-1941**

The method of determining transmission density of motion picture films shall be in accordance with the American Standard for Diffuse Transmission Density, Z38.2.5-1946. Where applicable, either diffuse visual density, Type V1-b, or diffuse printing density Type P2-b, shall be used.

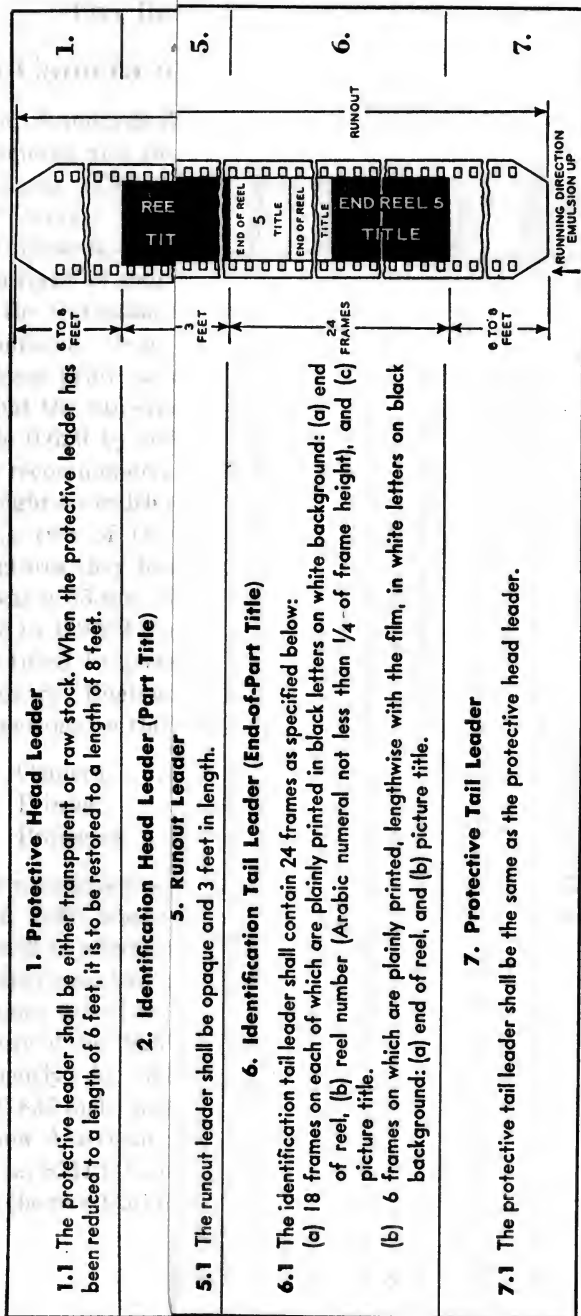
## Release Prints in 2000-Foot Lengths

American Standard Z22.55-1947 specifies the length and detailed makeup of head and tail leaders for 35-mm release prints customarily mounted on 2000-foot reels. This is the first time such information has appeared as a formal American Standard but it has been an "Academy Standard" used in substantially the same form for many years.

Because of vast quantities of release material that had been exchanged between Great Britain and the United States, the British hoped that the standards of both nations could be made alike in all respects, so the British Standards Institution transmitted their recommendations on the subject to the Research Council in March, 1945, requesting American consideration of their proposed standards. These were considered at a joint meeting of the Society of Motion Picture Engineers and the Research Council in May, 1945, when several modifications were incorporated in the proposed American Standard which was later submitted to Z22, the ASA Committee on Motion Pictures for approval.

During the Z22 balloting, Mr. John R. Clark, representing the Technicolor Motion Picture Corporation, suggested a modification in the terminology formerly used. He was opposed to the use of the word *trailer* since in the experience of the American motion picture industry the word trailer had come to refer only to the preliminary advertising films which are exhibited in advance of the feature. He suggested that the word *leader* might be substituted and all members of Z22 agreed, recommending that it appear in the standard as *head leader* and *tail leader* because the meanings would be easily understood by anyone familiar with commercial motion picture practice. The standard was subsequently validated in its approved form by the Standards Council of the ASA on September 29, 1947.

The standard specifies the size and location of change-over cue marks and states that the motor cue shall be circular opaque marks with a transparent outline printed from the negative. It is customary to use a serrated die for making these marks; however an alternate procedure of marking with ink is described.



**1. Protective Head Leader**

**1.1** The protective leader shall be either transparent or raw stock. When the protective leader has been reduced to a length of 6 feet, it is to be restored to a length of 8 feet.

**2. Identification Head Leader (Part Title)**

**5.1** The runout leader shall be opaque and 3 feet in length.

**6. Identification Tail Leader (End-of-Part Title)**

**6.1** The identification tail leader shall contain 24 frames as specified below:

- (a) 18 frames on each of which are plainly printed in black letters on white background: (a) end of reel, (b) reel number (Arabic numeral not less than 1/4-of frame height), and (c) picture title.
- (b) 6 frames on which are plainly printed, lengthwise with the film, in white letters on black background: (a) end of reel, and (b) picture title.

**7. Protective Tail Leader**

**7.1** The protective tail leader shall be the same as the protective head leader.

\*NOTE: To obtain the transparent outline, the use of a serrated die has been recommended. However, the following alternate method may be used: Insert in the base side of the cue mark hole in the negative a steeper of hard rubber or hard wood which has been dipped in coding ink, and rotate the steeper slightly in the film in order that the ink will form a thin ring around the edge of the hole. Only a very small amount of ink is necessary.





## 35-Mm Camera and Projector Apertures

American Standards Z22.58 and Z22.59, specifying apertures for 35-mm cameras and projectors, are identical with two American War Standards (Z52.37 and Z52.36) published in 1944 for the Army and Navy. Although not previously dignified as American Standards, these apertures have been in common use since shortly after the advent of sound motion pictures.

During the transition from silent to sound films there was a great deal of confusion about the amount of picture that would appear on the release print, so as a temporary measure the Society recommended that the cameraman compose the picture within the limits of a rectangle 0.620 by 0.835 inch. Projection apertures at the same time were recommended as 0.600 by 0.800 inch, which gave a three-to-four, height-to-width ratio. In spite of camera and projector apertures being two of the most vital interchangeability elements in motion pictures they have had a rather hectic history.

There was a 35-mm silent *SMPE Standard Motion Picture Aperture* 0.6795 by 0.9060 inch, adopted in 1922 with a recommendation that it be titled *Projector Aperture*. After three years of discussion in this country, England, and France, the Society announced proposed dimensions for the three apertures in 1925 as

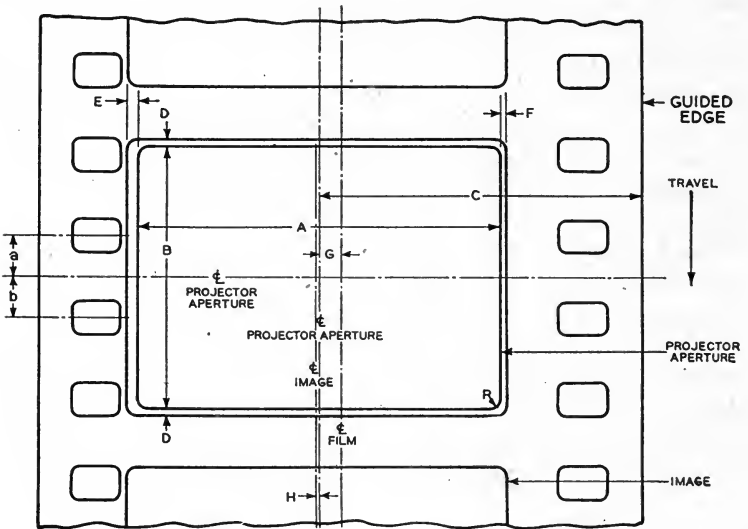
Camera.....	0.700 by 0.925 inch
Printer.....	0.757 by 1.000 inch
Projector.....	0.725 by 0.950 inch

They were mentioned on page 411 of *The Transactions* of the Society for August, 1927, where it was pointed out that the 1922 Standard was then still in effect and that since during the five-year period no projector apertures had been changed to agree with the new proposal, probably none would be, so no further action was taken to obtain approval of any of the 1925 proposals.

Subsequently, in 1934, the interim *Sound-Projector Aperture* (0.620 by 0.835 inch) was replaced by an *SMPE Standard* that agrees with the new American Standard shown here and which was accompanied by an *SMPE Camera-Aperture Standard* that also is in agreement with the new *Camera-Aperture Standard* published in this issue.

American Standard  
Picture Projection Aperture of 35-Millimeter  
Sound Motion Picture Projectors

ASA  
Reg. U. S. Pat. Off.  
Z22.58-1947



Dimension	Inches	Millimeters
A	$0.825 \pm 0.002$	$20.95 \pm 0.05$
B	$0.600 \pm 0.002$	$15.25 \pm 0.05$
C	$0.738 \pm 0.002$	$18.74 \pm 0.05$
D	0.0155	0.394
E	0.028	0.71
F	0.015	0.38
G	0.049	1.24
H	0.006	0.15
R	0.05 approx	1.3 approx

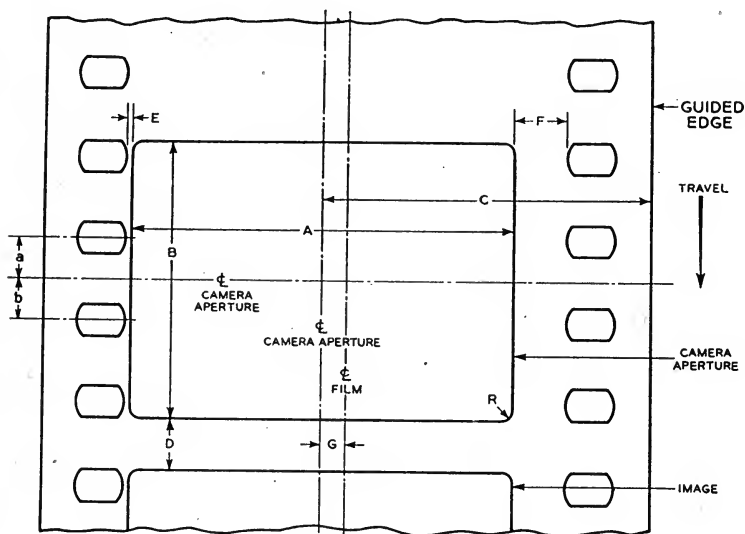
$a = b = \frac{1}{2}$  longitudinal perforation pitch.

These dimensions and locations are shown relative to unshrunk raw stock.

Note: The aperture dimensions given result in a screen picture having a height-to-width ratio of 3 to 4 when the projection angle is 14 degrees.

American Standard  
 Photographing Aperture of 35-Millimeter  
 Sound Motion Picture Cameras

ASA  
 Reg. U. S. Pat. Off.  
 Z22.59-1947



Dimension	Inches	Millimeters
A	$0.868 \pm 0.002$	$22.05 \pm 0.05$
B	$0.631 \pm 0.002$	$16.03 \pm 0.05$
C	$0.744 \pm 0.002$	$18.90 \pm 0.05$
D	0.117	2.97
E	0.010	0.25
F	0.121	3.07
G	0.055	1.40
R	0.03 approx	0.8 approx

$a = b = \frac{1}{2}$  longitudinal perforation pitch.

These dimensions and locations are shown relative to unshrunk raw stock.

Note: The aperture dimensions given in combination with an  $0.600 \times 0.825$  in. ( $15.25 \times 20.95$  mm) projector aperture result in a screen picture having a height-to-width ratio of 3 to 4 when the projection angle is 14 degrees.

## Definition of Safety Film

The American Standard Definition of Safety Photographic Film Z38.3.1-1943 defines a photographic film which is no more hazardous than common newsprint paper. In order to be classified as Safety Photographic Film, a photographic film must (a) be difficult to ignite, (b) be slow burning, and (c) evolve a limited amount of toxic oxides of nitrogen during decomposition.

The ease of ignition is determined by measuring the time of ignition after subjecting the sample to a uniformly maintained high temperature. The requirement for ease of ignition and the test method are the same as those specified by the British Standard Definition of Cinematograph "Safety" Film (1939) and other European standards for safety motion picture film.

The rapidity of burning and the method of measuring that characteristic are also the same as specified in the British Standard Definition of "Safety" Film (1939).

The toxic gases evolved when photographic films of cellulose nitrate are decomposed by heat are oxides of nitrogen, carbon monoxide, and hydrocyanic acid. Laboratory tests made available to the committee indicate that only oxides of nitrogen and carbon monoxide are evolved in sufficient quantities to constitute an appreciable hazard. These tests also indicate that photographic film does not evolve more carbon monoxide than does common newsprint paper when equal quantities of film and paper are decomposed in the same manner.

The maximum quantity of oxides of nitrogen which can evolve when safety photographic film decomposes is limited by stipulating in the definition the maximum nitrogen (present as nitrate) content of the material. Fumes from photographic film that comply with this standard will not be significantly different from fumes evolved from ordinary newsprint paper decomposed under the same conditions.

Photographic films made from materials for which this definition applies but which do not comply in one or more respects are not necessarily hazardous. For example, acetate film may fail to comply with the maximum nitrogen content specified in this definition and still not be significantly more hazardous than common newsprint paper under ordinary conditions.

The committee considered a maximum nitrogen content of 0.72 per cent and had some evidence that a safety film containing that proportion of nitrogen was no more toxic than films with a lower content.

However, the specification was set at a lower figure to correspond with the current requirements of the Underwriters' Laboratories. The method for measuring the nitrogen content was adopted from the Summary of *Requirements for Slow Burning Cellulose Acetate Film*, Underwriters' Laboratories, Inc., Chicago, Illinois.

The definition of Safety Photographic Film applies only to films, the supports for which comprise cellulose esters of simple fatty acids, combinations of cellulose esters and nitrate, and regenerated cellulose. Should photographic films in the future be made of other materials, this definition may have to be modified and additional requirements incorporated in the definition, which now specifies ignition time and burning time, outlines in detail the methods for measuring these two characteristics, and, in addition, presents a standardized procedure for determining nitrogen content of film samples.

This standard, a 6-page pamphlet, was supplied by the SMPE with the last set of fourteen standards furnished to Binder subscribers and is now also available in single copy form from the American Standards Association, 70 East 45th Street, New York 17, N. Y.

29 TEST FILMS, both 16- and 35-Mm are produced jointly by the SMPE and Motion Picture Research Council. Write for complete catalog.

40 AMERICAN STANDARDS on Motion Pictures are available. See page 279 of this issue for details.

MAGNETIC RECORDING reprints of six important papers published in the *Journal* in January, 1947, may be purchased from the SMPE for 75 cents.

MEMBERSHIP CERTIFICATES 11½ by 14 inches with your name hand engrossed and suitable for framing may be purchased from the SMPE for \$1.50.

**SOCIETY OF MOTION PICTURE ENGINEERS**

342 MADISON AVENUE

NEW YORK 17, N. Y.



*Signal Corps Photograph*

MELVIN E. GILLETTE

1892-1947

**C**OLONEL MELVIN E. GILLETTE was born in Illinois on November 15, 1892. Appointed to the Regular Army from Iowa, he served in both the Infantry and the Signal Corps. He retired on July 31, 1947, for physical disability incurred in line of duty, and died on September 11, 1947, in New York City.

In 1932-1933 Colonel Gillette pursued a course of instruction in motion picture production in Hollywood, under the auspices of the Research Council of the Academy of Motion Picture Arts and Sciences. Following this he was assigned as Officer in Charge of the Signal Corps Photographic Laboratory at the Army War College.

In August, 1935, he joined the Society of Motion Picture Engineers as an Active Member and later was elevated to the Fellow grade. Despite a heavy load of Army administrative and

other duties, he wrote two papers for the JOURNAL both of which dealt with the use of films in military training. In 1936 he prepared the Army directive outlining the scope and function of the training film, and later saw the pattern that he had prescribed used by all American Arms and Services.

In March of 1942 Colonel Gillette was assigned as Commanding Officer of the Signal Corps Photographic Center, then established in the former Paramount Studios at Astoria. Here his constant effort and organizing ability were responsible for the successful establishment of what became the largest government-operated motion picture studio in the world.

During World War II he served in the Mediterranean Theater as Photographic Officer to General Mark W. Clark, and later as Photographic Officer and Signal Officer in the Mid-Pacific. For his distinguished service Colonel Gillette was awarded the Legion of Merit and the Bronze Star Medal. He was a man of tremendous energy and had an intensity and sincerity of purpose and a devotion to duty that no one could fail to admire.

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# 63rd Semiannual Convention

## SOCIETY OF MOTION PICTURE ENGINEERS

Ambassador Hotel • • • Del Mar Beach Club  
Santa Monica, California • • • May 17-21, 1948

### OFFICERS OF THE SOCIETY

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DONALD E. HYNDMAN.....	<i>Past-President</i>
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Watson Jones, *Chairman*

#### MEMBERSHIP AND SUBSCRIPTION

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R. H. McCullough, *Chairman*

Lloyd C. Ownbey, *Vice-Chairman*

Assisted by officers and members Los Angeles Projectionist's Local 150

#### PROJECTION PROGRAM-16 MM

W. J. Colleran, *Chairman*

#### PUBLIC-ADDRESS EQUIPMENT

P. E. Brigandi, *Chairman*

## TENTATIVE PROGRAM

**Monday, May 17**

- 9:30 A.M. Registration, Sixth Floor, Santa Monica Ambassador Hotel  
Advance Sale of Luncheon and Banquet Tickets
- 11:00 A.M. Business Session, Magnolia Room, Ambassador Hotel
- 12:30 P.M. Luncheon, Ocean Room, Del Mar Beach Club
- 2:00 P.M. Technical Session, Magnolia Room
- 8:00 P.M. Technical Session, Magnolia Room

**Tuesday, May 18**

## OPEN MORNING

- 10:00 A.M. Registration, Sixth Floor, Ambassador Hotel  
Advance Sale of Banquet Tickets
- 2:00 P.M. Technical Session, Magnolia Room
- 8:00 P.M. Technical Session, Magnolia Room

**Wednesday, May 19**

- 9:30 A.M. Registration, Sixth Floor, Ambassador Hotel  
Advance Sale of Banquet Tickets
- 10:30 A.M. Demonstration by Thorobred Photo Service, Inc., Hollywood Park  
Race Track

## OPEN AFTERNOON

NOTE: Registration headquarters will be open this afternoon until 3:00 P.M. to those desiring banquet tickets and making table reservations.

- 7:15 P.M.-8:15 P.M. Cocktail Hour for holders of banquet tickets, Rouge  
Room, Ambassador Hotel
- 8:30 P.M. 63rd Semiannual Banquet (dress optional), Magnolia Room, Am-  
bassador Hotel. Entertainment and dancing

**Thursday, May 20**

## OPEN MORNING

- 2:00 P.M. Technical Session, Magnolia Room  
Joint Meeting with Inter-Society Color Council  
"Light Sources," by Norman MacBeth, Consulting Engineer  
"The Effect of Light Sources on Colored Objects," by E. I. Stearns,  
Calco Company  
"The Color Range of a Three-Color Subtractive System," by Carl  
E. Foss, Inter-Society Color Council  
"How the Eye Works," by I. A. Balinkin, University of Cincinnati
- 8:00 P.M. Technical Session, Magnolia Room  
Joint Meeting with Inter-Society Color Council  
"An Introduction to Color," by Ralph Evans, Eastman Kodak  
Company



## Friday, May 21

### OPEN MORNING

- 2:00 P.M. Technical Session, Magnolia Room  
 "Masking in Color Duplication," by Thomas Miller, Eastman Kodak Company  
 "Principles and Practice of Three-Color Subtractive Photography," by W. T. Hanson and F. Richey, Eastman Kodak Company  
 "Make-up for Color Photography," by Hal King, Max Factor  
 "Two-Color Photography," by Thomas Gavey, University of Southern California
- 8:00 P.M. Technical Session and Adjournment of the 63rd Semiannual Convention, Magnolia Room

The following additional papers have been tentatively scheduled, but the definite times of their delivery have not as yet been decided:

- "Technical Limitations and Possible Application of 16-Mm Film in Broadcasting and Television," by J. A. Maurer, J. A. Maurer, Inc.
- "16-Mm Motion Pictures for Television," by Jerry Fairbanks, Jerry Fairbanks, Inc.
- "Some Photographic Contrast Considerations for Television," by Fred Albin, Radio Corporation of America
- "Stereophonic Magnetic Recording," by M. Camras Armour Research Foundation
- "Magnetic Sound for 8-Mm Motion Pictures," by H. A. Leedy, Armour Research Foundation
- "Variable-Area Sound Track on 16-Mm Kodachrome," by R. V. McKie, Radio Corporation of America, and R. G. Hufford and N. L. Simmons, Eastman Kodak Company
- "A Silent Playback and Public-Address System," by Bruce Denney and Robert J. Carr, Paramount Pictures
- "Synchronized Sound and 8-Mm Pictures," by Phil Goldstone, Phonovision Corporation
- "Developer Analysis for Laboratory Control Procedures," by Anseo
- "Anseo Motion Picture Film Laboratory," by Anseo
- "New Motion Picture Processing Machines," by William Prager, Artochrome Motion Picture Laboratories
- "Report of Committee on High-Speed Photography," by A. P. Neyhart, Douglas Aircraft Company
- "Report of Standards Committee," by F. T. Bowditch, National Carbon Company
- "Animation," by Karel Dodal, Irena Film Studios
- "An Improved Camera Crane," by Research Council Staff Member
- "The Motion Picture Research Council—Its Functions and Activities," by W. F. Kelley, Motion Picture Research Council
- "Restoration of Early Motion Picture Films," by Howard Walls, Academy of Motion Picture Arts and Sciences
- "Visual Education," by Donald Doane, University of Southern California
- "Some Technical Problems Associated with the Foreign Release of American Motion Picture Films," by Randal Terraneau, Humphries Laboratories, England
- "The Use of Photography in the Naval Antarctic Expedition," by Naval Photographic Center

## GENERAL INFORMATION

### Hotel Reservations

Because out-of-town members and guests will attend the 63rd Semiannual Convention at the Santa Monica Ambassador Hotel and the Del Mar Beach Club, which is directly across the street from the Ambassador, the Pacific Coast Section officers have appointed a local housing committee under the chairmanship of Mr. Watson Jones, Radio Corporation of America, 1016 North Sycamore Street, Hollywood 38, California. There will be no room-reservation cards mailed to the membership, so all requests for room accommodations should be mailed or wired direct to Watson Jones. He will book, assign, and confirm all reservations sent to his attention.

Send your room reservations requests to Mr. Jones as early as possible. They are subject to date change, or cancellation, *not later than May 10, 1948.*

### Room Rates

The following European Plan rates are extended SMPE members and guests attending the 63rd Semiannual Convention:

Single rooms with bath, \$5.00-\$6.00

Double rooms, with twin beds and bath, \$7.00-\$8.00-\$9.00

There are a few parlor suites at the Santa Monica Ambassador Hotel at \$17.50 per day.

**NOTE:** The housing committee will have available additional rooms or bungalows at the Hotel Miramar in Santa Monica, which is about five blocks from convention headquarters.

When booking your room reservation with Watson Jones, be sure to specify the type of accommodations desired, day rate, and date of your arrival at Santa Monica, California. Please co-operate to insure your hotel reservations.

**NOTE:** Transportation, Los Angeles to Santa Monica: Out-of-town members and guests arriving in Los Angeles by train can take a taxi at the Los Angeles Union Station and go to Fifth and Hill Streets in Los Angeles, board a Los Angeles Railway Santa Monica Express motor coach which travels out Wilshire Boulevard direct to Santa Monica, and debark at the station within one block of the hotel. The distance from Los Angeles to Santa Monica is about 20 miles. If taxi transportation is used the fare will be about \$5.00.

### Rail, Pullman, and Plane Travel

Travel is still heavy and your Convention Committee suggests that you consult your local travel agent for rail, pullman, or plane accommodations to the West Coast and return, at least 30 days prior to your departure for Santa Monica.

### Convention Registration and Papers Program

The Convention Papers Committee can only function successfully in the early assembly and scheduling of the Convention Papers Program by receiving the title of papers to be presented, name of the author, and a complete manuscript mailed

to N. L. Simmons, 6706 Santa Monica Blvd., Hollywood 38, California, not later than May 1, 1948.

The Convention business and technical sessions will be held in the Magnolia Room on the sixth floor of the Santa Monica Ambassador. Registration headquarters will be set up at the entrance of the Magnolia Room.

Members and guests attending the Convention are expected to register and receive their Convention badges and identification cards. Registration fees are used to defray the Convention expenses.

### Convention Get-Together Luncheon

The Convention Get-Together Luncheon will be held in the Ocean Room of the Del Mar Beach Club, at 12:30 P.M. on May 17. Eminent speakers and entertainment are assured by the Luncheon Committee.

The luncheon fee will be \$2.50 per person, State Tax and gratuity included. The ladies attending the Convention are invited to attend this luncheon. Luncheon tickets should be procured in advance of the date of this function, either through the Pacific Coast Section Secretary, or W. C. Kunzmann, Convention Vice-President, during the week of May 9, at the Santa Monica Ambassador Hotel or at the registration headquarters prior to 11:00 A.M. on May 17 so that seating accommodations can be provided. There will be no seating guaranteed for holders of tickets purchased after 11:00 A.M. on May 17.

### Cocktail Hour

Holders of banquet tickets will be entertained at a social get-together "Cocktail Hour" in the Rouge Room on the fourth floor of the Santa Monica Ambassador Hotel, on May 19, between 7:15 P.M. and 8:15 P.M.

### Banquet

The Convention informal banquet (dress optional) will be held in the Magnolia Room on the sixth floor of the Santa Monica Ambassador Hotel on May 19, promptly at 8:30 P.M. This is your night for social get-together. Entertainment and dancing until 12:30 A.M.

The fee per person for Banquet tickets will be \$10.00, Federal Amusement and State Tax included, also the gratuity. Tickets for this function must be procured prior to noon on May 19, so that seating can be provided. Book table reservations at the Convention registration headquarters.

### Ladies' Program

The Ladies' Committee will have open house, and register the ladies attending the Convention in the Recreation Room of the Santa Monica Ambassador Hotel during the Convention dates.

Mrs. S. P. Solow, the Convention Hostess, and members of her committee assure the ladies attending the Convention an attractive and interesting entertainment program, which will be announced by the Ladies' Committee at a later date.

### Motion Pictures

The Convention identification card issued to registered members and guests is your means of identification at all scheduled sessions held at, and away from, the

hotel. This card will also be honored at the following de luxe motion picture theaters in Hollywood and Santa Monica during the Convention.

In Hollywood, the Convention identification card will be honored at the Pantages, Paramount, and Warner Brothers theaters located on Hollywood Boulevard. The Fox West Coast Theaters Corporation will issue special passes which will be honored at the Grauman's Chinese and Egyptian theaters in Hollywood and at the Criterion and Dome Ocean Park theaters in Santa Monica during the Convention.

### Recreation

A variety of recreational benefits and privileges can be enjoyed by those who register at Santa Monica hotels. These include roof solarium at the Santa Monica Ambassador Hotel, ocean-front walk, ocean sport fishing, bathing, golf, tennis, and horseback riding.

There are auto parking facilities at the Santa Monica Ambassador Hotel. Excellent transportation is available to all points of interest in the greater Los Angeles area. Consult the Convention registration headquarters for information pertaining to recreation and transportation to points in the immediate vicinity of Santa Monica.

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## SECTION OFFICERS

### Atlantic Coast

#### Chairman

William H. Rivers  
Eastman Kodak Co.  
342 Madison Ave.  
New York 17, N. Y.

#### Secretary-Treasurer

Edward Schmidt  
E. I. du Pont de Nemours & Co  
350 Fifth Ave.  
New York 1, N. Y.

### Midwest

#### Chairman

R. T. Van Niman  
Motiograph  
4431 W. Lake St.  
Chicago 24, Ill.

#### Secretary-Treasurer

George W. Colburn  
George W. Colburn Laboratory  
164 N. Wacker Dr.  
Chicago 6, Ill.

### Pacific Coast

#### Chairman

S. P. Solow  
Consolidated Film Industries  
959 Seward  
Hollywood, Calif.

#### Secretary-Treasurer

G. R. Crane  
212 24 St.  
Santa Monica, Calif.

### Student Chapter

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#### Chairman

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1046 N. Ridgewood Pl.  
Hollywood 38, Calif.

#### Secretary-Treasurer

John Barnwell  
University of Southern  
California  
Los Angeles, Calif.

## 1948 Nominations

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The 1948 Nominating Committee, as appointed by the President of the Society, was confirmed by the Board of Governors at its January meeting.

E. ALLAN WILLIFORD, *Chairman*  
40 Charles Street  
Binghamton, New York

JAMES FRANK, JR.  
18 Cameron Pl.  
New Rochelle, N. Y.

L. T. GOLDSMITH  
Warner Bros. Pictures  
Sound Department  
Burbank, California

EMERY HUSE  
Eastman Kodak Company  
6706 Santa Monica Blvd.  
Hollywood, California

PAUL J. LARSEN  
Los Alamos Laboratory  
University of California  
Albuquerque, New Mexico

J. K. HILLIARD  
2237 Mandeville Canyon Road  
Los Angeles 24, California

E. W. KELLOGG  
RCA Victor Division  
Radio Corporation of America  
Engineering Products Department 10-4  
Camden, New Jersey

K. F. MORGAN  
Electrical Research Products Division  
6601 Romaine  
Los Angeles, Calif.

M. G. TOWNSLEY  
7100 McCormick Road  
Chicago 45, Illinois

All voting members of the Society who wish to submit recommendations for candidates to be considered by the Committee as possible nominees, are requested to correspond directly with the Chairman or any of the members of the Nominating Committee. Active, Fellow, or Honorary Members are authorized to make these suggestions which must be in the hands of the Committee prior to May 1, 1948.

There will be ten vacancies on the Board of Governors as of January 1, 1949, which must be filled. Those members of the Board whose terms of office expire are:

President.....LOREN L. RYDER	Governor.....JOHN W. BOYLE
Executive Vice- President.....EARL I. SPONABLE	Governor.....ROBERT M. CORBIN
Editorial Vice- President.....CLYDE R. KEITH	Governor.....CHARLES R. DAILY
Convention Vice- President.....WILLIAM C. KUNZMANN	Governor.....DAVID B. JOY
Secretary.....G. TOEL LORANCE	Governor.....HOLLIS W. MOYSE

The recommendations of the Nominating Committee will be submitted to the Board of Governors for approval at the July meeting. The ballots will then be prepared and mailed to the voting members of the Society forty days prior to the Annual Meeting of the Society which is always the opening business session of the Fall Convention. This year it falls on Monday, October 25, and the Convention will be held at the Statler Hotel in Washington, D. C.

E. ALLAN WILLIFORD, *Chairman*, Nominating Committee

## Section Meetings

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### Midwest

Mr. Frank E. Carlson, Illuminating Engineer in the Lamp Department of the General Electric Company, at Nela Park, spoke on "New Developments in Mercury Lamps for Motion Picture and Television Studio Lighting"\* at the January 8, 1948, meeting of the Midwest Section. The paper described a cadmium-mercury source developed in England and showed its adaptation to standard lighting equipment units. Technicolor motion pictures and slides demonstrated its qualities with direct comparisons of material photographed with carbon-arc sources and the mercury source. Discussion brought out the fact that although many types of this light source are being developed in the United States, it will be some time before they will be available commercially.

Appreciation was expressed to the Eastman Kodak Stores for the use of two 1000-watt Master Kodaslide projectors and to the DeVry Corporation for a 35-mm projector.

There was a short business section at which was read the report of the last meeting and the financial report for the year ending December 31, 1947.

\* Presented September 30, 1947, before the Pacific Coast Section; published, *JOURNAL OF THE SMPE*, February, 1948, pp. 122-139.

### Atlantic Coast

At the February 18, 1948, meeting of the Atlantic Coast Section, L. A. Meacham, Research Engineer for the Bell Telephone Laboratories, presented a paper on "An Experimental Multichannel Telephone Transmission System Employing Pulse-Code Modulation". Mr. Meacham pointed out that speech or music translated into patterns of standardized on-off pulses may be transmitted by radio relay over any distance without accumulating noise or distortion. The problems involved in applying this technique (pulse-code modulation) to multiplex telephony have been explored in terms of a 96-channel system designed to transmit speech with commercial toll quality. Novel components of the system were described, including an electron-beam coding tube, the "Shannon-Rack decoder", pulse slicers, sampling circuits, and an instantaneous amplitude compander.

The demonstration allowed the audience to judge the quality of transmission of speech and music obtained with different numbers of characters in the pulse code.

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### Correction

On page 86 of the January, 1948, issue of the *JOURNAL*, the business affiliation of Mr. C. C. Dash, president of the Hertner Electric Company, was given incorrectly. The Fellow Award citation should read as follows:

C. C. DASH, Hertner Electric Company,

"for the design and manufacture of motor-generator sets used extensively in the motion picture industry."

## Book Reviews

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### **The Architects Manual of Engineered Sound Systems**

Published (1947) by the Radio Corporation of America, Camden, N. J. 284 pages plus 4-page index. Profusely illustrated.  $9\frac{1}{2} \times 11$  inches. Price, \$5.00.

Intended for the use of architects and others interested in the design of sound-distribution systems, the Manual is divided into two principal parts. The first section deals with Definitions, Graphical Symbols, The Microphone, The Amplifier, The Loudspeaker, Controls, Studios and Control Rooms, Acoustics, The Sound Film Projector (16-mm and 35-mm), and Antenna Systems. This section is not intended as an engineering text and the subject matter consequently is treated in an elementary fashion. It is obvious that the viewpoint of the architect and the layout designer is kept in mind. Architectural and engineering specifications for each equipment subject are included. The treatment is, generally, excellent though essentially nontechnical. A possible oversight, perhaps intentional, is noted in the failure to include definite recommendations for available amplifier power requirements in enclosures.

The second section covers Typical Layouts and Specifications. Suggested layouts are included for one or more of the following: Schools, Hospitals, Churches, Auditoriums, Stores, Industrials, and Hotels. Some treatments are very detailed in breakdown of departments. Specifications are set up around RCA equipment.

The Manual does not give the architect every element of information that might be required such as, for example, the correction of acoustic difficulties, although the treatment of the subject conforms to the more-or-less standard method of the elementary text. Neither the acoustic engineer nor the communications engineer is completely by-passed even assuming the architect to be letter-perfect in his acquaintance with the Manual's contents.

C. S. PERKINS

Altec Service Corporation  
New York 19, N. Y.

### **Television—Volume III (1938–1941)**

### **Television—Volume IV (1942–1946)**

Edited by Alfred N. Goldsmith, Arthur F. Van Dyck, Robert S. Burnap, Edward T. Dickey, and George M. K. Baker. Published by *RCA Review*, RCA Laboratories, Princeton, N. J. Volume III (1938–1941). 486 pages + xii pages. 288 figures.  $6 \times 9$  inches. Price, \$2.50. Volume IV (1942–1946) 498 pages + 12-page Appendix + xiv pages. 301 figures.  $6 \times 9$  inches. Price, \$2.50.

These two books continue the series established in 1936, which reprint the most significant papers published in the field of television by the RCA organization, with the addition of a few original articles.

Perusal of these volumes brings out strikingly the breadth of the field which must be explored and developed to build up the art of television, and the variety of effort expended upon it by one organization. It is handy to have this diversity of material brought together compactly in such a manner. This is especially

true for the motion picture engineer, to whom the changes in his art that may be brought about by the arrival of television constitute a provocative challenge.

The range of material presented has been classified as follows:

*Pickup*, in which the new development of the image orthicon is described, and the problems of studio and field television are treated.

*Transmission*, which covers, on the one hand, video signals and their propagation around the building, and, on the other hand, radio in its many aspects over the wide ranges of frequency used for the various purposes in the art.

*Reception*, comprising discussions on images produced by cathode rays and the methods of their projection, and covering the problems of receiving sets sold to the general public.

*Color Television*, summarizing work done by the RCA organization in this field.

*Military Television*, where are assembled the results of RCA television contributions to the war effort.

*General*, which is an assay of what the impact of this new art of television may be on our daily life in the coming years.

PIERRE MERTZ

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It is highly desirable that members avail themselves of the opportunity to express their opinions in the form of Letters to the Editor. When of general interest, these will be published in the JOURNAL of the Society of Motion Picture Engineers. These letters may be on technical or non-technical subjects, and are understood to be the opinions of the writers and do not necessarily reflect the point of view of the Society. Such letters should be typewritten, double-spaced. If illustrations accompany these contributions, they should be drawings on white paper or blue linen and the lettering neatly done in black ink. Photographs should be sharp and clear glossy prints.

Please address your communications to

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## American Cinematographer

28, 12 (Dec., 1947)

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Television Recording Camera Developed by Eastman Kodak (p. 436)

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13, 149 (Dec. 4, 1947)

Television Pictures from Kinematograph Film (p. 19) A. BUCKLEY

## International Photographer

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The Vitascope Dual-Purpose Projector (p. 17) L. CHADBOURNE

## Radio News

39, 2 (Feb., 1948)

Build Your Own Magnetic Tape Recorder (p. 39) L. B. HUST

Magnetic Tape Systems (p. 46) C. E. JACKSON

The Recording and Reproduction of Sound. Pt. 12 (p. 56) O. READ

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## Theater Engineering Conference

*Introductory Session*

# Advancement of Motion Picture Theater Design\*

BY BEN SCHLANGER

ARCHITECT, NEW YORK 21, NEW YORK.

*Summary*—During the past twenty years, great advances have been made in motion picture theater design and in theater engineering. The builder, architect, and equipment manufacturers have come to recognize the value of co-ordinating their work in order that an attractive, comfortable, well-equipped theater might result. There are outlined here some of these advances and some of the problems which have been studied in this connection.

WITH THE ADVENT of this convention the science and art of motion picture theater design becomes a recognized and worth-while endeavor. This is attested to by the fact that a large part of this convention is being devoted to a Theater Engineering Conference. At the 1931 Spring Convention of this Society in Hollywood, Mr. Crabtree saw the need for much improvement in motion picture theater design and he has been a consistent advocate of allowing theater engineering an important place in the scope of the work of the Society of Motion Picture Engineers. I proposed at that Convention sixteen years ago, that the motion picture theater had not yet developed a form that was necessary for the proper functioning of the art.

Until the period following that Hollywood Convention, there really was no theater that properly could be called a motion picture theater. The motion picture itself developed so fast that it had to be housed in buildings originally intended for stage presentations or in buildings which were intended for motion picture use but necessarily had to mimic the stage theater because the art and science of motion picture theater design could not conceivably have advanced rapidly enough to keep up with the great strides made in the film industry. Theater

\* Presented October 20, 1947, at the SMPE Convention in New York.

buildings are not built on a production-line basis. They are built scarcely more than one at a time by any one interest and, therefore, there could not be much individual initiative for the research that was necessary to advance theater design. This fact makes it necessary for organizations of the motion picture world to take the initiative in sponsoring research and standardization. This Society seems to have recognized this point increasingly as its past and present activities show. That it has called this Convention and arranged this program indicates that it will be of important service in making possible theater engineering design which will keep pace with the advancements made in motion picture art.

At this point it would be interesting to note how a motion picture theater was built approximately twenty years ago, today, and how it should be built under more favorable conditions. More recently the benefits of an architect's services have been increasingly recognized and there are less and less instances of theater structures being constructed without professional guidance. The architects have been capable of designing structures which keep the elements out and even prove attractive but they have not until recently realized the importance of theater engineering. Their designs and even their structures would be well advanced when scattered information from equipment manufacturers would be referred to. Sometimes the equipment manufacturer would be called in when it proved too costly to make changes to conform with engineering requirements. The contemporary theater architect must have an up-to-date knowledge of theater engineering, and depend on information from equipment manufacturers only to supplement his basic theater engineering knowledge. We are entering a period when the motion picture theater structure will be completely conceived on paper for every engineering function as well as the architectural considerations, thereby eliminating the trial-and-error methods in the construction phase of the work.

Just to show how much progress we are making, I am no longer the lone theater architect at these Conventions. You are going to hear from other architects and this is certainly a sign of progress because these architects in coming here surely must now be aware of the importance of the engineering functional aspects of theater design. We are certainly now past the period in which the motion picture theater auditorium design was thought of too much as a surface decorative, and not enough as a functional engineering problem.

There was a time in the history of this Society and motion picture design when it was difficult to be convincing enough as to the importance of theater engineering. That was when I had to be a member of the Projection Practice Committee of the Society of Motion Picture Engineers in order to promote engineering study for the entire theater structure. Yes, I worked for the rest of the theater from up there in that projection room until we found ourselves with a Theater Engineering Committee, and today we begin this important Theater Engineering Conference. I earned my seat in the Projection Practice Committee because I advocated theater design principles that led to the reduction of projection angles. They always reminded me of the architect who forgot to include a projection room in his design. The work done in this committee was really the beginning of theater engineering and can be considered a notable contribution in this field.

A theater survey study, a subcommittee activity of the Projection Practice Committee of this Society, can be considered one of the most important early developments in theater engineering research. A great many of the theaters that were checked in this survey were built originally for stage performances or for a combination of stage and film presentations. A similar survey made at this time may prove exceedingly valuable since the original survey was made in 1938. The observations noted in the analysis of this early survey have proved most valuable in theater engineering study, and it is still the basis for further work being done. A brief review of this early survey is now pertinent and here are some of the high lights.

1. Projection, screen, and viewing conditions varied over an extent of at least three times what might be considered tolerable.
2. For theaters built between 1930 and 1938 only 27 per cent had satisfactory conditions for motion picture presentation. The lack of published standard requirements was evident. Fulfillment of satisfactory viewing conditions was a matter of chance and not of intention.
3. Indications were that practical limitations were not the only causes of undesirable conditions.
4. Seating capacities became steadily smaller; 26 per cent of the theaters erected before 1930 had capacities of over 1500 with only 10 per cent of the theaters erected after 1930 with such capacity.
5. The theaters having over 2000 capacity showed a greater number of seats subject to undesirable viewing conditions.

6. The following principles determining the ideal motion picture theater form, considered from a purely technical standpoint, may develop into a form that may not in some instances fulfill all the rigid requirements set forth for the commercial motion picture theater: yet it is the obligation of the Society to indicate what would be the most desirable form of theater, and all those who are concerned with the design of theaters may adhere as closely to recommendations as may be practically possible.

The basic design of the motion picture theater depends more than anything else upon the ability to view satisfactorily the picture. The factors involved are:

- A. *Picture Detail* (visual acuity)
  - (1) Screen size in relation to viewing distance
  - (2) Screen brightness
  - (3) Contrast
- B. *Obstruction of View*
  - (1) By other spectators
  - (2) By fixed parts of the structure
- C. *Distortion of Picture*
  - (1) In projection
  - (2) In viewing
- D. *Angle of View* (affecting posture and bodily comfort)
  - (1) Horizontal
  - (2) Vertical
- E. *Psychological*

While this Conference is certain to prove valuable in exposing important technical data, it may well be remembered more as the turning point at which the motion picture has reached an important enough stage to justify buildings carefully and specifically designed for its use. The timing of this Convention seems to be quite logical. Perhaps it was necessary to take these past years since the advent of sound to convince the investor that theaters can be constructed for the motion picture art alone and prove a good risk. However with earlier recognition of the soundness of this risk, there would now be a far smaller number of substandard theaters.

It is hoped that at this time we can take the definite stand that no compromise need be made so that a theater building would have to house the stage performance as well as film exhibition. Any compromise in theater design in this respect will produce a theater which is not good enough for either of the arts, visually, acoustically, or



psychologically. The Theater Engineering Committee made further investigations as to viewing positions and picture size and also made a contribution toward creating a nomenclature of theater engineering.

Referring to the basic factors *A*, *B*, *C*, *D*, and *E* which determine the form of the motion picture theater, there are now considerable data available for solving the problems of factors *B* and *C*. However factors *A*, *D*, and *E* require a good deal of research. The determination of the advisable maximum viewing distance to the screen as fixed by past practice is subject to revision because a study has to be made of cinematographic practice in relation to this problem. Also it may very well be possible to have seating positions farther away from the screen than six times the picture width if the auditorium surfaces were so treated as to not let the spectator feel the distance from the picture to his seat. Most architectural treatments in existing motion picture theaters tend to emphasize rather than diminish the space between the picture and the viewer.

There are now sufficient data on hand to enable us to standardize on methods of determining sight-line clearances. A seemingly unimportant dimension such as measuring from a person's eye to the top of the head,

becomes a key dimension for calculating sight-line clearances. We shall have to establish this measurement. We now appreciate that the angle subtended to an average image on the motion picture screen can be approximately five times as great as the angle subtended to a group of two or three human figures on a stage in a flesh performance. (See Fig. 1.) This fact makes it necessary to so locate each theater chair so as to enable the viewer a wider clear view of the screen image in looking between the heads of the preceding spectators. Fig. 1 shows one of the important differences between stage and cinema theater design. On the top sketch you see the spectator and the angle subtended to what might be considered the amount of horizontal screen dimension that may have to be seen quite

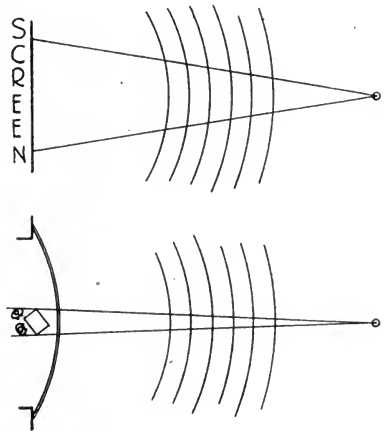


Fig. 1

frequently throughout a film presentation. On the bottom sketch you see the angle subtended from the spectator to some characters and a prop on a stage set. I often wondered why there were not more complaints about sight-line clearances in stage theaters since the head in front of the spectator was always an obstruction. This diagram should prove as enlightening to you as it has to me on this subject. The spectator would find it annoying to move his head to one side or the other to see around the head in front, but the amount of movement necessary to see the small subtended angle in the case of the stage theater is small enough to make the spectator head moving tolerable. This is especially so with the stage performance because the characters ordinarily do not shift often enough or to a great enough extent to cause the spectator annoying enough shifting of the head. Now we had inherited the theater form of the stage for motion picture presentation and the annoyance of head shifting became intolerable because, as the diagram shows, the larger image width and the ability for even a smaller image on the screen to flit about swiftly introduced new considerations.

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 a notable development, especially since it can be used also in improving sight lines by reseating existing theaters. Floor slopes for motion picture theaters would have become intolerably excessive if any attempt were to be made to gain vision over the heads of preceding spectators. The progress made in staggered-seating design in conjunction with the successful development of what was originally called the "reverse floor slope" and is now being recognized as a "dual incline floor," has developed a theater form which is purely inspired by the functions of viewing a motion picture. This new theater form was made possible because sight lines onto a motion picture screen (a vertical plane which is not necessarily fixed in position) presented a flexibility in design which was not possible for the stage theater because the stage (a horizontal plane) is necessarily fixed in position, and therefore limited the number of solutions to the floor-slope problem.

We have yet to determine by scientific testing, the tolerable and desirable angles of view upward and downward to the picture. The quality of a theater design from a patron-comfort standpoint is very much affected by this yardstick. Spectators in upper-level seating should not experience excessive downward viewing and those seated

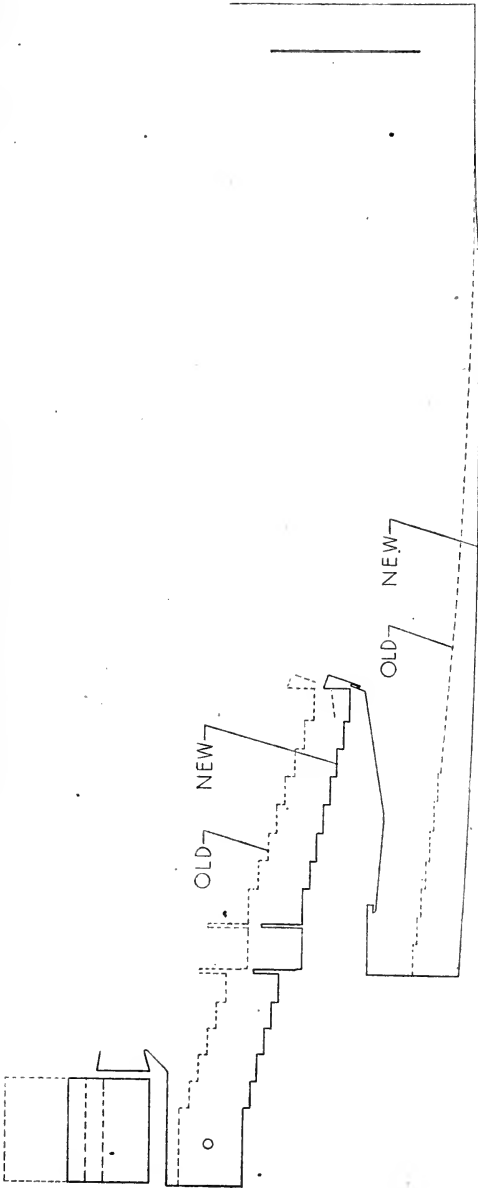


Fig. 2A

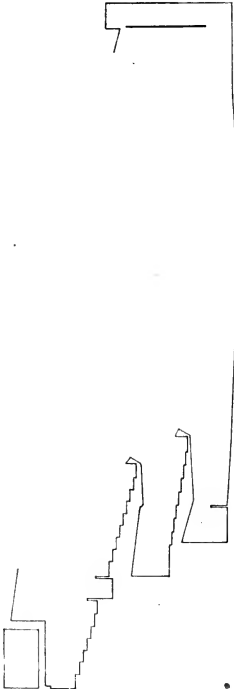


Fig. 2B

on the main floor should not experience excessive upward viewing. The ideal design would present the largest percentage of seating positions for the entire theater affording desirable vertical angles of view. Excessive floor slopes pitching downward only have in the past afforded better than necessary vertical viewing angles for the main floor seating while such slopes created upper-level seating from which the downward viewing angles proved much too excessive. Fig. 2 shows two contemporary examples of theaters now being completed incorporating these latest principles of design. There are now theaters all over the world constructed in this manner. (See Bibliography for examples.) There are also several hundred theaters built incorporating these ideas in whole or in part in which instances I have not participated in their design. In these theaters constructed by persons not fully versed in the medium, the quality in some instances may have suffered.

The earliest examples in which the reverse floor slope was used with a screen position that was somewhat too high were greatly improved upon when experience in what would be considered desirable upward viewing was better established.

Upper level seating has become very desirable because viewing distances and screen image sizes are decreased thereby. Or if a relatively larger screen image is desirable the shorter viewing distance will always make this possible. Upper-level seating also makes it possible to place more desirable viewing positions on a given area of ground space. With contemporary design methods such as illustrated in Fig. 2, upper-level seating can be at a comfortable level with relation to the picture level, and projection angles can be kept well within recommended limits. A maximum of 12 degrees has been established by the American Standards Association. In Fig. 2B, where two upper levels are shown in the Tacna Theater, it was possible to adhere to this limitation. This is the first example of a workable motion picture theater with two upper levels of seating where this was made possible.

In Fig. 2A, the theater with the single upper level of seating is outlined in solid and dotted lines, the solid lines being the advanced type of design and the dotted line being the type of theater influenced by the stage performance. This comparative study shows the improved downward viewing angles for the balcony viewing positions and the negligible increase in the upward viewing angle for the orchestra seating positions. Note that the new orchestra floor is lower in relation

to the level of the screen to any appreciable amount, only for the portion farthest from the 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. So that at no sacrifice in the quality of the orchestra seating, the balcony seating positions are improved considerably. The relative flatness of the orchestra floor slope is also a distinct improvement over the steep pitches formerly used. Another distinct improvement in these new forms is the elimination of the requirement for the familiar intermediate step in the balcony aisles, the extra step which had to be used to get from the level of one seating platform to the next. Since this step had to be shorter than the rest of the platform, it has always caused a hazard and most of the accidents in theater aisles have been due to this fault. Because the pitches of the balconies in the new theater form can be much less severe, there is no need for the extra short step between seating platforms. This is so even in the scheme with the two upper levels, which is the Tacna Theater in Lima, Peru. (See Fig. 2B.)

A type of seating arrangement commonly known as continental seating is now receiving some attention. The name comes from the fact that this type of seating has been used extensively in Europe. The 1943 edition of the National Board of Fire Underwriters Building Code and the new National Canadian Building Code permit such seating. Basically this calls for aisles along the side walls only with seats spaced farther apart for faster transverse circulation. Emergency exits are placed along the side walls where they are least objectionable. The use of floor space for seats, instead of interior aisles, produces a larger percentage of desirable viewing positions. This type of seating merits serious consideration.<sup>19</sup>

Now we come to a phase of motion picture theater design that deals with the artistic and psychological aspects which present a special and more elusive problem. In the motion picture theater, all of its architecture may be optional or the product of pure art, except for the auditorium where the requirements for the proper presentation of the projected picture must be the determining factor in the design considerations. We have, subject to further refinements, developed methods of assuring unobstructed vision and good acoustics. I think we are finally impressing the motion picture exhibitor with the importance of having an auditorium treatment subordinated and made complementary to the picture and not an auditorium of twinkling stars and out-

door pergolas or a replica of a French Renaissance ballroom or even the more modernistic decorative lines which shoot off in all directions in all colors of the rainbow.

What you see when you face the projected picture presents one problem and what you see when you leave the auditorium presents an entirely different problem. The latter view may well provide a decorative effect limited only to the discretion of the architect. The screen view of the auditorium, however, is one that must present a neutral atmosphere for the picture and therefore distracting decoration and lighting have to be avoided. Some of the care that is given to providing just the right frame and setting for an oil painting or still photograph should be given to surrounding the motion picture properly. It might be said that our million-dollar motion picture epics are worthy of this consideration.

The problem of auditorium lighting in the picture projection period is directly tied in with this latter problem. The light reflected from the screen can play an important part in light-tinting the surfaces which are seen along with the projected picture.<sup>11</sup> Secondary light sources must be used with great care in the auditorium to avoid any distracting effect. Lighting that draws attention to itself draws attention away from the screen.

We have some new fields to conquer. The cinematographic art and the art of presenting the film in an auditorium has to be reappraised to search out new methods for increasing dramatic effectiveness. A co-ordinated study by the cinematographer and the auditorium designer is necessary to accomplish these results. The size of detail images on the picture as now projected may be satisfactory, but it is possible that the picture should be larger to include more of the peripheral without enlarging detail images. Careful treatment of the peripheral is necessary to avoid distraction from the focal point of action. Sharp demarcation between the projected picture and its environs must be eliminated with even the black masking of narrow widths remaining a distraction. Modern projectors are capable of projecting a larger image but this should not be done until the auditorium designer and the cinematographer learn how to use it. These are thoughts for the motion picture exhibitors to consider seriously if they would improve the art and have something more than what home television motion pictures will offer.

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# Theater Engineering Conference

Introductory Session

## The Psychology of the Theater\*

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*Summary*—The motion picture theater, properly understood, has its own complex "psychology." This psychology must be understood in its component parts, and in its leading characteristics, so that all concerned may interpret it adequately. An appreciation of the mission of the theater, its activities, and its nature, plus the nature of its relationships will aid this understanding. Its place in the community will be determined finally by the manager's alertness, and his comprehension of the significance of the industry of which he is a representative.

THE QUESTION before us is, basically, how many theater managers, how many members of the Society of Motion Picture Engineers, how many other persons connected with the industry have a significant conception of what we are calling "the psychology of the theater." What is its meaning and significance? What is its rightful place in the community life? How can the character of this modern miracle be expressed in a personality which will walk on the same terms with other community enterprises? Is it possible that many persons in the industry, involved as they are in their own concerns, do not realize how really "big" this industry has become?

All of these questions are important! A manager, if he is to be an effective force in his community, must know both these questions and their answers. It is he who must interpret the psychology of the theater to the community. For the theater we think has a "psychology," just as every person who comes to it has a psychology. The theater's personality is a complex one. It is, first and foremost, a business. It is often a show place in itself. It is a center of entertainment. It is an important medium of education. It is a major factor in shaping customs, opinions, and behavior. It is a place of gathering for the community. It is, in all senses, an escape, for

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through its door pass those who are for a few hours free from care, from problems, from the monotony and the jangling voices of everyday life.

How many millions chained to one locality by circumstances, have passed through the theater door to the broad horizons of the wider world. They have sailed all the seas, have visited the capitals of the world, and have rubbed elbows with distant peoples and strange customs. The creations of artistry, the marvels of science, industrial processes, and travel pass across the theater screen, along with the explicit entertainment. Moreover and most important, the motion picture theater, be it in Times Square or in some remote village street, has become so interwoven with our modern social life that it has become indispensable. It is not too much to say that if tomorrow, through the operation of some almost unimaginable social cataclysm, every theater would be closed, on the next day there would be an almost universal demand for reopening! How true it is then that you men and women who are the stewards of the "colossal" force should have a real understanding of its significance.

#### THE MANAGER

The individual theater is the outpost of the industry and the manager is the visible representative. For all practical purposes the individual theater and the manager *are* the industry in their community. The manager must and should be one of the best salesmen of the community as well as of his product. He must never give the impression that he is in the community, but not of it. He should have sufficient latitude to enter into such community activities as will confer a mutual benefit—on the theater and on the community. Only a shortsighted management would forbid him from making such contributions of time and money as will lubricate good public relations. The manager is *there*. He knows what he must do, and what he can refuse to do if he is to maintain good community relations. His judgment must be trusted until it is found that his judgment in such matters cannot be trusted. A realistic fact to be kept in mind is that so many people have such a vivid idea of the gigantic size of the motion picture industry that the idea must never get abroad that the theater "takes" from the community without giving something back along with the entertainment.

Resourceful managers have done many different things to advance the legitimate cause of good human relations. They have joined

service clubs. Every manager should have a membership in such clubs. They have co-operated in constructive community enterprises. All managers should do so. Some have opened their doors for church services, when for some reason other quarters were not available. Some of the largest Sunday school classes in the country meet in theaters. Managers have provided the facilities, both space and films, for visual education of school children. Public meetings have been held. Other uses have been made. The underlying thought is not that you have to do any or every one of these, but that you should publish a *willingness* to try to meet any legitimate request. It is as true for theater managers as for anyone else, in the words of the poet, that, "What you keep is lost. What you give is forever yours!"

#### TECHNICAL ADVANCES

Technical advances, made very largely through the laudable work of the Society of Motion Picture Engineers, permit the alert manager to exhibit another interesting facet of the personality, the psychology of the theater, namely, the reduction of distraction in the modern show. We are so prone to take inventions and innovations for granted that we may be unmindful of the superb physical aspect of the modern theater. Compare it with the early motion picture house. The speaker can recall the first pictures he ever saw. They were shown by a man who is now a leading exhibitor in a not too distant city. The "theater" was the lower floor of a dwelling house, with all partitions removed. The projection machine was cranked and "hot flashes" were frequent. A man and woman seated behind the screen "talked" and made sound effects. Between pictures the manager sang some popular song whose words, enshrined in roses, and illustrated by two lovers in various paralytic poses, were flashed on the screen. The audience helped out with the dialog. The chairs were hard. Peanuts and popcorn added their merry note. And the admission was five cents. Many of you are too young to recall that there was a time when five cents was a substantial medium of exchange. People went then because of the novelty. Few persons thought that the novelty would last.

From that day to this we have come a long way in every phase of the theater. Technical progress in projection, sound, comfort, and safety has been striking. In theater architecture great advances have been made. While it is still recognized that a certain opulence of decoration is part of the theater's appeal, we have tended to move

away from the excessively baroque and what the author terms the "ro-cuckoo" styles of architectural embellishments. The Idle Hour of yesterday would hardly recognize its modern descendant.

#### ENGINEERING ADVANCES

But let us look at this idea which we have called the reduction of distraction in the theater made possible by striking engineering advances. And it would seem that the patrons should know what underlies the successful showing of a picture: Our measure of how successful is this reduction of distraction, is how completely the individual patron is enabled to concentrate on the picture without distraction by uncontrolled noise, faulty lighting, discomforts of any kind, or fears as to his safety if an emergency should come about. Continuous study is given to these matters by functioning committees of the SMPE, and theater managers have access to a wealth of technical information.

Let us look at a few of these innovations. How many persons know what comprehensive study is given to theater carpet, its quality, texture, "joints," and method of laying. We are all greatly impressed by projection and sound equipment, but part of the benefits of these technical advances would be lost were it not for the correct pitch of the floor and the proper arrangement of seats. And what improvements have been made in seats and in indirect aisle lighting, in the skillful arrangement of gallery steps and in the marking of top or bottom steps whose height may differ from the others thus causing a tripping and falling hazard if uncorrected. Such a simple and effective device as the increasing width of the aisle from front to rear has been noticed by millions who have no conception of its significance in emptying a theater.

#### SAFETY

Consider safety measures, which, though unseen to a large extent, must be present. The speaker is vitally interested in safety and in the safety of persons in places of public assembly. So are you! He is interested in a beautiful entrance and lobby, but more interested in how quickly and safely the entire theater can be evacuated. It may be well to repeat a statement from a previous paper: that if by reason of lack of provision for preventive measures a panic should happen in a theater, 20 years of good management can be undone in 20 seconds. So we come to consider all the study that has been given to the

number, the types, and the arrangement of exits, as well as the means which are used to inform patrons of exit locations. We are interested in proper lighting of outside exits, in the substitution of ramps for steps where possible, in the fact that all exits must lead to a safe place.

As fire is a leading cause of panic, you, the manager, and you, the engineer, give constant thought to fire prevention and to the training of staffs in the handling of possible emergencies. A constant correspondence is going on between the manager and the engineer in which questions are asked and answers given as to how the safety of a given theater may be increased. We do not often think of this, but in proportion to the millions of patrons handled, the motion picture theater is relatively one of the safest places in which to be! How many people know this fact? All of these advances come about through the teamwork of the engineer and the manager, with the public as the ultimate beneficiary. When a patron sits in a modern theater he is enjoying, consciously or unconsciously, a rich inheritance of technical and managerial excellence. Why not tell him more about it, as the manager moves about the community?

#### CONCLUSION

So, the manager has a great deal to sell, if he has the capacity to appreciate, as was said at the beginning, the real significance of that of which he is part. Some managers are on the defensive. They have an excessive deference to criticism, possibly because they are unsure of themselves or because they separate themselves, spiritually, from the producer, or, let us face it bravely, from Hollywood. That is rather silly, is it not? Something like a swimmer repudiating the water in which he swims, saying that he would do better if he had different water.

Let us look at Hollywood for a moment. Hollywood is where most of our pictures are made. It has been said once or twice that it is a rather fabulous place. Well, why would not it be? Put a large number of creative artists such as actors and actresses, producers, directors, and the innumerable technicians and others, all prima donnas in some degree, into one locality and what would you expect? Add to this happy company the great American vice of exploiting to the last degree any merchandisable commodity through every variety of publicity medium. Add also that army of hangers-on who make their fat livings battenning on gossip, on unconventionalities, on shattered

artistic reputations, so that every trivial work, happening, or opinion becomes inordinately magnified. If we buy a goldfish bowl and stock it, we shouldn't complain because thereafter we can see every movement of the fish, particularly if we have an announcer. An ultimate explanation of Hollywood doubtless never will be made, but some explanation that is reasonably comprehensive can be attempted. And it may be salutary to remember that the exhibitor would be in a rather curious position without Hollywood!

Another factor which puts certain managers on the defensive is patron criticism of "bad" pictures. There is really little defense for bad pictures. We may as well be frank; some of them are pretty poor. Yet the wonder of it all to an uninstructed layman like the author is not that there is a percentage of weak pictures, but that in an industry which has to maintain such production schedules for so many different tastes, so many reasonably good ones are put out.

What other industry of comparable scope do *you* know which within its limitations, must meet such a variety of tastes as the motion picture industry? The picture which nauseates the intelligentsia in one area, delights others. There is every possible provision for experimental pictures, for new forms, for "art" pictures. But such pictures never will be commercially profitable, nor would they ever satisfy the majority of tastes. Remember, this is no defense of mediocrity. It is a realistic appreciation of realistic problems.

The industry must make a profit, if it is to continue to produce pictures for exhibition. This is something the advanced thinkers sometimes forget. Certainly, pictures should be better. They will improve slowly as writers, producers, exhibitors, and *patrons* improve. The manager can at least discuss some of these facts with the critics before agreeing too glibly with them and subtly conveying the impression that if he were at the helm things would be different.

No, there is a psychology of the theater, but it is a psychology which must be studied constantly, and learned, and interpreted. This is no small activity with which you are connected. It is a "big" thing with magnificent opportunities and large responsibilities. It is an industry built on great technical proficiencies and artistic achievements. Its success will depend ultimately on the fullest co-operation among all concerned, the producer, the engineer, the exhibitor, and the patron. There must be the fullest awareness of the problems just as there is the great appreciation of the achievements. It is the managers, ultimately, the men and women at the distant outposts, who are the

interpreters. On this comprehension, their perception, and their alertness, the personality of the theater will largely depend.

Let us take a brief journey, not to one of the great theaters in large cities, but to a small "house" on the streets of a town. This particular house is a "two-shows a night." It is dusk. As the sunlight fails, the twinkling lights of houses and storefronts come on. The townspeople are at supper. The manager of the theater stands in front for a moment. He has lived here for a number of years and some of his roots are already deep in the life of the town. He sees lights in stores which would otherwise be dark were it not for the theater which brings the townsmen through the evening streets. He looks up and down the street, greets a few friends, and then passes inside. In a moment the bright lights of the marquee are turned on. The manager looks over the house, checks his little staff, and soon the patrons begin arriving.

In this simple procedure, something really tremendous has happened. From all of their diverse occupations, with all of their problems, their tastes and their hopes and fears these people have come to be entertained. But to the manager they are not just people. They are his friends, his fellow townsmen. In a real sense, he is the steward of a wider world than these people see every day, the world of the cinema, both the world of make-believe and the world of reality. Like Aladdin, when he turns on the lights of the theater, he turns on also the lights, the varied lights, of human experience. Certainly there is a psychology of the theater, there is a personality, a meaning.

Do we *know* it?

#### DISCUSSION

MR. WILLIAM H. OFFENHAUSER, JR.: There is a wide variation in the psychology that you find in theaters in different places. One goes to the Music Hall for instance, and one enjoys the depth of the seats. I have seen pictures in the open down in Africa, and I can assure you the psychology of the theater there is quite different. When I came back, I went up to New Hampshire for a little trip through the White Mountains. I happened to see a picture advertised in a local theater which I wanted to see. It was up one flight in what is called a fire trap. Incidentally, it was a two-projector house, but one of them was not running. The audience seemed to hark back to that old gag or trick of audience reaction that was rather common, I think, 35 years ago, of stamping between reels. That went on in this small town just two weeks ago.

Then when I come down here, we talk about a wide range of things, from what you might call the peak of industrial civilization as we have it here in New York, in the United States, and, the absence of it in some other places.

It seems to me that the psychology of the theater extends considerably beyond merely the matter of mechanics and of people. It is a question of adapting the mechanics to the people and the people to the mechanics in some way or other. How it can be done, I do not know, but it does make an impression when, let us say, two weeks or so ago I saw, in London, one of the Russian propaganda films in color, 90 minutes of so-called documentary, and then saw a film, one of our typical Class B minus gangster films in Africa, shown to Africans. They sit up in the six-penny seats. Incidentally they are interested in girly-girly shows, and all that sort of thing. They do not want the others. And then I saw what one might call a picture much closer to the Class A type—I wouldn't call it quite A, probably B plus, in this one-projector house in the United States. It seems to me that there is a wide diversity of material, conditions, and equipment that is encompassed by the motion picture industry, and much consideration could be given to it.

We could talk about it endlessly. But what good does it do? The reason we really want to come is to see a show.

MR. BEN SCHLANGER: There is one point that Dr. Cutter brought out which I think is worthy of a little further enlightenment, and that is the cinema-goer who comes to the theater to forget all his problems completely and be in the world of what he is looking at in the cinema. And that is what we need greatly, a theater auditorium where a person can sit down and look at what is ahead of him and not be conscious of the physical shelter in which he is enjoying that picture. He has to be able to look at that picture, lose himself in it completely, and have no reminder of the fact that he is in an enclosure and looking at a picture.

That is a pretty difficult thing to accomplish but I think it is worth striving for.

If you have auditorium walls with certain types of decorations, let us say Georgian and Colonial, and the picture that is being shown on the screen is a scene in the Sahara desert, they do not belong together at all. In other words, the auditorium has to be a completely neutral enclosure, to enable you to enjoy completely that which is being shown to you, and we have to try to make that picture that is ahead of us not appear as a picture, but as real life; in the motion picture it can appear even more like real life than in the stage theater, because in Hollywood the boys have a few tricks up their sleeves that can produce it.

CHAIRMAN JAMES FRANK, JR.: The African theater, I suppose, had no walls and no ceiling.

MR. SCHLANGER: You could project a picture in the open air, like in a drive-in theater, and you will have this: a very brightly lighted picture, and then the black of night around you. That is a little better than sitting in an enclosed theater with a bright screen and many other distractions, but there is still another point. You have to go even further than that. You have to accept the shelter that encloses you in an indoor theater and take advantage of the shelter and use the surfaces of that shelter to create a light tint which will be related to the picture instead of having a black surrounding around the picture, which is an artificial masking. We do not walk around all day long with a black frame in front of us

Theater Engineering Conference  
*Physical Construction*

# General Theater Construction\*

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*Summary*—This paper will discuss the uses of alternate materials and to some extent the varied requirements to be considered in the construction of a modest or low-cost type of theater as compared to the construction of the more elaborate or so-called de luxe motion picture house. It will neglect the considerations of the special features such as layout of a full-act stage, stage lifts, gridiron, dressing rooms, paint bridges, orchestra lifts, and other requirements of a full presentation or legitimate theater, as probably there will be few theaters of this description constructed in the immediate future.

## INTRODUCTION

WHEN CONSIDERING the construction of a theater of any type, it might be in order to mention that the estimates received at the present time, for the building of a proposed low-cost or modest house, take on the proportions of a de luxe theater; surely the prospective owners sincerely believe that the architect has included a fully equipped stage, solid-gold hardware, and mink-lined cosmetic rooms. However the prospects of a substantial reduction in the cost of theater building and theater equipment in the near future, are, in the author's opinion, not at all promising.

The matter of location of the theater, the accessibility to transportation, parking facilities, orientation of entrance features and marquees, vertical signs and similar questions will be discussed in detail by others, and therefore these topics, which of course are of primary importance, will be left for future consideration.

The more important functional and esthetic elements necessary in a good motion picture theater of both the modest and de luxe house, will be discussed in more or less the sequence of importance in which they affect and influence the average theater patron. Many will no doubt disagree with the order of presentation, but the theater patron will not be concerned with the sequence so long as all elements in one form or another are present. All are vitally important and necessary

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in the construction of a new theater; the functional elements to a far greater degree than the esthetic, which however, cannot entirely be neglected, in any theater.

Disregarding in this consideration such important requisites as cleanliness and courteous service, the following elements seem most vital and necessary:

1. Comfort while watching the show.
2. Good vision of the picture and proper projection.
3. Good sound.
4. Adequate and inviting toilet and rest-room facilities.
5. Ample and properly arranged lounge and circulating spaces.
6. Pleasing and attractive interior architectural treatment.
7. Attractive entrance and exterior treatment.
8. The physical structure of building.

#### SEATING, VENTILATION, LIGHTING

Under the first heading several factors will be considered, which will cause the patron to feel comfortable. Starting with the seats there is, of course, a wide range in both comfort and cost; however even the modest theater should have spring seats with upholstered backs of 20-inch minimum width, and spaced not less than 2 feet and 10 inches back to back of seats. The covering may be of leatherette, corduroy, mohair, or other serviceable material. In the de luxe theaters the covering materials would be of better quality, the seats and back upholstery would be deeper and more luxurious even to the extent of providing foam-rubber and upholstered arm rests, the seats should be 21 to 23 inches in width and back-to-back spacing from 3 feet to 3 feet 3 inches. Loge seats should be at least 22 inches wide and spaced not less than 3 feet 4 inches back to back. Orchestra rows 3 feet back to back with 21-inch-wide seats would be a good average for acceptable comfort.

The next consideration is "ventilation." Here again even the less-expensive theater must have adequate ventilation, without annoying or noticeable drafts. All theaters, where the hot summer season is of considerable duration, should be air-conditioned, at least provisions should be made in the ventilating system and layout of the fan room, so that cooling coils and refrigerating equipment, either for well water or compressor, could be installed in the future. If ventilation alone is installed the author recommends 35 to 50 cubic feet per minute of air per person; if well water is used, 30 cubic feet per minute

would be sufficient; and if cooling is obtained by means of compressors 20 to 25 cubic feet per minute per person should be provided. In the smaller inexpensive theater, where air conditioning cannot be provided, the ventilation may consist simply of large quantities of air with no return or recirculating ducts or trenches under the floor. In the better theaters return air ducts or trenches would be built under the orchestra floor, located in relation to sources of air supply; to provide even ventilation in all parts of the house.

A separate smoke-exhaust system should be installed wherever the budget permits; this should be a definite requirement for a de luxe theater.

In connection with recirculating ventilation systems there has recently been considerable discussion concerning automatic electric shutoff equipment on main fans by New York State Authorities; however, the author believes that a manually operated shutoff switch controlling the main supply fan could be provided in a readily accessible location in the auditorium, outside the fan room, and this would prove more practical in preventing the spread of smoke through the theater in case of fire.

A third element which vitally affects the comfort of patrons is the lighting of the auditorium, while the picture is on. In *all* theaters the amount of exposed lights, lighted wall, or ceiling surfaces above the patrons eye line should be reduced to a minimum. A major portion of light required in the auditorium can be obtained by providing a relatively brightly lighted aisle by means of closely spaced aisle lights. There should be no exposed bulb lighting on either walls or ceiling that might be a distraction.

#### VISION AND PROJECTION

The second fundamental features are good vision and projection. These are essential in all theaters in very much the same degree.

*Good projection* depends primarily on good projection equipment located in the projection booth as close to the center line of the screen as practical, and with as flat a projection angle as possible, together with a good screen of the correct size for the length of the theater.

*Good vision* will depend on a good sight line with sufficient slope or proper grading of the orchestra floor, and proper stepping arrangement in the balcony. The sweep and staggering of seats, the arrangement of aisles and crossovers and vision angles at front rows will also greatly affect the *proper vision* of the picture. This might be the best

time to discuss briefly the projection-booth layout. In the theaters with a very low budget the booth should be arranged for two active machines straddling the axis line, and also *space* for one additional machine as well as room adjacent to one side wall, on which the control panel for all house lights should be located. A rewind room even though it be small, should be arranged adjacent to the booth with vision ports permitting a view of both the screen and projection machines, while the film is being rewound. A generator or rectifier room is essential as well as a toilet room for the operator located as close to the booth as possible.

In the booth for the better theaters, there should be three projection machines, one spot machine, and space for a future machine or piece of equipment which may be required for television or other new projection equipment. This type of theater should have house lighting on dimmers and wall space should be provided for light panels and dimmer banks in the booth. A vision port should be provided through the front wall adjacent to the light panel. The upper walls and ceiling of the booth in a de luxe theater should be acoustically treated with fireproof acoustical tile or perforated transite board. There should also be a film lift provided from the street-level floor to the booth. This feature might be eliminated in a very inexpensive house.

### SOUND

Good sound first requires good sound equipment in the booth and at the screen. This is also a fundamental requirement in *all* sizes and grades of theaters. Good sound also will depend a great deal on the acoustics of the auditorium. In all theaters the acoustics can be controlled by the use of various acoustical materials on the walls and ceilings; by the shape of the auditorium; by the arrangements of forms and movement of the wall and ceiling surfaces; by the volume or cubical content of the auditorium; by the size and shape of the balcony; and also by the upholstery on the seats and the floor covering. In the low-budget theater a great deal can be accomplished by the use of highly absorbent materials on the few acoustically vital wall surfaces, and by shaping or sloping other walls in relatively inexpensive materials.

In the more-expensive type of theaters architectural embellishments can be used in forms and designs that will be decorative and also add to the acoustic properties of the auditorium. (Theater acoustics will be covered by other papers.)

## FACILITIES

The next consideration will be *ample and inviting toilet and rest-room facilities*. The location of the toilet rooms is most important. They should be readily accessible to all patrons with a minimum of travel and cross traffic. The necessity of having patrons use stairways to lounge and toilet rooms should be avoided whenever possible. There should be sufficient fixtures provided in all types of theaters; in smaller and less elaborate theaters, the proportion should be not less than one fixture for each 100 patrons, and in the better theaters the ratio should be not less than one fixture for each 75 patrons. In all toilet rooms the floors and wall wainscot to a minimum height of 5 feet should be of an impervious, easily washed material.

In the less-expensive theater the floors and base could be of tile or terrazzo, the toilet stalls of flush baked-enamel steel. The walls may be covered with tile, terrazzo, asphalt tile, linoleum, or composition tile. In the de luxe house the floors and base may be of tile or terrazzo or marble. The walls of structural glass, glass mosaic, tile, terrazzo, marble, or formica should have a minimum height of 6 feet and preferably extend to the ceiling. Remaining plaster surfaces should have a flat enamelled finish or they could be covered with washable wall paper. Toilet stalls for better theaters should be of structural glass, marble, tile, or porcelain-finished steel partitions, hung from ceiling supports. Wherever the budget will permit, all plumbing fixtures should be hung from the wall to facilitate frequent washing of the floors.

In all new theaters there should be cosmetic or anterooms of varying sizes leading to the ladies' toilet room. A men's smoking room need be provided only in de luxe theaters, in all others an entry space only, sufficient to provide privacy, is required.

## LOUNGES

Lounge space will vary in location, size, and shape in practically all theaters. In the smaller inexpensive house the orchestra promenade should be of ample size but the lounging space can be reduced to a minimum. In the larger and better theaters there should be large lounging and circulating areas provided, preferably near the rest rooms, arranged, however, so that the noises from the lounge will not be audible to people watching the show. In the de luxe theaters there will be a check room, a room for lost and found articles, also a so-called

crying room for infants, preferably with a window at which the parent may watch the picture while sitting with the child.

The manager's office should be located near the orchestra promenade, and, where finances permit, a toilet room, clothes closet, ticket closet, and built-in safe should be provided in the manager's office.

#### INTERIOR TREATMENT

*Pleasing and attractive interior treatment* applies to the promenade, foyer, and lounge areas, toilet room, as well as the auditorium. The interior architecture will be influenced by the money available for such treatment and also the ingenuity, designing skill, and taste of the architect, from whom, as is well known almost anything or everything can be expected.

In the inexpensive theaters pleasing effects can be obtained by grouping a few very simple attractive shapes and by changing the planes and directions of walls and ceiling, concentrating the interest at the stage or some special motif of design.

In the de luxe theater there will be greater latitude possible by using marble, real wood, mirrors, indirect lighting, run-plaster molds, and occasional cast-plaster features; most of which must be omitted to a great extent in the inexpensive theater.

More neon and cold-cathode lighting will be used in new theaters of the better type, but the cost will restrict to some extent the use of this type of lighting in the cheaper houses.

#### ENTRANCE AND EXTERIOR

An *attractive entrance and exterior treatment* are most important in all types and sizes of theaters, and particularly so in locations in which competition and transient patronage are essential considerations.

Even in the theater in which every dollar invested must be made apparent, it is good showmanship and good business to spend just a little more on an attractive and inviting exterior entrance treatment.

Instead of the scarce theater materials such as brick, tile, structural glass, terrazzo, and formica, stucco and aluminated aluminum can be used in interesting forms and colors. Here very high light intensity is a primary requisite.

In the better theaters, the use of materials such as marble, limestone, glass, mosaic, tile, granite, and terrazzo in conjunction with stainless steel or bronze will provide the opportunity for a more elaborate and diversified entrance treatment.

The box office should be outside of the first set of doors even in locations in which inclement weather is a serious consideration. It should be located to provide the best shelter for patrons under the marquee or canopy and also should be visible at the first sight of the theater entrance.

Structural glass doors probably should be used in the more-expensive theater, whereas, aluminum, formica, or natural wood doors could be used in the less-expensive house.

#### THE PHYSICAL STRUCTURE

We are all searching for some new and less-expensive materials or methods of erecting the known materials, so that more theaters can be built at lower costs. The details of the light-steel frame and exterior theater, as well as the wood frame and wood-exterior theater, will be presented in other papers. This article will cover briefly other types of construction.

• For the inexpensive theater, it probably will be found that a building constructed with brick side-wall piers to support roof trusses, which may be of either wood or steel, and walls of cement or cinder block, would cost the least at the present time. The blocks may be painted with water-resisting paint, or stucco may be applied which will stand up very well in the more moderate climates. The entrance features may be embellished by the use of aluminum, porcelain, enameled steel, or brick. The better construction for most locations in this country but more costly, of course, is skeleton steel frame for walls and roof, walls faced with brick and backed up with masonry block, and the roof of lightweight masonry plank, such as gypsum or porete support on steel.

In some locations in this country and in a great many foreign and South American countries reinforced concrete construction is used almost exclusively with excellent results. Very often steel is used for the roof trusses only. With lumber at its present high cost, the tendency, even in small theaters, is to use more fire-resistant materials throughout the theater, particularly in roof construction.

#### CONCLUSION

This subject is, as will no doubt be realized, limitless in its scope and there are so many special types of theaters, such as the first-run, high-admission house, the very small village and neighborhood theater, and on the other hand, the very large and showcase theater, that it has been impossible to discuss it all in the space allowed.

## Theater Engineering Conference

### *Physical Construction*

# Influence of West Coast Designers on the Modern Theater\*

BY S. CHARLES LEE

ARCHITECT, LOS ANGELES, CALIFORNIA

*Summary*—The influence of the motion picture studios on West Coast motion picture theater architecture is described. The typical present-day motion picture theater of West Coast design is discussed.

ON THE WEST COAST there is a point of view on theaters which may not be superior to any other part of the country, or the world, but which has been influenced by the ideas and desires of the people who make motion pictures. Being close to the motion picture studios we are guided a great deal by what the producers, directors, cinematographers, and other creative artists say at the time their pictures are being screened in the theaters. They often come into our office to present their observations and we have from time to time used designers from the studios who attack the problem strictly from the standpoint of showmanship and not from the staid architectural school. This has presented a rather free idea. We have developed the point of view that perhaps all of the things we were taught in architectural school were not the essentials of the motion picture theater.

The entrepreneur of the motion picture is attempting to create an illusion of reality, not reality itself, but a series of plausible situations which are interesting, exciting, and which provide the audience with a means of escape from the monotony of everyday existence. During the time the picture is being screened he does not want the possible distracting influence of illuminated interior decorations no matter how beautiful they may be, or of any other light or sound effect that might compete with the picture interest. He is in complete agreement that the motion picture theater should be an attractive showcase for his product; however, he will vigorously oppose anything that might interfere with the illusion he has created.

\* Presented October 20, 1947, at the SMPE Convention in New York.

The importance of our designs of interest in this paper begins and ends with the typical present-day motion picture theater operation. This type of design took hold on the West Coast about 1935 and the pattern is continuing at the present time.

The Academy Theater which we constructed in Inglewood, California (Fig. 1), is an outstanding example of advancements made in



Fig. 1—Academy Theater, Inglewood, California.

theater design on the West Coast. As the patron approaches this theater, a slender round tower 130 feet high attracts his attention. A spiral relief resembling a ramp carries a triple column of color-changing light which ends at the top in a scintillating ball of neon. The front and back of the tower displays the name of the theater in neon-outlined letters while the two sides support the word "preview" in neon, which is only visible when the tubing is illuminated at night.

The parking lot with an entrance at the left of the theater allows



the passengers to alight on the same side as the box office. Angular designs in the ornamental sidewalks of terrazzo suggest an approach to the streamlined box office of white metal. Translucent plastic letters announce the current pictures on the front and two sides of the marquee and the marquee soffit is studded with reflector-type incandescent bulbs and neon tubing in modern form. By the time the patron has passed through the wide lobby and glanced at the free-standing poster cases, he has been taken out of his everyday



Fig. 2—Black-light illumination in Academy Theater.

atmosphere into one of entertainment psychology. He is now better prepared to see the show inside.

The lobby reflects the conscious study to be modern without being severe. We do not believe the theater patron of today will enjoy an atmosphere of severe modernism devoid of surface ornament. The ornament should, however, be well placed and lean toward the unusual.

We believe that one of our outstanding contributions to modern motion picture theater design is what we term the "light trap." We have long recognized that extraneous light flashing across the screen

has been a barrier to good operation. This light, of course, appears from the foyer when a door at the end of the aisle is opened to admit patrons. In order to eliminate it we designed the light trap, a very simple device created by turning the doors at right angles to the screen. Consequently the light from the foyer will never enter into an aisle to distract attention from the screen. Some capacity is lost in gaining this end; however, we have found it well worth the sacrifice.

We believe that this theater is the first one in which a major experiment was made in the use of black light (Fig. 2). The coves in the

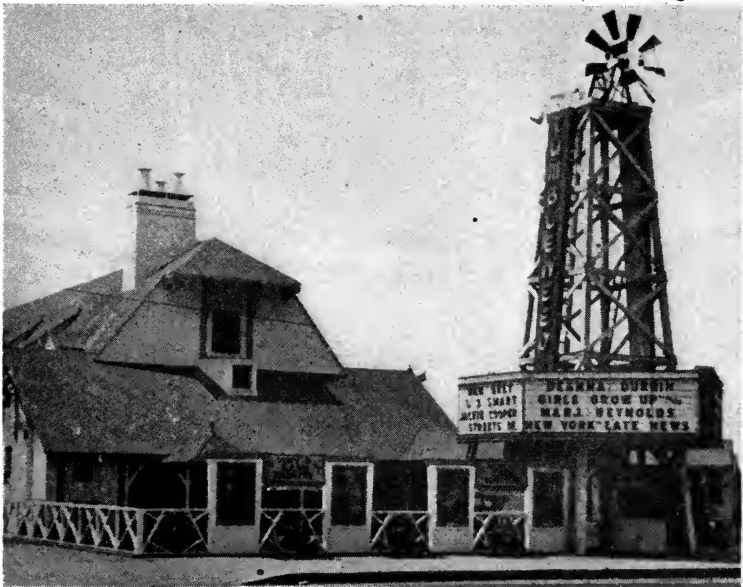


Fig. 3—Tumbleweed Theater, Five Points, California.

ceiling are designed to take dimmer-controlled neon lighting and in these same coves we have placed black-light sources. The wall decorations have been painted with fluorescent paint, and many combinations of neon and fluorescent colorings are available. The producers object to the use of fluorescent colorings during the time the picture, particularly one in color, is being screened, but inasmuch as the lighting may be controlled from the projection room it is only used when it is effective. The aisle carpet also is fluorescent and is illuminated with black light which aids greatly in seating. These

lighting units are placed at the aisle seats. Attempts were made to illuminate the aisle carpet from overhead, but the light reflected from eyeglasses was disturbing to the wearers of glasses.

We have used black-light decorations in many of our houses and found that lamp replacement offers a major problem to the operator. This may be due to the intervening war years in which these lamps were not available and while we built the first fluorescent-lighted theater in 1939 and several in Mexico in 1941, the black light was unavailable chiefly during the war years and our experience record is incomplete on this item.

We have built some very low cost theaters on the West Coast that have been extremely interesting and well-paying ventures (Fig. 3). Outstanding is probably the Tumbleweed Theater, Five Points, California, which we designed for the Edwards Circuit and which was built at a cost of \$30.00 per seat.

Having the problem of a small country area and a rural community the owner of this theater stated he would like to have a barn in which to put pictures. So the building sits back from the street with a barnyard in front which contains a wishing well, an old oaken bucket, and cast-plaster ducks and ducklings. Search was instituted for an abandoned windmill, and this was erected on a pump tower, operated by an electric motor, and is a landmark for miles about.

The marquee was built around the base of the mill tower, with a box office below, and forms the main entrance. Poster cases alternating with old wagon wheels, also the product of an entertaining search, form the fence for the yard. Gay farm colors of white, yellow, and blue with red wagon-wheel spokes make the exterior bright and cheery. The ranch atmosphere is carried out inside the theater by a foyer treated as the living room of a farm home. Papered walls with early American furniture make this appear authentic.

The auditorium has a ceiling formed by the roof trusses as barn beams would appear. Lighting fixtures are wagon wheels, three colors of lights being used in the glass rims of the wheels. Walls have appliqués of western rural ornaments. An interesting note is the fact that the chimney on the front of the building is used as a port for the ventilating system, fresh air being introduced into the front of the building and removed from the rear.

Our West Coast office has also had some interesting experiences in connection with food operations in the theater. This lucrative addition, which started as a folding candy and popcorn dispenser, has

developed into elaborate concessions which include soft drinks. We have even had proposed records, sheet music, and greeting cards.

In Mexico we were privileged to design a few theaters where we entered into the full impact of concessions in the theater. The showing habits in that territory were affected by the siesta period following which the theaters opened, usually around four o'clock in the afternoon, and considerable food was sold in the building. We, therefore, developed full-sized food concessions, usually consisting of a large room off the main lobby.



Fig. 4—Integral design of restaurant and theater fronts, Miami Theater, Miami, Florida.

In the Linda Vista Theater at Mexico City we provided two food departments, one directly off the main lobby for the service of sandwiches and the other connecting with the building and occupying a common patio with the theater for full food operation. The food concession inside the theater also handled candy, and serving light lunches and coffee, did a steady business.

One parallel operation in the United States is the Miami Theater, Miami, Florida (Fig. 4), which our West Coast office designed. Built on the main street of the city, it has a combination Huyler's

candy store and restaurant in conjunction with the theater. We accomplished the dual operation by having the candy department on the foyer floor open directly from the candy store to the foyer. Outside, the doors lead from the candy store to the box office, or from the street to the candy store, and we designed the mezzanine level of the theater to be the second-floor level of the restaurant. Service for candy and drinks operates on either the theater side or the luncheon side and there is direct access from the mezzanine of the theater to the restaurant.

Having the appearance of one operation, the flow of traffic is easily attracted from one to the other. The way the doors are arranged there are no serious problems in handling pass-out checks. The only construction problem encountered was the requirement of a fire wall

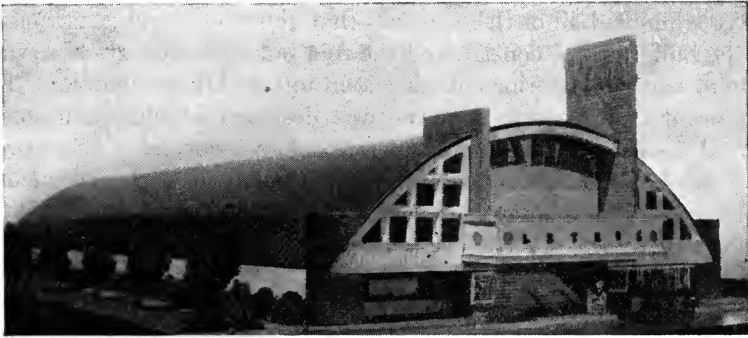


Fig. 5—Model of pre-cut-principle theater.

with fire doors between the two units. This was easily accomplished by handling our construction architecture accordingly.

The basement contains the entire kitchen facilities and food on the various levels is handled by dumbwaiters. The entire front of this building does not separate the theater and food departments except for the marquee and although the front portion of the second floor is entirely occupied by the food department, the outside appearance indicates that the theater uses the entire upper area.

We believe that the West Coast was one of the first areas to adopt large parking spaces for automobiles. Some areas potentially are on wheels and practically every patron arrives by motorcar. We started building large areas behind the theaters for accommodating the patrons and attempted to make the automobile park an integral part of the theater by having the park entrance directly under the

marquee and located so that passengers may alight as near the box office as possible while the driver, or attendant, parks the car.

Fig. 5 shows a successful design effort in what we believe is an answer to the complication of present-day low-cost theater construction. This is not a de luxe operation, it cannot be used in every situation, and it will be controlled somewhat by fire ordinances. It was designed first for Latin America and then applied to the United States. In the illustration shown the auditorium was left above ground level because of a high water table. Where the high water table does not exist we drop the stairs and start our construction two ways; one from the ground and the other by having the walls six or seven feet above the ground. This is not a prefabricated idea but is somewhat a precut principle.

We simplified all of the elements that go into general construction of the building and constructed the roof out of a proportioned wood system and the exterior covering is in interlocking aluminum. For the oramental feature, a tower was designed of aluminum pipes played upon by floodlights of different colors. Several of these projects are in construction and while they are still semiexperimental from a cost standpoint, we believe that our construction cost will be in the neighborhood of \$75.00 per seat.

## Theater Engineering Conference *Physical Construction*

# The Drive-In Theater\*

BY S. HERBERT TAYLOR

PARK-IN THEATERS, INC., CAMDEN, NEW JERSEY

*Summary*—The problems involved in planning and building a drive-in theater are outlined. The following topics are treated: selection of the site, grading, drainage, and traffic control. Also considered are the proper elevation of ramps, lighting, and landscaping.

ONCE AGAIN through the medium of invention, through its ability to reach more people, the influence and power of the motion picture industry is expanded.

With the advent of the Hollingshead Patent the drive-in motion picture came into being. It became possible for a whole group of people to attend the pictures, who previously could not, or preferred not, for one reason or another. In this class are invalids, their caretakers, parents with no one to mind their young children, and many others to whom the comforts of home mean more than seeing Betty Grable. Now the comforts of home can be taken right into a drive-in theater. Any drive-in manager has had the thrill of meeting crippled or otherwise handicapped people who, as a result of the drive-in are seeing their first motion picture in years, if not their first motion picture.

The drive-in theaters are so large that economical construction demands an engineering approach to many of the problems encountered. These are first a site problem; second, an earth-moving or grading problem; third, a drainage problem; fourth, a structural problem; and fifth, a traffic problem.

The site problem is often difficult to solve, particularly in mountainous or rolling country. The problem is, of course, to find a sufficiently large area within easy reach of a center of population. This cannot be just any land. The topography must be such that a theater can be constructed without too great cost.

The grading cost can be very critical. A drive-in theater of 660-car capacity covers approximately eight acres. Just one inch in height over an area of eight acres amounts to a thousand cubic yards.

\* Presented October 20, 1948, at the SMPE Convention in New York.

From this it is understandable that just any plot will not do. However, a variety of different topographies can be accommodated.

The ground can slope toward the screen but preferably at not a greater slope than four feet in 100. It may slope away from the screen but preferably at no greater slope than three feet in 100. It may slope from one side of the theater to the other but preferably at no greater slope than five feet in 100, and the side slope of the finished theater should not be greater than 4 per cent or discomfort will be experienced by those sitting on the slanted surface. Naturally the



Fig. 1—Photograph taken through the windshield from the rear seat with the car parked in the second ramp.

car will slant sideways at the side pitch of the theater. We like to hold this pitch to  $3\frac{1}{2}$  per cent or less. We have gone to 4 per cent in one or two cases.

This takes us into the grading problem. Each car must be positioned so that its occupants can see the screen. The people in each succeeding row must be able to see over those in the preceding row. (This art is taught by the Hollingshead patent.) Rear-seat vision must be obtained at least from the third ramp rearward. The first two ramps can be filled by cars having only front-seat occupants.

Adequate vision, particularly from the rear seat, requires that the



car be tilted or aimed toward the center of the screen. This is very important since with the large screens used, practically the whole windshield is filled with the picture. Naturally if the car were not aimed at the picture, the top, or bottom of the picture would be cut off. How critical this is, is shown by the fact that even in the second ramp of a large theater, at a point 173 feet from the screen, it is impossible to see the entire height of the picture through the windshield from a rear seat. Fig. 1 illustrates this. Fig. 2 shows that in the third ramp the screen becomes fully visible from the rear seat. The usual windshield height is 12 to 14 inches.

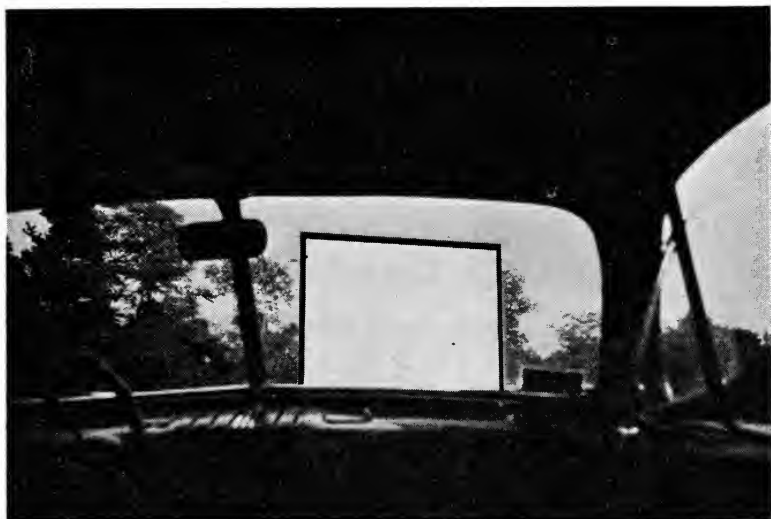


Fig. 2—Same view, with car parked in third ramp.

The front of the car is elevated for the aiming operation by use of a ramp and the operator can control the angle of the car by the distance he drives up the ramp. It is not enough, however, just to throw up a series of ramps and allow the driver to choose his pitch by the distance he drives. The occupants of each row must be able to see the bottom of the picture over the preceding row. This involves the correct relationship between the elevations of the ramps. We must go as high with each succeeding ramp as needed to accomplish this purpose, but no higher than necessary or we increase grading costs and complicate the drainage problem.

The calculation of the elevations of such a system of ramps is

relatively simple, but just one system will not do. We must have a large number of systems to fit the various topographies selected, and so avoid excessive earthwork cost. The different systems are obtained by varying the height of the screen. The higher the screen the lower the ramp system related to it. A one-foot jump in the height of the screen will lower the necessary elevation of the rear ramp three feet or more, depending on the number of ramps.

We can then select the system of ramps which best fits our site, and adjust its height to balance cuts and fills. This produces the

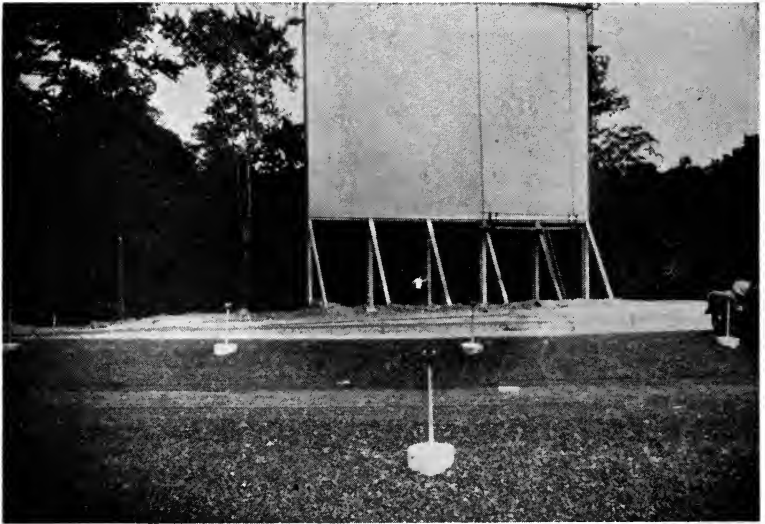


Fig. 3—All-steel screen in North Jersey theater. Note man standing at the bottom.

least amount of earthwork and allows the grading to be done by a short-haul "put-and-take" method. This is the type of grading that can be done very cheaply by bulldozers or carryalls.

Side pitch of the theater must be set at not less than 0.4 per cent and not more than the 4 per cent previously referred to. We may drain from the center to both sides or across the theater from one side to the other, depending upon the topography of the site and the drainage conditions.

Balancing earthwork means that we must cut into the existing ground surface at least a couple of feet at the low point. If drainage cannot be had from this elevation, it may be necessary to grade the

theater by bringing in fill from outside. This fill method is expensive, however, and increases the earthwork, in the case of an entire fill job, approximately fourfold. This is why sites that require fill, either from a drainage or a stable-soil standpoint, are expensive to convert into drive-in theaters.

If the ground does not slope away from the theater sufficiently, drainage often can be obtained by ditching or piping to roadside ditches or near-by streams. It is very important that the topography show these drainage possibilities.

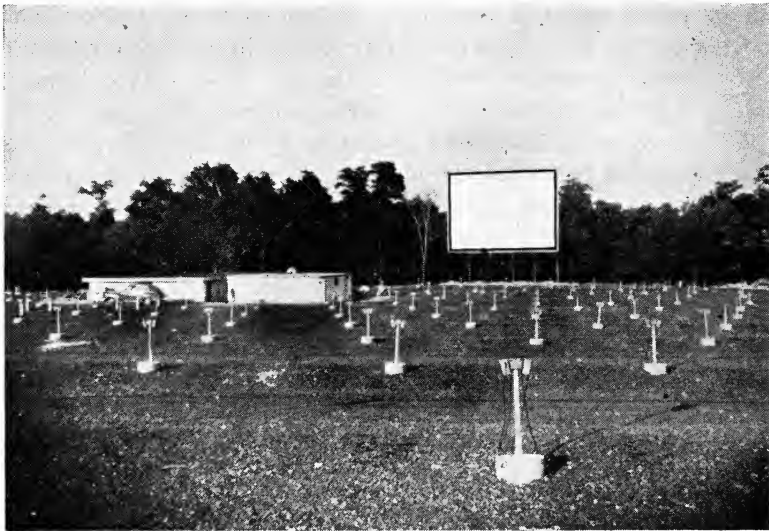


Fig. 4—General view of same theater.

Our structural problem mainly is in the screen. These run from a minimum of 35 by 45 feet to a maximum of 53 by 72 feet. The distance of the bottom of the screen from the ground is usually 18 to 22 feet. So in the case of the large screen, the top is approximately 75 feet off the ground; this is a structural problem of the first magnitude.

We are separating this problem from others by keeping all other buildings as separate structures. We believe this to be the most economical approach. This makes the screen a sort of special and glorified signboard. We believe in keeping it as simple as possible and merging it with the ground by proper landscaping. A number of interesting shapes are coming out of this conception. One of them is

illustrated in Fig. 3. A general view of the same theater is shown in Fig. 4. The open space at the bottom of the screen will be closed by a planting of shrubs and small trees.

The special structural problems of the projection and concession booths is to construct so as to occupy as little total height as possible. Too high a structure ruins parking in too many ramps at the rear of the theater. This dictates thin roofs placed at exactly the correct elevation. The roof should slant from front to back a proper amount to take advantage of all the height possible. In our designs, we fix these roof slants to give vision in the second row back of the booth.

A drive-in theater will need, of course, rest rooms and a ticket booth or booths. The rest rooms usually are placed in the projection building because it is somewhere near the theater center. The placing of the ticket booth brings us to our traffic problems.

The ticket booth should be placed in a wide driveway at least several hundred feet from the highway. In this way the driveway area on the street side is available for storage. Failure to provide this storage will result in a back-up of traffic on the highway and a resultant irritation of local and state traffic authorities. The amount of storage needed depends on the size and business of the theater.

The back-up occurs when the theater is originally loading and also when it is full and patrons are waiting for the show to change. At one North Jersey theater, the number of these waiting patrons resulted in a two-mile back-up on the highway. The solution was simple; a parking lot with a capacity of four to five hundred cars properly located so that vehicles could easily get into it from the entrance drive and easily out of it to the ticket booth. These parking lots are being incorporated into several large theaters under construction in this area, and are being added to some already built.

No mention has been made of the electrical problem. The in-car speakers require electric cable. This is usually sunk in the ground 10 to 12 inches and the speaker stands connected to it. These stands are 18 feet apart to allow for the parking of two cars between them.

The entrance and exit driveways should be lighted as well as the parking lot, if one exists. It is customary to mark the ramps at the sides and center of the theater with concrete posts on which are painted and illuminated the numbers of the ramps. The illumination is accomplished with a simple fixture which throws the light downward on the number. The numbers are placed on both sides of the post. They are needed to guide patrons back to their cars after

visiting rest rooms and concession booths. As the rear ramp in many theaters is 600 feet from the screen it is evident people need something to assist them to find their cars if they have left them.

A novel feature at a North Jersey theater is a hundred-foot pole at the rear of the theater, on the top of which are erected floodlights to bathe the theater in soft moonlight. On moonlight nights the artificial product is not used.

Landscaping is an important part of all drive-in theaters. The actual selection of materials to be used is left to the local owner. It is

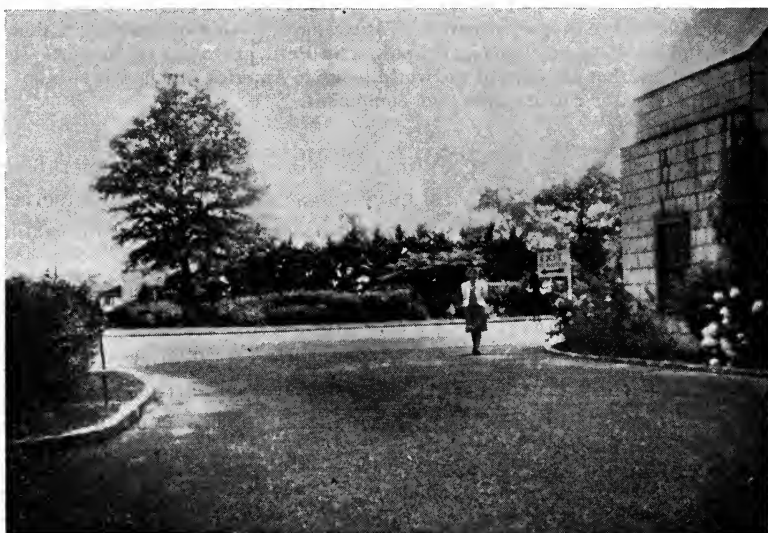


Fig. 5—A parking lot for a New Jersey theater.

presumed that he will use those materials best suited to his particular locality. (See Fig. 5.)

When Hollingshead conceived the idea of the drive-in theater, during the depression years, he said that he thought in terms of the things that the majority of people would give up last. He decided the two top items were automobiles and motion pictures. He put them together through his ingenious invention, and we have the drive-in theater. How good his judgment was is attested by the large number of theaters already in use. The experimental stage of the drive-in is past. It is here to stay as an ever-growing factor in the industry.

## Theater Engineering Conference

### *Physical Construction*

# Foreign Theater Operation\*

BY CLEMENT CRYSTAL

PARAMOUNT INTERNATIONAL THEATERS CORPORATION,  
NEW YORK 18, NEW YORK

*Summary*—The theater situation in Australia is treated extensively in this paper and building problems in Egypt and in Peru are outlined briefly. It is pointed out that the rest of the world looks to America for the latest innovations in theater construction and equipment.

NO MATTER where one goes in this world, people in general are much the same. They all have the same impulses as ourselves, like to live well, look well, eat well, and have all the luxuries possible, all of course governed by local custom and supply.

In Australia, the people are perhaps more like Americans than anywhere else in the world. They are gracious, hospitable, and great movie fans as well as motion picture builders and operators. The Australian theaters, in general, are large, well constructed, well designed from sight lines as well as acoustically. It is not unusual to find 3000 to 4000 seats in even the neighborhood houses. They are usually constructed of reinforced concrete, of modern design with beautiful patios surrounding their lobbies; the walls are of plaster and the acoustical materials well thought out in design, with indirect lighting. The foyers and aisles are usually carpeted and a real *de luxe* form of decoration is used throughout. Some theaters even were carpeted under all seats.

During the recent global war (which physically crossed Australian shores) their theaters were kept in operation. It is true, replacements were hard to obtain, but they did a splendid job and even now, with replacements still very difficult to acquire, they have kept and maintained their theaters in excellent condition.

Throughout Australia the fire and safety regulations are similar to ours. Only in rare situations can one find a theater with poor exit

\* Presented October 20, 1948, at the SMPE Convention in New York.

facilities. However, their fire-alarm systems, particularly in Adelaide, the capital of South Australia, far surpass ours. There they have the latest type of warning system throughout the city. In each place of business and on street corners where a fire-alarm box is stationed a loudspeaker microphone is built into the box which is hooked directly into the nearest fire station.

In the rear of the Paramount branch office, right by the film vaults, one of these fire-alarm boxes was on the wall. We pushed a button and within a second a voice came back over the loudspeaker from the fire station: "What's the matter, Paramount—what's wrong?" This enables one immediately to tell the Fire Department how serious the fire is, and the type of fire that it is. This method gives the Fire Department the opportunity of telling how to fight it and exactly what to do. In turn, the Fire Department knows exactly what type of apparatus to send out. This system is also hooked on to the sprinkler system, so that should a sprinkler go off it causes a flash in the main fire station—the minute the circuit is broken, you hear a voice coming over that same speaker saying, "What's the matter, Paramount?" In this case, should no one answer, certain apparatus is dispatched immediately. Should a fire break out and one be unable to remain near the fire box, they can speak to you over this microphone from a distance of better than a hundred feet.

At the fire station, in order to demonstrate the qualities of the system, a button was pushed which sounded in the rear of a theater. A voice came back, asking the Fire Department what was wanted. The fireman said an American was looking over the system and he wanted to show how it operated. Whereupon the fireman turned more power on the microphone and the voices of the actors from the screen could be heard. It was pointed out that a large fire, which most probably would have caused extensive loss of life and millions of dollars in damage, recently was prevented, due to this alarm system, as the Fire Department was able to tell the people turning in the alarm how to fight the fire until such time as the equipment arrived.

This system is also used throughout the streets of Adelaide and many lives have been saved—pedestrians as well as firemen—by not having to send out full equipment. When an automobile is on fire, a person can go to the box at the corner, push the button, and report the extent of the fire, and adequate rather than full equipment is sent out.

False alarms are prevented because if someone rings the alarm and

is asked, "What's the matter?" and the person does not say what is wrong, the fire station immediately turns the amplifier on full, so that the fireman's voice will reach blocks away throughout the neighborhood, with the control officer at the fire station calling out, "Catch the person who turned on the alarm!" In this way, the Fire Department is prevented from turning out equipment because of a false alarm.

Throughout Australia we found big, beautiful theaters in the suburban areas, so designed that in the rear of the orchestra on one side there is a double-glass partition which gives clear vision to the screen and a door which opens from the lobby into a room approximately 15 to 20 feet wide by about 8 feet deep. They call this room their "Crying Room" and they keep it exclusively for mothers who are forced to bring their infants and children to the theater. The room has its own amplifier horn and the mothers are able to see the picture through the double-vision glass, and nurse their babies. Should a child cry, the rest of the people in the theater will not be disturbed.

In the theaters that have no "Crying Rooms," they render the following service in order to attract the mothers to the theater: A patron comes in with a baby in a carriage—she buys her ticket (and generally speaking all seats are reserved). She gives the usherette the baby's bottle and tells her what time the child should get it; the usherette takes her ticket, fills out a slip which gives the woman's name, location of her seat, hour of feeding, and pins it on the child. At the proper time, the usherette heats the bottle, goes to the seat, gets the mother and the mother comes out and gives the child the bottle—returns to her seat and the usherette takes care of the child. This was really very amusing because we thought we had enough to do to operate theaters and take care of our public, without arriving at the stage where we also had to act as nursemaids! However, you would be surprised at the way this service is received and appreciated.

On the opposite side of the rear of the theater they have a similar room with about 12 seats which they set aside for private parties. People having a dinner party at home, and wanting to make a film show part of the evening's entertainment, can reserve this entire room for the performance. In this way they have the pleasure of having their own crowd together—separate and apart from the rest of the audience. Should they have had a little too much to drink, they, in no way, either by conversation or actions, disturb the rest of the people in the theater. This is a popular custom that might well be incorporated in our plans throughout this country. The only addition that might



be added would be to create a private lavatory within the confines of this room.

Generally throughout Australia you will find that many theaters are entered on the mezzanine, or as they call it, the dress-circle floor. To get to the stalls (which is the orchestra in our language) you must go down a flight of stairs. To get to the balcony you must walk up a flight of stairs. From this you will see they try to prevent the people using the better-class and more-expensive seats from having to climb stairs.

Most performances throughout Australia have reserved seats. They run three shows a day—matinee, 3:30, next show at 6:30, and the last show at 9 o'clock. Most theaters have usherettes. The girls are attractive and very well gowned. Their dresses, shoes, and stockings are supplied by the management and are in exceptionally good taste.

In short, and apart from the fact that they have usherettes instead of ushers, it is very difficult to be in many of the typical Australian houses and not believe that one is actually in Chicago, Kansas City, Toledo, or Atlanta. The spirit and operation of the American motion picture theater has reached there more completely than it has any other place in the world.

All the major American companies who have built and are operating theaters throughout the world have constructed them in the same style and manner in which I have just described. Wherever you go, any place in the world, you can generally tell from its operation whether the theater is run by American companies or by local interests.

In constructing a theater in Cairo, there is the additional problem that one cannot excavate deeply; generally speaking, 3 feet below the curb is the water line. Most buildings are constructed on wood or concrete piles, depending upon the type of building that is erected, and usually you have to walk upstairs to approach the lobby in order to create a basement floor. Reinforced concrete is used throughout, with the exception of the roof where, in some cases, large wooden trusses are used and in other cases, steel trusses. The fire regulations for exit purposes are similar to those in the United States. In Egypt, as elsewhere throughout the world, they look to our regulations as an example of the best methods of safety for their business.

Paramount is now building a theater which is very near completion in Lima, Peru. This house, when completed, will be the finest theater in all of Latin America. The structure is of reinforced concrete,

aluminum sheet roofing supported by steel trusses; the walls in general are plastered but in some cases have acoustical rock-wool blankets covered with perforated transite. This, of course, is only out in the front fascia of the balcony and around the rear-wall portion of the theater. The theater lighting system is especially designed with the new Frank Adam Electric Company dimmer. The main ceiling has a series of high-hat recessed electric fixtures so that all light shines directly down on the audience. The interior also has a series of neon lighting running around the auditorium at the mezzanine floor level. The theater is designed in such a manner that the smallest amount of floor space is used in the auditorium floor, mezzanine, and balcony. The theater is equipped with the American Seating Company body-form chairs, fully upholstered throughout.

It is customary in Peru that balcony patrons must enter the theater from a different entrance than those who patronize the auditorium and mezzanine floor. These people generally have been considered lower class and throughout Peru the balconies are equipped with wooden benches, concrete steppings, or wooden chairs. In other words, the poorer class of people are given no consideration whatsoever, so far as conveniences and comfort are concerned. However, we feel that low-price patrons shall be considered just as important as the others, and we have equipped the balcony with fully upholstered seats, given the balcony a lounge, nicely furnished, carpeted the floor and aisles to the balcony, and given them beautifully tiled, modern rest rooms.

Major American companies all feel the same way and we are striving to bring to the people of the world the better things in life which we have all been fortunate enough to give to all classes of people in America.

In America we are not allowed to have class distinction, but in many places throughout the world, and especially in Latin America, there is class distinction and the local theater owners and operators look down upon the low-admission people. American companies feel that they are the backbone of our business and that success can only come to us through continuous patronage of the theater by the middle and lower classes, and that a theater built to attract only the better classes can never be a successful venture.

On the exterior of the Lima theater there are a stainless-steel electric sign and marquee signs with flasher borders, equipped with Adler letters, using both neon and fluorescent lighting. The soffit of

the marquee is equipped with gold and white glass mosaic and some of the predominating free-standing reinforced concrete columns are also covered with the glass mosaic. The entrance doors are herculite glass, new for the Latin American field.

Much of the foregoing has had to do with improvements, innovations, new conditions, and new comforts which the American motion picture industry is bringing to many parts of the world.

#### CONCLUSION

The rest of the world looks to us for the latest innovations in theater construction and equipment and they try to follow in our footsteps. One deplorable factor is, however, that in their efforts and endeavors to be as American as possible, they are making use of outmoded American plans and devices and are heedlessly following them instead of checking to make sure that what they are doing represents the newest in development. We hope, in time, and with all of the cooperation at our command, to remedy this situation at the earliest practicable moment.

# Theater Engineering Conference

## *Physical Construction*

Note: For the Theater Engineering Session on Regular, Prefabricated, and Drive-In Theaters, Chairman Satz requested that all discussion be held until after the delivery of the last paper in this group. The material which follows, therefore, is in the nature of a panel discussion and deals with all four papers in this particular section.

### DISCUSSION

MR. S. CHARLES LEE: Is it better to enter a drive-in theater from the stage or from the rear? In one of your plans it appears that at least part of the time you enter from the rear of, shall we call it, the auditorium.

MR. S. HERBERT Taylor: The answer to that question depends upon local conditions. The important thing is to provide a considerable length of driveway before you reach the ticket booth, so that cars are not backed up on the highway. In some cases, if your screen were at the rear of the tract, you might possibly enter in the front of the theater, but where your screen is on the road side of the tract, which usually is the case, we are extending the entrance drive back in some cases to the rear ramp and in some cases about two thirds back in the theater.

MR. LEE: In other words, it has no effect on the operation, or from the standpoint of the lights of the car approaching the drive-in theater, whether you enter from the screen side or whether you enter from the rear.

MR. TAYLOR: The lights have been screened out when the car is making its turn into the theater tract. After that you can instruct drivers to turn out their lights. Very often natural conditions accomplish the screening.

CHAIRMAN LEONARD SATZ: I should like to ask Mr. McNamara if he considers the 23-inch seat a little too wide? By providing a seat of extra width, would it permit the patron to shift around in the seat too easily from side to side and thereby cause discomfort to the persons sitting directly behind? Is there any limitation that you would set on the width of the theater chair?

MR. JOHN J. McNAMARA: In my opinion 23 inches is not too wide, but anything beyond 24 might prove so wide that the people would slouch sideways rather than sit straight.

MR. BEN SCHLANGER: The 23-inch chair is too wide. It is advisable not to have a chair any wider than necessary, because it will permit the person in that chair to shift. What the person needs is not a 23-inch chair, but he needs elbow room, and, if possible, extra arm blocks for each person should be provided. In other words, I can visualize space in between seats. Even a very stout person can sit very comfortably in a 21-, or 22-inch chair, providing that he has enough elbow room.

MR. McNAMARA: My assumption was that it would be from center to center of seats, rather than having the seat itself 24 inches, so that 24 inches would take in the arm block.

CHAIRMAN SATZ: Then I think there has been a misunderstanding. Mr. Schlanger, we are very much interested in double-arm blocks. In fact, before

we placed orders for a large amount of seating recently, we inquired as to whether or not that would be practical. It did not work out, principally because of the high loss of seats that would result.

MR. H. E. GREENSPOON: Mr. Lee made a statement that he hoped to build theaters for about \$75.00 a seat. Could Mr. Lee elucidate and give us a little more detailed information about how that is possible? We are financing ourselves up in Canada, building theaters for about \$200.00 to \$225.00 a seat, and this information would be very welcome.

MR. LEE: It is possible to build a theater for \$75.00 a seat as at the present time I am doing it. The form of construction will only apply to areas in which the ordinance follows approximately the Uniform Code. I think the Uniform Code is now accepted in some 500 cities in the United States. So I shall confine myself to that.

The main form of construction that we have used is, starting with a flat slab, we built below ground with reinforced concrete and brought our walls up to six inches above grade. From this point on we are using what is known as the Lamella truss system without any reinforcing rods across the span. The truss system is adaptable; if you use a 50-foot span you can use 2-inch lumber, and by fireproofing it, we have found that we are well within the limits of the Code.

We have used plaster to the extent of nine feet above the grade, and over this we are applying a sheathing, first a good sheathing and over that an interlocked aluminum sheet. This gives us complete waterproofing, and a very low-cost application.

At the front of the theater, we designed a tower, and by building this tower of staggered pipes, we have been able to secure a very interesting effect. We have buried into the slab some floodlights, and by having changeable colors, I think we are going to get some showmanship out of it.

On the front, we have used a combination of stone and plaster and the major portion above the marquee line will be of ribbed glass running in two different directions.

The present indication is that the theater will be very interesting in appearance, and at the present time I have costs in which I can award a general contract at \$75.00 per seat.

CHAIRMAN SATZ: Would you mind explaining that aluminum interlocked construction. Does that carry right up and around the roof? Is the roof of curved construction?

MR. LEE: Completely around, yes.

CHAIRMAN SATZ: Similar to the radius of a Quonset hut?

MR. LEE: We have a slide here that shows one adaptation of it on a 2500-seat operation.

CHAIRMAN SATZ: And the interior finish?

MR. LEE: For the interior finish we are using expanded metal with an insulating material underneath the expanded metal. By painting the expanded metal we are going to obtain an architectural effect with our colors, and by having the insulating material, such as rock wool, behind the metal screen we shall take care of our acoustical correction. At the present time we are experimenting with Palco bark for that purpose, which on the West Coast is a little cheaper.

CHAIRMAN SATZ: Is that the only acoustical treatment you are giving the auditorium?

MR. LEE: No, the rear wall is a perforated masonite with rock wool.

MR. SCHLANGER: I should like to refer again to seating, because I think it is too important to ignore. You made a statement, Mr. Chairman, that the double-arm-block system used up too much space. I am not for or against double-arm blocks at the moment, but I do want to explain some dimensions. For example, if we had a 20-inch chair that had a double-arm block system, that is, on each side of the chair, it would be 20 plus 1½ inches on each side. That would be 23 inches. So that if you were willing to devote 23 inches to a chair, which is not unusual, then your arm blocks would not be taking up too much space. It is purely a matter of simple arithmetic.

You do not use double-arm blocks in all the seats, but in staggered-seating plans where you use this system to help control the position of each viewer, so that he has a clear view between the heads in front. It may very well be that when the exhibitor becomes accustomed to more space per patron, as he has in back-to-back dimensions, that 23 inches devoted to each person will not be considered very much in the near future.

CHAIRMAN SATZ: By a double-arm block, do you mean one solid piece of extra width or two separate blocks on separate standards?

MR. SCHLANGER: At the present time that is just two separate arm blocks made up of two separate chairs. Many seating companies seem to be investigating the possibility of combination arm blocks of a wider width.

CHAIRMAN SATZ: With double standard throughout the row?

MR. SCHLANGER: I do not know what they are going to do. It may be a regular standard, it may be a double standard. They are investigating that now, but have come to no decision.

CHAIRMAN SATZ: Mr. Alexa, would you care to say something about that?

MR. F. W. ALEXA: At the present time the standard chairs are from 18 to 22 inches, but the 18-inch chair is no longer used. The widest chair at the moment is 22 inches. Above 22 inches you run the cost of the chair up pretty high, because of the difficulty of preparing dies to form the steel backs. The average chair width normally used is about 21 inches. We have installed some chairs here recently that had an arm block that was about 4 inches wide, and the purpose of it was that it could be used for writing as well. This happened to be in a lecture room, and it did not have a bad effect at all. We used a chair about 21 inches wide with this wide arm block, and it did not take away from the comfort of the chair. There should not be too much objection to the idea of breaking up the chairs in sections and using double-arm blocks. The only cost involved there is an extra standard, and if that is going to achieve what you are after, good sight line and comfortable position, there should not be any objection.

MR. FREDERICK J. KOLB, JR.: In your drive-in theaters, Mr. Taylor, what level of screen illumination and what level of surrounding illumination are you seeking, particularly for a 60- or 72-foot screen? You said in one installation you provided some artificial moonlight which, I take it, provided a constant, perhaps fairly high level of scattered light, and I wonder what you are planning to reach in that level, and then what you do for screen brightness to provide a satisfactory picture.

MR. TAYLOR: I regret I am not prepared to give you an answer on that subject. The situation is this: Soft moonlight, we know by experience, does not interfere with the illumination on the screen. The illumination on a large screen is not up to indoor standards, we know that also. But we make up in size for lack of illumination.

It is remarkable how well you can see. If you care to drive just ten miles from New York City, you can go over to Paramus, New Jersey and see the size screen you were talking about. You can stand on the other side of the fence, some 700 feet from the screen, and see the picture fairly well.

CHAIRMAN SATZ: Mr. Kolb, do you have any ideas of your own as to what the level of screen illumination of that motion picture should be?

MR. KOLB: Well, I have some ideas, but I do not think anyone can reach them.

MR. LEE: May I ask Mr. Taylor what he considers the farthest row in which the occupants of the average car can see without complaints?

MR. TAYLOR: We are planning a theater now with a 15th row. A car in the rear ramp will be about 660 to 670 feet from the screen. That theater will have the largest size screen, of course. The capacity of that theater is over 1000 cars.

MR. LEE: That answers my question, although I have never been able to see clearly past the 7th row, myself.

MR. NEILL WADE: Mr. Taylor, could you say something about the surface treatment? Is there anything special needed on these outside screens?

MR. TAYLOR: The surface treatment of the tract itself, the ramps, or the screen itself?

MR. WADE: The screen on which it is projected.

MR. TAYLOR: No, they require very little special treatment, because the screen is so large that any slight irregularities are compensated for, by the size of the picture. We were somewhat afraid of that when we put steel plates on the face of the screen, because there is a slight rippling effect in the steel plate, but in actual practice it worked out very satisfactorily. The plates are simply painted white.

MR. WADE: The number of units that make up the screen brought that question to mind. Mr. Schlanger was talking about seats. With the advent of these new plastic materials, would they be suitable and wear longer than some of the fabric covers which are being used as an upholstery?

MR. SCHLANGER: I do not have any wear tests on those. If you mean the plastic-coated fabrics, some of the good ones stand up pretty nicely, and they are more sanitary than the fabrics. The fabrics are a little better from an acoustics standpoint. The fabrics are not so good from the cleanliness standpoint. There are many factors that enter into it. However, there is a large variation in wearing quality of these plastic-coated fabrics. Some of them are excellent.

CHAIRMAN SATZ: Mr. Wade, I might mention that during the Maintenance Session, I think there will be persons here who will be exceptionally well qualified to speak to you on the subject of vinylite resins or any of the other plastic-type coverings as compared to the old-style leatherette.

MR. J. S. CIFRE: Mr. Taylor, have you given any consideration to the inclined screen, that is, inclining the screen so that it reflects the light back to the eye of the observer?

MR. TAYLOR: Yes, we have such a screen under construction at the present time. It is not actually built as yet, but it is just about to be built.

MR. CIFRE: What do you expect for advantage in that type of construction?

MR. TAYLOR: You obtain a better throwback of light to the viewing area. Some of the light which is cast on a vertical screen is scattered upward, and that light is more or less lost so far as return to the theater patrons is concerned. We figure that with a slanted design we shall return more light directly to the cars that are parked in the theater.

MR. JOSEPH J. ZARO: Mr. Lee, I believe you said that you awarded a contract at \$75.00 a seat. Do you mean merely for your general contractor or for your entirely equipped theater?

MR. LEE: That is for the construction without any equipment, but includes heating and ventilating, electrical wiring, painting, and all construction items, ready to move in the equipment.

MR. ZARO: It is actually not a complete theater, then, at \$75.00 a seat.

MR. LEE: Unfortunately the parlance that the architect uses is usually for the construction of the building and the operator installs his own equipment.

MR. ZARO: What are your costs actually running?

MR. LEE: The equipment, as you know, could vary according to the type of equipment you selected and the seats. There are some persons who could tell you exactly how much your equipment will cost in a given size theater. For a 1000-seat theater, I would say that your equipment costs today run about \$38,000.

MR. ZARO: On your low-cost theater, what type of construction would you compare that to under prewar conditions? In other words, taking your theater as an over-all building, exterior and interior, how would that compare as far as cost?

MR. LEE: I should say that prewar that similar type of construction could have been built for nearer \$40.00 a seat.

MR. ZARO: Has any consideration been given on the West Coast to use of vermiculite construction in wall-panel construction for theaters?

MR. LEE: Yes, we have had vermiculite construction on the West Coast several times and have had it under consideration. We have a very great problem in connection with seismic loads, what you might term earthquake resistance, and we investigated vermiculite concrete from the standpoint of lessening those loads and also considered the crushing strengths that we could get out of it. We have never been able to use it with any degree of economy.

MR. R. T. VAN NIMAN: Mr. Taylor, what experience have these theaters had with the theft of car speakers, with damage from the weather, and with damage suits from patrons who drive off without taking the speakers off the car windows?

MR. TAYLOR: There has been very little loss of speakers. Of course, some occasionally are lost but not many.

So far as maintenance is concerned, the products that our company has handled have stood up very well. I know of no such instance where patrons have had damage done to their cars by driving off without taking the speakers off the windows and have sued the theaters.

CHAIRMAN SATZ: I should like to ask Mr. Taylor if there are any figures that he could use to explain his statement that family business predominates. Can you give us an average of how many people appear in each automobile, or is there any guess that you would care to give as to what percentage of your business is family business?



MR. TAYLOR: The average per car runs around three, and I would say that the family business is 75 to 80 per cent of the theater business.

MR. WADE: Mr. Taylor, could you give us any idea of how the cost per patron for the construction of drive-in compares with the figures we have already heard for the indoor theaters?

CHAIRMAN SATZ: Would not that have to be cost per car?

MR. WADE: Let us reduce it to a common denominator. What is the patron average?

MR. TAYLOR: A fully equipped drive-in theater, from 660 cars to, say, 850, will vary in cost from \$100,000 to \$200,000. If you take the number of cars and multiply them by three, you can pretty nearly produce a patron figure.

Of course, it is possible to construct drive-in theaters for less than that. But in the Metropolitan New Jersey section, they are going in for first-class construction right now.

CHAIRMAN SATZ: Do you base that on any particular average for wages or any standard in this area?

MR. TAYLOR: No, that is New Jersey experience. It is North Jersey, where you have a very high wage level.

MR. VAN NIMAN: I should like to ask Mr. Taylor whether there is any prospect, with the advent of high efficiency for the focal lens, that it would be desirable to move the projection room closer to the screen, so that not so much space will be lost in front of the booth because of the light beam. As it is now, it is about 200 feet for the average distance.

MR. TAYLOR: The usual distance at present is 239 feet. Perhaps Mr. Smith can answer your question.

MR. V. C. SMITH: I do not know whether I can answer that question or not. Recently, I was with Bausch and Lomb, talking over this particular problem, and apparently it is quite difficult to solve. I think it will be a few years before this becomes a possibility. It would be desirable for one or two reasons, in that you would be able to park cars in the space that you are now using for the projection booth, and you would also be able to cut down the amount of space between the projection equipment and the screen.

MR. VAN NIMAN: Who is going to make the lenses?

CHAIRMAN SATZ: You will just have to wait on that.

MR. ALBERT STETSON: I would like to have Mr. Taylor give us an expression regarding the advantages and disadvantages of wooden-screen structures compared with steel. I am thinking of safety as well as expense.

MR. TAYLOR: My vote goes for the steel. The screen structures are getting so large that I do not see how you can secure safe and economical construction with wood. It may be possible, but I prefer steel.

MR. LEE: Mr. Taylor, do you have any information where the run of the picture in the drive-in theater has paralleled the neighborhood run? What impact has the drive-in theater on the indoor-theater attendance?

MR. TAYLOR: That is a question I am not competent to answer.

CHAIRMAN SATZ: We shall try to get an answer for you, Mr. Lee, before you leave.

MR. JAMES FRANK, JR: Mr. Taylor, what is the amount of land required for various sized theaters, the number of acres for 500- to 700-car theaters?

MR. TAYLOR: I can, in a general way. The actual area of a 660-car theater is about eight acres; actually, eight and a half. This is just the bare ground for the theater. If you want to protect yourself from side encroachments, if you want ground for some other purposes that might develop in connection with your theater, you certainly want to provide more. As a general rule, you cannot buy just the acreage you need because the theater is more or less pie-shaped. So with the 660-car theater, I should say you would need from 12 to 15 acres; for an 850- to a 1000-car theater, you need from 15 to 20 acres.

Many times when you go to buy a site you will find that you can obtain the balance of the tract, which might be quite sizable for very little more than what is desired, and the choice part of it will cost you a lot more per acre than the balance of it will. So the tendency has been to take tracts that are larger than needed, which gives some reserve for future business which might develop in connection with the theater.

MR. SCHLANGER: Let us go indoors for a while. One of the things that I think would be helpful would be for the architects to collaborate on some standard on sight lines. Mr. McNamara, in figuring the clearance of sight lines in a theater, did you follow the principle of getting the clearance over the heads of the persons seated immediately in front or over the heads of people seated two rows in front of a spectator, or any other method? Soon this will become an item that will be settled by the Society but I think now is the time to get started.

MR. MCNAMARA: I think that it would be impracticable in most cases to obtain the sight line directly over the head of the row directly in front except in the forward rows of seats. More important would be the staggering and the sweep, rather than trying to see over the head of the row directly in front, which would be almost impossible in most cases.

MR. SCHLANGER: Do you calculate sight lines to clear the head two rows ahead?

MR. MCNAMARA: Not exactly, it would be more the second row with the staggering of the seats, which would give you a good sight line.

MR. SCHLANGER: I do not understand the answer very clearly yet. My question was, if in making your calculations, you make your calculation over the heads immediately in front, which you say you do not, and you would rather use staggered seating, as I gather, instead of trying to get over the heads in front, because that would be giving you too steep a slope. So then we have to figure that sight line over some head or some in-between compromise. So the question then is, do you figure the clearance ahead over two rows ahead?

MR. MCNAMARA: No. I do not figure it at all over the row ahead. I figure the sight line on an arithmetical progression, allowing sufficient space to give good sight lines, or with slight staggering, and leaving the front portion of the theater more or less flat.

MR. SCHLANGER: It still is not clear. I assume, then, you are looking between the two heads in front of you, that the heads in the front of you are not in the way, is that correct, the two heads in the next row in front of you are not in the way? You do achieve that?

MR. MCNAMARA: That is correct.

MR. SCHLANGER: Then, beyond that, must not the person see clearly over the head in front of that?

MR. MCNAMARA: Of course.

MR. SCHLANGER: Do you figure your sight lines over the heads two rows ahead?

MR. MCNAMARA: But I do not figure each row for the second row ahead or for the first row ahead. I do not think anybody does. You do not figure theater sloping on the basis of seeing over each row and figuring each second row, but use this theory as a method of checking the sight line.

MR. SCHLANGER: If we have the two heads in front of us out of the way, they are no longer a problem, so that the row immediately in front is no problem. Then the next problem is to be sure that you see over the head in front of that for the next row, and if you do see over the head two rows ahead, you are going to see over all the other rows. I have noted in the past, in checking up floor slopes in the history of theater design, that some compromise was made whereby they did not figure over the head immediately in front, and neither did they figure immediately over the head two rows in front. There was sort of a safety margin. They figured somewhere in between, which is a waste in theater floor slope. So I am just wondering what practice you or other architects follow.

MR. MCNAMARA: My practice is not to figure each row or each second row. We figure the entire house. The sight line is also determined by the location of the screen. So that the question of figuring just over the head of the person directly in front is not, in my estimation, a practical way to figure the entire sight lines for a house.

MR. SCHLANGER: It is impossible to figure a set of sight lines without having a set of assumptions. You have to start with an eye and it has to see over something. You have to figure clearance over some head.

MR. MCNAMARA: Maybe that is the way you figure it, Mr. Schlanger, but it is not the way I figure it.

MR. SCHLANGER: The other is a mystery. I should like to get it out in the open.

CHAIRMAN SATZ: May I suggest we get the opinion of a third architect. Would Mr. Lee care to tell us how he figures that?

MR. LEE: I think everyone here who is interested in sight lines would like to see these two series projected on a blackboard, or on a screen. There are two schools of thought here. Mr. Schlanger has one, which of course we highly regard, and Mr. McNamara has another, which is equally well regarded by the other school of thought. I think that it would be very interesting if they would present their views on the blackboard and give us a chance to then judge whether or not there are errors. (NOTE: The blackboard demonstration was not held because of time limitations.—*The Editor*.)

MR. SCHLANGER: These are not two theories. This is just simple arithmetic, the theory comes later. I really would like to use a piece of chalk and a blackboard and illustrate what has been said in order to follow the problem through intelligently.

CHAIRMAN SATZ: Maybe we shall be able to do that. In the meantime, could I dispense for a minute with the services of the engineers and ask a practical man to give us his opinion? He has made many installations and I am sure he knows a lot about the subject. Mr. Alexa, would you care to get into this controversy?

MR. ALEXA: In a way it rather crimps my talk tonight which is based on sight

lines. There is no doubt that the ideal condition is that the sight line should clear the head of the row directly in front, and as Mr. McNamara and I believe Mr. Schlanger agrees, it is impossible to do that because of the restrictions due to the codes that govern the slopes of floors. So the next approach to this would be to see between the heads of the people directly in front of you, and in that case all you have to do is to make sure your sight line clears your second row ahead of you regardless of where the patron may be sitting in relation to the direct line of view. In order to prevent the situation that presents itself where your chairs are directly behind each other, you would have to stagger the chairs and, as Mr. Schlanger says, it is a matter of mathematics that could be easily demonstrated on a black-board.

MR. SCHLANGER: Mr. McNamara said that the use of as flat projection angle as possible is desirable. What do you think, Mr. McNamara, is a maximum angle that you would adhere to, that is, not go over a certain angle?

MR. McNAMARA: About 20 degrees.

MR. SCHLANGER: The recent American Standards Association report mentions this as 12 degrees. The SMPE used to use 18 degrees. That is a pretty important angle. The distortion caused by 20 degrees is serious.

MR. McNAMARA: I said that would be the maximum.

MR. SCHLANGER: I believe the American Standards Association comes closer to what it ought to be, and that is 12 degrees. In a theater we designed in Lima, Peru, which Mr. Crystal explained, we had a double-balcony theater, and the degree of projection is somewhat less than 13 degrees.

CHAIRMAN SATZ: I should like to ask Mr. Lee to explain, or to amplify, his statement made before about dimming out neon. We recently had occasion to use cold-cathode illumination and we had quite a problem before we got the required intensity, that is, for running lights, and if you would like to amplify your statement, what you mean by dimmed-out neon, I should be very much interested.

MR. LEE: We have used dimmers on neon circuits for quite a number of years. My electrical engineer would have to go into the technicalities of the exact wiring diagram, but we use Autrostat dimmers, and with the Autrostat dimmer we have had no trouble whatsoever in dimming everything, except red.

CHAIRMAN SATZ: We used cold-cathode, and as we dimmed cold-cathode the color characteristics would change.

MR. LEE: I have corrected the color characteristic. In fact, recently we have used an entirely different theory. We have used white neon, and, by a very simple process of painting, have obtained the desired color. That left us with no problem at all. We started by using gelatine and then we abandoned the gelatine and painted a strip on the white neon. By simple experiment, it probably takes us half a day, depending on the colors we have used in the auditorium, to get the exact tone that we want on our neon, and it has eliminated a great deal of trouble.

CHAIRMAN SATZ: Have you used cold-cathode to any extent in any of your installations?

MR. LEE: We have cold-cathode, but not with the dimmer systems. We have always used neon.

CHAIRMAN SATZ: How large a transformer do you generally use for running lights, not house illumination?

MR. LEE: I do not think I can answer that.

CHAIRMAN SATZ: We found that 120- and 60-milliampere transformers in some circumstances were still too much. We had to use 30-milliampere.

MR. LEE: On our neon we have used 30's almost consistently; on the cold-cathode, I cannot say, we have used so little of it.

CHAIRMAN SATZ: We have also had good results where blue lights were indicated using colored tubes and the old-fashioned neon to get a low, dim intensity.

MR. LEE: You can do it with a paint that saves much time and money. In that connection, by using the white neon and painting the strips on it, you can change it, for instance, with the seasons. We have changed some houses entirely when we have gone from the cold season to the hot season. We have just wiped off the paint and changed the whole character of the auditorium.

CHAIRMAN SATZ: Is there any noticeable blistering or peeling of the paint which causes spotty illumination?

MR. LEE: Not at all.

CHAIRMAN SATZ: Would you consider that a practical thing to do?

MR. LEE: Absolutely. I can prove it by many years of use.

CHAIRMAN SATZ: Then I understand that you are in accord with atmospheric lighting in so far as summer and winter seasons are concerned.

MR. LEE: The operators have different opinions on that, but I think that there are quite a few of them in different territories that have taken the position if they can change the character of their houses from time to time, it adds interest.

## Theater Engineering Conference

### *Auditorium Design*

# Seating Arrangements, Sight Lines, and Seating Design\*

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*Summary*—This discussion will not be an attempt to consider, from a technical point of view, the problems of theater design as the author is neither an architect nor an engineer. Rather, it will be an attempt to call attention to some of the problems and advancements regarding the seating layout and the design of seating areas for visibility as they have been observed during twenty-three years' association with the American Seating Company as a technician.

IN THE PAST, the only part played by the seating company was the preparation of the seating plan to show the quantity and sizes of the chairs. Then, as motion pictures became more popular, the need for comfort and better visibility became evident, and architects and builders looked to the seating companies for better design and comfort of the seating equipment.

Reluctantly, the "legitimate theater" accepted the motion picture. With the growth of motion pictures it became apparent that the factors of design for these two separate fields of entertainment had to be approached differently. The "legitimate" had to be designed for clear visibility of the stage, a horizontal field of vision, while for motion pictures the field of vision is the vertical plane of the screen. Because of the functional difference of the legitimate theater and the motion picture theater, the combination of these two functions proved to be costly and unsatisfactory, with the result that a new approach to the design of the functional form of the motion picture theater had to be considered.

Important factors in theater design are clear and unobstructed

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sight lines to the screen, the vertical position of the screen being one of the controlling factors. In the past, the screen position was influenced by the stage level, and the physical conditions of the theater, such as the projection of the balcony over the orchestra floor, the height of the proscenium, and the projection angles. In other words, the location of the screen was a compromise to give the occupants of the orchestra floor and balcony the best possible vision under the existing conditions. Naturally, since the design was basically for a stage view someone had to suffer as vision to the top of the screen was obstructed for those seated under the balconies because of the balcony overhang. This screen location on the stage somehow became a fixed rule and notwithstanding the fact that the function was different many motion picture theaters came to be built still holding on to the traditional stage of the "legitimate" along with the rule of thumb that the screen should be located 12 to 24 inches above the stage.

It was in the early thirties that Ben Schlanger presented, at one of your conventions, his studies of floor-slope factors for sight lines for motion picture theaters as distinguished from theaters designed exclusively, or at least primarily, for stage performances, and the reverse slope then came into being. Like all new theories, at first it was belittled. However, this new method, like all new ideas, went through a series of improvements and steadily has been gaining recognition. This recognition is evident by the fact that our factory reports the need for manufacturing chair standards in a greater quantity for reverse incline than ever before, and this type of chair is now considered standard equipment.

Most of you will say you know all this but how does one go about designing a theater floor to obtain clear, unobstructed sight lines? First, there is no set rule that will give a standard floor slope for all theaters. Each theater must be studied and designed to meet the varying conditions of the site, capacity, and number of seating tiers desired, and the building code.

The ideal sight line is one that will give unobstructed vision to the screen over the heads of occupants of the row directly ahead. This has been termed "first-row vision." This would result in a floor slope that would exceed maximum floor pitches as defined by most building codes and would present practical difficulties in construction. Therefore, it becomes necessary to take advantage of being able to see the width of the screen between the heads of the occupants of the row directly ahead, with clear vision assured over the heads of all other rows,

and requires the viewer to shift himself in the chair to one side or the other. This has been designated as "one-row obstruction," the row directly ahead being the obstructing row. To overcome this objection, methods for staggering the chairs have been developed. The staggering of chairs requires careful study. Each chair must be taken into consideration as the visual angle changes with each chair position. When the chairs are properly staggered the result is the same as "one-row vision" and is the nearest approach to the ideal condition. In the side or wall banks of chairs the stagger is automatic for over 50 per cent of the chairs, while in the center bank very few seat positions are automatically staggered.

The following methods for staggering the chairs are now in use:

1. All chairs of the same size, with a half-chair stagger every other row; for example all odd rows having 14 chairs per row, all even rows 13 chairs. This would mean the loss of one chair every other row, and would result in a half-chair aisle indent at each side. This method is only partially corrective. It is completely corrective when not more than 10 chairs per row are used.

2. Varying chair widths for all rows with a varying aisle indent and sometimes no indent at all. This method is more corrective but requires special chair widths.

3. By using three chair sizes in each row and alternating the order of the chair sizes every other row, for example, five 19-inch, four 20-inch, five 21-inch in all even rows; with five 21-inch, four 20-inch, five 19-inch in all odd rows. There would be no aisle indent as all aisle standards would be in alignment, nor would there be any loss of chairs. This also is only partially corrective.

4. Varying chair widths for all rows and varying aisle indent similar to the second method described, except that the chair row or section would be broken up into two or more sections by the use of a double middle standard. In this way the varying chair width would be kept within the standard chair size eliminating the need of special sizes as would be required by the second scheme. This method is more corrective.

There have been a considerable number of staggered seat installations in recent years. As a matter of fact, at this time there are more installations coming in with staggered seating than previously. This is true especially in the case of reseating where it has been found that the introduction of staggered seating improves the sight lines while maintaining the existing floor slope. It may be well to note



that not all building departments have approved the staggered plan which results in an indented or jagged aisle. However, ways and means are being considered to overcome this objection.

The staggered-seating arrangement does not look so well on paper, nor when the empty theater is viewed from the stage. However, from the important point of view of the entrance end of the auditorium, appearance does not suffer. The irregular pattern formed by the line of the chair backs gives the impression that the chairs were just thrown in, in comparison to the nonstaggered plan where all the chairs are in alignment. Since the main consideration, however, is to have the best possible sight lines for the greatest percentage of seats any objection as to appearance should be secondary.

If the chairs do not fit the floor properly all careful calculations will have been of no avail. Since the chair standards for a downward and upward pitch are manufactured in increments of  $\frac{1}{4}$  of an inch up to 2 inches per foot for the downward pitch, with a recommended maximum of  $1\frac{1}{2}$  inches per foot and a recommended maximum of  $\frac{3}{4}$  inch per foot for the upward slope, the best result can be achieved when the floor slope is designed to these inclines. This will result in a slightly greater total pitch in the floor than required but it will be on the safer side both in chair comfort and in viewing comfort.

There are times when the design conditions call for an all-downward slope, while in other instances a floor slope, having an upward as well as downward slope, is desirable. In such a case, a careful study of the position of the screen must be made so that the downward viewing angles from the balcony, and the upward viewing angles from the main floor seats are balanced out to create the most comfortable angles of the greatest number of seats. In a 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 degrees formed by a horizontal line from the viewer's eye to the center of the screen.

The floor slope should be designed to place all of the rows as closely to this ideal angle as possible, taking into consideration, however, the contour of the site and other factors. The possibility of having seating depths as much as 44 rows, because of the ability to see the enlarged screen from such a distance, has created the need for a departure from the conventional downward slope. The all-downward slope, in such instances, would become excessive and would present difficulties in meeting grade conditions. Then again, the pitches of

balcony floors become needlessly excessive when a completely downward floor slope is used. The ability to make floors generally flatter to meet these conditions has been made possible by the positive, careful seat staggering now developed and tested, and the flexibility in floor-slope treatment which takes advantage of the fact that the screen is a movable element in the vertical plane, the latter factor being the key point in differentiating between the necessarily fixed position of the stage in a legitimate theater and the optional position of the screen in a motion picture theater.

It is no longer necessary to impress the theater public with overelaborate decoration or gilded gingerbread, but by keeping the design simple and by spending the time and money on the essential features of planning for the best sight lines and chair comfort, the departure from the old orthodox way will lead to better motion picture theaters and greater enjoyment from this type of entertainment.

#### DISCUSSION

CHAIRMAN JOHN EBERSON: Our speaker has talked about the most important things in theaters, spacing and staggered seating. He has covered a very important item in modern theater construction—out with gingerbread, in with the idea which makes a moving picture theater a place to relax and see a picture with the utmost comfort—staggered seating will do it.

MR. LEONARD SATZ: Would you mind repeating, Mr. Alexa, the second plan which you mentioned for staggered seating?

MR. FELIX ALEXA: The second plan is to vary chair widths for all rows with a varying aisle indent and sometimes no indent at all. This method is more corrective, but it does require special chair widths. In this case you would have to use chair widths that would range anywhere from 19 to 26 inches in width.

MR. SATZ: Do you not agree that the extra width as you mentioned, 26 inches, would allow the occupant to slide back and forth, and would not be in keeping with proper seating?

MR. ALEXA: It has been found that this is not the perfect solution. There is a tendency for the occupants to move from side to side in their chairs. Furthermore, it is costly to use special size chairs since most manufacturers have standard size equipment. They set up their equipment to certain widths and when you go beyond those standard widths, the maximum of which is 22 inches, it requires special handling. In most cases those chairs would have to be made by hand and would be very expensive.

MR. SATZ: In the average installation which of the three methods, in your experience, have you found will give the least number of dead seats or obstructed seats?

MR. ALEXA: The fourth method would give the least number of obstructed seats. There would be some bad seats in front, but you could still work out the scheme with standard size chairs.

MR. SATZ: Would you suggest that the indented row be illuminated for perfect aisle illumination?

MR. ALEXA: In the case of an indented aisle, I would recommend that the aisle be illuminated as much as possible. It might be a good idea for every standard to have a light on it so that people coming down the aisle could see these indented rows. The building departments in some cases claim that indented aisles form a hazard and that people walk into the projecting rows. If the aisle standards are equipped with aisle lights they no longer would be a hazard as the people coming down the aisles would be guided by the line of the lights.

MR. SATZ: Do you think that illuminating the indented rows would outline the aisle seats sufficiently to prevent that? It is much more expensive to wire up every row than it is every other row.

MR. ALEXA: That could be the solution. There would at least be enough light to indicate the back of the chair in front of the indented row and, I think, that is what is desired.

MR. BEN SCHLANGER: With the occasional double-arm-block system, the indent is minimized to such a point that it may amount only to about an inch or two in about 80 or 90 per cent of the cases. In some cases it will be about three or four inches. You are practically doing away with the indent if you take advantage of a double-arm block here and there. You are able to have center-to-center seating per person of almost any width you want, to make up the difference, so that the indent at the end can be eliminated.

However, it is desirable to light up the aisle as much as possible. In that case every other row would be sufficient; that is, every other row you diagonally skip across from one side of the aisle to the other. So, actually, you have light every row with an every-other-row lighting.

MR. A. L. TREBOW: Do I understand that you advocate not having the double-arm block on every seat on the main floor in order to take advantage of the staggered seating?

MR. SCHLANGER: It is not exactly advocating it. It is an expedient, the idea being comparatively new. The idea really is not new, that is, we are in the process of perfecting an idea which we see is good. Therefore, the manufacturers have not quite caught up with what they could do for us, although I know they are really working on the problem. As an expedient method, you could use a double-arm block only where needed. Eventually, I believe, instead of a double-arm block they may develop a single-arm block that is wide enough to take up the difference.

MR. TREBOW: What about the primary principle of having 80 per cent of the seating on stepping? I refer entirely to the fact that there are seats on level platforms, and 80 per cent of the seats shall be on level platforms two or three inches above the row preceding it, and the aisles then take the slope. Why would not that take care of a good deal of your sight-line problem?

MR. SCHLANGER: I think it was partly answered, but maybe not amplified enough in the paper that Mr. Alexa gave. We have found, I think, that there are a couple of hundred theaters erected, in which we have eliminated the need for such an excessive slope. Such a slope would cause the necessity for elevated platforms—level platforms—one above the other.

A floor slope is a necessary evil. Theoretically, an absolutely flat floor is better

than a sloped floor if it would give you clear vision. There was a theater built in Paris in the early '30's on an absolutely flat floor. It is usable because the bottom of the picture happens to be about nine feet above the floor, and the seats are very carefully staggered. That is not a complete solution, but it is at least an indication that flat floors are very possible. When I say flat floor, I don't mean a true flat floor, but something that is almost a flat floor.

Let us consider that theater in Paris and improve upon it. First, the screen is too high for the front rows. We shall cure that. The sight lines from the rear part of that theater may be not quite enough, because the floor is flat all the way back. We shall raise that floor up a little bit in the back, until we cure that. In the middle of that theater you will find that the sight lines are good. The objection in the front is that the people are sitting too far below the screen. If you had a curve there that was coming down from the back, going flat, and then coming up a little bit in the front, it would cure all faults.

MR. TREBOW: That is the theory of the upper reverse curve; the reverse curve as you call it.

MR. SCHLANGER: It was originally called a reverse curve, but it does not look like it. If you have seen some of these theaters, they look like flat floors. The layman walking in does not feel any particular slope because it is so flat.

MR. TREBOW: Does that not require staggering just the same?

MR. SCHLANGER: It certainly does. Staggering is an essential part of the design.

MR. TREBOW: What if you have a city code that requires even aisles?

MR. SCHLANGER: That is the thing that Mr. Alexa was discussing—how you can get an even aisle with staggered seats with the occasional double-arm-block system.

MR. TREBOW: Am I to understand you that it must resolve itself in an occasional double-arm-block system?

MR. SCHLANGER: That is the best system I have found so far for evening out the aisle line.

## Theater Engineering Conference

### *Auditorium Design*

# Increasing the Effectiveness of Motion Picture Presentation\*

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*Summary*—Ideas are proposed for refinements in the presentation of motion pictures. It is pointed out here that dramatic values can be heightened and visual comfort increased by different uses of a larger screen.

GOOD SOUND and color are already a definite part of the motion picture. The motion picture devotee now receives these marvels of science with an almost cold casualness. Motion picture engineers have developed a reputation that becomes a task to uphold. If you create the unusual, it is expected of you. The industry turns its head to science to help even out the business curve at the box office. In taking stock of the storehouse of ideas yet to be exploited, one must be impressed with the possibilities of the following thoughts.

The motion picture theater auditorium and the screen can be given fresh thought if it is realized that the motion picture can be delivered with greater dramatic impact to group audiences than is now experienced with present methods. This fresh thought can start with the basic idea that there could be a closer relationship between the film production problem and the problem of exhibiting the film. The cinematographer and film director can be aware of the fact that his work will be more effective if he considers the exhibition problem.

It should no longer be considered that the potential effectiveness of a film is limited to all the endeavors that go into it until the time that it is put into the can and marked for delivery to a theater. This attitude may be suitable in considering the phonographic record to be played in a juke box, but million-dollar picture productions deserve a more studied presentation, environment, and cinematography keyed to group-audience reception.

\* Presented October 20, 1947, at the SMPE Convention in New York.

A possible approach to this problem is based on a number of studies beginning with a paper by the author,<sup>1</sup> dealing with cinematographic technique followed by two other papers dealing with auditorium lighting<sup>2</sup> and screen-border synchronous lighting.<sup>3</sup> Reference is also made to a paper by Luckiesh and Moss<sup>4</sup> dealing with screen light and the lighting of its environs. All of these papers show that:

1. Cinematography has to be reappraised in the light of its relationship to auditorium viewing conditions.

2. There is a lack of transition between the projected picture and its environs, both from psychological and eye-comfort aspects.

3. The auditorium appearance is not one that enhances the projected image, and that it is a distracting element whereas it should function only as a neutral shelter. Cutter<sup>5</sup> also refers to this problem.

The thoughts presented here are intended to show that these are phases of one problem, that is to heighten the dramatic values and provide the maximum in visual comfort as a necessary part of this endeavor. The ideas proposed are for refinements in a known art, and since they are not revolutionary, no important changes in the highly developed mechanisms of taking and projecting pictures need be advocated. Most important is the point that the 35-mm film is adequate for the improvements proposed and that projection lighting systems now developed are also adequate. Experience has now shown that pictures up to 30 feet in width can be projected successfully, giving a satisfactory image. The recent increase in the number of drive-in theaters has furthered the development of projecting pictures even larger than this. The ideas here presented call for an increase in picture size of between 20 and 25 per cent. This amount of increase over present indoor picture sizes therefore comes well within the realm of practicability. If one thinks carefully about looking at the motion picture now, and especially from the rear half of the auditorium where some of the most important seating positions are, it will be realized that the picture looks like that smaller television screen at home even though physically the picture in the theater is so much larger than the television screen. The average architectural effect in the present theater auditorium and the size of the picture creates the appearance of that television screen in the home. Not only does the present screen have this disadvantage but it also, to a great degree, limits the cinematographer inasmuch as his central figure has to remain more or less in a fixed position even when it is supposed

to be in motion. To create motion he has to resort to having the background move while the foreground point remains more or less fixed. Although he has been fairly successful in creating this illusion of movement, it is too constricting as will be shown later.

A larger screen and a different use of a larger screen are here proposed. Many attempts to use a larger picture have failed in the past. It seems as though they have for several practical reasons. It will be remembered that one of the most effective results of the extra-large picture was when it was used only as a tonic to emphasize a panorama, the chorus line in a musical, or a special impact that was put across by the sheer scale of the image. This might indicate that the large screen, as it was used, was not necessary throughout an entire film presentation. The changing picture size in the old "magnascope" screen was managed by the use of irislike black masking and by changing lenses. This arrangement called for extra costly equipment and

still had the distinct disadvantage of a dark picture surround. Continuous use of the entire enlarged image as with the "Grandeur Screen" throughout a film led to having too much happening on the screen, resulting in a lack of dramatic concentration.

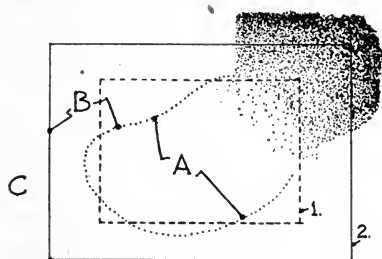


Fig. 1

The above shows the faults of both the enlarged and the present picture size. The purpose here calls for a large screen which is always revealed to the audience during performance time, but the screen would be used in an entirely new way. There will be no necessity for mechanical moving maskings as with the old magnascope idea.

Fig. 1 is a view looking at the proposed screen. The area enclosed by line 1 represents the average present screen size, while line 2 shows the proposed enlarged screen area. The bean-shaped form enclosed by the dotted line indicating area A will be referred to as the distinct visual field, while the area remaining between line-2 boundary and the bean shape will be referred to as the peripheral vignette. Area C outside of boundary line 2 is the surface outside of the screen area. The bean-shaped area A is intended as a momentary shape only; this shape may change in form and size in accordance with dramatic requirements. Assume first that instead

of projecting a picture of approximately 18 feet wide from 35-mm film, that a picture approximately 5 feet wider and of a height that would be consistent with present standard proportions is projected. Right here there seems to be a handicap presented by the difficulty of enlarging the screen area because of proscenium-size limitations and balcony overhang cutoffs in existing theaters. The answer to this is that wherever these difficulties can be overcome economically with a change in structure, the effect proposed would be most desirable, but where such conditions cannot be avoided economically, the effect still will be better than the present one because any portion of the enlarged screen that would be cut off from view because of an overhanging balcony would not create any serious loss of picture area. Loss of view of some portion of the peripheral vignette would not prove serious.

Now what happens in Hollywood? Generally the picture would be taken on film as it is now. But, the director and cinematographer become aware of a new freedom in picture composition and in creating dramatic impact. His focal point of action can be concentrated at center, left, right, any of the corners, or any part of the screen. The physical area of clearly defined picture area which would be the "pear shape" shown or any other desirable shape, will always be large enough to tell its story but need not and should not necessarily fill the entire screen area. When the director chooses to use the entire screen he will be doing so for special emphasis only. What happens with the rest of the screen area that is not being used for clearly defined images is very important and it is here that the peripheral-vignette idea comes into play.

For still photography the use of the vignette may be optional and be an artistic consideration only. For the motion picture, where it may be better to present more realism, the vignette may well be a suitable representation of the peripheral portion of our field of vision. In real life there is no opaque masking frame in front of us all the time. The vignette is more like what one experiences visually.

In still photography the vignette commonly fades to pure white at the extreme edges of a picture. This type of vignette would prove disturbing for the motion picture because of the competition created by stronger light at the edge of the picture in comparison to the light of the important part of the picture. The vignette recommended here is one that diminishes the light value toward the edges of the picture. Light and color values seem to dim out in the visual



peripheral. Colors do not change in hue, rather they seem to become grayer. The reduced light value proposed for the peripheral vignette is also the means of creating a transitional light intensity between the bright picture and the picture environment. This development at last gives something that will make it possible to eliminate the false black masking used around the motion picture.

Fig. 2 gives a rough idea of motion pictures as they are presented now. There one sees the highly illuminated screen with a contiguous black mask. Beyond this mask are the familiar drapes and then the decorations usually found beyond this point and farther wall and ceiling decorations. In addition to the fault of the sharply contrasted masking there is the basic fault of the ability of the spectator to be particularly conscious of the physical interior and of the depth from the picture to his seating position because of the measuring yardstick that the wall and ceiling decorations become. It is these faults that make the picture appear too small from the rear half of the auditorium even though the visual acuity, or ability to discern, may be satisfactory. It is these faults that do not permit the spectator to have the feeling of being close to or even being part of the action which is involved.

Fig. 3 is a rough sketch showing the enlarged canvas. It may be better to call it canvas rather than screen because the cinematographer is going to paint his action on that canvas with the freedom that an artist wants to express in creating a painting. Research for this approach to motion picture presentation can be found in the physiological studies by Helmholtz and in much of the research work done by some of the famous painters of the Impressionistic School. The dotted lines at the picture indicate the present screen size and the approximate proposed enlarged size. The shaded tones around the picture represent a neutral ceiling and wall-surface treatment completely void of decorations. These surfaces have a designed texture which reflects just enough of the screen light so as to keep the surface near the picture of such a light intensity as will enable them to blend with the picture. As these surfaces continue to go away from the picture, the texture of the wall is such as to diminish further the amount of light reflection from the picture, to come as near as possible to what we have in real life, that is, black, which is behind our heads. This type of wall surface has been successfully carried out in a great many theaters, and is therefore ready for the needed touch in improved screen presentation.

Fig. 2—Conventional projection in a conventional auditorium. Blackness surrounds the picture and light reflections from the screen outlines the many architectural forms of the auditorium.

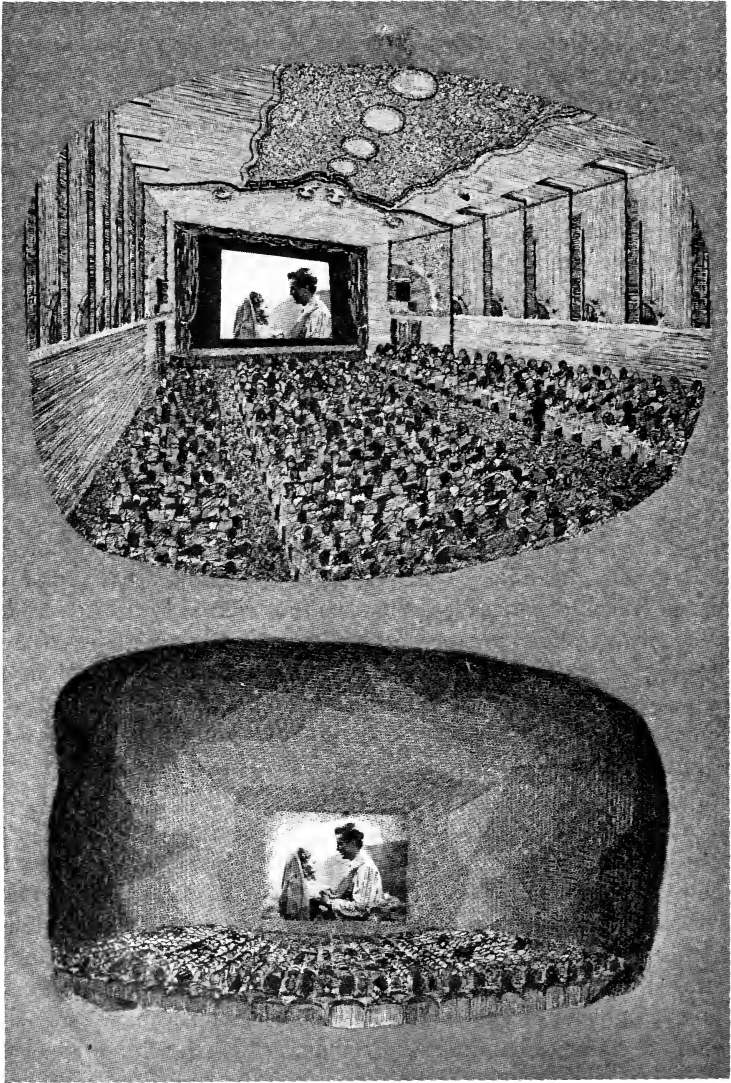


Fig. 3—Edges of picture are vignettes. Black masking is omitted. Wall and ceiling surfaces are stripped of all distracting architectural forms.

For immediate application of the idea proposed herein a very simple method can be used in producing a suitable film for trial purposes. The cinematographer and director of the trial film will anticipate the enlarged canvas and will introduce amounts of peripheral vignette and shapes of vignette that will heighten the dramatic effect to the greatest degree. An artist will paint on a white sheet within a rectangle of the standard screen proportions, a black-and-white tone blended from darkest at the edge to lightest toward center, leaving complete white in the main action area. Such tone frames would be made for the various picture compositions. The film would then be exposed to these blended tones and then be re-exposed in the regular manner for the actual picture taking. For interior shots this can be accomplished directly with lighting, thereby avoiding the special exposures for a vignette masking. The film would then be projected on the enlarged screen in the recommended neutral type of auditorium. It would be worth noting here the brilliant effects which would be achieved in colored film when the colorings toward the edges of the picture would come closer to what happens with color in the visual peripheral areas. It may then be possible to avoid that appearance of a small colored picture postal card sharply contrasted with the background. It may even be possible to forget that it is a picture one is looking at and thus help to attain the desired illusion.

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## Theater Engineering Conference

### Auditorium Design

# Dynamic Luminous Color For Film Presentation\*

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*Summary*—This paper presents for consideration a departure from the usual procedure of planning a motion picture theater, and to consider the possibility of designing the appearance of the whole auditorium on the same basis as the cinema screen itself is designed, to act as a reflector of light.

MANY OF US can recall the days when the cinema screen comprised a white surface mounted on a wall with surrounding areas painted or otherwise blacked out. There were no curtains or color lighting, and projection and screen efficiencies were poor. With the development of color-change lighting a new art of presentation began to evolve, and it is with continued development along these lines and its effect upon auditorium design that this paper is concerned.

It may be helpful if certain technical aspects of multicolor lighting are first briefly considered. Multicolor lighting equipment will give the widest range of results when it includes three circuits corresponding to monochromatic red, green, and blue lights. Starting with the correct hues as primary colors we can employ them in such a way that we can match almost any color known. To enable monochromatic red, green, and blue lights to match almost any color hue it is necessary to understand the factors of *hue*, *brilliance*, and *chroma*, the composition of tints and shades, and other factors including simultaneous contrast and after images. A brief summary of the former is as follows:

*Hue* is the attribute which leads us to describe colors as red, yellow, green, blue, and so forth.

*Brilliance* is the quality which distinguishes a lighter from a darker color by comparison with a surface of known brightness.

*Chroma*. With the additive system this concerns the amount of white light in a color, a fully saturated color having no content of white light.

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By specifying these factors it is possible to define any color, tint, or shade. Three-color lighting, as just stated, when blended in different proportions, will provide every desired hue and tint, including *white*, and the value of chroma can be varied because any pure hue can be desaturated by suitable proportions of all three primary colors. However, in practice it is often better to have a fourth circuit of white light, as this enables a number of mixtures to be obtained at a much stronger intensity.



Fig. 1—Type AB Rollocolor lighting controller being operated by the inventor.

To enable the primary colors (and white) to be blended together in different proportions it is necessary for each of them to be regulated by a brightness control; and this means four dimmers for each set of four-color lighting. Some manual dexterity as well as mental agility is required to merge directly from one color mixture to another, because having mentally calculated the factors of hue, brilliance, and chroma, one has then to manipulate up to four dimmers simultaneously in different directions for every set of lighting equipment with only two hands in order to produce the change. My progress in

color-lighting work was hindered for many years until I had overcome this difficulty by a patented form of lighting-control unit, which enabled a person unskilled in color to select and produce a desired hue simply by moving a pointer on a dial. This equipment was of the remote-control type and gave the choice of seventeen carefully selected color hues (later increased to twenty-three hues). For many years I used this control system extensively and it was supplied to many parts of the world.

After a time a controller was required which would give a greater range of color hues, provide the lighting changes at any desired speed, and be self-contained so as to be available in portable units. After

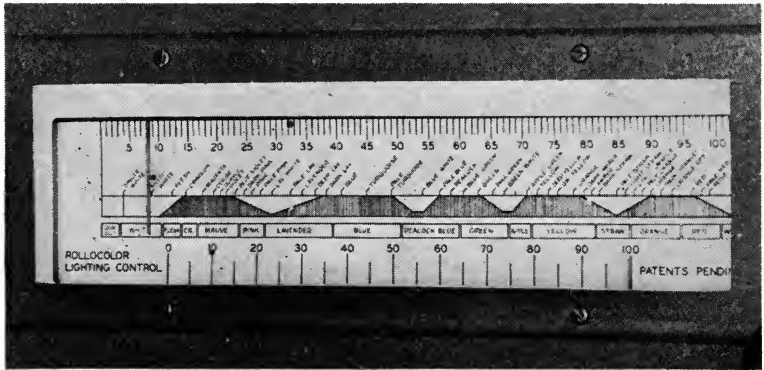


Fig. 2—Color scale of Type AB Rollocolor lighting controller.

further research a new machine was patented and was an immediate success when introduced on the British market. Some papers went so far as to say that a revolution had occurred in stagecraft. The unit controller provides a much larger range of colors, namely, 50 colors on the dial. The equipment is portable. When vaudeville acts or shows go on tour, the units can be taken around with them.

After considerable study of lighting conditions in America, the author is now concerned in the manufacture here of a new color-mixing controller which is based upon new principles, and is the subject of new patent applications.

The new controller will provide a *limitless* range of color hues. The main colors are graded in chromatic order and shown on a control scale so that colors corresponding to known tints (such as found in the theater gelatine range) can be identified immediately and

selected. Lesser known colors can be identified by their position between known colors. Any color hue can be selected just by moving a pointer and the change can be made at any desired speed. In addition the over-all brightness of any desired color hue or mixture can be obtained at any desired strength, without upsetting the proportionate values of the primary colors making up the hue. The brightness can be selected at the same time as the color hue, or it can be varied afterwards. A single dial can control loads of any magnitude and the apparatus can be arranged for hand or automatic operation. This controller is shown in Fig. 1 and Fig. 2 is an enlarged view of the color scale.

With additive-lighting problems reduced to the selection of any known color hue at any desired brightness from apparatus no more difficult to operate than a radio set, the mechanics of color mixing are behind us, and we are free to operate with *luminous* color. Since luminous-color hues can merge into each other, we are at once faced with the fascinating possibilities of *order* and *succession*. Entrancing as the static-color compositions obtained with paints and dyes can be compared to dynamic luminous color they are as photographic stills compared to colored motion pictures. Even this analogy is not correct, because luminous-color hues are usually much more beautiful than paints or pigments and the range of luminous color contains many hues quite unknown to most of us.

The subject of color harmony, contrast, and discord is one which few people fully understand, and when this concerns colored light we are almost on virgin ground. In the author's textbook *The Technique of Stage Lighting* he has endeavored to give some guidance on this subject and has suggested some lines to follow in building up color-lighting compositions.

The effect of dynamic luminous color on motion picture theater showmanship and technique will be very far-reaching, because more than anything else the show is constituted of *light*, stimulating imagination and making people "light-conscious." Colored films are also educating people to a sense of color appreciation.

During the period occupied by these lighting developments, great advances have been made with projector and screen efficiency, sound has replaced silent pictures, and color has come to the screen. Two things have remained unchanged, however: (a) the projection of the picture onto a white screen in the middle of a black surround and (b) the practice of providing an absolute minimum of auditorium lighting

during the showing of the pictures. Now these practices came into being in the early days of motion pictures when projection and screen efficiency were poor, and it may be that they are out of keeping with modern technique and methods.

It is suggested that a screen picture seen against a background of luminous color of the right intensity, instead of a black surround, will occasion less eyestrain especially with colored pictures and will have sharper definition. Furthermore the area of interest is enlarged and if the luminous color is dynamic, i. e., can be changed in hue, then we have the means of supporting the film story with an appeal to the eye as powerful as is the appeal of background music to the ear. Before going any further it is pertinent to quote from a report which followed a two-year investigation by a panel of ten experts appointed in 1936 by the technical committee of the Illuminating Engineering Society of Great Britain<sup>1</sup> to find among other things "whether improvement in the present lighting of auditoriums could be made without detriment to the screen picture. . . ." In the course of their investigations the panel carefully considered the effect of an increase of auditorium light on the visibility of the pictures presented on the screen and carried out some very interesting experiments on the brightness and contrast ranges of screen pictures. Their report<sup>1</sup> was published just before the war and made recommendations for a much higher standard of maintained illumination than is now common in Great Britain; it being shown that this would not affect the quality of the projected picture. On page 26 the report states "as is now well known the acuity and contrast sensitivity of the eye are both improved by suitably illuminating the surrounds of the central field of vision. With completely dark or very poorly illuminated surrounds the contrast sensitivity is probably not good enough for the eye to appreciate the smallest contrast present in the projected picture."

Experiments conducted by them showed, for example, that an illuminated border pale yellow in color appeared to enhance the contrasts in a black-and-white picture, an effect they attributed to the phenomena of spatial induction. They finally reached the conclusion that visibility of the picture was improved, and greater visual comfort enjoyed, by illuminating the picture surround to a low intensity. The author's experience all tends to show that dynamic luminous color is the visual equivalent of background music, and properly applied and used has tremendous possibilities for increasing the appeal of motion pictures.



It is now recommended that the screen be provided with a very narrow black edge a few inches in width and be placed *in front of* a color-illuminated area. This area must be completely smooth and so lighted that the greatest brightness comes from behind the edges of the screen, and then commences to decrease in intensity as it proceeds away from the screen. It is important that the screen be silhouetted against this color-illuminated area and that the brightness ratios over this area are correct, in which case the importance of the screen will be emphasized and it will receive dramatic support from the illuminated background.

Properly carried out, the screen and illuminated background will become one unit with this advantage, namely, the area on which the show now takes place (i. e., both screen and surround) can be double, or more than double, the size of the screen seen in a black surround. The cost of providing the "show" on this additional area is of course only a fraction of the cost of that on the screen.

A particular color hue of the illuminated background can remain on for periods long enough for it to become accepted as part of the natural scheme of things. Then when it is changed at some dramatic moment in the story the new color will have a more powerful effect.

Just before the outbreak of war an installation on these lines was made in Edinburgh, Scotland. Some months after the opening of the theater a letter was received from the owner in which he states that "the color effect round the screen has absolutely 'made' our new cinema." He goes on to say that "This week we were showing a re-issue of *Whoopee* in technicolor, and the effect was wonderful . . . the lighted screen changing to blend or contrast with the various color sequences . . . just puts this Eddie Cantor film up 50 per cent in entertainment value."

It seems probable that the general public will become educated to a greater sense of color appreciation through this method of associating color with specific moods and values and this in turn will enable them to obtain more enjoyment out of colored motion pictures.

In the Edinburgh installation the background lighting was controlled from color-mixing apparatus of the first type described in this paper, but in this case the control was finally vested in a row of small tab keys mounted on each projector in the bioscope room. The keys were marked not only with the color hue they would each produce if pressed, but also with the name of a specific mood, as for example: danger—red light; warmth and contentment—orange; kindness—

pale green; sinister—peacock blue; delicate emotion—violet. By reducing the mechanics of color mixing to this simple system we were able to obtain excellent results from the usual staff.

Prior to the war I was developing a system of decorative reflective effects from concealed color lighting, which introduced new conventions of decorative treatment, expressive of the conception of dynamic luminous color.

In a large concert hall in Britain, the proscenium opening is 60 feet wide. The large center feature is lighted very evenly, although there is not a lamp in this ceiling. The lighted-ceiling effect is reflected light. The lighting is projected from the cornices at the sides of the room, and the contours of the enrichments are calculated so that they gleam by reflected light. If we throw, say, a red light from one side and a green light from the other side, we cause compound-color reflections and we have a less expensive installation. There is no wiring to install, and we do not have any electrical maintenance troubles for this ceiling.

In Fig. 3, the vertical columns which form the sides of the stage opening were designed with special horizontal flutes in the plaster, so that they gleam when lighted. The designs on the face of the architrave were also contoured so they light up by reflection. The exits are between these columns, and they are kept lighted during the show. The horizontal lines on the side walls also light up by reflection. The black-and-white shading seen in the picture represents different colors.

At the Carlton theater in Dublin the large plaster domes in the ceiling light up only by reflection; there are no lamps in them. The complex features on the walls, on each side of the proscenium opening, are also contoured and silvered, and each detail lights up with compound-color reflections, when different colored light is thrown into them from different directions, so you have decorations painted in light.

There is a motion picture theater in a small mining village in South Wales, just a few miles from Swansea where the traditional picture-frame proscenium is gone, and the new surround is lighted by reflection. There are no lamps in it. The lighting equipment is concealed mainly in the stage and partly in the balcony and on the back wall of the auditorium.

In one of J. Arthur Rank's theaters, the stage sweeps across, but instead of the side of the stage going straight down, it curves around,

coming down behind dummy side walls, so as to make the whole proscenium opening wider. This decorative area is made of plaster. The circular cups are very carefully contoured and silvered, and each one gives you a mosaic of reflective points. When the color lighting was left on during the showing of pictures, the effect was tremendous, so much so that I believe Mr. Rank's engineers are considering something on these lines for the whole theater circuit.

The same idea was developed a little bit further in one of the largest motion picture theaters in Britain. The proscenium top sweeps



Fig. 3—Auditorium of motion picture theater in North Wales designed for "decoration with light." Architect, S. Colwyn ssoulkes.

around and comes down behind the dummy side walls. We put all the stage controls behind one of these walls, including the switch-board, so that the stage staff can look into the show and can watch it in just the same way as the public, which eliminates mistakes and enables much more ingenious lighting effects to be carried out.

In halls of this nature it is possible to provide, by a secondary and low-intensity system of multicolor floodlighting, a soft, dim, general illumination of the walls and ceiling of the auditorium itself, during the showing of the pictures. This lighting can change in color and give dramatic support to the story without glare spots or anything else to cause distraction. It may be thought that lighting up the

auditorium is a sufficient distraction in itself, but this is not the case, because decorative features and the degree of brightness and color of the lighting are all designed to lead the attention to the screen. In this way the dramatic value of the auditorium changes in harmony with the screen background, and the audience has the feeling of participating in the show instead of watching it from outside.

Apart from the dramatic values, people entering the theater from the daylight will be able to see their way easily and safely to their seats without the use of hand torches, and better lighting will be available in the case of emergency. This can be done without detriment to the quality of the picture, as has been shown by the British report already mentioned.

With color-change-maintained lighting it is necessary to provide foolproof means to ensure that *all* circuits cannot be dimmed out at the same time. Also it is desirable that both background and hall lighting be operated from the same control.

It will be evident that if there have been problems to overcome in order to produce desired single-color hues, there are additional problems when relating a number of different hues in a composite-color arrangement. These problems are in fact very great, but I believe that the new controller now being produced will give the complete answer to these difficulties.

The controller (Fig. 1) will not only give complete freedom of choice concerning individual color hues, but can enable hues from one set of lighting equipment to be grouped with different hues from other lighting equipment in composite arrangements. These composite arrangements can be set up or changed as desired, and can be operated from a single control dial. Thus selection of the dominant color will also cause all the supporting colors in a color composition to come on at the same time.

The results are always the same each time the controller is operated, so in the case of circuit theaters it will be possible at headquarters to work out a lighting plot for a particular picture and then to send out a simple cue sheet to the various theaters. All that the local staff has to do after making certain adjustments at the beginning of the run of a picture, is to move a pointer on a scale at each cue, and the controller will do the rest.

There is no limit to the number of cues that may be given and no restriction as to color hues, in fact the range of available colors is much wider than the entire range of theater gelatines.

It is not believed that we have by any means reached the ultimate in fundamental auditorium design, and the theaters which have been illustrated are only intended to indicate certain trends of design. The author thinks that the future fundamental design for a motion picture auditorium should be one in which all conventional methods of decoration are omitted, and the hall is created for "decoration with light." There should be no proscenium frame, but the screen should stand on its own with a very narrow margin of black edging, and be boldly silhouetted against a plain white background which curves round and merges into the walls and ceiling of the hall without a break. The areas in front of, around, and behind the screen would thus be unified into one set of surfaces, and the whole of them would be revealed by dynamic luminous color. The lighting would be brightest on the area behind the screen, so as to create a kind of aura behind its edges, and as the illumination spreads out toward the seating it would diminish and merge into other areas of differently colored light.

During intervals the lighting and color values would include the screen just as another white surface in the composite design. During the showing of pictures, however, the whole of the lighting conditions would be subordinated to the screen picture and would be arranged to provide the best conditions for visual comfort and picture definition as well as to provide dramatic visual values for the greater enjoyment of the story.

With this conception the motion picture theater would be completely and logically expressive of what the screen picture really is, an appeal to the eye in terms of contrasts of light, shade, and color.

#### REFERENCE

(1) H. C. Weston and E. Stroud, "The lighting of cinema auditoriums for visibility and safety," *Trans. Illum. Eng. Soc.* (London), 1939; presented January 10, 1939, Illuminating Engineering Society of Great Britain.

#### DISCUSSION

CHAIRMAN JOHN EBERSON: What does the audience believe about a very interesting innovation of the treatment of color and control which you are looking for in respect to screens, stage, auditorium, side walls, and ceilings?

MR. LESTER B. ISAAC: For years we have been trying to eliminate extraneous light in motion picture auditoriums. I am surprised that someone would try to induce or introduce extraneous light. It is true, we of the motion picture business are selling light, but only that light which represents the projected image on the screen. Any other light that serves to interfere with that projected light, which

is our screen image, certainly will cause the audience much discomfort. The eyes only accept so much light at one time, and a reasonable color or hue. To add any additional colors in addition to what is on the screen, will cause the iris of the eye to do gymnastics.

We admit that our auditoriums are not perfect, but we are trying to correct that. We are endeavoring to eliminate the use of all types of lamps from wall brackets, particularly those in the red family, or in the red spectrum, so that they do not injure the eye or interfere with the projected image.

The use of color borders is nothing new in this country. It was tried many years ago, as far back as 1919, when we used red, blue, and green borders. Before that, D. W. Griffith, the great picture director and producer, also thought he was an expert in lighting. In an attempt to add atmosphere to several of his pictures, and one I remember in particular was "Broken Blossoms," he introduced the use of the so-called X-ray lamp, which was on the side, top, and bottom of the screen. Through various scenes it would project either red, or a magenta, or a blue, or a green.

These additional colors certainly only added to the distraction and the discomfort of the audience. I should dislike to see what would happen to a technicolor picture with this color projected; the audience trying to concentrate on a moving object on the screen, and this changing light source at the same time.

I feel that the black stands out naturally. It has proved the best method that we have today of cutting off the extraneous light that may hit the screen. It also helps us to frame out distortion, which is caused by the booth's being constructed in the highest and most rear part of the theater. This is not the present-day method, but, unfortunately, in the great majority of theaters in the United States today the booth has that vertical pitch. That is why the black border is very convenient today, and I think it will continue to be so until some other method has proved much better.

I, personally, am opposed to any color light whatsoever that may interfere with the projected image on the screen, black or white, or any color.

Mr. R. GILLESPIE WILLIAMS: I was not recommending a border around the picture. I was recommending that the picture stand in front of an illuminated background and be silhouetted against it. Furthermore, I was under the impression that I was making a case, that under the proper lighting, people will see the picture better. I take it that Mr. Isaac has no objection to the public's seeing more detail of the picture than it has hitherto seen.

I have here a report which took a committee of experts two years to prepare. It is a detailed affair which gives conclusive scientific support for what I have just said, and proves that if lighting areas around the screen are properly employed, and I must emphasize that, the eye sees more detail in the picture than it has ever seen before.

Furthermore, I am going to make this statement authoritatively: that if you use the right contrasting colors around a Technicolor picture, you will have a greater appreciation of the colors in it than ever before.

In the motion picture industry nearly every innovation that is not directly concerned with film and film apparatus is usually opposed by the slogan that "the public pays to see the picture." I will rest my case on that statement: that the public pays to see the picture. The recommendations I have suggested will

enable the public to see the picture better. There will be less eyestrain, and there will be greater contrasts in the tones which make up the picture, and the color visibility will be improved.

This report, by the way, reduced to some simple rule-of-thumb formula, rather established a ratio of 200 to 1 between the brightness of the light falling on the screen (from the projector without a film or shutter) and the illumination of surrounding areas. However, on the other hand, the black border, which Mr. Isaac was defending, is bad for the eye.

You are asking people to sit in a dark hall and to stare at a brightly lighted white area, included in a fairly narrow angle of vision with the pupil of the eye trying to adjust itself to a brightly lighted area while in the same field of vision there is a large area of dead black. What is the eye to do? Is the pupil to open up for the black or close down for the brightly lighted area? The result is that it compromises. By trying to balance between dead black and bright white (which are the high lights of the picture), it does not see the subtle half tones, which are in the picture all the time. You are making it impossible for the eye to see them.

However, just lighting up a border around the screen or merely putting light on in the hall does not necessarily do what I have just said. It must be worked out scientifically. If it is properly done, and I have done it, you see more than you would otherwise see with a black surround. I think that is, after all, the general idea of what the screen is for.

**MR. BEN SCHLANGER:** Let us decide what the problem is if there is one. There is a problem. These effects actually have been tried. In the Roxy Theater you had a fixed intensity illuminated border for several months. I tried an illuminated border for a year in a theater up on Broadway and 95th Street. They were all unsuccessful, because any illumination around the picture which is not synchronous with the particular intensity or hue of color of the frame of picture being shown is as disturbing as a black border.

Consequently, after years of trying to solve this problem, I have at last come to the conclusion that its solution lies in what Hollywood does. A solution which necessitates having cue sheets and color effects, where one theater may do it a little better than the other theater, where it is left to chance, to some artist who thinks purple will be good for glamour, or whatever it is, is a dangerous method.

If you can have a simple solution, I think, like the one I presented here today, then it is much easier to go to some dim tint of light that is on the walls. When I say a dim tint of lights beyond the picture, it is not secondary illumination. It is probably  $1/100$  or  $1/150$  of the light intensity of the picture coming off as a reflected light from the walls. That is inexpensive to do. You do not have any lighting expense whatsoever. You do not have any cue sheets. You just project your picture and you are through.

There is a great deal of material on this subject in printed form. A test was made about seven or eight years ago in which this Society actually tested intensity of light around a picture. It is true, Mr. Williams is right, that black around the picture has been found disturbing by test. We agree on the problem that exists, but not on his solution.

**MR. WILLIAMS:** Mr. Schlanger, if you take a Technicolor picture and you wish the people to get the greatest sense of color out of it, you want to show that picture

against a field with a very low intensity of light, which is the correct contrasting color to the dominant color of the particular scene.

If you take the colors off that Technicolor picture and add them all together, as you would do if you were to take reflected light from the screen, or as we have done in Britain, having a special lens made, and blowing out the edges of the projected picture so the edges of the picture spread out, you get white light all the time, because you are adding with the "additive" system. If the Hollywood color expert had done his job properly, he would have obtained color harmony in the picture. When he has color harmony he has probably balanced his colors. If he has balanced his colors, you have white: when the various hues are superimposed by reflection can you get that color contrast?

I had a lecture demonstration outfit in England, with which I can show a surface lighted with ordinary white light. I can then show how it becomes a vivid green, or a vivid mauve, or blue, or red, or orange, or any color you like, by changing the lighting conditions which you see in the vicinity. The actual lighting of this surface never changes. I induce the colors in the eye by the right seeing conditions. Now if there is a scene on the screen in which fundamentally, the dominant color is yellow, I should do that, obviously, by putting a lot of blue in the vicinity to make the eye induce yellow.

I am not suggesting that we are so clever yet that we can change the lights all the time for every scene, but most important pictures have a few high spots in the story which are worth emphasizing, about six or eight times in the feature picture. Those can be cued up and done easily.

I was told by someone that he saw a demonstration, I think, in Universal Studios in 1936 in which the same scene was shown up several times with different types of background music. The effect the background music made was really remarkable. It completely changed its value. We accept background music when we see a talking motion picture as a convention. Why cannot we accept color as another convention?

You are dealing with the eye. The fact is that everything we see is an image of light which takes place in the eye. It is not in the screen. The picture we see is in the eye. All that comes off the screen are invisible light rays and invisible light rays come into the eye and become vision in the eye. What you see is just largely a matter of seeing conditions. If you master seeing conditions, you can induce or help to induce the picture in the eye, and make it better or make it worse.

MR. SCHLANGER: I am afraid if you were trying to get an effect of what happens in real life—and in real life we see in color—I do not think as we go about in real life that we have a purple or any other complementary color frame around what we are viewing. It is safer not to have any kind of a frame beyond the picture that you are looking at, be it color or be it anything else. I think we have to just be able to look at just a scene ahead of us, with no distraction whatsoever.

MR. MATTHIAS RADIN: I have operated chains of theaters throughout the United States, but the type of theater I ran was similar to the Cameo Theater in New York. I think the audiences that we had there were the most critical audiences in this country. We have tried the color proposition that you discuss, but we tried it the same way as you said, and not as Mr. Williams recommends, because we did not have the facilities for blending the color. All that we had to use upstairs was



a gelatine that the operator thought he would use, and had no conception of what he was doing.

It is a very easy thing for an architect, who has not actually operated theaters 365 days a year, to tell you how this picture should be presented and what it should not be, and that it detracts from the principles of the original producers.

However, I learned one thing: when I went to college, we had a music-appreciation class, for the reason that the greater percentage of boys who attended the college had no idea of the classics. They did like jazz. In those days they did not call it jazz, but they liked that type of music. After the students had been taught the beauty and the very fine things that come from musical classics, there was an appreciation so that when the boy heard that classic in the future he appreciated it. If he did not get it, he missed it.

The same proposition applies to those who may go to an art gallery. We go to the Louvre and we stand there, and I pass on in two minutes. Another man will stand there for an hour and view one particular picture, because he has been taught the appreciation and the beauty of that art.

If the motion picture theater teaches people to appreciate high-class music, as we are doing today, and also understand the beauty of light, its effects, something new brought into that theater, and when that appreciation has been cultivated by the people, it will add to instead of detract, if done properly. That is the main thing that Mr. Williams talks about.

MR. LAWRENCE COHEN: What is the purpose and need of the black border, small as it is, around the screen?

MR. WILLIAMS: That is to cover the ragged fringe of the picture, the light picture, which you always get on the screen. A five-inch black border will just cover that ragged edge. Furthermore, from an artistic point of view, it really looks very well.

MR. COHEN: It was a little distracting to me, because of the fact that it was between the color and the picture.

MR. WILLIAMS: The lantern slide actually was a composite picture made up afterward. I think the black border was painted in. The screen was about 26 feet wide, and the five-inch black border around it would not be quite so visible as it was in that slide.

MR. COHEN: Would it not be possible to compromise between color, as you describe it, and Mr. Schlanger's idea by illuminating the background and eliminating the black border?

MR. WILLIAMS: Theoretically, yes, but only if the projected picture could exactly end at the edge of the screen, I believe, which is not possible in practice.

I do not think it would be practical politics, if we do not have such control of the color lighting adjacent to the screen, that we can cause immediately the background lighting to the screen, and perhaps the whole environment of the hall to merge slowly into a new composition, selected from a number decided by experts in the first place.

Most managers see a picture through at least once a week. It is not difficult to take an envelope out of your pocket, and jot down a note, when an airplane is powerdiving to death, and you do not think the hero is going to get out, and the background is a ta-ta-ta-ta, and you are excited and frightened, so that later you tell the operator to put a finger on key No. 6 at that point. That is all he has to do.

In that way you can cue on the back of an envelope three or four points in the picture. The thing becomes practical politics. I assure you it would not become practical politics if the operator had to stand on one foot and use his hands and knees to try some color mixing.

Mr. SCHLANGER: I have actually experimented with trying to do away with that narrow black border. As Mr. Williams says, that narrow black border is the means of absorbing the fuzzy edge of a projected picture. Three inches might be all right for a small screen where there is not a steep projection angle, but if you have a steep projection angle three inches is not enough. However, this is all beside the point. I feel the narrow black border is just as bad as a wide black border. If I must have it, I am in favor of a wide black border, because in order to have a white picture and a black border and the light necessary, another contrasting value is disturbing. Until the time I see a complete solution to a proper blending from the picture out to its surroundings, I would be just as willing to have black as anything else.

## Theater Engineering Conference

### Auditorium Design

# The New Slide-Back Chair\*

BY W. A. GEDRIS

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*Summary*—The need for a retractable chair in theaters, and the features that should be embodied in a chair of this type are outlined.

WHY THE necessity for a retractable chair? In the author's experience in the seating business, which goes back some twenty-five years or more, the big problem has been, how can the necessity of standing up to allow others to pass between the rows of chairs in a theater be eliminated. In an overwhelming majority of theaters, the space between the rows of chairs is so narrow that it is absolutely necessary to stand up to let others pass, and when a person has a hat, overcoat, and perhaps a bundle or two on his or her lap, it becomes quite a problem to stand up, let alone allowing someone to pass.

There are two ways of eliminating this inconvenience. One method is by spacing the rows far enough apart so that there will be ample room for people to get through without the occupant of the chair having to stand up, or use a retractable chair that will serve the same purpose.

The seating industry, which has been faced with this problem, has devoted years of research and experimentation in trying to overcome this problem, and this is what has been found. In order to achieve the desired effect it has been found that chairs would have to be spaced at least 40 inches back to back to allow passage without body contact. On a spacing of 36 inches back to back, it was found that it was possible to pass with some difficulty. This, of course, was out of the question in most of the cases; the loss of seating capacity would not permit such practice. The demand is always for more capacity even at the expense of discomfort to the theater patron.

Now comes the retractable chair. In this research, all types of human models, both male and female were used, and the conclusion

\* Presented October 20, 1947, at the SMPE Convention in New York.

was reached that the average size of theater patrons is as follows: males 5 feet 7 inches in height, weight 165 pounds, females, 5 feet 4 inches in height, weight approximately 130 pounds. One can readily appreciate that chairs must be manufactured to fit the average size person. Using a man 5 feet 8 inches tall, weighing 170 pounds as a model, which is above average, it was found that there was more passing room with retractable chairs spaced at 32 inches back to back than with stationary chairs spaced the same distance with the occupant standing. There was more passing room with less body contact. It was also found that this same spacing of 32 inches back to back using retractable chairs gave more passing room than with the stationary chairs spaced 36 inches back to back with the chairs occupied. These facts concerning retractable chairs should be very interesting to the theater owner, as it enables him to put in the maximum number of chairs and still give his patrons more comfort than if he had used stationary chairs spaced at 36 inches back to back. Another interesting discovery is that there is more passing room with the retractables at 34 inches back to back than with the stationary chairs at 40 inches back to back. The same result was obtained using as a model a girl 5 feet 6 inches tall, weighing 120 pounds. The retractable chairs used in these experiments had a retraction of 6 inches.

During the past twenty-five years or more, numerous developments in retractable chairs have been patented only to be found impractical or so lacking in the necessary mechanical requirements that they were discarded. Some of these were absolutely fantastic. There is one outstanding example. In 1931 in Los Angeles a man showed something he had developed that he thought would revolutionize the entire seating industry. The device worked something like this. Two rows of chairs are fastened to a traveling conveyor much like a merry-go-round, which travels around at the push of a button. The usher brings two patrons down and seats them, pushes a button, and slides them over a couple of seats. This goes on until the two rows are filled. When a person wants to leave, he pushes a button and the chairs travel around until his chair arrives at the aisle. He then can get out without disturbing anyone. Now mind you, the inventor had taken out a patent on this device, which he was sure would revolutionize the seating industry. When asked what he figured the cost would be, he thought that it would cost about \$75.00 per chair. This was back in 1931 at a time when a good theater chair was selling for around \$10.00.

The second question that presents itself is, "what are we to expect in a retractable chair?" The following enumerates some of the things that should be embodied in a chair of this type to insure durability, comfort, safety, and years of troublefree service.

1. Ease of operation. The retractable chair should be so designed and constructed that the seat will move back on a horizontal plane smoothly without hindrance, and with the least amount of effort on the part of the occupant of the chair.

2. The retractable chair should embody an automatic retracting device that automatically retracts the chair when the occupant stands up to leave. This device should retract the chair slowly and smoothly without bumping or jarring the mechanism.

3. The retractable chair should embody a seat-lifting device which lifts the seat as the chair is retracted, to an angle of approximately 45 degrees. This leaves the seat in a position so that the occupant can sit down without the necessity of holding the seat down with his hands as he occupies the chair. With the chair retracted, and the seat raised, this 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 raising the seats when cleaning under the chair.

4. The retractable chair should embody the ultimate in relaxing comfort. This can be achieved by perfect posture, which is brought about through the proper relationship of the back to the seat, and by the use of deep spring cushions in the seat, and the proper padding of the back. The back should be so constructed that it completely covers the back of the seat, thus preventing the person sitting in the row in back from using the seat as a footrest. The bottom edge of the back should be so designed as to eliminate sharp edges that might bump the shins of the person in the next row as the chair is retracted.

5. The retractable chair should be so constructed that it will not require oiling, greasing, or other maintenance. The fact that this type of chair has more moving parts than the stationary chair should by no means mean that it will require more care than any other type of chair. On the contrary, the retractable chair should and can be built with oilless bearings that need no oil and will give troublefree service for years without any maintenance whatever.

6. The retractable chair should have no obstructions in its understructure that will in any way hinder cleaning under the chair.

7. The retractable chair should be designed and constructed so

that it will embody the flexibility required to compensate for floor conditions that are encountered, and to facilitate the installation of the chair.

8. For reupholstering purposes, the retractable chair should be so constructed that the upholstered parts can be removed from the chair, recovered and replaced with the least amount of effort, and without the need for specialized mechanics to do the job.

Finally, there is no reason why the retractable chair should not be just as attractive in style and design as the most modern conventional-type theater chair.

The retractable chair has proved itself and is definitely here to stay. The yearly increase of this type of seating compared to the total of chairs manufactured will be so marked, that at the end of a few years, the retractable-chair sales will pass those of the conventional type. A theater with a conventional-type chair, except in the balcony, will be as obsolete as a car without a self-starter.

## Officers of the Society

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LOREN L. RYDER  
*President*  
1947-1948



G. T. LORANCE  
*Secretary*  
1947-1948



DONALD E. HYNDMAN  
*Past-President*  
1947-1948



RALPH B. AUSTRIAN  
*Treasurer*  
1948-1949

## Officers of the Society

---



WILLIAM C. KUNZMANN  
*Convention Vice-President*  
1947-1948



JOHN A. MAURER  
*Engineering Vice-President*  
1948-1949



JAMES FRANK, JR.  
*Financial Vice-President*  
1948-1949



CLYDE R. KEITH  
*Editorial Vice-President*  
1947-1948



EARL I. SPORABLE  
*Executive Vice-President*  
1947-1948



## Governors of the Society

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ROBERT M. CORBIN  
1947-1948



JOHN W. BOYLE  
1947-1948



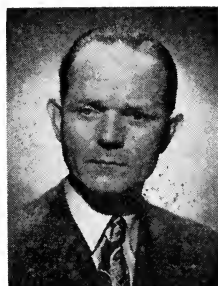
LLOYD T. GOLDSMITH  
1948-1949



GORDON E. SAWYER  
1948-1949



DAVID B. JOY  
1947-1948



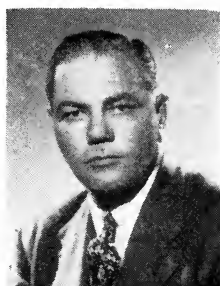
CHARLES R. DAILY  
1947-1948



ALAN W. COOK  
1948-1949

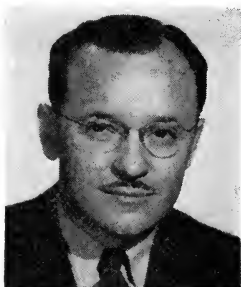


PAUL J. LARSEN  
1948-1949

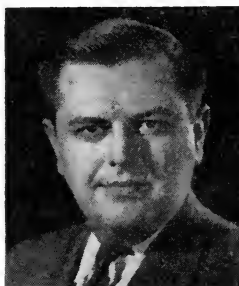


HOLLIS W. MOYSE  
1947-1948

# Officers and Managers of Sections



R. T. VAN NIMAN



W. H. RIVERS



S. P. SOLOW

## ATLANTIC COAST

W. H. RIVERS, *Chairman*  
 JAMES FRANK, JR., *Past-Chairman*  
 EDWARD SCHMIDT, *Secretary-Treasurer*

### Managers

H. B. BRAUN    THEODORE LAWRENCE  
 F. J. GRIGNON    O. F. NEU  
 W. F. JORDAN    E. S. SEELEY

## MIDWEST

R. T. VAN NIMAN, *Chairman*  
 A. SHAPIRO, *Past-Chairman*  
 G. W. COLBURN, *Secretary-Treasurer*

### Managers

E. E. BICKEL    R. E. LEWIS  
 W. C. DEVRY    C. E. PHILLIMORE  
 IRA JACOBSON    H. A. WITT

## PACIFIC COAST

S. P. SOLOW, *Chairman*  
 W. V. WOLFE, *Past-Chairman*  
 G. R. CRANE, *Secretary-Treasurer*

### Managers

A. C. BLANEY    F. L. EICH  
 P. E. BRIGANDI    N. L. SIMMONS  
 J. P. CORCORAN    F. R. WILSON

## STUDENT CHAPTER

UNIVERSITY  
 OF SOUTHERN  
 CALIFORNIA



THOMAS W. GAVEY

THOMAS W. GAVEY,  
*Chairman*  
 JOHN M. BARNWELL, JR.,  
*Secretary-Treasurer*

# Constitution and Bylaws of the Society of Motion Picture Engineers\*

## CONSTITUTION

### Article I

#### NAME

The name of this association shall be SOCIETY OF MOTION PICTURE ENGINEERS.

### Article II

#### OBJECT

Its objects shall be: Advancement in the theory and practice of motion picture engineering and the allied arts and sciences, the standardization of the equipment, mechanisms, and practices employed therein, the maintenance of a high professional standing among its members, and the dissemination of scientific knowledge by publication.

### Article III

#### ELIGIBILITY

Any person of good character may be a member in any grade for which he is eligible.

### Article IV

#### OFFICERS

The officers of the Society shall be a President, a Past-President, an Executive Vice-President, an Engineering Vice-President, an Editorial Vice-President, a Financial Vice-President, a Convention Vice-President, a Secretary, and a Treasurer.

The term of office of all elected officers shall be for a period of two years. Of the Engineering, Editorial, Financial, and Convention Vice-Presidents, and the Secretary, and the

Treasurer, three shall be elected alternately each year, or until their successors are chosen. The President shall not be immediately eligible to succeed himself in office. Under such conditions as set forth in the Bylaws, the office of Executive Vice-President may be vacated before the expiration of his term.

### Article V

#### BOARD OF GOVERNORS

The Board of Governors shall consist of the President, the Past-President, the five Vice-Presidents, the Secretary, the Treasurer, the Section Chairmen, and ten elected governors. Five of these governors shall be resident in the area operating under Pacific and Mountain time, and five of the governors shall be resident in the area operating under Central and Eastern time. Two of the governors from the Pacific area and three of the governors from the Eastern area shall be elected in the odd-numbered years, and three of the governors in the Pacific area and two of the governors in the Eastern area shall be elected in the even-numbered years. The term of office of all elected governors shall be for a period of two years.

### Article VI

#### MEETINGS

There shall be an annual meeting, and such other meetings as stated in the Bylaws.

\*Corrected to April 1, 1947.

## Article VII

### AMENDMENTS

This Constitution may be amended as follows: Amendments shall be approved by the Board of Governors, and shall be submitted for discussion at any regular members' meeting. The proposed amendment and complete discussion then shall be submitted to the entire Active, Fellow, and Honorary membership, together with letter ballot, as soon as possible after the meeting. Two thirds of the vote cast within sixty days after mailing shall be required to carry the amendment.

## BYLAWS

### Bylaw I

#### MEMBERSHIP

SEC. 1.—The membership of the Society shall consist of Honorary members, Fellows, Active members, Associate members, Student members, and Sustaining members.

An **Honorary member** is one who has performed eminent services in the advancement of motion picture engineering or in the allied arts. An Honorary member shall be entitled to vote and to hold any office in the Society.

A **Fellow** is one who shall not be less than thirty years of age and who shall comply with the requirements of either (a) or (b) for Active members and, in addition, shall by his proficiency and contributions have attained to an outstanding rank among engineers or executives of the motion picture industry. A Fellow shall be entitled to vote and to hold any office in the Society.

An **Active member** is one who shall be not less than 25 years of age, and shall be (a) a motion picture engineer by profession. He shall have been engaged in the practice of his profession for a period of at least three years, and shall have taken responsibility for the

design, installation, or operation of systems or apparatus pertaining to the motion picture industry; (b) a person regularly employed in motion picture or closely allied work, who, by his inventions or proficiency in motion picture science or as an executive of a motion picture enterprise of large scope, has attained to a recognized standing in the motion picture industry. In case of such an executive, the applicant must be qualified to take full charge of the broader features of motion picture engineering involved in the work under his direction.

An Active member is privileged to vote and to hold any office in the Society.

An **Associate member** is one who shall be not less than 18 years of age, and shall be a person who is interested in or connected with the study of motion picture technical problems or the application of them. An Associate member is not privileged to vote, to hold office, or to act as chairman of any committee, although he may serve upon any committee to which he may be appointed; and, when so appointed, shall be entitled to the full voting privileges of a committee member.

A **Student member** is any person registered as a student, graduate, or undergraduate, in a college, university, or educational institution, pursuing a course of studies in science or engineering that evidences interest in motion picture technology. Membership in this grade shall not extend more than one year beyond the termination of the student status described above. A Student member shall have the same privileges as an Associate member of the Society.

A **Sustaining member** is an individual, a firm, or corporation contributing substantially to the financial support of the Society.

SEC. 2—All applications for membership or transfer, except for Honorary or Fellow membership, shall be made on blank forms provided for the purpose, and shall give a complete record of the applicant's education and experience. Honorary and Fellow membership may not be applied for.

SEC. 3—(a) **Honorary membership** may be granted upon recommendation of the Board of Governors when confirmed by a four-fifths majority vote of the Honorary members, Fellows, and Active members present at any regular meeting of the Society. An Honorary member shall be exempt from all dues.

(b) **Fellow membership** may be granted upon recommendation of the Fellow Award Committee, when confirmed by a three-fourths majority vote of the Board of Governors. Nominations for Fellow shall be made from the Active membership.

(c) Applicants for **Active membership** shall give as references at least one member of Active or of higher grade in good standing. Applicants shall be elected to membership by the unanimous approval of the entire membership of the appropriate Admissions Committee. In the event of a single dissenting vote or failure of any member of the Admissions Committee to vote, this application shall be referred to the Board of Governors, in which case approval of at least three fourths of the Board of Governors shall be required.

(d) Applicants for **Associate membership** shall give as references one member of the Society in good standing, or two persons not members of the Society who are associated with the industry. Applicants shall be elected to membership by approval of a majority of the appropriate Admissions Committee.

(e) Applicants for **Student membership** shall give as reference the head of the department of the institution he is attending, this faculty member not necessarily being a member of the Society.

## Bylaw II

### OFFICERS

SEC. 1—An officer or governor shall be an Honorary, a Fellow, or an Active member.

SEC. 2—Vacancies in the Board of Governors shall be filled by the Board of Governors until the annual meeting of the Society.

## Bylaw III

### BOARD OF GOVERNORS

SEC. 1—The Board of Governors shall transact the business of the Society between members' meetings, and shall meet at the call of the President, with the proviso that no meeting shall be called without at least seven (7) days' prior notice, stating the purpose of the meeting, to all members of the Board by letter or by telegram.

SEC. 2—Nine members of the Board of Governors shall constitute a quorum at all meetings.

SEC. 3—When voting by letter ballot, a majority affirmative vote of the total membership of the Board of Governors shall carry approval, except as otherwise provided.

SEC. 4—The Board of Governors, when making nominations to fill vacancies in offices or on the Board, shall endeavor to nominate persons who in the aggregate are representative of the various branches or organizations of the motion picture industry to the end that there shall be no substantial predominance upon the Board, as the result of its own action, of representatives of any one or more branches or organizations of the industry.

**Bylaw IV****COMMITTEES**

SEC. 1—All committees, except as otherwise specified, shall be appointed by the President.

SEC. 2—All committees shall be appointed to act for the term served by the officer who shall appoint the committees, unless their appointment is sooner terminated by the appointing officer.

SEC. 3—Chairmen of the committees shall not be eligible to serve in such capacity for more than two consecutive terms.

SEC. 4—Standing committees of the Society shall be as follows to be appointed as designated:

(a) *Appointed by the President and confirmed by the Board of Governors—*

Progress Medal Award Committee  
Journal Award Committee  
Honorary Membership Committee

Fellow Award Committee  
Admissions Committees  
(Atlantic Coast Section)  
(Pacific Coast Section)

European Advisory Committee

(b) *Appointed by the Engineering Vice-President—*

Sound Committee  
Standards Committee  
Studio Lighting Committee  
Color Committee  
Theater Engineering Committee  
Exchange Practice Committee  
Nontheatrical Equipment Committee  
Television Committee  
Test Film Quality Committee

Laboratory Practice Committee

Cinematography Committee  
Process Photography Committee

Preservation of Film Committee

(c) *Appointed by the Editorial Vice-President—*

Board of Editors  
Papers Committee  
Progress Committee  
Historical Committee  
Museum Committee

(d) *Appointed by the Convention Vice-President—*

Publicity Committee  
Convention Arrangements Committee  
Apparatus Exhibit Committee

(e) *Appointed by the Financial Vice-President—*

Membership and Subscription Committee

SEC. 5—Two Admissions Committees, one for the Atlantic Coast Section and one for the Pacific Coast Section, shall be appointed. The former Committee shall consist of a Chairman and six Fellow or Active members of the Society residing in the metropolitan area of New York, of whom at least four shall be members of the Board of Governors.

The latter Committee shall consist of a Chairman and four Fellow or Active members of the Society residing in the Pacific Coast area, of whom at least three shall be members of the Board of Governors.

**Bylaw V****MEETINGS**

SEC. 1—The location of each meeting of the Society shall be determined by the Board of Governors.

SEC. 2—Only Honorary members, Fellows, and Active members shall be entitled to vote.

SEC. 3—A quorum of the Society shall consist in number of one fifteenth of the total number of Honorary members, Fellows, and Active members as listed in the Society's records at the close of the last fiscal year.

SEC. 4—The fall convention shall be the annual meeting.

SEC. 5—Special meetings may be called by the President and upon the request of any three members of the Board of Governors not including the President.

SEC. 6—All members of the Society in any grade shall have the privilege of discussing technical material presented before the Society or its Sections.

#### Bylaw VI

##### DUTIES OF OFFICERS

SEC. 1—The **President** shall preside at all business meetings of the Society and shall perform the duties pertaining to that office. As such he shall be the chief executive of the Society, to whom all other officers shall report.

SEC. 2—In the absence of the President, the officer next in order as listed in Article IV of the Constitution shall preside at meetings and perform the duties of the President.

SEC. 3—The five Vice-Presidents shall perform the duties separately enumerated below for each office, or as defined by the President:

(a) The **Executive Vice-President** shall represent the President in such geographical areas of the United States as shall be determined by the Board of Governors and shall be responsible for the supervision of the general affairs of the Society in such areas, as directed by the President of the Society. Should the President or Executive Vice-President remove his residence

from the geographical area (Atlantic Coast or Pacific Coast) of the United States in which he resided at the time of his election, the office of Executive Vice-President shall immediately become vacant and a new Executive Vice-President elected by the Board of Governors for the unexpired portion of the term, the new Executive Vice-President to be a resident of that part of the United States from which the President or Executive Vice-President has just moved.

(b) The **Engineering Vice-President** shall appoint all technical committees. He shall be responsible for the general initiation, supervision, and co-ordination of the work in and among these committees. He may act as Chairman of any committee or otherwise be a member ex-officio.

(c) The **Editorial Vice-President** shall be responsible for the publication of the Society's JOURNAL and all other technical publications. He shall pass upon the suitability of the material for publication, and shall cause material suitable for publication to be solicited as may be needed. He shall appoint a Papers Committee and an Editorial Committee. He may act as Chairman of any committee or otherwise be a member ex-officio.

(d) The **Financial Vice-President** shall be responsible for the financial operations of the Society, and shall conduct them in accordance with budgets approved by the Board of Governors. He shall study the costs of operation and the income possibilities to the end that the greatest service may be rendered to the members of the Society within the available funds. He shall submit proposed budgets to the Board. He shall appoint at his discretion a Ways and Means Committee, a Membership Committee, a Commercial Advertising Committee,

and such other committees within the scope of his work as may be needed. He may act as Chairman of any of these committees or otherwise be a member ex-officio.

(e) The **Convention Vice-President** shall be responsible for the national conventions of the Society. He shall appoint a **Convention Arrangements Committee**, an **Apparatus Exhibit Committee**, and a **Publicity Committee**. He may act as Chairman of any committee, or otherwise be a member ex-officio.

**SEC. 4**—The **Secretary** shall keep a record of all meetings; he shall conduct the correspondence relating to his office, and shall have the care and custody of records, and the seal of the Society.

**SEC. 5**—The **Treasurer** shall have charge of the funds of the Society and disburse them as and when authorized by the **Financial Vice-President**. He shall make an annual report, duly audited, to the Society, and a report at such other times as may be requested. He shall be bonded in an amount to be determined by the **Board of Governors** and his bond filed with the **Secretary**.

**SEC. 6**—Each officer of the Society, upon the expiration of his term of office, shall transmit to his successor a memorandum outlining the duties and policies of his office.

## Bylaw VII

### ELECTIONS

**SEC. 1**—All officers and governors shall be elected to their respective offices by a majority of ballots cast by the **Active**, **Fellow**, and **Honorary** members in the following manner:

Not less than three months prior to the annual fall convention, the **Board of Governors** shall nominate for each vacancy several suitable candidates.

Nominations shall first be presented by a **Nominating Committee** appointed by the **President**, consisting of nine members, including a **Chairman**. The committee shall be made up of two **Past-Presidents**, three members of the **Board of Governors** not up for election, and four other **Active**, **Fellow**, or **Honorary** members, not currently officers or governors of the Society. Nominations shall be made by three-quarters affirmative vote of the total **Nominating Committee**. Such nominations shall be final unless any nominee is rejected by a three-quarters vote of the **Board of Governors** present and voting.

The **Secretary** shall then notify these candidates of their nomination. From the list of acceptances, not more than two names for each vacancy shall be selected by the **Board of Governors** and placed on a letter ballot. A blank space shall be provided on this letter ballot under each office, in which space the names of any **Active**, **Fellow**, or **Honorary** members other than those suggested by the **Board of Governors** may be voted for. The balloting shall then take place.

The ballot shall be enclosed in a blank envelope which is enclosed in an outer envelope bearing the **Secretary's** address and a space for the member's name and address. One of these shall be mailed to each **Active**, **Fellow**, and **Honorary** member of the Society, not less than forty days in advance of the annual fall convention.

The voter shall then indicate on the ballot one choice for each office, seal the ballot in the blank envelope, place this in the envelope addressed to the **Secretary**, sign his name and address on the latter, and mail it in accordance with the instructions printed on the ballot. No marks of any kind except those above prescribed shall be placed upon the ballots or envelopes. Voting



shall close seven days before the opening session of the annual fall convention.

The sealed envelope shall be delivered by the Secretary to a Committee of Tellers appointed by the President at the annual fall convention. This committee shall then examine the return envelopes, open and count the ballots, and announce the results of the election.

The newly elected officers and governors of the general Society shall take office on January 1st following their election.

### Bylaw VIII

#### DUES AND INDEBTEDNESS

SEC. 1—The annual dues shall be fifteen dollars (\$15) for Fellows and Active members, ten dollars (\$10) for Associate members, and five dollars (\$5) for Student members, payable on or before January 1st of each year. Current or first year's dues for new members in any calendar year shall be at the full annual rate for those notified of acceptance in the Society on or before June 30th; one half the annual rate for those notified of acceptance in the Society on or after July 1st.

SEC. 2—(a) Transfer of membership to a higher grade may be made at any time. If the transfer is made on or before June 30th the annual dues of the higher grade is required. If the transfer is made on or after July 1st and the member's dues for the full year has been paid, one half of the annual dues of the higher grade is payable less one half the annual dues of the lower grade.

(b) No credit shall be given for annual dues in a membership transfer from a higher to a lower grade, and such transfers shall take place on January 1st of each year.

(c) The Board of Governors upon their own initiative and without a transfer application may elect, by the approval of at least three fourths of the Board, any Associate or Active member for transfer to any higher grade of membership.

SEC. 3—Annual dues shall be paid in advance. A new member who has not paid dues in advance shall be notified of admittance but shall not receive the JOURNAL and is not in good standing until initial dues are paid. All Honorary members, Fellows, and Active members in good standing, as defined in SECTION 5, may vote or otherwise participate in the meetings.

SEC. 4—Members shall be considered delinquent whose annual dues for the year remain unpaid on February 1st. The first notice of delinquency shall be mailed February 1st. The second notice of delinquency shall be mailed, if necessary, on March 1st, and shall include a statement that the member's name will be removed from the mailing list for the JOURNAL and other publications of the Society before the mailing of the April issue of the JOURNAL. Members who are in arrears of dues on June 1st, after two notices of such delinquency have been mailed to their last address of record, shall be notified their names have been removed from the mailing list and shall be warned unless remittance is received on or before August 1st, their names shall be submitted to the Board of Governors for action at the next meeting. Back issues of the JOURNAL shall be sent, if available, to members whose dues have been paid prior to August 1st.

SEC. 5—(a) Members whose dues remain unpaid on October 1st may be dropped from the rolls of the Society by majority vote and action of the Board, or the Board may take such action as it sees fit.

(b) Anyone who has been dropped from the rolls of the Society for non-payment of dues shall, in the event of his application for reinstatement, be considered as a new member.

(c) Any member may be suspended or expelled for cause by a majority vote of the entire Board of Governors; provided he shall be given notice and a copy in writing of the charges preferred against him, and shall be afforded opportunity to be heard ten days prior to such action.

SEC. 6—The provisions of SECTIONS 1 to 4, inclusive, of this Bylaw VIII given above may be modified or rescinded by action of the Board of Governors.

#### Bylaw IX

##### EMBLEM

SEC. 1—The emblem of the Society shall be a facsimile of a four-hole film reel with the letter *S* in the upper center opening, and the letters *M*, *P*, and *E*, in the three lower openings, respectively. The Society's emblem may be worn by members only.

#### Bylaw X

##### PUBLICATIONS

SEC. 1—Papers read at meetings or submitted at other times, and all material of general interest shall be submitted to the Editorial Board, and those deemed worthy of permanent record shall be printed in the JOURNAL. A copy of each issue shall be mailed to each member in good standing to his last address of record. Extra copies of the JOURNAL shall be printed for general distribution and may be obtained from the General Office on payment of a fee fixed by the Board of Governors.

#### Bylaw XI

##### LOCAL SECTIONS

SEC. 1—Sections of the Society may

be authorized in any state or locality where the Active, Fellow, and Honorary membership exceeds 20. The geographic boundaries of each Section shall be determined by the Board of Governors.

Upon written petition, signed by 20 or more Active members, Fellows, and Honorary members, for the authorization of a Section of the Society, the Board of Governors may grant such authorization.

#### SECTION MEMBERSHIP

SEC. 2—All members of the Society of Motion Picture Engineers in good standing residing in that portion of any country set apart by the Board of Governors tributary to any local Section shall be eligible for membership in that Section, and when so enrolled they shall be entitled to all privileges that such local Section may, under the General Society's Constitution and Bylaws, provide.

Any member of the Society in good standing shall be eligible for nonresident affiliated membership of any Section under conditions and obligations prescribed for the Section. An affiliated member shall receive all notices and publications of the Section but he shall not be entitled to vote at sectional meetings.

SEC. 3—Should the enrolled Active, Fellow, and Honorary membership of a Section fall below 20, or should the technical quality of the presented papers fall below an acceptable level, or the average attendance at meetings not warrant the expense of maintaining the organization, the Board of Governors may cancel its authorization.

#### SECTION OFFICERS

SEC. 4—The officers of each Section shall be a Chairman and a Secretary-Treasurer. The Section chairmen

shall automatically become members of the Board of Governors of the General Society, and continue in such positions for the duration of their terms as chairmen of the local Sections. Each Section officer shall hold office for one year, or until his successor is chosen.

#### SECTION BOARD OF MANAGERS

SEC. 5—The Board of Managers shall consist of the Section Chairman, the Section Past-Chairman, the Section Secretary-Treasurer, and six Active, Fellow, or Honorary members. Each manager of a Section shall hold office for two years, or until his successor is chosen.

#### SECTION ELECTIONS

SEC. 6—The officers and managers of a Section shall be Active, Fellow, or Honorary members of the General Society. All officers and managers shall be elected to their respective offices by a majority of ballots cast by the Active, Fellow, and Honorary members residing in the geographical area covered by the Section.

Not less than three months prior to the annual fall convention of the Society, nominations shall be presented to the Board of Managers of the Section by a Nominating Committee appointed by the Chairman of the Section, consisting of seven members, including a chairman. The Committee shall be composed of the present Chairman, the Past-Chairman, two other members of the Board of Managers not up for election, and three other Active, Fellow, or Honorary members of the Section not currently officers or managers of the Section. Nominations shall be made by a three-quarters affirmative vote of the total Nominating Committee. Such nominations shall be final, unless any nominee is rejected

by a three-quarters vote of the Board of Managers, and in the event of such rejection the Board of Managers will make its own nomination.

The Chairman of the Section shall then notify these candidates of their nomination. From the list of acceptances, not more than two names for each vacancy shall be selected by the Board of Managers and placed on a letter ballot. A blank space shall be provided on this letter ballot under each office, in which space the names of any Active, Fellow, or Honorary members other than those suggested by the Board of Managers may be voted for. The balloting shall then take place.

The ballot shall be enclosed in a blank envelope which is enclosed in an outer envelope bearing the local Secretary-Treasurer's address and a space for the member's name and address. One of these shall be mailed to each Active, Fellow, and Honorary member of the Society residing in the geographical area covered by the Section, not less than forty days in advance of the annual fall convention.

The voter shall then indicate on the ballot one choice for each office, seal the ballot in the blank envelope, place this in the envelope addressed to the Secretary-Treasurer, sign his name and address on the latter, and mail it in accordance with the instructions printed on the ballot. No marks of any kind except those above prescribed shall be placed upon the ballots or envelopes. Voting shall close seven days before the opening session of the annual fall convention.

The sealed envelopes shall be delivered by the Secretary-Treasurer to his Board of Managers at a duly called meeting. The Board of Managers shall then examine the return envelopes, open and count the ballots, and

announce the results of the election.

The newly elected officers and managers shall take office on January 1st following their election.

#### SECTION BUSINESS

SEC. 7—The business of a Section shall be conducted by the Board of Managers.

#### SECTION EXPENSES

SEC. 8—(a) As early as possible in the fiscal year, the Secretary-Treasurer of each Section shall submit to the Board of Governors of the Society a budget of expenses for the year.

(b) The Treasurer of the General Society may deposit with each Section Secretary-Treasurer a sum of money, the amount to be fixed by the Board of Governors, for current expenses.

(c) The Secretary-Treasurer of each Section shall send to the Treasurer of the General Society, quarterly or on demand, an itemized account of all expenditures incurred during the preceding interval.

(d) Expenses other than those enumerated in the budget, as approved by the Board of Governors of the General Society, shall not be payable from the general funds of the Society without express permission from the Board of Governors.

(e) A Section Board of Managers shall defray all expenses of the Section not provided for by the Board of Governors, from funds raised locally by donation, or fixed annual dues, or by both.

(f) The Secretary of the General Society shall, unless otherwise arranged, supply to each Section all stationery and printing necessary for the conduct of its business.

#### SECTION MEETINGS

SEC. 9—The regular meetings of a Section shall be held in such places and

at such hours as the Board of Managers may designate.

The Secretary-Treasurer of each Section shall forward to the Secretary of the General Society, not later than five days after a meeting of a Section, a statement of the attendance and of the business transacted.

#### SECTION PAPERS

SEC. 10—Papers shall be approved by the Section's Papers Committee previously to their being presented before a Section. Manuscripts of papers presented before a Section, together with a report of the discussions and the proceedings of the Section meetings, shall be forwarded promptly by the Section Secretary-Treasurer to the Secretary of the General Society. Such material may, at the discretion of the Board of Editors of the General Society, be printed in the Society's publications.

#### CONSTITUTION AND BYLAWS

SEC. 11—Sections shall abide by the Constitution and Bylaws of the Society and conform to the regulations of the Board of Governors. The conduct of Sections shall always be in conformity with the general policy of the Society as fixed by the Board of Governors.

#### Bylaw XII

##### AMENDMENTS

SEC. 1—These Bylaws may be amended at any regular meeting of the Society by the affirmative vote of two thirds of the members present at a meeting who are eligible to vote thereon, a quorum being present, either on the recommendation of the Board of Governors or by a recommendation to the Board of Governors signed by any ten members of Active or higher grade, provided that the proposed amendment or amendments shall have been

published in the JOURNAL of the Society, in the issue next preceding the date of the stated business meeting of the Society at which the amendment or amendments are to be acted upon.

SEC. 2—In the event that no quorum of the voting members is present at the time of the meeting referred to in SECTION 1, the amendment or amendments shall be referred for action to the Board of Governors. The proposed amendment or amendments then become a part of the Bylaws upon receiving the affirmative vote of three quarters of the Board of Governors.

### Bylaw XIII

#### STUDENT CHAPTERS

SEC. 1—Student Chapters of the Society may be authorized in any college, university, or technical institute of collegiate standing.

Upon written petition, signed by twelve or more Society members, or applicants for Society membership, and the Faculty Adviser, for the authorization of a Student Chapter, the Board of Governors may grant such authorization.

#### CHAPTER MEMBERSHIP

SEC. 2—All members of the Society of Motion Picture Engineers in good standing who are attending the designated educational institution shall be eligible for membership in the Student Chapter, and when so enrolled they shall be entitled to all privileges that such Student Chapter may, under the General Society's Constitution and Bylaws, provide.

SEC. 3—Should the membership of the Student Chapter fall below ten, or should the technical quality of the presented papers fall below an acceptable level, or the average attendance at meetings not warrant the expense of

maintaining the organization, the Board of Governors may cancel its authorization.

#### CHAPTER OFFICERS

SEC. 4—The officers of each Student Chapter shall be a Chairman and a Secretary-Treasurer. Each Chapter officer shall hold office for one year, or until his successor is chosen. Officers shall be chosen in May to take office at the beginning of the following school year. The procedure for holding elections shall be prescribed in Administrative Practices.

#### FACULTY ADVISER

SEC. 5—A member of the faculty of the same educational institution shall be designated by the Board of Governors as Faculty Adviser. It shall be his duty to advise the officers on the conduct of the Chapter and to approve all reports to the Secretary and the Treasurer of the Society.

#### CHAPTER EXPENSES

SEC. 6—The Treasurer of the General Society may deposit with each Chapter Secretary-Treasurer a sum of money, the amount to be fixed by the Board of Governors. The Secretary-Treasurer shall send to the Treasurer of the General Society at the end of each school year an itemized account of all expenditures incurred during that period.

#### CHAPTER MEETINGS

SEC. 7—The Chapter shall hold at least four meetings per year. The Secretary-Treasurer shall forward to the Secretary of the General Society at the end of each school year a report of the meetings for that year, giving the subject, speaker, and approximate attendance for each meeting.

# Awards

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In accordance with the provisions of Administrative Practices of the Society, the regulations for procedure in granting the Journal Award, the Progress Medal Award, and the Samuel L. Warner Memorial Award, a list of the names of previous recipients, and the reasons therefor, are published annually in the JOURNAL as follows:

## JOURNAL AWARD

The Journal Award Committee shall consist of five Fellows or Active members of the Society, appointed by the President and confirmed by the Board of Governors. The Chairman of the Committee shall be designated by the President.

At the fall convention of the Society a Journal Award Certificate shall be presented to the author or to each of the authors of the most outstanding paper originally published in the JOURNAL of the Society during the preceding calendar year.

Other papers published in the JOURNAL of the Society may be cited for Honorable Mention at the option of the Committee, but in any case should not exceed five in number.

The Journal Award shall be made on the basis of the following qualifications:

(1) The paper must deal with some technical phase of motion picture engineering.

(2) No paper given in connection with the receipt of any other Award of the Society shall be eligible.

(3) In judging of the merits of the paper, three qualities shall be considered, with the weights here indicated:

(a) Technical merit and importance of material . . . . .	45 per cent.
(b) Originality and breadth of interest . . . . .	35 per cent.
(c) Excellence of presentation of the material . . . . .	20 per cent.

A majority vote of the entire Committee shall be required for the election to the Award. Absent members may vote in writing.

The report of the Committee shall be presented to the Board of Governors at their July meeting for ratification.

These regulations, a list of the names of those who have previously received the Journal Award, the year of each Award, and the titles of the papers shall be published annually in the April issue of the JOURNAL of the Society. In addition, the list of papers selected for Honorable Mention shall be published in the JOURNAL of the Society during the year current with the Award.

The Awards in previous years have been as follows:

1934—P. A. Snell, for his paper entitled "An Introduction to the Experimental Study of Visual Fatigue." (Published May, 1933.)

1935—L. A. Jones and J. H. Webb, for their paper entitled "Reciprocity Law Failure in Photographic Exposure." (Published September, 1934.)

1936—E. W. Kellogg, for his paper entitled "A Comparison of Variable-Density and Variable-Width Systems." (Published September, 1935.)

1937—D. B. Judd, for his paper entitled "Color Blindness and Anomalies of Vision." (Published June, 1936.)

1938—K. S. Gibson, for his paper entitled "The Analysis and Specification of Color." (Published April, 1937.)

1939—H. T. Kalmus, for his paper entitled "Technicolor Adventures in Cinemaland." (Published December, 1938.)

1940—R. R. McNath, for his paper entitled "The Surface of the Nearest Star." (Published March, 1939.)

1941—J. G. Frayne and Vincent Pagliarulo, for their paper entitled "The Effects of Ultraviolet Light on Variable-Density Recording and Printing." (Published June, 1940.)

1942—W. J. Albersheim and Donald MacKenzie, for their paper entitled "Analysis of Sound-Film Drives." (Published July, 1941.)

1943—R. R. Scoville and W. L. Bell, for their paper entitled "Design and Use of Noise-Reduction Bias Systems." (Published February, 1942; Award made April, 1944.)

1944—J. I. Crabtree, G. T. Eaton, and M. E. Muehler, for their paper entitled "Removal of Hypo and Silver Salts from Photographic Materials as Affected by the Composition of the Processing Solutions." (Published July, 1943.)

1945—C. J. Kunz, H. E. Goldberg, and C. E. Ives, for their paper entitled "Improvement in Illumination Efficiency of Motion Picture Printers." (Published May, 1944.)

1946—R. H. Talbot, for his paper entitled "The Projection Life of Film." (Published August, 1945.)

1947—Albert Rose, for his paper entitled "A Unified Approach to the Performance of Photographic Film, Television Pickup Tubes, and the Human Eye." (Published October, 1946.)

The present Chairman of the Journal Award Committee is J. I. Crabtree.

## PROGRESS MEDAL AWARD

The Progress Medal Award Committee shall consist of five Fellows or Active members of the Society, appointed by the President and confirmed by the Board of Governors. The Chairman of the Committee shall be designated by the President.

The Progress Medal may be awarded each year to an individual in recognition of any invention, research, or development which, in the opinion of the Committee, shall have resulted in a significant advance in the development of motion picture technology.

Any member of the Society may recommend persons deemed worthy of the Award. The recommendation in each case shall be in writing and in detail as to the accomplishments which are thought to justify consideration. The recommendation shall be seconded in writing by any two Fellows or Active members of the Society, who shall set forth their knowledge of the accomplishments of the candidate which, in their opinion, justify consideration.

A majority vote of the entire Committee shall be required to constitute an Award of the Progress Medal. Absent members may vote in writing.

The report of the Committee shall be presented to the Board of Governors at their July meeting for ratification.

The recipient of the Progress Medal shall be asked to present a photograph of himself to the Society and, at the discretion of the Committee, may be asked to prepare a paper for publication in the JOURNAL of the Society.

These regulations, a list of the names of those who have previously received

the Medal, the year of each Award, and a statement of the reason for the Award shall be published annually in the April issue of the JOURNAL of the Society.

Previous Awards have been as follows:

The 1935 Award was made to E. C. Wentz, for his work in the field of sound recording and reproduction. (Citation published December, 1935.)

The 1936 Award was made to C. E. K. Mees, for his work in photography. (Citation published December, 1936.)

The 1937 Award was made to E. W. Kellogg, for his work in the field of sound reproduction. (Citation published December, 1937.)

The 1938 Award was made to H. T. Kalmus, for his work in developing color motion pictures. (Citation published December, 1938.)

The 1939 Award was made to L. A. Jones, for his scientific researches in the field of photography. (Citation published December, 1939.)

The 1940 Award was made to Walt Disney, for his contributions to motion picture photography and sound recording of feature and short cartoon films. (Citation published December, 1940.)

The 1941 Award was made to G. L. Dimmick, for his development activities in motion picture sound recording. (Citation published December, 1941.)

No Awards were made in 1942 and 1943.

The 1944 Award was made to J. G. Capstaff, for his research and development of films and apparatus used in amateur cinematography. (Citation published January, 1945.)

No Awards were made in 1945 and 1946.

The 1947 Award was made to J. G. Frayne for his technical achievements and the documenting of his work in addition to his contributions to the field of education and his inspiration to his fellow engineers. (Citation published January, 1948.)

The present Chairman of the Progress Medal Award Committee is F. E. Carlson.



PROGRESS MEDAL AWARDED FOR ACHIEVEMENT IN MOTION PICTURE TECHNOLOGY

### SAMUEL L. WARNER MEMORIAL AWARD

Each year the President shall appoint a Samuel L. Warner Memorial Award Committee consisting of a chairman and four members. The chairman and committee members must be Active Members or Fellows of the Society. In considering candidates for the Award, the committee shall give preference to inventions or developments occurring in the last five years. Preference should also be



given to the invention or development likely to have the widest and most beneficial effect on the quality of the reproduced sound and picture. A description of the method or apparatus must be available for publication in sufficient detail so that it may be followed by anyone skilled in the art. Since the Award is made to an individual, a development in which a group participates should be considered only if one person has contributed the basic idea and also has contributed substantially to the practical working out of the idea. If, in any year, the committee does not consider any recent development to be more than the logical working out of details along well-known lines, no recommendation for the Award shall be made. The recommendation of the committee shall be presented to the Board of Governors at the July meeting.

The purpose of this Award is to encourage the development of new and improved methods or apparatus designed for sound-on-film motion pictures, including any step in the process.

Any person, whether or not a member of the Society of Motion Picture Engineers, is eligible to receive the Award.

The Award shall consist of a gold medal suitably engraved for each recipient. It shall be presented at the Fall Convention of the Society, together with a bronze replica.

These regulations, a list of those who previously have received the Award, and a statement of the reason for the Award shall be published annually in the April issue of the JOURNAL of the Society.

The 1947 Award was made to J. A. Maurer, for his outstanding contributions to the field of high-quality 16-mm sound recording and reproduction, film processing, development of 16-mm sound test films, and for his inspired leadership in industry standardization.

The present Chairman of the Samuel L. Warner Memorial Award Committee is P. E. Brigandi.



SAMUEL L. WARNER MEMORIAL AWARD PRESENTED ANNUALLY FOR MOST OUTSTANDING WORK IN SOUND MOTION PICTURE ENGINEERING

#### Committees of the Society

Committee personnel will be published in the May, 1948, issue of the Journal.

# Society of Motion Picture Engineers

## MEMBERSHIP\*

*Changes for Period January–December 31, 1947*

	Hon.	Sust.	Fel.	Act.	Asso.	Stu.	Total
<i>Membership, Jan. 1, 1947</i>	6	64	154	561	1588	59	2432
New Members		3		107	238	88	435
Reinstatements				4	9		13
	6	67	154	672	1835	147	2880
Less: Resignations			-1	-6	-35	-4	-46
Deaths			-2	-3	-3		-8
Suspended		-24		-25	-109	-17	-175
	6	43	151	638	1688	126	2651
Changes in Grade:							
Active to Fellow			14	-14			
Associate to Active				54	-54		
Active to Associate				-3	3		
Associate to Student					-1	1	
<i>Membership, Dec. 31, 1947</i>	6	43	165	675	1636	127	2651

## NONMEMBER SUBSCRIPTIONS TO JOURNAL

<i>Subscriptions, Jan. 1, 1947</i>	779
New subscriptions and renewals, Jan.–Dec., 1947	408
	1187
Less: Expirations	-261
Subscriptions, Dec. 31, 1947	926

\* Grades: Honorary, Sustaining, Fellow, Active, Associate, and Student.

# Society of Motion Picture Engineers

## REPORT OF THE TREASURER

January 1-December 31, 1947

Members' Equity, January 1, 1947:

\$78,973.78

Receipts, Jan.-Dec. 1947:

Membership dues	\$28,115.42
Sustaining Memberships	20,575.00
Publications	12,381.66
Test Films	25,923.31
Other (Interest, etc.)	1,087.50

Total Receipts

\$88,082.89

Disbursements, Jan.-Dec. 1947:

General Office	\$41,573.15
Publications	17,700.62
Test Films	12,758.07
Dues and Fees to Other Organizations	485.00
Sections	1,274.71
Committee Activities	1,714.88
Other (Conventions, Awards, etc.)	947.95

Total Disbursements

76,454.38

Excess Receipts Over Disbursements, 1947:

\$11,628.51

90,602.29

Accrued Interest on Savings

Accounts

157.03

Members' Equity, December 31, 1947

\$90,759.32

Respectfully submitted,  
E. A. BERTRAM, Treasurer

The cash records of the Treasurer were audited for the year ended December 31, 1947, by Sparrow, Waymouth and Company, certified public accountants, New York, and are in conformity with the above report.

M. R. BOYER  
Financial Vice-President

## Society Announcements

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### Progress Medal Award

The SMPE Progress Medal Award is presented to an individual in recognition of his technical contributions to the motion picture industry. This is an annual award; however, it need not be presented in any given year if the Progress Medal Award Committee feels that there is no qualified candidate. Candidates may be proposed by any member of the Society as outlined in the formal committee procedure on page 409 of this issue of the Journal.

Proposals for consideration by the committee may be addressed to any member of the committee which is listed below, but must be received prior to May 15, 1948.

H. B. Braun, Radio City Music Hall, Rockefeller Center, N. Y. 20, N. Y.

R. M. Corbin, Eastman Kodak Company, Rochester, N. Y.

W. C. Miller, Metro-Goldwyn-Mayer, Culver City, Calif.

F. E. Carlson, General Electric Co., Nela Park, Cleveland 12, Ohio.

John W. Boyle, 139 $\frac{1}{2}$  Doheny Dr., Los Angeles 36, Calif.

The Progress Medal was inaugurated during the term of office of President J. I. Crabtree but much credit is due Mr. G. E. Matthews, the then chairman of the Historical Committee, for his efforts in obtaining an outstanding design. Sketches for the proposed medal were submitted by some of the better-known artists in New York City but these were mostly conventional featuring the laurel wreath. Fortunately Mr. Alexander Murray, a co-worker with Messrs. Crabtree and Matthews in the Research Laboratories of the Eastman Kodak Company, became interested in the problem and submitted a unique design incorporating many symbols peculiar to the photographic and motion picture art and donated his work to the Society. A picture of the medal is shown on page 410.

The design was approved unanimously by the Board of Governors, precision dies made by the Metal Arts Company, Rochester, N. Y., and the first gold medal struck in the year 1935 which, on recommendation of the Progress Award Committee, was awarded to Dr. E. C. Wentz of the Bell Telephone Laboratories.

The design of the medal is uniquely symbolic of progress in the cinema. On the obverse side, the center is a replica of the official emblem of the Society. Above and around the emblem are embossed the words "For Progress," and below are two laurel branches, Grecian symbols of achievement. A reproduction of film perforations forms a decorative motif surrounding the central portion of the design. Eleven concave panels fill the remaining area extending to the outer edge of the face, upon each of which the form of a bird in flight is embossed. Various movements of the flight are depicted, reproducing the work of E. Marey, a French scientist who, in 1886, designed a "photographic gun," using circular glass plates, for analyzing the movements of living things. Although it was not Marey's intention to reproduce motion, his plates embodied the essential elements of the motion picture and the representation of them is therefore symbolic of the early development of motion pictures.

On the reverse side, the central portion consists of a series of horizontal oblong panels arranged in a partial pyramidal form and bearing the embossed inscription "Awarded to (Name of Medalist) for Outstanding Achievement in Motion Picture

Technology." Crystals of silver bromide, the light-sensitive salt used in most photographic emulsions, are reproduced in two of the panels. Below the inscription is engraved the year of the award. Above it is a small rectangular panel upon which is engraved a sensitometric curve, representing the classical researches of Hurter and Driffield, who laid down much of the fundamental theory regarding numerical specification of photographic emulsion characteristics. Sine waves, symbolic of sound and light, are embossed upon two curved panels to the left and right of the central pyramid. In a slightly inclined panel surrounding almost the entire outer edge, the name of the Society appears in embossed letters.

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## Current Literature

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**I**N RECENT ISSUES of the *Philips Technical Review*, there have appeared articles which should prove of great interest to the motion picture engineer. The summary of one of these papers is given below.—THE EDITOR

### PROBLEMS IN PHOTOGRAPHIC REPRODUCTION, IN PARTICULAR OF SOUND FILMS

BY C. J. DIPPEL AND K. J. KEUNING

The resolving power of a film made by the usual photographic methods is limited by the circle of diffusion formed by the grains of the film. Consequently in order to get sharp pictures on the projection screen the images on the film must be of a certain minimum size. If the film carries a sound track and the speed of the projected film is fixed, then, in spite of a so-called cancellation method being applied when recording and copying, this limited resolving power results in a loss in the amplitude of high frequencies. In order to counteract the circle of diffusion it is desirable that the film should have a high gamma, of say 4 or 5. For picture reproduction, however, Goldberg's rule prescribes a gamma in the neighborhood of 1 or 2. The compromise that has to be reached when a picture film and a sound track have to be copied on a single film by the usual methods makes its influence felt throughout the whole of the present-day technique of cinematography.

A much simpler and less expensive solution of the problem of copying sound films is offered by a new method of photographic reproduction that was developed in the Philips laboratories during the war. This method is based on the use of a diazonium compound combined with a mercury salt. The most striking features of this method are the extremely high resolving power (1000 lines per millimeter) and the locally variable gamma (between, e. g., 1 and 8). A more detailed description of this method and its possibilities of application will be given in another article to be published in this journal shortly. (*From Volume 9, Number 3*)

**TENTATIVE PROGRAM**  
**63rd Semiannual Convention**  
**SOCIETY OF MOTION PICTURE ENGINEERS**

Santa Monica Ambassador Hotel  
Santa Monica, California

May 17-21, 1948

**Monday, May 17**

- 9:30 A.M. Registration, Sixth Floor, Santa Monica Ambassador Hotel  
Advance Sale of Luncheon and Banquet Tickets
- 11:00 A.M. Business Session, Magnolia Room, Santa Monica Ambassador Hotel  
Introduction of Society Officers  
Report of the President  
Report of the Convention Vice-President  
Standards Committee Report, F. T. Bowditch, Research Laboratories, National Carbon Company, Cleveland, Ohio  
Report of Committee on High-Speed Photography, A. P. Neyhart, Douglas Aircraft Company, Santa Monica, California
- 12:30 P.M. Luncheon, Ocean Room, Del Mar Beach Club, for members and guests. Mr. Loren Ryder, president of the Society, will preside.
- 2:00 P.M. Technical Session, Magnolia Room  
Session will open with a 35-mm motion picture short  
"Tentative Standards for Noise and Distortion Measurements," by E. W. Kellogg, RCA Victor Division, Radio Corporation of America, Indianapolis, Indiana  
"Variable-Area Recording with the Light Valve," by J. G. Frayne, Western Electric Company, Hollywood, California  
"A Light-Valve Variable-Area Modulator," by L. B. Browder, Western Electric Company, Hollywood, California  
"A 'Silent' Playback and Public-Address System," by B. H. Denney and Robert J. Carr, Paramount Pictures, Inc., Hollywood, California  
"Volume Compressors for Sound Recording," by W. K. Grimwood, Research Laboratories, Eastman Kodak Company, Rochester, New York  
"A Single-Element Unidirectional Microphone," by Harry F. Olson, and John Preston, Research Laboratories, Radio Corporation of America, Princeton, New Jersey
- 8:00 P.M. Technical Session, Magnolia Room  
Session will open with a 35-mm motion picture short  
"Flicker in Motion Pictures; Further Studies," by L. D. Grignon, 20th Century-Fox Film Corporation, Beverly Hills, California  
"Audio-Visual Materials—Prospects and Needs," by Donald C. Doane, Director, Audio-Visual Laboratory, University of Southern California, Los Angeles, California

Monday, May 17 (*Continued*)

- 8:00 P.M. Technical Session (*Continued*)
- "The Film Collection Program in the Academy of Motion Picture Arts and Sciences," by H. L. Walls, Academy of Motion Picture Arts and Sciences, Los Angeles, California
  - "Problems of Locating Theater Sites," by E. G. Faludi, City Planning Consultant, Toronto, Ontario, Canada
  - "Technical Aspects of 16-Mm Feature Motion Picture Production," by R. Adams, Telefilm, Inc., Hollywood, California
  - "Animation," by K. Dodal, Irena Film Studios, New York, New York

## Tuesday, May 18

- 9:30 A.M. Registration, Sixth Floor, Santa Monica Ambassador Hotel  
Advance Sale of Banquet Tickets
- 10:00 A.M. Technical Session, Magnolia Room  
Session will open with a 35-mm motion picture short
- "The Present State of the Art in Evaluating Loudspeaker Performance," by J. K. Hilliard, Altec Lansing Corporation, Los Angeles, California
  - "An Experiment in Stereophonic Sound," by L. D. Grignon, 20th Century-Fox Film Corporation, Beverly Hills, California
  - "Double-Width Optical System for Recording," by L. T. Sachtleben, RCA Victor Division, Radio Corporation of America, Camden, New Jersey
  - "The Technique of Reducing Sound Distortion by Compromise Adjustments and Anticipation of Noise Reduction," by R. A. Dupy, Metro-Goldwyn-Mayer Studios, Culver City, California
  - "Progress Report on the Standardization of Home Phonograph Recording and Reproduction," J. K. Hilliard, Altec Lansing Corporation, Los Angeles, California
- 2:00 P.M. Technical Session, Magnolia Room  
Session will open with a 35-mm motion picture short
- "Magnetic-Sound Recording for the Motion Picture Technician," by D. O'Dea, RCA Victor Division, Radio Corporation of America, Hollywood, California
  - "Magnetic-Recording Heads," by G. L. Dimmick, Radio Corporation of America, Indianapolis, Indiana
  - "Film-Drive System for a Combination Photographic and Magnetic Sound Recorder," by J. L. Pettus, RCA Victor Division, Radio Corporation of America, Hollywood, California
  - "Some Distinctive Properties of Magnetic Recording Media," by Robert Herr, Minnesota Mining and Manufacturing Co., St. Paul, Minnesota
  - "Magnetic Recording as a Solution to Certain Sound Production Problems," by J. T. Mullin, W. A. Palmer and Company, San Francisco, California

**Tuesday, May 18 (Continued)**

- 2:00 P.M. Technical Session (*continued*)  
 "Stereophonic Magnetic Recording," by Marvin Camras, Armour Research Foundation, Chicago, Illinois  
 "Magnetic Sound for 8-Mm Motion Pictures," by H. A. Leedy, Armour Research Foundation, Chicago, Illinois
- 2:00 P.M. Technical Session, Rouge Room, Fourth Floor, Santa Monica Ambassador Hotel  
 New Equipment Items. The equipment or techniques described will be on display  
 "An Improved Camera Crane," by Andre Crot, Motion Picture Research Council, Hollywood, California  
 "Soundproofing Generators," by Earl Miller, RKO Studios, Hollywood, California  
 "An Improved Artificial Snow," by M. Martin, RKO Studios, Hollywood, California  
 "Make-Believe Bullet Holes," by M. Martin, RKO Studios, Hollywood, California  
 "A Magnetic Device for Cuing Film," by James A. Larsen, Academy Films, Hollywood, California  
 "An Improved 35-Mm Synchronous Counter," by Robert A. Sater and J. W. Kaylor, Cinecolor Corporation, Burbank, California  
 "1000-Foot Bipack Magazine and Adapter," by W. R. Holm and J. W. Kaylor, Cinecolor Corporation, Burbank, California  
 "Splicing Machine," by E. J. Denison, United Artists Productions, Hollywood, California  
 "Depth of Field Indicator," by C. R. Daily, Paramount Pictures, Inc., Hollywood, California  
 "A Time-Interval Marking Device for Motion Picture Cameras," by C. N. Edwards, U. S. Naval Photographic Center, Anacostia, D. C.
- 8:00 P.M. Technical Session, Magnolia Room  
 Session will open with a 35-mm motion picture short  
 "Sensitometric Aspects of Television Monitor-Tube Photography," by F. G. Albin, RCA Victor Division, Radio Corporation of America, Hollywood, California  
 "16-Mm Film as a Medium for Television Program Material," by J. A. Maurer, J. A. Maurer, Inc., Long Island City, New York  
 "Programming Aspect of Television Production," by R. A. Monfort, Times-Mirror Company, Los Angeles, California  
 "Films for Television," by Jerry Fairbanks, Jerry Fairbanks, Inc., Hollywood, California  
 "Television Transmission Facilities to Be Provided by the Telephone Companies," by E. H. Schreiber, Pacific Telephone and Telegraph Company, Los Angeles, California  
 Demonstration of Direct Pickup Large-Screen Television



### Wednesday, May 19

- 9:30 A.M. Registration, Sixth Floor, Ambassador Hotel  
Advance Sale of Banquet Tickets
- 10:30 A.M. Demonstration by Thorobred Photo Service, Inc., at Hollywood Park Race Track; by arrangement with Colonel Nathan Levinson Warner Bros. Pictures, Inc.

This demonstration of the methods used in horserace photography is limited to registrants and wives. Cab service will be available from the Santa Monica Ambassador Hotel to Hollywood Park. A regular afternoon racing session begins at 1:00 P.M. Members are welcome to spend the afternoon at the track.

#### OPEN AFTERNOON

NOTE: Registration headquarters will be open on this afternoon until 3:00 P.M. for those desiring Banquet tickets and making table reservations.

- 7:15 P.M. Cocktail Hour, for holders of Banquet tickets, Rouge Room, Santa Monica Ambassador Hotel
- 8:30 P.M. 63rd Semiannual Banquet (dress optional), Magnolia Room, Santa Monica Ambassador Hotel. Entertainment and dancing

### Thursday, May 20

#### OPEN MORNING

- 2:00 P.M. Technical Session, Magnolia Room  
Joint meeting with Inter-Society Color Council  
Session will open with a 35-mm motion picture short (in color)  
"Characteristics of Light Sources," by Norman Macbeth, Consulting Engineer, New York, New York  
"Color Phenomena," by I. A. Balinkin, University of Cincinnati  
"Basic Principles of Color Systems," by Carl E. Foss, Inter-Society Color Council  
"Some Systems in Color Preference," by J. P. Guilford, Beverly Hills, California
- 2:00 P.M. Technical Session, Rouge Room  
New Equipment Items. . The equipment or techniques described will be on display  
"New Microphone," by Howard Souther, Stephens Manufacturing Company, Los Angeles, California  
"New Speaker for Separate Two-Way Systems," by Howard Souther, Stephens Manufacturing Company, Los Angeles, California  
"An Improved 35-Mm to 16-Mm Optical Reduction Sound Printer," by J. L. Pettus, RCA Victor Division, Radio Corporation of America, Hollywood, California  
"16-Mm Film Phonograph," by C. E. Hittle, RCA Victor Division, Radio Corporation of America, Hollywood, California  
"New Location Trucks," by Staff Member, RCA Victor Division, Radio Corporation of America, Hollywood, California

**Thursday, May 20** (*continued*)

- 2:00 P.M. Technical Session (*continued*)  
 "A New Film Gate," by C. Wagner, Chris Wagner Company, Los Angeles, California  
 "Notch Cued Sound-Track Control," by J. D. Stack, 20th Century-Fox Film Corporation, Beverly Hills, California  
 "Review-Room Footage Counter," by J. D. Stack and R. Quantstrom, 20th Century-Fox Film Corporation, Beverly Hills, California  
 "A Graphic Equalizer," by Fred R. Wilson, Samuel Goldwyn Studios, Hollywood, California
- 8:00 P.M. Technical Session, Academy Award Theatre, 9038 Melrose Ave., Los Angeles, California  
 Joint meeting with Inter-Society Color Council  
 Session will open with a 35-mm motion picture short (in color)  
 Demonstration Lecture: "An Introduction to Color," by Ralph M. Evans, Eastman Kodak Company, Rochester, New York

**Friday, May 21**

## OPEN MORNING

- 2:00 P.M. Technical Session, Magnolia Room  
 Session will open with a 35-mm motion picture short  
 "An Integral Disk Recording and 8-Mm Motion Picture Reel for Synchronized Sound Motion Pictures," by P. Goldstone and R. Like, Phonovision Corporation, Hollywood, California  
 "Specifications for Variable-Area Sound Track on 16-Mm Kodachrome," by R. G. Hufford and N. L. Simmons, Eastman Kodak Company, Hollywood, California, and R. V. McKie, RCA Victor Division, Radio Corporation of America, Hollywood, California  
 "Bipack Photography," by Thomas Gavey, University of Southern California, Los Angeles, California  
 "Make-up for Color Photography," by Hal King, Max Factor and Company, Hollywood, California  
 "The Motion Picture Research Council—Its Functions and Activities," by W. F. Kelley, Motion Picture Research Council, Hollywood, California
- 8:00 P.M. Technical Session, Magnolia Room  
 Session will open with a 35-mm motion picture short  
 "Principles and Practice of Three-Color Subtractive Photography," by W. T. Hanson and F. Richey, Research Laboratories, Eastman Kodak Company, Rochester, New York  
 "Masking in Color Duplication," by T. H. Miller, Eastman Kodak Company, Rochester, New York  
 "The Analysis of Developers and Bleach for Color Reversible Film," by A. H. Brunner, Jr., P. B. Means, Jr., and R. H. Zappert, Research Laboratory, Ansco Division, General Aniline and Film Corporation, Binghamton, New York  
 Adjournment of the 63rd Semiannual Convention

# Journal of the Society of Motion Picture Engineers

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## Theater Engineering Conference

### Floor Coverings

# Buying Carpet by the Pound\*

BY JOHN V. SMEALLIE

MOHAWK CARPET MILLS, AMSTERDAM, NEW YORK

*Summary*—Carpeting is a major cost in the theater furnishing budget and is still greater in the maintenance and replacement program. An approach to a better understanding of this problem is a study from the angle of "Buying Carpet by the Pound."

FACED WITH A dozen or more vital points in specifications governing the quality of carpet-fabric construction, a purchaser must have a rather simple but final rule to govern his selection not only between offers made by different supply factors but also between the several types of weave constructions. Each type of weave requires a proper balance of pitch in the weft, rows, or wires per inch in the warp, pile height, yarn type, and size as well as the quality of the materials used.

Realizing that as much as five sixths of the enormous tonnage of raw materials consumed in carpet production in the United States is imported, one can quickly appreciate that the major cost of the finished fabric is in the material with a relatively small percentage required for the fabrication in labor costs and sundries.

"Buying Carpet by the Pound" might, therefore, be suggested as a slogan to guide one in the decisions that will follow the use of more detailed formulas.

No one element of construction makes a carpet but rather the proper co-ordination and balancing of all elements are necessary in order to produce a fabric of maximum value. First it is conceded that only virgin-wool stable of the accepted Class Three dutyfree government specifications type will be used for the surface yarns. Years of laboratory testing, long spinning experience, and fabric-wear tests both on machines and in traffic use will determine the proper blending of many types of stable in varying percentages to obtain the ultimate

\* Presented October 21, 1947, at the SMPE Convention in New York.

perfection from the 200 or more kinds grown and imported from all the world continents.

The first point to be determined might well be the advisability of selecting woolen or worsted yarn for the desired installation. While sheep wool will be used in both instances, the fibers will be selected, scoured, blended, and spun into the two forms of yarn to be woven into different types of fabric, to be installed to serve different purposes, and to be maintained in different methods of procedure.

Woolen yarn, forming the greater yardage in common use, is spun from fibers measuring from the shortest up to about nine inches in length. These are interlocked as much as possible in fifty-four motions on the carding machines and then rather tightly twisted in the single yarn. When piled up and used in a cut-pile weave, woolen yarn will resist the penetration of dirt particles. It can be distinguished easily by a tendency to shed the very shortest fibers upon close examination and use.

Worsted yarn, in contrast, is spun from fibers between three quarters of an inch in length up to twenty inches or more after the shortest fibers have been combed out as noil and disposed of by the spinner as a by-product. Worsted yarn will be much smaller in diameter in the single strand than woolen and will have comparatively little twist. Worsted yarn will serve as the best form of yarn for most of the round wire or uncut looped pile constructions and the fibers will stand erect and parallel in the cut-pile constructions. Dirt particles will work down in the worsted-pile surface demanding more harsh and more frequent cleaning than woolen.

The many weaves and myriad qualities in woolen will serve best in all general installations where traffic wear is expected. Worsted construction will serve best where traffic is excessive, where cleanliness is demanded, and where frequent cleaning is possible. As the spinning of worsted yarn might cost approximately one third per pound more than woolen to manufacture there must be a very definite reason for its selection.

Long considered ideal for use in dining areas, Pullman cars, hospital installations, and the like, where woolen lint would be found objectionable, worsted is likewise of value in powder rooms, smoking lounges, and the like in theaters.

Carpet quality may vary in a dozen specifications but at least five seem to be the most important.

First, the pitch or the number of pile ends of surface yarn per inch

of weft width of the fabric, which is usually noted as 189 pitch or seven tufts to the inch in the 27-inch basic width, as in the standard Axminster construction and many woolen qualities. In the finer worsted yarn the pitch would be greater, as found in a good quality of the Wilton weave with nine and a half tufts to the inch and known as 256 pitch.

Second, the number of rows of tufts to the inch in the warp direction of the fabric in the Axminster and Chenille weaves and known as wires in the Tapestry, Velvet, Brussels, and Wilton weaves.

Third, pile height, which is the actual height of the tufts of surface yarn from the top of the fabric to the backing material.

Fourth, the pile yarn itself, whether woolen or worsted, and the size numbered according to a standard table. The question of the number of plies in the yarn used develops the thought that it is the density of the actual fibers that determines the wear of the finished fabric.

The United States Bureau of Standards formula, that is accepted by the carpet trade, declares that the wear index varies as the square of the density times the height of pile, or the formula  $D^2h$  indicating true value, with the height of pile covering only the luxury factor.

Fifth, the general quality standards of all the materials used including the backing yarns which are a proper combination of vegetable fibers such as cotton, jute, and kraftcord.

Carpet wool is a very rough, absorbent type of fiber which has a tremendous affinity for color matter allowing the use of twenty thousand shades of color or a many times greater number than any other fiber or forms of color use. Every crystal of dye used to obtain a desired color will be absorbed by the fiber adding bulk, weight, and wear. Again, wool is the highest in hygroscopic or moisture weight and will vary constantly with the changes in the surrounding atmosphere.

There are five general types of weaving methods in common use today. All will furnish suitable fabric constructions, color, and design accomplishments as well as meet different budget figures in theater furnishings. These weaves are not competitive but they will overlap in the price brackets. They can be woven and sold from approximately 50 cents per carpet yard to \$94.50 per square yard which was recently quoted for a theater-lobby rug in custom-order Chenille hand-carved to outline angelic figures in intaglio.

The weave names can be associated with the fingers on one's hand in order to place them in their relative price brackets. On the little

finger we can place the Tapestry round-wire weave as the lowest in the price scale and woven to meet the humblest budget. Worsted yarn and a chrome-set dye are commonly used when pattern is desired. This weave will give remarkable service with the traffic wear falling on the side of the yarn loops.

The second or ring finger will indicate the cut-pile Velvet weave where we find the volume yardage of plain or solid-color production from beams of yarn supplied as warp. Here again, the woolen or worsted yarns that are used must be chrome-dyed to withstand the scouring out of the flour used in applying the dye in patterned goods. Steam-set twisted yarns give splendid service in this weave.

The middle finger will indicate our only American invention in carpet-loom production, Axminster. Woolen yarns are used in unlimited color range to furnish almost one half of the total yardage in this middle price bracket.

The index finger will indicate the Jacquard Wilton weave where delicacy of design and a sense of luxury can be accomplished with the use of the Jacquard pattern control. The pile yarns that are not needed to form the pattern will be bound in the body and back of the construction giving this weave the concealed quality or cushion back that assures softness underfoot and a long-wear life. These four constructions furnish the popular demand and are woven on semiautomatic looms usually operated by small individual electric motors.

The thumb, in turn, will indicate custom-order Chenille, which is a twofold weave requiring a hand-tufting operation in the second weaving process. This type is known as "the weave of unlimited possibilities." It is woven up to thirty feet in width, seamless, any length, any shape, any coloring, and any design in woolen or worsted yarns or combination thereof. Popular in rug form or complete carpet coverage in theater lobbies, foyers, lounges, and other public spaces, this weave is finding new uses constantly through its versatility.

The modern texture trend allows for carved, embossed, etched, sculptured, or intaglio effects in cut-pile constructions. Irregularity of pile in both looped and cut-pile surfaces often gives added third-dimensional decorative effects. Many of these up-to-the-minute creations as well as special designing and coloring to suit architectural decorative desires can be obtained at no added per-pound cost.

With all these facts in mind a purchaser of carpet can appreciate that actually he is buying carpet by the pound. Also believing that no carpet is any better than the ultimate service that it renders, he



will be concerned further in the proper installation and maintenance. Absolutely smooth floor surfaces must be assured, for the slightest irregularities show up immediately in the fabric surface. The proper underlay should be chosen on the basis of budget cost which might be twenty per cent, rather than the mistaken idea that a thick or particularly resilient cushion will redeem an inexpensive carpet.

The use of modern tacking strips, such as Roberts Smoothedge, for example, will cost less than drilling and doweling holes in concrete floors. The use of these patented strips will allow for refitting or removal for cleaning more readily than former tacking and fastener methods used.

It has been proved that clean carpet will outwear dirty fabric. It is well to set up very definite rules for maintenance. Worsted cut-pile weaves should be cleaned harshly and often in order to extract the dirt crystals that have seven to seventeen cutting edges which will cut the wool fibers in traffic wear. Woolen cut-pile weaves should be vacuumed regularly as deemed necessary. As wool fibers have such a high moisture weight it must be assured that the needed water vapor will be carried in the surrounding atmosphere to guarantee a satisfactory wear life. Where air conditioning or control systems are functioning properly the carpet will render remarkable service.

## Theater Engineering Conference

### *Floor Coverings*

# Carpet Construction and Installation\*

BY OLIVER P. BECKWITH

ALEXANDER SMITH AND SONS CARPET COMPANY, YONKERS 1,  
NEW YORK

*Summary*—The factors affecting the service and wear of pile floor coverings are discussed, particularly in relation to theater carpets and rugs. An attempt is made to show how this information can be exploited by the theater operator to his own advantage in terms of obtaining longer wear and less replacement from his carpet.

CARPETS AND RUGS are not inventions of the nineteenth and twentieth centuries. They have been made by man for thousands of years to cover the floors of his home, whether it be a tent or a palace, a bungalow, or a mansion. Their manufacture, until recent times, has been an art in which the required skills were handed down from father to son.

Carpets and rugs suitable for public buildings, where the traffic over them amounts to hundreds of thousands of people per year, are creations of the twentieth century. While their color, design, and appearance are created by the artist with his age-old heritages from the masters of every century, their ability to receive the brutal punishment of thousands of footsteps for many years, and to retain their original beauty is an achievement engineered into them on the basis of knowledge developed in the modern laboratories of America.

The theater operator needs to know the factors of carpet construction and installation affecting wear. Any moderate-sized theater has an investment of hundreds of dollars in its floor coverings. Poor performance not only means the added costs of too frequent carpet replacement but costs of installation as well, by no means an insignificant amount. Then, too, intangible liabilities are created from

\* Presented October 21, 1947, at the SMPE Convention in New York.

wornout appearance and condition, customer reaction, and sometimes accidents and claims.

It might be in order at this time to classify the quality characteristics of carpets and rugs. These are shown in Fig. 1. It will be noted that the left-hand side relates the aesthetic wants; as these fall within the province of the artist and designer, not the engineer, we shall not consider them here. The right-hand side lists the practical wants, those of service and wear. In this paper we shall concern ourselves with two of the three items under service and wear, wear life and durability of original structure. Time does not permit discus-

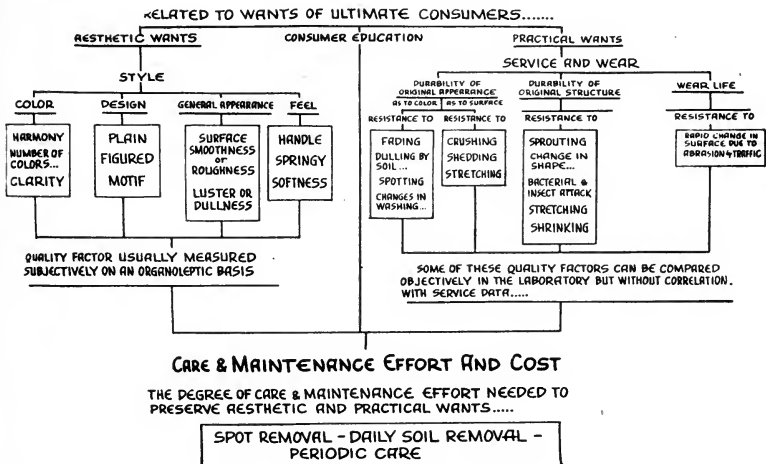


FIG. 1—Classification of the quality characteristics of carpets and rugs.

sion of the third, durability of original appearance, although it is a subject important enough to warrant a separate paper.

Wear life of carpet, that is resistance to rapid change in surface-caused abrasion by traffic, is affected by four things.

1. The kind of fiber used in the surface.
2. The processing to which the fiber has been subjected.
3. The construction in which the carpet has been woven.
4. The manner of installation.

Practically all pile floor coverings used in theaters today are made with a surface of carpet wools. These wools are imported into the United States since they are not raised here. They come from every continent and there are 200 or more different kinds and types. The

wear resistance of the various wools has been the subject of considerable study and research. Testing equipment developed by the United States National Bureau of Standards and by laboratories of carpet manufacturers has enabled the engineer to evaluate the wear life of the wools used as some carpet wools are longer wearing than others.

The manner in which the wools are processed during the fabrication of carpet affects the amount of wear obtained from the fiber. Wools have to be scoured in strong alkalis, dried at high temperatures, dyed in the presence of strong acids and at high temperatures, twisted and distorted in spinning, and stretched in weaving. All these things can reduce the amount of wear inherent in the original fiber if these operations are not rigidly controlled. As early as 1930 experimental work was performed which showed that prolonged boiling in water alone made tremendous reductions in the wear life of carpet whose pile yarn had been so treated.<sup>1</sup>

The foregoing two points are things which the buyer and user of theater carpet cannot control in the selection of his floor covering. He must depend on the technical skill of the manufacturer from whom he buys. Therefore his only safeguard that the fabric he buys contains the longest wearing wools, processed so as to retain practically all of their inherent wear value, is to know the extent to which the carpet manufacturer carries on research and development activities devoted to this end.

The construction in which the carpet has been woven plays a tremendous part in the wear life obtainable from it. Wear is a function of the amount of wool woven into the fabric; the more wool, the longer wear life. But the surface form in which the wool is woven into the fabric plays an important part in the wear life. It can be said that there are two factors of form which affect the amount of wear obtained. These are the density of the pile or the nap and its height. Research work<sup>2-4</sup> at the National Bureau of Standards has shown that, all other factors being constant, the wear index of a carpet varies as the square of the density times the pile height as shown in Fig. 2, taken from Research Paper<sup>3</sup> No. 640 of the National Bureau of Standards. Wear index is the number of thousands of revolutions of the wear-test machine required to wear out the carpet, i. e., reduce it to a mathematically determined end point. Translated into everyday terms this means that if one carpet is twice as dense as another, other things being equal, it will wear four times as long. On the other hand,

if one carpet has twice the pile height of another, other things being equal, it will wear only twice as long.

A practical lesson to be learned from the foregoing data is that when a theater operator buys a pile floor covering for wear and the choice is between two fabrics of about the same pile height, he should buy the fabric of the highest density. Another factor of importance to the theater operator when buying carpet for wear is the efficiency with which all of the wool woven into the fabric is used; wool is the wearing surface; it is the most costly component of the carpet; hence, for maximum wear value per dollar as much of the pile wool as possible should appear on the surface of the carpet.

The Velvet weave has a distinct advantage in that practically all of the wool yarn used in the rug appears in the surface and this advantage has given it its pre-eminent place wherever long wear is the outstanding quality characteristic desired.

The manner in which carpet is installed affects the amount of wear that can be obtained from it. Underlays increase wear life because they absorb some of the energy expended on the carpet by the action of moving feet. Without the underlay the carpet

absorbs all the energy and this promotes the process of wearing out more rapidly than if underlays were used.

Some underlays are more effective than others. Sponge rubber, for example, does a better job of prolonging carpet wear than felt. The reason for this is that sponge rubber is more permanently resilient. After considerable traffic the felt underlay compresses and loses much of its original thickness. Consequently it is then unable to absorb as much of the energy imparted to carpet by traffic as it did originally. On the other hand, sponge rubber, after an equal amount of traffic, will retain practically its original thickness and original ability to absorb energy.

Fig. 3 shows laboratory wear tests of carpet without underlay, with

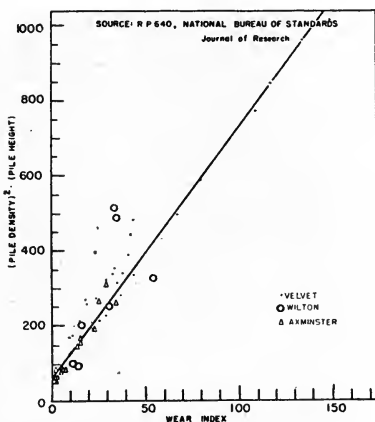


FIG. 2—Correlation of wear index with product of density squared and pile height.

a felt underlay, and with a sponge-rubber underlay. It will be noted that the felt underlay increased the wear 36 per cent over that of the same carpet without an underlay, but the increase from sponge rubber was 70 per cent.

The above results have been corroborated by service experience. In several installations on theater stairs it was found that carpet underlaid with  $\frac{1}{2}$ -inch sponge rubber lasted twice as long as carpet laid with 64-ounce felt.

One factor of carpet installation to which theater operators and carpet layers need to devote more attention is the protection of carpet

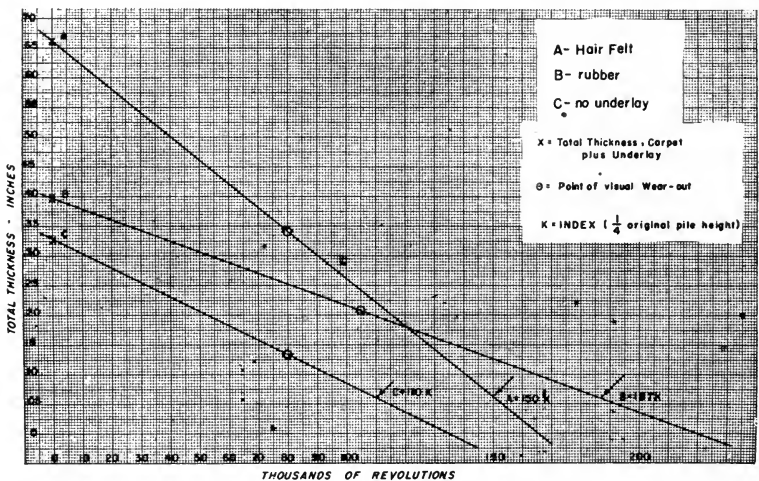


FIG. 3—Effect of underlay on wear-test index of carpet.

in areas where traffic is likely to be highly concentrated. For example, traffic will be much greater at the point where tickets are collected than at other areas, as at doorways, particularly narrow ones, where traffic is concentrated. On stairways that curve or change direction it will be found that most of the traffic takes the shorter arc. In locations such as these, extra provision should be made to protect the carpet. If it is a level area sponge rubber might be used in place of the felt used in the rest of the installation. If the area is on the stairs where the installation already calls for sponge rubber, use of a more dense rubber than on the rest of the stairs might be made. If no special precautions are taken to protect these areas then they should be frequently examined to determine the condition of the underlay.

Replacement should be made if there are evidences of marked loss in thickness of the underlay.

Durability of original structure affects carpet performance more than is realized. The ideal theater carpet is a relatively rigid structure whose backing yarns are for the most part inextensible materials such as jute or kraftcord. To cite an analogy, nylon, which can be molded readily as a plastic, is as high in tensile strength as some of our best steels. However, nylon could not be used as a construction material or for making machinery because it lacks the rigidity of steel. Carpet of every conceivable form of pile surface can be made with soft nonrigid backing materials. However, if this were put in use in a place such as a theater it would soon stretch, giving unsightly and hazardous ripples. This is particularly true in sloping aiseways of the orchestra section. The lengthwise stress on a carpet in such a location is very high and excessive stretching will take place if the back structure is not sufficiently rigid.

Installation conditions occasionally affect durability of original structure. Sometimes it occurs that a stairway having a very narrow tread, 10 inches or less, has to be carpeted. In such cases, it often happens that tufts are gouged out of the carpet on the riser area. This occurs because with a tread as narrow as this the heel of the foot in descending must necessarily scrape heavily over the riser portion. Where narrow-tread stairs are to be carpeted this condition should be watched for as time progresses. It is generally possible to replace tufts without difficulty if the condition is caught before it becomes widespread.

Indiscriminate wetting of carpet can result in serious damage to the floor covering. When the backing structure gets wet, as might occur in areas near drinking fountains and street doors, or after a carpet has been carelessly floor-shampooed, mildew may develop. This is particularly true in summer weather when high humidities prevent rapid drying. Dampness, darkness, and relatively high temperatures are ideal conditions for the growth of cellulose-destroying fungi. These microorganisms so lower the strength of the cellulose backing yarns that the carpet literally falls apart. While antiseptics are being developed for the application to the backing yarns of carpet, there is as yet no treatment that will provide complete mildew resistance under all conditions of use.

In conclusion it is hoped that this presentation has demonstrated the wealth of technical and engineering data available on carpet for

theaters which have been collected in the laboratory. The able theater operator could exploit this knowledge to his own advantage in terms of obtaining longer wear and less replacement from his carpet.

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## Theater Engineering Conference

### Floor Coverings

# Rubber Floor Coverings\*

BY T. S. SAVOURY

UNITED STATES RUBBER COMPANY, NEW YORK, NEW YORK

*Summary*—The most important problem with which theater operators have to contend is maintenance, i. e., the prevention of dirt, grit, slush, and moisture from being carried into the theater proper so as not to mar the desired clean atmosphere.

Rubber floor coverings of every description have been universally used for this purpose because of the material's ability to stand up under the most adverse conditions. These coverings consist of corrugated mattings, perforated mats, link mats, rubber tile, and sheet flooring. There are various types of each, and all are designed to serve definite needs.

**B**ASICALLY ALL rubber floor coverings are made of natural, synthetic, or reclaimed crudes. These crudes are mixed with other ingredients, such as fillers, pigments, and vulcanizing agents. The compounds formed are then vulcanized under extreme heat and pressure. The surface designs, such as corrugated, pyramid, or a smooth slick finish are accomplished by molds used in the vulcanization process. There are a wide range of thicknesses available from  $\frac{3}{32}$  to  $\frac{1}{2}$  inch to meet any flooring requirements. The use of mats and mattings is governed for the most part by location.

Let us consider the outer lobby first. What is desired of a rubber floor covering in the outer lobby? First of all, it should prevent slipping, second, it should pick moisture and grit off the patrons' shoes before the carpeted areas are reached, and third, it should be decorative, so that it will harmonize with your color schemes. All three purposes can be achieved with custom-made corrugated and perforated mats. Corrugations prevent slipping and act as silent foot scrapers. Perforations catch the grit and help keep it off the surface. Decorative schemes can be accomplished by variations in color and in-laid design. Experienced mat manufacturers today can produce practically any design in an almost unlimited variety of color combinations-

\* Presented October 21, 1947, at the SMPE Convention in New York.

Corrugated and perforated mats are generally made  $\frac{3}{8}$  or  $\frac{1}{2}$  inch thick. They are reinforced in the center with heavy, specially treated duck which prevents the mats from stretching out of shape, and increases their service life appreciably. While link mats can be used for the same location and service, they lack some of the features of the perforated and corrugated type. The most commonly used type of link mat is made of extruded rubber that is cut into small segments and assembled by wires. But decorative possibilities are limited. The rubber is not reinforced with fabric. Wires are subject to rust, corrosion, and distortion, thus shortening service life.

In the inner lobby, there is a great advantage in the use of custom-made perforated and corrugated mats. In addition to the features just pointed out, these mats are highly abrasion-resistant and have outstanding wearing qualities. They are relatively easy to maintain, because they can be taken up, cleaned, and relayed at frequent intervals, and they are *sanitary*. Inner-lobby mat designs and colors can be made to harmonize with interior decoration or to vary from those used in outer lobby mats, if desired.

Powder rooms and smoking rooms present different problems. Here either sheet flooring or rubber tile should be used, provided the floors are "above grade." These materials should never be used on or below grade where no air space is provided under the subfloor, and consequently where sweating is likely to occur. Sheet flooring and block tile can be made in practically any color, tone, or shade desired. Therefore a wide variety of color and design combinations can be accomplished with them. Both are usually made with highly polished surfaces and must be waxed frequently. Either sheet flooring or block tile must be cemented down by skilled experts, and not by the amateur. Rubber tile is made in blocks ranging from 4- to 36-inch squares and in thickness ranging from  $\frac{1}{8}$  to  $\frac{1}{4}$  inch.

Although sheet flooring used in theaters customarily is  $\frac{1}{8}$  inch thick, other gauges can be made ranging from  $\frac{3}{32}$  to  $\frac{1}{4}$  inch. Sheets usually are 36 inches wide and 25 yards long.

There is, however, a special type of sheet flooring that has unusual possibilities for theater use. With this type, intricate designs can be reproduced by assembling segments having different colors and shapes and vulcanizing the entire combination into an inseparable unit at the factory. Consequently, an entire floor covering of attractive design can be shipped in large units and laid without cementing. The surface of this type is not highly polished but has a suedelike finish

and has the soft appearance of a carpet. This contributes to safety, since it prevents slipping.

Sheet-rubber flooring can be used to advantage on steps and risers. Here, too, the long-wearing quality and easy maintenance of sheet-rubber flooring of correct construction will contribute to economy. Color can serve as an additional function, it can brighten and call attention to the stair edge, especially where soft lights are used. For instance, a narrow, brighter-colored contrasting strip can be inserted at the edge of the tread, and, of course, color harmony as well as safety can be accomplished.

Rubber nosing is used to prolong the life of carpet on stairs. Normally the edge of the carpet wears more rapidly than the flat surfaces. Frayed edges are not only unsightly but dangerous, and can cause tripping. In most cases nosings are used on steps where carpet has already frayed. The worn portions of the carpet are cut out across the full width of the tread, the nosing is then cemented to the step almost up to the edge of the remaining carpet, and the carpet tacked down over a recessed lip of the nosing. This makes a flush joint.

In the aisles and seating area, rubber should not be used, except in two cases. The two exceptions are first, the rubber-matting runner, a commonplace temporary covering. Its chief function in this area is to protect carpeting in bad weather. Most runners are made of reclaimed rubber and are generally made in black or maroon. They should have cloth insertions or cloth backs to prevent distortion and to prolong their life. The second exception is rubber underlay or lining which will be covered in the following paper.

Although considerable research work has been done toward developing practical rubber floor covering that is as quiet as carpet, we do not as yet believe that the problem has been solved. Therefore, we refer you to our friends in the carpet industry.

## Theater Engineering Conference

### Floor Coverings

# Carpet Wear Increased with Sponge Rubber\*

BY W. LLOYD JANTZEN

UNITED STATES RUBBER COMPANY, NEW YORK, NEW YORK

*Summary*—As is well known, sponge rubber as such, has been in use for many years in a variety of articles. And like so many other things made of rubber, great strides have been made in scientifically improving its compound to suit different conditions and circumstances.

FOR MORE THAN ten years sponge rubber in sheet form has been used as a carpet cushion until today a very large percentage of the production of sheet sponge rubber is used for this purpose. Repeat orders from the same users who started with it ten years or more ago prove conclusively that sponge-rubber cushions make carpets wear longer.

There are several reasons for this. First, rubber recovers or returns to its original thickness completely, whereas under pounding heels, other materials, such as hair lining or hair and jute, mat down. The mere fact that sponge rubber recovers its height completely and continuously naturally protects the carpet no matter how much pounding it receives. Second, in order to accomplish that super-lush softness many theaters resort to extra thick padding, with the result that people's feet sink too deep and since most of us do not lift our feet very high in our natural stride, the shoes scrape the carpet surface slightly thereby causing unnecessary wear on the carpet surface.

While produced in thicknesses of from  $\frac{3}{32}$  to 1 inch, for average locations, the carpet cushion in  $\frac{1}{4}$ -inch thickness is recommended and for areas where extra thickness is desired  $\frac{3}{8}$ -inch thickness is ample. It is produced in rolls of approximately 20 yards in 36- and 53-inch widths.

When used on stairs sponge rubber has extended the life of carpets,

\* Presented October 21, 1947, at the SMPE Convention in New York.

especially at the edge where the wear is greatest. A report issued recently by an outside testing laboratory regarding the results of tests conducted on different types of padding states: "There have been a number of inquiries recently about the efficiency of sponge rubber as a carpet underlay *versus* other underlay products. Our laboratory has forwarded information which summarizes tests made on installations of stair carpet using different underlays. Eight underlays were tested including three jute, two jute-hair, one cotton-paper, and two sponge-rubber underlays. As compared to an installation without underlay it was found that a jute-hair underlay of 0.42 inch in thickness gave the same increase in wear to the carpet as a sponge-rubber pad of 0.23 inch in thickness. However, during the test the sponge rubber maintained its thickness whereas the jute-hair pad reduced in thickness nearly 50 per cent. When the jute-hair pad mentioned was reused the increase in the carpet's wear life as compared to carpet without underlay was only about one half of the increase obtained when the new jute-hair pad was used. As shown by this test it is undoubtedly preferable to install new padding than to reuse the old. Because sponge rubber maintains its thickness under use and reuse it has a distinct advantage in this characteristic."

This sponge rubber is compounded of crude rubber and comes in black with a red marbled design. The odor of rubber has been removed and a faint pleasant aromatic scent has been added. It is easily laid directly to the floor, and can be bonded with the usual water-soluble glue. The edges are trimmed square and can be abutted with a pressure adhesive tape. The carpet laid over it should extend about  $\frac{3}{4}$  inch beyond the edge of the sponge-rubber underlay and anchored in the conventional way.

Sponge rubber has unusual gripping qualities and prevents carpets from slipping and creeping. This is especially noteworthy since most aisle carpets have a tendency to bunch up at the foot of the aisle. Sponge rubber anchors the carpets and prevents this common difficulty.

Carpets can be cleaned better and easier since grit cannot get into the sponge rubber and whatever does filter through the carpet goes no farther than the surface of the sponge and most of this is drawn out with vacuuming.

Also, sponge rubber is repulsive to vermin. There is nothing to feed on nor is there any way for vermin to get into it, the skin surface is impermeable and the pore structure is only partially porous.

Attention is drawn here to a very important point. You will note that this product is referred to as sponge rubber. The spongy pore structure of this product is accomplished with chemicals which react on the rubber in the curing process causing it to expand and form pores within the stock. These pores are only partially interconnecting—and both surfaces—there is no right or wrong side—are impermeable. This is as it should be for undercarpet application. Particular attention should be given to the difference between this chemically blown sponge designed for undercarpet cushions and foam rubber. While this could be called sponge rubber too, it is never referred to as such because of its totally different characteristics. Foam rubber is completely different from any other class of rubber in that it is porous through and through. The pores within the stock are entirely interconnecting, and both surfaces are also porous. You can blow air and smoke through it and you can pour water through it. Because of this extreme porosity it is ideal for seating, mattresses, and pillows, since it easily dissipates body heat.

The chemically blown sheet sponge rubber designed for carpet underlay has been in use in theaters, hotels, and Pullman cars since prewar days and as a result has grown remarkably in popularity. Where it came in contact with heater pipes along the edge of Pullman cars it had a tendency to crystallize slightly but the migration of this crystallization was confined to within an inch of the edge of the rubber and when rehabilitation work was necessary on the cars, no sponge-rubber cushioning was required to be replaced.

This product is now in production and is currently available throughout the country.

## Theater Engineering Conference

### *Floor Coverings*

# Vacuum Cleaning of Theaters\*

BY RICHARD WEBBER

THE SPENCER TURBINE COMPANY, HARTFORD 6, CONNECTICUT

*Summary*—This paper discusses the maintenance of soft floor coverings and its related subject, vacuum cleaning, and outlines the type of vacuum cleaners now available for theater cleaning, and their proper uses and maintenance, so that the carpets in theaters are always kept immaculately clean, the ever-present problem of the theater manager. Also it will attempt to show how expense in connection with the renewal of carpets and the cost of its maintenance can be held to a minimum by the use of properly designed vacuum-cleaning equipment.

**D**ETERIORATION in a carpet depends, of course, on the amount of traffic over its surface. The gradual thinning of the nap of the fabric is caused, however, mostly by imbedded sharp grit with nap-cutting action as the foot passes over the surface. Therefore, it is important that whatever cleaning medium is used it have sufficient power to remove the grit as well as the dust. For over 40 years the vacuum-cleaning industry has progressed steadily designing machines to meet the cleaning problems encountered in theaters. The problem today is that of selecting the vacuum-cleaning machine best suited to the specific need of the theater.

In considering vacuum cleaners, the first requirement is that it has to clean. Any other prevailing advantages it may have otherwise are worthless. Then we should consider the cost of labor, maintenance, power consumption, maneuverability, initial cost, and deterioration of the equipment. These are not listed in their proper sequence of importance, for what may be important to one manager may not be to another, but what is equally important to all is that there is an ever-present problem of cleaning the theater thoroughly, and to do so at a reasonable maintenance cost.

Basically there are several types of vacuum cleaners available, the stationary vacuum-cleaning system, commercial portable vacuum cleaners, and domestic portable vacuum cleaners.

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The stationary type, frequently referred to as the central or installed system, consists of a vacuum producer and dirt separator, both of which usually are located in or near the boiler room, with piping installed throughout the theater, having hose-connecting outlets so located that a porter using a 50-foot length of 1½-inch diameter hose can reach and vacuum any part of the auditorium, mezzanine, balcony, sound screen, organ loft, fly gallery, in short, the entire theater. The initial cost of installing a stationary system is high as compared with the price range of the commercial portable vacuum cleaner, and more so as compared with the domestic portable vacuum cleaner. Yet it must not be overlooked that the incredible low maintenance of this system invariably offsets the high initial investment, for it is a fact that in a great many theaters after thirty years of service the stationary systems are still in good working order.

The low maintenance cost of this system is attributed to the fact that the vacuum producer is equipped with either a squirrel-cage or direct-current motor using electricity from the power service and not from the light system. This is an advantage because the motor in this case operates at 3500 or 1750 revolutions per minute, which is considered a slow operating speed and requires a minimum amount of maintenance, only requiring lubrication of the two motor bearings by the engineer every month or so. There are no wearing parts that have to be replaced, and also there are no problems such as frequently occur with any type of portable, such as having the equipment misused by the porters, parts such as wheels and castings broken through carelessness in handling, or the lack of maintenance of the motor which is overlooked and eventually results in expensive repairs and putting the portable cleaner out of service, usually when badly needed.

The stationary system also is the most sanitary means of cleaning because as the dirt and litter are sucked up by the cleaning nozzle from the carpets they are carried through the hose, through the piping, and eventually deposited in the dirt separator in the boiler room. The foul air, after passing through the vacuum producer, is discharged into the boiler flue, leaving the theater "clean-smelling."

The commercial portable vacuum cleaner, also known as the tank-type, primarily is designed for continuous heavy-duty service, embodying to a lesser degree some of the advantages of the stationary system mentioned before in connection with suction and dirt capacity, and the compactness and portability of the domestic type.

Many different makes of commercial portable vacuum cleaners are



available varying in cost and efficiency, each make being of a different type of construction and general design, using different types of motors, size of dirt receptacles, and filter bags, all designed to operate on the lighting circuit, which is usually 110 volts, single-phase, and therefore, usually equipped with a Universal-type motor, from  $\frac{1}{3}$  to  $1\frac{1}{2}$  horsepower. It is important to remember that the speed of these motors will vary from 7000 revolutions per minute to a high 12,000 revolutions per minute, and the higher the speed of the motor the greater the wear of the motor brushes and wearing down of the commutator, with, unless given very frequent maintenance, the eventual burning out of the motor, and the machine out of service. That is what we mean by high maintenance. With the commercial cleaner, it is important that it have a liberal dirt pan and filter bag of ample size, and have efficient suction at all times, in order to permit the continual operation by the porter to do a good cleaning job without having to stop and shake the filter bag and empty the dirt receptacle too frequently.

The domestic type of vacuum cleaning has been of great value to the housewife the world over, but when considered for use in a theater it should be remembered that this type has been designed primarily for limited duty. There are innumerable makes available, both in the upright and tank types.

The disadvantage of either of these types is the fact that they have extremely high-speed operating motors varying from 13,000 revolutions per minute to 16,000 revolutions per minute, and therefore the cost of repairs, replacement of motor bearings, switches, cords, and general servicing is frequent and high, and their efficiency is very low due to their small dirt capacity and low suction.

It has been proved by laboratory tests that, to do the best job, the proper suction at the carpet nozzle for removing dust and grit is 39-inch water lift, sometimes referred to by its equivalent, 3-inch mercury lift, or  $1\frac{1}{2}$ -pound lift, and the cleaner that comes nearest to this requirement is the right machine for the theater.

In conclusion, the stationary system in all cases, no matter by whom manufactured, gives the desired results just outlined, and makes possible the thorough and most sanitary means of cleaning the theater. The commercial portable vacuum cleaner will vary considerably depending on the make selected. This domestic portable vacuum cleaner has an extremely limited place in theater cleaning. Its only advantage is the low initial cost but this definitely is offset by its limited efficiency and high maintenance cost.

## Theater Engineering Conference

### *Floor Coverings*

# Maintenance of Hard Floor Coverings\*

BY DANIEL FRAAD, JR.

ALLIED MAINTENANCE COMPANY, NEW YORK, NEW YORK

*Summary*—The maintenance of hard floors has many aspects, but this paper will be restricted to telling how floors can best be cleaned, scrubbed, and waxed in order to maintain for them an attractive appearance.

THE TERM "maintenance" is a broad one that has many meanings. To an airplane mechanic, it conveys the thought of maintaining a motor. To a roofer, it means roofing. To a plumber, it means plumbing.

Even cleaning is not so concrete a thing to talk about as one might think as there are no specifications for it. One can talk of the weight of a rug and the height of the pile, or one can talk of a pilot-tube reading on a vacuum cleaner. But what is "clean"? What standards are there for cleaning? Before trying to clean a floor, therefore, it must be determined what degree of cleanliness is desired, which will be clarified later.

To maintain a hard floor at the highest level of cleanliness, it would have to be covered with antiseptics every time someone walked across it. If, under those standards, anyone had the temerity to expectorate on that floor, the entire building would have to be put in an autoclave.

The author has not had many experiences in maintaining theaters, but has had some which may better illustrate the point about degrees of cleanliness. During the war, the author's company was called to Oak Ridge, Tennessee, as consultant on maintenance. Among other things, they were struggling with a problem in a small motion picture theater there. The last row of seats was flush against a beaverboard

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partition. Right behind and above each seat was a large grease spot from the heads of people who sat in this last row and naturally leaned backward.

"We use this theater Sundays for church services and the lights are on," they said. "It is quite unsightly to have these smears behind each seat. How would you suggest that we clean them?"

Beaverboard is very porous and hence resistant to solvents. It is not only difficult to get oil out of beaverboard, it is practically impossible. It was, therefore, suggested that a good quality mineral oil be used to wipe the whole beaverboard partition. The problem was solved not by removing the spots by cleaning, but by uniformly dirtying the wall.

Thousands of stores and other establishments that have light-colored hard floor coverings furnish another composite example. They are swept daily but mopped thoroughly only once a week, probably on Saturday night. Bright and early Monday morning the floor is beautifully white or light, then it starts to tone down and down until about Friday it is a pleasant-looking gray. The floor has been maintained reasonably. Extreme measures have not been taken to clean it, but proper health safeguards have been taken. True, these floors are not antiseptic, but no one expects them to be.

A curious thing about floors is that after many have been dealt with it will be discovered that each develops a personality of its own. Identical terrazzo floors put down by the same company in the Pennsylvania Station and the Museum of Modern Art are as different after the passage of a little time as a dead-end kid and little Lord Fauntleroy. One has been toughened and hardened by the carelessness of rushing, shoving thousands of careless commuters and travelers. The other remains dainty and ladylike as though blooming tenderly in response to the careful, gentle tread of art lovers with time on their hands.

The same may have been found in theaters or movie houses. In one section of town, the theater will be genteel because its frequenters are respectful of property. They might even be people who would not think of throwing chewing gum on the floor, certainly not without first wrapping it in paper. But in another part of town one might be lucky to have the seats still attached after a Saturday matinee attended by young ladies and gentlemen of teen age and less. Here the floors will reflect a far different personality, possibly one hardened even to bubble gum.

Then, there are climatic factors which strongly affect the personality of hard-covered floors. The same floors in Montreal in the winter and in Palm Beach get different treatment, therefore have to be given different treatment in cleaning. In cities where there is snow on the ground most of the winter, it is necessary to cope not only with snow brought in, but with salt and snow which are tracked in, and must be cleaned differently than the light dust which is the most found at Palm Beach.

With the foregoing factors in mind, the one thing which will help most in solving some individual floor problem is the cleaning compound used. Irrespective of whether cleaning is done manually or by a scrubbing machine, the cleaning compound used will determine the efficiency of your operation.

To be more specific, the detergents or sequestering agents in a cleaning compound will determine whether cleaning is efficient and inexpensive or inefficient and expensive. The better the detergents, soap powders, or particular compounds used for a particular job the less will be paid for manpower or the less the electric bill will be for using a scrubbing machine.

It has been found in maintaining many floors that the greatest efficiency is obtained by the use of properly compounded materials, usually custom-compounded for particular types of jobs.

There are all sorts of cleaning compounds, such as soaps, on the market. They are all good for particular purposes. But none are good for all purposes. That is why care must be taken to use the right cleaner for the particular type of floor covering to be cleaned.

The way surface-reducing agents or water softeners (the compounds mentioned above) work, is as follows. The man with the mop spreads out the water containing the cleaning compounds, which should reduce surface tension, dilute the dirt, and begin to float it off the floor. If the compound does its work properly and softens the water, the mop slips easily and the worker accomplishes more. If the compounds are wrong, the mop lacks an easy slip, the man works too hard, and accomplishes less.

Among the best bases for many cleaners is trisodium phosphate. As a matter of fact, it is a very good cleaner in itself. But it is strong and must be used with care because it is also a good paint remover. If the workers are not careful and splatter it against the wall, the wall paint starts peeling off.

Also when trisodium phosphate is used, it must be buffered carefully to prevent crystallization. When this phenomenon occurs and the compound goes out of solution, crystals are formed and remain in the cracks of the floors. This crystallization develops great force, and will chip and spoil your floor.

Aside from finding the right compound, the next important thing is to buy mops with care. The average user will call up and say, "Send me a mop stick." There are five-foot mop sticks and seven-foot mop sticks. To bring costs down, get the long one. It is obvious that a man swinging the longer mop covers more ground over a wider arc and gets more done quicker.

The maintenance of composite floors, such as asphalt tile and linoleum, is a very large field, and much can be said about it. One must be very careful with asphalt-tile floors. Too many floors have been ruined by using the wrong type of wax and solvents. Asphalt tile has become very popular. It is made out of the end products of the destructive distillation of petroleum, and hence soluble in most organic solvents.

When a floor of this type is waxed a water-emulsion wax must be used. Carbon tetrachloride, for example, cannot be used to take out stains as asphalt is soluble in this and other organic cleaners. These floors can be hardened by mopping with just salt water. Bleeding, meaning the colors starting to blend together and becoming a sort of amorphous color rather than a well-defined one, can be stopped by using certain acids. Vinegar has been found to be an excellent acid for the purpose and easily obtained.

Marble floors present other problems. For example, a very strange thing happened at LaGuardia Field when the author's company took over the maintenance of the International Air Terminal. It was found that the floor became dirty quickly. It was a nice, red Tennessee-marble floor that had been treated so brutally that it was white, bleached. Too strong detergents had been used on it, and when a marble floor is too clean, the first person who walks on it leaves marks. It was necessary to dirty the floor a bit to bring it back to its nice red color.

Red Tennessee marble is a very common floor covering in lobbies. It should be pinkish, and the way to get it pink, if it is white, is not to wash it for a while, just let it get good and dirty. If it is desirable to keep up the appearance a bit, wash it with water only and mop it. As a matter of fact, this is an excellent way to clean a floor. If enough

water is put on a floor, most of the dirt will float off. Of course, the surface-tension reducing agents in water softeners help.

Some may ask why all this fuss about mopping a floor. This is perfectly natural if you have only small areas and little usage with which to contend:

Maintenance and cleaning always have been the forgotten and neglected factors in most business operations, but in recent years, there has been a decided change-over from the assignment of misfits and failures in other departments to the maintenance and cleaning chores. Business executives have found that it makes a decided difference in the profit-and-loss columns if maintenance problems are handled with as much thought and research as are given to other business problems.

Therefore, with regard to hard floor coverings, have an intelligent person carefully study your cleaning operations for three or four days. Have him check the cleaning compounds used to be sure that they are the right ones for the type of floors. Make sure that the mops and other equipment utilized are as efficient as possible and better floors and a less-expensive operation, irrespective of the area you have to keep in condition, will result.

# Theater Engineering Conference

## Floor Coverings

Note: At the request of Chairman A. Griffin Ashcroft, all discussion was held until the sixth and last paper in this group was presented. The material that follows, therefore, is in the nature of a panel or round-table discussion.

### DISCUSSION

MR. WADE: Mr. Beckwith, I am interested in knowing a little more about the qualities of this rubber lining. The name "sponge" is used, and that to my mind brings up the natural sponge which is quite water-absorbent. I imagine the name was just accidental rather than well thought out. I believe, from your description, this material is not water-absorbent. Is that correct?

MR. O. P. BECKWITH: I am not a rubber expert, so I cannot answer that, but I think the gentlemen from the United States Rubber Company can. I do not believe the sponge rubber absorbs water at all like natural sponge which we get from the sea. It is just a term used to describe the structure of the rubber itself which does look like a sponge. But I do not think whether or not it will absorb water would be too much of a problem in a theater, do you?

MR. WADE: In general, no, except for areas around water fountains where you might get a little splash, and then pass the water into the base of the rug.

MR. LLOYD JANTZEN: Answering your question as to the reason the word "sponge" is employed, that has probably been in existence for 25 years. Sponge rubber as such was developed in Europe about that number of years ago, and the structure of the stock itself appears spongy, similar to a marine sponge. It has a tendency to absorb moisture.

This particular class of sponge is highly absorbent (referring to foam rubber). The class of sponge that is used for undercarpets is only partially porous, within the stock, but as I stated earlier, the surfaces are impermeable, which means that they are absolutely airtight. No water can pass through the surface.

They can be cleaned. We do not recommend that they be swabbed by pouring water too freely on them, but they can be cleaned with a damp mop. You will find that the water will remain on the surface, and not go into the sponge in this undercarpet sponge. However, if this were used (referring to foam rubber), we do not, of course, recommend this. I only brought this along to show the contrast between foam rubber and sponge rubber. This material is used entirely for seating, mattresses, and pillows, because it dissipates body heat completely and entirely. That would not be a practical product for carpet cushioning. It does not have the tensile strength that the other does, nor does it have the abrasive resistance that this has. This is designed for the undercarpet job.

MR. WADE: In some of these sponge or foam rubbers there is a sort of recovery time. Whereas I do not think there is any actual flow of the material, there seems to be a sort of viscosity associated with some of the sponge or foam rubbers. Is there anything like a viscosity constant of any value associated with this material used in undercarpets?

MR. JANTZEN: I have never run across anything like that.

MR. WADE: Does it recover practically immediately from any deformation?

MR. JANTZEN: That is correct. It is merely a case of taking a steel plate and putting the rubber on it and pounding it for all you are worth with a hammer, and its recovery is immediate and complete.

MR. ZARO: Mr. Savoury recommended that rubber floor coverings not be laid on grade since I inferred no cement has been found which will retain the rubber to a cement slab on grade. On the other hand, Mr. Jantzen, in discussing the sponge-rubber underlay, made mention of fastening the sponge rubber to the surface with an insoluble water cement and binding the edges.

We have done a lot of experimenting and I have had considerable correspondence with your company on just this sort of thing. I wonder if you can explain that point to me.

MR. JANTZEN: Your question has to do with the type of bonding agent to use for bonding the sponge rubber to a cement floor?

MR. ZARO: That is right.

MR. JANTZEN: My experience has shown that the usual water-soluble type of glue employed for cementing linoleum to floors is also satisfactory in applying this to cement floors as well.

MR. ZARO: Actually we have used at least ten different types of adhesives and in each case eventually the rubber has crept. That was another question I wanted to ask. How actually could you prevent the rubber from creeping? You made mention of the fact that the rubber would grip the carpet, but in using a rubber underlay or floor covering in an aisle, where you have a certain amount of elevation, you do get a great deal of creeping. So far no one has ever explained to me what I could use or what could be used to eliminate it.

MR. JANTZEN: That has been one of the features of bonding the quarter-inch sponge rubber to the floor and then placing the carpet immediately over it, anchoring it at the edge in the conventional way where you anchor your carpet to the floor with the studs in the usual fashion. The nature of the sponge rubber is such that usually it does not skid on any kind of smooth surface even if not bonded. I do not know how to demonstrate that to you. Let us take a sheet of steel for example. You cannot make the rubber skid. As a matter of fact, this material in three thirty-seconds of an inch is usually sold as a nonskid underlay for scatter rugs. It serves no cushioning value. It just serves as a nonskid agent.

MR. ZARO: I can understand that on a flat area, but where you have an area where you have a definite incline, you do get a certain amount of creep in the rubber itself.

MR. JANTZEN: You mean if the rubber were cemented to the floor?

MR. ZARO: Yes. We have found that the rubber will not stay cemented to the floor.

MR. JANTZEN: That might be entirely due to the cement that you have used.

MR. ZARO: Can you recommend a cement since I have not been able to find one yet?

MR. JANTZEN: I think so.

MR. ZARO: Then may I go back to Mr. Savoury to ask if you have found a cement which is satisfactory, why you do not recommend using the rubber sheeting that you mentioned or the rubber tile on slabs which are not on up grade.



MR. TOM SAVOURY: We are talking about two different things. I mentioned the fact that it is not recommended to apply any hard tile; what we call a hard tile is a sheet-rubber flooring or a blocked tile or below grade. Actually in the industry we have not found a cement that would keep the flooring down for any length of time that would be profitable to use it that way.

Probably there is a way of attaching sponge undercarpet padding for the purpose, but they are two different problems. Is your problem one of keeping the sponge underlay, where you have a carpet, in place or is it to put down a rubber flooring such as a sheet flooring or a tile floor?

MR. ZARO: It seems to resolve itself into the same problem, in that the rubber sponge will not adhere to the floor.

MR. SAVOURY: Probably Mr. Jantzen can amplify this a little better. So far as we are concerned, wherever we are required to apply a rubber flooring, one that has no relation to carpets or to sponge, whenever the areas are on or above grade where there is no space underneath it to aerate it properly, there is no cement on the market that will keep it down. That is quite positive.

MR. ZARO: I realize this is very costly, but it has been recommended to me to use copper sheeting between the slab and the rubber. Do you know whether or not it actually is successful?

MR. SAVOURY: Yes, we have installed several jobs in Florida. My company has actually put down slab copper that is very thin; I believe it is called an electrolytic copper. That is put down with an asphalt emulsion, and over that is cemented the rubber flooring. That can work, but it is really a very scientific and difficult job to install, but it has been done, and it is kept in place.

MR. LEONARD SATZ: Mr. Smeallie mentioned that humidity control is desirable in the preservation of carpet. That is, controlled humidity. Am I correct in assuming that?

MR. JOHN SMEALLIE: Yes.

MR. SATZ: Do you understand that the majority of our air-conditioning systems are not centrifugal-type cooling systems, in that we use well water? For that reason, we remove as much humidity from the air as possible in order to introduce comfort into the auditorium. We do not have true air conditioning, really, in the average theater installation in that we do not return through the air a proper or controlled amount of humidity. We remove as much of it as we can. Under those circumstances, I take it the air-conditioning system means nothing in the preservation of the carpet.

MR. SMEALLIE: It would not add anything. In wool the water content is great and the variation probably up to one fifth of its weight. You can see how quickly the lack of density would allow for wear.

MR. SATZ: Is there a greater weight of wool per given area for a five-frame Wilton than there is in a three-frame Wilton?

MR. SMEALLIE: That, of course, would depend upon the height of the pile.

MR. SATZ: All factors being equal.

MR. SMEALLIE: You get only one yarn in the surface to form the pattern, while the others would lie buried in the body and the back, and the more frames you add the more varied your surface yarn.

MR. SATZ: How about the weight of the wool, the weight of the yarn in the given area of carpet, pitch and height of pile being equal?

MR. SMEALLIE: The more frames you use the more would be buried, because each frame is not used in the surface to effect the pattern. The others in turn would be buried in the full warp length.

The only thought I want to convey there is that the yarn used in the pile surface has the greater length. The buried yarns would only run the straight length of the fabric, but for every frame added you would add to the wool basic weight in the body, and the back of the fabric. That is why so many carpets in the Wilton field would be, say, two and a half or three and a half frames against perhaps a household quality that might be considered practical in a full six-frame. If you can accomplish your pattern, not bury too much surface yarn, and make it up perhaps with a lesser cost in your stuffer yarn, you would accomplish the same thing and would have relatively less wool weight in the per yard or similar specifications.

MR. SATZ: Would you consider it important, in so far as wear is concerned, that most of the weight of the yarn in a five-frame Wilton would run underneath or through the backing, as compared to a carpet that has most of the pile above the backing?

MR. SMEALLIE: I do not think there would be great added wear value, except it is a softer yarn than those generally used as stuffers. You must have a definite amount of body and so-called stuffer warp, but I think you could readily get beyond the practical side if you wanted to get a full-frame fabric without accomplishing the design.

MR. BECKWITH: In the Wilton weave, as was brought out by the comments that have passed between Mr. Satz and Mr. Smeallie, in order to achieve pattern effects, the amount of yarn used in the surface will vary. In a five-frame Wilton, the yarn used in weaving the pile surface will be greater than in a two-frame Wilton; however, the amount woven into the nap or surface remains the same. Thus, as the number of frames increases, the proportion of the pile surface yarn to the total pile yarn decreases, and, in the case of a five-frame Wilton, runs approximately 50 per cent.

On the other hand, in other weaves, such as the Velvet and the Axminster, you have about 95 per cent of the total yarn appearing in the surface. It has been our opinion in the Smith mills that the amount of wear that is obtained is not very greatly affected by the amount woven into the back as occurs in the Wilton, but I think there probably is some cushioning effect.

CHAIRMAN ASHCROFT: In connection with Mr. Satz's question on humidity, it might be commented that the experience of the testing laboratories has indicated that the wear life is increased as humidity rises; that is, as the amount of moisture in the air is increased. This is in nearly direct proportion, that is, it is a straight-line picture. We are comparing in these instances dry indoor winter heating conditions and moderate humidity, not high humidity.

I should hazard a guess that the average theater humidity probably does run up around 40, 45, 50 per cent, even when the moisture is relatively removed by the system, and in that case I think Mr. Smeallie's comment is justified. If it ran at 20 per cent humidity as may exist in the average home, you would have a distinct difference in life.

MR. JAMES FRANK, JR.: Apparently one of the places where carpet wear is most serious in the theater is on the stairs, and Mr. Beckwith told us about the

fact that wear depends to a great extent on the density. And yet on the stairs we normally take the same carpet that we put elsewhere in the theater and we bend it over so that we obviously are materially reducing the density on the edge of the stair tread where the greatest wear occurs.

In one of the Society's committees we have talked about this for a long time, but just to get it on the record, I should like to know whether any consideration has been given or can be given to a special type of carpeting for the stairs with a much heavier density, so that when it is bent over it still will give the same kind of wear that you would get on the flat surfaces in the theater.

You might also comment on preformed carpets for stairs, so that if it were practicable for the sake of economy you would have your very heavy density in certain portions of a 27-inch strip of carpet where it would be bent over and the rest of it would be the normal density.

MR. BECKWITH: It is possible mechanically to do what you say, to weave a carpet of different density which might be so woven as to fit the contour of the stairs and to have at the edge of the stairs areas of varying density, but I think the cost of making such a carpet would preclude its use in theaters.

Then, your first point about using a carpet on the stairs of differing density from that on the other surfaces, or one which would have a density at the nose equivalent to carpet on the level can be answered by stating that I think most manufacturers have several grades of floor coverings which might be suitable for different conditions of theater use.

For example, we have one particular grade that is used in many theaters, but we also have another grade that is even higher in density, and it would seem to me that your problem would be to place on the stairs the carpet of higher density and on the level, the carpet of lower density.

MR. FRANK: That is an answer, providing that one of two things is done. Either that the theater owners are convinced that a special pattern is required to minimize hazard on the stairs and therefore that the pattern of the carpet on the stairs has no relation to the other carpet, or that the same pattern is available in both qualities of carpet, so that if a man wants to forget about the hazard problem or considers that it is not serious, he can have uniform design in both places. I do not know that that has been done so far as regular pattern carpet in the theater is concerned.

MR. BECKWITH: It is perfectly feasible to do exactly what you say, to have this higher density or higher wearing grade of the same pattern exactly as that used on the surface. It is wholly a question of merchandising and sales. If sales wants to do that, and they have enough demand for it, they do it, and if the problem exists in large enough areas to warrant it, they will do it.

MR. FRANK: I do think that perhaps conferences and discussions such as this may help to create a demand for that if it is the right thing to do.

CHAIRMAN ASHCROFT: As I recall it, the noses of stairs and the location of the wearing surface, where it is the most severe, is at the start of the curve downward and never very far on to the maximum curvature. Therefore, I should hazard the guess that the difference in density occurring there is a very small difference at that particular point, granted that at the exact nose, the outer nose, it is considerable.

MR. FRANK: That is all right, but then I would say that the heavier density would still probably give longer life on the stairs itself, because it is where your

foot hits the floor on the step, I grant you, that you get the greatest wear. Is it not true that if you had heavier density you would have longer wear?

Mr. Beckwith, can you give us, as the result of the test you discussed before very briefly, some very definite recommendations as to the best method of installing carpet on stairs? There is quite a variation. We have, as everybody probably knows, a number of different ways of attaching the carpet to the stairs, but it seems to me that there must be one or two recommended methods, and I think we ought to have that in our records, too.

MR. BECKWITH: We have had some experience with stair-carpet installation in theaters, and it has been our opinion and our recommendation as the result of these studies in several theaters in the metropolitan area, that in principle we should use approximately a 64-ounce felt-hair underlay. This would be used on most of the tread portion of the stair, and then at the area covering the nosing, we would have a few inches of sponge rubber. We have used products of different manufacturers, du Pont, for example, and Sponge Rubber Products, and we would recommend a strip about two or three inches in length which would be cemented on the tread of the stair, and the sponge rubber would then overhang the edge of the nose.

We have used linoleum cement for fastening the underlays in those installations, and then the carpet is laid over that. In some of the installations where we have run experiments, we have seen used an oak slat which is fastened to the stairway—this happened to be a marble stairway that I am thinking of now—and that was fastened by appropriate expansion nuts. Then the carpet was fastened to that tacking strip or slat, and no underlay was used on the riser portion.

This particular installation which we considered a recommended installation for one involving severe traffic, had the carpet fastened on the tacking strip not by the use of the customary carpet tacks but by the use of screws and washers, rather small ones, and not unattractive in appearance.

With such an installation, of course, you have the area of the carpet that receives the most wear protected by the most resilient and longer wearing underlay, that is, the sponge rubber, and you use a minimum amount of the sponge rubber, because the sponge rubber costs more than the other types of underlays. Therefore you would not use it for covering the whole stairs, particularly in the balance of the tread, where the 64-ounce felt will do just as well.

With such an installation, you have a very permanent fastening of the carpet. No doubt it has been the experience of many theater operators that stair carpet fastened in the conventional manner, that is, tacked to the tacking strip, often-times pulls away, and in that case you have looseness developing and a potential hazard.

In general we should recommend the use of sponge rubber at the nose in minimum amount, the use of 64-ounce felt for the balance of the tread, a very adequate tacking strip, and a very good fastening to the tacking strip.

CHAIRMAN ASHCROFT: Do you wish to mention provision for moving the carpet in order to get the greatest economy in use of the carpet?

MR. BECKWITH: I rather took that for granted, but I believe it should be standard practice anyway in the installation of carpet on the stairs to leave enough at the top so that as the carpet covering the stair nosing gradually wears out,

you can then shift the carpet so that the area which was on the nosing is then moved to the point of intersection of the tread and the riser.

MR. JANTZEN: What did you have in mind in relation to the difference in thickness between the 64-ounce felt and the thickness recommended according to your ideas of the sponge rubber on the nosing, where you evidently splice the two products in order to abut them or overlap them? In other words, in 64-ounce you probably would be resorting to about a half-inch thickness of sponge rubber to balance in with that thickness of Ozite or felt. Is that correct?

MR. BECKWITH: Yes, we should use a one-half-inch sponge rubber approximately, and that is perhaps a little bit thinner than the 64-ounce felt, but with a little traffic the condition is equaled out by the 64-ounce felt diminishing in thickness.

MR. JANTZEN: Mr. Beckwith mentioned something about a firmer density of sponge rubber. There is available for stair nosing a sponge rubber in a firmer density than is used elsewhere, perhaps, as an underlay, and if there is any advantage to a firm density of sponge rubber, that is available in any thickness ranging from three thirty-seconds on up.

MR. SMEALLIE: I should like to volunteer the thought that for better types of theaters or theaters with large budgets, it is very possible to use the Chenille weave and break it the wrong way. Chenille is an Axminster weave with the cross rows very much pronounced, but if you order it the reverse way and break it with the weft direction, you see you have a remarkable edge standing a great deal of wear through the sense of the density factor that has been brought up. There is a very pronounced advantage in it. Different weights of Chenille for some of the larger and finest hotels and theaters have been accomplished, and according to price, it costs about 10 per cent more to weave it so wide and so short in length. The minute you have a width of, say 30 feet, and only weave it three feet long, there is an added cost in production, as you might see, but it is a very valuable suggestion in a better budget situation to order the Chenille in the reverse fashion, order the length with the width and break it where the weft is shown here against any ordinary opening of the usual carpet form.

MR. FRANK: To my surprise I ran into a theater owner who almost insists that we install carpet in the standee portion crosswise and bind it to the carpet lengthwise that runs down an inclined aisle. I think that it ought to also go on record as to what is the proper way of installing carpet in the auditorium, and the reasons for it, if Mr. Beckwith would be good enough to tell us that.

MR. BECKWITH: I am not too familiar with that problem. The standard practice in the standee portion is to have the carpet laid lengthwise to the length of the house, is it not? We have no real data in the laboratory as to the effect of wearing of the carpet across the surface in the manner that you are talking about there. I do not know whether it will affect wear so much as it will affect the appearance.

Laying the carpet crosswise to the direction of traffic might, it seems to me, result in these troubles with shading of which anyone familiar with floor covering is aware. Whereas, if the carpet is laid so that its lengthwise direction is in the same line as that of the traffic, you would not incur those troubles in shading. That is just a guess on my part.

MR. PAUL GARST: The most desirable method of laying the standee carpet is to follow out the aisle wherever possible. However, in numerous installations it is

more feasible to treat the standee separately and in this case it is necessary to butt-joint the aisle carpet to the standee carpet. We fully appreciate that this explanation is not concise enough but, on the other hand, we must bear in mind the peculiarities of each theater. Very often by extending the aisle where the standee is narrow it runs to quite a loss in matching. This calls for extra carpet, the initial cost of which is very high, and thus increasing the over-all cost of the installation. By treating the standee as a separate room, using the width for the length much of the waste for matching is eliminated and if a careful butt joint is made the wear should prove very satisfactory.

A friend of mine in the theater business who has had a great deal of experience with carpets brought up the subject about surface shampooing, and so far no one has mentioned that.

MR. BECKWITH: We are considerably interested in methods of care and maintenance of floor coverings, and particularly in the problem of taking care of floor coverings that are wall-to-wall installations and that cannot be removed and brought to the rug-cleaning establishment for cleaning.

Cleaning in a cleaning establishment is the ideal way to take care of floor coverings, because the floor covering there can be treated with soap and brushed and thoroughly rinsed and washed out. You cannot take up carpet that is tacked down wall to wall, and when you clean it in a wall-to-wall location you cannot apply soap indiscriminately and rinse it out and remove it.

If I talk first about the difficulties of floor cleaning it may be helpful. The application of soap to the pile of the fabric represents a difficulty in wall-to-wall location cleaning, because you cannot adequately remove it, and if you do not adequately remove the soap that has been deposited by the cleaner, then you are liable to run into trouble, because the soap fats that remain may cause rancidity, and they may cause very rapid accumulation of soil after the cleaning so that the carpet will look worse in a few days after cleaning than it did before.

The second problem in floor cleaning is that too much moisture will be deposited onto the fabric so that the back wets out. Mildew may develop, particularly in the summertime, because the carpet cannot dry out readily because of high humidity.

The cleaners and the manufacturers of soaps and detergents have done considerable work toward improving detergents and soaps, and it has been our experience and I think that of the rug-cleaning industry as well, that the use of synthetic detergents rather than the natural kind of soaps gives a much better cleaning job.

One reason why it does that is that with most of the synthetic detergents, if the water that is used is hard, you do not get the mineral materials in the hard water precipitating out on the pile surface, and leaving a scum. With soaps, the mineral matter constituting the water hardness is precipitated out and a scum is left on the surface, which, although it may not readily be apparent, will cause rapid resoiling. With synthetic detergents, that does not happen in general.

CHAIRMAN ASHCROFT: The problem of on-location cleaning is one that the industry has recognized as a very difficult one and for which there is no perfect solution.

Not only the carpet industry but the cleaners themselves are beginning to become aware that they should help to solve this problem. Consequently, during the last three months, a committee of the New York Rug Cleaners Institute and the Carpet Institute's Technical Committee have met together to lay out a

program of research which will perhaps give a satisfactory answer to on-location cleaning. I do not know how soon that answer will be forthcoming. They are conducting independently and together a series of experiments. The Committee is cleaning the carpets in the Institute offices by several different methods to collect exact data as to the effect of these different cleaning methods and detergents that are used. The Rug Cleaners themselves are also conducting research to see if they can set up a system sufficiently satisfactory to recommend it to theater owners and public-building carpet cleaning.

The two precautions Mr. Beckwith has mentioned are valid, however. If you must clean on location, do so with a synthetic detergent which does not leave the soap fats, but leaves a deposit; perhaps, that is less serious, more innocuous to resoil, and also requires less wetting out of the pile underneath the surface.

There is one caution which you might keep in mind, and that is that the soil which you are removing is on the surface, it is not down in the pile. Along the lines of Mr. Fraad's comments, you can do a surface job that is reasonably satisfactory, but it requires study and care and special techniques.

**MR. DANIEL FRAAD, JR.:** We obtained very poor results from on-location cleaning of rugs. We have done a few things, though, that possibly could be made applicable to the theater owner. In connection with the runners of airplanes, we take them out and instead of vacuuming them we blow through them. We have found that that is a very satisfactory way of cleaning. The rug is reversed over a grating and compressed air is forced through the back of the rug out to the grating, the vacuum attachment sucking away the dust. That method is also used in Pullman cars.

Certainly, from a cleaning standpoint, I should like to see large areas of carpeting put down so that they can be taken up readily and cleaned. We find in cleaning rugs that the most difficult thing, if you have to put water and soap on them, is to get it out. It always gets down in, and the resoiling of the rug is so much more rapid that you are better off to leave it dirty.

**CHAIRMAN ASHCROFT:** Mr. Smeallie mentioned a newer type of installation which makes possible the removal with greater ease of the carpet (these tacking strips), and that is something that perhaps might well be investigated in certain areas where traffic is heaviest. It might be possible to remove the carpet with greater ease with this particular method which does not employ tacks or screws through the carpet, but catches the carpet from underneath with protruding brads which makes possible, by a stretching process, the pulling off and replacing of the carpet.

**MR. M. J. FESSLER:** In connection with your remarks about the Carpet Institute carrying on the investigations for cleaning carpet, I might offer a suggestion. I think it devolves itself more to a mechanical as well as a cleaning agent, and if the Institute could devise a unit that will use a solvent, that could be pushed across the floor, as you do with a scrubbing machine, we would have something which would leave the carpet clean and last for possibly a year instead of maybe a week.

In the course of Mr. Fraad's remarks, he spoke of soap as not being the ideal cleaning agent because of the fact that concerns like Armour and Wilson and other people who sell beef have a surplus of fat and so get fatty acids which are saponified into soap, which leave, when used, a thin film on the surface.

Mr. Fraad, what has been your experience with the vegetable oils as a

substitute? Have you used any wetting agents in connection with your cleaning? Have you also had any experience with such products as Naeconol or Santomerse? Most of us understand that cleaning with a detergent or a soap primarily involves lubrication and flotation, and in order to obtain an ideal cleaning job, we must have something that will penetrate the soil. In these last few years these wetting agents have played a great part to reduce labor in the factor of cleaning.

MR. FRAAD: First of all, so far as the wetting agents are concerned we use sodium polyphosphates in quite a few of our compounds. It is very important but it must be tempered. You can get too much wetting agent in and hence you lose slip. You have to look for the compounding to an organization that will compound something that fits your purpose, but you should look for wetting agents and surface-tension reducing agents.

As a matter of fact, for the whole idea of cleaning, we take a soap as we know it. If we saponify a fat or a fatty acid, we get a soap. I do not say that soap is not good, but I have found that in commercial operations the ordinary saponified oils are inferior to the wetting agents, and the surface-tension reducing agents. The action of soap is more of an emulsifying reaction rather than a surface-tension reducing agent, which the wetting agents, such as trisodium phosphate, are.

We do use sulfated oils and we find that sulfonated oils are very good. However, their cleaning action is very strong. You can bleach to a point that you have cleaned too much and that is as dangerous as not cleaning enough because the aesthetic effect is very bad. However, you are perfectly right in saying that there are certain oils that they are using to great advantage.

MR. FESSLER: Do you use the sulfated fatty alcohols at any point exclusively, or do you use them in conjunction with vegetable-oil soaps?

MR. FRAAD: We do not use them in conjunction with vegetable-oil soaps. What we do is to take a compound like Orvus, which is put out by Procter and Gamble, and which is, I think, a fatty alcohol sulfate. We add trisodium phosphate to it and work that way.

CHAIRMAN ASHCROFT: You might be interested in a test that was developed in the laboratory to evaluate the resoiling factors of different fats, fatty acids, soaps, and synthetic detergents by casting them out in thin films, that is, evaporating them out on plates, so that what might be considered the minimum deposit of film was left, and then studying the action of that film against powdered charcoal, or carbon black, in its retention of that soil, by blowing it over it and then removing it by blowing or air pressure.

We found a distinct difference in the adherence of carbon black, at least, if not various other soils, to these different films, and there is no question but that the natural fats have greater adherence than the synthetics.

MR. ROBERT SCHMID: There are many means of sewing carpets, and the problem which I should like to bring out for the concern of the carpet manufacturers is that in the manufacture of long-pile carpets today there is a tendency to clip the side wall and leave a void space at the edge. The machine-sewn carpets have a tendency to try to pull this carpet together in order to make up for this lack of wool. What happens is that you have a hard or inflexible joint at this place, and I think if you will observe various carpet installations, you will see that their wear is at the seams in a great many cases, and I think it is due to that fact. Have the manufacturers anything to say about that?



MR. BECKWITH: I should not attribute the wear at the seam to the fact that there is a clipping of the pile or pile left out as you say at the edge. I attribute this wear at the seam to the fact that in the sewing operation you tend to create a slight ridge in the surface so that the pile of the carpet right at the seam is always slightly higher than that of the surrounding surface, and therefore when people walk over it, that area at the seam always gets most of the wear because it happens to stick up a little more.

When I was working for the Army in the Quartermaster Corps, we were very much interested in the wear of Army uniforms, and we found, for example, that in the case of trousers, wear occurs on the fly because of the fact that the cloth covering the buttons is elevated over the rest of the surface, and I think that the analogy holds true there in floor coverings at the seams. The pile is elevated slightly and therefore it receives the initial wear of the foot before the surrounding areas.

You will find that that kind of effect will be duplicated if you have a ridge in the floor. If you have a ridge in the floor, then you will find that the carpet covering the ridge will suffer more wear at that point than in the others.

CHAIRMAN ASHCROFT: Your question was really directed at the manufacturers doing something that would make it possible to have a slower wear at the point of seaming, whether or not that is the major contribution to wear by, for example, increasing the wool coverage at the edges. I think it is common practice to have extra wool at the edges. That is my recollection of the standard practice in narrow carpets. Is that true, Mr. Smeallie?

MR. SMEALLIE: Yes.

MR. SCHMID: I do not believe that is wholly true. If you take a long-pile carpet in a light fabric, and if you take a moderate hand-sewn machine, one that does not exert too much pressure at the joint, and you sew it so you have a flexible joint at that point, that carpet will not match. The point is you are either going to raise a ridge and have the seam close, or you are going to lay the carpet where it will wear the longest and have a line showing.

# Optical Sound-Track Printing\*

By JOHN A. MAURER

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*Summary*—It is well known that the nearly universal practice of printing sound tracks by contact on the periphery of a rotating sprocket introduces significant amounts of flutter, and also amplitude modulation of the higher frequencies of the record, principally at the sprocket-hole frequency.

An optical one-to-one ratio printer in which the negative and the printing stock are driven separately by good constant-speed mechanisms has given substantially improved quality in printing 16-mm sound tracks. In contact prints of 7000-cycle records it is easy to demonstrate rapid fluctuations of output level of the order of 6 to 8 decibels. In optical prints from the same negatives such fluctuations do not exceed  $1/2$  decibel. High-frequency response is improved, to the extent of 5 decibels at 7000 cycles. The cross-modulation cancellation density for variable-area track prints is increased by about 0.1 in the region of practical interest. Listening tests show an immediately noticeable improvement in quality when optical prints are compared with contact prints made from the same negatives.

The optical system for sound-track printing must be able to resolve patterns several times finer than the highest frequencies on the sound negative, and, for printing on color films, must be especially free from the higher-order chromatic aberrations, secondary spectrum and chromatic variation of spherical aberration. Ordinary photographic lenses are unsuitable. One system which meets the requirements using commercially available microscope lenses is described.

**D**URING THE PAST twenty years motion picture sound engineers have expended a great deal of effort in improving the mechanical performance of recorders and projector soundheads, in improving high-frequency definition of optical systems, and in reducing the distortions inherent in amplifiers and in light modulators. During this same period almost no change has been made in the methods and equipment used for printing sound tracks. This is, in a way, a remarkable tribute to the basic excellence of the Bell and Howell Model D Printer and its close descendents, the Bell and Howell Production Printer and the 16-mm Model J Printer. Nevertheless, since nearly all sound for motion pictures is re-recorded, and therefore the printing process enters at least *twice* into the production of

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almost every release print, it would appear that if we are serious in our attempt to improve the quality of motion picture sound records, we ought to give careful consideration to the printer.

#### DEFECTS INTRODUCED BY CONTACT PRINTING

Probably the best published account of what happens when sound track is printed by contact on the periphery of a sprocket may be found in two papers by J. Crabtree, of the Bell Telephone Laboratories.<sup>1,2</sup> This work was done in the year 1933. Crabtree showed experimentally that individual prints exhibit large fluctuations in high-frequency output, indicating variations in the contact between the negative and the positive raw stock as they pass in front of the printing aperture. He also showed that there is an over-all loss of level of the higher frequencies which varies in a regular manner with the pitch of the perforations of the negative and the positive film stock, and which is demonstrably due to the slippage that must occur between the two films as they are carried along by the teeth of the sprocket.

Figs. 1, 2, and 3 are diagrams which illustrate, in a deliberately exaggerated way, how difficult it is to avoid these defects of continuous contact printing. The exaggeration consists in showing a sprocket having only eight teeth instead of the much larger number usually employed, and in showing the film as though it were much thicker than it actually is.

Fig. 1 shows a sprocket feeding two films both of which fit it perfectly. It will be observed that this relationship between the sprocket and the two films can exist only when the negative has shrunk until it is the right amount shorter than the standard perforation pitch, and at the same time the sprocket must be of the right diameter, so that the perforations of standard positive film fit the teeth when the

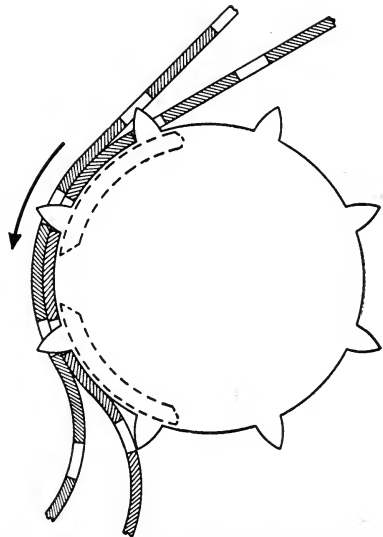


Fig. 1—Contact printing—the ideal case. The negative is shrunk the right amount to permit both films to fit the teeth of the sprocket.

positive film is threaded on top of the negative. The printing condition shown in Fig. 1 is the ideal, but it is almost never realized in practice.

Fig. 2 shows the same sprocket and standard positive film with a negative of approximately standard perforation pitch. This is the condition encountered when prints are made from a freshly processed negative. Since the negative is too long to fit the sprocket teeth, it is driven by the tooth on the entering side, and it must be pushed

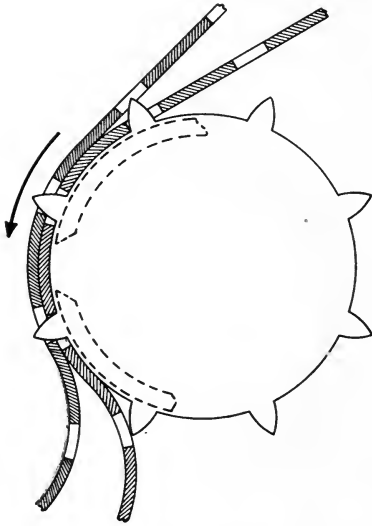


Fig. 2—Contact printing—the condition usually encountered. The positive film fits the sprocket, but the negative is too long.

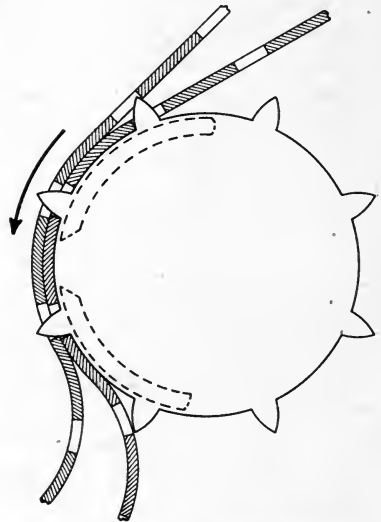


Fig. 3—Diagram showing that the condition illustrated in Fig. 2 is not greatly improved by increasing the diameter of the printing sprocket.

ahead under the positive stock each time a new tooth comes into engagement. This means that there is periodic slippage between the two films, and it is obvious also that there is a tendency for the negative to buckle under the positive because that part of the negative which is farthest ahead of the driving tooth may not move ahead fast enough. When such buckling occurs it causes variations of contact, such as were observed by Crabtree.

Fig. 3 shows a sprocket of greater diameter, on which an unshrunk negative fits the teeth perfectly. The positive, being supported on a greater radius, is now too short to fit the sprocket teeth and is driven

by the tooth nearest the point of disengagement. Each time a tooth disengages, the positive film must slide back until the next tooth is in driving contact. This condition is probably better than the one shown in Fig. 2, since it does not tend to cause buckling of the negative, but it does, nevertheless, involve loss of sharpness in the print because of the necessary slippage.

Crabtree showed that, with the film stocks used in 1933, the printer sprockets in use had too few teeth, that is, were too small in diameter to permit the ideal printing condition shown in Fig. 1. Practically all the negatives then being printed were too long for best operation. Since that time, improvement of film base has resulted in lower shrinkage, which has made the printing condition worse instead of better.

Nonslip contact sound printers<sup>3,4</sup> give appreciably better results than sprocket-type printers, but the industry has not accepted them for general use in release printing.

In the printing of 16-mm sound tracks the disadvantages of the sprocket-type printer are much more noticeable than in 35-mm printing for several reasons. The sprocket holes are farther apart, and therefore the amount of slippage which must take place when each sprocket tooth engages or disengages is greater. The high-frequency pattern recorded on the negative is two and a half times finer, which makes the blurring effect of a given amount of printer slippage correspondingly more serious. Furthermore, the distance between sprocket holes is greater than the height which it is practical to make the printing aperture. This means that since some parts of the sound track are and other parts are not in front of the printing aperture at times when slippage occurs, both 24-cycle flutter and 24-cycle amplitude modulation of the high frequencies of the record are introduced. The corresponding 96-cycle flutter and 96-cycle amplitude modulation introduced in the printing of 35-mm sound tracks are much less serious if we may judge by the lack of reference to them in published sound-film research.

That these effects are real will be demonstrated by the next four illustrations. Fig. 4A shows the appearance of a 7000-cycle negative on 16-mm sound-recording film, Eastman Type 5372. It will be observed that the peaks and valleys of the waves are both sharply defined, though the graininess of the film does introduce some perceptible irregularities.

Fig. 4C shows the appearance of one point on a contact print made from the negative shown in Fig. 4A on a Bell and Howell Model J

Printer which is believed to be in good adjustment. This appearance is typical of a large number of points along the sound-track print which show comparatively good definition.

Unfortunately, there are numerous other points along the printed track which have the appearance shown in Fig. 4D. Figs. 4C and D were enlarged from points less than  $\frac{1}{4}$  inch apart on the same film. Here it is obvious that slippage occurred during the time this part of the film was in front of the printing aperture. It is also obvious that

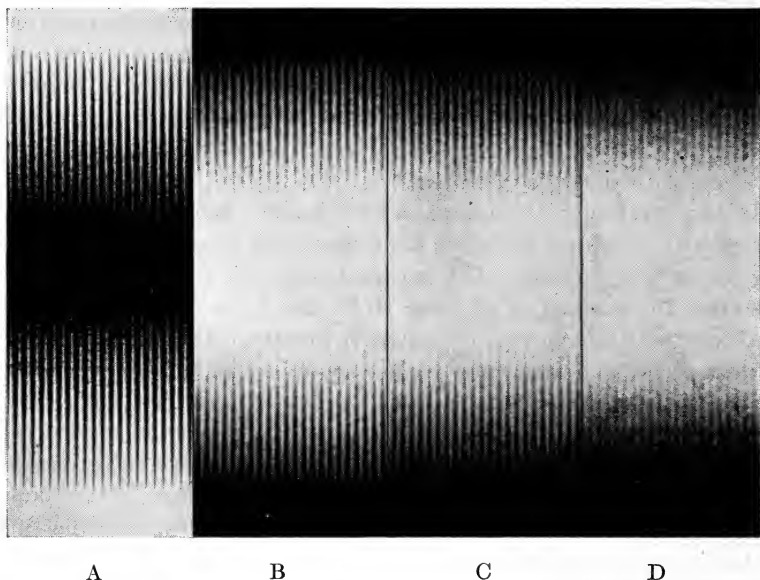


Fig. 4—Photomicrographs of 7000-cycle, 16-mm negative, and prints made from it on optical printer, B, and on sprocket-type contact printer, C and D.

this part of the track will not reproduce at as high a level as the part shown in Fig. 4C.

A convenient way of studying these variations in the definition of the printed sound track is to re-record from a print of a high-frequency sine-wave negative such as the one shown in Fig. 4A. When this is done the variations of output level in the print are converted into variations of amplitude in the new record, and these are readily apparent to the eye. Fig. 5A shows two lengths of 7000-cycle negative track re-recorded from the print which furnished the samples enlarged for Figs. 4C and 4D. It will be observed that there are

numerous constrictions in the envelope of the record which obviously correspond to points of poor definition in the print. It will also be observed that while these constrictions do not occur at perfectly regular intervals, there is a strong tendency for them to appear at distances corresponding to the spacing of the sprocket holes. This shows that these irregularities of output are, in fact, connected with the process of meshing and unmeshing of the film with the sprocket teeth, as would be predicted from a study of Figs. 2 and 3.

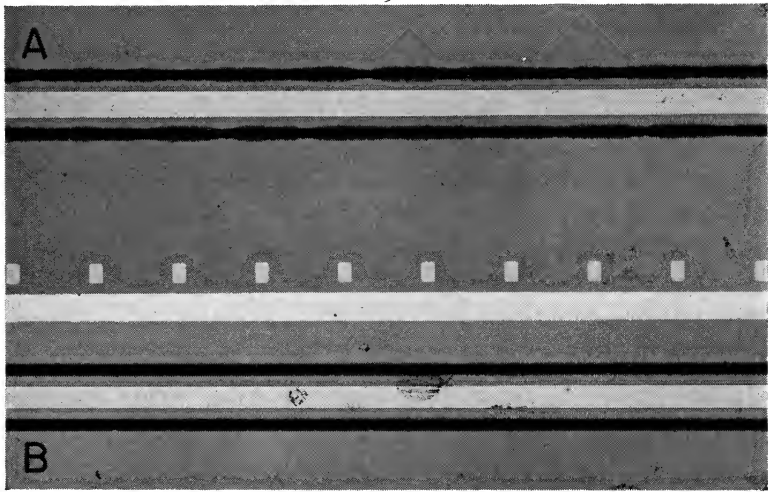


Fig. 5—7000-cycle negatives re-recorded from prints made on sprocket-type contact printer, A, and on optical printer, B, showing variations of output level in the prints.

These tests were not made to show an extreme case. It would have been easy to exaggerate the defects by printing the negative while it was still fresh from processing. Actually the case presented is typical of most 16-mm release printing. The negative was not used until it was two weeks old, at which time it had reached a shrinkage of 0.17 per cent.

#### HISTORY OF OPTICAL SOUND PRINTING

Since these printing defects are due to nonuniform relative motion of the negative and the positive raw stock, caused by divergences from the ideal perforation-pitch relationship which it is not practical to control, the writer in 1938 came to the conclusion that the best

possibility of substantial improvement was in optical printing at unit magnification. In an optical printer the negative and the positive raw stock can be moved separately at speeds which are constant, and if the image is transferred by a good enough optical system, the resulting prints can be substantially free of the three defects, flutter, amplitude variation of high frequencies, and over-all loss of high frequencies.

All those who are familiar with the history of 16-mm sound films will, of course, recall that optical sound-track printers were in use from about the year 1934 for making 16-mm prints from 35-mm negatives. Unfortunately for the progress of the art, however, the excellent results obtained in optical reduction printing generally have been attributed to the fact that the 35-mm negative is larger and therefore presumably better defined than the 16-mm negative required for contact printing. Batsel, Sachtleben, and Dimmick<sup>5</sup> pointed out in 1934 that an optical printer can produce prints that give a steadier output at high frequencies than is obtained from contact prints, but no application of this observation to either 35-mm or 16-mm printing appears to have been made until the writer built his first 16-mm one-to-one ratio printer in 1938.

A brief description of this printer was given in a paper presented at the Hollywood Convention of the Society in April, 1939,<sup>6</sup> and prints made with it were demonstrated. At that time it was found that white-light 16-mm prints made optically gave  $1\frac{1}{2}$  decibels higher response at 6000 cycles than nonslip prints from the same negatives. This indicated what has since been confirmed on many occasions, that a good optical system is able to transfer the fine details of an image slightly better than can be done by contact printing under the best conditions.

Printers of the 1938 design have been in commercial use since that year. These machines drive the two films by sprockets at the printing points, so that defects of film motion are not entirely eliminated, though they are much less serious than in printers of the sprocket-contact type.

Another application of optical sound-track printing was made in connection with Walt Disney's *Fantasia*.<sup>7</sup> In this case the optical printer was apparently used in order to transfer sound-track images to locations on the film in which it was not practical to record them. Mention is made, however, of the low flutter content and excellent high-frequency definition of the prints.



## OPTICAL REQUIREMENTS FOR SOUND-TRACK PRINTING

Neither of the publications just mentioned gives the details of construction of the optical system required for good image transfer. Since the design of a suitable system involves a few rather unusual problems, it will be discussed here in some detail.

Unpublished experiments performed by the writer during the development of 16-mm sound recorders have indicated that measurable improvement in the recording of high frequencies results from reduction of the width of the recording light beam from 0.0002 or 0.00015 to as little as 0.0001 inch, when using modern sound-recording films. On this basis it may be inferred that the optical system of a sound-track printer ought to be able to resolve, as a minimum, 5000 lines per inch, or 200 lines per millimeter. In order to accomplish this in a one-to-one ratio system, physical-optical theory indicates<sup>8,9</sup> that the relative aperture looking out of each end of the system as it is actually installed, ought to be of the order of  $f/4.0$ . The lenses must be "perfectly" corrected, which, in practical terms, means that spherical and chromatic aberrations must be corrected within the well-known Rayleigh limit<sup>10</sup> of  $1/4$  wavelength of light.

These considerations show that it is futile to attempt to use any ordinary photographic lens for one-to-one ratio optical sound printing. In order to be capable of sufficiently high resolution the lens would have to possess an aperture, in ordinary terms, of  $f/2.0$ . Even if such a lens were available which gave substantially "perfect" definition when used on an object at an infinite distance, it could not be expected to perform well at a magnification of unity. Very few photographic lenses specifically corrected for the latter condition have ever been made.

On the other hand a cemented doublet lens of 3 to 4 inches focal length can easily be designed to have a relative aperture of  $f/4.0$ , with spherical aberration well within the Rayleigh limit. Such a lens, in fact, is nothing more than the equivalent of an ordinary short-focus telescope objective. Two such lenses, arranged one on each side of a central diaphragm, probably would give excellent results in printing black-and-white sound tracks if the chromatic correction were of the "purely photographic" or "astrographic" type.<sup>11</sup> On the basis of mechanical considerations a suitable distance between the negative and positive films is 8 inches, or 200 millimeters.

A printer for 16-mm sound tracks, however, is often required to

print the track on color-duplicating stock, which is sensitive to all wavelengths of light from about 390 to 650 millimicrons. For this application about the best obtainable color correction is the type generally referred to in the literature as "ordinary photographic achromatism."<sup>11</sup> With this type of color correction in a system made as described above, the variation of focal distance over the necessary wavelength range exceeds the Rayleigh tolerance by about six times.

Lenses of the telescope-objective type which had been designed for another application were available, and a combination was set up and tested. It was found that, as predicted, the definition on color film was not sufficiently good for sound-track printing, although visually the definition was excellent.

This rather long discussion of an unsatisfactory lens system has been presented because the system made up of two telescope objectives is the first one that naturally suggests itself for the solution of this problem, and it is rather unusual to find that the possibility of correcting chromatic aberration is the limiting factor. The writer has seen some optical-reduction sound-track printers in which this error was made, and which, in consequence, gave prints of mediocre quality.

There are three possible ways out of this difficulty. The first is to resort to more complicated lens construction and special types of optical glass in order to reduce the secondary spectrum and the chromatic variation of spherical aberration. Such lenses are extremely difficult to design and construct, and are not so favorable for the correction of spherical aberration as the simpler types. For these reasons this is not a promising approach to the solution of the problem.

The second possibility is to reduce the distance between the two films in the printer until the necessary focal length of the lenses in the system becomes short enough that the color errors become negligible. The over-all distance would have to be reduced to about  $2\frac{1}{2}$  inches. This would not permit the mounting of adequate fly-wheels for filtering the motion of the two films, and therefore this solution is impractical.

The third solution is the optical system shown in Fig. 6. The lenses  $L_4$  and  $L_7$  in this figure are commercially available 16-mm microscope objectives of the type made for metallographic microscopes. The first objective  $L_4$  forms a magnified image of the sound-track

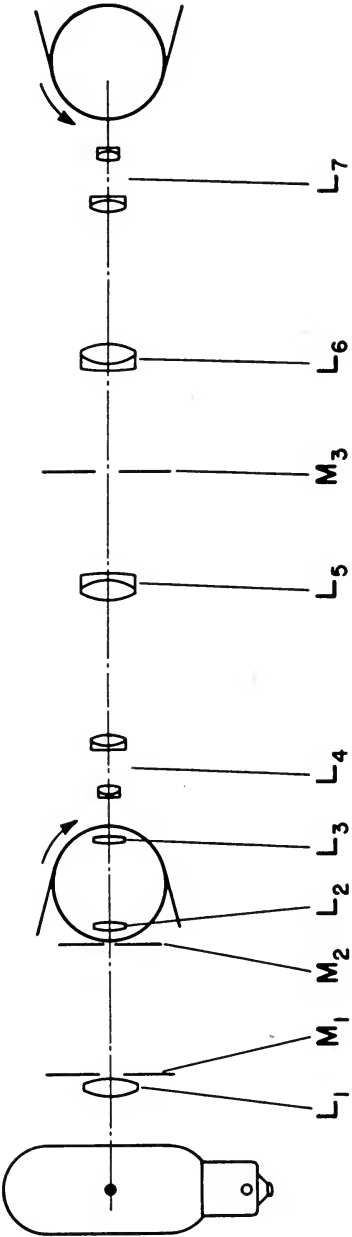


Fig. 6—Schematic drawing of the optical system of the printer described in this paper.

negative in the plane of the central mask  $M_3$ , the distance normally required being shortened by the presence of the doublet field lens  $L_5$ . The two field lenses  $L_5$  and  $L_6$  collect the light and redirect it so that it all goes through the second objective lens  $L_7$  on the opposite end of the system.  $L_7$  forms on the positive film a reduced image of the central mask and the sound-track image in it. This final image is of the same size as the sound track on the negative, and travels in the same direction as the positive film at the same speed. The central mask  $M_3$  defines the printed area on the film and limits the effective height of the printing "aperture."

The final chromatic aberration of the system shown in Fig. 6 is very nearly the same as would result from the use of the same two microscope lenses "back to back" in the very short system referred to above. Since the focal length of each lens is only 16 mm, the chromatic errors are small enough to have no adverse effect on the resolving power of the system. The only serious fault is curvature of field, which makes the image deteriorate beyond a width of about 0.080 inch. The circle of excellent definition, however, is large enough to give good results in printing 16-mm sound tracks.

The illuminating system which is shown at the left of  $L_4$  in Fig. 6 uses a standard type of phototube exciter lamp, and three lenses. Lens  $L_1$  is the condenser. It forms an image of the lamp filament on a circular mask  $M_2$  located close to the rear of the film-driving drum. The next two lenses  $L_2$  and  $L_3$  are located inside this drum, which carries the negative film. Their focal lengths are so calculated that they image the field mask  $M_1$  in the plane of the negative film and at the same time, in combination with the front doublet of microscope objective  $L_4$ , they image the small circular aperture  $M_2$  in the exit pupil of  $L_4$ , which practically coincides with the outer surface of its larger (rear) doublet. This image of  $M_2$  constitutes an "optical diaphragm" which limits the aperture of  $L_4$  to  $f/4.0$ . The illumination produced by this system is uniform over the sound-track area, and no unnecessary light is allowed to enter the track-imaging lens system. This is an important point in designing to keep stray light to a minimum. All lenses in the system should be coated to reduce surface reflections.

#### MECHANISM OF PRINTER

A new printer using this straight-line optical system has been designed during the past year, and the first completed machines have

now been placed in service. Fig. 7 shows the operating side of one of these machines.

The film-driving mechanism at each end of this printer is identical with that used in the 16-mm Sound Recorders and Film Phonographs made by J. A. Maurer, Inc. The films are driven by smooth drums with which they are kept in firm contact by spring-tensioned idler rollers above and below. These two film-drive systems are

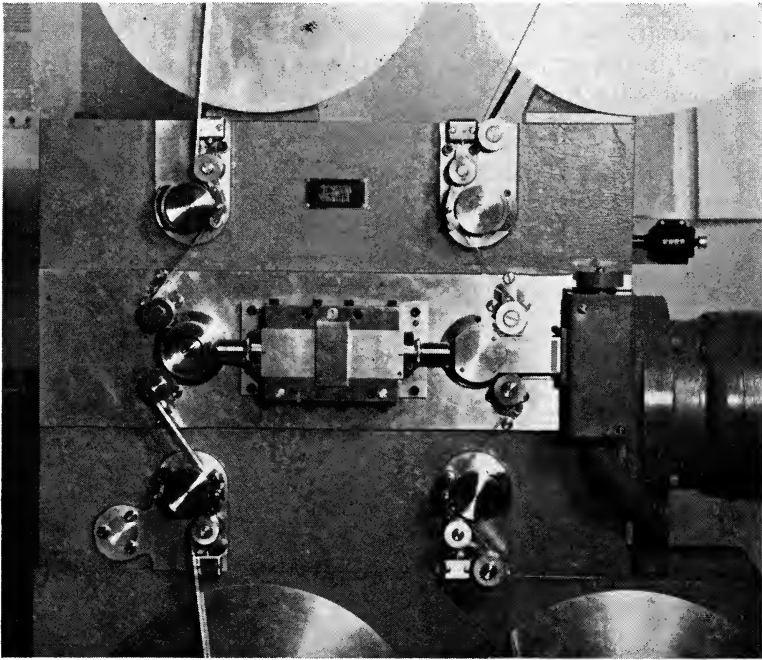


Fig. 7—View of operating side of optical 16-mm sound printer, showing lamp-house, optical system, and film-threading paths.

actuated from a common transverse shaft. The 9-inch diameter flywheels are driven through oil films in a manner originated by E. W. Kellogg,<sup>12</sup> which is analogous to his magnetic drive. The constants of the mechanical filters are such that no more than the length of the average threading leader is required for the two films to reach constant speed. The speed of operation is 72 feet per minute. At this film speed the combined filtering efficiency of the two flywheels is approximately twice as great as the efficiency of one of them in the Recorder for which it was designed.

## COMPARISON OF OPTICAL AND CONTACT PRINTS OF HIGH FREQUENCIES

The quality of high-frequency definition obtained with this printer is shown by Fig. 4B, which is enlarged from a print made on Eastman film, Type 5302, from the 7000-cycle negative shown in Fig. 4A.

If Fig. 4B is compared with Fig. 4C, it will be observed that the best portions of the contact print appear to have been made with reduced galvanometer amplitude, although actually the two prints were made from the same negative.

The variations of definition shown by Figs. 4C, 4D, and 5A are not found in the optical print, which is of uniformly good definition from point to point. This is proved by the 7000-cycle track re-

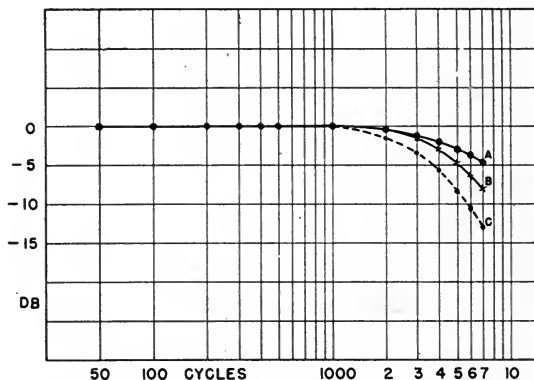


Fig. 8—Frequency-response curves of 16-mm direct positive *A* and prints made from a 16-mm negative, optically *B*, and on a sprocket-type contact printer *C*. The records were made at constant amplitude.

recorded from it, sections of which are shown in Fig. 5B. Fluctuations of level as indicated by this re-recorded track are of the order of only  $\pm 1/2$  decibel instead of the large and rapid changes of as much as 6 to 8 decibels shown in Fig. 5A.

Microscopic examination of the track shown in Fig. 5B does reveal small but very rapid changes of level which are of an interesting character and probably deserve further investigation. They are apparently the result of the additive graininess of the negative and positive films, since they occur much too rapidly to be attributable to any mechanical disturbance, such as vibration of the machine.

The frequency-response curve of the optical printer as obtained by printing a constant-amplitude multifrequency negative is shown

by Fig. 8. Curve *A* shows the measured response of a "direct positive" constant-amplitude record made at image density 1.1 on Eastman Type 5372 film. This provides a reference standard of what can be accomplished, since this track was produced without printing. It will be noted that the loss at 7000 cycles is 4.5 decibels.

Curve *B* shows the measured response of an optical print made on the new printer from a constant-amplitude negative of image density 2.2. The print, on Type 5302 film, has a density of 1.5. The loss at 7000 cycles is 8 decibels, or  $3\frac{1}{2}$  decibels more than is found in the direct positive.

Curve *C* shows the measured response of a print made from the same constant-amplitude negative on the Bell and Howell Model J Printer. The measured level at high frequencies is, of course, the average of the rapidly fluctuating output as indicated by a meter too sluggish to follow the rapid changes. Apart from this, the measured difference in response between the optical print and the contact print is sufficient to account for the audible superiority of the sound reproduced from the optically printed records.

#### EFFECT OF OPTICAL PRINTING ON CROSS MODULATION

One important result of the superior sharpness of the optical print is a change from the usual relationship of negative and positive image densities for "cancellation" in the well-known cross-modulation test.<sup>13,14</sup> As an example, Fig. 9 shows cross-modulation curves obtained by printing a variable-area negative of silver-image density 1.88 on the optical printer and on the Bell and Howell Model J Printer that was used for the other contact prints referred to in this paper. It will be observed that the best cancellation density is approximately 1.27 for the contact printer and 1.38 for the optical printer. The prints were made on Eastman Film Type 5302, developed normally.

The test negative used to obtain the data shown in Fig. 9 was a 6000-cycle tone modulated at 400 cycles, the modulation being about 85 per cent. The writer prefers to use 6000 cycles as the high frequency in this test rather than 4000 cycles as specified in American Standard Z22.52-1946 because it makes the test more sensitive, and also because 6000 cycles is closer to the frequency of the "ess" sounds in speech which are the first to betray the presence of cross-modulation distortion when variable-area sound-track prints are made to improper densities.

The special characteristics of the optical printer also have a significant effect on the over-all processing of variable-density sound records. Since the negative is illuminated with very nearly parallel light, effective printing densities are much closer to specular densities than to the usual diffuse densities, and the effective negative gamma is higher than in contact printing by a factor approximately equal to the Callier coefficient of the film. This fact was also observed by Dimmick, Batsel, and Sachtleben.<sup>5</sup> The result is an apparent increase in the recorded level of the sound in the variable-density negative. Because of the many combinations of negative gamma and

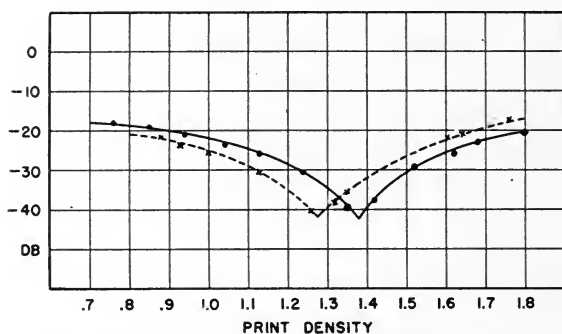


Fig. 9—Cross-modulation levels of prints made optically (solid line) and on sprocket-type contact printer (dotted line) from 6000-cycle negative modulated at 400 cycles. Negative on Type 5372 film, silver-image density 1.88. Prints on Type 5302 film.

negative and positive densities which can be used successfully in variable-density recording and printing, a full analysis of this aspect of optical sound printing would require a long paper in itself, and must be left for another time.

#### OVER-ALL QUALITY IMPROVEMENT

The improved quality obtained by optical printing in comparison with contact printing of 16-mm sound negatives is such as to be immediately noticeable in a listening test with average reproducing equipment. There is a marked gain in naturalness. For example, musical instruments such as the oboe and clarinet, are clearly differentiated in an optical print, whereas they may sound almost alike in the reproduction from a contact print of the same negative. The sound is decidedly "brighter," and at the same time "cleaner," and the



intelligibility of speech is considerably improved. While equally striking results are not to be expected from the application of the optical printing technique to 35-mm sound tracks, the writer is of the opinion that it would be a worth-while development, and might well lead to an improvement in quality of the same order of magnitude as the improvement which resulted when the industry changed from the older coarse-grained release-printing film stocks to the modern fine-grain positive films.

#### ACKNOWLEDGMENTS

The writer wishes to acknowledge the help he has received in the preparation of this paper from the staff of the Precision Film Laboratories, Inc., and also from members of the engineering staff of J. A. Maurer, Inc. Austin Hill was largely responsible for the mechanical design of the new printer, and L. Fanoë and M. Christensen made the measurements on which Figs. 8 and 9 were based.

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# Use of G-3 Film-Processing Tank\*

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*Summary*—The processing of lengths of film by winding the film back and forth between immersed spools is possible because of the activity by solutions entrapped between windings as well as the activity of solutions on the film in transit. Field and laboratory processing methods have been developed for the G-3 tank which handles both 16-mm and 35-mm film up to 100-foot lengths.

THE NEED FOR the processing of an occasional hundred feet of film, or the field processing of film without continuous machines, has given rise to several types of film-processing systems, the most widely known being the Stineman system. The introduction of the G-3 tank\*\* has enabled more convenient manipulation with results differing as a consequence of basically different conditions. Whereas the Stineman system places the film on a spiral in a flat tank, the G-3 tank depends on winding the film back and forth between immersed spools. The success of this method depends on the frequent winding of the film to refresh the exhausted chemicals entrapped between layers of film between windings. The solutions are also acting on the film as it travels from one winding to the other, though this time is small in comparison to the dwell between windings.

The confinement of developing solutions between film layers is not the same type of condition for which the standard mixture is formulated such that modifications by the addition of antifoggants are usually of value (Tables I and II). This is because of the effect of confinement of a restricted quantity of solution which may, depending on the image density, become fatigued prior to rewinding and

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\*\* Morse Instrument Company, Hudson, Ohio.

consequent changing of the solution next to the same portion of film. Under certain conditions of exposure, subject matter and developer choice, the effects of developer fatigue do not require modification of common developer to obtain satisfactory image quality. This condition is found usually in the photography of cathode-ray oscilloscope traces on Super-XX processed in Dektol, largely because of the small amount of development required to deposit a single small line over a whole width. An empirical test should be adequate in such a case (Fig. 1) to determine if developer ghost is a problem.

The time of fixing is much longer than the customary time, as is the development, due to the small amount of solution in contact with



Fig. 1—Typical triple-trace recording on 35-mm Linagraph pan Type 5244, processed in D-72 as described in Table II. The processing was very satisfactory for routine laboratory-research work.

the entire film length at any one time. Consequently, the use of more rapid fixing by the modification of conventional fixing baths by the addition of ammonium chloride (Tables I and II) is a welcome relief from unnecessary winding or cranking of the film in the tank.\*

A further aspect of this system of development is the effect of film length. Thus, the shorter the film,<sup>1</sup> the more film is put through fresh solutions, if one cranks by the rule of cranking continuously, so that a shorter processing time results from the greater chemical activity possible. If, however, the cranking is done on the basis of so

\* The use of an additive to prepared commercial hypo formulas was chosen for field use because of convenience only.

TABLE I  
U. S. ARMY DATA  
G-3 PROCEDURES FOR 100-FOOT ROLLS OF SUPER-X TYPE 5256 AND SUPER-XX TYPE 5261 AT 70 DEGREES FAHRENHEIT

Operation	Formula	Time of Treatment			
		Super-X (5256) Negative*	Super-XX (5261) Negative*	Reversal*	Reversal*
Prehardening	Prehardener and backing re- movaal solution	15 min.	15 min.	15 min.	15 min.
	Formalin		5.0 cc		
	Sodium sulfate (desiccated)		150.0 grams		
	6-Nitrobenzimidazole nitrate (Kodak antifog No. 2)**		0.2 gram		
	Tamol (Rohm and Haas)		2.0 grams		
	Kodalk		5.0 grams		
	Sodium hydroxide		1.0 gram		
	Water to make		1.0 liter		
Rinse	Running water or fresh water each cycle	4 min.	4 min.	4 min.	4 min.
Development	D-19	15 min.	...	...	...
Super-X Negative	D-19 plus 2 grams per liter so- dium thiocyanate	...	25 min.	...	...
Super-XX Reversal	D-88	...	...	25 min.	38 min.
Super-XX Negative and Reversal	Running water or fresh water each cycle	...	4 min.	...	4 min.
Rinse	Potassium dichromate	...	10.0 grams	...	...
Bleach	Sodium acid sulfate (sodium bi- sulfite)	...	100.0 grams	...	...
Super-X	Water to make	...	1.0 liter	...	...

TABLE I (continued)

Operation (continued)	Formula	Time of Treatment			
		Super-X (5256) Negative*	Reversal*	Super-XX (5261) Negative*	Reversal*
Bleach Super-XX	Chromic acid Sodium acid sulfate Water to make Running water or fresh water each cycle	...	...	...	6 min.
Rinse	60.0 grams 70.0 grams 1.0 liter				
Clear	Running water or fresh water each cycle	...	4 min.	...	4 min.
Rinse	CB-1 (9 per cent aqueous solution of desiccated sodium sulfite)	...	6 min.	...	10 min.
Flash	Running water or fresh water each cycle	...	2 min.	...	2 min.
Redevelopment	8 inches from No. 2 Photofool at 115 volts D-88 plus 0.25 gram per liter potassium iodide. NOTE: For chemical fogging (when light flashing is not convenient) omit potassium iodide, add 2 grams per liter hydrazine sulfate	...	6 min.	...	6 min.
Fixing	F-5 plus 50 grams per liter of ammonium chloride	...	6 min.	...	12 min.
Washing	Running water or fresh water every cycle	12 min.	10 min.	12 min.	10 min.
		10 min.	10 min.	10 min.	10 min.

\* Time may be reduced for lower contrast.

\*\* For color, use 5 minutes and increase first development time 5 minutes.

TABLE II  
SOME SPECIFIC FORMULAS, TIMES, AND TEMPERATURES FOR NEGATIVE PROCESSING

It is impossible to give a single set of formulas, times, and temperatures which will apply to all types of films. However, the directions given in the following table will apply quite well to several commonly used types and will serve as a guide for other procedures.

The times indicated are intended for use with 100-foot rolls of either 16-mm or 35-mm film. Shorter rolls require less time, a 50-foot roll requiring about two thirds the time required by a 100-foot roll. Thus, while a 100-foot roll of Super-XX film requires 18 minutes of development, a 50-foot roll of that type requires 12 minutes of development.

Operation and Formula	Duration of Cranking	Temperature of Liquid
Development		
Eastman D-72		
0.2 per cent solution of Eastman antifog No. 1 (prepared as directed on container)	For films such as DuPont Superior I and Eastman Super-X	15 min.
Water (distilled preferred)	For films such as Eastman Super-XX and Kodak Recording Negative (Linagraph Pan)	18 min.
Rinse		70 ± 1/2 F
Water		
Glacial acetic acid	4 min.	60-70 F
Fixing		
Anso acid hypo or Eastman F-5 fixer dissolved as directed on container: amount of this solution	Twice clearing time	60-70 F
Ammonium chloride, C. P.		
Wash		
Water	10 to 20 min. in running water or at least 6 to 12 separate 5-min. washes	60-70 F

many complete windings and no more in a certain length of time, the speeding of processing for shorter lengths is not so pronounced.

The effect of the cubic quantity of solution which is in contact with the emulsion is a source of difficulty with punchings, splices, and other modifications of the film as to thickness or width. This is

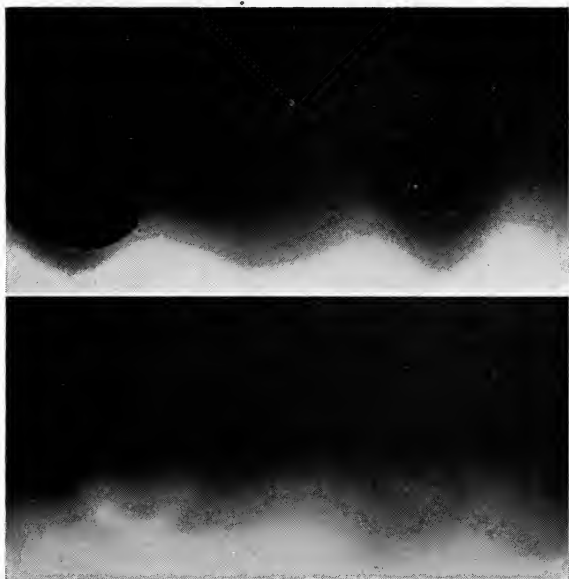


Fig. 2—To determine the basic characteristics of the tank, a roll of 35-mm microfilm negative stock was over-processed to show the limits of the method. The upper piece shown is a clipping from the film showing the two original punchings, the lower clipping being that portion of the film wound next to the punches during processing. The developer effects adjacent to the punches are quite obvious. The lower piece shows the ghosts of the holes as they took various positions after winding during development. (The picture is a positive.)

directly a result of the increase in entrapped fluid resulting from the spreading apart of the successive wound layers by the extra base thickness of the splice, or the absence of base by punched marks. Punched marks may appear faintly on the emulsion some distance down the film as a result of developer-fatigue differences brought about by the pattern of increased developer storage when wound

(Figs. 2, 3, 4, and 5). In practice, such peculiarities are not of importance as a punch mark is rarely anywhere but the end of the film and a splice is rare in camera film in any case. The suggestion that

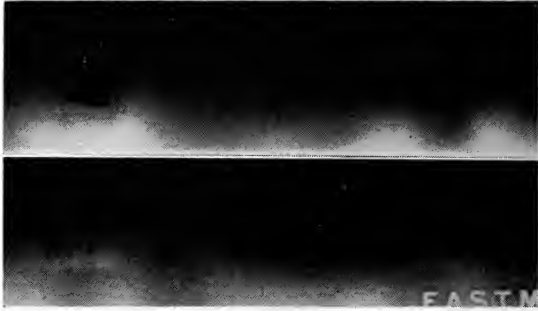


Fig. 3—Although Fig. 2 shows much the same general effect as the above, the reversed ghost effect can be expected occasionally as shown in the farthest left impression of the left punch in the lower clipping. (The picture is a positive.)

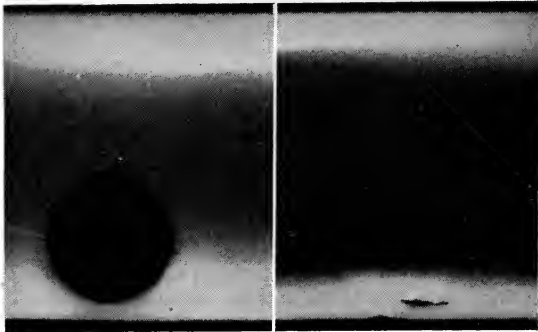


Fig. 4—Very exaggerated overdevelopment of a film produced not only edge fog by the very slightly greater chemical replenishment there but also a weakened emulsion which adhered and pulled away as shown in the lower right as a jagged hole.

the G-3 tank be used for the quantity processing of end-to-end lengths of 36-exposure stills on 35-mm film (Leica-type) is, however, of no great value because of the effect of the splices.

For field processing where loading may be done by a changing bag



and full advantage taken of the daylight processing construction of the tank, temperature control is often impractical as well as the complete elimination of dust and dirt on the film or possibly in the tank. In such situations the prehardening solution of formalin, Tamol (Rohm and Haas), and other ingredients listed in Table I was found to be a good protection against physical damage to the emulsion. The use of the prehardener results in a loss of effective



Fig. 5—A slight crease in the base allows local entrapment of a greater volume of developer which in turn develops more before fatigue with consequently greater density. Such a crease effect due to development is difficult to distinguish from pressure fog. The above vertical arc corresponds with the crease.

exposure speed and must therefore be decided upon prior to exposure of the film.

### CONCLUSIONS

Full knowledge of the basic principles underlying the operation of the G-3 tank enables the satisfactory processing of films under conditions hitherto considered impossible. Under ordinary conditions the G-3 offers a degree of convenience not enjoyed by rack or Stineman development methods though with different limitations as to the choice of solutions.

A process has been written (Appendix I) to enable use of the G-3 by completely untutored personnel.

## APPENDIX I

INSTRUCTIONS FOR THE USE OF THE MORSE G-3 MOTION PICTURE  
FILM-PROCESSING TANKA. *General Remarks*

Examine the G-3 tank and note the following parts:

1. The two spring clamps, one at each end of the tank, which hold the cover in place.
2. The removable cover with two cranks and a central opening which can be used for the admission of liquids or as a vent.
3. A window with a cover capable of being snapped shut.
4. Below the window, an opening which can be used either as a drain or as an entrance for liquids.
5. A rubber stopper fastened to the tank with a chain, the stopper being used to plug the opening beneath the window.
6. Inside the tank, two removable reels. These should be placed on the spindles with the flat sides of the reels down. When the cover is then put on the tank, the cranks contact the reels and can be used to drive them. Note that the upper side of each reel is adjustable so that the reel can accommodate either 16-mm or 35-mm film. The adjustment from one size to the other is made on each reel as follows:  
Remove the reel and rotate its two sides in opposite directions so that the upper side unlocks from its original position. This movable side can now be moved toward (or away from) the fixed side and can be locked in place by again twisting the two sides in opposite directions. Between the two disks of each reel is a slot for holding an end of the film. When a lever which protrudes through a hole in the upper disk is moved, the slot can be opened or closed; opened to receive or release film, closed to hold it.
7. Inside the tank, next to the window, a cylindrical roller. The tank is used with the window side toward the operator. The cover should be placed so that the word "turn" under each crank is in the normal position for reading, namely on the same side as the window.

B. *Statement Concerning Lights*

Until a rather late stage in the process, the film is sensitive to light. Therefore, until this point has been reached, *the film must be handled*

*in complete darkness* (or, in the case of certain special films, with a proper safelight).

A feature of the G-3 tank is the fact that, regardless of room illumination, the interior of the tank is completely dark so long as the tank and window are both covered. This light-tight feature permits much of the processing to be done with the operator working in a well-lighted room.

The point at which it becomes safe to expose the film to any light occurs when the film has been thoroughly desensitized by the fixing solution or special desensitizing solutions.

### *C. Loading the Tank*

Remove the cover and both reels from the tank. Make sure that the entire system (tank, cover, reels) is clean and dry, that both reels are properly adjusted, and their film slots are in the open position.

Place the camera spool containing the film (not a G-3 reel) on the spindle on the right-hand side. Orient the reel in such a way that it will unwind counterclockwise.

Insert about an inch of the loose end of the film in the slot of one of the G-3 reels, clamp the slot, and place the reel on the left spindle.

Rotate the right reel clockwise so that it winds up any film that is either loose or wound on the left reel. Check to see that the film is not twisted or off the reel. To ensure a natural, unstrained setting for the film, open the film slit of the left reel and rotate that reel two or three turns clockwise. Then close the film slit.

Transfer the film to the left reel by rotating the left reel clockwise. This can be done either with or without the cover on the tank. If the cover is used, the operator can use the crank and can illuminate the room. (Be sure that the tank and its window are covered before the room lights are turned on.)

Fig. 6 illustrates the method. Note that this operation turns the film "inside out"; that is, the film is wound on the left reel with its emulsion side out (an important requirement), whereas it normally comes off of the original reel with its emulsion side facing in.

When the film has been completely transferred to the left reel, remove the right reel. Insert an inch of the loose end of the film into the slot of the second G-3 reel and clamp the slot.

Place the reel in the tank over the right spindle, taking care to insert the connecting film between the window and the roller. Rotate the left reel clockwise until it takes up any film that is loose or

wound on the right reel. Make certain that the film passes between the window and the roller, that the film is not twisted, and that it has not slipped off the reel.

Loosen the film slot on the right reel, rotate that reel two or three turns counterclockwise, and again clamp the film slot.

The arrangement at this stage is illustrated in Fig. 7.

Rotate the left wheel clockwise until the right reel is unwound.

Put the cover on the tank, lock it in place with the two spring clips, and make sure that the window cover is snapped shut.

From this point on the room can be illuminated so long as the tank and window are covered.

#### D. Processing the Film

Processing the film consists mainly in winding the film back and forth from one reel to the other through various liquids. This

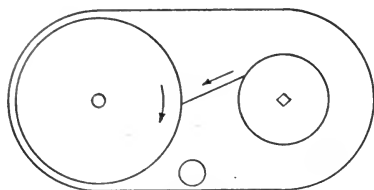


Fig. 6—Transferring the film from the camera spool to the left G-3 reel.

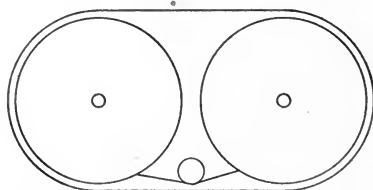


Fig. 7—Proper arrangement of film and G-3 reels in tank.

winding is accomplished by means of the two cranks fitted into the cover. Be sure to turn the cranks in the directions indicated on the cover. The left crank is turned clockwise, the right crank counterclockwise. *Turn only one crank at a time.* (The second crank will follow naturally.)

When a "cranking cycle" has been completed, that is, when a film has been completely transferred from one reel to the other, the crank will jerk to a stop. At this point, start a new cycle, that is, start turning the other crank in the proper direction and continue this process for the periods indicated in such directions as those given in Table II. Make the jerk at the end of each winding very mild at all times.

The times and temperatures recommended in Tables I and II are important particularly in the case of development. Furthermore, they depend upon the rate of cranking. Therefore, a standard rate has been adopted: approximately two crank revolutions per second.

(For a 100-foot roll of film, the duration of a cycle will then be about one minute.) However, an exception to the standard cranking rate is found in the very first cycle in the first liquid (normally the developer). This cycle should be wound as rapidly as possible without losing control of the operation or causing a jerk at the end.

During development, be particularly careful not to stop cranking during a cycle and not to delay between cycles. Measure the time of development (and of the other operations also) from the beginning of the first cycle to the end of the last cycle. Do not stop the development during a cycle; always finish a cycle that has been started. However, in order to satisfy the critical time requirements in development, it may be necessary to increase or decrease the rate of cranking over the last one or two cycles—so that a cycle will end reasonably close to the termination of the development time.

Liquids can be admitted into and drained from the tank in either of the following ways. In both methods the tank and its window are covered.

1. The "dry-sink" method. Place the tank in an unstoppered sink. Fill the tank by plugging the hole (beneath the window of the tank) and pouring the liquid into the tank through the hole in the cover. In using this method prepare two quarts (64 ounces) of the liquid if 35-mm film is used, or one and one half quarts (48 ounces) if 16-mm film is used. These quantities will permit a moderate amount of loss through spillage. Drain the tank by removing the plug. Gently rocking and tipping the tank may aid in the efficient removal of the liquid.

2. The "deep-tank" method. In this method the liquid is in a deep tank; and the G-3 tank, with its stopper pulled out, is lowered into the deep tank, causing the liquid to enter the G-3 through the hole (below the window).

Drainage of the G-3 tank is effected simply by raising the G-3 above the surface of the liquid and allowing the liquid to run out of the G-3 drain. Here again, as in the "dry-sink" method, efficient removal of the liquid may be aided by gently rocking and tipping the G-3 tank.

The amount of liquid used in the deep tank should be such that when the G-3 is immersed, the liquid will easily cover all the film but will not cover the entire lid of the G-3 tank.

In using either of the above methods, the developer should be admitted to the G-3 tank very quickly. It is particularly important

that operation proceed smoothly and without delay from the time the developer is introduced until the time the film has been run through a few cycles of the rinse that follows development.

It will be noted that in Table II the duration of the fixing is given as "twice clearing time." This statement may require further direction.

After the film has been cranked through the fixer for five minutes, the film can be safely exposed to bright light. When this point has been reached, open the cover of the window (or remove the cover of the tank) and observe the film as it passes, stopping the film occasionally for closer inspection. At first a whitish color may be visible on parts of the film, but it will disappear gradually. The time required for the elimination of *all whitishness* is called the "clearing time." The duration of fixing should be at least twice this clearing time. For instance, if the removal of all whitishness required eight minutes of cranking, one would have to continue the cranking for at least another eight minutes before fixing could be considered complete.

As the fixer is used repeatedly, the clearing time will increase. When this time becomes intolerably long or when the fixer becomes very frothy, discard the old fixer for a new solution.

Also note in Table II that the duration of washing is listed as "10 to 20 minutes." The choice depends upon how long the film is to be preserved. If it is to be kept permanently, wash for 20 minutes at least. If it is to be kept for only a few days, 10 minutes is sufficient.

If a sufficient supply of running water is available, place the tank in an unstoppered sink and, with the G-3 drain open, run water into the tank fast enough to keep the film covered. Allow the water to run in this manner for the duration of the wash. (Continue cranking during the wash.)

If sufficient water is not available, plug the G-3 drain and fill the tank with water as described in the "dry-sink" method. Crank for five minutes, then discard the used water. Refill with fresh water and repeat this operation for a total of 6 to 12 times, the number of times depending upon the useful life expected of the film (as indicated above).

During the wash, regardless of which of these methods is used, occasionally rock the G-3 tank so that any remnant of a previous solution will be washed from the cover and upper parts of the tank.

#### *E. Drying the Film*

When the washing has been completed, wind the film entirely onto

one of the two G-3 reels. Remove both reels from the tank and open their film slits. Free the end of the film held in the unwound reel.

Various devices are used for drying film. One of the simplest is a sprung rack or frame around which the film can be wound and allowed to dry naturally. Before being wound around such a frame, the film should be wiped free of excess water. This can be done by drawing the film between two fine viscose film sponges. The sponges should be squeezed occasionally to remove their water, though allowing them to remain damp. (Sponges should never be used with any part of them completely dry.) In winding the film on the frame, face the emulsion outward so that the frame will not mar it. (If directions are followed, the emulsion will be on the outside of the windings on the G-3 reel.)

Some drying devices are more complex and have features such as automatic "sponging" and forced-air drying. Follow technical orders for each machine.

Regardless of the method of drying the film, be sure that it is perfectly and entirely dry before winding it on its final reel.

#### *F. Life of Solutions*

If the "deep-tank" method is used, each solution, after use, is allowed to drain back into its supply tank and can be used several times. If the "dry-sink" method is used, some of the solutions can be poured into supply bottles and reused several times.

The number of times a solution can be used depends partly upon the quantity of liquid in the supply from which it is drawn for use and to which it is returned after being used. The number also depends upon the amount of film treated each time. That is, one 100-foot roll is approximately equivalent to two 50-foot rolls in regard to the life of the solutions. Similarly one 35-mm roll is roughly equal to two 16-mm rolls.

Table III indicates the number of times the various solutions are to be used on 100-foot 35-mm rolls *per quart of supply solution*.

Example: Using the dry-sink method, with 10 quarts of fixer kept in the supply bottle, the solution should be replenished or replaced after using it on twenty 100-foot rolls of 35-mm film (or on forty 50-foot rolls of 35-mm film, or on eighty 50-foot rolls of 16-mm, etc.).

Using the deep-tank method, with 10 quarts of fixer in the tank, the solution should be replenished or replaced after fixing thirty 100-foot 35-mm rolls (or the equivalent).

If the solutions are stored (covered) without regular use, they will retain their usefulness for months, with the exception of developer. Spoilage of developer can be reduced by observing the following precautions: keep the developer cool; cover the developer in such a way as to have little or no air in contact with the solution; do not

TABLE III  
NUMBER OF 100-FOOT 35-MM ROLLS TO BE TREATED PER QUART OF SUPPLY SOLUTION

Solution	Dry-Sink Method	Deep-Tank Method
Prehardener (see Table I)	4	6
Developer	Use the solution only once	1
Short stop	Use the solution only once	1
Fixer	2	3

mix unnecessarily large quantities of developer at one time. If, however, it is particularly desirable to store developer as a solution, store it as the concentrated "stock solution" (prepared as indicated on the purchased container) and follow the above two precautions; and avoid contaminating developer with any other solutions. Thoroughly rinse hands and other objects of uncertain cleanliness before putting them in the developer.

#### REFERENCE

- (1) Ralph Haburton, "Reversal processing of motion picture film," *Minicom Photography*, February, 1947.



# High-Intensity Projection Arc Lamp\*

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*Summary*—This paper describes mechanics and design of the Peerless Hy-Candescent 120- to 180-ampere projection arc lamp, the Hy-Speed condenser-lens system, and the light heat filter unit.

PROBABLY because of the extremely limited sales field which has made it impossible to manufacture high-current, condenser-type high-intensity projection arc lamps on the same production basis as other types of projection arc lamps, very little, if any, development work was done prior to the introduction of the Peerless Hy-Candescent lamp.

The sales field for this type of projection arc lamp has recently been broadened by the extreme projection requirements of the automobile drive-in theater which has become popular during the past several years. Before their advent, however, only the largest theaters, at home and abroad, found that the good light distribution, high light output, and higher operating cost of the condenser-type high-intensity arc justified continuance of their use.

To supply these users with an arc lamp of modern design, engineered to meet the operational problems that develop from the intense heat or currents up to and above 180 amperes<sup>1</sup> the Peerless Hy-Candescent lamp in combination with the Hy-Speed  $f/2$  condenser-lens system offers them a means for obtaining a level of screen illumination impossible with projection arcs employing reflectors and the commercially available copper-coated carbon combinations.

Experience with high-current projection arc lamps has disclosed that high internal lamphouse temperature was the greatest contributor to troublesome operation of the mechanics of the burner and hence was one of the prime problems to consider (Fig. 1).

Mindful of the general trend toward burning higher and higher arc currents and to provide a sufficiently large lamphouse to handle the high heat generated by these arcs, this lamphousing measures 49 inches long, 29 inches high, and 22 inches wide and has a cubical content of approximately 9 feet.

\* Presented October 22, 1947, at the SMPE Convention in New York.

## LAMPHOUSE VENTILATION

An 8-inch diameter chimney base, instead of the customary 6-inch, is provided to assure sufficient cubic-foot-per-minute exhaust of the heated air and gases from the lamphouse at a velocity that will not disturb the burning arc.

Built inside the lamphouse top and located directly over the arc, is a conical metal canopy measuring 16 × 16 inches at the bottom, the top of which is connected directly to the 8-inch chimney opening at the top of the lamphouse. This canopy is entirely separate from the lamphouse and it has no pockets or corners, hence it can efficiently

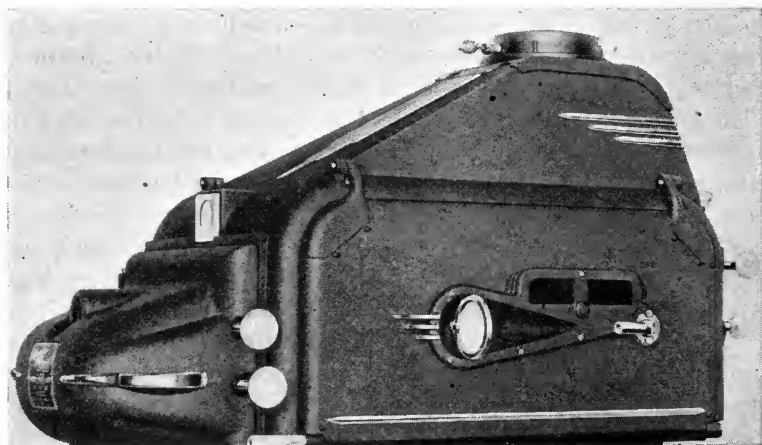


Fig. 1—Hy-Candescant lamp from rear and right-hand side.

conduct the arc heat and gases directly out of the lamphouse and prevent them from circulating around the interior of the lamphouse.

To ensure egress for the heated air in the rear upper portion of the lamphouse, outside of the canopy, separate vents are provided in the casting that forms the chimney base so it may exhaust into the projection room.

Normal air intake is provided for by an extremely large opening in the bottom of the rear cover door and through the light cone at the front and, in addition, by a blower connected to the arc-feed motor which alone delivers over 60 cubic feet per minute of air, distributing it over the entire base of the arc-burner mechanism (Fig. 2).

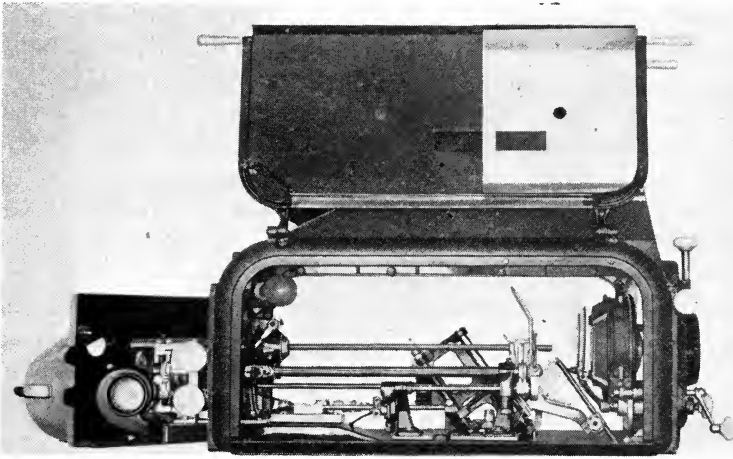


Fig. 2—Right-hand side of lamp showing carbon feeding and burner mechanisms.

#### LAMPHOUSE CONSTRUCTION

The lamphouse body is comprised of a formed sheet-steel base of heavy gauge to which are attached the two side frame castings that form the frames for the two side doors as well as the support for the

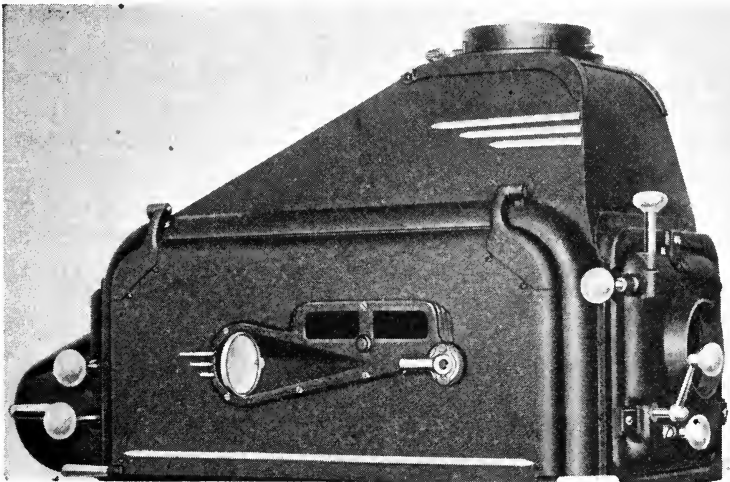


Fig. 3—Lamp from front and right-hand side.

sheet-metal top. These side frames are fastened to the base and likewise to the front and rear castings at points that have machined surfaces, resulting in a final assembly that is extremely rigid.

Both the right and left side doors are  $1\frac{1}{2}$  inches in thickness, they are double-walled, hinged at the top, and on their inside walls are each provided with a slidably mounted steel heat baffle plate, opposite the arc. These baffle plates are removable and present three thicknesses of metal with two air spaces to heat-insulate effectively the outside surfaces of the doors from the high arc temperature.

Because of the generous size of the side doors and the fact that the rear cover door is "slip-hinge" mounted, the means for complete accessibility to the burner mechanism are provided (Fig. 3).

#### CONDENSER-LENS MOUNTING

Slidably mounted to the lamphouse front casting is a second casting which functions as the light cone and the support for the condenser-lens mount. It is machined for accuracy and is made manually adjustable up, down, and sideways by conveniently located control knobs.

As the condenser-lens holder, when placed in its support cradle, is carried with this casting it can readily be seen that these adjustments provide a perfect means of aligning the condenser lenses to the optical axis of the projector, independent of the position of the lamphousing proper, as was shown in Fig. 2.

The condenser support cradle is also slidably mounted to this casting and means are provided thereon for focusing the condensers to the arc crater. The rear dowsers, because it is supported by the cradle casting, moves to or away from the arc according to condenser-focusing requirement.

The rear dowsers is pivoted below and to the left of the optical center, hence it swings upward and to the left of the condenser when it is open and is completely out of the path of the arc tail flames (Fig. 4).

#### CONDENSER-LENS HOLDER

A totally new and highly efficient method of lens mounting is accomplished by providing the condenser-mount casting with several narrow machined prongs into which the rear lens fits. Contact with the rear lens is only at these points. Accurate spacing of the condensers is had by a spun sheet-metal separator ring having several thin sheet-steel radial webs that contact the curved surface of the rear

and front lenses. Hence variation in the thickness of the edges of the lenses will cause no change in the correct spacing of their facing curved surfaces. Both lenses with their separator are retained in the main holder casting by a threaded ring at the front of the holder, which likewise is provided with prongs to hold the lenses and spacer assembly in place and in alignment. Thus means are provided to use the full aperture of both condensing lenses (Fig. 5).

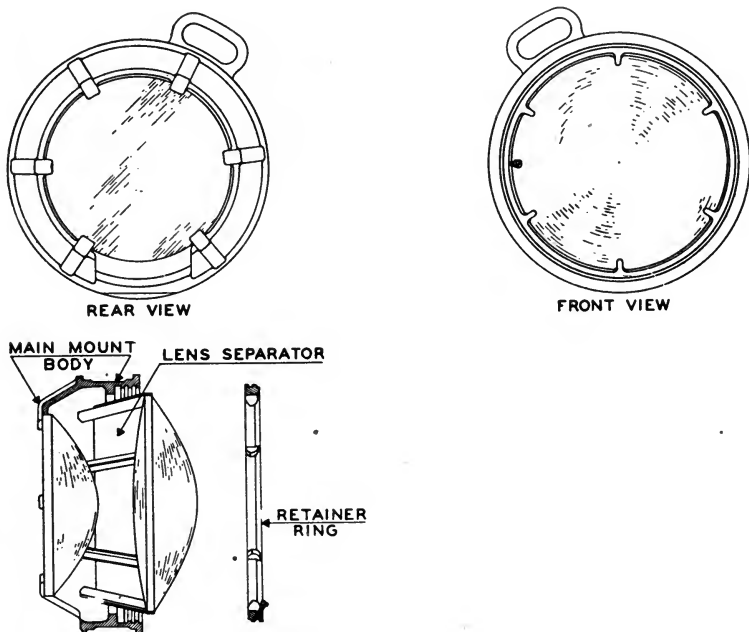


Fig. 4—Diagram of condenser mount.

#### LAMPHOUSE SIDE DOORS

The right side of the lamphouse door has two arc-viewing ports, the front one for direct viewing of the arc and the rear one, which is provided with a lighter colored glass, may be used to view the operation of the burner mechanism and to determine carbon length, and so on. The glasses are held in their frames by springs and hence are easily replaceable. An arc-image projector is also built onto the outside of the right side door. It includes a ground-glass screen upon which is projected an image of the burning arc. This

screen is recessed into the door and the image is visible to the projectionist from the rear as well as the front of the lamphouse. The angle of the screen may be altered to a vertical plane, notwithstanding the angle at which the projector and lamphouse may be inclined.

The left side of the lamphouse door is provided with only one viewing port having a dark glass for viewing the arc when it is lighted (Fig. 6).

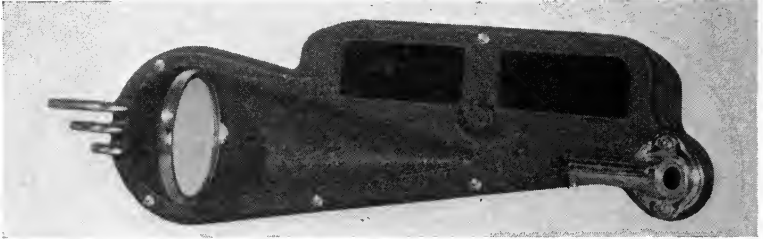


Fig. 5—Arc-image projector on right door.

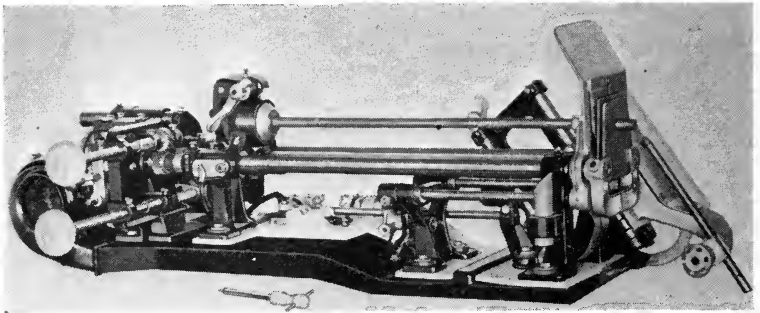


Fig. 6—Burner mechanism.

### BURNER

The arc-burner mechanism, including the carbon-feeding mechanism, blower unit, and motor, are built as a complete unit and held in position inside of the lamphouse by only one screw at the rear and a threaded stud at the front end. It is completely removable with a minimum of effort (Fig. 7).

The carbon-feed mechanism attaches to the burner-base casting at the rear end. The feed-mechanism main frame also provides the mounting for the blower unit and feed motor. As before stated; a positive supply of air is directed into the lamphouse via the

channeled burner base which is utilized as an air duct and air distributor.

To provide a wide latitude of carbon-feed speeds for each carbon, infinitely variable hardened and ground overriding clutches are provided. This arrangement allows the use of a constant-speed motor, hence the motor operates at its maximum torque at all times and eliminates the need of a controlling rheostat in the motor circuit. Likewise this method of drive results in a constant rotating speed (18 revolutions per minute) of the positive carbon, regardless of the rate of feed thereof.

The lineal feed of the positive carbon is variable between 0 and 35 inches per hour and the feed of the negative may be varied from 0 to

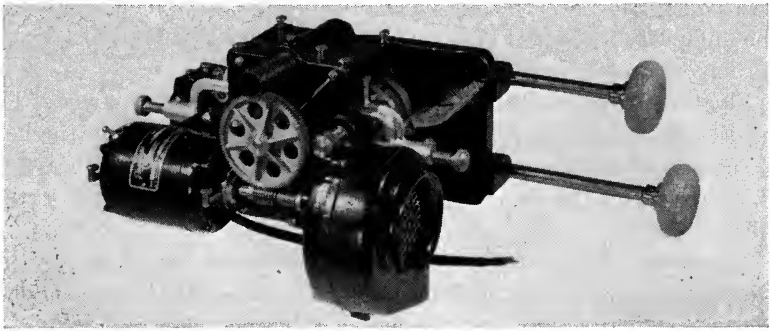


Fig. 7—Feed motor and associated mechanism including ventilation blower.

8 inches per hour which amply takes care of the consumption rate of all currently available high-intensity projection arc carbons.

The burner accommodates a 22-inch-long positive carbon without resetting, and  $4\frac{3}{4}$  inches of the 9-inch negative can be fed at one setting, this is more than sufficient to last through the burning of an entire length of positive carbon.

Handles for the manual control of the carbons or adjustment of the arc extend outward from the right side of the carbon-feed mechanism and are conveniently located.

The burner as a complete unit may be raised, lowered, and moved laterally within the lamphouse to place the positive carbon crater in the optical axis to the projector.

The positive carbon is fed forward and rotated by a carriage which travels on two ground steel tubes. The right side of the tube is

slotted to permit engagement of the carriage follow-pin tooth into the acme-threaded feed screw which rotates within the tube.

Convenient means have been provided to disengage manually the positive carriage follow pin from the longitudinal feed screw to allow rapid hand movement of the carriage in either direction as may be required for trimming.

A spring-operated collet clamps the rear end of the positive carbon to the rotating mechanism and the simple moving of a lever is all that is required to release instantly the collet to loosen the carbon for changing.

A nickel casting with a circular hole a little larger than the carbon constitutes the positive carbon guide. It is located just back of the positive contacts and the carbon is forced to the bottom of this hole by the angularly machined pads on the carbon contacts which keeps the carbon constantly in a fixed central position.

Floating positive carbon contacts of pure nickel are employed. The adjustable contact pressure spring is located well back from the heat of the arc, and a cam, operated by a special trimming wrench, is provided to spread the contact pressure arms to facilitate easy insertion of new carbons.

By rotating this contact release cam to its limit the spring pressure is completely overcome and both contacts may be lifted upward out of their operating position for cleaning or replacement.

Ahead of the positive contacts are located three nonmagnetic heat baffles each spaced  $\frac{1}{8}$  of an inch apart from the other, to facilitate the radiation of air between them for cooling. These baffles are held in position by gravity, in machined grooves, hence are easily removable for inspection or cleaning. The first or front baffle is made of a special metal alloy that is almost impervious to the disintegrating effect of the heat and hot gases of the arc.

The entire positive rotating carriage, as well as the baffles and contact spring arm at the front end of the burner, are thoroughly insulated so that current can only reach the carbon via the contacts, thereby preventing the current from by-passing to the carbon through any moving or other parts of the burner.

The positive bus bar that conducts the current from the main terminal, located at the rear end of the burner base, to the positive contact shunt clamp base, located at the forward end, is provided with a movable collar attached to which is one of the ampere-meter leads. This bus bar therefore acts as the meter shunt and by the adjustment



of the collar along the bus bar the meter reading can be adjusted at any time it might become necessary.

A permanent magnet of cast No. 6 "Alnico" is employed to draw the positive tail flame of the arc away from the rear condenser lens and also neutralize other stray magnetic fields that might detrimentally affect the burning arc. The magnet support bracket is designed for reversible mounting either to the front or rear face of the right front tube support casting of the burner. This permits a  $1\frac{3}{16}$ -inch change to be made in the distance between the magnet and the arc. The most rearward position is recommended for arc currents of from 120

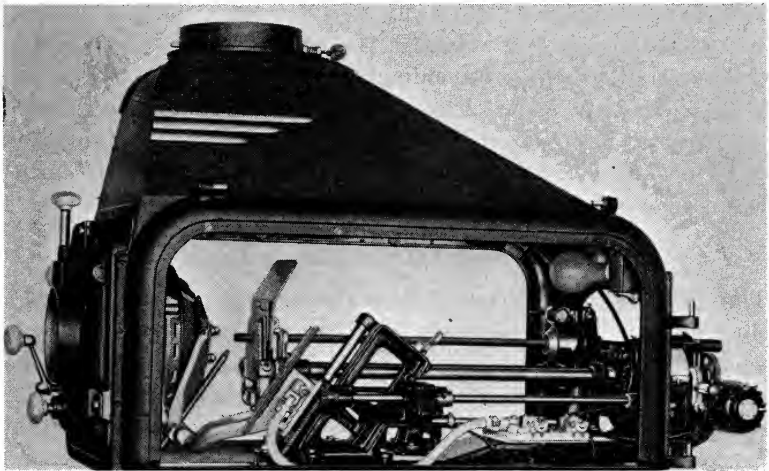


Fig. 8—Left side of lamp showing lamp mechanism.

to 140 amperes and the forward position for higher currents to 180 amperes (Fig. 8).

#### NEGATIVE CARBON CARRIAGE

In the design of the negative carbon carriage a substantial departure from conventional practice has been adopted because, instead of locating all its mechanism beneath the arc where it is subjected to the intense heat thereof, it has been placed well to the rear and to the left side of the arc. This has enabled us to employ much more substantial construction as well as much closer bearing tolerances, since the temperature at this location is low enough to use ordinary lubricating oil without carbonizing.

The negative carbon is carried at an angle of 55 degrees from the positive carbon axis. This permits operation of the positive crater relatively close to the rear condenser without fear of interference between the negative carbon holder and the condenser-lens mount.

A rack and pinion on the negative carbon feed carriage permit rapid manual striking of the arc and the lowering of the carbon arm when a new carbon is to be inserted.

The negative carbon arm is accurately machined and readily removable and is attached to a metal dowel plate in advance of the insulation point, hence its removal for cleaning or replacement is accomplished without having to break down its insulation or performing any realignment operation.

To counterbalance the weight of the negative carbon arm and its carriage and likewise correspondingly decrease the load on the feed gearing and motor, a flat clock spring is connected to the negative pinion shaft at its inner end and the spring housing at its outer end. By this means an effortless featherweight feed of the negative carbon holder is accomplished.

#### "HY-SPEED" $f/2$ CONDENSER LENS

The Peerless "Hy-Speed"  $f/2$  condenser-lens system is ground exclusively for us by Bausch and Lomb Optical Company of Rochester, New York. The rear lens is obtainable, made of either fused quartz or of Pyrex glass. It is  $6\frac{1}{4}$  inches in diameter. The fused-quartz lens is furnished with a  $\frac{3}{8}$ -inch edge on the rear surface to permit quite a number of resurfacing operations when it becomes badly pitted from exposure to the burning arc. The front lens is made of Corex Glass and is  $7\frac{3}{8}$  inches in diameter.

The operating distance between the arc crater and the rear surface of the rear lens is 3 inches and the working distance between the foremost point of the front curve of the front lens and the film line is  $12\frac{13}{16}$  inches. These operating distances provide 80 degrees side-to-center screen-light distribution (Fig. 9).

#### LIGHT-HEAT-FILTER UNIT

Because of the high order of light and light heat encountered when 160 to 180 amperes is drawn at the arc in combination with our "Hy-Speed"  $f/2$  condenser-lens system, to prevent film damage, some years ago we developed and made available to theaters using these high currents, an air-cooled, glass heat-filter unit.



staggered relationship to each other. Hence the air stream from the blower may pass completely over all surfaces as well as the edges of each strip of filter glass and, in consequence, efficiently radiate the heat each glass strip absorbs from the light.

Convenient means are provided to attach the motor-blower assembly to the projector pedestal. We recommend that the blower motor should be connected to the open end of the arc-lamp switch to ensure its operation simultaneously with the energization of the arc-lamp circuit when the arc switch is closed to strike the arc.

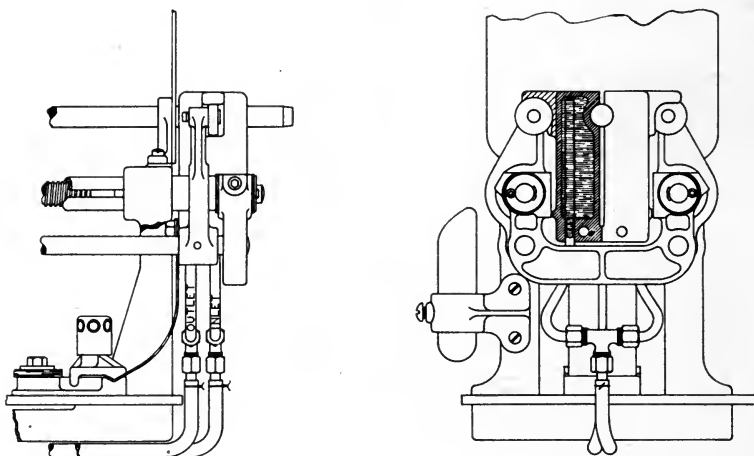


Fig. 10—Special water-cooled positive carbon contacts.

In operation the air is conducted from the blower to the hollow compartment of the filter main frame by a flexible plastic tubing of ample diameter. The air directed into the glass frame compartment mounted on the mechanism rear-shutter housing, passes over and all around each individual filter-glass strip and exhausts upward, out of the vent at the top of the main frame into the projection room.

Corning Glass Alko No. 3966 filter glass is employed and has proved to be very satisfactory in performance.

NOTE: The foregoing described equipment has already been installed and is in use by Radio City Music Hall, Roxy Theater, Balaban and Katz Chicago Theater, and hundreds of the foremost theaters as well as drive-in theaters in the United States and abroad.

## WATER-COOLED POSITIVE CONTACTS

To aid in the work being conducted by the National Carbon Company at Fostoria, Ohio, on the 290-ampere, 13.6-mm experimental projection arc carbon trim and also the Eastman Kodak Company at Rochester, N. Y., who are concerned with the high light temperatures that film will be subjected to through the use of these currents in theater projection, we developed and furnished each of these companies a modified Peerless Hy-Candescent lamp that was equipped with water-cooled positive contact units and certain burner mechanism changes to accommodate the higher consumption rate of these carbons.

Probably the most unique item of these modifications is the water-cooled positive contact assembly (Fig. 10).

The facing halves of the contacts are made of pure silver castings, the rear halves are of brass castings. Each pair of mated castings is cupped out in the center section so that when they are assembled together a hollow compartment results for the circulation of water. The inlet for the water into each contact compartment is through a copper tube leading upward to the top of the compartment, the outlet is by another tube at the bottom of the compartment, the cubical content of each contact compartment is  $5\frac{1}{2}$  inches.

Extremely satisfactory operations were obtained when up to 290 amperes were used at the arc and with only a  $\frac{1}{2}$ -inch positive carbon protrusion from the front face of the contacts and without the usual heat baffle plates being used between the arcing end of the carbon and the contacts.

Temperature tabulations were as follows:

Total water flow . . . . .	0.138 cubic foot per minute (approximately 1 gallon)
Room temperature during test . . . . .	72° F.
Outlet water temperature before test . . . . .	69° F.
Outlet water temperature after 10 minutes of operation . . . . .	88° F.
Outlet water temperature after 20 minutes of operation . . . . .	93° F.
Maximum temperature rise of water above room temperature . . . . .	21° F.
Maximum temperature rise of water after 20 minutes of operation . . . . .	24° F.

Because this water-cooled contact unit is adaptable to the standard Hy-Candescent projection arc lamp and its operation at 290 amperes was so highly satisfactory we expect to make it available to theaters now using our standard 120- to 180-ampere lamp, who are willing to provide the necessary water-piping requirements for it in their projection rooms.

## REFERENCE

- (1) *J. Soc. Mot. Pict. Eng.*, vol. 48, no. 1, January, 1947.

# Four-Channel Re-Recording System

By HOWARD RANDALL AND F. C. SPIELBERGER

RCA VICTOR MEXICANA, S. A., MEXICO, D. F.

*Summary*—A 35-mm re-recording channel consisting of four film phonographs, a projector, associated power supplies, and a mixing console, providing low installation cost and extreme operating economy, were required for an installation in Brazil. A rather unique and practical solution to the problem is presented.

THE CURRENT trend in the layout and design of motion picture sound recording and reproducing equipment is toward much more elaborate, complicated, and expensive installations. Flexibility is, of course, a prime consideration and no modern re-recording channel would be considered complete without a multitude of film phonographs, preamplifiers, booster amplifiers, equalizers, electronic mixers, limiting amplifiers, reverberation chambers, signal systems, and Selsyn-drive systems that provide for synchronous rewind of all film phonographs.

A studio in Brazil, however, required a four-channel re-recording system providing most of the usual conveniences and, at the same time simple, compact, and easy to maintain. It had to have low installation cost and provide for extreme operating economy without seriously compromising the quality of the final release-print sound track. Amplifiers and the mixing console were relatively straightforward and presented no serious problem since it was possible to keep the quality up and cost within reasonable limits at only a nominal sacrifice in flexibility, by getting along without many of the now customary "refinements" that represent a substantial item of expense.

The film phonographs, projector, recorder, and their motor-drive systems presented a difficult problem that had no such ready solution. It was necessary to break with tradition and develop a "packaged" system of somewhat unconventional design.

The film phonographs and projector must, of course, remain in "sync" at all times, while it is only necessary for the recorder to run at synchronous speed during a "take." Synchronism is not required during the acceleration period. For this reason it was decided to use one three-phase synchronous motor on the recorder and another three-phase synchronous motor driving the four film

phonographs and projector through a common mechanical interlock system.

Standard pedestal mounting of the film phonographs was out of the question and since the entire system, with the exception of the mixing console, was intended for two-man operation, the soundheads were

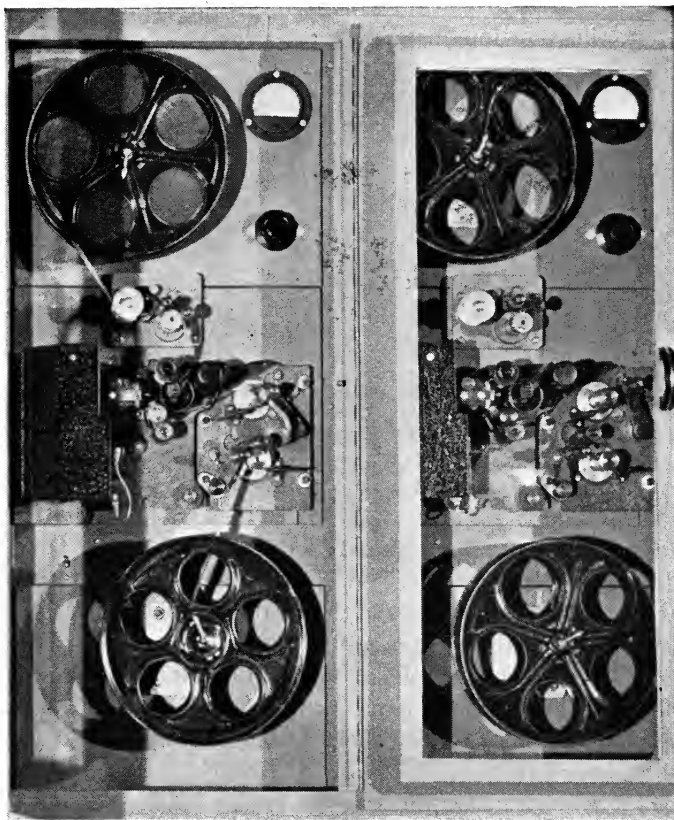


Fig. 1

arranged at extremely close quarters in a single metal cabinet. A close-up of two of the units is shown in Fig. 1; the left cabinet has the glass door opened showing accessibility for threading. The film rewind mechanism and control for the magnetic film drive are mounted on the upper panels. Standard RCA reproducer heads are

mounted on the center panels and the take-up mechanisms are mounted on the lower panels.

Power is supplied to all film drives from a common shaft running the length of the cabinet and driven by a one-third-horsepower, 110-volt synchronous motor mounted on the right end of the cabinet as shown in Fig. 2.

The projector is driven directly from the other end of the motor shaft. By introducing just the right amount of mechanical com-

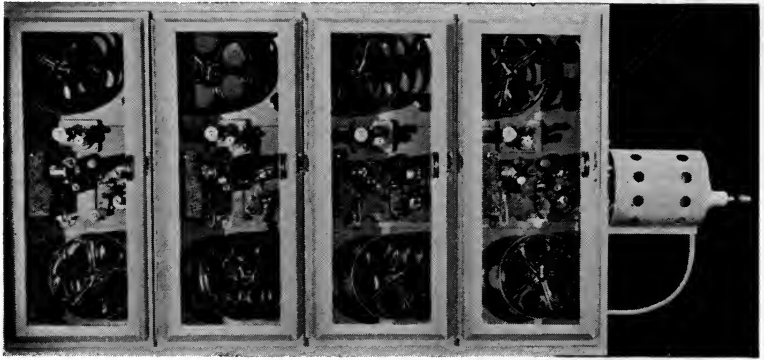


Fig. 2

pliance between the motor and sound-film drives, "reflections" from the projector mechanism are reduced to a minimum and do not appear as motion disturbances in the reproduced sound.

Shortcomings of this system are recognized; however, the solution of several very practical problems should be of interest to equipment designers and application engineers who have also been faced with the problem of putting a bushel of sound equipment into a half-bushel basket.



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(CORRECT TO MAY 6, 1948)

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(Under Organization)

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(Under Organization)

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To make recommendations and prepare specifications for the operation, maintenance, and servicing of motion picture film, sound recorders, re-recorders, and reproducing equipment, methods of recording sound, sound-film processing, and the like, to obtain means of standardizing procedures that will result in the production of better uniform quality sound in the theater.

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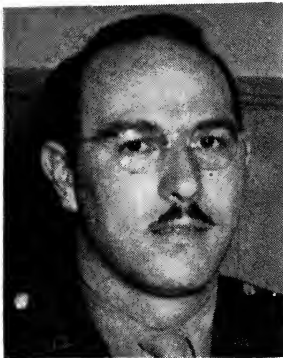
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### MARGARET C. KELLY

Miss Margaret C. Kelly, Office Manager for the Society of Motion Picture Engineers, resigned her position on May 1, 1948, and has moved to Scranton, Pennsylvania, to join her husband Mr. Harry Reiley. Miss Kelly first was Financial Assistant for four years before becoming Office Manager in 1947. She was born in Wilkes-Barre, Pennsylvania, and attended Wyoming Seminary and Bucknell University. Before joining the staff of the SMPE, she was Office Manager for the Lion Chemical Company.



Margaret C. Kelly



Sigmund M. Muskat

### SIGMUND M. MUSKAT

On April 9, 1948, Sigmund M. Muskat took up his duties as Office Manager for the SMPE. Mr. Muskat was born in Newark, New Jersey, and is now attending the School of Business at the City College of New York, where he is working toward the degree of Bachelor of Business Administration. During the war, he was connected with the Army Exchange Service and taught accountancy in the Army Exchange Service School. He has had varied experience in the public and private accounting fields and before joining the staff of the Society of Motion Picture Engineers was Budgetary Comptroller for a soft drink manufacturer.

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## Section Meetings

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### Pacific Coast

Approximately 300 members and guests attended the January 28, 1948, meeting of the Pacific Coast Section, which was held in the Electrical Research Products review room in Hollywood. Loren L. Ryder, president of the SMPE and head of the sound department of Paramount Pictures in Hollywood, presented the first paper of the evening on "Theater Television by the Paramount 35-Mm Film Method." He briefly described the system recently installed in the New York Paramount Theater whereby the received television image is photographed and relayed to the theater audience with a time lapse of 65 seconds. The technique was demonstrated in a 15-minute reel which included dramatic scenes and excerpts from the Louis-Walcott fight.

The second paper on "The Trichromatic System of Color Measurement and the Chromaticity Diagram" was presented by Alan M. Gundelfinger of the Cinecolor Corporation. In this first of a series of academic lectures by experts on various technical subjects planned for this year, Mr. Gundelfinger explained how any color can be matched by a suitable mixture of three selected radiations and how this fact is utilized in defining colors in the International Commission on Illumination system.

Added attractions were a three-color cartoon in Cinecolor, and a demonstration by Colonel George W. Goddard of the United States Air Forces of three-dimensional strip films made from the air by cameras using a slit aperture and film travel synchronized with the speed of the plane.

The February 10 meeting, held at the Republic Studios in North Hollywood, was attended by more than 650 members and guests. The subject of the evening was "Truecolor: An Integral Color Process for Printing from Bipack Negatives." Brief remarks about various phases of the process were made by Sam A. Cohen, color co-ordinator, Consolidated Film Industries; Jack Mara, cinematographer, Republic Productions; E. H. Reichard, chief engineer, Consolidated Film Industries; Carl Hauge, chief chemist, Consolidated Film Industries; and Dan Bloomberg, chief engineer and director of sound, Republic Productions.

Each of the speakers described that phase of the process with which he is concerned. The audience was particularly impressed by the sharpness of the image, the luminosity of the colors, and the excellent sound quality.

Truecolor was described as a print process using double-coated film having no color sensitivity but containing appropriate color couplers so that a single-color developer will produce a red-dye image on one side and a blue-dye image on the other.

The meeting opened with a two-reel documentary film entitled "Biography of the Motion Picture Camera," and closed with a feature picture in Truecolor.

### Midwest

The February 12, 1948, meeting of the Midwest Section was attended by 125 members and guests. Robert Lewis described the method and techniques used in producing a sound color cartoon drawn on to the film which opened the meeting. This was followed by a color film in abstract patterns and motions.

R. Paul Ireland, of the Engineering Development Laboratories, presented the first paper on "A New 16-Mm Sound-Track Reader," which described a small self-contained unit  $6 \times 6 \times 6$  inches, including amplifier and speaker which may be placed between a pair of rewinds to edit 16-mm sound film. Mr. Ireland's discussion was followed by a demonstration of the equipment.

"Comparison of Lead-Sulfide Photoconductive Cells with Photoemissive Cells Especially with Respect to Source Color Temperature," was then given by Norman Anderson, of the Continental Electric Company, Geneva, Illinois.

Ralph W. Engstrom, of the Gas-Tube and Phototube Division, Engineering Department, Radio Corporation of America, RCA Victor Division, Lancaster, Pennsylvania, presented a paper on what RCA is doing about the lead-sulfide cell for motion picture uses. He discussed proposed standards in tube design and characteristics.

Discussion from the floor followed these papers with Mr. Anderson and Mr. Engstrom answering the questions.

## Current Literature

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THE EDITORS present for convenient reference a list of articles dealing with subjects cognate to motion picture engineering published in a number of selected journals. Photostatic or microfilm copies of articles in magazines that are available may be obtained from The Library of Congress, Washington, D. C., or from the New York Public Library, New York, N. Y., at prevailing rates.

### American Cinematographer

- 29, 2, February, 1948  
 Photographic Highlights of 1947  
 (p. 43) G. E. MATTHEWS  
 New Services Launching 16-Mm  
 Television Newsreels (p. 53)  
 The Cinema Workshop. Pt. 20.  
 Distributing Your Film (p. 58)  
 C. LORING  
 DeVry Introduces Lightweight 16-  
 Mm Projector (p. 63)

### British Kinematography

- 12, 1, January, 1948  
 The Law of Copyright and the Film  
 (p. 1) A. KRESTIN  
 The Technical Design of the Pro-  
 jector (p. 13) R. ROBERTSON

### Electronics

- 21, 3, March, 1948  
 Television Receiver Laboratory  
 (p. 86) F. R. NORTON

### La Cinématographie Française

- 30, 1239, December 27,  
 1947  
 Cinquante Ans de Cinéma Pathé  
 (Fifty Years of the Pathé Cinema)  
 (p. 33)

#### TECHNIQUE ET MATÉRIEL

- Les futurs développements du cinéma  
 en couleurs (Future developments  
 of color motion pictures) (p. III)

### International Projectionist

- 23, 2, February, 1948  
 Black-and-White vs. Color Cinema-  
 tography (p. 7) J. VALENTINE  
 16-Mm Projection: from Purchase  
 to Picture (p. 14)

### PSA Journal

- 14, 2, February, 1948  
 Photographic Reversal Effects  
 (p. 107) E. P. WIGHTMAN

**Electronic Engineering**

20, February, 1948

Noiseless Sound Recording Equipment (p. 48)

The New Television Camera (p. 59)

C. P. S. EMITRON

Commercial Disk Recording and Processing (p. 61)

**Radio News**

39, 3, March, 1948

Television—Exclusively! (p. 48)

M. ALTH

The Recording and Reproduction of Sound. Pt. 13 (p. 62) O. READ

Interference Traps for Television (p. 70) S. N. FINLEY

**Ideal Kinema**

14, February 12, 1948

Television Sweep Circuits. Their Function and Operation. Pt. 1 (p. 23) A. BUCKLEY

When the Film Found Its Voice (p. 25)

**International Photographer**

20, 2, February, 1948

50,000 Feet of Commercial Kodachrome Used in Filming Pineapple Industry (p. 18)

Kodak Building "Photo-Memory" for Navy Electronic "Brain" (p. 29)

**I**N RECENT ISSUES of the *Philips Technical Review*, there have appeared articles which should prove of great interest to the motion picture engineer. A summary of one of these papers is given below.—THE EDITOR

### DETERMINING THE LIGHT DISTRIBUTION AND LUMINOUS FLUX OF PROJECTORS

BY J. BERGMANS AND H. A. E. KEITZ

In every illuminating engineering laboratory instruments are used for registering the distribution of light from light sources emitting rays in all directions. The light source is suspended in a certain fixed position, the luminous intensity (candle power) is measured in several meridian planes, a polar graph of the light distribution is plotted and from that one calculates the total flux (usually with the aid of a Rousseau diagram). In the case of projectors this method is not directly applicable. If it is a small projector emitting a very narrow beam, the light source can be set up in a fixed position and the light distribution determined by means of a number of isolux curves on a projection screen perpendicular to the optical axis of the beam, the flux then being found by integration. In all other cases the photometer has to be set up in a fixed position and the light beam moved in such a way that each part of the beam is successively thrown on the photometer; for this purpose two different types of rotating apparatus are used. From the results of the measurements taken an isocandle diagram can be obtained. Before the luminous flux can be determined that diagram has to be reproduced on a flat plane, employing the sinusoidal method or Lambert's azimuthal reproduction, both of which are area-proportional. It has advantages when the measurements are so carried out that the successive directions of measurement lie on a conical surface around the optical axis of the light beam. To make this possible Philips Laboratory for Illuminating Engineering has constructed and is using a special rotating apparatus, which is described in this article. (*From Volume 9, Number 4*)

## Book Reviews

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### **Applied Architectural Acoustics, by Michael Rettinger**

Published (1947) by the Chemical Publishing Company, Inc., 2 Court St., Brooklyn, N. Y. 182 pages + 7-page index + xi pages. 69 illustrations.  $5\frac{3}{4} \times 8\frac{3}{4}$  inches. Price, \$5.50.

Directed to architects, engineers, contractors, and all those connected with the planning and construction of buildings in which the acoustic properties are of high importance, this compact work is not intended as a text but rather as a handbook for the man in the field. While the treatment is largely practical, sufficient theoretical matter is introduced to support adequately the techniques presented. The first four chapters (of a total of seventeen) are devoted to principles and theoretical reasoning.

Following chapters consider specific practical applications of the science of acoustics to motion picture theaters, scoring and sound stages, reverberation chambers, broadcast and television studios, hospitals, churches, and auditoria. The optimum shape and size of motion picture theaters and studios are specified as well as reverberation characteristics. Consideration is given to the monaural acoustic perspective occasioned by the "single-ear" performance of the microphone.

While acoustic insulation is a chapter subject, methods of insulating studios and stages are explained in detail in the respective chapters. A discussion of the performance characteristics of various types of microphones is included in the chapter "Auditoria," also suggestions for the effective use of microphones in public-address applications.

Although most of the reasoning is based upon geometrical acoustics, the groundwork is laid for the more exact analyses of physical or wave acoustics. As a handy pocket companion, this book offers much to the worker in architectural acoustics.

C. S. PERKINS

Altec Service Corporation  
New York 19, N. Y.

### **Patent Notes for Engineers, by C. D. Tuska**

Published (1947) by the *RCA Review*, Radio Corporation of America, RCA Laboratories Division, Princeton, N. J. 146 pages + vi pages + 4 pages + 15-page index. 37 illustrations.  $6\frac{1}{4} \times 9\frac{1}{4}$  inches. Price, \$2.50; foreign postage, 20 cents extra.

This book was published primarily for the use of the Patent Department of the Radio Corporation of America, and for the information of the scientists and engineers employed in RCA Laboratories Division and in all other RCA subsidiary companies. Nevertheless, it should be of general interest to all scientists engineers, attorneys, and others concerned in any way with patent matters. The publisher refers to the book as the first volume in a new Engineering Book Series published by the *RCA Review* Department, the original manuscript being prepared by C. D. Tuska, Director of the Patent Department of the Radio Corporation of America.



The first chapters deal with the broad subject of what is, and what is not invention, and cite many examples and illustrations of patentability as determined by the courts in different fields of human endeavor. These chapters clearly indicate to scientists and engineers that "patentable intention" does not carry a label so inscribed.

As noted above, the book was written for a specific purpose, and so there is a chapter on invention record keeping, which is complete with illustrations of the invention disclosure forms in use by RCA. This information can be used to excellent advantage by all inventors.

The book also gives information on the prosecution of patent applications through their original preparation, amendments, appeals from Examiners' decisions to reissues and disclaimers. This is followed by a chapter containing general information on the technicalities involved in determining who is entitled to a patent on a single invention being disclosed and claimed in different applications. This should be of particular value to patent attorneys.

In the last chapter, the author has delved into his many years' experience for his pithy remarks relative to the ownership and use of patents, their purchase, licensing, and general value.

Considering the compass of the book, Mr. Tuska has presented a thorough, factual story of the realities of patents under existing patent law, and he does not indulge in any special theories or patent reforms. The book is well indexed, will be found to be an excellent tool for new patent practitioners, and is written in language readily understood by the layman interested in patent matters.

IRL R. GOSHAW

RCA Laboratories Division  
Hollywood 38, California

## Ten-Year Index 1936-1945

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Late in March, 1948, a Ten-Year Index, covering the years 1936-1945, inclusive, was mailed to the membership of the Society. This Index contains a list of subjects and a list of authors, both of which are cross-indexed.

Copies are for sale at \$2.00 each, postpaid, and may be obtained from

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# Journal of the Society of Motion Picture Engineers

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JUNE 1948

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# Society of Motion Picture Engineers

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Section Officers and Office Staff listed on page 618.

# Report of SMPE Progress Committee\*

*Summary*—This survey of the more important technical progress made by the motion picture industry during 1947 is classified as follows: A—Introduction, B—Cinematography, C—Sound Recording, D—Picture and Sound Reproduction, E—Television, and F—Standards. Developments relating to 35-, 16-, and 8-mm films are discussed under the major headings.

## A. INTRODUCTION

AT THE END of 1946, anticipation was high in the industry that the year of 1947 would be one of outstanding technical progress. It was felt that a sufficient postwar period had elapsed to permit consolidation of wartime advances with peacetime design.

Although this survey may, perhaps, indicate that progress was not so marked throughout this broad field as had been expected, 1947 was still a year of real achievement, not only for the definite improvements that were recorded in many instances, but for the strides which were made in the industry at large toward the advances which are yet to come. It is necessary to bear in mind that progress is not necessarily tangible, but rather cumulative. Important developments do not come into being overnight, but as the result of years of endeavor by a great many individuals and organizations.

## B. CINEMATOGRAPHY

### 1. 35 Mm

#### a. *General*

The previous trend toward an increasing use of color continued last year with available processes working at full capacity. More pictures were photographed "on location" in an effort to get more authentic backgrounds. Electrically operated camera dollies and booms were more widely used and practically all camera lenses are now treated with antireflection coatings and are photometrically calibrated for light transmission. Latensification of picture negative was adopted on a large scale by one studio to secure increased film latitude and better laboratory processing control.

#### b. *Lighting Equipment and Techniques*

The changes in lighting techniques during the past year have been confined largely to color photography. Cinematographers who

\* Original manuscript received by the Society, April 20, 1948.

formerly photographed only in black and white are becoming accustomed to color and are rapidly learning how far they can deviate from strictly technical requirements in order to achieve dramatic effect. This knowledge is simplifying photography on color sets.

*Carbon Arcs*—Mole-Richardson "Brute" lamp, which operates at 225 amperes is reducing the numbers of lamps on large sets.<sup>1</sup> A single-arc flood-type lamp, which may be used as a camera light for close-ups or in certain small areas, has been introduced. Spotlamp-type arc units have been manufactured in England for operation in series with little or no ballast resistance, but as yet have not been used in Hollywood studios.<sup>2,3</sup>

*Incandescent Bulbs*—An incandescent bulb small enough to hide behind a man's thumb, yet efficient enough to produce photographic exposure at close range is finding applications in special photographic work. Another type, 1.5 inches in diameter and with a reflector-type bulb, is used to produce a splash of photographic light at close range in addition to many other uses.

Airplane landing lamps of the sealed-beam type, fitting present automobile headlamp holders and producing light of extremely high brightness levels, have now made day shots showing lighted car headlamps quite realistic. Under certain conditions the headlight beam will show on an object in front of the car even in bright sunlight.

*Mercury-Source Lamps*—The lamp department of the General Electric Company reports favorable progress on the development of high-wattage color-corrected mercury sources of the type recently described in the JOURNAL.<sup>4,5</sup> The Westinghouse Electric Company started some field experiments in the early part of 1947 toward the use of cadmium with mercury in a flood-type unit. The idea of using mercury and cadmium in an enclosed arc is not new, however, its development received considerable impetus during the war in England where both the British General Electric Company and the British Thomson Houston Company, Ltd., worked on a lamp of this kind for the British Navy.<sup>6</sup>

The Motion Picture Research Council, Inc., is conducting an investigation of the mercury-cadmium sources to determine the requirements for their use in color photography. Whatever information the Council obtains in this regard will be made available to the manufacturers of sources and housings.

During 1947 the Mitchell Camera Company delivered a number of complete process projectors<sup>7</sup> to motion picture studios all over the

world. This equipment was built according to specifications provided by the Research Council and includes  $f/2.0$  relay condenser optical systems and Mole-Richardson Type-250 automatic carbon-arc lamps.<sup>1</sup>

The new General Electric Type PR-1 exposure meter was introduced<sup>8</sup> in October, 1947. This meter is made for use with reflected or incident light, and also for use with either still or motion picture cameras. Other features include a pointer lock mechanism, logarithmic scale, and a calculator dial which eliminates the necessity of reading the meter deflection to calculate exposure. New Salford Electrical Instruments, Ltd., telescope-type photoelectric brightness meters were used and found to be of great value in color when provided with interchangeable color filters.<sup>9</sup>

### c. Color Processes

In the Hollywood studios there was an increased use of Technicolor, Cinecolor, Trucolor, and Ansco Color. Improvements in the techniques of bipack negative and printing have been numerous during the past year. Two-color methods have largely filled the needs of the studios for pictures of western and other classes which have not been on three-color schedules. The increase in production of two-color features has been phenomenal.

The extended use of three-strip negative is indicated by the fact that Technicolor has reported the manufacture of new three-strip cameras in order to increase their volume of photography.<sup>10</sup>

*Climbing the Matterhorn*, a two-reel subject in Ansco Color, was released. It won the Academy Award for two-reel shorts. A full-length Ansco Color feature *Sixteen Fathoms Deep* has been completed with processing by the Houston Corporation.

The color process recently announced by Polacolor is a three-color release-printing method. Polacolor has not announced a taking method and all prints made to date have been made from cartoon or other separation negatives. The Polacolor method is a photochemical procedure of dye replacement using standard release-type printing stocks. The Paramount cartoon subject *The Circus Comes to Clown* which is now in release was done by the Polacolor Process.

In addition to improvements in sharpness and color rendition Cinecolor made the following progress during 1947:

1. Final development of a three-color process now being utilized for cartoons and short subjects.

2. Development of 1000-foot magazines and adapters for bipack photography.

3. Development of technique for producing three-color 35-mm prints from 16-mm low-contrast Commercial Kodachrome (EK-5268).

4. Development of technique for producing 35-mm three-color prints from 35-mm Ansco Color.

Republic Studios made a number of features in Trucolor which were processed by Consolidated Film Industries. Trucolor is an integral color process for printing from bipack negatives. The film consists of a safety base coated on both sides with noncolor-sensitive positive emulsions, one of which contains a color coupler which will form a blue dye with the color developer and the other side a color coupler that will form a red dye with the same color developer. Simple fixing, bleach, and further fixing removes excess silver halides and silver image. The sound track is a silver compound obtained by special treatment.<sup>11</sup>

Twentieth Century-Fox Studio was the first to utilize a new design of motor system developed in co-operation with Western Electric, making use of a 96-volt direct-current interlock motor running at 1440 revolutions per minute with a normal 24-cycle interlock frequency. In this system the motor is connected directly to the camera shutter, and, with the 24-cycle interlocking frequency, makes background projection-shutter phasing automatic. The system will interlock from standstill, can be easily increased in power for excessive cold-weather requirements, can be made to operate at over and under speeds for "wild" operation, and can be manually speed-controlled for location work or operated with automatic speed-control equipment in the studio.

Also newly developed for interlock motor systems using a synchronous motor drive of a distributor is the Western Electric RA-1354 clutch. This clutch was designed to have the action depend upon acceleration and deceleration with the maximum torque available when the two shaft speeds are the same. It provides a smooth starting characteristic of uniform duration with the action independent of variations in load.

*16-Mm Cinematography*—Prior to 1947, the supply of professional type equipment was so small as to handicap greatly direct production of 16-mm films. During the year, however, equipment introduced in late 1946 became available in quantity, greatly stimulating progress



in this field. In addition, commercial Kodachrome became available in quantities for the first time, lending additional impetus to direct 16-mm production.

At the April Convention of the Society in Chicago, considerable attention was paid to developments in substandard cinematography, recording, and reproduction. Orton H. Hicks, of Loew's International Corporation, pointed out that "We are removing the economic barrier (to international understanding) by introducing 16-mm



Fig. 1—Maurer 16-mm professional motion picture camera.

operations into . . . remote corners of the world where 35-mm could not operate profitably."<sup>12</sup>

This same financial factor, together with ease of portability, furthered the trend to 16-mm work in the instructional, industrial, and scientific fields, where the limitations of the medium were not so great as to interfere with its suitability. Progress was particularly marked in the medical field, since films of operations and disease conditions not only serve an important instructional purpose, but are of great value in the study of case histories.<sup>13</sup>

Among the 16-mm cameras coming into wide use during 1947 were

the Auricon, the Bell and Howell Model 70, the Maurer (Fig. 1), and the Mitchell. Each of these cameras was designed for professional use, the Model 70 featuring a four-lens turret and a 400-foot daylight-loading magazine.

Accessory equipment which came into use included 16-mm matte boxes and filter holders from the Camera Equipment Company and Bardwell and McAllister, Inc. Closely resembling their 35-mm counterparts, these filter holders were developed to permit the effects possible in standard size cinematography.

A new series of coated Baltar lenses for 16-mm cinematography was announced by the Bausch and Lomb Optical Company, the lenses being made in 15-, 17.5-, 20-, and 25-mm focal lengths. Each of them is of a high-speed type, with a relative aperture of  $f/2.3$ .

*8-Mm*—Although 8-mm cinematography equipment could not be said to be professional, some progress was made during the year to bring higher standards than those heretofore possible. The problems involved in obtaining the best possible result from limited film dimensions were discussed by Lewis at



Fig. 2—Bell and Howell, film auto-8 camera.

the Spring convention.<sup>14</sup> Bell and Howell introduced the Film Auto-8 camera, featuring magazine loading and a two-lens turret (Fig. 2).

## C: SOUND RECORDING

### 1. 35-MM OPTICAL

#### a. General

An unusual amount of newly designed film recording and re-recording equipment was supplied during 1947. This was characterized by better operating convenience, improved performance, and attractive appearance. While it is too early to evaluate the extent to which greater reliability has been realized, it may be stated that more attention has been given to accessibility for maintenance.

There was a trend toward more reverberant music recording and there was more use made of the "echo chamber," particularly for individual sections of the orchestra during original music recording to secure a better balance and a more pleasing effect for certain orchestrations. Postsynchronization of sound was more widely used to give greater freedom to the camera and to the actors on the sound stage and on location. Radio communication between mobile sound trucks and the studio became more widespread.

*b. Equipment*

Three new types of 35-mm recording equipment were introduced by Blue Seal Cinematography Devices, including a portable system, a



Fig. 3—RCA unidirectional microphone, MI-10001.

studio-location system, and a fixed system. Recorders and galvanometers for variable-area track are identical in each type, the additional equipment being of different design in each of the systems.<sup>15</sup>

The Radio Corporation of America introduced a number of new units that may be used to augment existing equipment or in combination with complete film-recording channels.

The polydirectional microphone Type 77D was designed primarily for indoor use, to combine the better features of velocity- and pressure-operated types. A screw-driver adjustment permits bidirectional, unidirectional, or nondirectional operation. Low-frequency response below 300 cycles has a three-position adjustment to accommodate music or voice pickups. Unidirectional microphone, MI-10001, was specially designed to meet film-recording requirements with emphasis

on frequency characteristic and relative immunity to air currents. Its response to air currents, when operated without a windscreen, is roughly 4 decibels less than older ribbon types operated with a windscreen. The front view of a field-trial model of this microphone, less suspension mounting or stand, is shown in Fig. 3 and its response characteristic is shown in Fig. 4. New amplifiers by RCA include the MI-10235 power amplifier,<sup>16</sup> and its companion unit the MI-10236 ground-noise-reduction amplifier for use with biased galvanometer or shutter methods of noise reduction. The power amplifier has a frequency characteristic flat within 0.5 decibel from 20 to 10,000 cycles and will deliver 10 watts of power (+40 dbm)\* with no greater distortion than 0.5 per cent. These units are designed for either

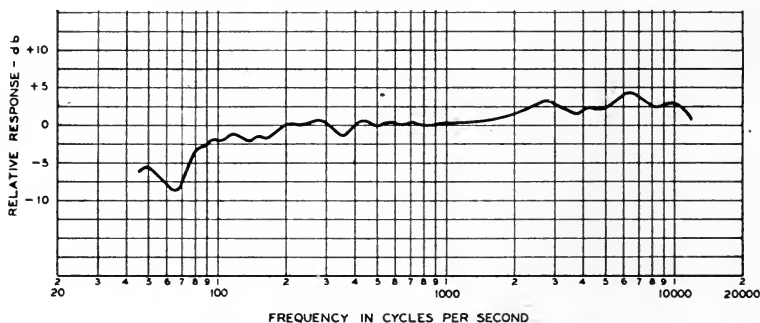


Fig. 4—Response characteristic of RCA MI-10001.

alternating- or direct-current operation and for either bridging or matching inputs. They are cradle-mounted on roller slides which permit their being slid out, inverted, or removed in a matter of seconds.

A variable-dip filter, MI-10135, was developed to permit the sharp attenuation (50 decibels) of a narrow frequency band anywhere in the range of 30 to 9000 cycles. It consists of a multistage, zero-gain amplifier in which a three-terminal, continuously adjustable Wien bridge is used as the coupling circuit between two amplifier stages. Liberal feedback from the output to the input of the amplifier permits retention of narrow bandwidth at cutoff frequencies. The bandwidth of the rejected frequency is 15 per cent at 6 decibels attenuation and 3 per cent at 30 decibels attenuation referred to the peak attenuation frequency.

\* Decibels with respect to 0.001 watt.

The new RCA PR-31 recorder<sup>17</sup> was designed for low flutter content, quiet operation, and ease of adding accessories such as 200-mil optics and magnetic-recording heads. Features of this recorder are an advanced optical system<sup>18</sup> and an improved galvanometer.<sup>19</sup> A new lightweight portable recorder for 35-mm operation<sup>20</sup> (PR-33) was also developed.

A typical studio channel employing the new units is shown in Fig. 5. The left-hand rack contains the power controls, power meters, fuse panel, and battery-charger controls. A PR-33 recorder is shown in the



Fig. 5—Typical RCA studio channel with PR-33 recorder.

center. The top center panel contains the motor-speed and power-frequency indicator, camera-motor ammeter, and monitor speaker. The right-hand rack contains (top to bottom) the film-loss and dialogue equalizer, MI-10235 power amplifier (slid out and inverted), volume-control panel, audio test panel, MI-10236 ground-noise-reduction amplifier, electronic mixer, 80-cycle high-pass filter and isolation amplifiers (cover removed). The plate-supply dynamometer and multisection filter is in the rear center compartment.

A new monitor loudspeaker, Type LC1A, developed by the RCA

Laboratories, consists of a duocone mechanism and an acoustically designed cabinet. The duocone mechanism consists of a 2-inch, high-frequency cone coaxially mounted with a 15-inch low-frequency diaphragm. This speaker is rated at 20 watts input and provides low distortion response from 50 to 15,000 cycles together with wide-angle radiation.

Western Electric introduced a number of pieces of new equipment, the result of development work extending over the postwar period. Two new channels were developed for 35-mm operation: the 335D system, a high-quality, portable, lightweight channel, a Type 435



Fig. 6—Location recording by Emelco Studios in Argentina.  
WE-435A System.

channel which was designed as fixed high-quality studio production equipment with accessories. Both of these systems may be adapted for either 200-mil push-pull or 100-mil standard tracks with either variable-area or density-type modulation. These channels are being used by several studios in Hollywood, and have been sent to Europe, India, and Latin and South America (Fig. 6) by the Westrex Corporation.

New re-recording equipment includes new machines and several new types of mixing consoles (Fig. 7) making use of variable equalizers and other recent advances in circuit design. These machines are housed in a vertical-type cabinet designed for side-by-side installation

both to minimize the installation space required and to make for easier operation. At the Metro-Goldwyn-Mayer Studios, this idea has been carried further in that their recording machine and recorder control cabinets for their re-recording channels are similarly constructed.<sup>21</sup> (Fig. 8.)

A light-valve-testing console was built for Paramount Studios, and is interesting in that it incorporates elaborate means for projecting images of the light-valve ribbons so that they can be viewed in actual operation. Accurate measurements of light-valve resistance are also made with this console.

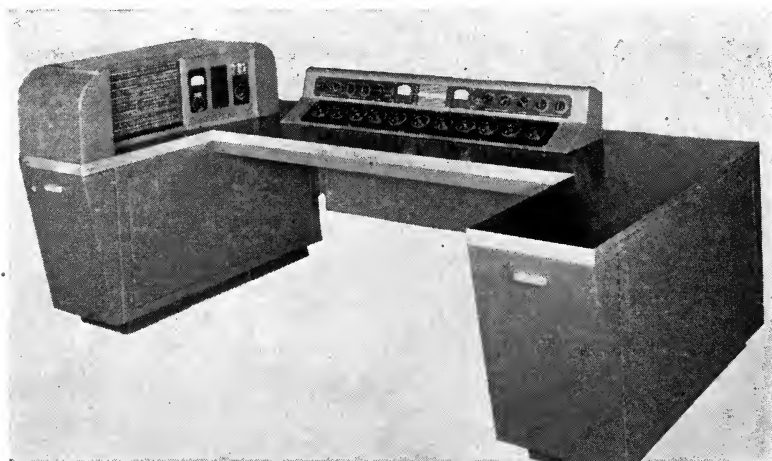


Fig. 7—Western Electric RA-1407 re-recording console.

One of the important elements of the new Western Electric recording and re-recording systems is the new "Davis" film drive, which has been incorporated in recorders, re-recorders, and theater reproducers.<sup>22</sup> This is a simple, easily built, and easily maintained film-drive mechanism which, through the use of an ingenious combination of spring-connected rollers and a flywheel, has reduced flutter to a negligible amount.

Another important development has been the design of the new high flux-density self-damping light valves. Through the use of increased flux density the new light valves have been made to have a very small rise in response at their resonant frequencies. A series of these valves has been built for recording either 200-mil push-pull or 100-mil single sound tracks, either variable-area or variable-density.

Newly designed modulator units have been built to use the new type valves. Incorporated in these units are phototube monitoring facilities, blooming lamps, lamp-current intensity meters, automatic shutters, and for area modulators, a visual monitor.

Another interesting development has been the design of an automatic recorder control unit. With this unit all the operations of starting and stopping the motor system, turning on and off the lamp

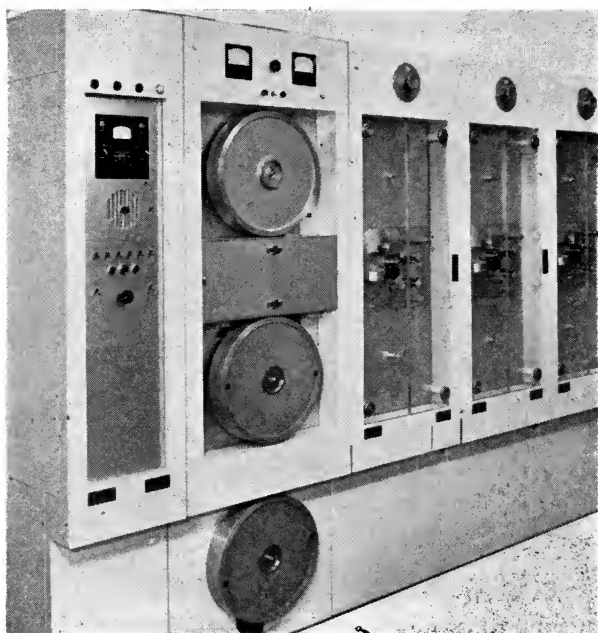


Fig. 8—RA-1340A recorder control cabinet, RA-1310A recorder with spare magazine, and three RA-1251C re-recorders as installed at MGM Studios, Culver City, California.

current, bias current, light valve, and phototube-monitor circuit and for opening and closing the shutter, are done automatically in their proper sequence (Figs. 6 and 8). This unit has been appreciated by operators because it removes the possibility of errors caused by the necessity of operating many switches in proper sequence.

## 2. 16-MM RECORDING

With the trend toward direct 16-mm production (see Cinematography) so well defined, there appeared on the market several 16-mm



recorders. The Auricon camera of Berndt-Buch, Inc., incorporates a single-system recorder which provides a variable-area track.

The Maurer recording system provides for both variable-area and variable-density recording, the Maurer organization feeling that certain advantages inherent in variable-density track will cause a decided trend in the future toward that type of recording for the 16-mm field. The Maurer recorder is capable of recording frequencies in excess of 10,000 cycles, although the response of the recording amplifier is cut off at 6500 cycles.

RCA introduced a lightweight, portable recorder, coded PR-32, which is similar in design and construction to the 35-mm PR-33, except for the necessary differences in film-handling elements and sprocket speeds.<sup>20</sup> Western Electric's 316D system is also designed for portability and high-quality 16-mm recording, being similar to the 335D system.

An optical printer designed to improve the high-frequency response of 16-mm recordings was developed by J. A. Maurer.<sup>23</sup>

### 3. 8-MM RECORDING

Some work was done on 8-mm sound, 1947 seeing the introduction of the first commercial 8-mm sound projector, manufactured by Continental Products Corporation under the trade name Movie-Sound-8. The equipment uses a  $33\frac{1}{3}$  speed disk with an automatic synchronous film and disk start.<sup>24</sup> A demonstration was also given at the Spring Convention of the Society and a later Midwest Section meeting of magnetic recording on 8-mm film by the Armour Research Foundation of Illinois Institute of Technology.<sup>25</sup> Tangible progress has been made in magnetic recording on wire, quarter-inch tape, and film.

### 4. MAGNETIC RECORDING

Toward the end of 1946, studio representatives began meeting with organizations developing magnetic-recording materials and equipment to discuss the basic problems involved in the application of magnetic recording to sound films. This work, under the sponsorship of the Society and the Research Council, is continuing.<sup>26</sup> Wire is under consideration for certain portable applications, while quarter-inch tape is being standardized for the broadcast industry and other nonsynchronous applications. Thirty-five-millimeter film with a magnetic coating is desirable for motion picture use since existing equipment can be adapted and film can be accurately synchronized

with cameras. DuPont and Minnesota Mining have both been active in the development of magnetic material on films with 35-mm perforations. This film probably will be on safety base, with a film speed of 18 inches per second.

Several of the studios have been using  $1/4$ -inch wide magnetic paper tape for recording sound effects. At Warner Brothers, several such recorders are kept instantly available for recording sound effects on location, narration for radio broadcasts, talent tests, and talent rehearsals. The recorders use tape speeds of 7.8 inches per second and are equalized to give recordings which are substantially flat from 50 to 7000 cycles. The equipments are provided with the standard VU meter, headphones as well as loudspeaker for monitoring, and synchronous motors. On locations where 115-volt alternating current is unavailable, recorders are operated from a vibrator and 12-volt storage-battery supply.

On a recent feature picture, which was of such a nature that it was possible actually to photograph in sequence a complete reel at a time, the magnetic recorder was used on every rehearsal and the recording played back to the cast and director for study before the "take" was made. A considerable saving in recording material was realized by being able to use the tape again and again.

## D. PICTURE AND SOUND REPRODUCTION

### 1. 35-MM FILM

There are now approximately 83,000 theaters in the world, of which about 16,500 are located in this country. The latter group was increased very little during 1947 because of building problems, but there was a relatively large increase in the number of drive-in theaters. Although new picture and sound systems or components were installed in theaters during the year, it is understood from estimates by suppliers that the extent of modernization was about the same as during 1946, both in the United States and abroad. The improvement in realism and entertainment thereby made available to a vast audience was the result of new equipment, some of which became available in quantities after having been introduced in 1945 and 1946.

More specifically, there was a trend toward high-intensity arc operation in the larger theaters; coated lenses of high-quality were more widely used; and dry-disk-type rectifiers for arc supply gained

in favor. Modern sound projectors provided more uniform film motion, easier threading, and called for less maintenance. Tungar-bulb exciter-lamp rectifiers were converted to selenium in the interest of securing a more uniform output voltage and longer life. Amplifier systems were of greater capacity with resulting decrease in distortion. Practically all new loudspeakers installed were of the permanent-magnet type and were designed for improved performance. The previous trend toward three projection machines continued along with increased installation of dual-amplifier systems or other facilities for emergencies. This was particularly true in the thousands of theaters which operated upward of 100 hours per week.

These progressive trends in theater equipment and its installation reflect the growing desire on the part of exhibitors and projectionists to present their film programs in the most attractive and, in the long run, the most economical manner. Progress toward optimum presentation of the picture and sound films was also appreciated by the public. An interesting example of audience concern with quality of reproduction was noted during a survey of Westrex of theater conditions in South America where the use of better soundheads,<sup>22</sup> amplifiers, and loudspeakers greatly improved the intelligibility of Spanish dialog by clearly reproducing the important final syllables.

An interesting discussion of the engineering problems involved in the construction of drive-in theaters was presented by S. Herbert Taylor during the SMPE Convention in October.<sup>27</sup> Over 100 of these theaters were constructed last year, including smaller layouts for 350 cars built for the first time on the outskirts of cities of only 25,000 population.

In addition to the smaller drive-in theaters, built mostly in the eastern part of the country, several unusually large ones were opened in the West. An example of perhaps the largest is represented by the Midway drive-in at Tucson, Arizona, with a capacity of 800 cars. Some idea of the problem of projection can be realized when it is noted that the throw is 300 feet with a picture size of 48 by 64 feet. Super high-intensity lamps are used with water-cooled 16-mm positive carbons operating at 210 amperes.

The Screen Brightness Committee of the SMPE made definite progress in a survey of screen conditions in about 25 cities. Their preliminary report<sup>28</sup> states that about 50 per cent of the first 18 theaters had a screen brightness below the 9 to 14 foot-lamberts standard now in effect.

Several newly designed items of equipment were introduced in 1947 of which the following are of interest: DeVry No. 12000 sound-film theater system, the Forest electronic arc lamp as well as new arc lamps by McAuley, Peerless, and Strong. Blue Seal Cinematography Devices, Inc., introduced the Superior Model A picture projector. The Type 800 loudspeaker was introduced by Altec-Lansing and a complete line of new theater loudspeaker systems was introduced by Western Electric.<sup>29</sup>

A 35-mm visual test film (VTF-1, 450 feet) was issued in 1947 by the Research Council and the SMPE. This film is composed of three sections which may be ordered separately as Focus and Alignment Section (VTF-FAS) Travel Ghost Target Section (VTF-TGS), and Jump and Weave Target Section (VTF-JWS). A 35-mm sound test reel was released by Altec-Lansing Corporation.

## 2. 16-MM REPRODUCTION

The manufacturers of 16-mm sound-film projectors were unusually active in supplying equipment in this country and abroad. In general, they were portable systems for use in the educational and industrial fields. There was also an increase in the use of 16-mm equipment in smaller theaters, particularly abroad.<sup>12</sup> To increase screen intensity, Strong introduced an arc system specifically designed for 16-mm operation. The lamp uses  $6/5\frac{1}{2}$ -mm carbons and draws 30 amperes at 28 volts. To our knowledge, there were no novel developments which came into extended use during the year except as applied to television. However, there was a large amount of engineering effort devoted to this field with assistance by the Government which gives promise for the future. One of the possibilities is the use of equipment for reproducing magnetic sound tracks with picture.

## 3. 8-MM REPRODUCTION

In the 8-mm field, there was considerable activity toward the manufacture and supply of home projection equipment of quality superior to that heretofore available. The design objectives involved were discussed in a paper delivered at the Spring Convention by Thomas J. Morgan.<sup>30</sup> Several new projectors were introduced during the year which embodied novel features at low cost.

## E. TELEVISION

During 1947, television began to realize the promise it has held in

recent years. The number of television receivers rose from about 7000 at the end of the war to better than 160,000 at the end of 1947. In addition, the Federal Communications Commission was so inundated by applications for channels that its chairman anticipated that existing channels for metropolitan areas of 50,000 population or more would be completely assigned by the end of 1948. Existing stations during the year made progress from the standpoints of both programming and technical quality.

Microwave relays and coaxial cables were used for remote pickups of sports and other events in addition to providing facilities for increased intercity exchange of programs. In the East it became possible to furnish programs originating in Washington to points as distant as Schenectady. Progress was also made in establishing a transcontinental coaxial-cable link, which may be used for television later.

Intensive activity grew in the production of films as a transcription device for television stations. In addition to commercial advertisements, the number of shorts produced for exclusive television use rose steadily during the year, several producers entering this field.

Television cameras were developed to function with special motion picture projectors in television stations. RCA introduced the TK-20A camera which provides for switching instantly from one projector to the other without moving the camera, while a slide projector is also included for station breaks and spot announcements.

Films played an increasingly important role in another phase of television with the introduction of cameras designed to photograph the kinescope image on film. These cameras were especially developed to photograph the 30-image-per-second television picture at the 24-frame-per-second motion picture speed.

In order to make full use of these films, facilities were developed which permit the processing of the film and its projection about one minute after the original filming. By this process, it is possible to employ the greater screen intensity of film while showing the action only a very brief time after its reception on the kinescope. This method also gives opportunity for documentation of transmitted programs, for program storage, and for providing network syndication.

A system of this kind developed by RCA consists of a receiver, monitor, a sound motion picture film camera, high-speed developer, and special projector. The monitor employs a kinescope, the face of which is focused on the motion picture film thus providing the means for recording the video program. All the components in the system

can be made continuous in operation with a total lapsed time between receiving the video signal and projecting the film in the projector of less than one minute.

Several discussions of theater television problems were made at the October convention of the Society. A. G. D. West<sup>31</sup> explained the current status of theater television in England, pointing out that large-screen direct projection has been feasible there for several years, the major problem now being the determination of commercial value of the equipment rather than in immediate technical advancements.

In this country, several demonstrations were given of large-screen direct projection from the kinescope. At the SMPE Convention, RCA gave a very interesting and promising showing of direct projection television on a screen  $6 \times 8$  feet. In other demonstrations, RCA showed a picture of this type  $15 \times 20$  feet, while announcing that a picture  $18 \times 24$  feet was possible by using a large kinescope tube. With a beaded screen, the illumination furnished by this equipment has been measured in excess of 5 foot-lamberts in the high lights.

Paramount, Warner Brothers, and Twentieth Century-Fox, are investigating with DuMont and RCA the future possibilities of theater television. The major problem facing the industry at large today would seem to be that of ascertaining the proper commercial application of these new entertainment facilities.

#### F. STANDARDS

Considerable work toward standardization of necessary equipment, films, and methods was carried forward in order to facilitate the large-scale production and distribution of these items throughout the world. Particularly active in this work were the Research Council and several committees of the SMPE which submitted proposals to the SMPE Standards Committee and to the ASA Committee on Standards for Motion Pictures, Z22. Fourteen American Standards were approved by the latter group<sup>32</sup> during 1947. Three of these applied to emulsion position and four to cutting and perforating dimensions of 35, 16, and 8 mm, prints and raw stocks, the principal changes being dimensions measured from the edges of sprocket holes rather than from center lines. Z22.35—1947, 16-Tooth 35-Mm Motion Picture Projector Sprockets, was approved with a 0.943-inch diameter instead of 0.945-inch to reduce film wear. Two new standards on camera and projector apertures were based on Z52 War Standards. Nine

proposed standards on 35-mm test films (Z22.60–Z22.68, inclusive) were prepared by the Motion Picture Research Council, Inc., and submitted by letter ballot to members of the Z22 Committee.

All ASA standards on motion pictures will be submitted to the International Standards Organization for consideration. The ASA Z-57 Committee on Sound Recording was organized with the sponsorship of the IRE and the SMPE to consider proposed standards on film, disk, and magnetic methods.

### G. CONCLUSION

We believe you will concur in the conclusion that the technical progress of the motion picture industry during 1947 was of creditable merit and magnitude. Of greater importance is the fact that its effects, unlike this report, did not terminate as of December 31. The next summary of progress may begin by mentioning the Rose Bowl game televised on a 12- × 16-foot screen at the Shrine Auditorium, Los Angeles, which was enjoyed by approximately 4000 persons. That was, perhaps, the first commercial large-screen, large-audience presentation of this new entertainment method in this country. Many additional advances will be recorded within the next few years.

The chairman wishes to express appreciation for the assistance given by members of the committee and the many others who furnished information and helpful comments.

C. R. SAWYER, *Chairman*

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# New Three-Color Camera

BY JACK H. COOTE

BRITISH TRICOLOUR PROCESSES, LTD., LONDON, ENGLAND

*Summary*—There is described here a beam-splitter color camera which utilizes the principle of a single-reflection prism block to expose three films in the combination of “bipack and one.”

**D**ESPITE MANY prophecies made, to the contrary, during the past decade, present indications are that the importance of color cameras in association with subtractive color printing processes is likely to continue.

It was because of a firm belief in the superiority of the “three-strip” method of color photography that British Tricolour, after developing its subtractive printing process to a pilot-plant stage in 1946, decided to design and build a beam-splitter color camera, the outline elevations of which are seen in Figs. 1 and 2.

The camera decided upon utilizes the well-known principle of a single-reflection prism block to expose three films in the equally well-known combination of “bipack and one.”

The two film transport mechanisms are of the Vinten “Everest” type and are standard black-and-white movements both threading from the same relative direction.

Employment of two standard movements effects obvious economies, but involves certain problems of design. It will be clear from Fig. 3 that it is likely to be difficult to thread No. 2 gate while the movement is in its operating position; particularly since with a gold dividing surface to the prism block the bipack is used with greatest light efficiency in the reflected light beam.

In order to avoid such threading difficulties it was decided to make the whole of No. 2 mechanism a movable assembly, swinging into and out of its operating position as required. It was considered necessary to be absolutely certain that the design and construction of such a “swinging gate” would prove satisfactory under all working conditions.

Various measurements, therefore, were made on the camera in order to test the consistency of register of the relevant moving parts

of the camera mechanism, and also to check for variation of register between the two film gates at various temperatures.

The swinging gate was repeatedly opened and closed, measurements of position being made at each closure after clamping tightly with the clamp. A suitable target was mounted on the gate and viewed with a microscope mounted on the fixed frame of the camera.

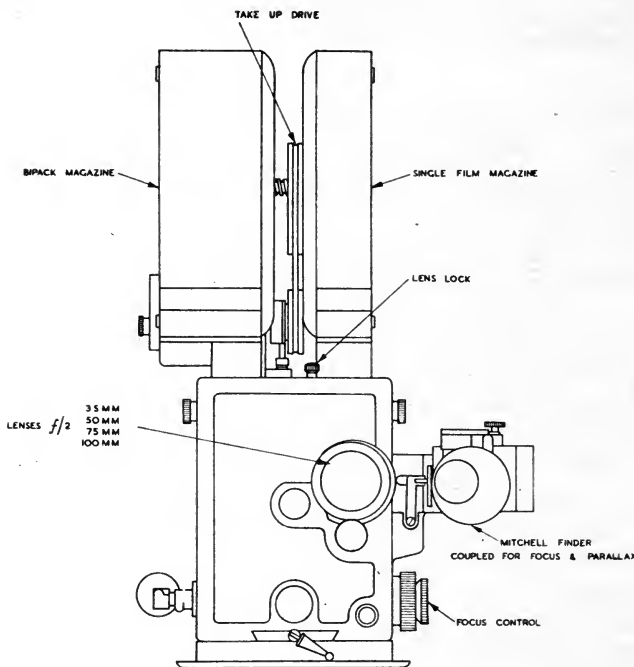


Fig. 1—Front view of camera.

Movement in a vertical or horizontal direction did not exceed 0.0001 inch.

Measurement of angular position was made with an autocollimator and reflector. An angular variation of  $\frac{1}{2}$  minute about a vertical axis was obtained, because of slight variations in the clamping pressure. This amount represents about 0.00015 inch over the width of the film gate.

The method of locating the prism block with a dovetail slide and

end stop, gave location both for angle and position, with variations of not more than 0.0002 inch.

A crossed line target graticule was mounted in each film gate so that the images were approximately superimposed when viewed through the prism system with a long-focus microscope.

The whole camera was placed in a refrigerator and allowed to settle to a steady temperature of approximately zero degrees centigrade.

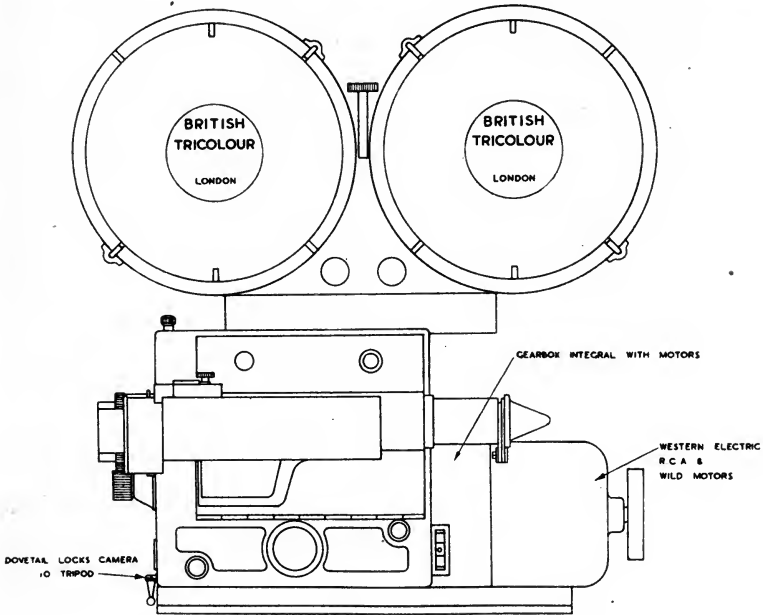


Fig. 2—Single film side of camera.

The camera was then removed and the microscope was set up to view the targets through the prism; measurements were then made of the relative positions of the targets both horizontally and vertically.

The temperature was gradually raised to approximately 100 degrees Fahrenheit (38 degrees centigrade), microscope observations being taken at intervals. Some difficulty was experienced at the lower temperatures because of condensation on the glass surfaces, but variations measured in either direction did not exceed 0.0005 inch.

The way in which the No. 2 assembly can be swung away from and

returned to its operating position should become apparent after reference to Fig. 4. The main drive shaft runs along the base of the camera, driving No. 1 movement through a combination of helical and spur gears and No. 2 movement via a train of three gears located ahead of both the mechanism and the shutter. The outer surfaces of the forward bearings of the main shaft provide the journals on which the whole of the movable assembly is pivoted.

It will now be realized that although the closed or exposing position of the movable gate has been referred to as its operating position, the mechanism can, in fact, be rotated while in its open or loading position, a feature which is essential for efficient threading.

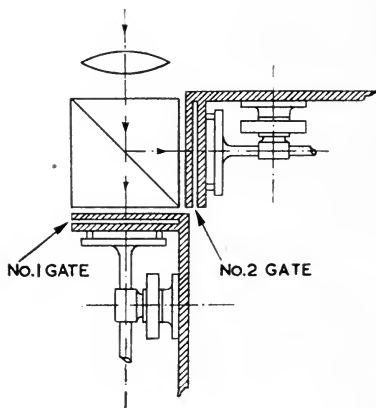


Fig. 3—Relative positions of two gates.

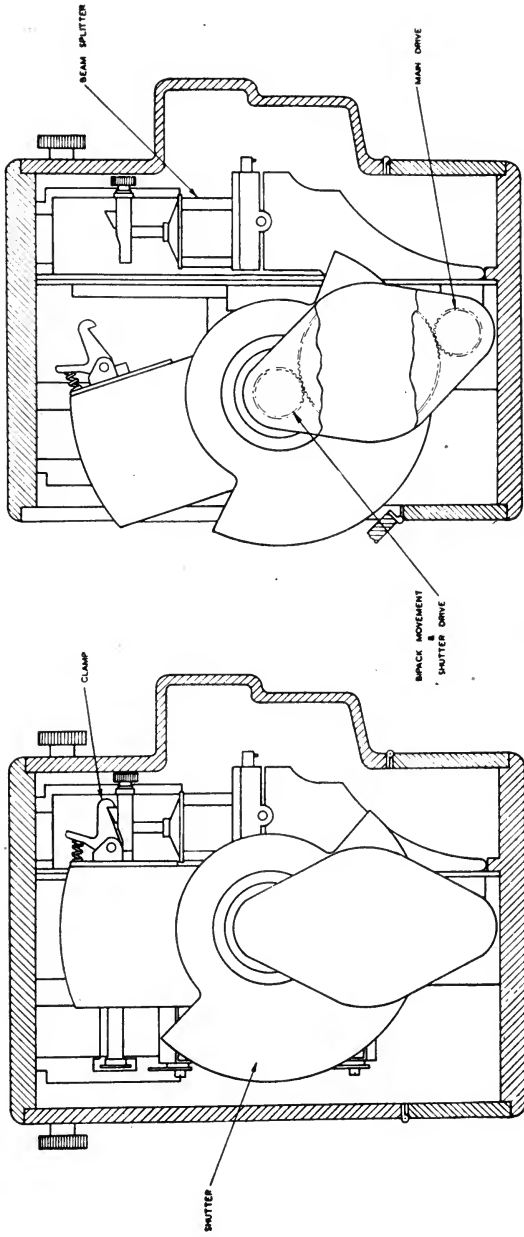
images formed at the two gates. Since it is essential in practice for the prism block to be removed easily for cleaning, means must be provided for replacing it quickly with at least as high a degree of accuracy as that set for any other associated movable component.

The most convenient method of checking the position of the prism block in relation to the two exposure apertures is to illuminate two identical target images while located in the gates by the register pins, and to view them from the lens position by means of a simple microscope. The target images may be made photographically upon normal film stock, or may consist of a pattern of holes drilled coincidentally through two strips of thin metal carrying accurate negative perforations.

Except when the prism block is perfectly adjusted, the two targets

The bearings at the base of the movable assembly operate in conjunction with a tongue at the top of the gate which enters a slot for lateral location and butts against an anvil set at right angles to the direction of swing. The assembly is locked into its closed position by means of a spring catch and single thumb-screw.

Accurate placement of the two film-moving mechanisms of a color camera represents only a part of the problem of ensuring precise registration between the



BACK MOVEMENT : LOADING POSITION

BACK MOVEMENT : RUNNING POSITION

Fig. 4—Movable gate in operating and threading positions.

will not appear coincident when viewed through the microscope, and it seemed desirable that any adjustment of the prism block should be observed continuously through the microscope without the necessity of removing the block from the camera in order to effect adjustment in any of the desired directions.

The adjustable mount which was adopted is shown in Fig. 5. There are three directions of movement provided (Fig. 6), two rectilinear,  $A - A_1$  and  $B - B_1$ , and one pivotal  $C - C_1$ . All these movements are controlled by micrometer screws and locked with setscrews.

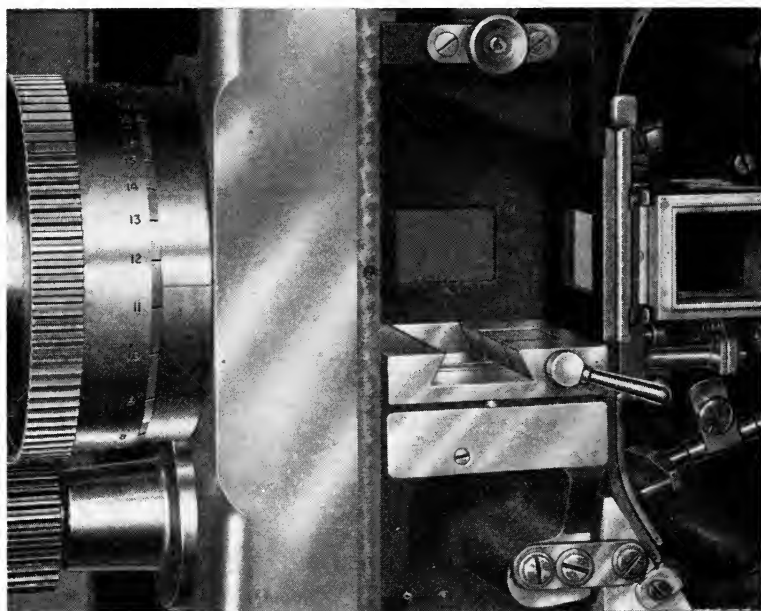


Fig. 5—Dovetail slide for prism mount.

The three prism-block movements, together with the prior location of the two exposure planes in a precisely vertical position at right angles to each other with registration pins in a common horizontal plane, provide the means of obtaining perfect registration.

It has already been mentioned that the reflecting surface of the prism block is metallized with gold in order to take advantage of the well-known dichroic effect which is peculiar to thin films of that

metal.<sup>1</sup> With the gold surface a single high-speed orthochromatic emulsion is exposed behind a yellow filter in the transmitted beam while a bipack with a high-speed noncolor-sensitized element in front and a highly red-sensitive element in the rear provides the blue and red records, respectively. The emulsion of the front element of the bipack carries a red-filter layer.

An unavoidable result of inserting any light-dividing means, except rotating reflectors, between the camera lens and the film planes is a serious increase in the minimum separation which it is possible to have between the rear element of the lens and the film planes. As this minimum distance is usually about 50 mm, even the advantage to be gained from the use of a glass with a high index of refraction for the prism block does not reduce the effective distance sufficiently to permit the use of normal 25- or 35-mm lenses.

This difficulty had been met by the use of lenses of the negative-telephoto type, which have an effective focus considerably less than their back focus.<sup>2</sup> Unfortunately this solution of the problem gives rise to distortion and cannot, therefore, be considered satisfactory. With this in mind, C. G. Wynne of Wray, Ltd., succeeded in computing a 35-mm objective without recourse to a supplementary lens,<sup>3</sup> although a negative supplementary still has to be tolerated for a lens of 25-mm effective focus.

However, it cannot be suggested that the performance of the objective is the only factor influencing definition in any camera using bipack, for the inferior resolution which results on the rear element of any bipack sets a most serious limitation upon the definition of the final composite print. Loss of definition from this cause cannot be avoided, but it can be reduced to a minimum in two ways: by the use of the most suitable emulsion (coated at an optimum coating weight) for the front element of the bipack, and the maintenance of the most perfect contact obtainable between the two films of the pack consistent with freedom from excessive drag or scratching during exposure.

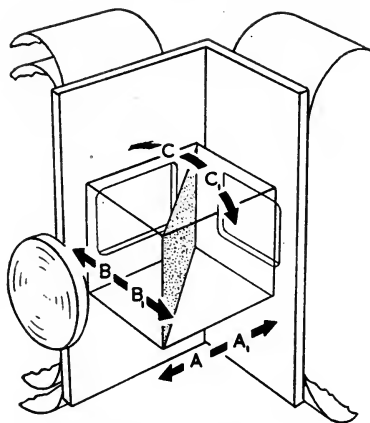


Fig. 6—Three directions of prism adjustment.

Both roller pressure pads and solid-metal pressure pads with slightly convex surfaces have been and are being used,<sup>4</sup> but two glass pads having a 0.003-inch crown were chosen for the British Tricolour camera. This means of providing good contact between the two films has resulted in the rear element resolving 25 lines per mm, at the same time as the front element resolves 45 lines per mm.

Focus adjustment may be made at the camera by means of a control knob, or remotely by means of Magslip motors, the latter method always being used when the camera is in its blimp. For focusing di-

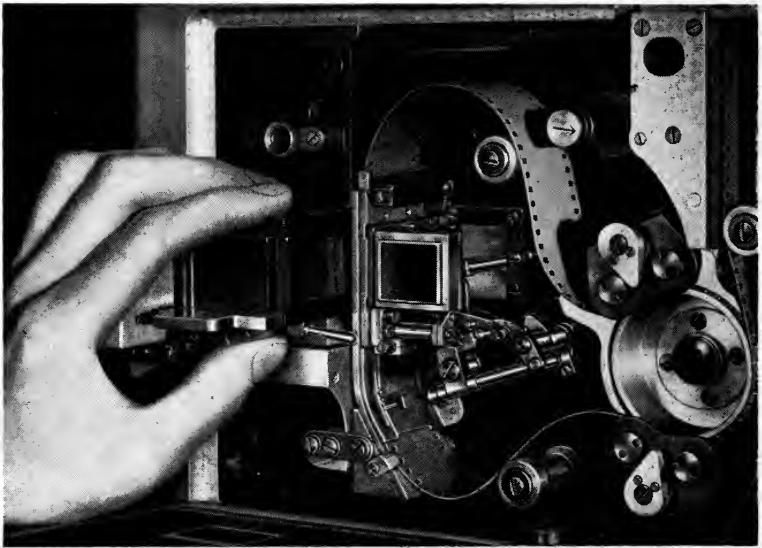


Fig. 7—Single-film mechanism and removable prism block.

rectly onto the single green record film, a magnifying “look-through” system is provided, and the image is observed through the glass pressure pad (Fig. 7).

Parallax compensation is effected automatically by the operation of focusing the camera lens. A Mitchell erect-image self-focusing finder is used, but it has been found possible to reverse the optical head and thereby reduce the separation between camera and finder lenses to about 4 inches.

The means by which parallax is automatically corrected for all



lenses is thought to be novel and should merit detailed description. Each lens mount carries its own permanently attached annular cam, which upon insertion of the lens into the camera, engages with one of two rollers attached to a pivoted arm (Figs. 1 and 8). A flat bearing

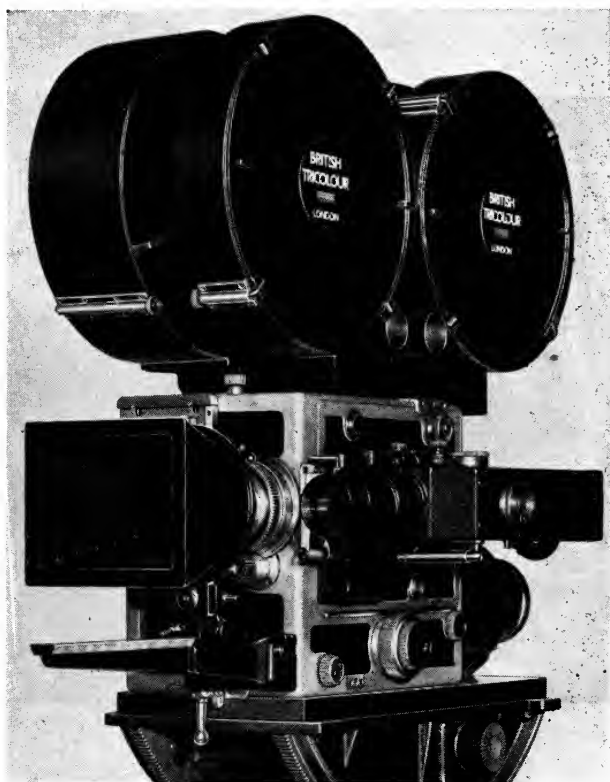


Fig. 8—British Tricolour camera.

surface attached to the inside forward end of the finder is urged by spring pressure into contact with the second roller on the pivoted arm. Upon rotation of the lens sleeve during focusing, its accompanying cam serves to alter the position of the pivoted arm and with it the angular relationship between the finder and the camera.

The Magslip motors required for the dual purpose of focusing the lens and adjusting the view finder are somewhat larger than would be

necessary for focusing only, but it is considered that the inconvenience of the additional weight is more than offset by the advantages of having combined focusing and parallax compensation under all operating conditions.

While a single magazine could have been made to house the three films, it was decided that certain advantages could be obtained by using one bipack and one single-film magazine. The chief advantage



Fig. 9—Bipack side showing removable guide roller.

of this arrangement is that with one magazine loading from each side of the camera, it becomes possible to reload while the camera remains in its blimp. Furthermore, the problem of minimizing film flap, particularly serious when three films must be transported simultaneously, is to some extent simplified when the two films comprising the bipack run through the camera in combination, although fed from separate 1000-foot rolls and wound up side by side in the same magazine.

In order to restrict undesirable movement of the bipack loops, while still permitting the two films to turn through a right angle and so

enter and leave their exposing position without undue tendency to twist, a removable trapping roller is used, and this is rotated by the progress of the films themselves (Fig. 9.)

This reduction of film flap and the extremely quiet Vinten movements combine to produce a color camera with a reasonably low noise level, although it is still necessary to employ a blimp which is large when judged by black-and-white standards.

The image formed by the Mitchell finder, which remains attached to the camera when the latter is in the blimp, is conducted through the wall of the blimp by means of a simple series of mirrors.

A range of driving motors with integral gear boxes permits the camera to be used in conjunction with the usual sound systems including Western Electric 220-volt interlock and 12-volt direct-current lock; Radio Corporation of America and British Acoustic 220-volt synchronous, as well as for "wild" shooting.

The exposure rating of the camera, when the combination of stock already described is used, is equivalent to Weston 8 to daylight or corrected high-intensity arc light. This rating means that a key-lighting level of 350 foot-candles is required when exposing at full aperture.

#### ACKNOWLEDGMENT

The author is indebted to Gilbert Murray, the engineer who was responsible for all of the construction and most of the design of the camera.

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# Versatile Measuring Instrument for Theater Sound Service\*

BY C. S. PERKINS AND E. S. SEELEY

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*Summary*—A new measuring instrument of unusual versatility has been designed specifically for theater sound service. This meter is a part of a co-ordinated group of new test instruments which together meet efficiently all measurement needs of theater sound equipment.

EVERY DAY, millions of American men and women depend, for their uninterrupted enjoyment and relaxation in motion picture theaters, on the work of a man of whose existence they are entirely unaware, the sound-service engineer. To discharge this great responsibility, the abilities of the service engineer must grow with the constantly rising standards of sound quality which the public, consciously or unconsciously, expect in their theaters. The engineer's equipment, personality, experience, and tools, determine his ability to meet the emergencies and the advancing requirements of sound service and this paper deals with a part of the latter category, sound service tools.

The most essential tools of the service engineer are his meters. Meters make the difference between qualitative and quantitative knowledge of equipment performance, the difference between loose thinking and concrete information. We have no practical means of knowing whether equipment is operating at optimal efficiency short of connecting a meter to it and measuring it. When the system performance is below normal, exploratory internal investigation is required to discover which member is giving trouble; but man's senses unaided are not able to learn significant facts about a system's internal organs. The meter is the engineer's sixth sense and little can be hidden from a suitable searching and appraising measuring instrument in the hands of a competent investigator.

Since so much importance attaches to the service inspector's meter, too much thought cannot be given to planning and devising the ideal form for this tool. Fifteen years ago meters were developed

\* Presented October 24, 1947, at the SMPE Convention in New York.

for the field forces servicing theater sound equipment which culminated in what we believe to be the original introduction of the small pocket meter. This form of meter later became highly popular wherever portable measuring instruments were required, and meter manufacturers sold many instruments of this type to laboratories, factories, and service personnel in all fields. The two companion black bakelite meters have since been seen at work in nearly all theater booths in the world where regular equipment service is given.

TABLE I  
AS-1800 SERVICE METER MEASUREMENT RANGES

D-C Voltage	
At 20,000 $\Omega/V$ .....	1V to 2500V, 8 ranges..... Accurate to 2%
At 10 megohms.....	1V to 1000V, 6 ranges..... Accurate to 5%
A-C Voltage	
At 5000 $\Omega/V$ .....	1V to 2500V, 8 ranges..... Accurate to 3%
At 1 megohm.....	1V to 10V, 9 ranges..... Accurate to 5%
D-C Current	
Low resistance.....	0.1 MA to 10 A, 6 ranges..... Accurate to 2%
At 10 megohms.....	0.1, 1, and 10 $\mu A$ ..... 20%, 10%, 5% resp.
D-C Resistance—over-all range	
0.2 ohm (first division) to 10,000 megohms in 8 ranges	

These meters were sturdy and convenient and are still doing a good job today. However, the meter art has advanced and it is now possible to produce more versatile and sensitive instruments.

Therefore a new meter is designed solely for the service of theater sound equipment now and in the future. The design is based on four major considerations: versatility, portability, accuracy, and co-ordination with other new service test equipment. Consideration of cost was not allowed to compromise the fullest achievement of these objectives.

To achieve maximum versatility requires that all the needed or desirable measuring functions be embodied, and for many of these, high sensitivity. The instrument must be capable of reading direct, alternating, and signal voltages at any point in a sound system and to disturb as little as possible the levels existing prior to connection of the meter to the circuit. The range of resistance which must be measured, varies from fractions of an ohm to thousands of megohms. (See Table I.)

These requirements led to incorporation of a direct-current vacuum-tube voltmeter with 10 megohms input resistance, and an alternating-current amplifier with 1 megohm input resistance having gain enough to read and make audible by earphone the low signal levels at phototube output and elsewhere in the system. The amplifier permits monitoring at such points by earphone during a show. The direct-current vacuum-tube voltmeter permits reading phototube voltage and current, grid bias at tube grids; and as a microammeter of 0.1 microampere, full-scale sensitivity, it makes possible reading phototube current, and the resistance of capacitors and cable lines as high as 10,000 megohms by employing the contained 30-volt battery. When television reaches the theater, the instrument will be enabled to read to several hundred megacycles by the simple addition of a rectifying probe for use with the direct-current, vacuum-tube voltmeter.

The term "portability" is here considered to embrace facility in carrying and general sturdiness or ability to withstand many years of the hard knocks it will receive in living and traveling with a service inspector. To facilitate carrying, all functions are embodied in a single instrument equipped with a detachable hinged cover and a carrying strap; and every attention was given to keep the dimensions and weight at a minimum. The instrument is  $9 \times 5\frac{3}{4} \times 4$  inches and weighs 5 pounds. Sturdiness is obtained by employing the most rugged meter movement obtainable of the required sensitivity, a durable case, and attention to secure mounting of all components. For facility of use and lightness of weight, batteries are contained in the instrument.

It will be noted from Fig. 1, that a larger number of ranges are provided to insure good accuracy. All voltage ranges including those employing the vacuum-tube voltmeters are based on the unusual 1-2.5-10 system which makes for simplicity in interpreting scale values. All alternating-voltage ranges fit a common scale. All decades are represented in both the current and resistance ranges. Since decibels are of such great importance in theater service work, the decibel scale is placed in a highly favored position, and readings to  $-20$  dbm\* at 500 ohms may be read without amplification.

On the lowest resistance range, the first division on the scale is 0.2 ohm. At  $R \times 10,000$ , the "100" division represents 1 megohm and at  $R \times 50,000$ , 5 megohms. The last scale marking on the

\* Decibels with respect to 0.001 watt.

"OHMS" scale is 1000, representing 50 megohms on the  $R \times 50,000$  range. Megohms are read by connecting the unknown resistance between the internal 30-volt battery and the 10-megohm input to the direct-current vacuum-tube voltmeter. The maximum scale indication of 10,000 megohms is adequate for service operations in theaters.

The movement is fully protected from damage by any overload when one of the tube circuits is in use. This is an attractive feature in many measurements but most particularly when measuring noise level at an amplifier output. Such measurements expose the meter to the hazard of great overload, often 1000 times full scale,

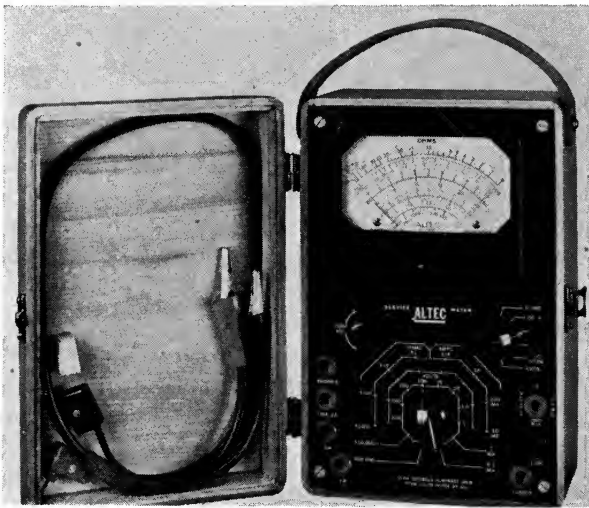


Fig. 1—AS-1800 Service Meter.

since the meter will usually be set to a sensitivity to read noise levels 60 to 70 decibels below the full output capacity of the amplifier, and amplifier oscillation or other disturbance may suddenly occur which results in overloading output levels. This protective feature is so attractive that consideration was given to employ tubes in connection with all voltage- and current-measurement functions. Decision was otherwise, however, in order to secure greater accuracy where needed and to avoid complete loss of use due to failure of a tube or battery.

A few details of construction may be of interest. To minimize

size and weight, four subminiature vacuum tubes are used. One of these serves as a direct-current vacuum-tube voltmeter and three as an alternating-current amplifier. The tubes are powered by the batteries required for the ohmmeter; namely, a 1.5-volt flashlight cell of the commonest variety and the smallest available 30-volt B battery. The life of the B battery will be shelf life in nearly all cases and the filament cell will operate the amplifier for two eight-hour days if used continuously. In intermittent use, the filament cell will probably operate nearly a year if too frequent use is not made of the low-resistance range of the ohmmeter.

The alternating-current amplifier has a voltage amplification of 60 decibels after feedback averaging 14 decibels. The feedback minimizes changes in gain caused by battery depreciation, and, since the feedback is adjustable, it offers a means of compensating the variation of gain between tubes. The output power capacity is comfortably over the 1 volt required to drive the 10,000-ohm alternating-current voltmeter or the earphone. The gain is sufficient to require shielding of the entire instrument and the compact assembly of the amplifier requires shielding between stages.

An internal adjustment of sensitivity of the direct-current vacuum-tube voltmeter is provided to correct for variation between tubes. The zeroing adjustment is brought through the panel on the same shaft as the ohmmeter zero adjustment.

Alternating-voltage ranges with superior characteristics were made possible by the use of germanium crystal diodes connected as a two-element bridge. Multifunction meters, employing copper-oxide rectifiers, ordinarily are limited to a low range of 2.5 volts at 1000 or 2000 ohms per volt, and a separate scale is usually required for this lowest range to avoid exceeding 3 per cent error. In this instrument, the lowest unamplified alternating-voltage range is 1 volt, the resistance is 5000 ohms per volt, and duplication of scale for the lowest range was not necessary to meet the same accuracy requirement. In addition to these improvements, the alternating-current ranges of the service meter have improved temperature stability and a very much superior frequency characteristic. In this connection, the best copper-oxide meters are down 4 per cent at 10,000 cycles, whereas the low alternating-voltage range of this instrument rises slightly in response with increase of frequency and is up 1 decibel at 350 kilocycles.

It was considered advisable to employ a hardwood case and



bakelite panel to afford the user maximum protection from possible shock when reading high voltages. The wood case has the further advantage of being safe to set on the exposed wiring of an inverted chassis during testing without risk of a short circuit. The inside surfaces of the case and the underside of the panel are sprayed with metal to provide complete shielding.

A service inspector requires a large amount of equipment and this frequently must be carried up the many stairs and sometimes a ladder to the booth. It is therefore of great importance that his equipment be co-ordinated in order to avoid burdening him with instruments



Fig. 2—AS-1600 Oscillator.

having duplicated functions. The Service Meter was intended to meet his electrical measurements needs during routine visits when special measurements could not or need not be made. For those calls when a complete transmission test or tune-up is to be made or when special trouble shooting is required, additional instruments are carried to the booth. These instruments, together with the Service Meter, constitute a fairly complete portable electronics laboratory. In addition to test films, special cords, replacement parts, and tools, the added equipment includes the AS-1600 oscillator and the AS-1900 Decabridge, both of which were developed and designed for use with the Service Meter.

The AS-1600 Oscillator, shown in Fig. 2, is a resistance-capacitance type of audio-frequency signal generator providing signals of any frequency from 18 to 22,000 cycles. This instrument includes a panel

meter and an output attenuator having a range from zero to 100 decibels in 5-decibel steps, and provides output impedances of 0, 30, 200, and 500 ohms and 10 megohms. Sound methods are available for modifying the impedance to any other value required. These provisions permit the instrument to be used in conjunction with the service meter for measuring the gain of any amplifier or amplifier system. The attenuator has an accuracy of  $\pm 0.1$  decibel over most of the range, and a sensitivity adjustment is provided for the panel meter permitting it to be set to the same small error as exists in the particular service meter used in the gain measurement. These provisions allow gain to be measured to a high accuracy.



Fig. 3—AS-1900 Decabridge.

The oscillator has good stability with respect to line voltage. The wave form contains 0.6 to 0.7 per cent harmonics and over most of the range the distortion is well below that figure. This instrument is  $6\frac{1}{2} \times 6\frac{1}{2} \times 10$  inches and weighs  $7\frac{1}{2}$  pounds.

The AS-1900 Decabridge, shown in Fig. 3, is so named because it combines principally a set of resistance decades and a capacitance-measuring bridge. Several lesser functions, important in transmission testing, are also embodied in this instrument. It is a companion to the AS-1600 Oscillator since external dimensions, housing, and type of construction are identical in all possible respects. It weighs 9 pounds. The testing facilities provided are indicated in Table II.

The high sensitivity of the service meter to alternating current makes it an admirable detector for the capacitance bridge and its

ability to indicate resistance to thousands of megohms qualifies it for measuring the leakage resistance or current of any imperfect capacitor.

TABLE II  
AS-1900 DECABRIDGE TESTING FACILITIES

Decade Resistance		
Range.....	0.1 to 1000, 4 decades.....	Accurate to 5%
Dissipation.....	50 watts continuous.....	100 watts 3 minutes
Capacitance Bridge		
Capacitance range.....	100 $\mu\text{F}$ to 10,000 $\mu\text{F}$	
Power factor range.....	0-50%	
D-C polarization.....	0-550V	
Signal Source of 60 cps.....	0-5V with 20 db and 40 db attenuators	
Switching Facilities for Transmission Test		

The facilities provided for transmission testing permit the rapid evaluation of speaker impedance and amplifier-output terminal impedance. The 60-cycle source is provided for measuring the gain

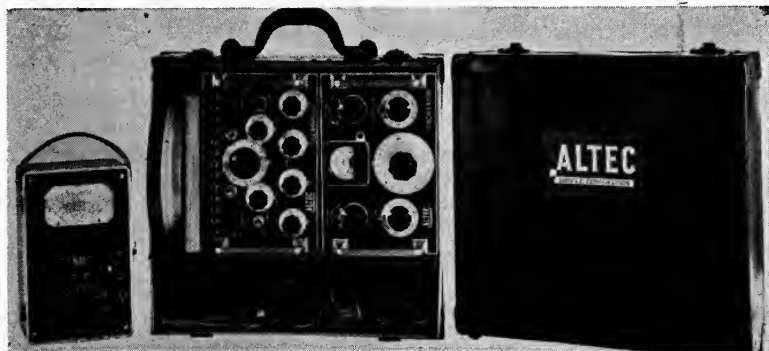


Fig. 4—Instruments in carrying case—Service Meter removed.

of the amplifier system at this frequency from phototube to output. This test, made in addition to the over-all system gain test from film, is a valuable part of the standard transmission test.

The instruments described were designed to be carried in an efficient carrying case, although the service meter was also intended to be carried frequently by itself. A carrying case has, therefore, been carefully designed to carry the instruments along with certain concomitant tools and supplies, to protect the contents, and to have

minimum dimensions and weight. This case is made of black fiber of correct thickness with aluminum reinforcing and is equipped with partitions to separate and contain the major parts. The case accommodates the oscillator, decabridge, service meter, test cords, test film, soldering iron and other small tools, report pads, and testing procedures manual.

The design excluded the use of wood blocks or other dead weight for holding the units in place. The case alone weighs 7 pounds and when fully loaded with the above items weighs 35 pounds.

It is believed that the group of instruments described will permit the service inspector to maintain theater sound systems at their top efficiency, and that they will serve the industry for five to ten years or until improvement in the art permits their replacement with better instruments.

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## Versatile Noise-Reduction Amplifier\*

By KURT SINGER

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*Summary*—This paper describes a noise-reduction amplifier which is capable of supplying bias current to several types of light modulators. Its current capacity and output impedance are arranged so that it will operate in conjunction with low- or high-impedance galvanometers and also with noise-reduction shutters.

IMPROVEMENTS IN galvanometers have resulted in a return to the biased galvanometer system of noise reduction. This offers comparable performance with a simplification in the recording channel by the omission of the noise-reduction shutter which means a corresponding economy in maintenance and investment. This consideration made it desirable to design the MI-10236 noise-reduction amplifier so that it can supply bias current either to galvanometers or to shutters for noise-reduction purposes. Thus, the one amplifier will operate equally well with old and new equipment.

When the design of this amplifier was started, the following specifications were set up:

\* Presented April 22, 1947, at the SMPE Convention in Chicago.

1. Input impedance 500 to 600 ohms or bridging.
2. Sufficient gain to obtain all the bias current required for 100 per cent modulation when operating from a  $-2$ -VU bus.
3. The frequency characteristic had to be flat within 1 decibel from 30 to 10,000 cycles.
4. The amplifier had to be capable of delivering the necessary bias current to either high or low impedance, biased galvanometers, or noise-reduction shutters.
5. Its output impedance had to be dimensioned in such a manner that there should be no loading of the high-impedance galvanometer at audio frequencies. The fulfillment of this condition is particularly important when one considers the fact that the new RCA high-impedance galvanometer has such low inherent distortion that loading and rectification effects in a noise-reduction amplifier output stage can become so pronounced that the distortion thus created can surpass the inherent galvanometer distortion considerably.
6. Residual ripple components in the direct-current output had to be at least 50 decibels below the 100 per cent modulation level.
7. Opening and closing time had to be dimensioned in such a manner that no audible clipping or thumping would occur.
8. It had to be possible to operate the amplifier on either alternating or direct current.
9. The mechanical arrangement had to provide for 100 per cent front service. This requirement is considered very important when one has to work with installations where the rear of the amplifier rack is not easily accessible.

All of these specifications were met and some were even surpassed as will be shown later.

Fig. 1 shows the circuit schematic. An input transformer with a gain control across its secondary feeds a 6J7 pentode voltage amplifier stage which is resistance-coupled to a 6V6 cathode follower. This cathode follower is transformer coupled to a full-wave 6H6 rectifier, the output of which is fed to a resistance-capacitance filter and then applied to the grid of a 6V6 direct-current amplifier. A short explanation of the reasons for this circuit arrangement appears in order. The 6V6 tube which drives the rectifier was used as a cathode follower because in this manner a low impedance can be presented to the rectifier driver transformer. It is also possible to prevent the direct-current plate current of this driver tube from flowing through the transformer primary without having to go to a shunt-fed choke.



Keeping the step-up ratio of the rectifier driver transformer low and working from a low-impedance source results in an arrangement whereby the first filter capacitor charges from a very low impedance. It is also easier to build a transformer with low leakage inductance if the step-up ratio and source impedance are low. Charging the first filter capacitor from a low impedance is mandatory if one wishes to retain good peak reading ability. Peak reading ability in this case is defined

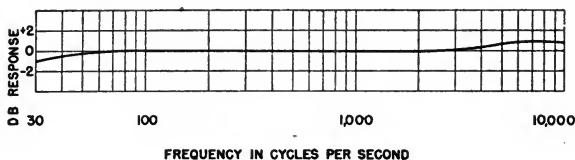


Fig. 2—Frequency characteristic.

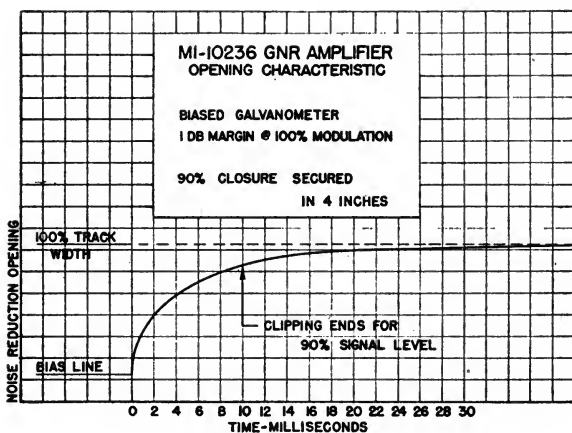


Fig. 3

as the ability of the device to respond to nonsinusoidal wave-form peaks (as, for instance, spikes) to a degree approaching its sine-wave response. This amplifier has been tested with a spike generator which produced positive spikes of a duration of  $1/10$  millisecond which reoccurred at a rate of 100 cycles, that is, every hundredth second. It was found that comparing the output from the direct-current amplifier at a current corresponding to 100 per cent modulation, its response to these reoccurring spikes is 3 decibels below the sine-wave response.

A signal applied to the input of the amplifier will produce a direct

current through the modulator or shutter which is connected across terminals 11 and 12 of the output plug. The initial magnitude of the bias current with no signal can be adjusted by means of the variable

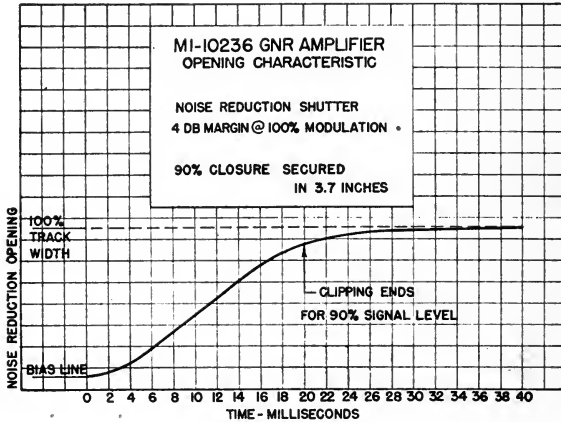


Fig. 4

resistor located in the cathode of the direct-current amplifier. A suitable meter indicates bias current. This meter is also used for measuring the plate current of the amplifier tubes. To accomplish this one has to press a push button and actuate a rotary switch which

transfers the meter across appropriate metering resistors. In order to maintain the output impedance of this device high, in respect to the impedance of the modulator, it was necessary to introduce a filter choke in series with its output. This expedient was necessary since the direct-current amplifier, while inherently a pentode, operates in this circuit essentially as a triode

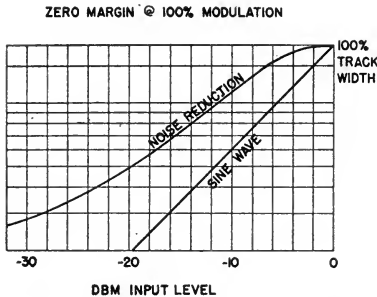


Fig. 5—Input-output characteristic.

and its impedance under this condition is in the order of only about 4000 ohms. With the series filter choke, the output impedance is raised to such an order so as not to load the galvanometer. This series choke also serves another function, namely, it acts like a filter choke for leakage voltages which otherwise would be



built up across the galvanometer, since the capacitance of the secondary of the rectifier driver transformer to ground, presents

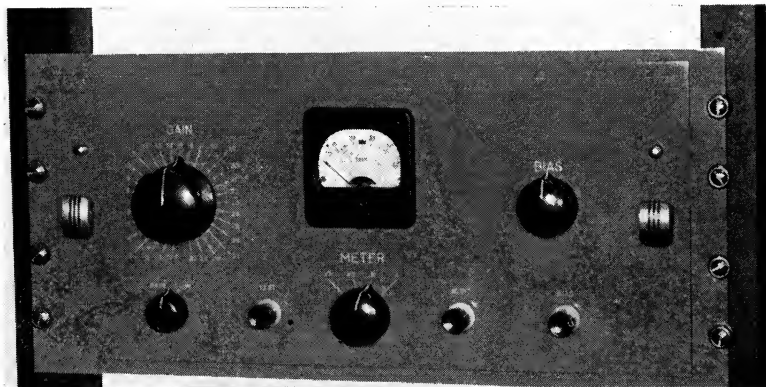


Fig. 6—Photograph of MI-10235 amplifier, front panel.

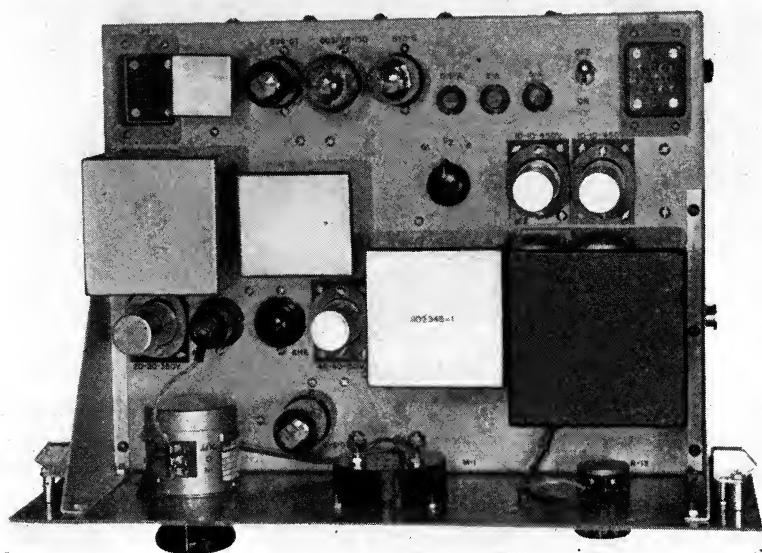


Fig. 7—Top view of chassis.

a leakage path which shunts out the filter section at high frequencies. It would have been possible to avoid any detrimental effects of this leakage path if it had been feasible to place the light

modulator or shutter in series with the plate of the direct-current amplifier output tube. However, this alternative is highly undesirable since it places one side of the galvanometer above ground by more than 200 volts. It is true that this could be avoided by grounding the positive side of the B supply, but other complications arise when this is done, since it is then impossible to operate this noise-reduction amplifier from a B supply common with other equipment in the recording channel. Considering all alternatives, the arrangement

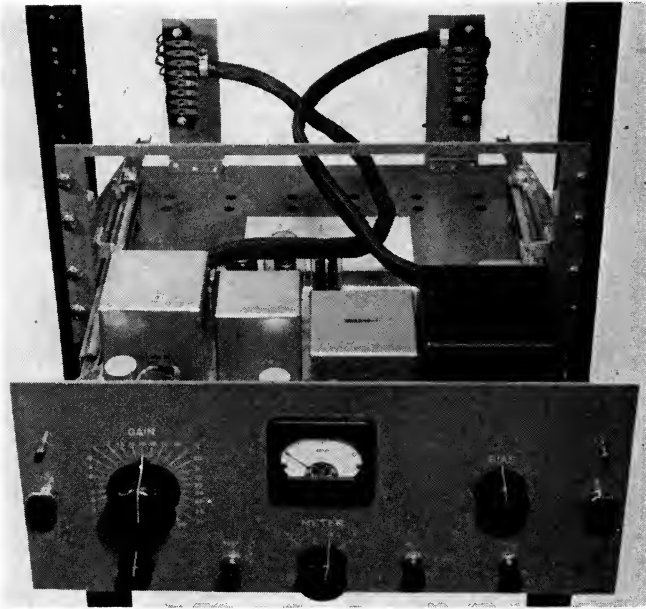


Fig. 8—Amplifier chassis pulled out.

which has been used presents as good a compromise between elimination of leakage effects and addition of components as could be achieved with the requirements that had to be met.

Switch *S-4* is used to permit operation with two different types of galvanometers, that is, high and low impedance, and with the noise-reduction shutter. The circuit of the noise-reduction amplifier itself is not changed in any way when used with different modulators or noise-reduction shutter. The only thing that is accomplished by operating switch *S-4* is the selection of the proper substitution resistance. That is, for setup purposes, it is sometimes necessary to

disconnect the modulator or shutter and substitute a resistance in its place. Switch *S-4* permits the selection of the proper resistance which corresponds to the direct-current resistance of the particular modulator or shutter which is in use.

A self-contained power supply permits operation from either 115- or 230-volt alternating-current mains. In addition, by means of a simple switching arrangement operation from external power supplies like batteries or dynamotors can be obtained. This flexibility is of particular interest for truck installations.

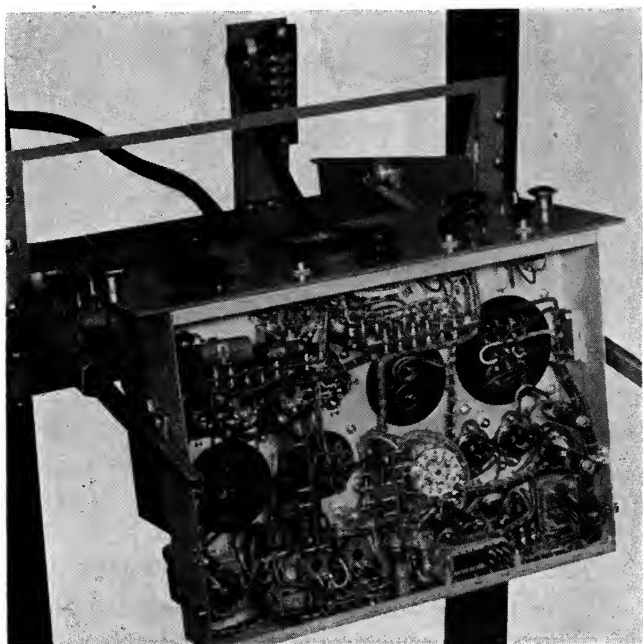


Fig. 9—Amplifier chassis pulled out and tilted.

Fig. 2 shows the frequency characteristic of the device. Fig. 3 shows the shape of the opening characteristic plotted against time. This curve was obtained with the use of a galvanometer. Fig. 4 shows a similar curve obtained with a noise-reduction shutter. It can be seen that because of shutter inertia, the shape of the opening characteristic is not nearly so steep as compared to the curve obtained when using the galvanometer. The curve obtained with the galvanometer produces less clipping and does not introduce objectionable

thump which has been proved in careful listening tests. Fig. 5 shows the input-output characteristic of the amplifier.

The gain of this device is sufficient to permit satisfactory operation from a -2-VU recording bus. Figs. 6, 7, 8, and 9 show the mechanical arrangement of the unit. This arrangement is the same as that shown at a previous Hollywood Fall Convention in connection with a paper<sup>1</sup> on a new recording power amplifier. Drawer slides similar to those used in file cabinets permit pulling the amplifier chassis out from the rack. A tilt arrangement which is shown in Fig. 9 renders

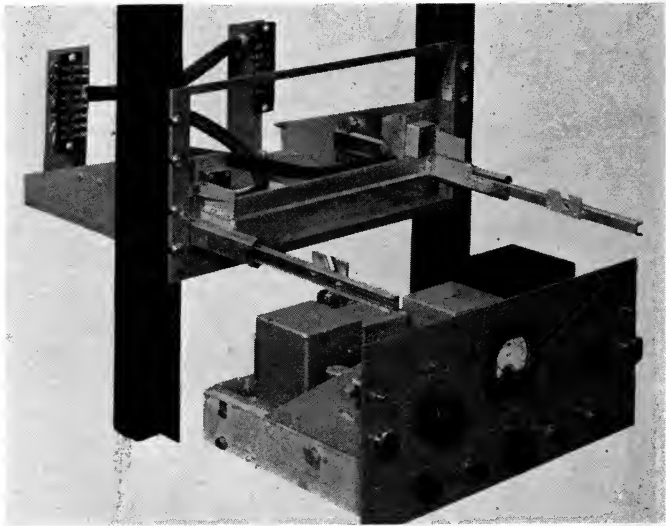


Fig. 10—Amplifier chassis removed from carriage.

the underside of the chassis, with all its wiring and components, accessible. This front-service arrangement doubtless will appeal to anyone who has to service recording amplifiers since it simplifies reaching any part of the unit. If necessary, an entire amplifier can be replaced in a matter of minutes. How this is accomplished is shown in Fig. 10, where the amplifier chassis proper is shown removed from its carriage, with the cable plugs which normally connect it into the system disconnected. This versatility and serviceability will be of real economic value to any customer.

The electrical design of this noise-reduction amplifier was done by J. F. Clark III.

#### REFERENCE

- (1) Kurt Singer, "A high-quality recording power amplifier," *J. Soc. Mot. Pict. Eng.*, vol. 48, pp. 560-569; June, 1947.

## Theater Engineering Conference

### Lighting

# Lighting Ideas Offering New Opportunities in the Theater\*

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GENERAL ELECTRIC COMPANY, NELA PARK, CLEVELAND, OHIO

*Summary*—Long the leaders in prompt utilization of advanced resources of the lighting art, motion picture theaters yielded this place as a result of wartime restrictions and early postwar conditions. Many now find themselves in marked need of rehabilitation in this respect.

Some of the newer forms of light sources produced during the war and since, offer ways to expand the techniques of lighting. New materials and old ones in new forms are becoming available for modernizing the theater. Combinations of these sources and materials increase the scope of lighting treatments available to serve the special purposes of the motion picture exhibitor.

In this paper, the authors present some of the new types of lighting elements and suggest applications to marquee, lobby, foyer, standee space, and public rooms.

MOTION PICTURE THEATER operators and their designers long set the pace in the use of light for gaining attention and for creating atmosphere, mood, and distinction. They were motivated to a large extent by keen competition and by the very nature of a mass-recreational business. However, in the past few years, crowded houses were the rule, and less need was felt for quickly applying every new resource of the art. To be sure, restrictions on new building and modernization programs limited the opportunity to apply new techniques. But, by contrast in the field of retail merchandising, where competition is keen and growing keener, merchants, architects, and designers have been making rapid strides in finding ways to apply the newer forms of light sources for more profitable store operation. As their conditions change the theater people will step to the front again, giving attention to the many houses that need modernizing and to new projects.

\* Presented October 22, 1947, at the SMPE Convention in New York.

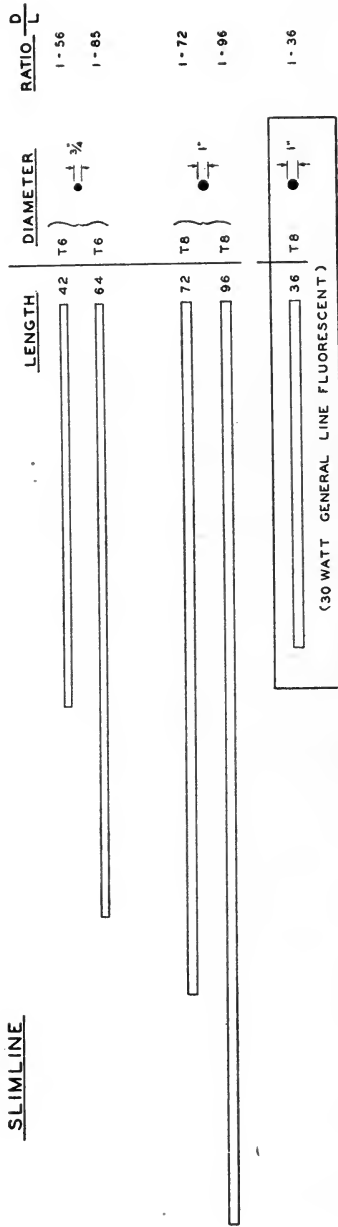


Fig. 1—Lengths and diameters of fluorescent lamps.



Fig. 4—Long lamps give fewer socket interruptions in continuous rows.

What are some of the new sources and materials of illumination and how are they to be used in the theater?

### SLIMLINE FLUORESCENT LAMPS

The Slimline fluorescent lamp is rapidly entering the field of store, restaurant, and display lighting because it combines several new lamp

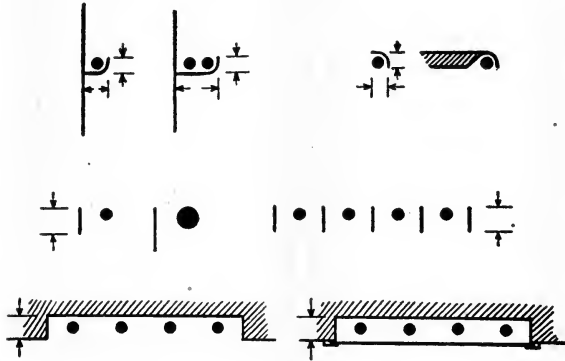


Fig. 2—Small-diameter lamps make possible small cross sections for coves, narrow bands, and other lighting elements.

features, notably instant-start operation and longer unbroken lines of light with minimum dark areas in continuous lines. In the theater, too, the Slimline offers many opportunities to solve old lighting problems and suggests new treatments.

First, examine Slimline dimensions. Four sizes of lamps are available (Fig. 1). Until its introduction, the greatest ratio of length to diameter was 1 to 36 in standard fluorescent lamps produced in quantities. Now the ratio is increased 1 to 96 in the 8-foot lamp. These dimensions serve to give new proportions for luminaires; the small diameter permits small cross sections in lighting elements (Fig. 2), and in reflectors for control of light (Fig. 3). Long lamps cause fewer interruptions in continuous

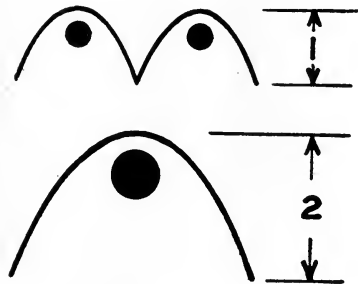


Fig. 3—For the same control reflector size is in proportion to diameter of the lamp. In many cases the shallow reflector may be fitted into structure more easily.

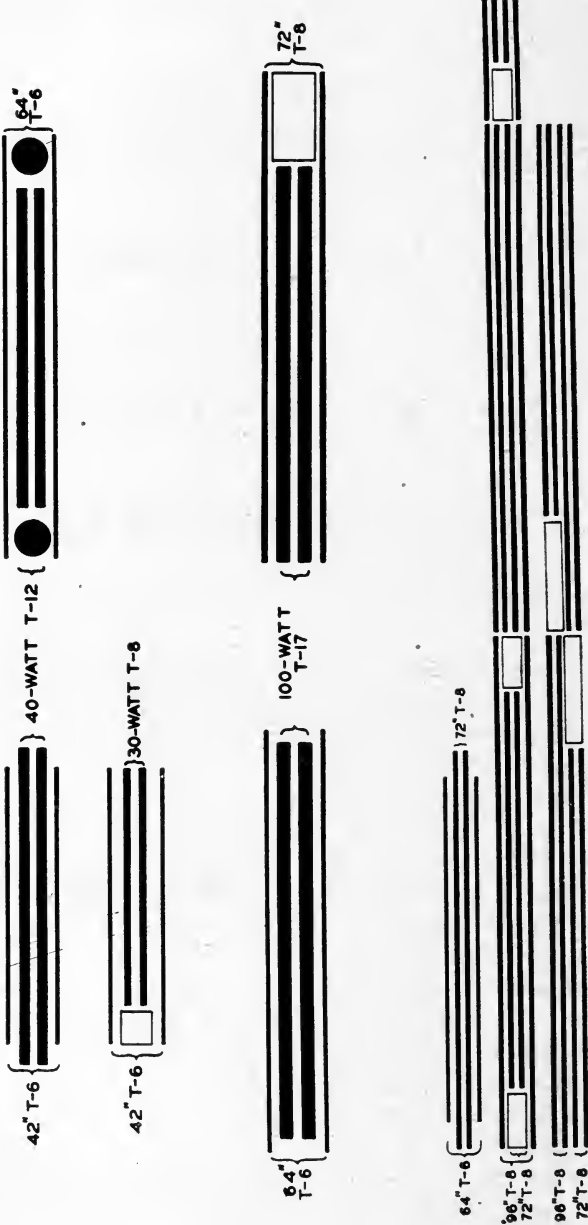


Fig. 5—The four sizes of Slimline lamps expand the combinations of patterns in luminaires for fluorescent lamps.



lines of light than shorter ones (Fig. 4). Then, too, the different lengths make possible numerous combinations with other lamps for variety and flexibility in design (Fig. 5). Moreover, the shorter lamps were designed to fit in typical "4- and 6-foot" spaces.

Second, as to electrical characteristics. Each lamp may be operated over a range of currents or watts, thus providing a choice of lamp brightness and light output. Ballasts are available to supply 100, 120, 200, or 300 milliamperes. The resulting values of light output, brightness, wattage, and luminous efficiency are given in Table I.

TABLE I  
APPROXIMATE TECHNICAL DATA  
4500-Degree White Slimline Lamps

Lamp	Milli-amperes	Lamp Watts	Initial Lumens	Lamp Initial Brightness (Foot-per Watt Lamberts)	Recommended Minimum Starting Voltage	
F96T8/45W	100	29	1800	62	1000	
	120	34	2100	62	1200	750
	200	51	3050	60	1650	
	300	69	3950	57	2150	
F72T8/45W	100	22	1340	61	1000	
	120	26	1590	61	1200	600
	200	38	2250	59	1650	
	300	51	2850	56	2150	
F64T6/45W	100	24	1370	57	1600	
	120	27.5	1570	57	1800	600
	200	39	2150	55	2450	
	300	51	2600	51	3000	
F42T6/45W	100	16	880	55	1600	
	120	18	990	55	1800	450
	200	25	1320	53	2450	
	300	33	1620	49	3000	

For example, this type of fluorescent lamp gives the opportunity to step down from high brightnesses (300 milliamperes) under the marquee, through the lobby at medium brightness (200 milliamperes) into the foyer at still lower levels (100 milliamperes) without changing the character of luminaires or luminous pattern.

The Slimline fluorescent lamps start instantly. The longer lamps provide this feature with greatest economy because the ratio of starting voltage to operating voltage is about 2 to 1. Thus, under operating condition, the lamp and ballast have nearly the same voltage drop, providing good regulation over the range of line voltages normally encountered.

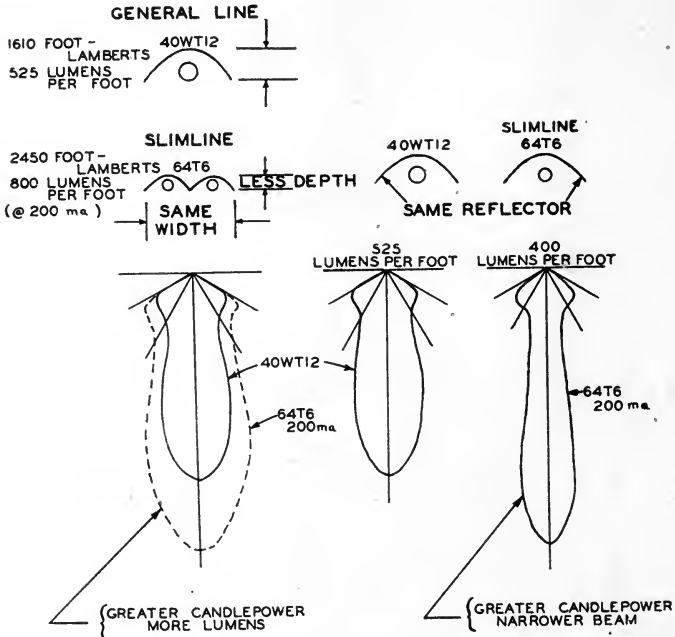


Fig. 6—In spaces of the same width and less depth, the Slimline lamp operated at 200 milliamperes will produce greater candle power and more lumens as compared with the 40-watt T12 lamp. In the same size reflector the beam will be narrower and of greater candle power.

By comparison, the familiar 40-watt fluorescent lamp because of its shorter length (4 feet) and larger diameter (T12) has a ratio of cold-starting voltage to operating voltage of about 4 to 1. Hence instant-start operation of this lamp results in greater losses than obtained in the more usual circuit in which starters are used to pre-heat the cathodes and thus to bring the hot-starting voltage down to twice the operating voltage.

The longest Slimline also offers the highest efficiency of any of the

standard fluorescent lamps made to date. One of the principal factors is that in long lamps the wattage lost at the cathode becomes a smaller proportion of total lamp watts.

Third, optical control. Light from fluorescent lamps can be controlled in a plane perpendicular to the axis of the tubes, and the width of reflector required is proportional to tube diameter. This means that more rows of Slimline lamps can be put in a given space for the same control than with lamps having larger diameters, as shown in Fig. 6. The light-distribution curves are based on an accurate parabolic reflector having a specular surface. Tests have shown that a

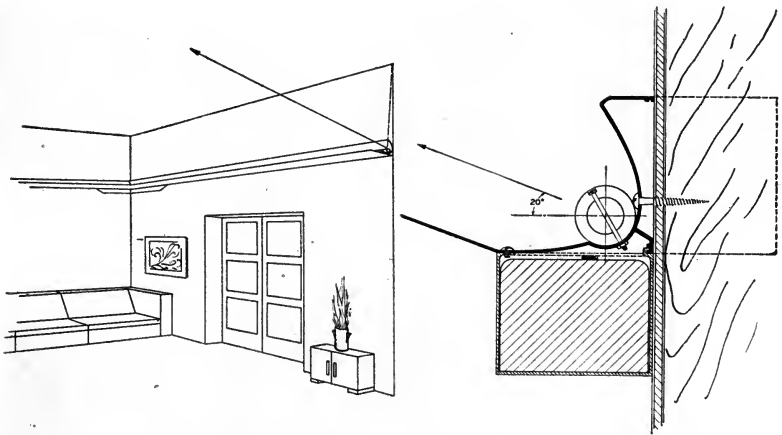
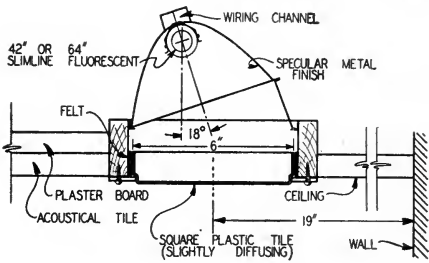
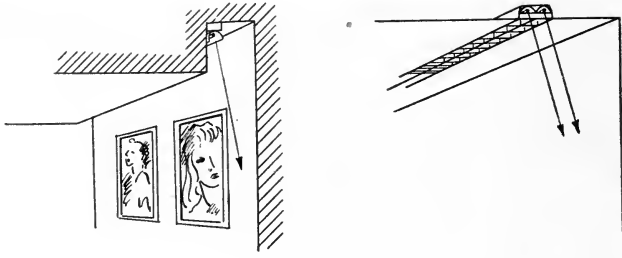


Fig. 7—Cove lighting from elements of small cross section has been something designers have wanted for a long time. Reflectors are required for effective utilization of the light. The section for an attached or built-in cove illustrates a method of providing a luminous band as well as lighting for the ceiling.

satisfactory degree of control for most purposes can be achieved where the reflector width is at least four times the lamp diameter. Thus a T6 ( $3/4$ -inch) diameter Slimline with a 3-inch reflector becomes an effective lighting device for it can provide higher utilization of light and more effective appearance in such places as:

1. *Cove Lighting.* Where a uniformly lighted ceiling is desirable from an unobtrusive lighting element, the small diameter and long lengths are advantageous (Fig. 7).

2. *Wall Lighting.* One of the most effective means of creating a cheerful, stimulating appearance in a room is to light the perimeter areas. Optical control is necessary if the light is to cover the surface



(a) For wall lighting in new installations recesses may be left between ceiling and wall for the lighting or a recess may be provided in the ceiling. Lightly diffusing glass or plastic will give good appearance and will only slightly spread the wedge of light.

(b) A valance may be attached to ceiling to conceal reflectors. The lamps and reflectors may be shielded from endwise view by louvers.

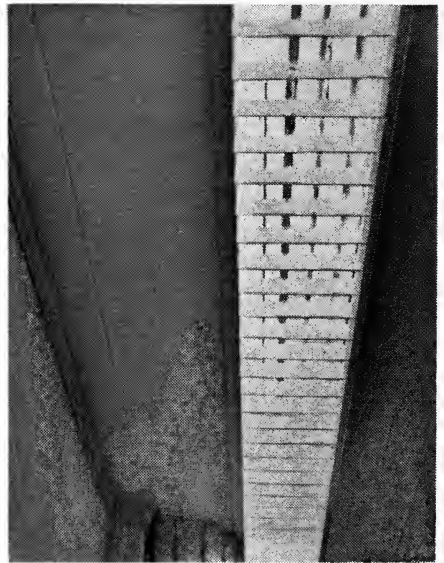
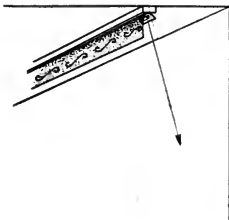
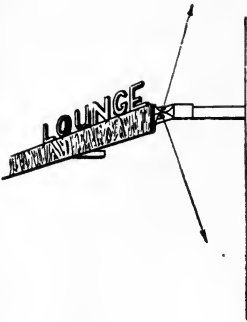


Fig. 8



(c) Another method is an architectural frame or valence attached to wall having a concentrating type of reflector.



Fig. 8 (continued)

fairly uniformly without too great a brightness difference between the top and bottom of the wall (Fig. 8).

3. *Poster Panels.* Often exposed lamps or lamps with inadequate shielding are used around the panel and while this may have some attention value, the result is distracting and the patron's reaction may

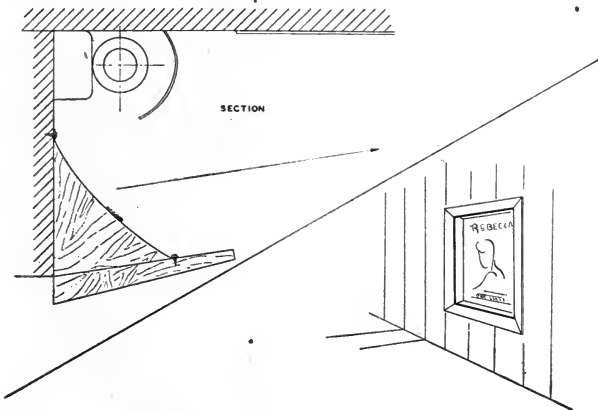
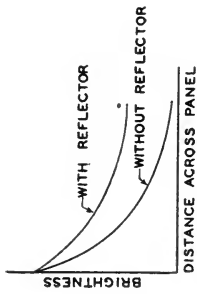
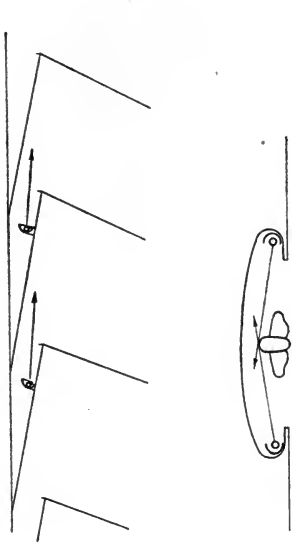
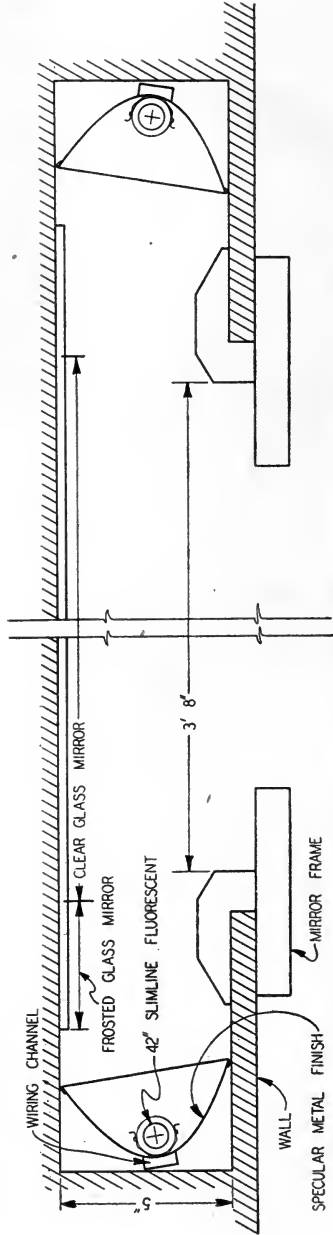


Fig. 9—A new technique for lighting poster panels is suggested here. The lamp is entirely concealed and still the light from both sides of the frame will be well distributed over the poster.



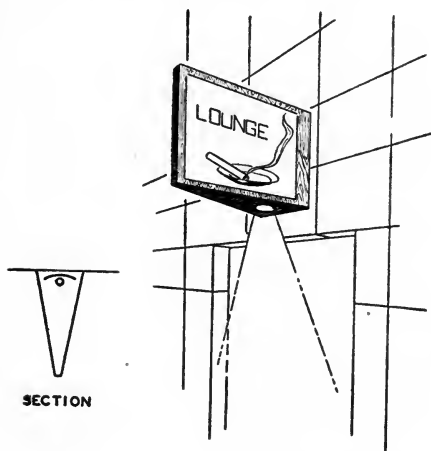
(a) In some architectural elements a sheet or wedge of light is required. Where space for the lighting is restricted, the Slimline in narrow beam reflectors is very useful.



(b) In shallow space around a mirror with a center display, the narrow units may be easily concealed. Fig. 10



(b)



(c) Uniform lighting of the wedge-shaped sign requires the control so easily obtained with 'Slimline' in reflectors. Illumination of surface behind letters may be done with a minimum depth of shield for the lighting units.

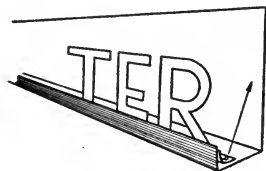


Fig. 10 (continued)

be to look away immediately because of uncomfortable brightness. The method shown in Fig. 9 assures complete shielding of the lamps and will provide nearly uniform brightness across the panel for good appearance and far better composition.

4. *Architectural Elements.* Some of the elements for decoration and illumination take a form which requires control of light distribution for adequate uniformity on a reflecting or transmitting surface (Fig. 10).

In all of the above examples, the range of available light-output values in each of the Slimlines increases the scope of application.

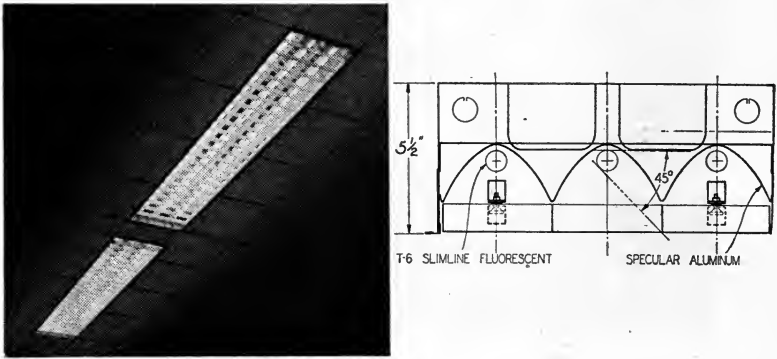
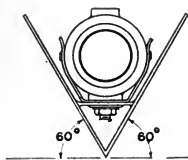


Fig. 11—Example of a shallow recessed fixture with good control.

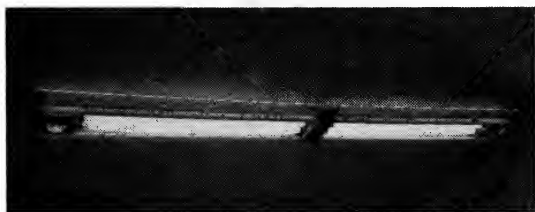
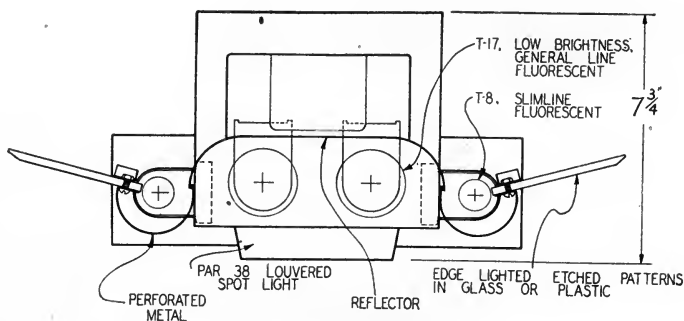
Control of light is also an important consideration in many types of luminaires. Fig. 11 is an example. The proportions of the lamps make possible designs having an appearance of minimum bulk because the sides of such luminaires may be narrower for the same degree of shielding as compared with the large-diameter fluorescent lamps. This means the dimensions of the projected view may be small in relation to the length. While those shown in Fig. 12 were not designed particularly for the theater, they may suggest some possibilities. Some designs may combine Slimline lamps with other sizes of fluorescent lamps and, in some cases, with filament sources.

An idea for creating versatility in effect with simple standard types of luminaire chassis is illustrated in Fig. 13. The chassis houses the ballast, the sockets, and wiring, but may have a character which is adaptable to many variations in treatment with accessories





(a) Patterns produced with suspended small "V" section housing Slimline. The system is combined with flush panel units. In theaters different colors might be used in each system.

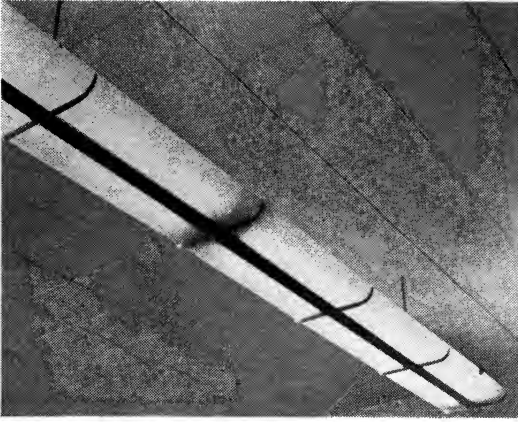


(b) Narrow side view with Slimline lamps shielded by perforated metal. Lamp set at edge of plastic for lighting etched pattern. Compact projector lamps integrated in the design for lighting wall displays.

Fig. 12

of various kinds of materials, varying in texture, finish, color, brightness, and form. Then, too, the units may be arranged in numerous ways to give greater versatility in pattern (Fig. 14).

While the small diameter of Slimline lamps is advantageous in providing good optical control, the same characteristics of small



(c) A suspended luminaire with slender lines made possible with Slimline lamps. It has a "lightweight" appearance and either bent glass or extruded plastic of light diffusion may be used.

(d) The proportions of the Slimline lamps give architects and designers opportunity for creating many types of luminaires. In this example, 72-inch lamps are employed. The slot in the bottom is finished in another color to conform to the color scheme.

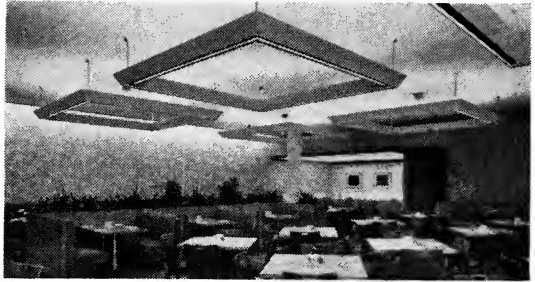


Fig. 12 (continued)

diameter plus their range of light output make them very useful in built-in luminous or attached lighting elements. It is especially true where spaces for recesses are limited or when cross sections of small dimensions are required for appearance reasons (Fig. 15).

The design of luminous panels often becomes a problem where depth for a recess is at a minimum and the effect desired on the face is uniform brightness. This is due to the fact that uniformity is a function of the spacing between lamps and the distance from the diffusing face, and the brightness is a function of the light output of the lamp and the light-reflecting efficiency of the cavity. Here the choice of light output available in Slimline lamps gives flexibility in obtaining in a small space uniformity at desired brightness value (Fig. 16).

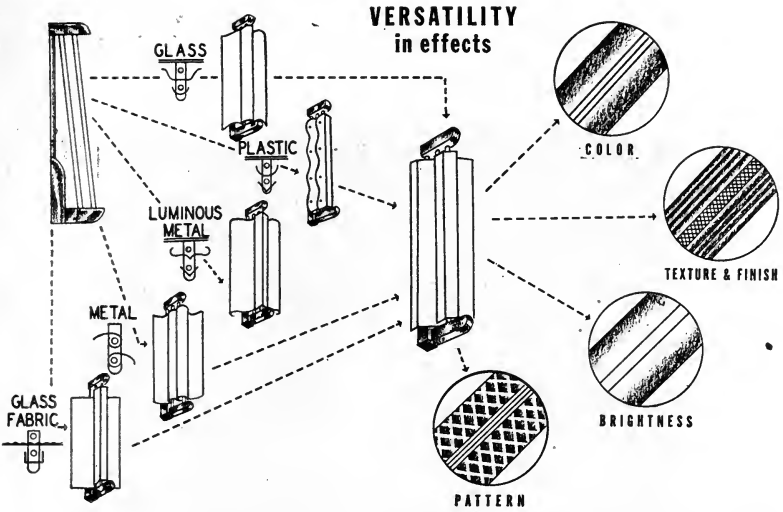


Fig. 13—A few of the many types of decorative diffusing shields which may be fitted to a basic fixture unit. Differences in shape, surface, finish, color, and texture of shields expand the variety of effect.

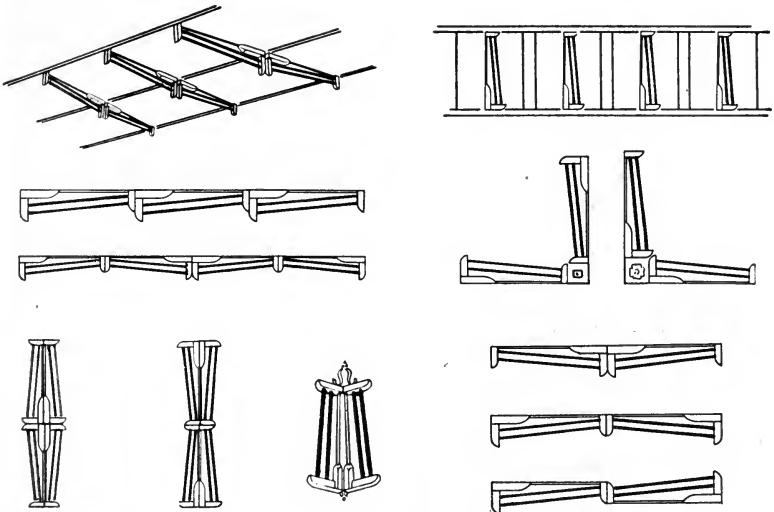


Fig. 14—Some of the ways the standard units may be combined to create a variety of patterns.

Slimline lamps may be combined with incandescent lamps for additional attention value. One example is the attraction panel for the marquee also shown in Fig. 16.

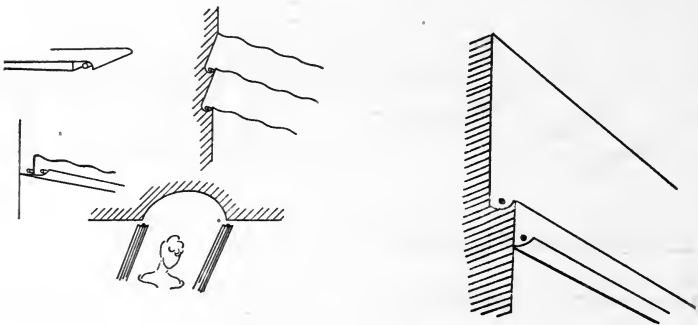


Fig. 15—Small diameter is useful in edge lighting and for fitting lamps into small spaces for decorative effects. The several values of light output from Slimline lamps give a choice of brightness.

#### CIRCLINE FLUORESCENT LAMPS

Another example of a new form of fluorescent lamp is the Circline. Originally designed to meet the demand for fluorescent sources in portable lamps, it has many other applications in decoration and display, as well as some uses for purely illumination purposes.

The first size available is 12 inches in outside diameter. An 8 $\frac{1}{4}$ -inch size has been announced to be followed later by one about 16 inches in diameter. These two will become available as manufacturing facilities permit. Such standard shapes expand the number of designs that may be developed for decorative elements in the

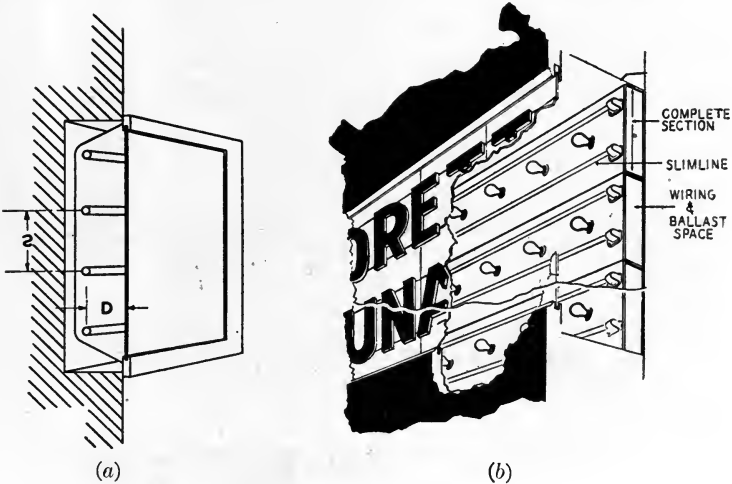


Fig. 16

(a) Small-diameter fluorescent lamps of several light outputs are ideal for shallow recess. The ratio of *S* to *D* should be about 1 $\frac{1}{2}$  to 1 where good diffusing material is used for the panel.

(b) A combination of incandescent lamps and Slimline gives attraction panels greater attention value when the incandescent lamps are flashed or dimmed for color and brightness changes.

32 WATTS  
 1600 LUMENS  
 50 LUMENS  
 PER WATT  
 2040 FOOTLAMBERTS

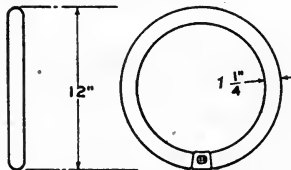


Fig. 17—Circline fluorescent lamp.

theater. Obviously, they may be combined with the linear fluorescent lamps and also with incandescent lamps for an unlimited range of effects.

First, examine this lamp as to dimensions and electrical characteristics (Fig. 17). It is operated on a conventional preheat circuit with a glow-type starter. With this circuit, a minimum starting

voltage is required. The two cathodes are close together, which gives a minimum unlighted section in a circle. The 4-pin connector is adjustable through a small angle to facilitate installation of the lamp.

The brightness of the 12-inch lamp is 2040 foot-lamberts (considerably more than that of the 40-watt straight lamp) and should be, in general, shielded from direct view in the interest of greater comfort and better appearance. The shields may be of several types and can provide a decorative form as well as serve as signs, directional markers, and the like (Fig. 18).

These luminous forms may be utilized as part of a pattern and also

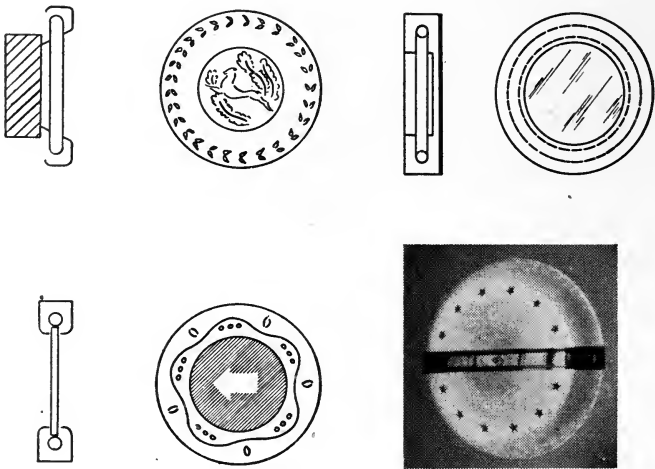


Fig. 18—A few of the ways Circline lamps may be incorporated in plaques or medallions for decoration or markers.

serve as a shield for the housing incorporating the ballast when used in conjunction with other fluorescent lamps (Fig. 19), such as the Slimline applied in bands. In other patterns the Circline lamp may introduce another form combined with a difference in color quality of light. Circline is a logical shape to use around a reflector or projector lamp particularly when the housings for such lamps are attached to the ceiling. The Circline will provide light on the ceiling to lower contrast between the projector lamps and their surroundings.

Many of the newer designs of portable floor and table lamps embody the Circline (Fig. 20). These lamps may be employed in lounges and

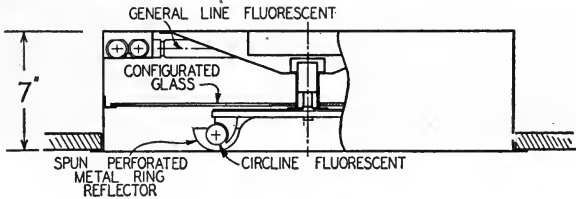
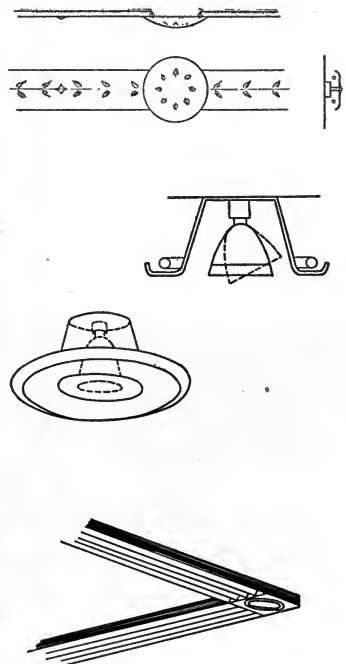


Fig. 19—Decorative bands offer many possibilities for ceiling and wall treatments. Here are some of the ways the Circline may be utilized in parts of pattern in luminaires or to provide upward light around the housing of downlights.

rest-room areas to afford good lighting with a clean, fresh, color appearance.

PROJECTOR AND REFLECTOR LAMPS

Lamps with integral reflectors are coming into wide use largely because of the results produced with their convenience and simplicity in application. Sealed inside the bulb, the reflector does not deteriorate due to dust and dirt, and when the lamp is replaced, initial efficiency is automatically restored without further cleaning of equipment.

The molded-glass type, known as PAR-38, has an accurately formed heat-resistant glass reflector bulb and is made for spot or flood distribution of light. It may be used out of doors without danger from thermal shock caused by rain and snow. Metal accessories for holding color roundels or shields (Fig. 21*a*) may be clipped directly to the rim of the bulb. This lamp may be supported by the rim as shown in Fig. 21*d*. A recent PAR-38 lamp in 150 watts is the "compact" projector. As the name implies, it requires less space than the standard screw-base type. It is well suited for mounting in a gimbal



Fig. 20—New designs in floor lamps incorporating the Circline.

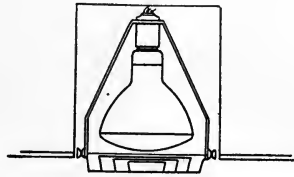
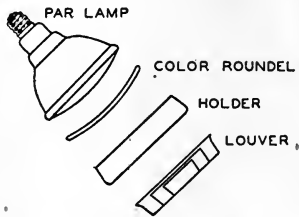
as in Fig. 21*c* and can be recessed in a space less than 5 inches high either in the ceiling or luminaires.

The most common blown-bulb reflector type is designated as the R-40. A blown bulb is inherently somewhat less accurate in contour than the molded type. In soft glass it is more susceptible to thermal shock and, therefore, not suitable for outdoor use exposed to rain and snow. While it is lighter in weight than molded PAR lamps, it should always be supported by the screw base (Fig. 21*b*). Shields and color accessories touching the bulb may result in unsatisfactory performance and, therefore, are not generally recommended. Such accessories for best results should be incorporated in a housing or in open-frame supports.



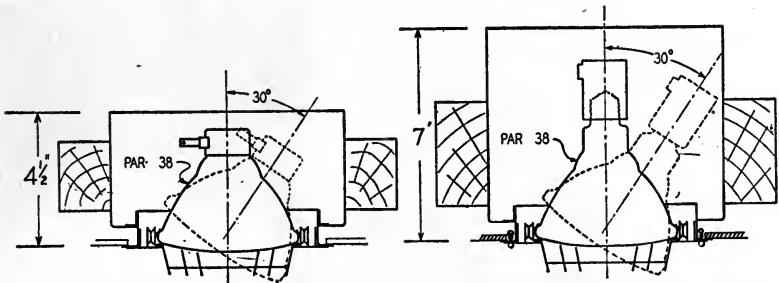
The line of lamps is shown in Fig. 22.

Lighting of displays is a prime function for these sources. In many cases flexibility in aiming is required and numerous mountings and housings are manufactured to achieve this purpose. One of the newer ones is the gimbal which permits aiming in any direction up to 30 degrees from the vertical. Wherever a patron in the theater is likely to look into the beam of light from the lamp it is best to use



(a) Projector lamps are recommended where accessories are to be attached directly to the lamp.

(b) In most installations metal enclosures should be used for reflector or projector recessed in ceiling. The reflector lamps are supported by the base.



(c) The compact projector saves space.

(d) The projector lamp may be supported by the rim.

Fig. 21

louvers or shields. If color or shielding accessories are to be clamped to the lamp, the PAR types are preferred.

Units are available for mounting in the ceiling, attached to the ceiling, and suspended. In addition, there is a trend to incorporate the lamp in fluorescent-lamp luminaires, particularly in stores, thereby keeping the number of wiring outlets to a minimum. In lobbies and foyers of the theater, this technique offers similar possibilities (Fig. 12c).

Reflector lamps are handy units for installation in the soffit of

marquees to project light on the sidewalk and pedestrian traffic. The PAR type is generally selected when the lens is to give an appearance of being on the same plane as the soffit surface. The R-40 reflector type should be used only when protected from rain. If it is mounted to extend a half inch or so below the surface it presents



Fig. 22—Reflector and projector spot and floodlamps are useful tools for many jobs in the theater.

greater brightness than does the edge of the PAR unit at normal angles of view and thus imparts greater life and sparkle.

There has been no intention to make this discussion comprehensive but rather to suggest some of the ways newer light sources fit into many of the lighting applications posed by the theater and thus to help the theater designer and owner in their never-ending quest for new and better solutions.

## Theater Engineering Conference

### *Lighting*

# New Circlarc Fluorescent Lamp\*

BY EUGENE W. BEGGS

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*Summary*—The 18-watt, 12-inch, T8 Circlarc fluorescent lamp is a standardized curved fluorescent lamp made in the form of a half circle 12 inches in diameter. Used singly or in multiple arrangements, it provides a flexibility of application not obtainable with the full-circle (Circline) lamp. The arc stream of each lamp is short so it may be operated directly from the 110- to 125-volt alternating-current lighting circuit with a small low-cost choke as a ballast or from 110- to 125-volt direct-current circuits with special auxiliaries. The semicircular shape makes it possible to obtain, with a curved fluorescent lamp, the advantages of mass-production machinery previously available only with straight-tube lamps.

The lampholders required must provide a preheat and an operating circuit and must allow a tolerance for variation in lamp diameter and base-pin location. A spring support at the center of the lamp holds it in place. The ballasts must develop proper electrical values to operate the lamps at designed wattage without excessive loss or overheating.

Lamps mounted on walls and ceilings provide pattern lighting using a production lamp. Bare-lamp clusters provide new novelty for suspended fixture design. The half circle simplifies design, installation, and maintenance of built-in lighting with curved fluorescent lamps. Portable lamps and other fixtures with several Circlarc lamps now can be provided with multilevel fluorescent lighting.

WITH THE ADVENT of the newly standardized half-circle fluorescent lamp, known as the "Circlarc," manufacturers have broken with the traditions of the past and now provide a production lamp that can be incorporated in bare-lamp installations to provide a flowing pattern of light on walls or ceilings. The half-circle design also releases the architect or lighting designer from many of the restrictions imposed by straight tubes or the full-circle lamp known as the Circline. It is too early now to predict the extent to which this new half-circle lamp will be used in theater lighting but there is little doubt that this field of application will be one of the more important ones in which it is applied.

The 18-watt, 12-inch, T8 Circlarc fluorescent lamp is a curved

\* Presented October 22, 1947, at the SMPE Convention in New York.

fluorescent lamp made in the form of a half circle 12 inches in diameter (Figs. 1 and 2). Used singly or in multiple arrangements, it provides a flexibility of application not obtainable with the full-circle lamp. The arc stream of each lamp is short so it may be operated



Fig. 1—The 18-watt T8 Circlarc fluorescent lamp, a newly standardized shape available to widen the field of use for fluorescent lamps.

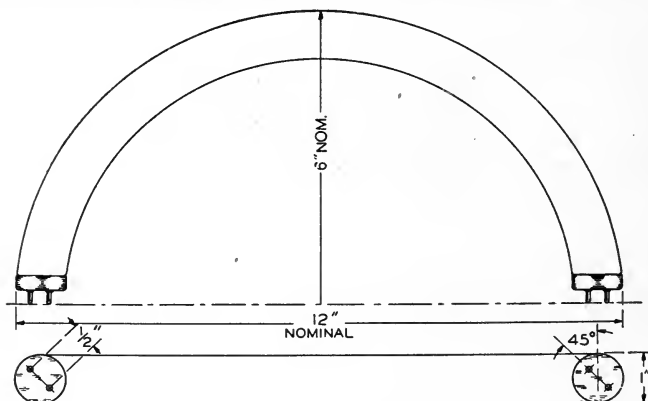


Fig. 2

directly from the 110- to 125-volt alternating-current lighting circuit with a small low-cost choke as a ballast. Also, the semicircular shape makes it possible to obtain, with a curved fluorescent lamp, the advantages of mass-production machinery previously available only with straight-tube lamps.

The 18-watt Circlarc lamp operates on a simple reactor-type ballast

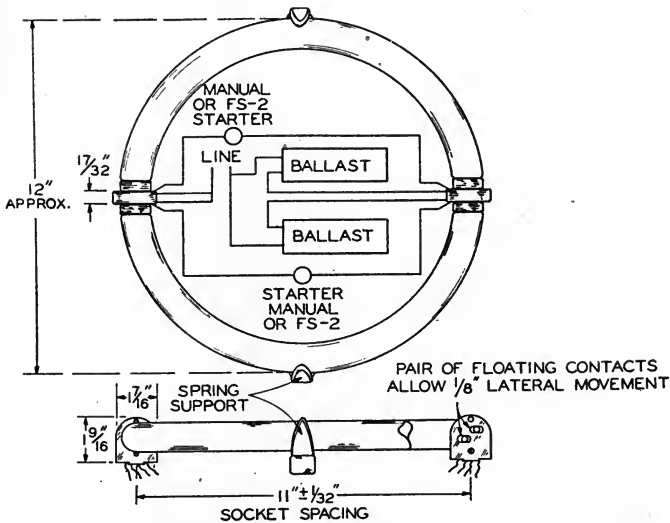


Fig. 3—A pair of 18-watt Circlarc lamps may be mounted to form a 12-inch circle.

TABLE I  
ESSENTIAL TECHNICAL DATA

Designation.....	Circlarc
Service.....	General lighting
Watts (lamp only).....	18 (approx.)
Bulb shape.....	Semicircle—12" nominal diameter
Lamp dimensions:	
Diameter of tube.....	1" (T8)
Outside radius of lamp.....	6" $\pm$ 1/8"
Center-to-center spacing of bases..	11" $\pm$ 3/32"
Operating ampere.....	0.380
Operating volts.....	54.5
Open-circuit volts.....	110-125
Preheat ampere (center value).....	0.55
Base.....	Medium bipin
Color.....	White
Initial lumens.....	710
*Rated life (at 3 hours per start).....	2500 hours
†List price.....	\$1.25

\* 4000 hours at 6 hours per start and 6000 hours at 12 hours per start.

† Subject to change.

with the regular manual or the FS2 glow switch starter used for 15- and 20-watt standard fluorescent lamps (Fig. 3). Ballasts used with

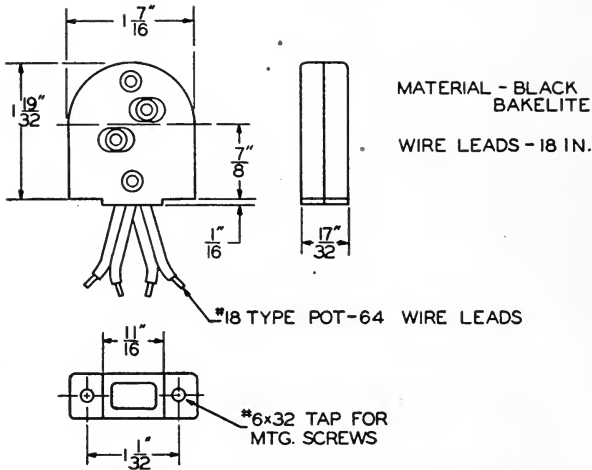


Fig. 4—Circlarc lampholders are arranged for base pins to be pushed into easy "finding" tapered openings. Lateral play allows for small tolerance in lamp dimensions.

the 18-watt Circlarc lamp should be suitable to carry the 0.380 operating ampere without overheating.

The Circlarc base pins are located at 45 degrees to the plane of the lamp which allows the pins of the two opposing lamp bases to overlap and reduces the thickness of a 2-lamp holder to a minimum. Holders

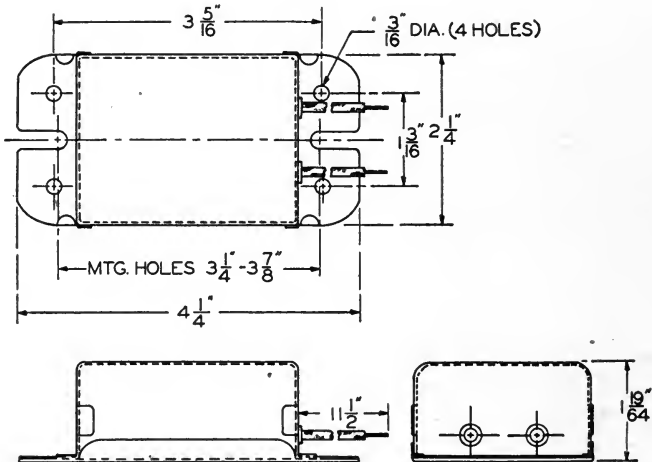


Fig. 5—Circlarc lamps need only a small choke-type ballast to operate the lamp at the proper electrical values.

should provide good electrical contact with the pin receptacles arranged to float laterally about  $\frac{1}{8}$  inch so as to allow for the lamp manufacturing tolerances in diameter required (Figs. 4 and 5).

#### PATTERN AND BUILT-IN LIGHTING

The Circlarc lamp provides a fluorescent shape that is badly needed for new type lighting throughout the theater. For example, this semicircular lamp can be used to form a pattern of light on the ceilings and walls and, in warm climates, on the marquee and the theater sign. Built-in lights for the niche over the water fountain, an arch of

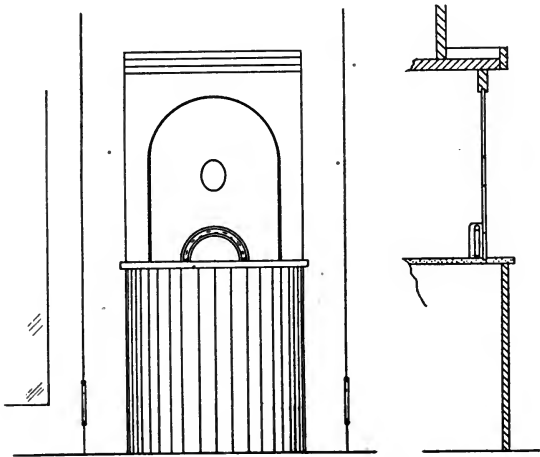


Fig. 6—Ticket sales beneath an archway of light. The Circlarc provides luminescent tubing around the opening in the ticket window placing light at the spot where it is needed.

light over the ticket window, pedestal lighting beneath or above flowers or statuettes, Figs. 6 and 7, and a diadem of light over small exhibits, such as costume jewelry, all represent new and interesting uses of fluorescent lamps which require a semicircular shape of lamp.

Pinup-type wall fixtures with the half-circle lamp in the horizontal position extending out from the wall provide downward or upward light where needed on or near the wall. For example, beneath a small picture, Fig. 8, the Circlarc is better than a straight tube against the wall because the center of the luminous tube is automatically extended from the wall by the graceful curve of the fixture and this makes it possible to throw a greater intensity of light to the top of the picture. Similarly, where a wall fixture is inverted to throw light downward,

this provides an excellent illuminant for growing plants or vases of flowers mounted on tables or against the wall in the lobby or elsewhere in the theater building.

Naturally, appearance of lighting equipment is of great importance in the theater. Aside from the technical advantages of the Circlarc lamp, there is also the basic fact that the curved form is interesting and attractive in contrast to the straight rodlike shapes of most standard fluorescent lamps in general use today. Where single lamps are used in desk, wall, and other types of fixtures, this curved shape is perhaps the most important contribution offered by the new Circlarc lamp.

SIMPLIFIED MAINTENANCE

The half-circle lamp makes replacement of "burnouts" a simple and practical operation even in fixtures using more than one complete circle of fluorescent tubing. Such relatively elaborate units are commonly required in large areas as theater buildings where a single Circline lamp would be inadequate. Two of these tubes form a complete circle and produce lighting results comparable to the Circline lamp. A circle of light built up with two Circlarcs can be taken apart and a



Fig. 7—Half circle of light highlights a vase of flowers in the theater lobby.

burned-out lamp readily replaced whereas it is difficult to relamp a Circline fixture using more than one lamp since these ring-shaped lamps cannot be threaded through one another. It is this flexibility in the use of the Circlarc lamp that will recommend it for larger multiple lamp fixtures in the theater.

In the design of ceiling fixtures of the conventional type, we have become accustomed to square ends or continuous runs in our design.

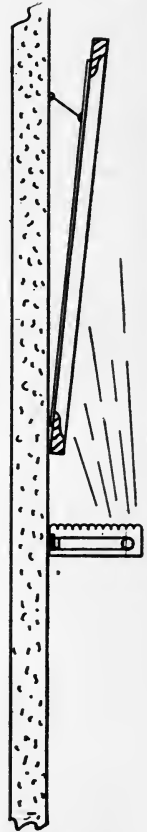


Fig. 8—Small graceful wall bracket with half-circle lamp lights wall-hung painting.



Architects and designers, however, have not been pleased with this condition but have always wanted a rounded end of the fixture (Fig. 9). The Circlarc lamp can now be used to provide this improvement, particularly desirable where the appearance of the room is important as is the case in the lighting of theaters or their associated buildings and areas. The Circlarc lamp not only rounds off the fixture making it more attractive but introduces luminosity at the end which is desirable to avoid shadows. This rounded end also makes it possible to nest downlights using the reflector-bulb lamp mounted inside the curve without loss of beauty in the fixture.

#### DIRECT-CURRENT OPERATION

The 18-watt Circlarc lamp is designed basically for operation on alternating current but it may be operated on direct current with quite satisfactory results if the proper auxiliaries are used and the line voltage is between 110 and 125 volts. Under these conditions, the lamps can be expected to give about 80 per cent of the normal alternating-current life performance. The end blackening of the tube will be a little more severe than on alternating current resulting in a somewhat lower lumen maintenance throughout life.

To assure dependable lamp starting, an inductive ballast as well as the regular direct-current resistance ballast must be used. This provides the necessary voltage surge that establishes the arc between the electrodes at each end of the tube. The inductive ballast used may be the standard ballast used for alternating-current operation and it may be installed as for normal alternating-current service. A suggested arrangement of the resistance ballast is at the baseboard outlet with a provision for plugging in a complete standard alternating-current fixture with its complete alternating-current circuit and auxiliaries.

It may be necessary to reverse the flow of current periodically through the lamp to prevent dimming at one end caused by migration

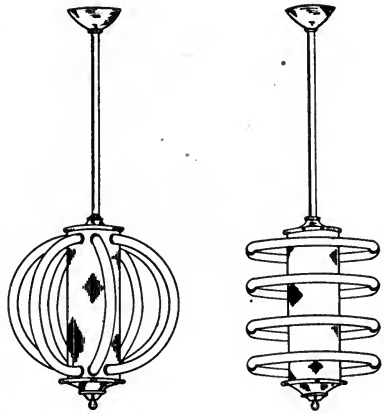


Fig. 9—Multi Circlarc lamp ceiling fixtures are practical to make and to relamp due to semicircular shape of lamp with push-in base pins.

of the mercury vapor. This is a characteristic of direct-current operation of fluorescent lamps. If the lamps operate continuously or for several hours at a time, some of the mercury will become concentrated at one end of the lamp and cause the other end to become dim. The use of a polarity-reversing switch or simply reversing the base-plug terminals in the baseboard outlet once or twice a day will serve to eliminate this condition.

The recommended values of series resistance and other technical data of interest in connection with direct-current operation of these lamps are given in Table II.

TABLE II

Direct Lamp Current (Amperes)	*External Resistance Required (Ohms)		†Ohms per Volt	Approximate Auxiliary Watts Loss per Lamp (Resistance plus Inductance)
	110 Volts	120 Volts		
0.32	148	180	3.2	21

\* These values of resistance must be used in series with the regular alternating-current inductive ballast used with this lamp. This resistance is in addition to the 24 ohms internal resistance of the inductance. Resistors must be capable of carrying the lamp current without overheating and should be within about 10 per cent of the values shown.

† For other line voltages, the resistance required may be corrected by adding or subtracting the number of ohms indicated for each volt difference.

The Circlarc lamp is now available in one size, an 18-watt T8 curved fluorescent lamp in the form of a half circle 12 inches in outside diameter. It is provided with the standard bipin base at each end but the base pins are located at an angle of 45 degrees to the plane of the lamp so that two lamps can be mounted to form a 360-degree circle with a minimum of dark space. The use of the preheat hot-cathode design permits operation of the lamp on a very small, simple, choke-type ballast directly from the 120-volt alternating-current lighting circuit. This reduces the space occupied by the auxiliaries required for the lamp's operation and also, of course, minimizes the initial investment in this type of lighting.

Ultimately it is quite possible that the Circlarc lamp will be made available in other sizes and in other colors beside the present standard white (3500-degree Kelvin color temperature). At present, however, the lamp will be available in only one size and one color. Since the new lamp was introduced largely because it can be adapted to manufacture on automatic machinery, this one size and the machines to make it in volume will be perfected before other sizes are introduced.

It is hoped that the 18-watt 12-inch Circlarc lamp will be found in practice to be as important as it would appear to be. Its designers and makers will feel that their efforts are well repaid if it does help extend the use of fluorescent lighting in the American theater.

## Theater Engineering Conference

### Lighting

# New Techniques in Black Light\*

By RONALD J. ELLIOTT

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*Summary*—The basic requirements which govern the success of black-light installations in the motion picture theater have been accurately determined. The demonstrated difficulty of satisfying those requirements indicates the need of a new technique. A prefabricated and ready-packaged mural and black-light combination is suggested as the answer to the problem.

IN THE SPACE of a few brief years, black-light† murals have won a recognized place among the major forms of theater decoration. Motion picture audiences have demonstrated that they are intrigued by colorful wall paintings which glow in the semidarkness of the theater without any visible source of illumination. In consequence, the exhibitor who plans either a new building or an extensive remodeling program is increasingly likely to consider black light for decoration. Under these circumstances, it seems pertinent to examine the technique of making a successful black-light installation.

The very existence of a specific technique represents a significant development. Until a comparatively recent date, there has been little or no literature available on the subject, and even now it is slight in volume. For this reason, hundreds of the existing black-light murals were perforce installed on the basis of trial and error. Today, however, the use of fluorescence for decoration is defined by rules no less precise than those which govern all the other phases of theater design and operation.

The first of these rules may be stated very simply: *Use plenty of black light.* The precept is so obvious that it may be regarded as elementary. Nevertheless, it has been and still is being frequently ignored. The costliest four-star film feature will be less than successful if presented on a poorly lighted screen. In exactly the same way, even the largest and most spectacular of fluorescent murals will appear dim and ineffective unless it is literally saturated in a flood of black light.

\* Presented October 22, 1947, at the SMPE Convention in New York.

† The term "black light" is commonly used to designate ultraviolet radiation of wavelengths just shorter than those to which the human eye responds.

There is no need to fear that the mural will "wear out." Modern fluorescent paints, such as are used by every reputable muralist, have been formulated expressly to withstand constant exposure to the ultraviolet of black-light equipment. They will not fade, and if kept clean, will glow with undiminishing brightness, year in and year out.

Be sure, then, to use plenty of black light. If your mural is more than 6 feet high or more than 6 feet wide, or if its total area exceeds 30 square feet, a 250-watt black light is essential. A mural only 30 square feet in area would be out of place in all but the smallest of today's motion picture theaters. It is safest, therefore, to regard 250-watt equipment as a minimum requirement for any black-light decoration in this field.

Experience has further indicated that if your mural is more than 10 feet wide, you will need an additional 250-watt black light for every additional 10-foot width or portion thereof. A mural that is 28 feet in width will therefore require not two, but three 250-watt units. Black lights should never be spaced more than 10 feet apart because the beam pattern of a 250-watt black light is an extremely elongated ellipse which cannot be more than 10 feet wide at effective range. Regardless of the height of the mural, this rule of never more than 10 feet between lights must always hold.

The placement of the black lights in relation to the position of the mural is also a matter of basic importance, covered by specified rules. Ceiling mounting of the units is recommended for black-lighting wall decorations. In the ideal installation, they are recessed in the ceiling at a distance from the wall line equivalent to one half the distance from the bottom of the mural to the ceiling. Suppose that your mural is 14 feet in height and runs up to a point 2 feet below the ceiling. The distance from the bottom of the mural to the ceiling is then 16 feet and your black light should be placed 8 feet from the wall line.

The angle at which the equipment is mounted is another important consideration. Best results are achieved when the center of the beam from the black light is directed at a point approximately one third of the distance from the bottom to the top of a well-designed wall mural. Observance of these rules further will serve to keep the ultraviolet out of the eyes of theater patrons. It may be noted, in passing, that modern black-light equipment makes observance easy because it permits the angle of lighting to be adjusted by as much as 45 degrees.

The standards of performance of the modern black light are likewise

dependent on careful adherence to established principles. The 250-watt unit recommended for theater installations is a high-intensity mercury lamp. Its operational characteristics are by no means complex; on the other hand, they cannot be ignored without impairing the life of the lamp. Every high-intensity mercury lamp demands an adequate and sustained flow of electrical current. A 250-watt lamp requires approximately 7 minutes to reach its maximum intensity. During this initial warmup period, it may actually draw up to 375 watts. Unless the wiring is heavy enough to carry this additional load, the lamp will almost certainly go out. It must then be allowed to cool before it can be expected to relight. Similar difficulty will be encountered if a line is overloaded by placing an excessive number of black lights on any one circuit.

For these reasons, a wire size not smaller than No. 12 B and S gauge is urgently recommended. In many instances, a No. 10 wire will prove an investment in freedom from trouble. Line voltage should also be carefully checked at the time of installation. Quality equipment always includes a 3-tap transformer, and it is a matter of common sense to make sure that the hookup meets local voltage conditions.

All the principles enumerated to this point have dealt with the black lights themselves. The electrical equipment, however, constitutes only half the story. Its function is solely to energize, to bring to life, the fluorescent materials used in the painting of the mural. The electrical installation may be perfect in every detail. Nevertheless, it cannot of itself put brilliance into a fluorescent mural. *That* is the responsibility of the artist who executes the mural.

The first of our rules, as you will remember, is to use plenty of black light. Where the mural itself is concerned, the rule becomes "use plenty of paint." The artist who works in the fluorescent medium is literally "painting with light." It is almost as if he were studding his canvas or other working surface with millions of miniature light bulbs. Sparse application or dilution of the fluorescent paint is closely akin to bulb-snatching. It can have but one result: a greatly diminished glow.

Fluorescence in black light makes it possible to achieve effects which lie entirely outside the range of ordinary colors. If this is the aim of the artist, he will begin by selecting a subject which offers the fullest possibilities for fluorescent treatment. He will never be satisfied to overlay an orthodox, everyday picture with random daubs of the fluorescent material. He will paint under black light, of course,

and if he is working in his own studio, he will try to approximate the lighting conditions, both black light and extraneous visible light, of the theater where the mural is to be displayed. Always he will be guided by the necessity of assuring maximum color brightness under actual operating conditions. Every detail of his composition and his rendering will be governed by the established requirements of the fluorescent technique.

These, then, are the essential factors in the successful utilization of black light for theater decoration. Up to the present, the exhibitor who wished to use black-light murals has been faced by the necessity of bringing together and effectively co-ordinating the skills of the architect, the electrical engineer, and the decorator artist. Even where such a procedure has been feasible, theater management has frequently found it too costly for all but the most elastic budgets. The result has been evidenced not only in murals which represent, all too often, a compromise with the ideal, but also in the fact that millions of motion picture patrons have yet to see their first black-light decorations.

The need for a new approach to the problem has been clearly indicated. It has recently been met with the introduction of a pre-fabricated mural and black-light combination, developed and produced by an entirely new technique and as simple to install as the most conventional of theater decorations.

The exhibitor who sets out to purchase new carpeting or new drapes does not have to concern himself with the problems of the designer, the weaver, and the dyer. On the contrary, all that he does is to examine a variety of samples at his own convenience, select the one he prefers, and place his order. He may now obtain black-light decorations in much the same way.

Prefabricated fluorescent murals are offered in a variety of patterns or subjects, ranging from pictorial scenes to formalistic designs. The exhibitor selects the picture he likes the best. It is delivered to him complete with the framing materials necessary for mounting it on the wall of his theater. The package further includes black-light equipment designed and constructed especially for use with the particular mural he has purchased. Any carpenter can mount the mural. Any electrician can follow the simple instructions for installing the black light.

The advantages of this new technique are three: convenience, economy, and assurance of a successful installation.

The convenience of the prefabricated mural scarcely needs detailed explanation. The exhibitor is freed from the complexities of locating and of negotiating with an artist who understands the fluorescent medium and its application to the theater. He is spared the equally burdensome task of determining lighting requirements governing his specific installation and of selecting the proper equipment. Costs and delivery schedules are positive factors, not estimates, which may be decided even before the project is undertaken.

Economy is inherent in prefabrication. The greatest part of the cost of a theater mural, as of any other painting, represents the charge for the artist's time. Much of it constitutes makeready time, used up in originating the theme of the picture, in drafting preliminary sketches, and in planning the layout. When a theme and a layout are utilized only once, the whole of this makeready cost necessarily is charged up to the purchaser of that one mural. A prefabricated mural essentially is a copy of an original subject. It is executed by hand, with exactly as much precision and artistry as the first rendering of the same picture, but with this one important difference: the makeready cost is spread over a number of murals. The obvious saving is substantial.

Greatest of all the advantages of the new technique, however, is the assurance it conveys of a successful installation. The element of experiment, of trial and error, is completely eliminated. The basic requirements for the effective use of black-light decorations in the theater are no longer a matter of guesswork. As outlined in this paper, they are clearly defined by an established framework of tested principles. The prefabricated mural and black-light combination is designed expressly in accordance with those principles.

The mural is painted on a heavy velour. This material has been selected because its pile surface enhances the remarkable illusion of depth in the completed picture under exposure to black light. It is not easy to work with velour, but no other material satisfies so completely the requirements of the fluorescent medium.

In a striking departure from the usual technique, the entire background is rendered in fluorescence together with the major objects depicted in the composition. Nonfluorescent paints are used only for shadow effects and for essential contrasts. There is added cost to this procedure, but it is more than offset by the basic economies of prefabrication.

In executing the painting, moreover, full recognition is given to the

fact that the radiant energy of any black light is greatest at the center of the beam pattern and diminishes steadily toward the outer edges. This unevenness is accentuated when, as in the preferred theater installation, the black light is mounted in the ceiling and its beam directed on the wall at an angle. The composition and the color scheme of the prefabricated mural are arranged to offset this characteristic and to assure an even degree of fluorescent brightness over the entire area of the mural. The end result of these measures is a picture that glows in the theater with an incomparable and hitherto unobtainable degree of fluorescence.

The standard width of the new type of mural is 9 feet and the standard height is 14 feet. The height may be modified, if necessary, without affecting the design, but the width is fixed at 9 feet.

These dimensions are dictated by the requirements of maximum fluorescence at the level of visible illumination usually found in the motion picture theater. Each  $9 \times 14$  mural is accompanied by a 250-watt black-light spot equipped with a modified parabolic reflector, engineered specifically to concentrate the largest possible amount of ultraviolet on an area  $9 \times 14$  feet. The equipment includes an adjuster, newly designed to fit between standard 16-inch centered joists for recessed ceiling mounting. This enables the black light to be set at the correct angle for directing its invisible radiations at the proper point, one third the distance from the bottom to the top of the mural. The adjuster further permits the black light to be serviced either from above or from below. The lighting equipment operates on 110-volt, 60-cycle alternating current.

To sum up, here is a compact, packaged combination which for the first time makes black-light decorations practical for the smallest theater as well as for the largest. Unquestionably, there will always be a demand for other types of fluorescent murals which do not come within the measure of prefabricated specifications. For the great majority of exhibitors, however, who have long indicated a preference for decorations which do not entail complicated technical problems, the prefabricated, ready-packaged black-light mural seems likely to provide the ideal answer.

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## Theater Engineering Conference

### *Lighting*

# Theater Dimmer\*

BY DANIEL M. ROLLINS

WARD LEONARD ELECTRIC COMPANY, MOUNT VERNON, NEW YORK

*Summary*—The proper control of the intensity of the lighting in a theater is essential to the comfort and safety of the audience. The theater dimmer is the device which provides means of adjusting these intensities as required by the season of the year or the time of day. Of the various types of theater dimmers available, the autotransformer dimmer provides the most efficient and desirable unit for the small neighborhood theater. Units of large capacity are available, which will operate at high efficiency and low maintenance cost.

THE THEATER DIMMER is usually associated with stage lighting. The production of a dramatic play or musical show requires a great variety of lighting instruments, each of which must be controlled in intensity by means of a theater dimmer. Thus the proper blending of colors and intensities produces the required balance of light and shade desired by the director. The neighborhood picture house is rarely equipped with a stage or any type of stage lighting. Therefore, it has been more or less assumed that the theater dimmer is unnecessary equipment.

The successful operation of a motion picture house depends first of all on the ability of the exhibitor to secure pictures which attract patrons to his theater. However, in order to maintain this patronage the exhibitor must provide features in his theater which promote the comfort and safety of his audience. With modern transportation facilities and the number of privately owned automobiles, people do not necessarily go to the nearest picture house if the same picture is playing in another house within a reasonable distance, and they know that they will be more comfortable and enjoy pleasanter surroundings in the more remote house. Therefore, to maintain his audience the manager installs the most comfortable seats that he can obtain, proper ventilation or air conditioning, and last but not least good lighting.

The problem of good lighting begins in the lobby and is carried all the way through the auditorium to the screen. Obviously, proper and

\* Presented October 22, 1947, at the SMPE, Convention in New York.

adequate instruments and fixtures must be installed and correctly adjusted to give the desired distribution and balance of light. Next, the lighting in the house must be of the proper intensity to prevent eye-strain or discomfort when viewing the picture. The intensity of the lobby should be adjusted to eliminate any abrupt change from brilliant daylight to a dark interior. The transition from the outdoor intensity to the low level of picture lighting should be gradual and well balanced.

Adequate lighting in the corridors and ramps is essential to prevent those minor mishaps which can often be a considerable nuisance to the theater manager.

#### ADJUSTABLE INTENSITIES ESSENTIAL

The lighting intensities in these various locations should vary with the conditions such as the season of the year or the time of day or the type of outdoor weather. A warm, cheerfully illuminated lobby adds immeasurably to the pleasure and comfort of people entering the theater from the cold, rainy outdoors. On the other hand, a dim, cool light is refreshing when the weather outside is extremely hot and humid. The intensity of the picture lighting should vary with the picture being presented. High screen brilliancy should have a higher level of picture lighting than a low-intensity screen, otherwise the contrast may be objectionable and uncomfortable. It is only by the use of a theater dimmer that these adjustments in lighting intensities in the foyer, the corridors, and in the auditorium can be accomplished. The theater dimmer alone provides the means of accurately adjusting these intensities for any circumstances.

#### TYPES OF THEATER DIMMERS

Three basic types of theater dimmers are available: the resistance, the autotransformer, and the reactance types.

The resistance-type dimmer, while the least expensive on initial installation, has the disadvantage that it must dissipate an appreciable amount of heat and consume a fair proportion of the wattage of the circuit when left in a dimmed position. Adequate ventilation must be provided to dissipate this heat and the loss of energy is expensive.

The reactance dimmer is the most expensive on initial installation, but it does operate at high efficiency and requires little or no maintenance. However, the cost for these installations is such that they are usually restricted to the very large presentation houses.

The autotransformer dimmer, is a relatively new device and is the most desirable unit for the small neighborhood theater. This type

of dimmer is essentially a transformer having a variable output voltage from zero to full line voltage. Because of the transformer action, the output voltage is independent of the load connected to the dimmer. For instance, a single unit of 4000 watts capacity will control any load from 10 to 4000 watts. This feature alone is a distinct advantage as the theater manager may want to relamp the auditorium or the lobby with different sized lamps from time to time,

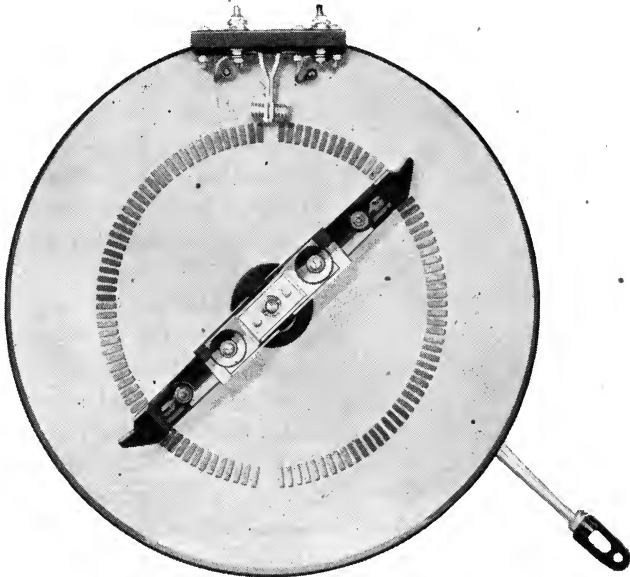


Fig. 1.—Resistance-type dimmer. Vitreous-enameled construction with 110 steps for flickerless dimming.

and the autotransformer dimmer will adequately control whatever load is connected, provided the maximum capacity is not exceeded.

The autotransformer dimmer operates at very high efficiency. Even with as low as 3 per cent of light output on the lighting circuit the efficiency is better than 90 per cent. This increased efficiency means that there is less energy dissipated in the form of heat and special provisions for ventilation are not required for this type of dimmer. Furthermore, the autotransformer dimmer is available in units of larger capacity. Single units of 8000 watts capacity are now being manufactured. Because of these larger capacity units less space is required for the dimmer equipment and fewer units must be operated to obtain the desired results.

## PICTURE LIGHTING

It has been the practice in many theaters to provide a special circuit of low intensity for picture lighting. By the use of the new auto-transformer dimmer, this circuit can be eliminated and the general auditorium lighting dimmed to the desired intensity. This at once provides means of varying the intensities in accordance with the change in the screen's brilliancy. The picture-lighting intensity must

be adjusted so it does not disturb or distract, but should add to the comfort and ease of the audience. This dimmer permits the theater operator to provide the most comfortable lighting conditions for his audience at all times and in doing so he is operating his equipment at low cost.

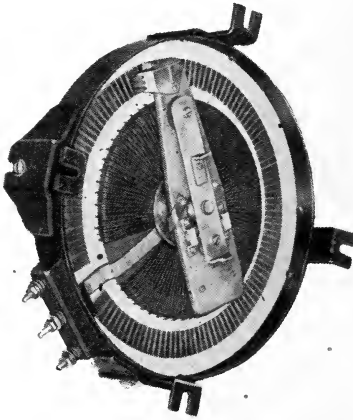


Fig. 2.—Autrastat (autotransformer-type) dimmer. 8000-watt capacity, radial construction.

Cold-cathode lighting has become more and more popular for general auditorium lighting in the small neighborhood house and this, too, can be dimmed equally well with the autotransformer dimmer. Smooth, continuous dimming control is possible from full intensity to

levels as low as 15 to 20 per cent of light output. Likewise, the new Slimline fluorescent lamps can be adjusted to the desired intensity to create a subtle atmosphere of restfulness and relaxation.

## LOBBY AND FOYER LIGHTING

The rear of the auditorium should be illuminated at a slightly higher intensity so that the people can find aisles and seats readily. The lighting in the corridors and the lobby should be at higher intensities so that there is a gradual and continuous change in the level of intensity from the street to the auditorium. This will prevent an abrupt change of intensity that causes eyestrain or discomfort to the patrons on entering or leaving the theater. The addition of colored lighting circuits in the lobby allows the manager to tone the lighting in the lobby to fit the season or outdoor weather. The actual intensity of the lobby should vary from daylight to afternoon and evening.

## INSTALLATION OF DIMMER EQUIPMENT

The space available for the installation of the dimmer will have some bearing on the type of assembly that finally is to be used. Dimmer controls for the lobby and corridor lighting would usually consist of one or two units which can be mounted on the wall above the lighting panel, in a closet, or other space adjacent to the lobby.

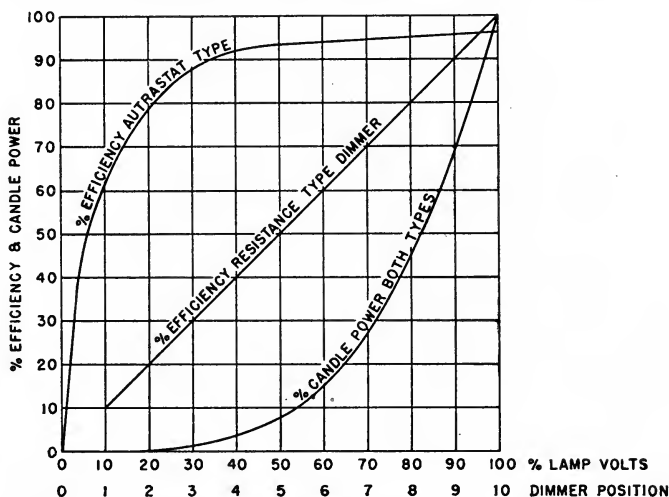


Fig. 3—Comparative efficiencies of Autrastat and resistance dimmers.

To eliminate the necessity of additional help simply for the purpose of operating the dimmers, it has been found desirable to install the dimmer controls for the auditorium where they can be conveniently operated either by the projectionist, the head usher, or the manager.

The least expensive installation obviously is the individually, manually operated dimmer unit. Where a number of these dimmers are located in the same place, they can be assembled edgewise to the wall on which they are mounted and occupy a reasonably small area. Usually the most convenient location for this equipment is the motor-generator room adjacent to the projection booth. However, the operator is obliged to go to that room in order to operate the dimmers.

By the use of an interlocking construction it is possible to mount the dimmers in a space directly above the projection booth and by means of extension rods through the ceiling locate the operating handles within the booth. In this manner the projectionist is able to adjust the intensity of the auditorium lighting without leaving his station.

### REMOTE-CONTROLLED EQUIPMENT

Where space is not available to locate the dimmer equipment conveniently for manual operation, remote-controlled motor-operated dimmer equipment is available. With momentary contact push-button stations for operation this assembly can be placed in any convenient spot where the wiring installation will be a minimum.

Motor-operated dimmer equipment has other advantages. First of all, control stations can be located at several points so that the dimmer may be operated by both the projectionist and the chief usher or the theater manager from his office. Furthermore, the dimmer equipment can be made semiautomatic.

By semiautomatic we mean that a definite program of intensities can be set up beforehand so that the projectionist or operator automatically can secure the desired intensity by pushing one of a series of buttons. For instance, buttons would be provided for full bright, blackout, picture lighting, and perhaps one or two other intermediate intensities. By momentarily pushing any of these buttons, the dimmers automatically will move to the desired position. Still another system of control provides a dial for selecting the desired intensity to which the dimmers will move automatically whenever the control switch is closed. These automatic controls eliminate errors in judgment by the operator as the same intensity which has been selected as proper for the particular condition can be secured immediately by the motor-operated dimmer equipment.

### ELECTRONIC-CONTROLLED REACTANCE DIMMERS

In installations where refinement of control is of particular importance, the reactance-type dimmer with electronic control provides the highest refinement. Here again the heavy dimmers and auxiliary equipment are located in any desired space where the wiring connections are reduced to a minimum. Control stations may be located in two or more places so that different individuals may operate the dimmer equipment. Furthermore, it is possible to preset intensities in advance and secure semiautomatic control of the lighting by push-button control. Miniature dimming controls having graduated dials are usually provided so that the intensity can be adjusted accurately by the operator.

Regardless of the type of dimmer involved there is definitely a place for the theater dimmer in the neighborhood motion picture house. It is only by accurately adjusting the various intensities of lighting in the lobby, clear through to the picture screen, can the theater manager provide the most comfortable and pleasing lighting conditions for his patrons and thus induce their return to his theater.

## Current Literature

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THE EDITORS present for convenient reference a list of articles dealing with subjects cognate to motion picture engineering published in a number of selected journals. Photostatic or microfilm copies of articles in magazines that are available may be obtained from The Library of Congress, Washington, D. C., or from the New York Public Library, New York, N. Y., at prevailing rates.

### American Cinematographer

29, 3, March, 1948

Electronic Flash for Still Exposures  
During Shooting (p. 85)

A New Light Source for Motion  
Picture and Television Studio  
Lighting (p. 88) D. W. PRIDEAUX

### British Kinematography

12, 3, March, 1948

Problems of 16-mm Projection  
Maintenance of Equipment (p. 81)  
W. J. HUMBERSTONE

Requirements and Maintenance of  
Prints (p. 82) J. W. HISSEY

The Operator and His Problems in  
the Field (p. 84) G. EAST

### Ideal Kinema

14, March 11, 1948

Magnetic Sound Recording and Re-  
production. Recent Develop-  
ments Abroad (p. 19) R. H. CRICKS

### International Photographer

20, 3, March, 1948

Who Said "Television"? (p. 5) H. H.  
BIRCH

Review and Preview of Television  
(p. 20) D. SARNOFF

### PSA Journal

14, 3, March, 1948

Electronic Flashtube Illumination  
for Specialized and Motion Picture  
Photography (p. 149) H. M.  
LESTER

### La Technique Cinematographique

19, 61, February 5, 1948

Problèmes relatifs à la reproduction  
photographique et en particulier à  
celle des films sonores (Problems  
concerning photographic reproduc-  
tions, particularly sound films) (p.  
46) C. J. DIPPEL AND K. KEUNING

19, 63, March 4, 1948

Nouvelles sources lumineuses à cor-  
rection chromatique pour cinéma  
et télévision (New light sources  
for color correction for motion  
pictures and television) (p. 89) H.  
BOURNE AND E. BOESON

19, 64, March 18, 1948

Nouvelles sources lumineuses à cor-  
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et télévision (New light sources  
for color correction for motion  
pictures and television) (p. 111)  
H. BOURNE AND E. BOESON

La procede Ivanoff de cinema en  
relief (Ivanoff procedure of relief  
motion picture) (p. 112)

### International Projectionist

23, 3, March, 1948

Projection Room Handling of Prints  
(p. 5) R. A. MITCHELL

### Radio News

39, 4, April, 1948

The Recording and Reproduction of  
Sound. Pt. 14 (p.72) O. READ

## Current Literature

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ON PAGE 314 of the March, 1948, issue of the *Proceedings of the I.R.E.*, there appeared an article which should be of interest to the motion picture engineer. A summary of this paper is given below.—THE EDITOR

### A PROPOSED LOUDNESS EFFICIENCY RATING FOR LOUDSPEAKERS AND THE DETERMINATION OF SYSTEM POWER REQUIREMENTS FOR ENCLOSURES

BY H. F. HOPKINS AND N. R. STRYKER

In this paper the authors describe a method of calculating the efficiency of a loudspeaker which relates the input power to the loudness of the loudspeaker rather than to its output power. Such a rating should be more useful than the power efficiency and more descriptive of the loudspeaker performance than free field pressure (outdoor) measurements on or near the horn axis.

Since loudness is a subjective phenomenon, the authors first derive from data on intensity versus frequency distribution of speech and music, a set of curves expressing loudness as a function of frequency. From the average of the speech and music loudness curves, another curve is computed in which the frequency range from 100 to 6000 cycles is divided into ten bands each having equal loudness increments. This includes 96 per cent of the entire loudness spectrum and defines the weighting factor by means of which pressure measurements may be converted to loudness. By arranging a sweep-frequency oscillator so that the sweep occupies equal intervals of time in each of these frequency bands, a single integrated pressure measurement over the audio spectrum provides a measure of the loudness. It has been found possible to make a further simplification by limiting the sweep to a range between 300 and 3300 cycles since this includes 75 per cent of the loudness. While an oscillator could be built to give this time-frequency weighting, the authors have found it more convenient to use a linear time sweep (6 cycles per second) combined with an equalizer giving corresponding amplitude variations. A flat noise spectrum equalized in this manner is also suggested as an input source.

Measurements made according to the above method give the loudness at a point in free space in terms of pressure measurements. However, when listening in an enclosure, such as an auditorium, it is necessary to consider the total radiation since a large proportion of the energy reaching the observer is reflected from the walls and may have been radiated from the loudspeaker in a direction far from a straight line between the two. In general the power radiated from a loudspeaker varies markedly both with change in frequency and change of direction. In order to avoid the very extensive measurements necessary to cover the required angles (up to 360 degrees at the lowest frequencies) the authors compute a correction factor for converting axial-pressure measurements to total acoustic



power radiated. This correction factor (called Directivity Index) is in turn converted to Loudness Directivity Index. Curves are given by means of which the Loudness Directivity Index may be found for most loudspeakers.

Experimental verification of the above computations has been obtained by computing the loudness efficiency of a wide variety of loudspeakers and comparing such figures with the results of listening tests. In most cases the calculated loudness came within one decibel of the values obtained by listening.

Further calculations are made to determine the amount of electrical power necessary to create satisfactory loudness in enclosures (rooms or auditoriums), taking into account the volume of the enclosure and the loudness efficiency of the loudspeaker. It is pointed out that while these measurements and calculations are useful in comparing the loudness which may be expected from various loudspeakers, with a given electrical input, they do not take into account such factors as uniformity of frequency response, distortion, damping, distribution, and other factors which are necessary in determining the relative over-all merits of loudspeakers.

## Book Review

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### Elements of Acoustical Engineering, by Harry F. Olson

Published (1947) by D. Van Nostrand Company, Inc., 250 Fourth Ave., New York, N. Y. 527 pages + 11-page index × xviii pages. 341 illustrations.  $6\frac{1}{4} \times 9\frac{1}{4}$  inches. Price, \$7.50.

The second edition of this well-known work treats acoustics from the electrical viewpoint, with heavy emphasis on equivalent circuits and the electro-acoustical aspects of audio engineering. Hence the reader with a background of general circuit and audio-frequency theory, aided by the methodical arrangement of the topics, will readily obtain usable and detailed information.

Especially well written are the portions on acoustical elements, loudspeakers, microphones, and measurements, which comprise over half the book. The properties of acoustical radiators, mechanical sound recorders, and pickups are also treated extensively, and there are excellent summaries of information on room acoustics, complete sound systems, and psychophysiological acoustics. Chapters on underwater sound and ultrasonics, embodying much war and industrial experience, are new to this edition. As a whole the book contains about 50 per cent more pages and 75 per cent more illustrations than the first edition; all chapters have been revised, and new material added.

As an aid to the user of electroacoustic transducers additional emphasis might have been placed on their use in systems. For example, in use the efficiency of a loudspeaker also depends on its ability to absorb power from the source, as well as its ability to transfer the accepted power to the output efficiently. The author accords the first item much less space than the second.

The usefulness of the book as a general reference is somewhat impaired by the

## Book Review

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emphasis placed on the work of the author and his associates. In particular, the material on magnetic recording and on anechoic chambers contains inadequate recognition and citation of the recent contributions of other workers. A newcomer to the field may be perplexed by the fact that not only do one fifth of citations given refer to the author's own work, but that also many of these are repeated. The most striking instance is in the chapter on Underwater Sound, where fourteen references are made in ten consecutive pages to the author's "Dynamical Analogies," which contains no specific material on underwater sound.

The text is written in a clear style with little use of ambiguous words. The only one deserving more than a mild objection is the use of "supersonic" to denote "high intensity." Present standardization efforts and usage tend to favor the denotation "velocity exceeding that of sound." However, as the foregoing comments are largely matters of opinion, this reviewer can unqualifiedly recommend this text as one that should be on the bookshelf of every practicing audio engineer.

VINCENT SALMON

Jensen Manufacturing Company  
Chicago, Ill.



### Correspondence

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It is highly desirable that members avail themselves of the opportunity to express their opinions in the form of Letters to the Editor. When of general interest, these will be published in the *JOURNAL* of the Society of Motion Picture Engineers. These letters may be on technical or non-technical subjects, and are understood to be the opinions of the writers and do not necessarily reflect the point of view of the Society. Such letters should be typewritten, double-spaced. If illustrations accompany these contributions, they should be drawings on white paper or blue linen and the lettering neatly done in black ink. Photographs should be sharp and clear glossy prints.

Please address your communications to

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New York 17, N. Y.

## Section Meetings

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### Midwest

Chairman R. T. Van Niman called to order the March 22, 1948, meeting of the Midwest Section at the Hotel Stevens in Chicago. A motion picture short entitled "Atomic Energy" by Encyclopaedia Britannica Films was shown.

Mr. W. C. DeVry was introduced as Honorary Chairman for the meeting. The first speaker of the evening was Dr. V. C. Arnsperger, Executive Vice-President of Encyclopaedia Britannica Films, who addressed the audience with "The Role of the Instructional Film in Human Enlightenment."

Mr. O. H. Coelln, Jr., editor and publisher of *Business Screen* and *See and Hear* magazines, was next introduced. His subject was "Harnessing Picture Power in Business and Industry." This talk was reinforced with several samples of excellent sound films used in industry.

A short discussion period followed the films in which both speakers and people from the floor were involved.

Ninety members and guests attended the April 15, 1948, meeting of the Midwest Section of the Society of Motion Picture Engineers. Chairman R. T. Van Niman presided.

The meeting opened with a 16-mm color print entitled "Let's See," which concerns the British optical industry.

Percival H. Case, of Excel Movie Products, gave a talk on "A 16-Mm Sound Projector for the Mass Market," in which he described a machine which is designed for the home and other small groups. A 10-minute sound film showing the projector and how it operates was projected with one of these machines.

Phillip L. Karr, chief engineer of the same company described the technical aspects of the Apollo Sound Projector. This low-cost unit eliminates the conventional sound optical system and amplifier. The exciter lamp is replaced by a small piece of resistance wire which is heated in the infrared range with raw alternating current. The phototube, the size of an ordinary rubber tip of a pencil, is the Cashman lead-sulfide cell.

A piece of glass stirring rod is used as a cylindrical lens to image the heated wire on the sound track at a 12-to-1 reduction. This gives a slit image of approximately  $1\frac{1}{1000}$  of an inch. The voltage of the phototube is fed to a two-tube oscillator of the type used for phonograph-record-player broadcast.

A radio is used to produce the sound. The oscillator may be tuned to an open space on the radio broadcast band. There is no direct wire connection between speaker and projector.

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## ~ New Products ~

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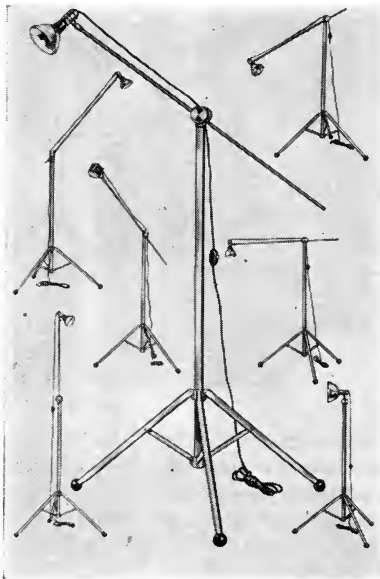
### Portable Tripod and Baby Boom Light

Radiant Manufacturing Company  
2627 W. Roosevelt Rd., Chicago 8,  
Illinois, recently announced that the  
production of their Champion (Model  
K) new portable tripod is under way.  
This is an economical lightweight unit  
which features a new swivel handle  
which folds inward, a space-saving

Baby Boom utility light, a flexible,  
mobile light unit. A boom rod is held  
in place by a pair of matched-teeth  
metal grippers; a twist of a knob on  
the grippers and the boom adjusts to  
an almost limitless variety of angles  
and heights from vertical to more than  
90 degrees. No counterbalance is re-  
quired, and it features finger-tip  
control.

### Photometering Unit

The model 400 Photometering Unit  
manufactured by **Photographic Pro-  
ducts, Inc.**, 9032 West Pico Boulevard,  
Los Angeles 35, California, provides  
light flashes of extremely short duration  
for photographing meters or other fast-  
moving mechanical objects at precise



feature when storing screen; a new  
spring-adjusting lock, which permits  
fingertip adjustment of screen to any  
desired height; and fully adjustable  
rubber-tipped tripod legs.

Another new product is Radiant's



time. The flashes are triggered by an  
external electrical pulse so that they can  
be synchronized with other apparatus  
or with a position of a moving object.

Up to three lamps can be used with  
each unit and each produces enough  
light to photograph objects at a dis-  
tance of about 3 feet with moderate  
lens openings. The flash time is ap-  
proximately 50 microseconds.

## ~ New Products ~

**F**urther information concerning the material described below can be obtained by writing direct to the manufacturers. As in the case of technical papers, publication of these news items does not constitute endorsement of the manufacturer's statements nor of his products.

The triggering pulses can be at regular or irregular intervals up to a speed of about 20 per second. The over-all time delay from the start of the triggering pulse to the flash is in the order of 40 microseconds.

The unit is made for 19-inch telephone rack mounting. The panel is 10 $\frac{1}{2}$  inches high and 8 inches deep and the weight is 25 pounds.

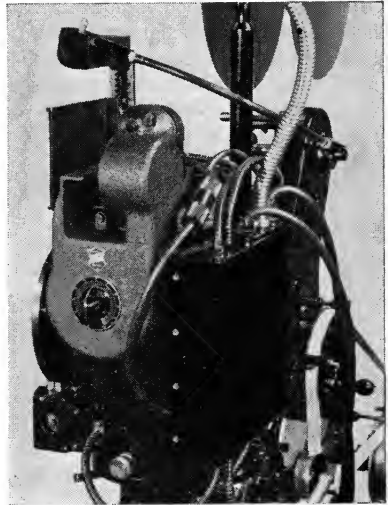
### 300-Watt Printing Lamp

Bell and Howell, 7100 McCormick Road, Chicago 45, Illinois, have announced a newly designed, self-contained, high-intensity incandescent lamp attachment which is now available for all their Model D 35-Mm and Model J 16-Mm continuous contact printers. The attachment has been so designed that it can be quickly installed on any printer now in the field, without machine work or special tools. The 300-watt projector-type lamp, with bi-plane filaments, provides sufficient light for printing any type of black-and-white fine-grain film or any existing color film, and also the color temperatures required to print either Ansco or Kodachrome color films.

The new lamp attachment is equipped with the Bell and Howell prealignment gauge, to position accurately the lamp filaments regardless of physical

variations in the lamp. Illumination is controlled by varying the lamp current.

An induced-draft cooling system and motor-driven fan provide adequate heat protection for lamp, reflector, and filters.



Incorporated in the lamp attachment is a removable filter holder which permits the use of gelatin color filter combinations for the printing of color films. Neutral density filters may also be used as an additional control over the intensity of the illumination reaching the printing aperture.

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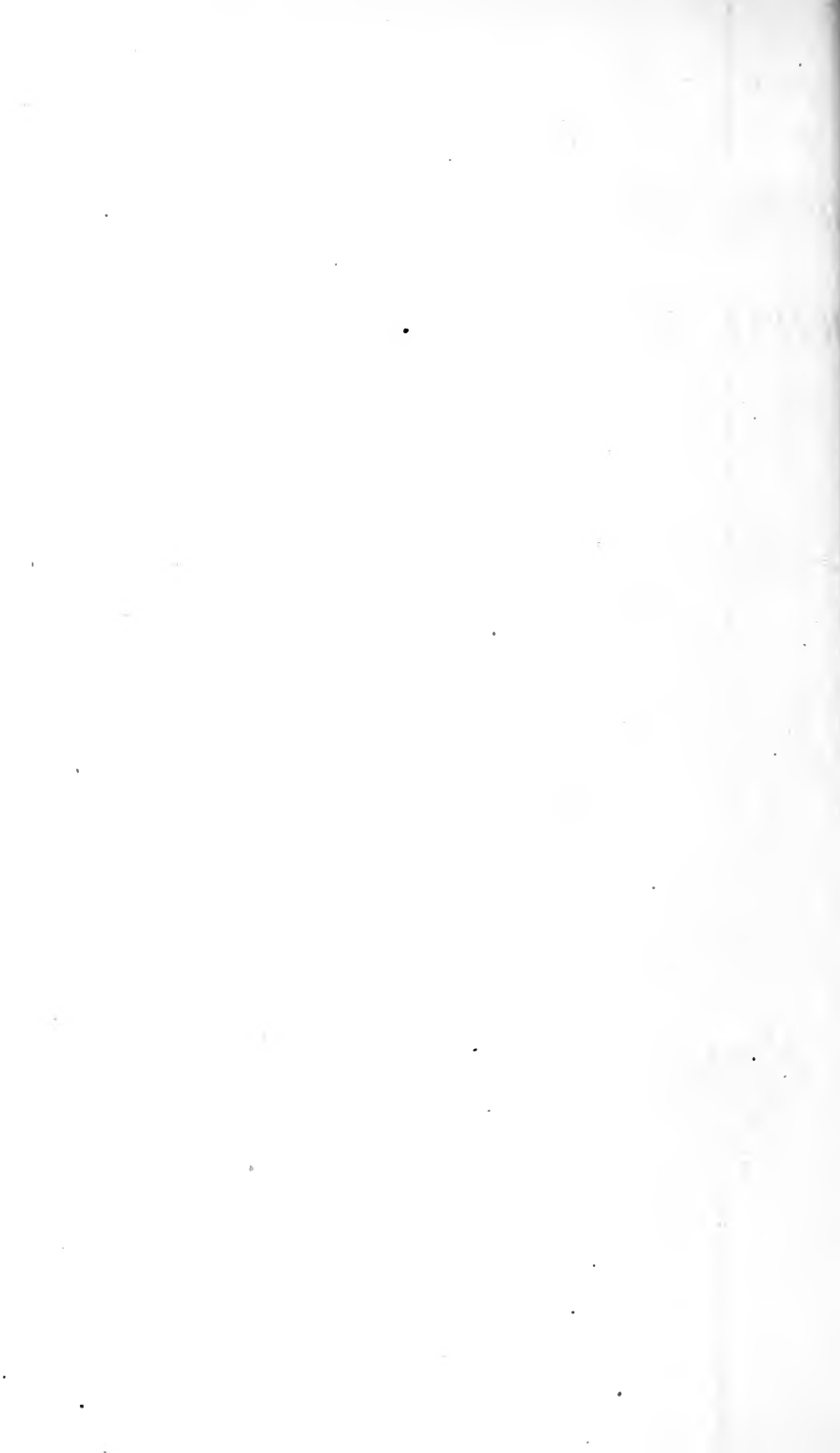
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*January—June, 1948*



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Part II—Index to Volume 50*





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